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5/9-2017

Fylkesmannen i Sør-Trøndlag
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Deres referanse: 2017/3136-432.1 Vår referanse: 2017/Fiske i marint verneområde

Innspill til oppstartsmelding i forbindelse med opprettelse av marint vern i sjøområdet Kråkvågsvaet – Grandfjæra – Bjugnfjorden i Ørland og Bjugn kommune

Sammendrag

Statsnail AS viser til Ramsar Handbooks 4th edition, Handbook 1: Wise use of wetlands. (Se http://www.ramsar.org/sites/default/files/documents/library/hbk4-01.pdf) Denne håndboka gir en beskrivelse av hvordan artikkel 3.1 i Ramsarkonvensjonen skal tolkes. På side 45 i håndboka omtales management av fiskerier. Her slås det fast at det skal legges til rette for bærekraftig fiske i Ramsar områder og at lovverket skal utformes i samarbeid med de som fisker.

Statsnail AS har utviklet en metode hvor vi håndplukker snegl ved bruk av fridykkere på en meget miljøvennlig måte og at påvirkning på havbunnen og bifangst er minimal. Statsnail AS vil dokumentere at dette fiske er meget bærekraftig. Håndplukking av strandsnegl er derfor den type høsting Ramsar konvensjonen applauderer.

Statsnail AS mener at håndplukking av skjell og snegl er i tråd med «wise use» nevnt i Ramsar konvensjonens punkt 3.1 og bør derfor likestilles med fiske i nye verneforskrifter for hele det planlagte verneområdet slik det er i lovverket for øvrig. Det er ingen grunn til at håndplukking av snegl/skjell/kråkeboller skal behandles annerledes en annet fiske.

Innledning

Fiske av Strandsnegl

Statsnail AS er et selskap som fisker strandsnegl. Vi eksporterer sneglene Frankrike som mat. Strandsnegl er en relativt uutnyttet resurs i norske farvann som vår høste metode gjør det mulig å utnytte. Vi forsøker å utnytte den i tråd med regjeringens intensjon om utnyttelse av nye ressurser i havet og vi ser at hvis vi lykkes med å gjøre høsting til næringsvei nå så kan oppdrett av strandsnegl bli det neste. Vi har i dag 14 medarbeidere og ser store muligheter i å utvikle nye arbeidsplasser ut fra havets ressurser.

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I 2015 høstet vi 2,8 tonn. I 2016 høstet vi 52 tonn og prognosen for 2017 er på ca 50 tonn. Vi ser at hvis vi klarer å opprettholde produksjonen så kan vi overleve som bedrift. Det er derfor svært viktig for oss at vi kan høste strandsnegl i langgrunne områder langs kysten tilsvarende de områdene man finner i Ørland og Bjugn kommune. Vi har lagt ned betydelige ressurser i å kartlegge fjæresonen. Innenfor planlagt verneområde har våre medarbeidere har svømt hele vegen fra Djupfestvågen til Vikavegen på Nes i Bjugn kommune og fra Likskjæret til Bruholmen (inkludert Garten og Grandefjæra) i Ørland kommune. Vi har også kartlagt Bjugnholmen og Kråkvågsvaet og vi har innhentet tillatelse til å høste strandsnegl fra over 30 grunneiere i området. Vi har utviklet kartverktøy for å sikre at vi bare høster der vi har tillatelse.

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Kartleggings og utviklingsarbeidet har pågått siden 2011, men Statsnail AS ble ikke stiftet før i 2015.

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Issue 3: Management of fisheries

- Participatory management in appropriate sites should be encouraged and facilitated by revising any existing laws and regulations that exclude it.
- Fisheries legislation and regulations should promote the participation of stakeholders in the formulation of policies for the management of the resource.
- Measures should be adopted to control to the use of fisheries in Ramsar Sites and other wetlands.
- Measures should be put in place to minimize or prevent by-catch through the use of appropriate fishery techniques.
- Where ecologically damaging fishing practices or gear (which may include activities which significantly alter habitat structure, prevent movement of species, or otherwise alter ecological character), are affecting, or are likely to affect, a listed Ramsar wetland, appropriate action should be taken to address the threat of damage.

Essensen i avsnitt 3, side 45 er at i Ramsar områder så skal lover og forskrifter endres slik at det legges til rette for et bærekraftig fiske, og de som fisker skal inviteres til å delta i prosessene for å endre lover og forskrifter. Fiske skal selvsagt kontrolleres, man skal finne teknikker som begrenser bifangst og man skal unngå ødeleggende fiskemetoder. Mye av dette er allerede oppfylt da Fiskeridirektoratet holder fortløpende kontroll med hvor mye som høstes og vurderer om kvoter er nødvendig. Håndplukking er en metode som gir lite bifangst og påvirker området det høstes i minimalt og er derfor i tråd med Ramsarkovensjonens intensjon.

Statsnail AS synes derfor det er rart at høsting av bløtdyr er omtalt negativt i oppstartsmeldingen. Vi viser her til følgende tekst i oppstartsmeldingen:
Side 4: «Det dykkes etter kamskjell i området. Tidligere har det også forekommet maskinell skjellskraping.»
Side 8 og 9: «Det har nylig blitt startet opp kommersiell høsting av strandsnegl i Ørland/Bjugn og det pågår flere steder innenfor marint verneområde. Pr i dag finnes det ingen forskrift som regulerer høstingen, bortsett fra de verneområder der forskriftene i seg selv setter forbud mot slik aktivitet.» Så noen sider senere står det «Det har tidligere foregått skjellskraping i området. Slik aktivitet har stor påvirkning på bunnen og bør ikke forekomme i verneområdet. Kommersiell høsting av bløtdyr i stor skala, som for eksempel strandsnegl, høsting av kamskjell (?), kan påvirke økosystemet negativt. Det må gjøres en vurdering på om slik aktivitet skal være forbudt i hele eller deler av området. Akkurat som tangskjæring blir ikke slik aktivitet regulert av havresursloven på privat grunn (ut til 2 meter dybde/marbakken)»

Mye av det dette er også feil og/eller lovstridig. Statsnail AS anfører:

Utsagnet «Akkurat som tangskjæring blir ikke slik aktivitet regulert av havresursloven på privat grunn (ut til 2 meter dybde/marbakken)» er ikke riktig. Høsting av strandsnegl innenfor marbakken er definert som fiske av Havresursloven. Både tangskjærere og sneglеplukkere må blant annet registrere seg i henhold til Havesurslovens §38, føre fangsten i land etter Havesurslovens §15 og forholde seg til de forskrifter Nærings- og Fiskeridepartementet måtte utforme angående gjennomføring av høsting etter Havesurslovens §16. Dette lå også til grunn da Fylkesmannens vedtak datert 30.01.2017 med referanse 2015/4805-432.6 ble omgjort i vedtak av Miljødirektoratet datert 28.04.2017 med referanse 2017/2407. Det eneste som er spesielt ut til marbakken er at grunneier har enerett til resursene. Statsnail AS spør derfor grunneierne om tillatelse til å høste og har så langt fått tillatelse fra ca 30 grunneiere innenfor det planlagte verneområdet. Det er en dry jobb å gå rundt å spørre grunneiere om tillatelse så det er ikke bare å flytte på seg.

Skadevirkningene på havbunn av skjellskraping og høsting av skjell/snegl for hånd er ikke sammenlignbart. Skjellskraping og høsting for hånd bør derfor ikke sammenblandes på den måten det er gjort i oppstartsmeldingen. Vi opplyser her om at all høsting av snegl og skjell innenfor foreslått marint verneområde foregår, så vidt oss bekjent, ved håndplukking eller fiske med teiner. Det gjelder strandsnegl høstet med fridykkere av Statsnail AS, kamskjell høstet med yrkesdykkere av Seashell og kongesnegl høstet med teiner av flere fiskerer som leverer til blant annet Hitramat AS.

Hypotesen om at «Kommersiell høsting av bløtdyr i stor skala, som for eksempel strandsnegl, høsting av kamskjell (?), kan påvirke økosystemet negativt.» er et brudd på Naturmangfoldslovens § 8, første ledd som sier at «Offentlige beslutninger som berører naturmangfoldet skal så langt det er rimelig bygge på vitenskapelig kunnskap om arters bestandssituasjon, naturtypers utbredelse og økologiske tilstand, samt effekten av påvirkninger» «Vitenskapelig» i § 8 må bety at en slik hypotese kan ikke fremsettes i et høringsdokument uten at den er underbygd med logisk resonnement og/eller referanser til vitenskapelig faglitteratur på samme måte som hypoteser må underbygges i vitenskapelig litteratur forøvrig. Det faktum at en hypotese er fremsatt uten logisk resonnement og referanser i et høringsdokument som sannsynligvis vil bli lagt til grunn for en forskrift er alvorlig.

Hypotesen er også feil. Det logiske resonnementet som tilbakeviser hypotesen er:

1) Det ble høstet 827 tonn med taskekrabbe i 2016 i området Frohavet/Lyngholmråsa/Kråkvågfjorden som planlagt marint verneområde er en del av. [1]
2) Taskekrabbe lever av bløtdyr i form av blant annet strandsnegl og kamskjell som den knuser med klørne. [2]
3) Normalt vil ca 10% av biomassen i en næringskjede overføres fra et nivå til det neste. [3]
4) Taskekrabben som ble fisket i 2016 har fortært ca 5000 tonn med bløtdyr i form av skjell og snegl. Vi har trukket fra litt fordi Taskekrabbe også spiser andre krepsdyr og børstemark.

Det betyr at man kan trykt høste inntil 5000 tonn med bløtdyr innenfor området Frohavet/Lyngholmråsa/Kråkvågfjorden da dette tilsvarer den mengden bløtdyr som ville blitt spist av oppfisket kvanta av Taskekrabbe uansett, og man kan sannsynligvis høste mye mer da taskekrabbe ikke er eneste predator på snegl og skjell og man har heller ikke tatt hensyn til den mengden taskekrabbe som ikke ble fisket. Dette forutsetter naturligvis at høstingen foregår skånsomt f.eks ved håndplukking. Man kan beregne hvor mye som trykt kan høstes innenfor planlagt verneområde ved å sammenligne lengden på kystlinje innenfor planlagt verneområde og området Frohavet/Lyngholmråsa/Kråkvågfjorden. Det er ikke helt enkelt siden arealet av fjæresone og gruntvannsområder spiller inn, men selv et meget forsiktig anslag på at 10% av kystlinjen i Frohavet/Lyngholmråsa/Kråkvågfjorden ligger innenfor planlagt marint verneområde vil gi at man trykt kan høste minst 500 tonn med bløtdyr innenfor planlagt marint verneområde hvert år. Dette er mye mer en man vil kunne høste med de metoder som brukes i dag, og hvis man i fremtiden nærmer seg dette nivået kan Nærings og Fiskeridepartementet begrense høstingen ved kvoter dersom de vurderer det som nødvendig.

Konklusjonen blir at man kan trykt høste minst 500 tonn med bløtdyr innenfor planlagt marint verneområde hvert år uten at det vil påvirke økosystemet negativt. Fiske av skjell og snegl bør derfor likestilles med annet fiske i nye verneforskrifter. Dvs. at håndplukking av skjell og snegl bør være lov da dette ikke forstyrrer bunnen mer en annet fiske. Det blir feil å forby håndplukking (og fiske med teiner) av snegl, skjell, krabbe og kråkeboller når fiske med snurrevad er tillatt dersom man ønsker å forstyrre havbunnen minst mulig.

Strendsneglforekomst i Åfjord komune fotografert av Lasse Olsen

Referanser som underbygger analysen er:
[1] E-post fra Råfisklaget som oppgir mengde fanget Taskekrabbe i Frohavet/Lyngholmråsa/Kråkvågfjorden. (Man får 827 tonn hvis man summerer han og ho krabbe i tabellen i mailen på under).

Hei!
Viser til tlf.
Sender som avtalt oversikt over fangst av skalldyr og bløtdyr i område 0725 i de siste 3 år + hittil i 2017.

Fangst av skalldyr/bløtdyr i 2014 -2015 - 2016 og hittil i 2017:

Rundvekt					
Radetiketter	**2014**	**2015**	**2016**	**2017**	**Totalsum**
0725 Frohavet/Lyngholmråsa/Kråkvågfjorden	626015,6	753516,7	837684,8	6477,1	2223694,2
HUMMER	390,3	379,9	363,4		1133,6
KAMSKJELL	1293		1418		2711
KONGESNEGL		212	3798	5260	9270
SJØKREPS	2123,3	1700,8	4972,9	1149,1	9946,1
TASKKR HAN	184824,5	220740,5	248544,5		654109,5
TASKKR HO	437384,5	530483,5	578588		1546456
OSKJELL				68	68

Mvh
Einar

Einar Sande
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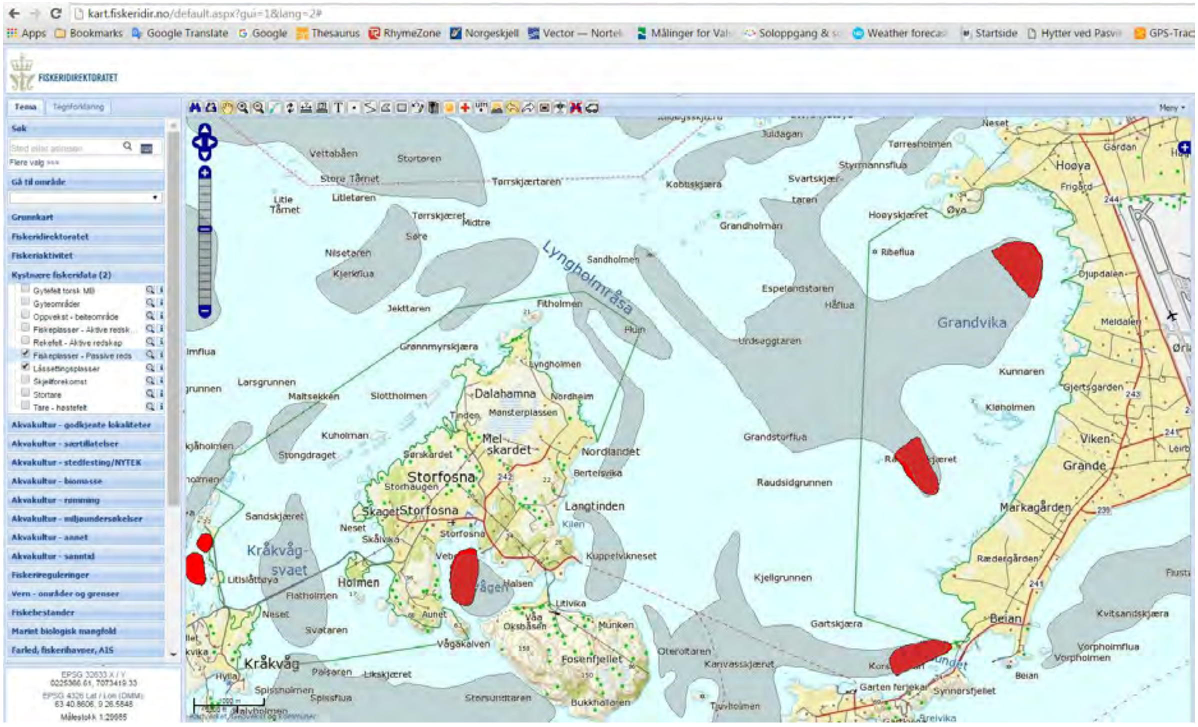
NORGES RÅFISKLAG
www.rafisklaget.no

[2] Store norske leksikon, Taskekrabbe
[3] Store norske leksikon, Næringskjede (Økologi)

Konklusjon ut fra Statsnail AS sine kommentarer til brev datert 26.06.1017 med referanse 2017/3136-432.1

Håndplukking av strandsnegl bør likestilles med annet fiske i nye verneforskrifter for hele det planlagte verneområdet slik det er i andre verneområder og i lovverket for øvrig. Det er ingen grunn til at håndplukking og fiske med teiner etter snegl/skjell/kråkeboller skal behandles annerledes en annet fiske.

Det bør legges til et punkt som presiserer at fiske er tillatt innenfor Kråkvågsvaet fuglefredningsområde da det pågår et betydelig fiske i dette området som er potensielt ulovlig ifølge verneforskriften slik den står i dag. Se kart fra Fiskeridirektoratet over fiskeplasser.



Dette bør rettes opp i nye verneforskrifter da Statsnail AS ikke ser noen grunn til at fiske i Kråkvågsvaet fuglefredningsområde skal være forbudt. Det er uheldig at dette i dag er uklart og det kan føre til unødvendige forvaltningssaker. Det kan også vurderes om det skal presiseres at fiske er tillatt i andre verneforskrifter i Sør-Trøndelag som e.g. Innstrandfjæra, Bjugnholmen, Hovsfjærna, Været, Bingsholmråsa.

Til slutt vil Statsnail AS påpeke at det er brudd på Forvaltningslovens §17, første ledd dersom en forvaltningsmyndighet villeder opinionen og overordnede myndigheter med udokumenterte hypoteser i høringsdokumenter. Forvaltningslovens §17, første ledd sier at «Forvaltningsorganet skal påse at saken er så godt opplyst som mulig før vedtak treffes.» Det at regjeringen vedtar en forskrift må i aller høyeste grad anses som at et «vedtak treffes».

For å utvide kunnskapen om strandsnegl har vi lagt ved relevante artikler. Vi anbefaler spesielt Cummins et al. [7] som omhandler bærekraftig høsting i Irland.

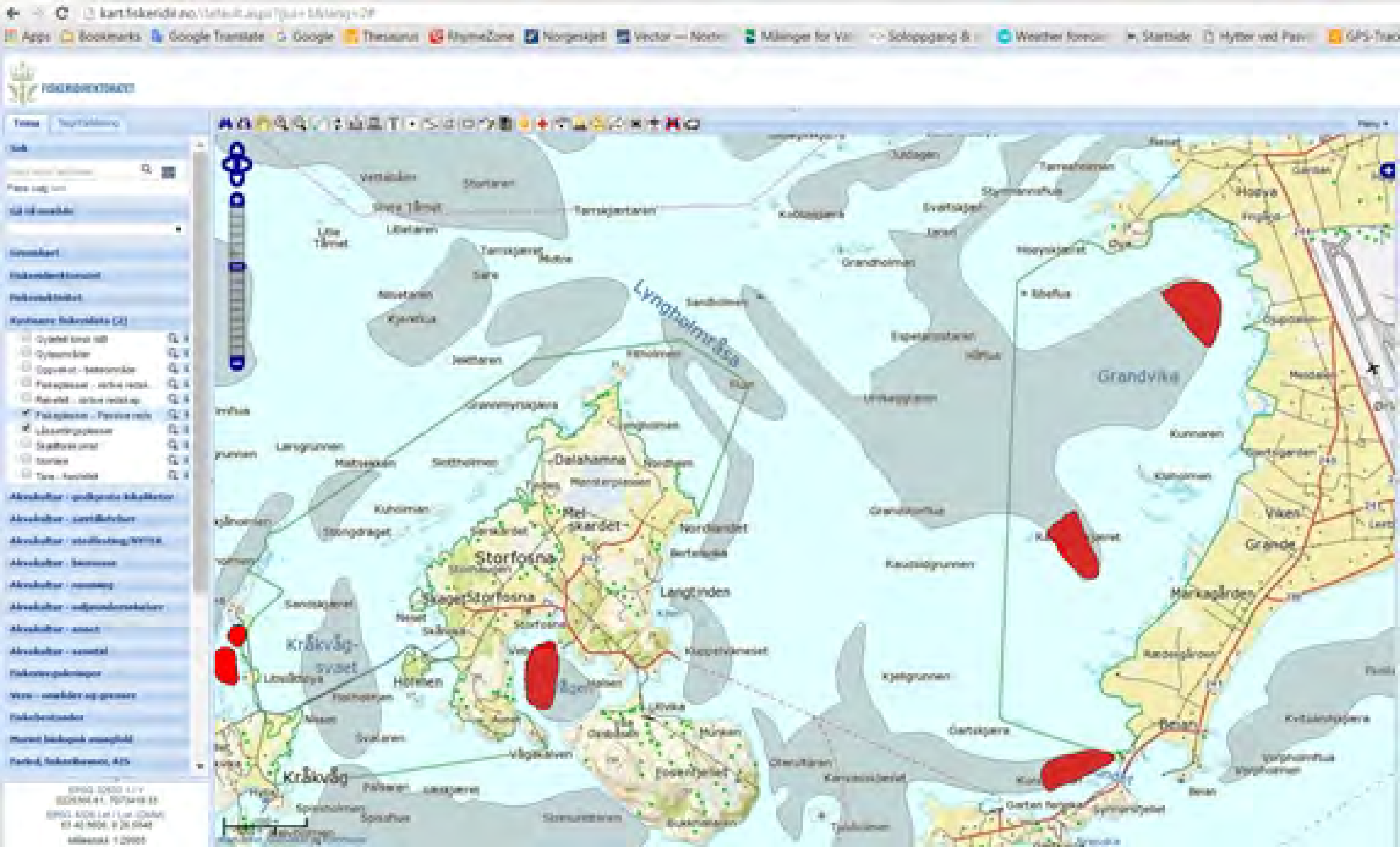
Vennlig hilsen

Jon Eirik Brennvall

Dr. Ing. Jon Eirik Brennvall
Styreformann i Statsnail AS

Faglige vedlegg

[1] Alarm response of the intertidal snail Littorina Littorea to predation by the crab Carcinus Maenas, Robin P. Hadlock, Biol. Bull.,159 p269-279. (October, 1980)
[2] An Assessment of the Potential for the Sustainable Development of the Edible Periwinkle, Littorina littorea, Industry in Ireland, Valerie Cummins, Susan Coughlan, Orla McClean, Niamh Connolly, John Mercer, Gavin Burnell, 2002, 97.IR.MR.012 of the Marine Research Measure
[3] Environmental Change and the Evolutionary History of the Periwinkle (Littorina littorea)in North America, Geerat J. Vermeij, Evolution, Vol. 36, No. 3 (May, 1982), pp. 561-580
[4] Infuence of trematode infections on in situ growth rates of Littorina littorea, Kim N. Mouritsen, A. GorbushinO and K. Thomas Jensen, J.Mar. Biol. Ass.U.K. (1999), 79, p425-430
[5] Common periwinkle, Littorina littorea
[7] An Assessment of the Potential for the Sustainable Development of the Edible Periwinkle, Littorina Littorea, Industry in Ireland
[8] Når miljøet er i ubalanse : hva gjorde Havforskningsinstituttet da det oppsto en giftig algeoppblomstring (1990) http://hdl.handle.net/11250/110214


Apps
Bookmarks
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RhymeZone
Norgeskart
Starthide
Lynghoimråsa
Grandvika
Dalahamna
Storfosna
Langtinden
Nordlandet
Kråkvåg
Hornsen
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Sammendrag

Avrenning fra jordbruket er nevnt på side 4 i oppstarts meldingen med setningen «Det finnes mange landbruksarealer i Ørland som har avrenning til kanaler og som munner ut i Grandefjæra. Dette medfører med stor sannsynlighet utslipp av næringsstoffer til Grandefjæra.»

Statsnail AS vil dokumentere at for Grandefjæra er denne avrenningen minimal. Statsnail AS vil også påpeke at noe avrenning er ønsket da det bidrar til å opprettholde algeproduksjonen. Vi viser her til artikkel fra Havforskningsinstituttet [8] som sier «Skulle algenes produksjon minke, vil derfor produksjonen av fisk, sjøfugl og sjøpattedyr også uvegerlig måtte avta.»

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Agriculture

Resolution VIII.34 on *Agriculture, wetlands and water resource management* was adopted by COP8 in 2002. Among its clauses are the following:

3. FURTHER RECOGNIZING that agriculture is also a major form of land use and that river valleys, floodplains, and coastal lowlands in particular have frequently been used for agriculture because of their natural suitability and the demands of agriculture for flat, fertile land and a ready supply of fresh water, and that therefore there is a high priority to ensuring that agricultural practices are compatible with wetland conservation objectives;

4. AWARE that wetlands can play important roles in relation to agriculture, such as abating the effects of storm and flood events, thus helping to protect both habitation and agricultural land, contributing to the replenishment of aquifers that are the source of water for irrigation, and constituting the habitat of wild relatives of cultivated crops and grasses;

7. CONSCIOUS on the one hand that drainage and intensive cultivation of such areas have led to widespread and continuing wetland loss, and on the other hand that sustainable agriculture supports some important wetland ecosystems;

12. CONVINCED that, in conformity with the Ramsar 'wise use' concept (as defined by the Conference of Parties), concerted efforts are required to achieve a mutually beneficial balance between agriculture and the conservation and sustainable use of wetlands, and to prevent or minimize the adverse effects from agricultural practices on the health of wetland ecosystems throughout the world (…);

19. CALLS UPON Contracting Parties to ensure that management plans for Ramsar Sites and other wetlands are developed within wider integrated catchment management approaches which duly acknowledge the need for appropriate implementation of agricultural practices and policies that are compatible with wetland conservation and sustainable use goals, and URGES Parties to identify and enhance positive incentives for the conservation and sustainable use of wetlands, including sustainable agricultural systems related to these wetlands;

21. URGES Contracting Parties, when reviewing their agricultural policies, to identify possible subsidies or incentives that may be having negative impacts on water resources in general and on wetlands in particular, in their territories and/or elsewhere in the world, consistent with their other international rights and obligations, and to remove or replace them by incentives that would contribute to wetland conservation;

22. INVITES Contracting Parties that have not yet done so to initiate intra- and inter-ministerial dialogues (…), with a view to enhancing integration of relevant policies related to the conservation of water resources, wetlands, and biodiversity.

Essensen er at det skal legges til rette for at landbruk kan foregå på en slik måte at våtmarksområder ikke blir ødelagt. Målet er med Ramsar konvensjonen altså å sørge for at landbruket er kompatibelt med vern av våtmarksområder. Det er ikke å fjerne landbruket fra våtmarksområdene.

Landbruket rundt planlagt marint verneområdet er hovedsakelig produksjon av melk. På åkrene dyrkes det hovedsakelig gras og korn. Mange av bøndene driver økologisk hvilket betyr at de kun gjødsler med kumøkk. I 2002 kom «Forskrift om husdyrgjødsel» som har som formål å hindre forurensning til luft, vassdrag, grunnvann, fjorder og havområder som følge av husdyrhold, gjennom å sikre at husdyrgjødsel utnyttes best mulig som en ressurs for planteproduksjonen.

Statsnail AS kan bekrefte at forskriften virker etter formålet. Dette kan vi si fordi Statsnail AS er pålagt av Mattilsynet å teste sneglene for E.Coli som stammer fra kumøkk. Statsnail AS har så langt i år tatt 9 prøver fra Grandefjæra ukentlig i perioden 4/7 til 28/8-2017. Målingene ble utført av Prebio. Samtlige målinger unntatt en har vist 20 eller færre MPN/100g som er det beste resultatet man kan oppnå. Målingen 21/8-2017 viste 220 MPN/100g. Dette er fortsatt innenfor det som er tillatt hvis sneglene skal brukes som menneskeføde. Rapporter fra Prebio er vedlagt.

Som det fremgår av Havforskningsinstituttet artikkel «Når miljøet er i ubalanse» [8] så trenger alger fosfor og nitrat for å vokse. Alger er grunnlaget for alt annet liv i havet og man ønsker derfor algevekst. Det man søker å unngå er store utslipp av fosfater og nitrater over kort tid som kan føre til voldsomme, potensielt giftige algeoppblomstringer.

Rutiner for gjødsling i landbruket har endret seg mye siste 15 år. Det er nokk riktig at det fortsatt er noe utslipp av næringsstoffer til Grandefjæra fra Landbruket, men som Statsnail AS sine målinger viser så er det snakk om meget begrensede mengder. Det bør derfor nye gjøre studier på mengder av næringsstoffer som slippes ut i dag, og hva som er kildene til disse næringsstoffene. Videre bør det gjøres en vurdering på hvor mye dagens utslipp bør reduseres slik at man unngår at mengden liv i Grandefjæra blir dramatisk redusert fordi man struper næringstilgangen.

Konklusjon ut fra Statsnail AS sine kommentarer til brev datert 26.06.1017 med referanse 2017/3136-432.1

Det må gjøres nye studier slik at det kan vurderes om det i dag er signifikant avrenningen fra Landbruket, da «Forskrift om husdyrgjødsel» allerede har redusert utslipp av næringsstoffer betraktelig. Det er åpenbart at redusert mulighet til å gjødsle vil gi landbruket i området problemer, både med å bli kvitt kumøkk og med produksjon av gras, korn og kraftfor, noe som vil gå utover lønnsomheten i en allerede presset næring. Statsnail AS anbefaler derfor at det ikke legges restriksjoner på landbruket uten at det først dokumenteres vitenskapelig at dette er nødvendig.

Til slutt vil Statsnail AS påpeke at det er brudd på Forvaltningslovens §17, første ledd dersom en forvaltningsmyndighet villeder opinionen og overordnede myndigheter med feilaktige udokumenterte hypoteser. Forvaltningslovens §17, første ledd sier at «Forvaltningsorganet skal påse at saken er så godt opplyst som mulig før vedtak treffes.» Det at regjeringen vedtar en forskrift må i aller høyeste grad anses som at et «vedtak treffes».

For å utvide kunnskapen om strandsnegl har vi lagt ved relevante artikler. Vi anbefaler spesielt Cummins et al. [7] som omhandler bærekraftig høsting i Irland.

Vennlig hilsen
Jon Eirik Brennvall

Dr. Ing. Jon Eirik Brennvall
Styreformann i Statsnail AS

Faglige vedlegg

[1] Alarm response of the intertidal snail Littorina Littorea to predation by the crab Carcinus Maenas, Robin P. Hadlock, Biol. Bull.,159 p269-279. (October, 1980)
[2] An Assessment of the Potential for the Sustainable Development of the Edible Periwinkle, Littorina littorea, Industry in Ireland, Valerie Cummins, Susan Coughlan, Orla McClean, Niamh Connolly, John Mercer, Gavin Burnell, 2002, 97.IR.MR.012 of the Marine Research Measure
[3] Environmental Change and the Evolutionary History of the Periwinkle (Littorina littorea)in North America, Geerat J. Vermeij, Evolution, Vol. 36, No. 3 (May, 1982), pp. 561-580
[4] Infuence of trematode infections on in situ growth rates of Littorina littorea, Kim N. Mouritsen, A. GorbushinO and K. Thomas Jensen, J.Mar. Biol. Ass.U.K. (1999), 79, p425-430
[5] Common periwinkle, Littorina littorea
[7] An Assessment of the Potential for the Sustainable Development of the Edible Periwinkle, Littorina Littorea, Industry in Ireland
[8] Når miljøet er i ubalanse : hva gjorde Havforskningsinstituttet da det oppsto en giftig algeoppblomstring (1990) http://hdl.handle.net/11250/110214

Fra: Jon Eirik Brennvall[jeb@statsnail.com]
Dato: 05.09.2017 22:08:36
Til: FMST Postmottak
Kopi: Postmottak Miljødirektoratet; postmottak@fiskeridir.no; bondelaget@bondelaget.no; postmottak@landbruksdirektoratet.no
Tittel: Re: Foreslått marint værneområde

Hei

Her er analysene fra Prebio.

Mvh
Jon Eirik

On 05/09/2017 21:53, Jon Eirik Brennvall wrote:

> Hei
>
> Vi viser til vedlagt innspill fra Statsnail AS til Fylkesmannens oppstartsmelding for Kråkvågsvaet-Grandefjæra-Bjugnfjorden datert 26.06.2017 med referanse 2017/3136-432.1
> Denne gangen er det reduksjonen i avrenning fra Landbruket de siste årene vi vil kommentere. Vi legger også ved våre kommentarer angående fiskeri på nytt.
>
> Ha en fin dag.
>
> Mvh
> Jon Eirik Brennvall
>
> Best regards / Med vennlig hilsen
> Dr. Ingeniør Jon Eirik Brennvall
> Phone: +47 92634023
>
> Statsnail AS
> Klæbuvegen 141C
> 7031 Trondheim
> Norway
>
> **[1] Hadlock1980.pdf**
>
> **[2] An_Assessment_of_the_Potential_for_the_Sust...**
>
> **[3] Vermeij1982.pdf**
>
> **[4] LittorinaGrowth_Parasites1999JMBA.pdf**
>
> **[5] Littorina littorea.pdf**
>
> **[6] 1979 - 1. Utkast til verneplan for våtmarks...**
>
> **[7] An_Assessment_of_the_Potential_for_the_Sust...**
>
> **[8] Når miljøet er i ubalanse.pdf**
>
> **[30] Avgjørelse i klagesak - Søknad om plukking...**
>
> **EinarSande.png**

--
Jon Eirik Brennvall
Phone: +47 92634023

Statsnail AS
Postboks 2
7159 Bjugn
Norway

Avdeling Fosen

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Att: Joakim Skjefstad
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7031 TRONDHEIM

Dato: 30.06.2017
Prøve ID: N2017-6071
ver 1

ANALYSERESULTATER

Prøvemottak: 28.06.17 Analyseperiode: 28.06.17 - 30.06.17 Prøvetaker: Leverandør

2017-6071-1 **Skalldyr, annet** Tatt ut: 28.06.17 Kl. 10:00

Merket: Strandsnegler Referanse: Valset 1622-7/2

Parameter	Metode	Resultat	Enhet	Måleusikkerhet
ß-gluc.-pos. E.coli MPN	ISO/TS 16649-3	**70**	MPN/100 g	

Med hilsen Kystlab-PreBIO AS

Aase Mariann Vemundstad

Aase Mariann Vemundstad
Avdelingsingeniør Fosen

Kopi til
Joakim Skjefstad (E-mail)

Laboratoriet er ikke akkreditert for prøvetaking eller vurdering og fortolking av prøveresultater.
Måleusikkerhet fåes ved henvendelse laboratoriet.
Resultatet gjelder kun mottatt prøve. Rapporten skal ikke gjengis i utdrag uten vår skriftlige godkjenning.

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Org.nr.:
NO: 986 208 933 MVA

Avdeling Fosen

STATSNAIL AS
Att: Joakim Skjefstad
Klæbuvegen 141 C
7031 TRONDHEIM

Dato: 06.07.2017
Prøve ID: N2017-6297
ver 1

ANALYSERESULTATER

Prøvemottak: 04.07.17 | Analyseperiode: 04.07.17 - 06.07.17 | Prøvetaker: Leverandør

2017-6297-1 **Skalldyr, annet** | Tatt ut: 04.07.17

Merket: Strandsnegler | Referanse: Grandefjæra 1621-64/4

Parameter	Metode	Resultat	Enhet	Måleusikkerhet
ß-gluc.-pos. E.coli MPN	ISO/TS 16649-3	**20**	MPN/100 g	

Med hilsen Kystlab-PreBIO AS

Gunn Heidi Husby Lian

Gunn Heidi Husby Lian
Laboratorieingeniør Fosen

Kopi til
Joakim Skjefstad (E-mail)

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Dato: 13.07.2017
Prøve ID: N2017-6543
ver 1

ANALYSERESULTATER

Prøvemottak: 11.07.17 Analyseperiode: 11.07.17 - 13.07.17 Prøvetaker: Leverandør

2017-6543-1 **Skalldyr, annet** Tatt ut: 11.07.17

Merket: Strandsnegler Referanse: Grandefjæra 1621-64/9

Parameter	Metode	Resultat	Enhet	Måleusikkerhet
ß-gluc.-pos. E.coli MPN	ISO/TS 16649-3	**<20**	MPN/100 g	

*) Laboratoriet er ikke akkreditert for denne analysen < betyr: Mindre enn

Med hilsen Kystlab-PreBIO AS

Aase Mariann Vemundstad

Aase Mariann Vemundstad
Avdelingsingeniør Fosen

Kopi til
Joakim Skjefstad (E-mail)

Laboratoriet er ikke akkreditert for prøvetaking eller vurdering og fortolking av prøveresultater.
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Resultatet gjelder kun mottatt prøve. Rapporten skal ikke gjengis i utdrag uten vår skriftlige godkjenning.

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Avdeling Fosen

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Att: Joakim Skjefstad
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Dato: 20.07.2017
Prøve ID: N2017-6803
ver 1

ANALYSERESULTATER

Prøvemottak: 18.07.17 Analyseperiode: 18.07.17 - 20.07.17 Prøvetaker: Leverandør

2017-6803-1 **Skalldyr, annet** Tatt ut: 18.07.17 Kl. 13:00

Merket: Strandsnegler Referanse: Grandefjæra 1621-64/3

Parameter	Metode	Resultat	Enhet	Måleusikkerhet
ß-gluc.-pos. E.coli MPN	ISO/TS 16649-3	**20**	MPN/100 g	

Med hilsen Kystlab-PreBIO AS

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Joakim Skjefstad (E-mail)

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Att: Joakim Skjefstad
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Dato: 27.07.2017
Prøve ID: N2017-6977
ver 1

ANALYSERESULTATER

Prøvemottak: 25.07.17   Analyseperiode: 25.07.17 - 27.07.17   Prøvetaker: Leverandør

2017-6977-1   **Skalldyr, annet**   Tatt ut: 25.07.17 Kl. 11:00

Merket: Strandsnegler   Referanse: 1621-63-1, Grandefjæra

Parameter	Metode	Resultat	Enhet	Måleusikkerhet
ß-gluc.-pos. E.coli MPN	ISO/TS 16649-3	**<20**	MPN/100 g	

*) Laboratoriet er ikke akkreditert for denne analysen   < betyr: Mindre enn

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Resultatet gjelder kun mottatt prøve. Rapporten skal ikke gjengis i utdrag uten vår skriftlige godkjenning.

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Dato: 03.08.2017
Prøve ID: N2017-7150
ver 1

ANALYSERESULTATER

Prøvemottak: 01.08.17 Analyseperiode: 01.08.17 - 03.08.17 Prøvetaker: Leverandør

2017-7150-1 **Skalldyr, annet** Tatt ut: 01.08.17

Merket: Strandsnegler Referanse: 1621-64/3 Grandefjæra

Parameter	Metode	Resultat	Enhet	Måleusikkerhet
ß-gluc.-pos. E.coli MPN	ISO/TS 16649-3	**<20**	MPN/100 g	

*) Laboratoriet er ikke akkreditert for denne analysen

< betyr: Mindre enn

Med hilsen Kystlab-PreBIO AS

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Torill Aune Vatn
Avdelingsleder Fosen

Kopi til
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Dato: 09.08.2017
Prøve ID: N2017-7236
ver 1

ANALYSERESULTATER

Prøvemottak: 07.08.17 Analyseperiode: 07.08.17 - 09.08.17 Prøvetaker: Leverandør

2017-7236-1 **Skalldyr, annet** Tatt ut: 07.08.17

Merket: Strandsnegler Referanse: Grandefjæra 1621-64/8

Parameter	Metode	Resultat	Enhet	Måleusikkerhet
ß-gluc.-pos. E.coli MPN	ISO/TS 16649-3	**50**	MPN/100 g	

Med hilsen Kystlab-PreBIO AS

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Dato: 16.08.2017
Prøve ID: N2017-7476
ver 1

ANALYSERESULTATER

Prøvemottak: 14.08.17 Analyseperiode: 14.08.17 - 16.08.17 Prøvetaker: Leverandør

2017-7476-1 **Skalldyr, annet** Tatt ut: 14.08.17 Kl. 12:00

Merket: Strandsnegler Referanse: Grandefjæra 1621-64/6

Parameter	Metode	Resultat	Enhet	Måleusikkerhet
ß-gluc.-pos. E.coli MPN	ISO/TS 16649-3	**20**	MPN/100 g	

Med hilsen Kystlab-PreBIO AS

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Dato: 23.08.2017
Prøve ID: N2017-7674
ver 1

ANALYSERESULTATER

Prøvemottak: 21.08.17 | Analyseperiode: 21.08.17 - 23.08.17 | Prøvetaker: Leverandør

2017-7674-1 **Skalldyr, annet** Tatt ut: 21.08.17

Merket: Strandsnegler Referanse: Grandefjæra 1621-64/17

Parameter	Metode	Resultat	Enhet	Måleusikkerhet
ß-gluc.-pos. E.coli MPN	ISO/TS 16649-3	**220**	MPN/100 g	

Med hilsen Kystlab-PreBIO AS

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Att: Joakim Skjefstad
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Dato: 30.08.2017
Prøve ID: N2017-7920
ver 1

ANALYSERESULTATER

Prøvemottak: 28.08.17 Analyseperiode: 28.08.17 - 30.08.17 Prøvetaker: Leverandør

2017-7920-1 **Skalldyr, annet** Tatt ut: 28.08.17

Merket: Strandsnegler Referanse: Grandefjæra 1621-64/20

Parameter	Metode	Resultat	Enhet	Måleusikkerhet
ß-gluc.-pos. E.coli MPN	ISO/TS 16649-3	**<20**	MPN/100 g	

*) Laboratoriet er ikke akkreditert for denne analysen

< betyr: Mindre enn

Med hilsen Kystlab-PreBIO AS

Torill A. Vatn

Torill Aune Vatn
Avdelingsleder Fosen

Kopi til
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Reference: *Biol. Bull.,* **159**: 269–279. (October, 1980)

ALARM RESPONSE OF THE INTERTIDAL SNAIL *LITTORINA LITTOREA* (L.) TO PREDATION BY THE CRAB *CARCINUS MAENAS* (L.)

ROBIN P. HADLOCK [1]

Department of Biology, Bowdoin College, Brunswick, Maine, 04011, and Department of Zoology, University of Rhode Island, Kingston, Rhode Island 02880

Many aquatic organisms rely on chemical senses to detect predators. Often avoidance behavior is elicited by distance or contact chemoreception of predator "odor" or "taste" (Mackie and Grant, 1974). Some species, however, have evolved alarm or escape responses to juices from the injured tissues of crushed conspecifics; these behaviors are found in minnows (von Frisch, 1938), amphibian tadpoles (Kulzer, 1954), sea urchins (Snyder and Snyder, 1970), sea anemones (Howe and Sheikh, 1975) and gastropod molluscs (Kempendorff, 1942; Snyder, 1967; Snyder and Snyder, 1971; Atema and Burd, 1975; Atema and Stenzler, 1977; Stenzler and Atema, 1977).

Snyder found in laboratory studies that 19 of 30 snail species tested respond to conspecific juice. He suggested that, in general, alarm reactions are responses to predation. Predators were tested for their ability to crush snails and elicit alarm responses in the laboratory. However, until Ashkenas and Atema (1978) reported that burrowing *Ilyanassa obsoleta* are rarely attacked by *Carcinus maenas* in the laboratory, no studies had tested whether responding with alarm behavior helps an individual snail avoid being eaten. Direct field observations of predation, which could support the antipredator hypothesis, have been lacking.

The present study was undertaken to test this antipredator interpretation. This paper describes the alarm response of *Littorina littorea* and field and laboratory observations of *Carcinus* predation on *L. littorea* and presents results of studies testing the utility of alarm behavior in preventing crab predation.

MATERIALS AND METHODS

Alarm behavior of Littorina littorea

Field experiments on the alarm repsonse of *L. littorea* were performed in tide pools of the rocky intertidal mid- and high zones at Bailey Island, Georgetown, and Harpswell, Maine. Snails found in small pools (< 25 cm deep, < 0.75 m^2 area) were tested in order to present snails with a high concentration of snail juice in tide-pool water. Snails responded to crushed conspecifics by moving to sites in the pool where they were less visible to a human observer. This response was measured by placing an octagonal grid (60 cm diameter, suspended from a circular plastic frame) over the tide-pool surface. Each trial lasted 60 min and consisted of a 30 min control period (min 0–min 30) followed by the experimental

[1] Present address: Department of Biology, Osborn Memorial Laboratories, Yale University, New Haven, Connecticut 06520.

period (min 30–min 60). At the beginning of the control period (min 0), two intact snails were dropped into the center of the grid area. At min 30 (beginning of experimental period) two crushed snails were dropped into the center of the grid area ($N = 6$ trials). The locations of snails visible under the grid were recorded at 10-min intervals for the full 60 min of each trial (after Atema and Burd, 1975).

Wet weight of snail tissue added to tide pools was determined by shell length–wet tissue weight regression. Mean wet tissue weight of intact snails added to pools was 0.68 ± 0.07 g, $N = 6$ trials (in this and subsequent sections, values are reported as means $\pm$ one standard error). Mean wet weight of crushed snail tissue added was 0.48 ± 0.20 g, $N = 6$ trials. Fifty-nine $\pm$ 24.1 (range 17–122) snails were followed per trial.

A second experimental series was designed to test for responses to chemical stimulation by the snail juice alone. At min 0 (beginning of control period) 6.25 ± 0.75 ml sea water was substituted for the intact snails of the first experimental series and at 30 min (beginning of experimental period) 5.45 ± 0.75 ml of filtered snail juice was substituted for the crushed snails ($N = 4$ trials). Snail juice was prepared at poolside just prior to each trial by crushing two individuals of *L. littorea* of known shell length (distance from apex to base of aperture) in a dish, adding sea water from another pool, and filtering the mixture through Whatman #1 filter paper into a 50 ml filtration flask. Both sea-water control and snail juice were released from a pipette into the center of the grid area; again, each snail juice test followed a control trial. Separate pipettes were used to avoid contamination between control and test stimuli. The concentration of snail juice added was estimated by first determining the wet weight of crushed tissue from shell length–wet tissue weight regression. The approximate concentration added was 0.12 g/ml of snail tissue in sea water before filtration and release into a tide pool. In each trial 66.5 ± 33.3 snails (range 35–106) were followed.

In two additional blank trials the experiment was conducted in the same way but the test stimulus at min 30 was omitted. In each trial 52 ± 36.9 snails (range 3–101) were followed.

To examine the rate of crawl of individual snails, in one Bailey Island pool 11 snails were marked individually with Pla enamel (Testors Corp., Rockford, Il.). Positions of six individuals were recorded at 10-min intervals during a 30-min control (sea water) and a 30-min experimental test (filtered snail juice) period. This pool was tested on April 14 and May 3, but not every snail marked was present for both tests. The movements of these individuals were also recorded during a 50-min blank trial on April 22 during which sea water, but not test stimulus, was added.

Predation by Carcinus maenas

To test the effectiveness of the *L. littorea* alarm response in preventing crab predation, the times required for crabs to find snails in "sheltered" and "exposed" sites were compared in the laboratory. Also, the time required for snails to hide was compared to the duration of the "consume phase" of crab feeding behavior (Fig. 2).

The first comparison was simplified by using only one type of sheltered site chosen by snails in the field: a rock crevice. Two round glass bowls (each 20 cm diameter, 6.5 cm deep) filled with sea water to a depth of 6.0 cm were used to simulate tide-pool habitat. The bottoms of these bowls were lined with several flat rocks. Crabs were tested with "exposed" snails by placing snails in the center of a rock surface at one end of the bowl. In trials with "sheltered" snails, snails were placed in the approximately 2.0-cm-deep crevices formed between rocks.

Crabs used in these experiments were collected by commercial fishermen in Rhode Island, held in a damp refrigerated room for 3 days, and then transferred to two large (20- and 45-gal) aquaria in a recirculating sea-water system until experiments began 4 days later. Crabs were not fed during this time. Individuals of *L. littorea* were collected in Narragansett, Rhode Island, on the first day of the experiment and held in a damp glass bowl thereafter.

Crabs were placed in the bowls, allowed to acclimate for 10–30 min, then removed for 2–5 sec while a snail was positioned in the bowl. Both pools were used in "sheltered" and "exposed" trials. Between trials, pools were rinsed with hot water and refilled with fresh sea water. Distances between crab and snail were the same (approximately 16 cm) at the start of all 12 trials. The experiment took place in a dark room with the pools lit by a microscope illuminator. Crabs were observed for 20 min or until they had picked up a snail and moved it to the "attack" position in front of the mouthparts.

In a second experiment the time required for crabs to injure and consume snails was estimated using the same glass bowls. The goal of this test was to determine how long a crab takes to consume one snail before searching for the next, since this is the period of time available to intact conspecifics to find shelter. The "consume phase" of the predation sequence begins with first injury to the snail body and release of snail juice to the surrounding water. The exact time of first injury was difficult to determine, so this moment was standardized by equating it with a behavior involving sure injury, the "pull from mouthparts" (see below). The end of the "consume phase" was marked by completion of all feeding behavior. Each crab was placed with a small (<9.0 mm shell length), medium-sized ($\geqslant 9.0$, $\leqslant 18.0$ mm), and large (>18.0 mm) snail (Underwood, 1973) and observed until all the snails in the bowl were consumed or the crab showed no searching behavior for 10 min after consuming a snail.

Field observations of *Carcinus-Littorina* interactions took place in tide pools at Appledore Island, Maine. Feeding crabs were found at night by sweeping the red beam of a 9 V lantern (lens covered with a #2423 red plexiglas disc) over pool bottoms. Crabs were also observed feeding along the stony bottom of a cove at high tide during the day.

Results

Snail alarm behavior

The proportion of snails visible in the grid area decreased significantly in the 10 min period following addition of crushed snail ($P \leqslant 0.05$) or snail juice ($P \leqslant 0.025$) relative to changes in the proportion visible 10 min after introduction of intact snails or sea water (angular transformation of proportions; analysis of variance for paired data; Sokal and Rohlf, 1969). Snails tested in these trials hid by crawling into crevices, under fronds of macroalgae, or under rocks. In one pool, snails grazing at the tips of *Chondrus* blades moved down among the blades toward the holdfast. There was no significant change in the proportion of snails visible during the same intervals of blank trials (Fig. 1).

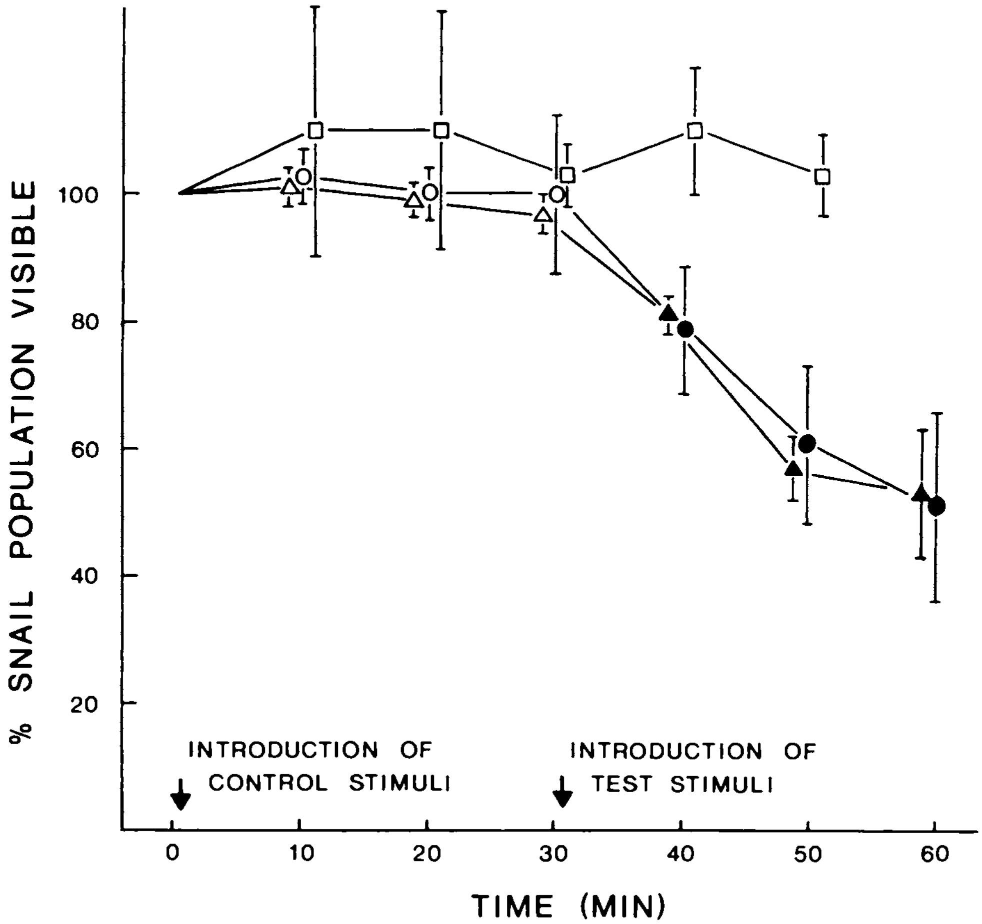

FIGURE 1. Percent of *L. littorea* populations visible following introduction of control and test stimuli, relative to percent visible at min 0. Stimuli introduced: open circle = intact *L. littorea* control; closed circle = crushed *L. littorea* (N = 6 trials). Open triangle = sea water control; closed triangle = crushed *L. littorea* juice (N = 4 trials). Open box indicates blank trials: intact snail or sea water was added at min 0 but no test stimulus was introduced (N = 2 trials). Symbols and bars represent means ± 1 standard error.

In general, snail activity in tide pools increased after addition of crushed snail or snail juice. Individuals in one pool increased rates of locomotion significantly, from 0.32 ± 0.07 cm/min (N = 6) in the 20-min interval preceding addition of snail juice to 1.40 ± 0.31 cm/min (N = 6) in the 20-min period following addition of juice ($P \leqslant 0.03$; Wilcoxon's signed-ranks test). In applying this statistical test, it was assumed that snails responded independently, although no experimental test for independent responses was conducted. There was no significant change in crawling velocity during the same periods of the blank trial.

Crab feeding behavior

Feeding crabs were observed in the laboratory and in the field. Detailed description of feeding behavior was based on laboratory observations.

Search phase. Feeding behavior begins when the crab detects, apparently by olfaction, the presence of nearby snails. First the antennule flicking rate increases (antennule beat, Fig. 2) and antennule position changes from primarily vertical to pointing at different angles from the carapace (antennule point, Fig. 2). The third maxillipeds then begin to sway from side to side and one may be wiped over the other several times. This may last for several minutes until the crab begins to move forward. The advance is accompanied by chelae and walking-leg raking, in which the chelae and walking legs are extended from the carapace and

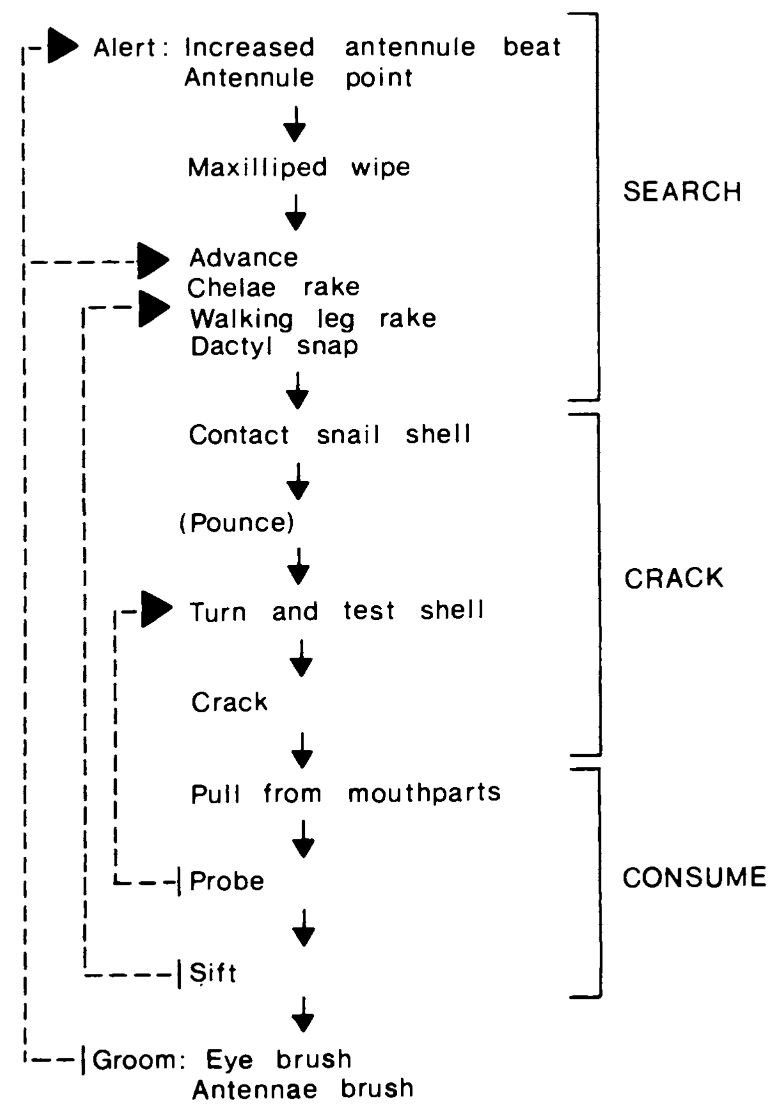

FIGURE 2. Sequence of crab (*Carcinus maenas*) predatory behavior. Dashed lines indicate points at which crabs may return to search or cracking behavior after having begun to consume a snail. This greatly lengthens the consume phase and increases the time available for intact snails to hide.

swept across the substratum with a semicircular swiping motion. While raking, the dactyl of the claw opens and closes (dactyl snap, Fig. 2).

Crack phase. Crabs begin their attack after contacting the snail shell with walking leg or claw. The crab may simply pull the snail from the substratum and bring it to the attack position in front of the mouthparts. Or the crab may suddenly pounce on the snail, pinning it between the carapace and substratum and then pushing the shell forward toward the mouthparts with the walking legs. Once the shell is in front of the mouthparts, the crab turns the shell over with the chelae, pausing to insert the dactyl of the claw into the shell aperture (probe, Fig. 2). The crab then removes the dactyl from the aperture and resumes turning the shell, stopping occasionally with one claw around the shell spire and the other supporting the shell. The third maxillipeds help support the shell during this turning and testing.

If the snail is small relative to crab size, the crab quickly crushes the shell with a claw or breaks off the top of the spire. If the shell is too large to crush, the crab uses alternative methods to expose the snail body; either chipping the outer lip of the aperture until the operculum is no longer flush against the shell and then grasping the snail body behind the operculum with one claw while the other claw tugs the shell in the opposite direction; or gradually chipping away the side of the shell. Either of these techniques requires further cracking of the shell after the first mouthful of snail tissue has been taken.

Consume phase. Once the snail body is exposed, the shell is held up to the mouthparts, supported by both chelae, and the mandibles and maxillipeds tear off bits of flesh. A small cloud of fluid appears around the mouthparts. While mouthparts grip the snail body, the shell is pulled away with the claws, exposing more snail body, until it is consumed. Occasionally the shell is dropped when the snail is only partially consumed but the crab is unable to crack more of the shell.

If the shell has been crushed or broken, the crab picks up the fragments again (sift, Fig. 2) after consuming the snail body. At the end of the "consume phase" the crab sits quietly, resumes searching, or grooms. A summary of the entire predation sequence appears in Figure 2.

In the field, crabs were usually discovered holding periwinkles in the "attack" position, but on one occasion the entire sequence of feeding behavior (search through consume) was observed in a tide pool.

Crab predation: laboratory experiments

Attention was focused on two periods of this predatory behavior to test the utility of snail alarm behavior in preventing crab predation. The two periods were the "search phase" (time between a crab's becoming alerted to the presence of a snail and its attack on the shell); and the "consume phase" (the interval between first injury to snail body and the start of a search for the next snail victim). If responding to snail juice helps snails avoid crab attack, then crabs should require more time to locate and attack sheltered than exposed snails. Also, the response time of snails to snail juice should be less than or equal to the duration of the "consume phase" of crab feeding behavior.

Crabs found and began attacking exposed snails in approximately 4 min, but required longer than 16 min to discover and begin attack on snails in crevices ($P \leqslant 0.005$, Wilcoxon two-sample test, Table I). Only three of six crabs tested

TABLE I

Results of tests comparing crab predation on L. littorea *in crevices or exposed on rock surfaces: Means ± one standard error. Crab size (carapace width in mm) exposed trials: 47.74 ± 1.15; sheltered trials: 47.44 ± 1.46. Snail size (shell length in mm) exposed: 9.83 ± 0.16; sheltered: 9.59 ± 0.19.*

Variable	Snail location: Exposed	Sheltered	
Time to crab alert (sec)	31 ± 14	25 ± 8	
range	(1–60)	(1–90)	
Time from crab alert to attack* (sec)	240 ± 79	972 ± 110	$P \leqslant 0.005$
range	(13–465)	(490–1199+)	

* Trial terminated at 20 min even if crab hadn't yet attacked.

with sheltered snails were able to find snails and attack within the 20 min limit of a trial. Crabs became alerted (signaled by antennule pointing) to snail presence equally quickly in both cases, but took longer or were unable to find sheltered snails. Also, once a crab's walking legs or claws had contacted snails in crevices, crabs seemed to have difficulty performing the claw movements required to extract snails from crevices. The time required to consume individuals of *L. littorea* depended on snail size (shell length). The regression equation relating snail size and time required to consume snails was: ln consume time = − 3.28 + 0.488 shell length, $R^2 = 0.40$, N = 16. Crabs took longer to consume medium-sized snails than small snails ($P \leqslant 0.05$, analysis of variance). This difference reflects different methods of attack on the two size classes of snail. All crabs consuming medium-sized snails interrupted actual feeding on snail tissue to resume attack on the shell. Small snails' shells were usually crushed immediately. Large snails were attacked (65%) but none consumed (Table II).

DISCUSSION

The size, shape, and structure of gastropod shells is often considered a snail's single or primary defense against shell-destroying predators such as birds, fish,

TABLE II

Crab predation success and the amount of time required to consume small, medium-sized, and large individuals of L. littorea.

	Snail size: Small	Medium	Large	
Number of snails presented	17	17	17	
Number (proportion) attacked	13 (0.76)	14 (0.82)	11 (0.65)	
Number (proportion) consumed	8 (0.47)	8 (0.47)	0 (0.00)	
Consumed snails				
Snail shell length (mm)	7.88 ± 0.20	10.53 ± 0.29	—	
Crack phase duration (sec)	30 ± 6	1164 ± 442	—	
range	(2– 45)	(25–3625)		
Consume phase duration (sec)	134 ± 52	594 ± 277	—	$P \leqslant 0.05$
range	(15–480)	(163–2505)		

and decapod crustacea (Heller, 1976; Vermeij, 1974, 1976, 1978; Vermeij and Covich, 1978; Hughes and Elner, 1979; Zipser and Vermeij, 1978). In this paper I have assembled evidence for an alarm response of *L. littorea* and its function as a complementary antipredator device. To test the hypothesis that alarm behavior in this snail is an antipredator adaptation, answers to two questions were sought: Do crushing predators prey on *L. littorea* in the field? Is the snail's alarm behavior adapted to predator search and feeding behavior? Answers were derived from laboratory and field observations of crab predation, and from results of field studies of snail alarm behavior. Although further analysis of this behavior would require identification of the alarm substance, such tests were not included in this study.

Both direct and circumstantial evidence suggest that crabs feed on periwinkles in the field. *Carcinus* was observed eating *L. littorea* in tide pools and a stony-bottomed cove. The abundance of broken shells found with shell injuries matching shell damage known to have been inflicted by *Carcinus* in the laboratory suggests that crab predation is not a rare event.

Three characteristics of snail alarm behavior seem adapted to defense against the search and feeding behavior of *Carcinus*: the form of the alarm response, the means by which alarm is communicated, and the time taken by snails to hide.

Individuals of *L. littorea* responded to juices of crushed conspecifics by increasing crawl velocities and moving toward rock crevices and under macroalgae fronds. Thus, the result of alarm behavior is movement to sites where snails are less likely to be stumbled upon by crabs. A snail in a sheltered site is more likely to avoid detection or attack than a snail exposed on a rock surface (Vermeij, 1974) or on the tide pool floor. In the present study it was found that crabs required more time to find periwinkles in crevices and were less successful in attacking once these sheltered periwinkles were found. It is likely that sites under rocks provide a similar refuge.

The majority of gastropod species tested by Snyder (1967), including the mud snail *Ilyanassa obsoleta,* responded to conspecific juice with self-burial. In the laboratory, buried individuals of *I. obsoleta* were attacked by *Carcinus* less frequently than were mud snails exposed on the surface (Ashkenas and Atema, 1978). Responding to a chemical signal is adaptive in defense against activities of a nocturnal tide pool predators such as *Carcinus.*

It is not immediately obvious that a gastropod could avoid being consumed by simply crawling away from its predator or by moving to sheltered sites, since snails are notoriously slow creatures. The key to understanding why this strategy works is knowledge of the predator's feeding behavior and the type of refuge sought by snails. *Carcinus* uses different techniques to attack and devour bivalve and gastropod prey depending on prey size (Elner, 1978; Kitching *et al.,* 1966; Hughes and Elner, 1979; Zipser and Vermeij, 1978). The crab employed a similar size-specific strategy for *L. littorea.* Small periwinkles were crushed and consumed in 3 min, while cracking and eating medium-sized snails took about 26 min longer. Large snails were never successfully consumed in the laboratory. Thus, large individuals of *L. littorea* appear to have a size refuge like that reported for *I. obsoleta* (Ashkenas and Atema, 1978), *L. rudis,* and *L. nigrolineata* (Elner and Raffaelli, 1980).

Individuals of *L. littorea* found sheltered sites in approximately 10 min. Thus, the time required by snails to hide corresponded closely to the amount of time required by crabs to consume medium-sized snails, once first injury to snail tissue had occurred. Although small snails are crushed and eaten too quickly to allow nearby conspecifics time to hide, with increased distance from the predator snails gain time to find shelter.

If the juice of crushed conspecifics signals a real threat to intact snails, crabs must search for a second snail after consuming the first (Snyder, 1967). All 11 crabs which consumed at least one *L. littorea* in the laboratory continued searching behavior after the first snail had been eaten. These crabs had been without food for 7–10 days when tested. In the field *Carcinus* probably feeds more frequently and may never consume more than one snail per feeding period. However, the single green crab observed through an entire episode of feeding in the field resumed searching as soon as the first snail was gone. Additional field observations are needed on this aspect of the snail alarm–crab predation relationship.

Of course, crabs are not the only predator of *Littorina* able to release snail juice. Carnivorous whelks (*Thais*), herring gulls, ducks, fish, and lobsters have also been reported to eat *L. littorea* (Pettitt, 1975). The shelter-seeking behavior of the snails may also be an effective defense against visual predators, such as birds. The alarm response would be equally effective against any predator which injures snail tissue, takes more time to consume a snail than snails require to hide, and consumes more than one snail per feeding period. However, the volume and mixing of water along the shore at high tide is so much greater than the volume and mixing in a tide pool at low tide that stimulus molecules probably do not reach concentrations sufficient to affect any snails but those a few millimeters from the crushed snail. Thus, alarm responses may only occur in tide pools or other areas where water is shallow and still, such as a tidal marsh at low tide.

In an evolutionary race between shell-crushing predators and their gastropod prey, the evolution of elaborate shell ornamentation, short shell spires, narrow opercula, or thick shell walls may be one line of defense for a snail (Vermeij, 1978). However, these morphological adaptations are more often found among tropical than among temperate species. It appears that a complementary first-line strategy for the temperate *L. littorea* is behavioral defense: alarm behavior which helps a snail avoid detection or attack. Perhaps the most interesting challenge remains: the unraveling of interactions among all selective pressures which together determine whether shell structure, alarm behavior, or a combination of the two evolves for snail defense.

The section on snail alarm behavior was first prepared as an undergraduate thesis under the supervision of Beverly Greenspan and James Moulton, Department of Biology, Bowdoin College. William and Barbara Hadlock made possible the frequent field site visits. I appreciate Tom Seeley's interest and assistance with pilot field studies. The comments of Jelle Atema, J. Stanley Cobb, and Tom Seeley on different drafts of the manuscript improved its final form. This work was supported in part by the Lerner Fund for Marine Research, American Museum of Natural History; and the Elliott Fund of Bowdoin College.

Summary

Individuals of *Littorina littorea* in rocky intertidal pools crawled to pool sites where they were less visible (into rock crevices; under rocks and macroalgal fronds) when either crushed conspecifics or juice from crushed conspecifics was added to

these pools. A significant proportion of snails hid in 10 min or less; individual snails in one pool tested quadrupled their crawling velocities after snail juice was added.

Field observations and laboratory experiments tested the hypothesis that this alarm behavior helps *L. littorea* avoid being eaten. Green crabs (*Carcinus maenas*) were observed consuming individuals of *L. littorea* in tide pools at night and along the shore at high tide during the day. In the laboratory, crabs required more time to locate and attack periwinkles in rock crevices than periwinkles on rock surfaces. The amount of time required to consume specimens of *L. littorea* depended on snail size (shell length), reflecting different methods of attack by crabs. Small snails (< 9.0 mm) were crushed, then consumed in approximately 2 min 30 sec. Crabs could not consume large snails (> 18.0 mm), but destroyed medium-sized snails ($\geqslant 9.0$, $\leqslant 18.0$ mm) by cracking the shell, tearing off bits of tissue, then resuming shell cracking to expose more snail tissue. This required a mean time of 9 min 54 sec once first injury to snail tissue had occurred, which approximately equals the 10-min response time of snails exposed to crushed snail or snail juice in the field. These findings indicate that the alarm response of *L. littorea* serves in defense against *Carcinus maenas*.

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An Assessment of the Potential for the Sustainable Development of the Edible Periwinkle, Littorina Littorea, Industry in Ireland

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An Assessment of the Potential for the Sustainable Development of the Edible Periwinkle, *Littorina littorea*, Industry in Ireland

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Final Report

2002

(Survey completed 2000)

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TABLE OF CONTENTS

SECTION 1 - INTRODUCTION

1 Background to the Study and Project Objectives

The edible periwinkle *Littorina littorea* (L.) has been exploited as a food source in Ireland since the stone age (Woodman, Anderson and Finlay, 1999). Today there is a large market for the edible periwinkle on the continent, principally in France. Pearson (1994) estimated that the Irish periwinkle industry was worth approximately €6.34 million (£5 million) in exports per annum. The edible periwinkle industry remains a fishery of economic and sociological importance in peripheral coastal communities. It is particularly important as an additional source of income in areas where few other employment opportunities exist.

According to the Department of Marine and Natural Resources (DoMNR), 2,635 tonnes of periwinkles were exported in 1998. However, this is considered by some to be a gross underestimate of the size of the industry. Unofficial figures provided by a wholesaler at the 1997 Shellfish Association AGM, suggested that, at the time, closer to 7,000 tonnes were exported per annum.

The difficulty in assessing the true scale of the Irish periwinkle industry lies in its black market nature. In addition, periwinkles are a "non-pressure stock" species which means that the fishery is completely unregulated. Indeed, many wholesalers claim that over-harvesting of the resource is jeopardising the recruitment of periwinkles on our shores.

Prior to this study, there was little or no scientific information available on the state of Irish periwinkle stocks, nor was there an accurate estimate of the scale and value of the Irish industry. This project aimed to redress this situation.

The main objectives of the project were:

- To establish the distribution and abundance of the edible periwinkle populations along the Irish coast and to provide a benchmark against which subsequent studies could be compared.

- In reviewing the Irish periwinkle industry, to assess its socio-economic impact on Irish coastal communities and to determine the potential impact of developments within this sector.

- To incorporate the resultant data into a Geographical Information System (GIS). The GIS would then be used as a decision making tool in developing a management strategy for the industry.

Primary field workers were Ms. Valerie Cummins and Ms. Orla McClean (both from the Coastal and Marine Resources Centre, National University of Ireland, Cork), and Ms. Susan Coughlan (from the Shellfish Research Laboratory, National University of Ireland, Galway). Ms. Cummins took over from Ms. McClean in June 1999. Field sites along the coast were arbitrarily split in two, with the Shannon estuary as the point of division. Ms. Coughlan was responsible for sampling and interviewing relevant individuals north of this point (i.e. County Clare to County Donegal), and Ms. Cummins and Ms McClean south and east of this point (i.e. County Kerry to County Louth), including regular sampling of Bullens Bay in

County Cork. Regular meetings were scheduled to ensure continuity of methods and exchange of ideas. Several other research assistants were employed at various stages of the project to aid with sampling and measurement of animals.

Plate 1. The edible periwinkle, *Littorina littorea.*

SECTION 2 - OVERVIEW OF PERIWINKLE BIOLOGY

2 Overview of Periwinkle Biology

2.1 Anatomical description

The edible periwinkle, *Littorina littorea* (Linnaeus, 1758), is a Prosobranch gastropod of the Family Littorinacea. It is one of the most common, and one of the largest, shore Gastropods of the Irish coast. It can attain a height of approximately 35cm. The head and tentacles of the animal are covered with dense transverse black lines; in some individuals, the head and tentacles are uniformly black. Sexes are separate and easily distinguished (at least when the animals are ripe) by the presence of a penis on the right hand side of the male and a whitish ovipositor in the equivalent area of the female. Under certain conditions, including the presence of the anti-fouling pollutant tributyltin (TBT), females may show abnormal development of a penis (pseudohermaphroditism) (Casey, *et al*., 1996).

Mature shell height ranges from approximately 10.6mm – 52.8mm (Reid, 1996). The shell is usually dark brown, and can appear almost black when wet. Other shell colours such as pale cream and orange occur occasionally. The outer lip of the aperture is defined by brown lines. The columella is white (except in old animals, where it may discolour to a darker cream). Juvenile *L. littorea* are more difficult to identify. They have a crenulated shell, and may be mistaken for the rough periwinkle, *Littorina rudis.* A particularly distinguishing feature of *L. littorea* is the alternate light and dark banding on the outer lip of the shell (Fish and Fish, 1989).

2.2 Distribution

L. littorea is distributed from the White Sea (and perhaps Spitzbergen) to Southern Portugal in the eastern Atlantic, and in the western Atlantic from Labrador to Virginia. The rapid spread of *L. littorea* along the northwestern Atlantic coast, following human settlement in North America in the nineteenth century, provides one of the most well documented examples of the dispersal of marine species (Reid, 1996).

The species is common around the coast of Ireland, Britain, the Outer Hebridies, Orkneys and Shetland Islands (Smith and Newell, 1955; Reid, 1996). However, it is rare on certain small offshore islands, including the Isles of Scilly (Smith & Newell, 1955), Lundy and St Kilda (see Reid, 1996). This has been attributed to probable low rates of colonization by planktotrophic larvae from mainland populations, and the difficulty in maintaining populations where endogenous larvae may be swept away by currents (Reid, 1996).

L. littorea is typically found on rocky shores, where its vertical range extends from high water neap tide level to extreme low water spring tide level (Moore, 1937). Occasionally it may occur sub-littoraly to depths of approximately 60m (Fretter and Grahame, 1960). The vertical level at which periwinkles may be found on the shore is variable and depends on factors such as exposure and weed cover (Lubchenco, 1983). Food scarcity appears to set the upper limit to the vertical distribution of *L. littorea* (Yamada and Mansour, 1987). While *L. littorea* is found mainly on semi-exposed to sheltered coasts, it is also tolerant of estuarine conditions and great exposure (Boulding and Alstyne, 1993; Fish, 1972; Williams, 1964).

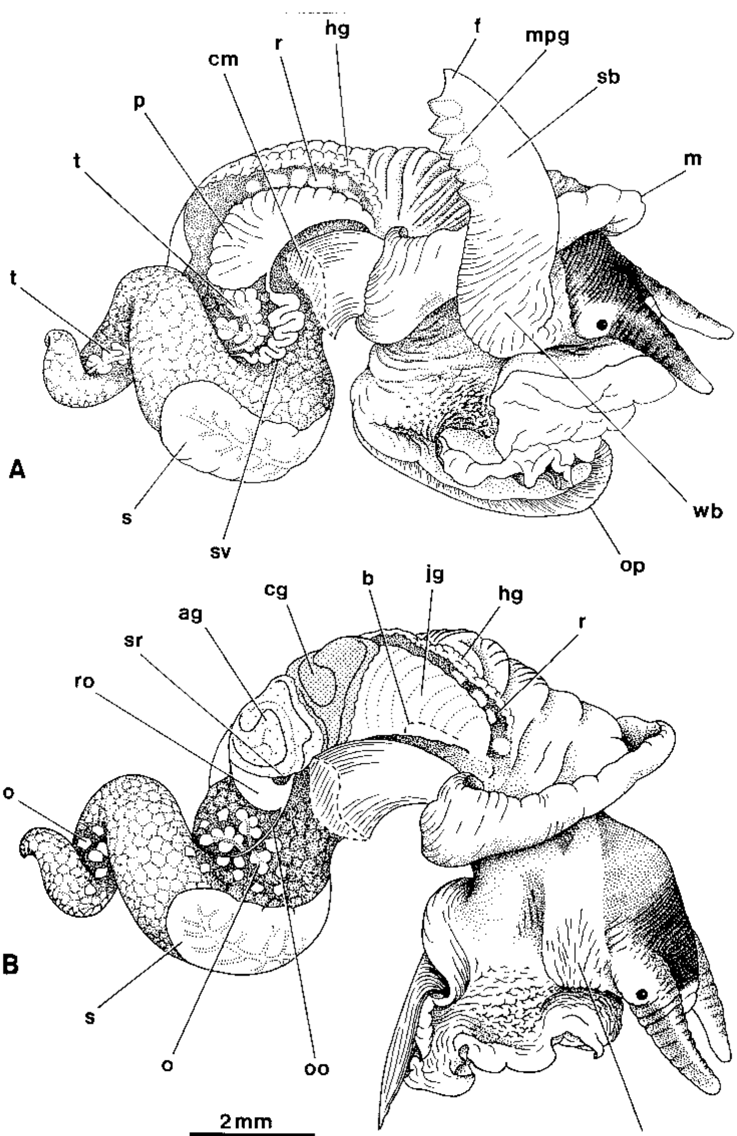


Figure 1. **A mature male (A) and female (B) of a representative littorinid (*Littorina compressa*) the anatomy of which closely resembles that of *L. littorea*.** This diagram from **Reid (1996)** is more accurate and representative than the diagram from Fretter and Grahame (1968). The animals are removed from their shell and undissected. Abbreviations: ag albumen gland, b, copulatory bursa (visible by dissection); cg, capsule gland; cm, insertion of columelllar muscle on shell; f, filament of penis; hg, hypobranchial gland; jg, jelly gland; m, mantle edge; mamillliform penial gland (visible by transparency); o, ovary (ramifying in digestive gland); oo, ovarian oviduct; op, operculum; ovipositor; prostate gland; rectum; ro, renal oviduct; s, stomach; sb, smooth region of penial base; sr, sv, seminal vesicle; t, testis (ramifying in digestive gland); wb, wrinkled region of penial base.

2.3 Spawning and development

Gastropods living on rocky shores exhibit a wide range of reproductive strategies and patterns of embryonic and larval development (Underwood and McFayden, 1983). Within the Family Littorinacea, different species show different methods of reproduction, ranging from direct development in benthic egg capsules (e.g. *L. mariae*, Fretter and Graham, 1962), to ovoviviparity (e.g. *L. saxatilis,* Berry, 1961), to pelagic eggs and planktotrophic larvae (e.g. *M. neritoides,* Lebour, 1935; *L. unifasciata*, Underwood and Chapman, 1989).

A detailed account of the male and female reproductive systems of *L. littorea* has been given by Linke (1933), and is summarised by Fretter and Graham (1962). Williams (1964) distinguished five development stages (which he described for each sex): immature virgin, maturing individuals/recovering spents, fully mature and spawning, partially spent, and spent (Table 1). This method has been adopted by several authors to enable comparison between different populations (Fish 1972; O Sullivan 1977; Doyle 1993).

Maturity is thought to occur 12-18 months after settlement once a shell height of approximately 11mm has been reached (Williams, 1964). Populations of *L. littorea* vary in their time of spawning. Even at the same latitude; maturation, copulation and spawning times show wide local variations depending on food availability and exposure (Fish, 1972). Breeding and spawning in Irish and UK populations occurs from January to June, (Tattersall, 1920; Moore, 1937; Williams, 1964; Fish 1972, 1979). A fortnightly rhythm of egg release related to the tidal cycle was suggested by Grahame (1975), and conclusively demonstrated by Alifierakis & Berry (1980), following experiments in the UK.

Fertilisation is internal, after which, the females release planktonic egg capsules. These egg capsules are pelagic, asymmetrically biconvex with a flat peripheral rim. The egg capsules contain a maximum of nine eggs (Linke, 1933); more commonly, they contain one to three (Thorson, 1946; Fish, 1979). Upon release, the egg capsules swell osmotically and burst after five to six days. Each egg hatches into a free-swimming veliger larva and remains in this planktonic stage for six to seven weeks. This planktotrophic development stage results in widespread dispersal and genetic uniformity. Metamorphosis may be delayed if conditions are not suitable. This results in considerable variation of settlement times, with larvae settling on the shore throughout several months of the year.

Table 1. Female and male development stages of *L. littorea* (after Williams, 1964).

Females

Stage	Ovipositor	Gonad	Caps gland/ albumen gland	Covering gland
Stage I Immature	Heavily pigmented	No trace	Vestigial	Vestigial
Stage II Maturing	Lightly pigmented	Diffuse light pink areas	Small but distinct	Small but distinct
Stage II Recovering	Lightly pigmented	Extensive light pink areas	Large, often swollen, yellow-brown	Dark brown
Stage III Ripe	Lightly pigmented and well defined	Very extensive light pink areas	Very swollen, white	Dark brown
Stage IV Partially spent	Lightly pigmented	Extensive; dark pink/red	Slightly swollen, yellow-cream	Very dark brown
Stage V Spent	Heavily pigmented	Scarce, red or red/brown areas	Poorly developed, Dark yellow brown	Poorly developed, yellow brown

Males

Stage	Penis	Vas deferens	Prostate	Gonad
Stage I Immature	Minute	No trace	Faint trace	No trace
Stage II Maturing	Very small	Lightly coiled, possibly with some sperm	Distinct	Scattered yellow areas
Stage II recovering	Quite well developed	Lightly coiled, possibly with some sperm	Distinct	Extensive light yellow
Stage III Ripe	Large	White, much coiled, swollen; full of sperm	Well developed, cream-white	Very extensive, light yellow
Stage IV Partially spent	Well developed	Much coiled, not swollen, sperm in lower coils	Distinct, yellow-brown	Extensive, yellow-brown
Stage V Spent	Very small	Gently coiled, dark brown	Small, dark brown	Poorly developed, localised dark brown areas only

2.4 Diet and feeding

L. littorea is an omnivorous grazer. However, it is highly selective in favour of the foliose ephemeral green algae *Ulva lactuca* and *Enteromorpha intestinalis*. The fucoid *Ascophyllum nodosum* and *Coralinia officinalis* are rejected even after prolonged periods of starvation. These algae are not readily digestible; the latter species is heavily calcified and presents a physical barrier to grazing. In addition, drift algal material is frequently exploited as a food source (Watson and Norton, 1985), especially at higher shore levels (Woodbridge, 1978).

Feeding activity is influenced by tidal cycle and season. The animals are stimulated to feed when immersed by the tide and when damp conditions prevail (Newell, 1958; Moore, 1936; Williams, 1964). The grazing activity of periwinkles can have a habitat modifying impact on a shore. The grazing process removes sediment from hard substrates which precludes the development of an algal canopy (Bertness, 1984). At high densities, *L. littorea* can clear shores of *Enteromorpha* sp. and can inhibit settlement of barnacles *Balanus* sp. (Petratis, 1983).

2.5 Growth

Growth rate is defined as the change in body mass or weight over time. *L. littorea* shows considerable variation in growth rate for the first four years of its life. Shell height is the commonly employed measure of growth. Fretter and Graham (1962) describe shell formation in two major phases: 1) cellular processes of ion transport, protein synthesis, and secretion, and 2) a series of photochemical processes in which crystals of Calcium Carbonate (CaCo3) are nucleated, orientated, and grow in intimate association with a secreted organic matrix. Through growth, mineralised granules form rounded flattened crystals, each covered by a delicate organic membrane. The layering of the crystals appear as striations to the naked eye. Each spiral grows around and partly conceals the surface of the previous whorl. Thus, the most recently secreted part of the shell is that by the mouth. Where the inner sides of the spirally coiled whorls are brought into contact with on another, there results a more or less solid pillar, the columella, around which the whorls of the shell rotate (Fretter and Graham, 1962).

A shell height of approximately 8-9mm is achieved by the end of the first year (Williams, 1964). This increases to about 16mm by the end of the third year. A pattern in growth rates was observed by Lambert & Farley (1968), and by Gardener and Thomas (1987). The general trend was for growth rates to increase from May to early July, followed by a decrease in growth rates from mid-July to mid-August. Growth rates were observed to increase again in early September, before declining in the winter months. Although *L. littorea* are capable of breeding all year round, periods of shell growth are interrupted when conditions are favourable for reproduction (Williams, 1964). For example, Williams (1964) observed active shell growth on a shore in Wales, from July to October, which corresponded with a period when mature animals were fully spent. Growth rates decreased when gonad maturation began again the following November. However, Fretter and Graham (1960) observed a looser growth cycle, when, on reaching sexual maturity a cessation in growth occurred in correspondence with a period of maximum sexual activity.

The growth rate decreases rapidly with age (Fretter and Grahame, 1960) and absolute growth rate is affected by food availability and habitat (Moore 1937; Williams, 1964, Griffin, 2000).

Parasite infection and predation also affect growth and survival. Population density can affect growth rates in natural populations, with competition for resources acting to limit growth at higher values. Griffin, (2000) found exceptionally high growth rates (K = 0.0277 per 21 day period), on a high density, semi-exposed shore in Southern Ireland. The mid-shore region exhibited the highest growth rate. The lowest growth rates were found on the lower shore. Griffin (2000) concluded that periwinkles have an opportunistic growth strategy, which is attributed to competition, food availability and quality. High population densities can also prevent re-settlement of a food source. At high densities, *L. littorea* can clear shores of *Enteromorpha* sp. and can inhibit settlement of barnacles *Balanus* sp. (Petratis, 1983).

2.6 Migration

Gendron (1977) showed some evidence for a seasonal migration on a shore in North America. The periwinkle population density at the uppermost station established during his study showed a decrease in density between October and January, while an increase at the same station occurred during early summer. Gendron (1977) attributed this change in density to a shoreward spring migration. Williams and Ellis (1975), recorded similar patterns for a population in Yorkshire; however, Smith and Newell (1955), while studying a shore in Kent, suggested that periwinkles tend to remain at the beach level they adopt during the first year of life after larval settlement. *L. littorea* also show evidence of a "homing instinct", whereby dislodged individuals have the ability to find their way back to the zone from which they were displaced (Newel, 1958). Wave action is considered to be the most likely stimulus by which the animals orient themselves (Gendron, 1977).

2.7 Life span and maximum size

Periwinkles are capable of a long life as shown by Woodward's (1913) record of an individual that had reached more than 20 years in an aquarium. The largest recorded specimen came from Scotland and was 52.8mm in height (Reid 1996).

SECTION 3 - RESOURCE ASSESSMENT

3.1 Introduction

High density *L. littorea* shores are attractive sites for periwinkle harvesting activities. The harvesting of this gastropod provides a valuable source of income to rural coastal communities (Pearson, 1994). However, little is known about the impact of such harvesting activities on periwinkle populations. Wholesalers and pickers have reported problems of over-picking in the past on several shores around the country (T. Tobin, *pers. comm.,* 2000), leading to fears that the sustainability of the industry may be in jeopardy. Up until now, there was no scientific information on the distribution or density of *L. littorea* populations in Ireland.

Data collected for this study from 1998 to 2000 are examined in this chapter with a view: to describing the distribution and abundances of *L.littorea* on Irish shores; to describing the size and dynamics of periwinkles within these populations; and to providing a benchmark against which subsequent studies could be compared. Studies were also undertaken to identify some of the factors that impact on both individuals and populations of *L. littorea.*

Bullens Bay is situated on the north-westerly corner of the Old Head of Kinsale, on the County Cork coastline. It is harvested throughout the year by approximately five local pickers, however, harvesting activities are most intensive during the winter period there. The site was selected as a re-survey site to observe temporal changes in population dynamics of *L. littorea.* Bullens Bay is a sheltered site, protected from the prevailing south-westerly winds. The intertidal zone extends downwards over a gently sloping gradient. It is largely a rocky foreshore, with a small sandy beach that is exposed during low tide. Observed fauna during surveys included typical rocky foreshore species, the major components being the limpet *Patella vulgata*, the flat periwinkle *Littorina littoralis*, the dog whelk *Nucella lapillus*, and the topshells *Monodonta lineata* and *Gibbula umbilicalis*. The main source of food of the browsing species is provided by large algae, (such as *Fucus* sp. and *Ascophyllum nodosum*), as well as various microscopic algae.

3.2 Research Methods

3.2.1 Materials and methods for shore surveys

A total of 124 shores around the coast were surveyed during the project. Survey sites were selected (after consultation with wholesalers, fisheries officers and harvesters), on the basis that they provide suitable habitats for harvestable quantities of periwinkles; these were usually sheltered or semi-exposed shores. Other sites were selected (e.g. exposed coasts) for comparative purposes. In the present study, a survey site is described as an area of coast with homogenous shore type with respect to rock form, seaweed cover, exposure etc. This sometimes led to discrete sites existing along a lengthy section of shoreline.

All shores were surveyed on spring tide. At each site three belts of approximately 30m width, chosen randomly, were divided into three biologically defined zones representing upper, middle and lower shores: (i) *Fucus spiralis* to *Ascophyllum nodosum*; (ii) *A. nodosum* to *F. serratus;* (iii) *F. serratus* to the low water level.

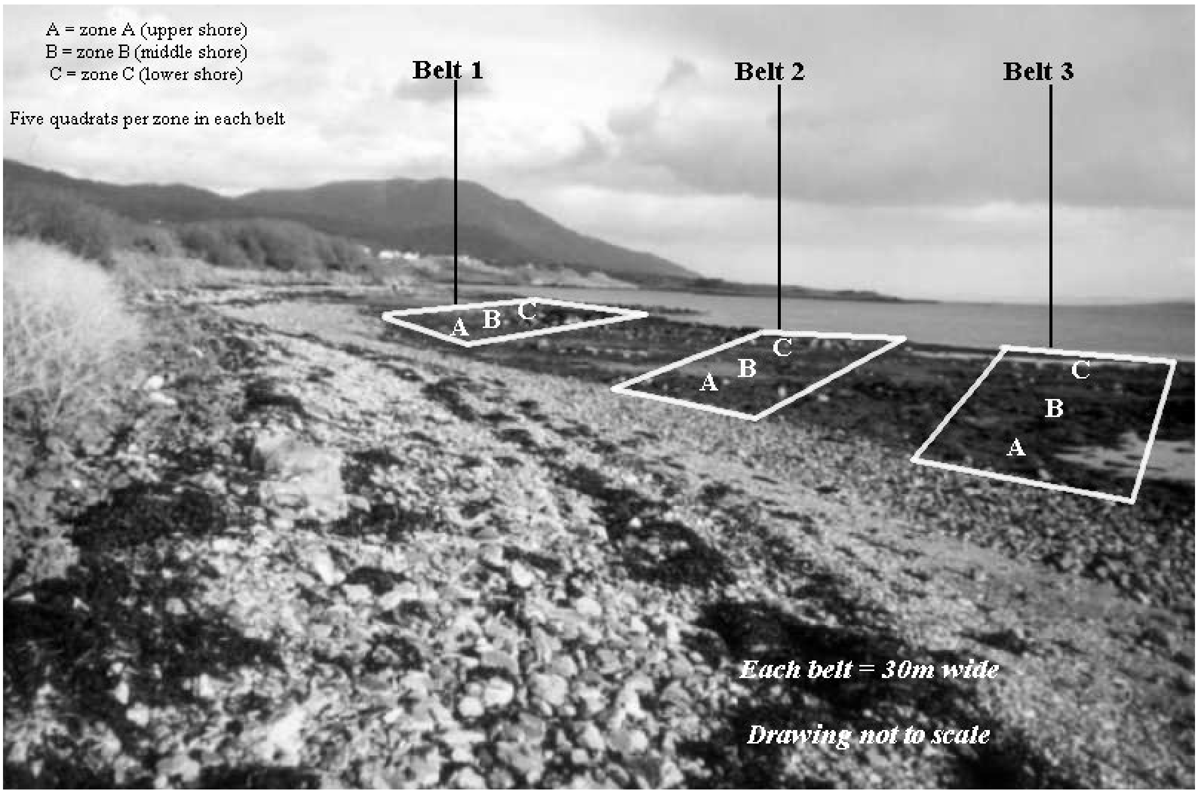


Figure 2. Example of the sampling procedure used on the shore. At each site, three belts of approximately 30m width, chosen randomly, were divided into three biologically defined zones representing upper, middle and lower shores: (i) *Fucus spiralis* to *Ascophyllum nodosum*; (ii) *A. nodosum* to *F. serratus;* (iii) *F. serratus* to the low water level.

The length of each of the three belts was measured. The bearing of each belt was also recorded. A handheld Global Positioning System (GPS) was used to mark the starting point of each belt, in addition to the start and end point for each site. This, and other relevant data were subsequently added to a Geographical Information System (GIS). GIS software facilitates the storing, manipulating and displaying of a wide range of temporal and spatial data. The maps used for this report were produced using Arcview GIS software. On completion of the study a copy of the Periwinkle Project GIS was made available to the Marine Institute in Dublin (Appendix B).

Exposure of sites was rated on a scale of one to five, after Lewis (1964) (Appendix A). One represents very exposed sites, and five represents very sheltered sites. In some cases, the exposure scale was subdivided to allow more flexibility in describing shores. As a result, there were ten possible degrees of exposure i.e. 1, 1.5, 2, 2.5 etc. (a modified version of the Lewis (1964) scale). Five quadrats ($0.25m^2$) were placed randomly within each zone and all *L. littorea* within the quadrat were counted, removed, and placed in labelled polythene bags. The samples were returned to the laboratory and frozen to preserve them for further analysis.

The percentage cover of rockpool, seaweed, bedrock, rock, stones, gravel, sand and mud was also recorded from each quadrat. Any influx of freshwater into the belt, or any other potential impact from sewage or shellfish culture was noted.

A comparison was made between the numbers of *L. littorea* on different substrate types, as recorded during the surveys, using the Chi-squared test. Substrate types included bedrock, rock, stone, gravel, sand and mud.

3.2.2 Temporal variation in density at Bullens Bay in County Cork

Bullens Bay in County Cork was selected for several re-surveys in order to assess temporal variations in periwinkle distributions on the shore. The survey method used was the same as the method described in Section 3.2.1. Table 2 shows when surveys were undertaken. Eleven re-surveys were undertaken at Bullens Bay.

Table 2. Survey dates at (a) Bullens Bay, County Cork

Date	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1998			x					x			x	
1999	x			x				x		x	x	
2000				x				x			x	

3.2.3 Shell measurements of L. littorea

In order to investigate shell morphometry and the effects of environmental variables on shell shape at various sites, frozen samples collected from surveyed shores were measured to 0.1mm using vernier callipers. Periwinkles less than 5mm were recorded as such and were not measured. This was due to the physical difficulty of handling such small animals and due to the increased significance of any errors of measurement at such sizes (Crothers, 1992). Three measurements of each shell were taken: shell length (SL), shell width (SW), aperture length (AL). Aperture width (AW) was also measured for a number of samples. In total 6,056 periwinkles were measured for shell height, width and aperture height. In addition, 1,795 periwinkles were measured for aperture width.

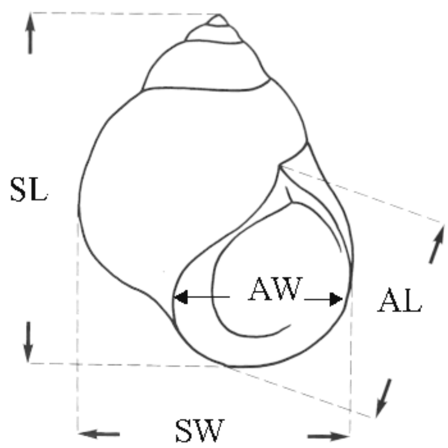


Figure 3. Morphological measurements recorded from shells. SL= Shell length; SW = Shell Width; AL = Aperture Length; AW = Aperture Width. After Reid (1996).

All statistical analysis was carried out using SPSS version 9.0. Graphs were plotted using SPSS or Excel 5.0. Error bars on all graphs where mean data is presented represent the 95% confidence interval. Non-parametric statistical tests were applied due to the bi-modal nature of the data. Spearman rank correlations were used to determine what, if any, relationships exist between the physical/ biological parameters studied and shell shape. The main factors examined for associated effect with shell morphometry in this study were:

1. Exposure
2. Vertical position on the shore (i.e. zone).

While only two factors are considered in this analysis, it is very likely that many other factors also impact on various aspects of shell shape, particularly predation (Robertson, 1992) and salinity (Reid, 1996).

3.2.4 Length frequency histograms

Histograms of shell length/frequency were plotted with the aim of investigating patterns in recruitment, growth and various aspects of population dynamics. Forty-seven sites were used for this purpose and measurements from all periwinkles >5mm shell length were used. Periwinkles <5mm shell height were excluded due to the difficulty of measuring aperture length accurately on very small shells. (However, measurements of shell height were taken from (n= 12) shells <5mm, prior to the methodology being finalised, the results of which were included in this analysis).

Bullens Bay, County Cork, was selected as a re-survey site to observe temporal changes in the length frequency distribution of the population. Bullens Bay was surveyed 11 times (Table 2). Measurements were taken from data collected from six of the 11 visits due to time constraints in measuring all of the samples. The six visits covered the period from November 1998 to August 2000. The months selected represent the months of November, January, April, August (twice) and October. Size frequency histograms were plotted from this data. The measurement data were used to examine changes in growth rates.

3.3 Results

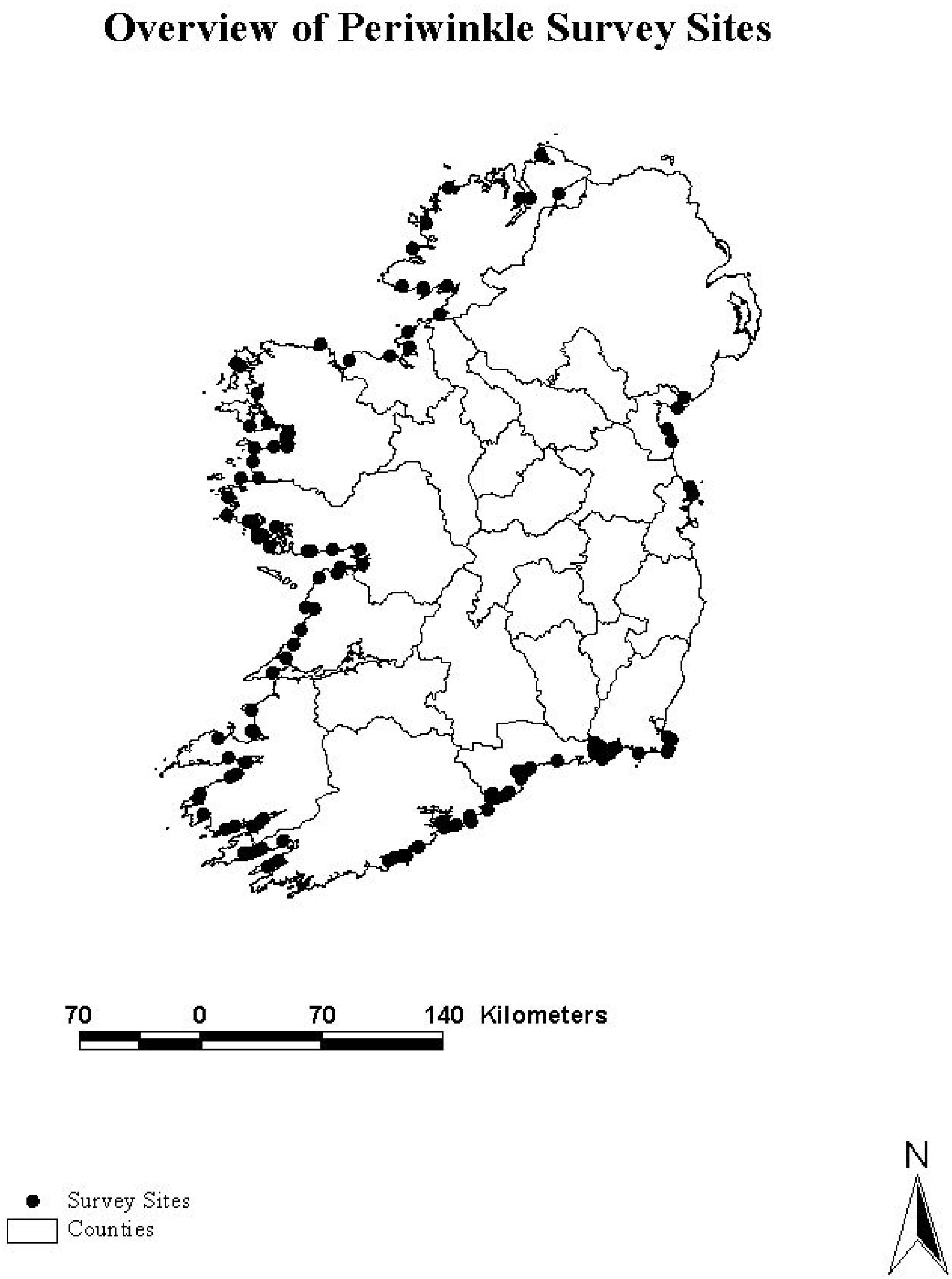


Figure 4. Overview of locations of periwinkle survey sites.

3.3.1 Results of shore surveys

Table 3. Mean periwinkle densities per m^2 at all survey sites. Exposure is based on the modified Lewis (1964) scale.

Site	County	Exposure	Mean periwinkle density per m^2
Bullens Bay	Cork	4	63
Oysterhaven	Cork	4	94
Howes Strand	Cork	1	58
Roches Point	Cork	3	69
Garrettstown	Cork	3	23
Ballycotton Island	Cork	3	31
Ballycotton	Cork	3	64
Knockadoon	Cork	3	161
Whitegate Bay	Cork	5	37
Broadstrand	Cork	4	110
Dinish Island	Cork	4	39
Ballyshane strand	Cork	2	112
Trabolgan	Cork	3	47
Youghal Town	Cork	2	8
Ardnahinch	Cork	3	104
Ballynakilla	Cork	4	52
Rocks NE of Fort Point	Cork	4	86
Aghabeg	Cork	5	48
Seal Harbour	Cork	3	121
Rocks NE of Reen Point	Cork	4	89
Reenabulliga	Cork	4	116
Kilcrohane	Cork	2	124
Whiting Bay	Waterford	3	50
Whiting Bay 2	Waterford	3	196
Ardmore Strand	Waterford	3	182
Clonea strand	Waterford	3.5	180
Helvick head - N side	Waterford	3.5	71
Ballynacourty - E side	Waterford	3	47
Youghal-East	Waterford	4	45
Ardmore East	Waterford	3	115
Dungarvan West	Waterford	5	16
Dungarvan East	Waterford	5	16
Dungarvan - Abbeyside	Waterford	4	75
Dunmore East	Waterford	5	93
Passage East	Waterford	5	38
Passage East 2	Waterford	5	26
Boatstrand	Waterford	2.5	1
Duncannon	Wexford	3	26
Duncannon 2	Wexford	3	22
Netherton	Wexford	2.5	15
Kilmore Quay	Wexford	3	15
Grange Strand	Wexford	3	24
Carnivan Bay	Wexford	3	9
Fethard Quay	Wexford	4	10

Site	County	Exposure	Mean periwinkle density per m^2
Bannow	Wexford	4	26
Patricks Bay	Wexford	2.5	69
Crossfintan Point	Wexford	3	26
Rosslare Harbour	Wexford	4	74
Greenore Point	Wexford	2	49
Ormonds Island	Kerry	4	91
Fenit 1	Kerry	4.5	26
Cromane	Kerry	4	9
Anascaul	Kerry	2.5	116
Fenit 2	Kerry	5	53
Ballyheige	Kerry	2.5	46
Fermoyle	Kerry	4	11
Glanlough	Kerry	4	38
Cove Harbour	Kerry	4	58
Ballinskelligs	Kerry	2	78
Doulus Bay	Kerry	3	49
Rossbeigh	Kerry	3	34
West of Rossbeigh	Kerry	3	47
Knightstown	Kerry	4	10
Tuosist Castle	Kerry	3	42
Loughaunacreen	Kerry	3	47
Eyeries	Kerry	2	74
Carlingford Lough	Louth	5	70
Rathcor	Louth	3	54
Corstown Bridge	Louth	2	73
Near Clogher Head	Louth	2	106
Skerries	Dublin	1.5	70
Rush	Dublin	2.5	124
Quilty	Clare	3.5	5
Fanore	Clare	2	3
Ballyvaughan	Clare	4.5	9
Doonbeg	Clare	4	19
Poulnasherry	Clare	5	6
Rehy	Clare	4	20
Lehinch	Clare	3	9
Haggs Head	Clare	2.5	19
Finavara Point	Clare	4	17
Murrisk	Mayo	5	1
Achill Sound	Mayo	4	3
Gubinwee	Mayo	3.5	15
Mullranny	Mayo	3	16
Louisburg	Mayo	2.5	22
Salleen Bay	Mayo	4	30
Roonagh Point	Mayo	2.5	31
Claggan Cove	Mayo	4.5	8

Table 3 contd. Mean periwinkle densities per m^2 at all survey sites. Exposure is based on the modified Lewis (1964) scale.

Site	County	Exposure	Mean periwinkle density per m^2
Bunlough Point	Mayo	3	26
Carrowholly	Mayo	4.5	5
Ballycastle	Mayo	2.5	35
Outer Belmullet	Mayo	2.5	19
Shellfish Laboratory, Carna	Galway	5	16
Mweenish	Galway	3	26
Loughaconeera	Galway	5	8
Letterard	Galway	4	53
Ervallagh	Galway	3	28
Finish (inside island)	Galway	4	16
Garumna Island	Galway	3.5	16
Inveran	Galway	3.5	34
Bundoran	Donegal	3.5	21
Fahan	Donegal	4.5	13
Rossbeg	Donegal	3	29
Rathmullan	Donegal	3.5	17
Meenlaragh	Donegal	3	34
Burtonpoint	Donegal	4.5	7
Doagh Isle	Donegal	2	2
Lough Foyle	Donegal	4.5	17
Kilcar	Donegal	3	62
Iniscrone	Sligo	3	14
Aughris Head	Sligo	4	39
Rosses Point	Sligo	4.5	8
Pollmolasha	Sligo	2.5	48

Table 3 contd. Mean periwinkle densities per m^2 at all survey sites. Exposure is based on the modified Lewis (1964) scale.

- Substrate data

Bedrock and stones were the most common substrate types found to occur on the surveyed shores (total percentage coverage of bedrock was 41%, percentage coverage of stones was 18%) (Figure 5). A comparison of the substrate data from different sites showed a significant relationship between gravel and periwinkle numbers, with higher numbers of periwinkles occurring on gravel sites than on other substrate types (Chi-sq value 26.67, $P<0.001$). Thus, in tests for comparisons of densities of *L. littorea* from replicated gravel sites, results indicated that the presence of gravel can have a significant influence on the densities of *L. littorea* on a shore. Results from the other Chi-squared tests were not significant. The resulting values were: *bedrock P = .817; rock P = .133; stone P = .051; sand P = .891.*

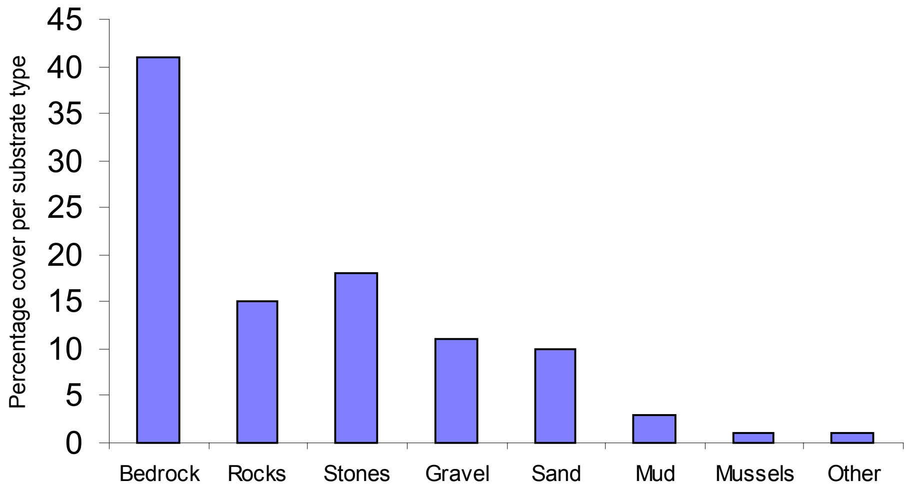


Figure 5. Total percentage cover of different substrate types recorded during the survey.

- Density and exposure

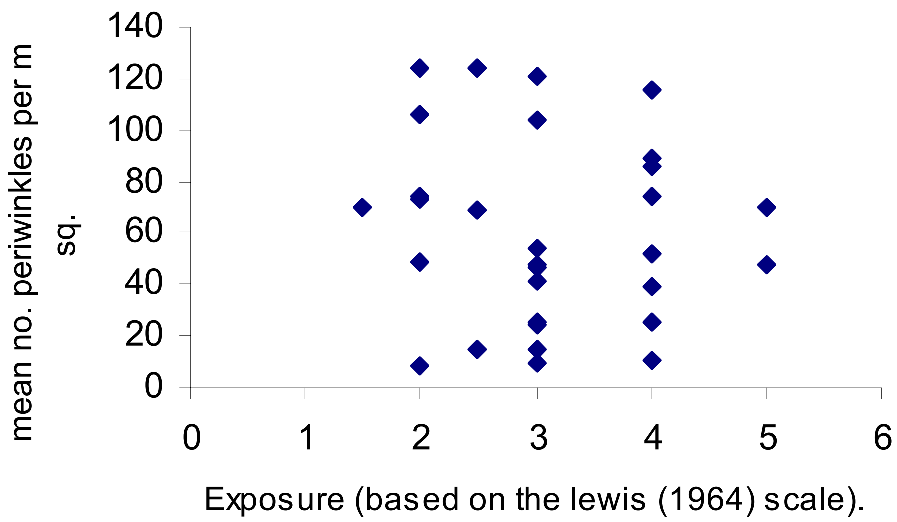


Figure 6. The relationship between density and exposure in *L. littorea* based on the mean number of perwinkles per site. The sites have different exposure levels classified according to the Lewis (1964) scale of exposure.

An examination of periwinkle densities at the study sites, indicate that in general the greatest densities of *L. littorea* occurred on shores of exposure 2-4 as defined by the Lewis (1964) scale (Figure 6). It should be noted that density decreases at the extremes of the exposure scale.

- Shoreline distributions

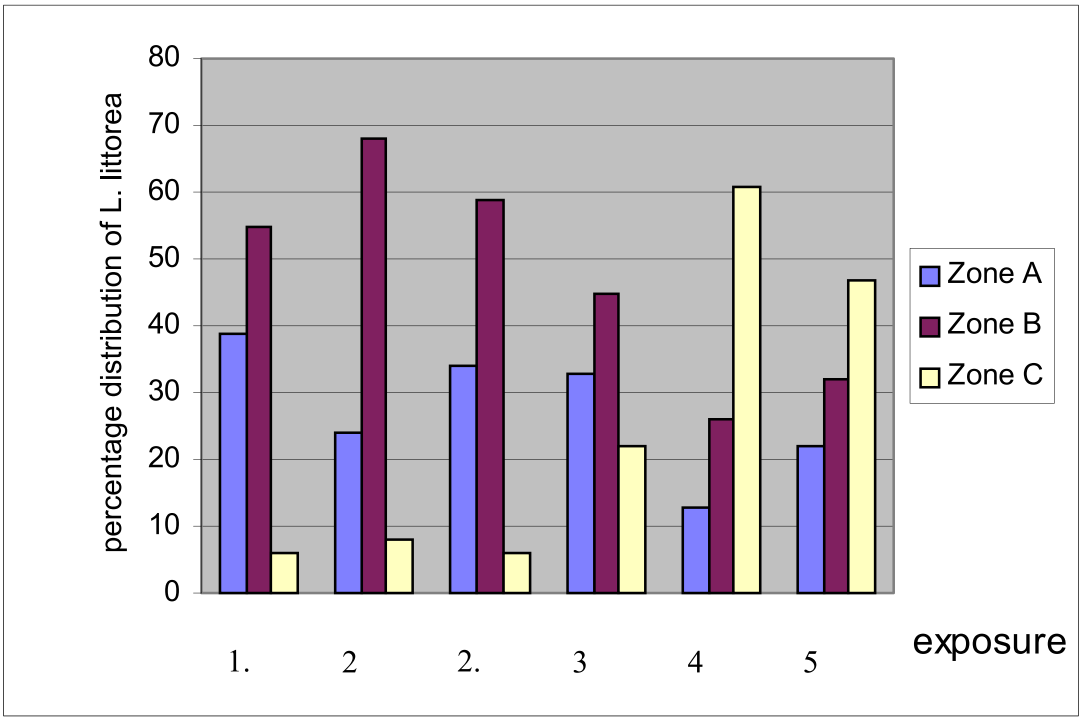


Figure 7. Percentage distribution of *L. littorea* on different levels of the shore in relation to exposure (using the modified Lewis scale).

L. littorea appear to show marked changes in preferred tidal height with exposure. This trend was noted during sampling. A graph of distribution at various exposures is presented in Figure 7. There is a reasonably consistent increase in relative density at higher shore levels on more exposed coasts. This is particularly clear in Zone C, which is the lowest of the three vertical divisions, where the percentage distribution falls from between 50% and 60% on extremely sheltered and sheltered shores, to less than 10% on exposed shores (2.5 to 1.5 on the Lewis (1964) scale of exposure).

3.3.2 Temporal variation in density at Bullens Bay in County Cork

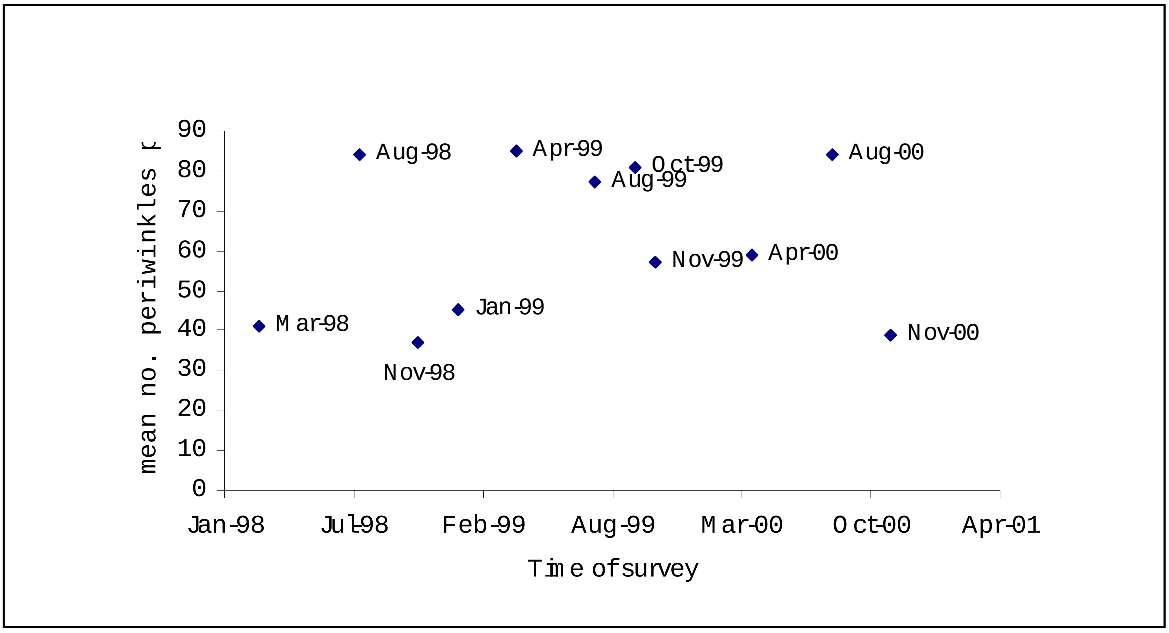


Figure 8. Changes in the mean numbers of periwinkles per m^2, over a three year period, at Bullens Bay, as recorded at different sampling times.

The shore at Bullens Bay was observed to have a mean density of *L. littorea* over the study period, of approximately 63 per m^2. There were sizeable differences in density at Bullens Bay between the sampling times, with a definite rise in densities between April and October in all three years (Figure 8). The numbers of *L. littorea* on the shore fell by over 50% between August and November in 1998 and in 2000. In 1999, periwinkle densities fell from a mean number of 81 periwinkles per m^2 in October, to 57 periwinkles per m^2 in November.

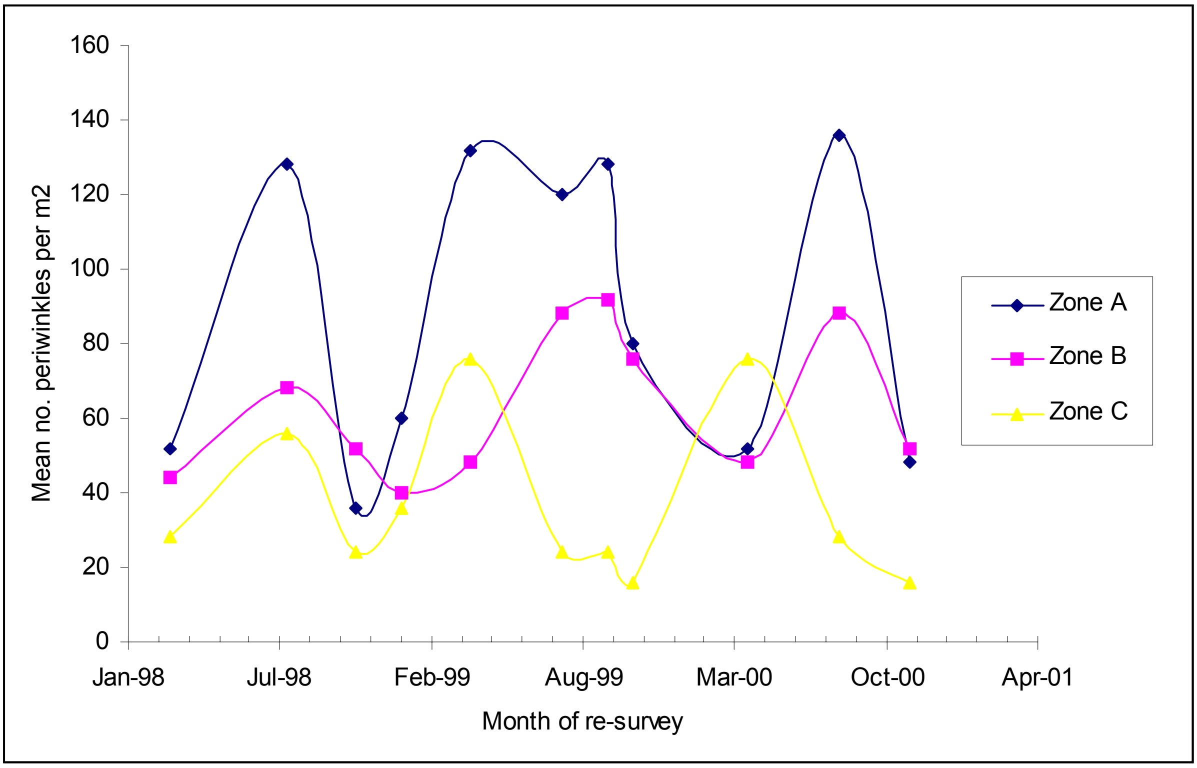


Figure 9. Mean densities of *L. littorea* on the upper, middle and lower shore at Bullens Bays over a three year period.

Densities of *L. littorea* per zone over the three year sampling period are shown in Figure 9. It can be seen from this graph that the highest numbers of periwinkles were found at the upper shore levels (zones A and B). April 1999 and April 2000 were the only periods when the number of periwinkles at the lower shore level (zone C) were observed to be higher than the number of periwinkles higher up the shore.

3.3.3 Shell measurements of L. littorea

- Exposure and shell morphometry

Results from a Spearman rank correlation show a weak correlation between shell length and exposure ($P>0.05$). The correlation between shell width and exposure is significant ($P<0.05$). These relationships are presented graphically in Figures 10 and 11.

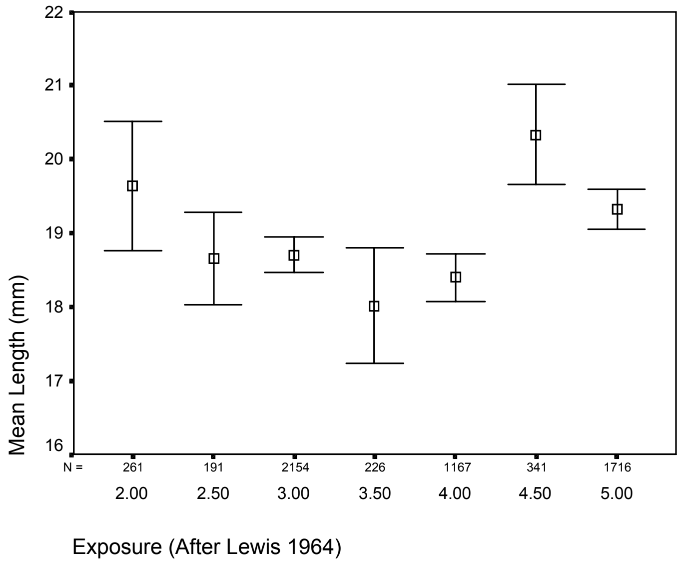


Figure 10. Relationship between mean shell length and exposure in *L. littorea*. Error bars represent the 95% confidence interval.

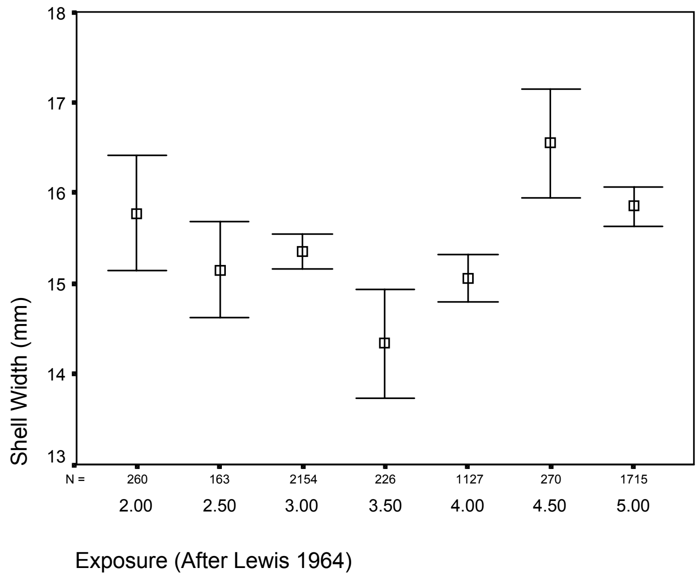


Figure 11. Relationship between mean shell width and exposure in *L. littorea*. Error bars represent the 95% confidence interval.

The relationship between exposure and mean shell height/ aperture height ratio is significant($P<0.01$). The relationship between mean shell height to aperture height ratio and exposure is shown graphically in Figure 12.

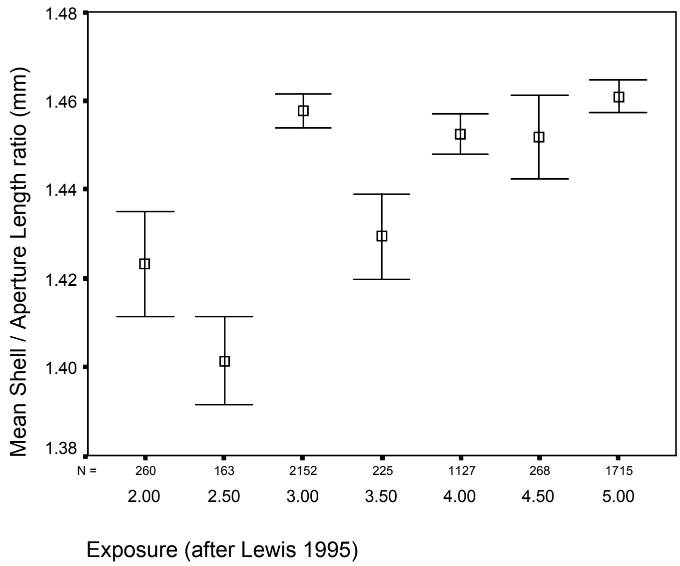


Figure 12. Relationship between mean shell height/ aperture height ratio and exposure in *L. littorea*. Error bars represent the 95% confidence interval.

- Vertical position (zone) and shell morphometry

Zone A represents the upper shore, zone B represents the middle shore and zone C represents the lower shore. The Spearman rank correlations between zone/height, zone/width and zone/aperture height/shell height ratio are significant at the 0.01 level for each parameter. It can be seen from Figure 13 that there is a distinct increase in shell height at lower shore levels. Figure 14 shows that relative aperture height decreases at lower shore levels.

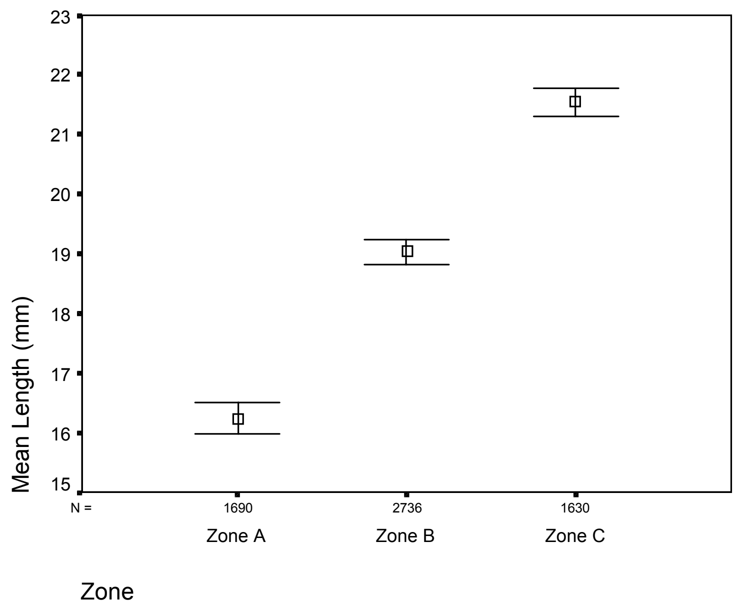


Figure 13. Relationship between shell height and zone in *L. littorea*. Error bars represent the 95% confidence interval.

3.3.4 Length frequency histograms

Length frequency distributions for 47 measured sites were plotted (Figure 14) in order to determine time of recruitment and to identify different cohorts as indicated by discrete peaks on the histogram. The mean shell height varies considerably from shore to shore, ranging from 13.0mm at Doulus Bay, County Kerry to 28.6mm at Burtonpoint County Donegal. Reports in the literature for mature shell height in *L. littorea* range from 10.6mm to 52.8mm (Reid, 1996). The largest speciman of *L. littorea* measured in this study was 37.0mm in shell height. It was found at Netherton, County Wexford.

In Bullens Bay, where seasonal variation in shell size was observed over a three year period, the mean shell length recorded was 18.3mm ± 6.2. The largest shell size attained in Bullens Bay, measured as a maximum length, was 34.1mm. The length frequency distributions for Bullens Bay varied according to the time of year the sites were surveyed. The population structure of *L. littorea* from November 1998 to August 2000 is shown in Figure 15. The population was generally bimodal during this period.

Figure 14. Length/frequency histograms from shores of varying exposure based on the modified Lewis scale. Graphs are presented in order of exposure, beginning with exposure 2 and ending with exposure 5. Site codes relate to the county where the survey was conducted , e.g. DL09 is site no. 9 in Donegal. (SO- Sligo, MO- Mayo, CE- Clare, K- Kerry, C- Cork, WD- Waterford, WX- Wexford, DN- Dublin, LH- Louth)

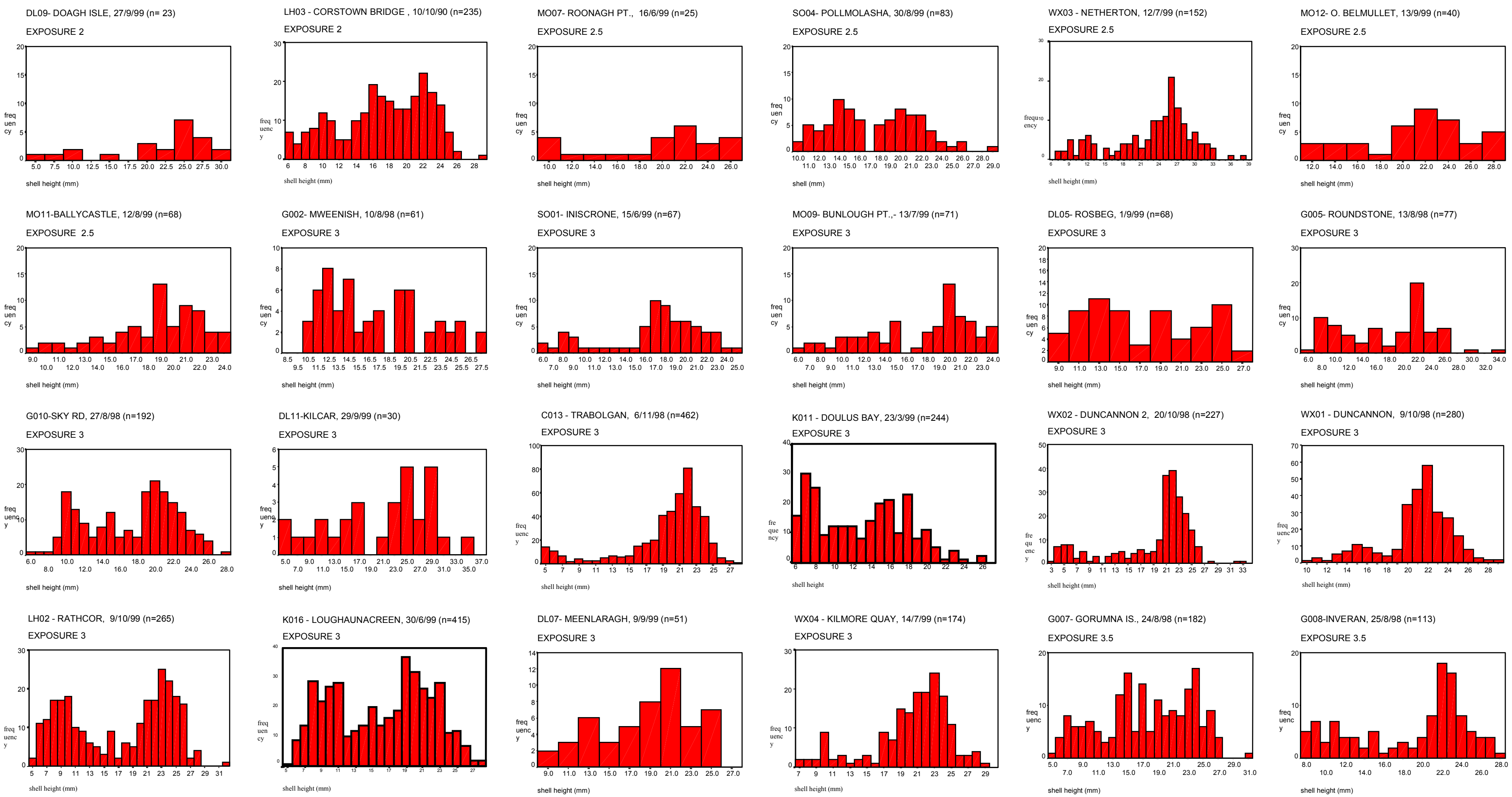
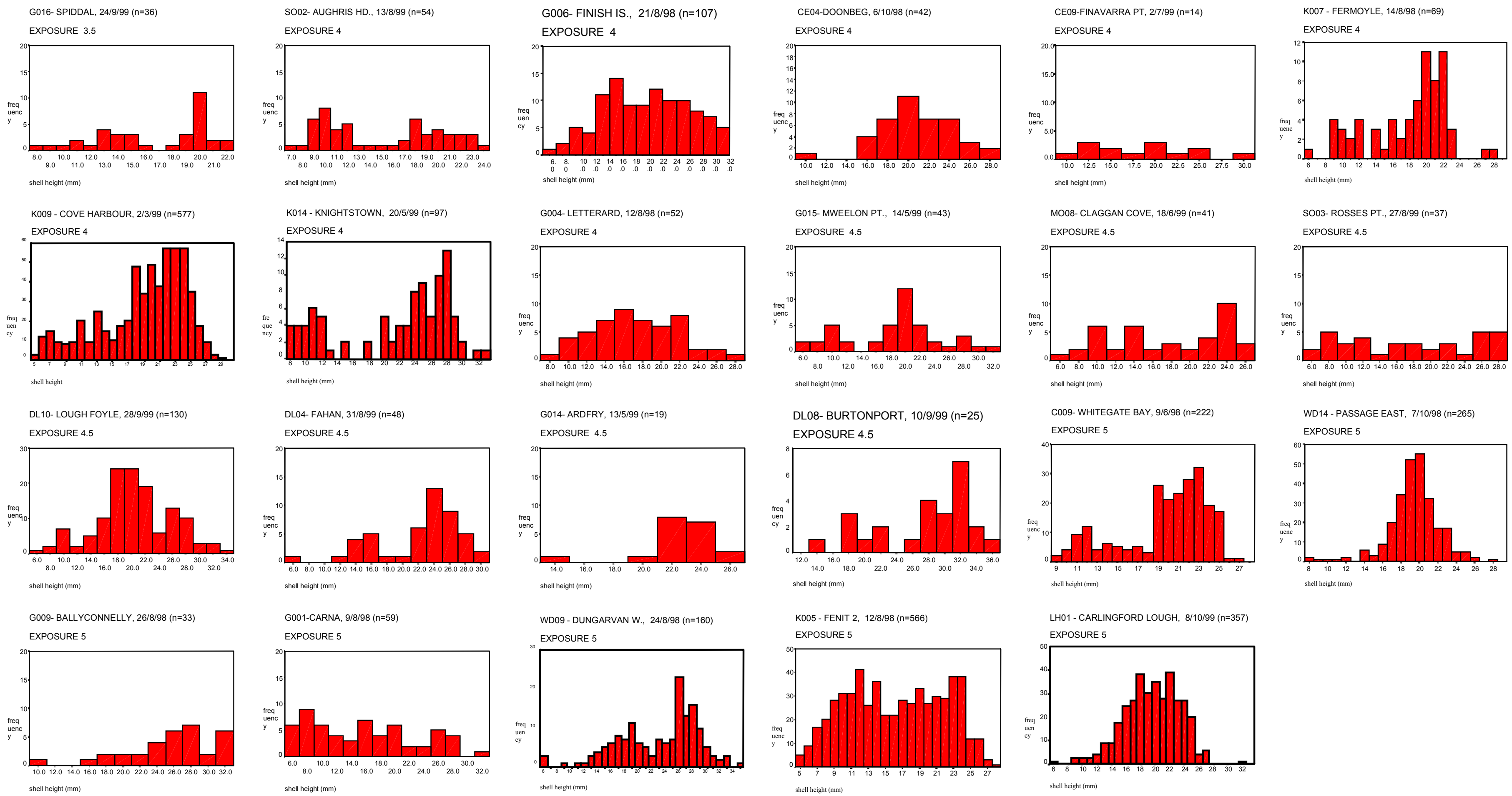


Figure 14 contd'. Length/frequency histograms from shores of varying exposure based on the modified Lewis scale. Graphs are presented in order of exposure, beginning with exposure 2 and ending with exposure 5. Site codes relate to the county where the survey was conducted , e.g. DL09 is site no. 9 in Donegal. (SO- Sligo, MO- Mayo, CE- Clare, K- Kerry, C- Cork, WD- Waterford, WX- Wexford, DN- Dublin, LH- Louth)



BULLENS BAY DATA

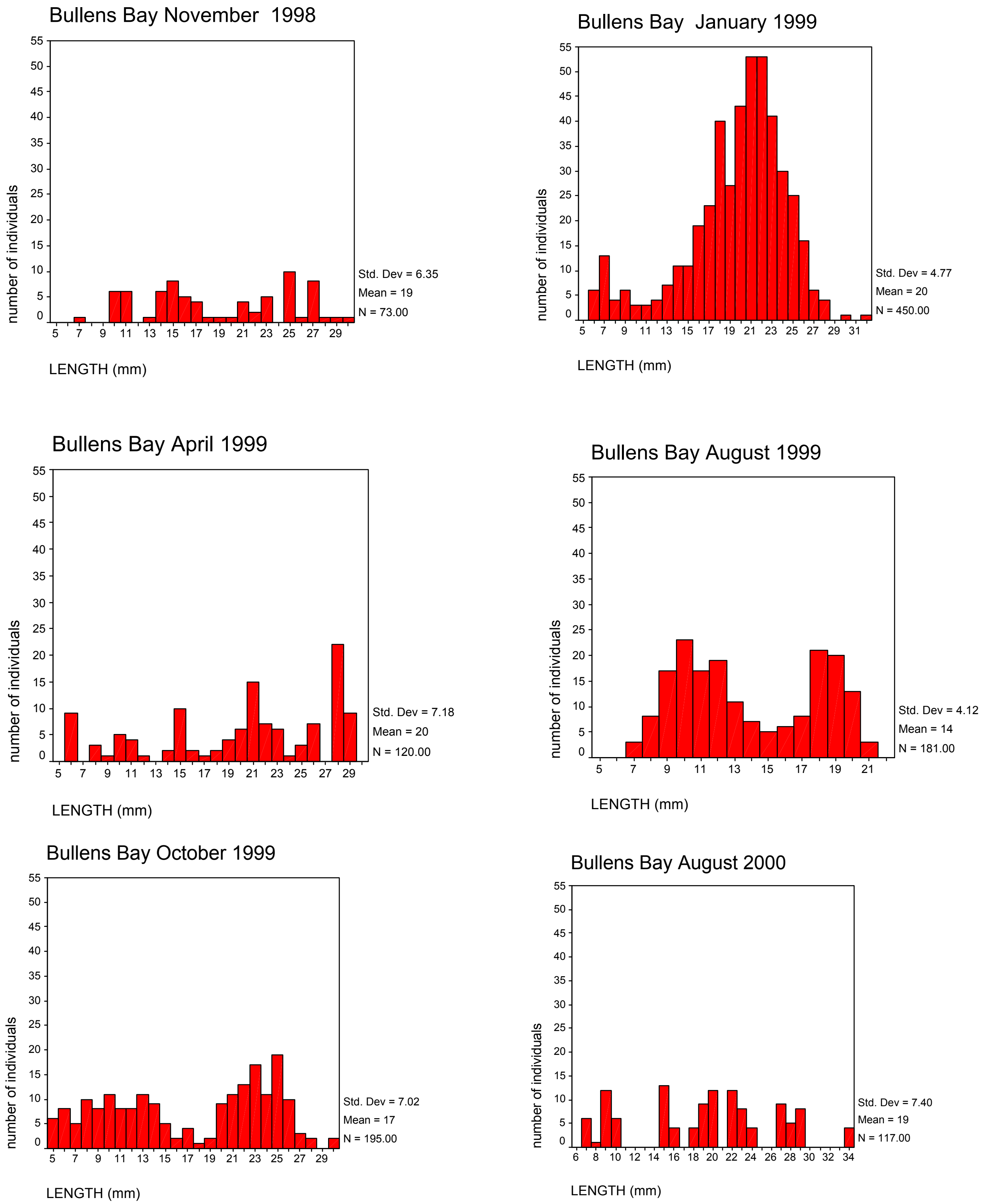


Figure 15. Length frequency distribution graphs of measurements of *L. littorea* taken from one site at Bullens Bay, County Cork. Data were collected over a three year period. Bullens Bay is a sheltered site.

3.4 Discussion

3.4.1 Abundance and distribution of L.littorea

There was a noticeable trend in periwinkle densities between the east and the west coasts, with the lowest densities consistently occurring on the west coast. It is possible that this trend is a consequence of the varying geology around the coast, which gives rise to different types of substratum. The lowest densities of *L. littorea* on harvestable shores were observed to occur around Galway Bay. The sheltered granite shores of Galway afford few crevices and are likely to provide a less suitable habitat for large numbers of *L. littorea.* Some of the highest densities of periwinkles were recorded along the eastern shoreline of County Cork and County Waterford (e.g. 196 per m^2 Whiting Bay, 182 per m^2 Ardmore Strand and 180 per m^2 Clonea Strand). Much of this inter-tidal area is composed of finely stratified mudrock and shale, which when weathered leads to an abundance of small sheltered crevices, ideal habitats for periwinkles.

L. littorea are reported to congregate in hundreds or thousands in depressions and small gullies, especially where algal debris occurs (Lewis, 1964). A significant relationship was noted between periwinkle densities and gravel as a substrate type. Small gullies in which gravel can aggregate so that the substratum is in fact quite stable, provide ideal settlement conditions for larvae; firstly, by providing a large surface area for settlement, and also by providing protection from desiccation, dislodgement and predation (Atkinson and Newbury, 1984). The presence of gravel offers similar advantages to older animals, in particular as a source of protection from dislodgement and predation.

Williams (1964) found very high densities of *L. littorea* on a moderately exposed shore at Craig-y-Wylfa, Wales. This trend is in accordance with the findings of the present study. Moderately exposed shores supporting large populations of *L.littorea* have been described in other studies (Ballantine, 1916; Graham and Mill, 1992; Hylleberg & Christensen, 1977; Lewis, 1955; Stephenson & Stephenson, 1972).

There is a general trend for the number of periwinkles per unit area to drop as one moves from the upper shore (Zone A), to the lower shore (Zone C). This was found to be the case for example in Bullens Bay, Kilcrohan, Carnivan Bay and Patricks Bay. This is in accordance with the documented research on periwinkle ecology (Crothers, 1992; Williams, 1964). However, there were a number of sites where the density incline appeared to be reversed e.g. Carlingford Lough and Aghabeg. These two shores were the only shores with a classification of 1 (extremely exposed) on the Lewis (1964) scale of exposure. It has been suggested that the degree of wetting on an exposed upper shore allows periwinkles to extend their range upwards (Moore, 1940). Perhaps the opposite is true for an extremely sheltered shore; further studies would have to be undertaken with more sampling locations to conclude this with certainty. In addition, there were a number of sites where the highest density of *L. littorea* occurred in Zone B, the middle shore. This was most notable on the east coast around Wexford, (e.g. Netherton; Crossfintan

Point; Rosslare Harbour), Dublin (e.g. Skerries; Rush), and Louth (e.g. Rathcor; Corstown Bridge; Clogher Head). The coastline on the east coast is generally flat and not as rugged as on the south and southwest coast. As a result, zonation is not as pronounced as it is on rocky, rugged shores. This could be the reason why higher densities of *L. littorea* appear to occur on the middle shore, in particular on the east coast. It was also noted during sampling that periwinkles on exposed shores were largely confined to rockpools, thereby avoiding much of the dessication effect associated with living high on the shore. Food availability may also be a factor in shoreline distribution, as most algae on the sampled exposed coasts were found in rockpools.

Environmental conditions such as temperature and input of freshwater were observed during the surveys. Freshwater inputs were observed at some sites (e.g. North East of Fort Point, Cork), in the form of streams flowing to the sea. However, these did not appear to have any impact on *L. littorea* populations at particular sites, even though an abundance of *Ulva lactua* was often associated with the streams. It is impossible to draw any conclusions from the recordings of temperature that were made, as most of the surveys were done between June and September, with no significant variation in temperature recorded during those months. Seasonal variation in periwinkle densities, observed at Bullens Bay, where samples were collected at different times over a three year period, may be attributed to many factors. These include population dynamics, as well as external factors such as storminess, degree of wetting, variation in collection rates by pickers etc. Temperature is one of many factors that may potentially influence the variation in population densities.

Finally, periwinkles are never uniformly distributed and shorelines are never uniform in nature. The methodology adopted for this study was designed to ameliorate these features; however, it is very difficult to represent an entire shoreline on one visit, in just three 30m belts. In conclusion, it is unlikely that the density of populations of *L. littorea* is determined by a single factor, but rather from a combination of many acting together, to provide optimal conditions where adults can thrive in large numbers, and where optimal settlement may occur and hence maintain a high density. Several factors were examined (exposure, topography of the shore, and algal cover). However, other factors are likely to be involved, which were not taken into consideration, such as the absence or scarity of important competitors (especially limpets); settlement conditions; intraspecific competition for food; intraspecific competition for space; and tidal range and emersion periods. Exposure and substratum of a shore, however, are likely to be amongst the most important factors.

3.4.2 Temporal variation in density at Bullens Bay in County Cork

At Bullens Bay, where temporal variation in density was observed, it appears that lowest densities of periwinkles occur during the winter period. This may be a consequence of natural mortality, or increased harvesting activity, as this shore is intensively picked during the winter. Another possibility for the reduced densities in winter could be a result of a sub-tidal migration. Sub tidal winter migrations may minimise exposure to freezing temperatures at this time of the year (Gendron, 1977). The effect of temperature extremes created by daily tidal immersions would also be minimised due to reduced periods of exposure. It is unlikely that periwinkle harvesting is responsible for the reduced numbers of *L. littorea* on the upper and mid shore regions during the winter period, as picking tends to be concentrated on the lower shore, where the largest periwinkles are to be found. It is possible that settlement of new juveniles (assuming that settlement occurs in early January/February in Bullens Bay) is responsible for the apparent increase in the density of periwinkles observed on the shore in late spring. Gendron (1977) working on a population of *L. littorea* in North America, found that the largest decrease in the density of periwinkles occurred between October and January. A similar pattern of change is apparent in the results from Bullens Bay.

3.4.3 Shell measurements of L. littorea

Intensive over-picking of a shore can have an impact on shell height as many of the larger animals are removed. However, no clear relationship between shell height and over-picking was identified from the data collected from one off site visits in this study. The intensity of the picking effort varies considerably from shore to shore and will often depend on current market prices and the time of year. In addition the mean shell height obtained for a shore does not reflect the number of very large or small periwinkles found in a population. Due to the extended planktotrophic larval stage in *L. littorea*, which leads to a relatively genetically heterogenous population, most observed morphometric variation is considered to be a result of natural selection and/ or the ability to adapt to the surrounding environment (Crothers 1992, Reid 1996).

In an examination of the relationship between shell measurements and exposure, the correlation between shell height and exposure was weak, however, the correlation between shell width and exposure was significant. While it is clear that the periwinkles from the most sheltered shores are larger than those from shores of intermediate exposure, the pattern is not one of consistent increase in size with decreasing exposure. This may be a consequence of small sample size, as measurements were only taken from seven shores with exposures greater than 3 on the Lewis scale of exposure.

L. littorea have been observed to adapt their shell morphometry, particularly their shell shape ratio, in relation to exposure. An increase in the value of the shell shape ratio corresponds to a decrease in aperture height. In *L. littorea* a smaller aperture, more characteristic of sheltered shores, is believed to be an advantage in avoiding predators (such as birds and crabs), which feed more effectively on sheltered shores (Crothers 1985, Robertson 1992). The larger aperture of animals from more exposed coasts is believed to allow for a larger foot and consequently a stronger hold on the substrate; this pattern was shown for other Littorinids by Raffaelli (1982). Crothers, 1992 also suggested a relationship between shell length and exposure. A lower spire reduces drag and hence provides an advantage on exposed shores. Exposure was shown to have a demonstrable effect on relative aperture height with significant correlation between exposure and shell height/aperture height ratio. In this case, an increase in the value of the shell height/ aperture height ratio corresponds to a decrease in aperture height, so a positive correlation points to a reduced aperture height on sheltered shores.

The effects of vertical position (zone) on the shore are quite distinct. Shell height is very strongly correlated with zone i.e. shell height increases down the shore. This agrees with the findings of other authors in studies of the influence of shore height on shell length in *L. littorea* (Vermeji, 1972; Gendron, 1977). The relationship between vertical position (zone) and shell morphology may indicate a seaward migration of older animals, or perhaps it is only on the lower shore that periwinkles achieve the largest sizes. McQuaid (1981) suggests that the greater tenacity of adults allows a gradual downshore migration of growing animals in response to gradients of food availability. This could be explained by the greater availability of food on the lower shore, where algal densities are higher. In addition *L. littorea* are stimulated to feed when immersed by the tide and when damp conditions prevail (Newell, 1958; Moore, 1937; Williams, 1964). Thus, the larger animals found on the lower shore have greater opportunities for feeding due to the regular influence of the tidal cycle on immersion rates.

3.4.4 Population structure of L. littorea

Sites favoured for settlement seem to be shores of moderate exposure (Lewis scale 3-4) with rocky and/or gravel substrates e.g. Rosbeg County Donegal (DL05), Kilcar County Donegal (DL11), Sky Road County Galway (G010), and Mweenish County Galway (G002). Three possible reasons for this pattern are outlined:

1. Sheltered sites are favoured by juvenile periwinkles for settlement purposes;
2. Mortality rate of newly settled juveniles on sheltered shores is considerably greater;
3. Growth rates are less on exposed shores.

While it is likely that growth on more exposed shores is slower, this does not explain the low levels (or absence) of juveniles on very sheltered shores, for example, at Ardfry, County Galway (G014), Ballyconnelly County Galway (G009), and Passage East, County Waterford (WD14). One explanation for this pattern put forward by Crothers (1992), involved what he described as the "whiplash effect" of dense fucoid algae which sweep away newly settled juveniles. Once juveniles survive early settlement, animals grow rapidly and may live for many years. In contrast, on an exposed shore, while conditions for settlement may be favourable, especially on barnacle covered rocks, few individuals survive winter storms (Crothers, 1992).

Large numbers of small periwinkles were observed at the Carna site (G001), however, this site was not as muddy as many sheltered sites and consisted of large areas of gravel and small stones. Seaweed cover is sparse in areas where the substrate is unstable, which would reduce whiplash effect. Water flow was also greater than would be expected due to considerable influx of freshwater and run-off from a tidal lagoon. A site in County

Kerry, Fenit 2 (K002), also does not conform to this pattern, proving that each shore is unique and many environmental parameters may affect settlement.

The shell height of cohorts will vary according to the time of year the site was surveyed and the time of settlement at the site. Spawning times are known to vary geographically; in addition, *L. littorea* has an extended spawning time (Fish, 1972). These factors may confuse the interpretation and comparison of length frequency histograms. However, it is usually possible to determine size/age classes from within an individual shore. Many of the histograms from exposed or semi-exposed shores show evidence of 2-3 size classes e.g. Rosbeg, County Donegal (DL05), Meenlaragh, County Donegal (DL07), Loughaunacreen, County Kerry (K016) and Corstown Bridge, County Louth (LH03). The smallest size class would, if a spring spawning were to be presumed, represent that year's settlement. It is rarely possible to decipher more than three age-classes, probably a result of a slowing of growth with age and maturity.

In sheltered shores, where there appears to be less recruitment, periwinkles appear to be larger and this is borne out by statistical analysis. In terms of population dynamics, it makes more sense that recruitment is highest where mortality is highest. This may also indicate that sheltered shores, where the largest periwinkles occur, are more susceptible to the effects of over-picking.

3.4.4.1 Population structure of L. littorea at Bullens Bay

In general, the length frequency distribution for the sampled population of *L. littorea* at Bullens Bay appears to be bi-modal. The data for periwinkles measured in November 1998 represent a low number of samples, for periwinkles less than 10mm. The cohort with a modal height of 7mm in January 1999 appears to have reached a shell length of 10mm by August 1999, and a shell length of 15mm by August 2000. Assuming that settlement occurs in late spring (May), the snails with a shell length of 10mm in August 1999 could be up to 15 months old. It could be said that the animals that obtained 14mm in August 2000 were approximately 27 months old. In November 1998, there was a high density of *L. littorea* at a modal height of 15mm. By August 2000, this cohort appears to have achieved a length of 20mm. Thus, it could have taken 21 months to grow from 15mm to 20mm. This would indicate that animals with a shell length of 20mm could be up to 4 years old. Previous studies have shown that a shell length of approximately 8mm is achieved at the end of the initial year of growth, increasing to about 16mm in length by the end of the third year (Williams, 1964; Hughes & Answer, 1982; Crothers, 1992). The findings at Bullens Bay are in keeping with these approximations of growth. However, Moore (1937) suggested faster growth rates in a study on *L. littorea* in Plymouth, for example, *L. littorea* has been shown to grow to 14mm shell length in December of its first year and reach a shell length of over 27mm by its fifth year.

L. littorea shows considerable variation in growth rate for the first four years of its life (Moore, 1937; Williams, 1964). The results from Bullens Bay indicate variable growth rates (approximately 8 months to grow from 0.5mm to 7mm; 7 months to grow from 7mm to 10mm; 12 months to grow from 10mm to 14mm). These figures assume that settlement occurs in early summer (Smith & Newell, 1955; Williams, 1964), and that *L. littorea* settle at a shell height of approximately 0.5mm (Smith & Newell, 1955). They do not take into account possible spurts in growth at productive times of year. A pattern in growth rates of *L.littorea* was observed by Lambert and Farley (1968) and by Gardener and Thomas (1987). The general trend was for growth rates to increase from May to early July, followed by a decrease in growth rates from mid-July to mid-August. Growth rates were observed to increase again in early September, before declining in the winter months. Periods of shell growth are interrupted when conditions are favourable for reproduction (Williams, 1964). Williams (1964) observed active shell growth on a shore in Wales, from July to October, which corresponded with a period when mature animals were fully spent. Growth rates decreased when gonad maturation began again the following November. Fretter and Graham (1960) observed a looser growth cycle, when, on reaching sexual maturity a cessation in growth occurred in correspondence with a period of maximum sexual activity. Maturity is thought to occur 12-18 months after settlement once a shell length of approximately 11mm has been reached (Williams, 1964). However, analysis of specimens collected from a shore in Galway during this study, showed the age of first maturity as approximately 15mm for males, and slightly higher for females; the smallest ripe female had a shell length of 17mm (Unpublished PhD data, Shellfish Research Laboratory, Carna). Taking this into account, it is unlikely that observed variable growth in animals less than 14mm in August 2000 can be attributed to sexual activity. Factors such as temperature, food availability, exposure, predation, competition and salinity also have an impact on growth (Pertraitis, 1982, 1987; Crothers, 1992; Reid, 1996; Robertson, 1992). It is possible that these factors have a greater impact on growth in periwinkles less than 14mm in Bullens Bay. The mean density on the shore was found to be high, approximately 63 periwinkles per m^2. Thus, competition could be an important factor limiting growth of the periwinkles on the shore in Bullens Bay.

There were considerable variations in the numbers of periwinkles >25mm shell length on the shore in Bullens Bay over the sampling period. This pattern could be attributed to harvesting pressure, as the largest periwinkles are the most desirable on the market. For example, in November 1998, a cohort with a modal height of 26mm was identified. By August 1999 no periwinkles >21mm were observed in the samples. However, by October 1999 a peak at a modal height of 25mm re-appeared. It is questionable if this same group grew to the observed shell length of 28mm in August 2000, as growth rate has been shown to decrease rapidly with age. Very little research has been carried out on growth rates in larger animals, although it is known that periwinkles >25mm must be several years old. The largest animal measured from Bullens Bay was 34.1mm in shell length.

A difficulty arises in using a harvested shore, such as Bullens Bay for studying the population structure of *L. littorea* as one of the main factors influencing such population structure will be harvesting itself. Temporal variation in periwinkle harvesting at Bullens Bay leads to difficulty in the interpretation of the impact of this activity, however, it is likely that harvesting has an impact on the population structure of *L. littorea* at this site, and that this impact extends to periwinkles that are greater than 14mm in shell length. In addition, the lack of measurements of periwinkles <5mm shell length meant that variations in recruitment patterns could not be observed. Nevertheless, it has been possible to suggest a model of growth in Bullens Bay.

SECTION 4 - INDUSTRY REVIEW

4.1 Introduction

Littorina littorea is collected in large quantities for human consumption. Collection is usually carried out by part time fishermen and by women (O Sullivan, 1977). Wright (1936) states that in the Blackwater Estuary, Essex, commercial quantities of periwinkles were dredged from sublittoral channels; however, gathering in Ireland is carried out by hand. Periwinkle harvesting is done during spring tides. Periwinkles are easier to harvest during this period as the lower shores, where the largest periwinkles are found, are more accessible. Some picking is done during periods of neap tides, but the quantity harvested is considerably less (T. Tobin, Youghal, pers. comm., 2000). When demand for periwinkles on the continent is high, and when prices are good, there is an increase in the number of people picking, and in the quantity of periwinkles exported. Extra demand for periwinkles at Christmas drives the price up from approximately £1,400 to £2,200/tonne, making Christmas one of the busiest times for periwinkle pickers and wholesalers. Some harvesters only pick at this time of the year, as the higher prices make it more worthwhile, and the extra cash is often needed. There is a subsequent post Christmas lull in the demand for periwinkles; demand increases again around Easter (K. Flannery, Dingle, pers. comm., 2000). Demand for periwinkles in the summer months has increased in recent years attributable to the increased volume of trade experienced in France by restaurants at that time of year.

Traditionally, the price obtained for periwinkles varied throughout the year, in accordance with the demand from foreign markets, (Wright, 1936). Seasonal trends in price still occur today. Price also depends on the size of the periwinkles, and whether they are graded or not. Wholesalers can also have an impact on the price a picker can get. Some wholesalers keep the price artificially high; this ensures the loyalty of the pickers when there is competition amongst wholesalers for stocks, and also encourages pickers to harvest in the run up to Christmas. Generally speaking, a picker could receive as little as 80p per kilo, but this can increase to around £1.50/kg at Christmas time. Wholesale prices are in the region of £2.10/kg for periwinkles less than 13mm, and about £2.50/kg for periwinkles greater than 15mm. Periwinkles are usually exported with other shellfish, and transport costs vary from 12p/kg plus VAT, to 22p/kg plus VAT for groupage.

The market price plays a major role in the number of people picking at any one time (McKay and Fowler, 1997). Market prices were very good in 1999, but they were subsequently affected by the oil tanker (the *Erika*) accident off the Brittany coast in December 1999. There is a demand for Irish periwinkles from French oyster farmers who use them to graze the algae that fouls the oyster bags. As a result, any impact on the French oyster industry, such as an oil spill, has a knock-on effect on the Irish periwinkle market.

There are no regulations in place to control the quantities of periwinkles harvested per year. Periwinkle picking is very much a 'free for all' situation; establishing oneself as a picker requires little more than a bucket. Despite the evident lack of regulatory control, all periwinkles collected in Ireland must meet the end product standards outlined in the European Community Directive on Shellfish Hygiene 91/492/EEC. This requires all shellfish harvesters to maintain a Harvester Book, which should log details of the species gathered, time and location of harvesting, quantity collected and destination of the shellfish. Rigid implementation of the harvesters book system is difficult to ensure in this industry. These regulations also require that wholesalers operate from a registered dispatch centre, which has been allocated a veterinary inspection number. This number is necessary in order to obtain an export licence. It also confirms that the premises has passed the required standard in terms of hygiene. These controls are enforced by the Department of the Marine and Natural Resources.

Historically, the only information on the Irish periwinkle industry has been compiled by the Department of Marine and Natural Resources (DoMNR). Up until now, no effort has been made to examine the periwinkle industry in Ireland as a discrete entity. In this section, an attempt has been made to estimate the true size and nature of the periwinkle industry in Ireland. The research methods and results are presented below.

Plate 2. Bags of harvested periwinkles, *Littorina littorea,* awaiting collection from a shore in Galway.

4.2 Research Methods

A confidential questionnaire, directed at periwinkle wholesalers, was designed to obtain information on the periwinkle industry. Twenty-six wholesalers were identified nationally, all of whom responded to the questionnaires, which were distributed between between June 1999 and January 2000. This represents the majority of periwinkle exporters in the country. However, periwinkles are sometimes purchased directly by French and Belgian buyers, which makes it extremely difficult to account for all of the exports. The aim of the questionnaire was to assess the quantity of periwinkles exported from different areas, and to obtain an impression of any changes in the supply of periwinkles from pickers to wholesalers over the last five years. Wholesalers were also asked their opinions about potential management strategies that might contribute to the future sustainability of the industry.

In addition to questionnaires, meetings were organised with as many wholesalers as possible. This was particularly advantageous when visiting a stretch of coastline for the first time, as wholesalers could pinpoint harvested sites for future surveys. Individuals with knowledge of the industry, while not actively partaking in commercial dealings in periwinkles (for example, fisheries officers), were also consulted.

Fisheries landing data was sought from the Department of the Marine and Natural Resources (DoMNR), the responsible authority for maintaining sea fisheries statistics. Periwinkle statistics are collected by Sea Fishery Officers and are then processed by the Department.

Eight seafood restaurants, six in Cork and two in Galway, were contacted by telephone to document the perception of periwinkles as a restaurant food in Ireland, and whether there might be potential to develop the home market further.

4.3 Results

The information obtained from the questionnaires is presented by dividing the coastline into five areas, which represent the main wholesaling areas in the country (Figure 16).

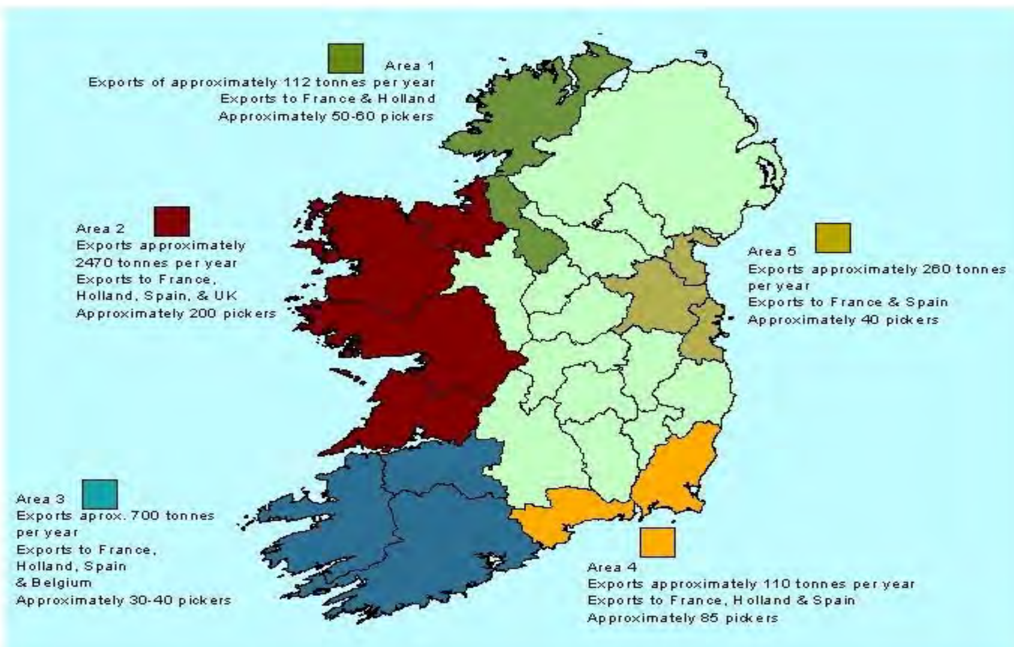


Figure 16. Industry review areas and summary of periwinkle industry activities

4.3.1 Area 1

This coastal area stretches from Rathmullan in County Donegal to Rosses Point in County Sligo. There is one major wholesaler operating from here, as well as two known agents who supply a large percentage of the picked periwinkles to wholesalers in Area 2. Results from questionnaires and interviews indicate that approximately 112 tonnes are exported directly from here per year. The exports are shipped to markets in France and

Holland. Each interviewee claimed that there was a decrease in the quantity of periwinkles being supplied to them; they attributed this to over-picking, picking during the breeding season, and pollution. They also said that regulations need to be put in place to conserve stocks, and mentioned closed seasons and minimum harvesting size as the best options for control. There are an estimated 50 to 60 pickers in Area 1. Periwinkles are exported to France and Holland from this area.

4.3.2 Area 2

This stretch of coastline extends from Rosses Point to Kilrush in County Clare. Seven wholesalers and agents were interviewed in this area, which includes some of the biggest wholesalers operating in the country. These wholesalers export approximately 2,470 tonnes per year. Two individual wholesalers account for over half of this total. All of the wholesalers said that they had experienced a decrease in the quantity of periwinkles they were receiving. While overpicking was cited as the major cause of the decrease by three of the wholesalers and agents, some additional factors, such as a shortage of labour, less picking effort, and pollution were listed as other potential explanations for the decrease in periwinkle supplies. This area contains the largest number of pickers, as there is an extensive area of suitable coastline. Based on wholesaler information, there are an estimated 200 pickers here. Periwinkles from Area 2 are exported to France, Holland, Spain and Britain. A proportion of this harvest is also retained for sale on the domestic market. However, this accounts for less than one percent of the total. Beach front vendors in Kilkee County Clare have operated a seaside business there for over a century. Sales of periwinkles in Ireland are also to be found further up the coast in the seaside town of Lahinch (County Clare) and in County Donegal at Killybegs. All of the interviewees said that regulations should be enforced to help the future sustainability of the industry. They suggested that minimum harvesting size and closed seasons would be the most practical way of achieving this.

4.3.3 Area 3

Area 3 extends from Tarbert in North Kerry to the coastal town of Youghal in East Cork. This area produces a conservative estimate of approximately 700 tonnes per year and there are at least 11 wholesalers operating from here. Periwinkles from this area are exported to France, Holland, Belgium and Spain. All of the wholesalers in this area noticed a decrease in the number of periwinkles made available to them by pickers. They also noticed a decrease in the average size of the periwinkles picked. Over-picking was listed as a major factor in the decline of periwinkle stocks, while less picking effort also featured as a possible cause. In 1998, the North West Kerry Shellfish Co. Ltd., under proposals for the conservation of inshore stocks of shellfish, submitted to the Minister for the Marine and Natural Resources, a proposal that a minimum size should be introduced for periwinkles harvested and that a closed season should also be introduced. No action was taken on behalf of the government at the time on this issue. Several exporters, pickers and people associated with the industry have expressed a genuine concern for the sustainability of the industry in this area. There are approximately 100 people reliant on income derived from periwinkle picking in this part of the country. Estimates vary according to which wholesaler is providing the information, but there is general agreement amongst the wholesalers that the number of pickers is declining. Many attribute this to the fact that fewer young people are involved in the industry, as there are now more attractive sources of employment elsewhere. One set of figures provided by a wholesaler, showed a decrease in the number of harvesters in an area in east Cork from 30-40 pickers ten years ago, to 7-8 full time pickers today.

One of the wholesalers interviewed in Area 3 said that the average size of the periwinkles being supplied to him had *increased* in recent years. On further questioning, he said that in the early 1990s, he used to purchase undersize periwinkles to sell to oyster-farmers in Brittany (mesh size of less than 13mm). These periwinkles were required to graze the algae in oyster bags. The on-grown periwinkles were then sold to the local markets by the oyster farmers. This practice ceased in 1993 when the French oyster production suffered problems with disease. As a result, the market for seed, small and medium periwinkles gradually decreased.

4.3.4 Area 4

This area consists of the coastline from Youghal to Rosslare, and includes the sheltered Dungarvan Bay, where much of the periwinkle picking takes place. Approximately 110 tonnes of periwinkles are exported annually from this area. There are three major wholesalers operating from here, two of whom rely on agents from other parts of the country to supply additional stocks when the demand is high. Shipments are made through the port at Rosslare, and the periwinkles go to France, Spain and Holland. All of the wholesalers in this area stated that the quality of the periwinkles, in terms of size, was good, and that the quantity being supplied to them remained stable. The largest of these wholesalers stopped accepting undersize periwinkles a number of years ago, and he attributes the recent prevalence of very big periwinkles to this practice. Nevertheless, all of these wholesalers said that regulations should be introduced to control the industry nation-wide, and they all favoured closed seasons and minimum sizes as the best methods of control. There are approximately 40 regular pickers from Dungarvan to Passage East in County Waterford, and a further 45 pickers from Arthurstown to Rosslare Harbour in Wexford. Some of this harvesting is reportedly done by ‘New Age Travellers’ who have been harvesting periwinkles in the region in recent years. Locals have commented on seeing groups of up to ten 'New Age Travellers' work a stretch of shore for the duration of a spring tide, and then move on to the next stretch of coastline. Several of the locals that were interviewed in the area were worried about the impacts of this intense harvesting method on the local periwinkle stocks.

4.3.5 Area 5

The coastline north of Rosslare to Dublin is largely made up of sandy, muddy foreshores, so periwinkle harvesting does not occur on a commercial scale in this region. Consequently, Area 5 extends from the North Dublin coast as far as Carlingford Lough in County Louth. There is one wholesaler from the Republic operating in this area. He also collects periwinkles from north of the border. He stated that fewer people are picking periwinkles in the region now than before, and that over-picking is not a problem. His volume of trade has increased in the past few years due to other wholesalers relinquishing their business. There are about 20 pickers between Clogher Head and Carlingford Lough that pick all year round. This number increases to approximately 30-35 people in the winter season (November to March). There are a similar number of harvesters that work the coast between Clogher Head and Rush. These are all local people; up to 90% of the picking is done by men.

4.3.6 General results

During meetings with the wholesalers, it became apparent that many would be interested in exploring the potential for on-growing. On-growing would involve taking seed and small periwinkles and maintaining them in an aquaculture system until they were of commercial size.

There is little, if any, post harvest processing. Some wholesalers provide special 10kg collection bags for the pickers to fill. These bags are collected, given quick inspection for general size of the periwinkles, and packed for immediate export. In the country of import, the periwinkles are usually separated into small 5kg bags. These are then placed into one large 40kg or 50kg bag, and sold to shops and restaurants. The 5kg bags are convenient for restaurants with large turnovers, as the periwinkles can be 'boiled in the bag'. Alternatively, the periwinkles are packaged loosely into 5kg polystyrene boxes. These boxes can be stored in the fridge, and the required quantity of periwinkles can be removed and cooked as desired. The periwinkles will remain fresh for several weeks in the fridge.

Ten of the 24 wholesalers said that they grade the periwinkles prior to export. The larger periwinkles command a higher price, making the process worthwhile. Grading is achieved by riddling the periwinkles using a bar or mesh riddle. The bar or mesh spacings vary in size and sort the periwinkles into undersized (to be discarded), medium, large, or jumbo. Most wholesalers classify a periwinkle passing through a mesh size of >15mm as being large. Wholesalers may also have to discard periwinkles that are covered in barnacles, as these are unmarketable. Periwinkles that are not graded in this country are usually graded by the importer on their arrival at their country of destination.

A further value adding technique, practiced by four of the wholesalers, involves allowing the periwinkles to crawl up vertical sheets of Perspex (a practice known as 'crawling'). Using this method, weak and dead periwinkles can be identified and removed prior to packaging. Buyers will pay more for this higher quality product.

One individual wholesaler investigated cooking and freezing the periwinkles so that they could be vacuum-packed and supplied to the market year round. He tried introducing the product at several trade fairs in France, but quickly realised that there was little demand.

Plate 3. Ungraded periwinkles photographed at a wholesalers premises in County Mayo.

Plate 4. A periwinkle grading machine.

4.3.7 Analysis of official fishery statistics

Annual reported catches of periwinkles can be seen from the sea fish landings by species, collated by the Department of Marine and Natural Resources. These figures are based on information provided by the wholesalers to the DoMNR's Sea Fisheries Officers. The wholesalers are under no statutory obligation to do this, thus the reliability of the data can often depend on the level of trust built up between the two groups.

Annual reported catches of periwinkles since 1973 are given in Figure 17. This data indicates that an average of about 2,370 tonnes per year were landed in the 1970s, with a peak of 2,995 tonnes in 1975. There was a decrease in the catch during the 1980s when the average figure was 1,604 tonnes per year, and landings fell to 1,198 tonnes in 1981. Periwinkle landings have gradually risen again since then, and in the most recent years for which data are available, catches have remained higher than the 1970s average. This is in direct contrast to the information derived from the questionnaires, which indicates that wholesalers have experienced a general decline in the quantity of stocks handled by them since 1995.

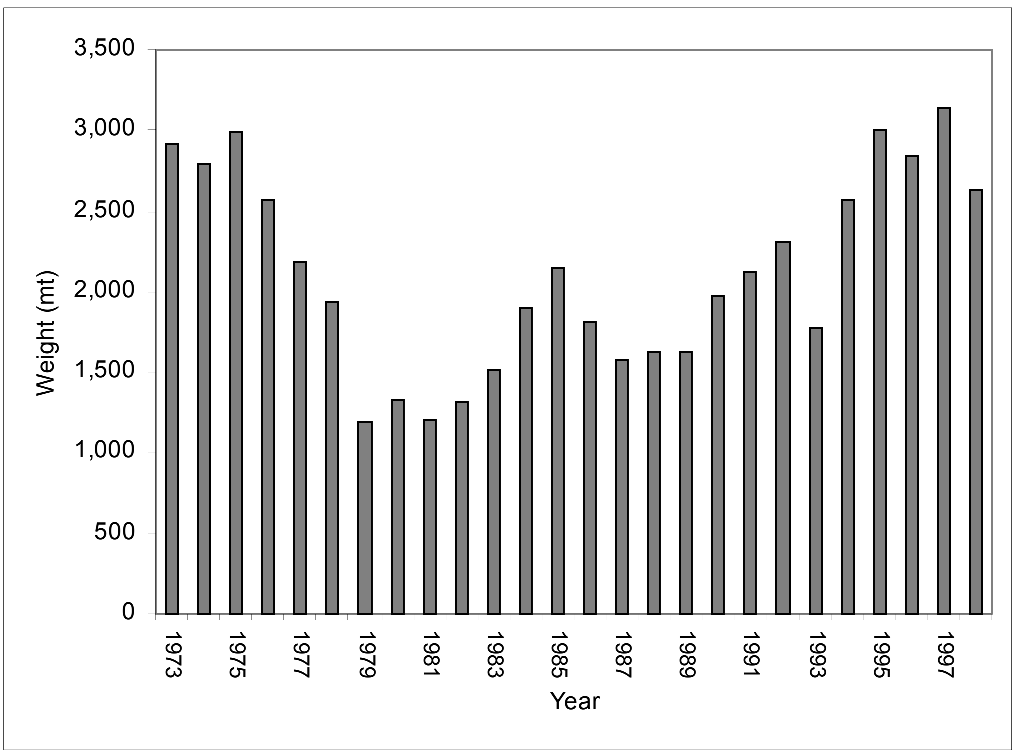


Figure 17. Catches of periwinkles in Ireland 1973 to 1998.
Source: Department of Marine and Natural Resources.

4.3.8 Feedback from seafood chefs

Three out of the eight restaurants contacted had periwinkles on their menu at one time or another. Two of these restaurants stopped serving periwinkles, due to the lack of demand. The general opinion of all of the chefs interviewed, was that periwinkles are tedious to eat and people are not practised in extracting them from the shell. There are also limitations on how they can be cooked and presented. One chef thought that the modern trend for convenience foods had made people reluctant to put effort into extracting the snail from the shell. On the other hand, the chef of a French seafood restaurant thought that this aspect of the food source was one of the attractions.

In general older people, in the 50 plus age bracket, eat periwinkles; traditionally in Ireland periwinkles were boiled in milk with onions. Irish people living in the coastal counties are more inclined to eat periwinkles than are their inland counterparts.

Three of the chefs stated lack of familiarity with the supply chain as a reason for not using periwinkles. Fear of contamination was also stated by two of the chefs as a reason for not using them.

When asked if there would be any potential for increasing the quantity of periwinkles being used in Irish restaurants, the replies were positive from six of the eight chefs questioned. The general opinion was that Irish people were experimenting more with the types of food they eat. The increasing popularity of mussels and oysters over the last 10 years was given as an example of this change. It was observed that if periwinkles were well marketed, there could be a change in attitude towards eating periwinkles, either as bar food, or as part of a seafood platter.

The main potential for selling more periwinkles on the Irish market comes from the increasing numbers of tourists visiting Ireland each year, especially the French and the English. Five of the chefs said that they would consider putting periwinkles on their menus (if they could find suppliers), during the tourist season; one of the chefs, who already does so, said that periwinkles were popular with his customers.

4.4 Discussion

Many of the results presented in this section of the report are based on the opinions of wholesalers. Due to the difficulty in identifying harvesters willing to discuss their involvement in the industry, the wholesalers themselves were also reluctant to provide detailed information on the sources of their supplies, to protect those individuals who may also claim unemployment and other social welfare benefits. As a result, the findings presented here reflect the difficulty in obtaining a clear picture of what is happening in this 'black economy' type industry.

In other ways, the wholesalers were very forthcoming with regard to how they operated their businesses. However, many of the export figures provided are thought to be an underestimate of the true quantity of periwinkles landed. The figure of approximately 3,650 tonnes exported per annum, obtained from the results of the questionnaires, is likely to be a conservative estimate of the true quantity of periwinkles actually harvested. This may be due to a reluctance to reveal figures for periwinkles that are exported unreported. In addition to this, there are cases around the coast, where pickers have built up contacts with importers in Belgium and France, and export their harvest directly. It is also difficult to estimate the quantity of periwinkles taken out of the country by French buyers who bypass the Irish wholesalers. As a result, it would be reasonable to estimate that the true quantity of periwinkles exported from Ireland may be closer to over 4,000 tonnes per year. Using these figures and current market prices, it is estimated that in excess of £7 million worth of periwinkles are exported from Ireland annually.

There appear to be approximately 500 part-time pickers employed by the industry, although this figure fluctuates depending on the time of year. While this is thought to be a fairly accurate reflection of the current situation, the number of pickers is very much dependant on the economic climate of the day and on the market price for periwinkles abroad.

Further research into the feasibility of **on-growing** could have an impact on the future of the industry. The main aim of this process would be to maximise growth rates so that the periwinkles would be marketable within a profitable time period. On-growing has never been tested on a commercial basis here in Ireland, although research trials conducted in Bantry Bay (Griffiths, 1996) and in Scotland (Cashmore and Burton, 1998) both concluded that benefits may be gained from this type of operation. Development of an artificial diet is something to consider for any large-scale aquaculture activity. An artificial pellet was tested in the Bantry Bay on-growing trials, but it was concluded that several changes would have to be made before this diet would be suitable for periwinkle culture (Griffiths, 1996). Observed problems with the diet included leaching, and lack of palatability. For small scale on-growing of periwinkles, costs would have to be kept to a minimum to ensure profitability of operations. Periwinkles are a low value species in comparison to some other farmed shellfish (such as oysters and abalone). William Connolly's Redmills Ltd. is currently developing Abalone diets, but these will market at £500 - £600 per tonne. For this reason, it might be better to feed the periwinkles on a natural diet of seaweed gathered from the shore. The development of aquaculture facilities suitable for intensive rearing also requires consideration. Such facilities may include a pump-ashore system where environmental parameters could be manipulated to ensure optimal feeding and growth rates. More work needs to be carried out to determine factors such as seasonal changes in growth, the benefits of providing supplementary feed, and the effects of parasitism.

Polyculture is another option for on-growing small periwinkles. This involves growing the periwinkles to a marketable size with another cultivated species. This practice is commonly used by French oyster farmers. The advantage of this procedure is that the periwinkles are very effective at keeping the oyster bags clean of fouling algae. In France, many oysters are grown in intertidal ponds, or parcs, which are ideal for confining the periwinkles with the oysters. Although parcs are not used in Ireland, one oyster farmer in Dungarvan successfully incorporates periwinkles in with his oyster bags as a method of biological control of fouling organisms. Surprisingly, it is not common practice among other oyster growers (R. Harty, pers. comm., 1999).

Post harvest processing of the periwinkles could also be suggested as an area for future focus. The current practice of packaging the periwinkles in 10kg bags keeps the costs down, however it does not ensure a quality product for the buyer. One exporter practising this technique has had non-payment for goods due to the large proportion of undersized periwinkles in some bags. Some pickers have also been known to add weight to the bag by adding stones to the middle. Despite this, many wholesalers believe that minimal handling is the most economically viable strategy. However, there seems to be little room for development in the area of post harvest processing; the greater majority of periwinkles are consumed fresh, either as an appetiser or as a minor part of a seafood platter. Potential seems to exist for selling more periwinkles to Irish restaurants, particularly during the tourist season. Picking during the summer to provide for the home market is unlikely to have any major impact on periwinkle stocks, as the potential size of the market is small.

Grading. As a large number of periwinkles are exported without being graded, it must be assumed that many undersize periwinkles end up in the market place, or that the importers dump them. This trade in undersize periwinkles is of particular importance at a time when so many of the wholesalers have expressed concerns about the resource. On the other hand, each of the wholesalers that employ sorting techniques said that they either return the undersize periwinkles to the shore, or make use of them in some other way. For example, one wholesaler relays them in oyster-bags where they graze the fouling algae from the trestles. Another wholesaler in Kerry uses them to clean his lobster tanks as the periwinkles feed on fouling macro and microalgae. While the return of undersized periwinkles to the shore must be welcomed, its unclear how well the animals recover. However, they obviously fare better than those periwinkles that (as has been suggested) are buried to prevent harvesters from re-picking them.

A number of wholesalers blamed **pollution** for a reduction in periwinkle stocks in certain coastal areas. It is known that *L. littorea* are affected by TBT based antifoulants, which were commonly used on vessels, primarily on leisure craft, until a partial ban was introduced in Ireland in 1997. A study in the UK, on *L. littorea* populations in the estuary of the river Crouch (Essex), showed that the numbers of *L. littorea* eggs and veliger larvae progressively increased following the ban on TBT-based anti-foulings on small boats by the UK government in 1987 (Matthiessen *et al*, 1995). This suggests that TBT may have impaired periwinkle reproduction and/or survival of the eggs and larvae. Another effect of TBT on *L. littorea*, termed imposex, causes formation of male sexual characteristics in females. The effects of imposex on periwinkles in Cork Harbour were studied by Casey and Burnell (1998). Imposex is not fatal and affected populations do not exhibit a male dominated population structure (Baur *et al*., 1995). Also, due to dispersal during the pelagic larval stage of *L. littorea,* populations do not necessarily become extinct as a result of imposex. The majority of harvested shores are located away from harbour areas where TBT might still be present in the sediment, making it unlikely that TBT plays a major role in the availability of the resource at present. However, it may have had a more significant role on the impact of periwinkle populations prior to the introduction of the ban. The other major pollution threat to populations of *L. littorea* is from oil spills; however, these usually have a localised impact, and there has not been a significant spill in Irish coastal waters in recent years.

The official landing statistics from the Department of the Marine and Natural Resources show that there has been a steady rise in the number of periwinkles landed throughout the 1990s (Figure 17). This can be misleading when presented out of context. It is unlikely that this rise is due to increased picking effort, but to a combination of other factors. The introduction of EC Directive 492, which defines end product standards for shellfish, led to improved accountability within the industry. This has had a substantial impact on landing figures since 1991. In addition, the DoCMNR has increased the number of sea fishery officers, so that more accurate information has been collected in recent years. Furthermore, landing figures for the early 1970s (when landing data would have been much more difficult to obtain) are roughly the same as figures for the late 1990s. The figures from the 1970s are likely to be an underestimate; if this is the case, this supports the conclusion that picking effort may be in decline.

Finally, the **overexploitation** of the resource in some locations has been outlined by the wholesalers, but at the same time many of them have noticed a decrease in the number of periwinkles made available to them by pickers. Part of this could be attributed to a reduction in the number of people becoming involved in harvesting. The age profile of harvesters indicates that a shortage of pickers may become a problem in the near future (Section 5). Only 18.5% of pickers interviewed were under the age of 40. Young people perceive periwinkle picking as intensive work, with very little financial return for the effort involved (Section 5).

Based on the feedback from wholesalers, it appears that localised over-picking does occur. The action taken by the North West Kerry Shellfish Co. Ltd. in submitting a proposal for conservation to the Minister for the Marine reflects the level of concern about over-picking in that area. Harvested shores are characterised by easy access, both to the site and to the bottom of the shore. As a result, intensive collecting tends to occur in these areas. This can reduce the overall numbers and size of animals in a population. However, in the absence of a comparable study, it is difficult to determine whether this is a large-scale problem. In addition, *L. littorea* is less vulnerable to the long term effects of over-exploitation than many other species due to its very long planktonic stage and its consequent ability to disperse and re-seed in over-picked areas. As a result, it appears that the major threat to the future of the industry may not be from over-picking, but from the decline in the number of people engaged in harvesting. Section 5 shows that there has been a decline in the number of people involved in picking periwinkles in recent years. The current strong economy in Ireland offers people of all ages a wider range of job opportunities than ever before, and entices them to abandon traditional sources of income. It could be said that the current shortage of periwinkle pickers will provide periwinkle stocks with the opportunity to regenerate themselves, and that it is perhaps the survival of the *periwinkle picker* over the *periwinkles themselves* that we must consider in the future. This reduces the immediate need for regulations to be implemented and should be taken into account before a management strategy is considered.

Regulations to ensure the sustainable development of the periwinkle resource would be welcomed by those who are worried about the conservation of periwinkle stocks. Several exporters, pickers and people associated with the industry have expressed a genuine concern for the sustainability of the periwinkle industry, and were very anxious that regulations are put into place in the near future. A closed season and a minimum harvesting size were the most widely supported regulations presented to harvesters and wholesalers alike.

Closed season. It appears that the motivation behind some of the support for a summer-closed season may be for reasons other than concern for the species. One of the main advantages of a closed season is that it would be easy to enforce. It seems many wholesalers would rather not handle periwinkles during the summer months, when prices are low and periwinkles are difficult to keep. One of the main reasons for continuing to sell periwinkles at this time of year is to maintain foreign customers who might acquire a different wholesaler or agent (perhaps from Scotland) if supplies were not forthcoming. Among pickers, the support for a closed season stems from the fact that few people pick during the summer anyway. A closed season at this time of year would suit those pickers who work on fishing boats or on farms during the summer. As a result, a closed season during the summer, when harvesting is at its lowest, makes little sense. The proposed timing however, makes little biological sense as *L. littorea* appears to spawn in the late winter and spring, and a summer closed season would not protect the animal during this time.

A closed season spanning the months of January to possibly April would best protect spawning periwinkles (pending conclusive research that this is the spawning season for most Irish populations). However, it is unlikely that pickers and wholesalers would support a closed season at any time of the year other than during the summertime. A closed season outside of the summer period could result in a serious loss of income for pickers and wholesalers, due to the closure of the fishery at a time when prices for periwinkles are likely to be high.

Minimum harvesting size. One of the classic signs of imminent problems for a fishery is the increase in sub market size individuals in the catch. The demand for undersize periwinkles by French oyster farmers undoubtedly had a negative impact on Irish periwinkles stocks on certain shores. However, many tonnes of periwinkles continue to be wasted every year because the size of the periwinkles gathered by the pickers is unacceptable for the market. Grading eliminates much of this waste, but it is likely that a large number of periwinkles are dumped, rather than returned to the shore.

The main advantage of the introduction of a minimum landing size therefore would be to force pickers to avoid shores where a large proportion of sub market size periwinkles occur. The majority of the wholesalers questioned suggested 13mm (shell height) as the minimum landed size that should be introduced. This corresponds with the smallest sized periwinkle that would be acceptable on the general market, but fails to take age/size of maturity into consideration. It must be noted that in Galway Bay at least, periwinkles do not mature until they are 15-17mm shell height, (Unpublished work, Shellfish Research Laboratory, Carna), which means that the minimum size advocated by the wholesalers might not protect the species as desired.

The introduction of a minimum landing size would be more difficult to enforce than closed seasons, as a number of wholesalers export periwinkles without grading them. Ideally, the pickers should be held accountable for any sub market size animals in a catch. However, due to the difficulty of identifying pickers, the wholesalers would have to be made responsible for failure to comply with this regulation. The enforcement of this regulation would mean that small exporters would have to buy grading equipment which, possibly, they could not afford. It would also be impossible to ensure that the graded, undersized periwinkles are returned to the shore to allow them to grow to a marketable size.

SECTION 5 -SOCIO-ECONOMIC IMPACTS OF THE IRISH PERIWINKLE INDUSTRY

5.1 Introduction

The aim of the socio-economic study was to evaluate the impact of the Irish periwinkle industry on coastal communities. This section gives an overview of the socio-economic issues derived from the study. These are closely linked with the nature of the periwinkle industry, as outlined in Section 4.

5.2 Research Methods

5.2.1 Questionnaires

A questionnaire was developed to collect information about the socio-economic aspect of the periwinkle industry. Originally, it was intended that the harvesters' questionnaire would be filled out by the harvester in the presence of the picker. However, it became evident that pickers were slightly intimidated by this, thus, a more informal approach was adopted, where questionnaires were filled out after a meeting with a picker. The age, occupation, and gender of the picker was recorded, together with their opinions on prospective regulations and the state of the industry.

5.3 Results

Fifty-four harvesters were consulted during the course of sampling. Of these, 81% were male and only 7.5% were not local to the area. The age profile showed that only 18.5% of pickers were under the age of 40. Most of the pickers interviewed relied on farming/fishing for their main source of income (60% from farming /fishing background: 25% farming and 35% fishing). While picking is almost exclusively used as an income supplement, at least one picker encountered in County Cork makes a reasonable living out of picking alone. There appears to be a real culture of periwinkle picking (often extending back through several generations) as an income supplement in small fishing/farming communities such as Carna, County Galway, and Kilkee, County Clare.

A few pickers took the fishery for granted commenting that "the periwinkles would always be there". However, there was widespread belief that there was a decline in periwinkle numbers in the recent years; many pickers (39%) suggested that this may be a consequence of overpicking; other pickers (15%) suggested that summer picking was the primary cause of decline.

It was impossible to ascertain the precise income of the interviewees. In some instances pickers were so reluctant to talk that even introducing such a question would have made the individual suspicious and unlikely to answer further questions. In many cases, other pertinent questions could not be asked. However, it would be reasonable to assume that most of those interviewed were on a comparatively low income. Many wholesalers and others who have knowledge of the industry claim that pickers rely heavily on social welfare payments, and that this would account for some of their unwillingness to be interviewed.

5.4 Discussion

The industry on the island of Inis Meain, County Galway, (one of the Aran Islands), has been studied by Evelyn Moylan and Paul Cashburn of Taighde Mara Teo. There are 16 harvesters on the island; eight pickers are seasonal workers and only pick in winter when demand is greatest. One interesting demographic to emerge was that most pickers were single men; only two of the 16 pickers were married. It is believed that the industry is worth around £17, 000 per annum to the islanders.

At one point, attempts were made to develop the industry on the island, it was initially hoped to conduct on-growing experiments and to develop a value added brine-pickled product. These projects were aimed at getting local women involved in natural resource based employment. The intended target market was the summer tourist trade. However, those involved became embroiled in arguments over foreshore rights (where certain pickers believed themselves to have the right to pick a certain area, and only that area). The pickers lack of co-operation eventually proved to be an insurmountable obstacle. The periwinkle population on Inis Meain is thought to be heavily overpicked. The area with exploitable quantities of periwinkles is very small and pickers have complained that "Jumbo" sized animals have disappeared. However, there appears to be little understanding that this has, most likely, resulted as a consequence of overpicking (Moylan, E., pers.comm. 1999).

It is of interest to compare the current socio-economics of the industry with those of the periwinkle industry in the early 1900s. The scope and dynamics of the industry were outlined in a study by Browne (1903) and this report provides evidence for a significant decline in the dependence on the fishery in the last 100 years. Browne's report states that around 300 to 400 people were involved in the industry in the early 1900s in the Belmullet (County Mayo) area alone; in 1998 a picker interviewed claimed that only two to three individuals now pick regularly in the area.

Many interviewed said that young people perceived periwinkle picking as being hard work for little return and that well paid work was now easier to come by. The age profile of harvesters may reflect the increasing age profile of many rural areas. Fewer young people now remain in traditional occupations such as fishing and farming (where quotas and regulation have made earning a living increasingly difficult) rather heading for more profitable work in towns and cities. The increase in third level attendance over the last twenty years may also have had an effect. Research carried out by the ERSI in 1999 showed that 6,000 people left all the Gaeltacht areas (traditionally areas with a high level of harvesting) in the past five years, 40% of whom were under 25 years of age. 50% percent of those leaving had third level qualifications (cited in Ireland on Sunday 16/1/00). This decline in the numbers picking regularly was mentioned by several wholesalers. Many complained that pickers were simply dying out and the age profile of pickers seems to confirm that this is the case. During the Christmas season, at least one wholesaler keeps the price paid to the harvesters artificially high in order to provide an incentive to pick and hence ensure continuity of supply. Other notable changes since the turn of the century include a shift from the mainland UK (particularly London) to European markets as the focus for export.

The recent high price of periwinkles has made them more attractive to pickers, thereby increasing the pressure on this fishery. The average price per tonne has risen steadily in the last few years;- from £569 in 1991 to £788 in 1996 (Central Statistics Office, 1999). This high price has removed some of the stigma attached to periwinkle harvesting that has existed in the past when periwinkle picking was considered a menial occupation.

SECTION 6 - CONCLUSIONS AND RECOMMENDATIONS

6.1 Summary and Conclusions

6.1.1 Resource Assessment

- The survey of harvestable shores showed geographic variation in the abundance of *L. littorea*. These variations may be a consequence of the varying geology around the coast. The highest densities of *L. littorea* per area on harvestable shores, as indicated by the present study, occur along the coasts of County Cork (east) and Waterford. Much of the inter-tidal area along the eastern shoreline of County Cork and County Waterford is composed of finely stratified mud rock/shale, which, when weathered leads to an abundance of small sheltered crevices, ideal for periwinkles.

- The lowest densities of *L. littorea* on harvestable shores, as recorded by the survey, were shown to occur around Galway Bay. The sheltered granite shores of Galway afford few crevices and are likely to provide a less suitable habitat for large numbers of *L. littorea.*

- The highest densities of periwinkles, occur on semi-exposed shores, (as recorded on shores such as Knockadoon and Ardnahinch, East Cork), with lower densities at both very sheltered (e.g. Ardfry and Mweelon Point, County Galway) and very exposed sites, (e.g. Fanore, County Clare).

- A large variance in population densities of *L. littorea* existed at the different survey sites. It is unlikely that the density of a population is determined by a single factor, but rather from a combination of many factors acting together. Migration, recruitment and harvesting have an impact on periwinkle densities on a shore. Exposure and substratum of a shore, are also likely to have considerable impact on population densities.

- Exposure has an effect on zonation on the shore. Periwinkles on exposed coasts were found higher on the shore than those on sheltered shores.

- It was found that the highest densities of *L. littorea* tend to occur on moderately exposed shores, 2-4 on the Lewis (1964) scale of exposure.

- There was a significant relationship between gravel as a substrate type and periwinkle densities; gravel can provide significant protection from dislodgement and predation.

- The largest periwinkles were found on the most sheltered shores; however, no consistent pattern of increase in size with decreasing exposure was detected.

- Aperture height is smaller in animals from sheltered shores, this is in accordance with the findings of other authors.

- There is a strong correlation between periwinkle size and position on the shore. Most large animals being found at the lowest inter-tidal levels.

- Aperture size of larger individuals is generally relatively smaller than that of small animals. This may be due to the fact that most large animals were found on sheltered shores, or that the selection pressure for a large foot is not as great for large/ lower shore animals.

- Minimum densities of *L. littorea* occurred during the winter period at Bullens Bay, which may be a result of natural mortality, harvesting pressures or sub tidal migration. Further observations could be carried out in this area to investigate migration patterns.

- It appears that localised over-harvesting of periwinkles occurs in certain coastal areas; however, with a lack of historic scientific data, it is difficult to determine whether this is a large scale problem. The resource assessment carried out for this project provides a bench-mark to which subsequent studies can be compared for evidence of overpicking.

- Harvesting almost certainly has an impact on population structures in Bullens Bay, and that this impact extends to periwinkles that are greater than 14mm in shell length.

6.1.2 The Irish periwinkle industry

- Results from questionnaires indicate that approximately 3,651 tonnes of periwinkles are exported from Ireland per annum. However, it would be reasonable to estimate that the true quantity of periwinkles exported is higher, due to the black market nature of the industry. Using this figure and current market prices, it is estimated that in excess of £7 million (approx €8.9 million) worth of periwinkles are exported from Ireland annually.

- There were approximately 500 part-time pickers working in the industry in the study area in 1998/1999. This figure is based on estimates provided by the wholesalers. The number of people involved in periwinkle picking at any one time is very much dependent on the economic climate of the day and the market price for periwinkles abroad.

- The age profile of pickers indicates that a shortage of harvesters may become a problem in the near future. Only 18.5% of pickers met with on the shore were under the age of 40.

- Young people perceive periwinkle picking as difficult, labour intensive work, with very little financial return for the effort involved. Within the current economic climate, alternative, better paid work is easier to come by.

- Sixty percent of the pickers interviewed came from a fishing (35%) or farming (25%) background.

6.1.3 Management Options

- Several exporters, pickers and people associated with the industry have expressed genuine concern for the sustainability of the periwinkle industry. They were very anxious that the findings of this project would result in regulations being put into place in the near future. However, there is no conclusive evidence to suggest that stocks are over-picked. In addition, the decrease in the number of people picking reduces the immediate need for regulations to be implemented.

- A closed season and/or a minimum landing size were both discussed as potential regulations to control over-picking. When asked, pickers and wholesalers were in favour of a summer closed season. This coincides with the time of year when there is little harvesting, as prices are low, and pickers become involved in fishing, farming or tourist related industries. However, a closed season during the summer would be of little benefit to periwinkle stocks. A closed season that coincides with the spawning period of *L. littorea* (possibly January to April, pending conclusive research that this is the spawning period for most Irish populations) would appear to be one of the best options for ensuring the protection of periwinkle populations. It is less likely that pickers and wholesalers would support a closed season at any time of the year other than during the summer.

- If the implementation of regulations becomes necessary in the future, a closed season would be the best management option to consider.

- Over the duration of this project, larval rearing trials were carried out at the Shellfish Research Laboratory, Carna. During the course of this work, it was found that the spawning season at Carna, County Galway extends from January to April/May. The spawning season is known to vary geographically, so further research needs to be carried out to establish the spawning season for Irish *L. littorea* populations.

- A minimum landing size of 13mm was suggested by many of the wholesalers. This corresponds with the smallest sized periwinkle that would be acceptable on the general market, and fails to take age/size of maturity into consideration. It must be noted that, in Galway Bay at least, some periwinkles do not mature until they are 15-17mm shell height. This means the minimum size advocated by wholesalers might not protect the species as desired.

- Widespread reports of over-picking must be considered in the context of the decline in the number of commercial harvesters involved in the industry, and this should be taken into account before any consideration is given to introducing regulations.

6.1.4 The future of the industry

- The future of the periwinkle industry in Ireland may be heavily dependent on the future economic climate of the country. If economic growth continues or at least stabilises at its present level, then the main threat to the industry will be the lack of harvesters to ensure a continuity of supply.

- The lengthy planktotrophic stage of *L. littorea* makes it less subject to the effects of localised overexploitation than species without such ability to disperse. Where populations of large periwinkles are removed from one area, larvae can be recruited from more distant shores, and so, in time, over-picked areas may be re-seeded. The periwinkle fishery in Ireland has withstood the test of time and has almost certainly come through periods of very intense picking pressure in the past (as shown by periwinkle landing data from the 1903 Browne Report).

- The potential for adding value to exports by post harvest processing appears to be limited. A fresh live periwinkle is the product most sought after on the continent, especially France.

- At certain times of the year, the demand for periwinkles is so high that the supply does not satisfy the demand from foreign markets. During periods of peak market demand, Irish wholesalers could export greater quantities of periwinkles if more periwinkles were picked or available. Developments in on-growing and polyculture could provide areas of future growth for the industry. In the future if prices should rise as a consequence of a decline in supply, ongrowing and polyculture may become economically viable. There is also potential for selling more periwinkles to Irish seafood restaurants, particularly during the tourist season.

6.2 Recommendations

- It must be appreciated that this report is a baseline study of the periwinkle industry carried out over a short time frame. Thus it would be unwise to make any immediate long term predictions or assumptions or to precipitate untimely protective measures without the benefit of ongoing data to demonstrate or validate their necessity.

- On the basis of this study no immediate action appears to be required in regard to protective legislation for periwinkles either by closed season, catch or size limitations or closed/protected areas.

- Periwinkle stock status should be continually reviewed and updated from strategically located key sites where calibrated sampling should be structured to include estimates of natural and fishing mortality, catch per unit effort, (CPUE), as well as overall trends in population composition. Thus, in the event of any untoward alteration in any of these parameters, rapid remedial action could be decided based on the updated predictive model. Such data could be used to counteract long-term effects due, for example, to overfishing, poor recruitment etc. by carefully selected legislation.

- Complementary investigations should also be undertaken to determine seasonality in spawnings for populations around the coast, as well as development of methods to predict yield per recruit, and thus determine relative year class strengths as a component for long term yield predictions. Also without such knowledge it is impossible to identify closed seasons in the event they might be necessary to protect adults during the spawning season.

- It may be that inaccessible periwinkle populations have historically acted as a reservoir to ensure regular recruitment into exploited areas of the fishery. If fishing pressure increase significantly it is suggested that an extended protection of such areas may be a logical management option which would be more readily supported by the industry than other alternatives.

- Should a requirement emerge in the short term requiring protective measures relating to season or size, these would have to be unilateral as any such local regulations would prove very difficult to enforce due to the movement patterns of post harvest stock.

- Developments in on-growing and polyculture could provide areas of future growth for the industry. Interest in these was expressed during the survey and it is recommended that government agencies take a more pro-active role in encouraging feasibility trials in this area, as there is currently little support or expertise available on the subject.

- There is potential for selling more periwinkles to Irish seafood restaurants, particularly during the tourist season. Fears about the safety of eating periwinkles contaminated by pollution need to be allayed and seafood chefs need to be made aware of where to obtain local supplies.

- It should be noted that the periwinkle may be well suited to demonstrate the operation, practices and benefits which can derive from understanding the biology and population dynamics of a species. It might be an appropriate case study as an example for other inshore commercial species and additionally could provide opportunities for and benefit from post graduate research as well as "hands on" experience and training in applied fisheries practices.

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Appendix A. The Lewis Biological Exposure Scale Defined (Lewis, 1964)

1. Very Exposed Shores

   i. A very wide *Verrucaria* belt *entirely* above tidal level, and reaching perhaps 40-60ft. or more above the barnacle line.
   ii. *Littorina neritoides* abundant throughout the lower *Verrucaria* zone; density varying greatly with substrate but not less that 1 per 5 $cm.^2$ on open surface, or 5-10 per sq. cm. in crevices.
   iii. *Porphyra/*Myxophyceae belts well developed above the barnacle line persisting throughout the summer in the north, especially on flatter slopes.
   iv. *Fucus distichus anceps,* and *F.sp*. f. *nanus* present (in the north and west).
   v. *Lichina pygnaea* locally abundant (especially on verticals and in the south) and covering 20-40% of surface at level of maximum density.
   vi. Eulittorial zone dominated by barnacles and limpets (with minimum densities of 100-150 per 5 $cm.^2$ and 50-100 per sq. metre respectively), or by *Mytilus*/Rhodophyceae communities which cover at least 50% surface in levels of maximum density.
   vii. *Patella aspera* the dominant limpet in the middle and lower shores
   viii. A belt of lithothamnia/*Corallina* and other Rhodophyceae usually present above the *Alaria* zone when the midshores lack *Mytilus*/Rhodophyceae communities.
   ix. The upper sublittoral zone dominated by *Alaria*/lithothamnia and *P. aspera* and rising to M.L.W.N or above.

2. Exposed Shores

   i. A *verrucaria* belt 10-30 ft. wide, largely above tidal levels.
   ii. *Littorina neritoides* abundant, some *L. saxatilis* present.
   iii. Some development of *Porphyra*/Myxophyceae belts (especially in north).
   iv. *Lichina pygmaea* abundant (especially in the south).
   v. Midshores dominated by barnacles and limpets alone, or by barnacles, limpets and *F.v.* f. *linearis* in flatter areas; the latter ranging from scattered solitary plants (especially in the south) to 50% cover or more (especially in the north).
   vi. *Mytilus*/Rhodophyceae communities local, rarely dominant; most common in north and west.
   vii. *Patella aspera* abundant in lower shore.
   viii. *Thais lapillus* abundant; groups of several hundreds, or a scattered density not less than 10-20 per sq. metre.
   ix. Well-developed belt of *Himanthalia* and /or Rhodophyceae (*Gigartina, Corallina* especially).
   x. Some *Balanus perforatus* possible in S.W. England and *Bifucaria* in S.W. England and Ireland.
   xi. The upper sublittoral zone dominated by *Alaria* in north, *Alaria* and *Laminaria digitata* in south.

3. Semi-Exposed Shores

i. *Verrucaria* belt about 4-10 ft. deep, partly within reach of the tides.
ii. *Littorina saxatilis* dominant, astride lower limit of *Verrucaria; L. neritiodes* becoming scarce especially in north.
iii. Distinct belts of *Pelvetia* upshore and/or *Fucus serratus* downshore (especially on flatter surfaces).
iv. *Chthamalus stellatus* becoming scarce (in north-west and west).
v. *Lichina pygmaea* present but zone barely detectable.
vi. Midshores of mixed barnacles, limpets and short *Fucus vesiculosus.*
vii. *Monodonta lineata* and *Gibbula umbilicalis* present (in south and west); 1-5 per sq. metre, more locally, especially near pools.
viii. *Thais* present and *L. littorea* appearing but local density varying greatly with topography.
ix. *Fucus serratus* belt associated with or surmounted by Rhodophyceae *(Laurencia* spp., *Gigartina, Rhodymenia, Lomentaria*); locally replaced by *Balanus perforatus* especially on verticals or in shade.
x. *Patella aspera* present but largely confined to lower littoral and sublittoral zone, or to lithothamnia pools.
xi. *Laminaria digitata* and lush growths of small algae dominate the sublittoral; *Saccorhiza polyschides* locally abundant in south and west.

4. Sheltered Shores

i. *Verrucaria* zone narrow and within reach of waves.
ii. *L. saxatilis* abundant (50-100 per sq. metre at least) when upper fucoids scarce.
iii. Full sequence of fucoid zones *(Pelvetia, F. spiralis, Ascophyllum* and/or *F. vesiculosus, F. serratus*), but cover not sufficiently dense to exclude barnacles completely.
iv. Barnacles, usually large, thinly scattered or patchy except on verticals.
v. Abundance of *Littorina littorea* and *L. obtusata* on all coasts, and of *Monodonta* and *Gibbula umbilicalis* in south and west.
vi. *Patella vulgata* abundant; *P. aspera* scarce or absent.
vii. *Laminaria digitata* dominate in the upper sublittoral zone.

5. Very Sheltered Shores

i. Extreme compression of *Verrucaria* zone to a 1-3 ft. belt lying *entirely* within reach of spring tides.
ii. Complete dominance of fucoids, and especially of long fronded *Ascophyllum* (4-12 ft. or more).
iii. Extreme scarcity of barnacles, except on some verticals, and their upper limit usually below M.H.W.N. (especially in *Balanus* areas).
iv. A well-developed *Catenella/Bostrychia*/Myxophyceae belt (especially in south and west).
v. The sublittoral zone dominated by *L. saccharina/Halidrys* with a *Chondrus/Furcellaria*

Appendix B. Periwinkle GIS Operations Manual for the Marine Institute

Contents **Page**

Background to the Periwinkle Project

The edible periwinkle *Littorina littorea* has been exploited as a food source in Ireland since the stone age (Woodman, Anderson, Finlay, 1999). Today there is a large market for the edible periwinkle on the continent, principally in France. The edible periwinkle industry remains a fishery of socio-economic importance in peripheral coastal communities. It is particularly important as an additional source of income in areas where few other employment opportunities exist.

Prior to this study, there was little or no scientific information available on the state of Irish periwinkle stocks, nor was there an accurate estimate of the scale and value of the Irish industry. This project aimed to redress this situation significantly.

The main objectives of the Periwinkle Project were:

- To establish the distribution, size and age distribution of the edible periwinkle populations along the Irish coast.

- In reviewing the Irish periwinkle industry, to assess its socio-economic impact on Irish coastal communities and to determine the potential impact of developments within this sector.

- **To incorporate the resultant data into a Geographical Information System (GIS). The GIS would then be used as a decision making tool in developing a management strategy for the industry.**

Further details on the Periwinkle Project can be obtained from:

The Marine Institute
80 Harcourt Street
Dublin 2

Information is also provided on:
www.cmrc.ucc.ie/pages/research

This section provides an overview of the GIS database that was completed for the project. Operation of the GIS is explained within the context of this document.

Introduction to (GIS)

GIS stands for Geographical Information Systems. GIS has been compared to the high tech equivalent of the map. The first GIS, which emerged in the early 1980s, allowed for the basic overlaying of geographically referenced data onto digital maps. Since then, these computer systems have developed rapidly in functionality, and can now facilitate the assembling, storing, manipulating, and displaying of a wide range of spatial and temporal data. The capabilities of GIS can broadly be categorised as follows: map production, data retrieval, data warehousing, report generation, data modelling, data integration, data transformation to a common projection and data overlays. There are several different types of GIS software packages available. MapInfo, GeoMedia and ArcView are amongst some of the more popular GIS packages used in this country. ArcView was the package used for this project as this software was already in place in the Coastal Resources Centre, UCC, where there is a large amount of expertise in using this system for the mapping of natural resources and other coastal data.

Data Capture Methods

During the project, 124 shore surveys were carried out. The bulk of the data held in the GIS originates from these surveys. Survey sites were selected on the basis that they provide suitable habitats for harvestable quantities of periwinkles; these were usually sheltered or semi-exposed shores. Other sites may have been selected (e.g. exposed coasts) for comparative purposes.

Three belts of approximately 30m width were divided into three biologically defined zones representing upper, middle and lower shores. (i) *Fucus spiralis* to *Ascophyllum nodosum*; (ii) A. *nodosum* to *F. serratus;* (iii) *F. serratus* to the low water level. Exposure was rated on a scale of one to five (after Lewis, 1964); one represented extremely exposed sites, and five represented very sheltered sites. In some cases, the exposure scale was subdivided to allow more flexibility in describing shores. As a result, there were ten possible degrees of exposure i.e. 1, 1.5, 2, 2.5 etc. Five quadrats ($0.25m^2$) were placed randomly within each zone and all the edible periwinkles, *L. littorea,* within each quadrat were counted, removed, and placed in labelled polythene bags. The samples were returned to the laboratory and kept in freezers to preserve them for further analysis.

The percentage cover of rockpool, seaweed, bedrock, rock, stones, gravel, sand and mud were also recorded from each quadrat. Any influx of freshwater into the belt, or any other potential impact from sewage or shellfish culture was noted.

The length of each of the three belts was measured and the bearing of each was also noted. A handheld Global Positioning System (GPS) was used to mark the starting point of each belt, in addition to the start and end point for each site. This, and other relevant data were subsequently added to a Geographical Information System (GIS).

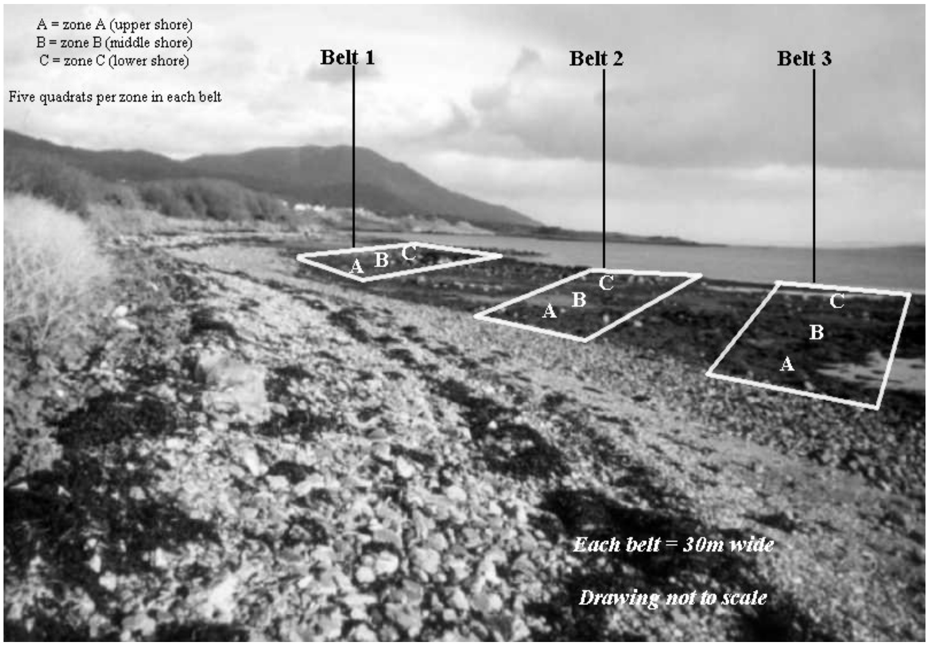

Figure 1. Sampling procedure carried used on the shore

Overview

The results from the shore surveys identify the areas of our coastline that are currently harvested for periwinkles. Results show periwinkle densities at these locations, and the average size of periwinkles measured at selected sites, taken from nearly 22,000 measurements of shell size. Additional data collected from individual sites were also included. The GIS facilitated the production of resource maps at various scales, with colour coded labels for additional attributes. These maps were used in the production of the final report.

Additional data layers were also added to the GIS from other sources. For example an outline of the coastline of Ireland, plus the county boundaries provide the backdrop for most of the information. Data from the Ordnance Survey 1:50,000 digital maps, such as roads, car parks and urban areas, were also added. This was obtained from the Marine Access Project, (completed by the Coastal Resources Centre for the Marine Institute), which contains the location of piers and jetties all around the country.

A project to map and assess the seaweed resources (*Ascophyllum nodosum, Laminaria spp.*) off the West Coast of Ireland was conducted in 1998 (Hession, Guiry and Joyce, 1998). This database was also incorporated into the Periwinkle Project GIS as another data layer.

The Periwinkle Project GIS can be interrogated to provide information on all aspects of the industry as described above. The flexibility of these computer systems means that future data can easily be incorporated, thus providing decision-making bodies with a powerful management tool.

Getting Started

Insert the CD entitled "Periwinkle Project GIS". The project information is stored on the CD in the D drive, in the 'winkle' folder. Select the 'winkle' folder, copy it, and paste it to your C drive. It is preferable that the periwinkle GIS is installed as C:\winkle. If it is installed under a different path, then you will need to make changes to your startup settings in Arc View[1].

Open ArcView by going to Start – Program – Esri – ArcView GIS. When ArcView has loaded, go to file and click on open project. Select C:\winkle\winkle.apr (this is the project file). Wait for a couple of seconds for the project to open. The project will open in a **VIEW WINDOW**. An outline of the Irish Coast and County Boundaries will become visible in the **map display**. These are **themes** and the visible themes are listed in the **table of contents** to the left of the map display. These themes are **ticked** to show that they are turned **on**.

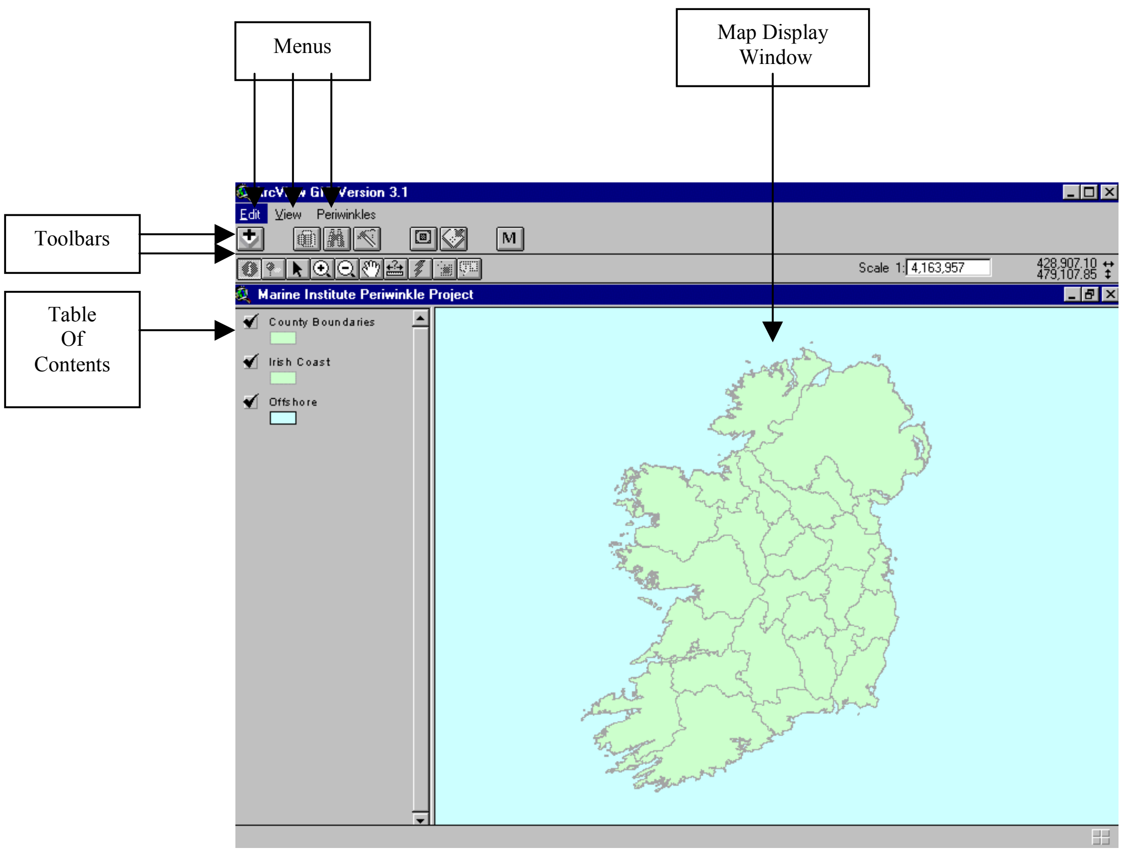

Figure 2. Overview of the first view to open in the periwinkle GIS.

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[1] To install the periwinkle GIS under an alternative path to C:\winkle, go to C:ESRI\AV_GIS30\ARCVIEW\ETC\Startup. Select the Startup File (not the PS File). Open this file in Wordpad. Scroll down to the bottom of the text, to where it says: System.SetEnvVar("DATADRIVE","C:\winkle\"). Change the datadrive details to the new path where the periwinkle GIS will be installed.

Structure of the GIS - (Themes and Topics)

The data was grouped into six different **topics**, which made up six different data layers on the GIS. The topics are basically the subject areas into which the data are divided. The topics are: survey information, industry information, morphometric data, topographic data, seaweed data, bathymetry. Each of these topics contains a range of **themes**, which can be added to the table of contents and viewed in the map display where they will be displayed as lines, points or polygons, depending on the type of data. Table 1 shows a breakdown of each topic and theme.

Topic	*Sub Heading*	*Theme*
Site Information	Survey Information	Access to Sites
		End of survey site
		Exposure
		Harvested sites
		Rockpool coverage
		Rugosity
		Seaweed coverage
		Start of survey site
		Substrate type
		Winkles per m2
	Belt Data	Belt locations
		Freshwater impact
		Winkles per quadrant
	Site Photographs	Site photographs
Industry Information		Wholesalers
Morphometric Data	Shell Measurements	Maximum shell height
		Mean aperture width
		Mean shell height
		Mean shell width
Topographic Data	OS 1:50,000 Discovery Series	Beaches
		Coastal features
		High water mark
		Low water mark
		Piers, slips, jetties
		Place-names
		Rivers
		Roads
		Tourist features
		Urban areas
Seaweed Database		Seaweed data
Bathymetry	Admiralty Chart Data	Contours
		Grid derived from spot depths

Table 1. Themes and Topics in the GIS

Viewing the Data

The Periwinkle Project GIS was saved into a customised version of ArcView, with many of the more advanced functions removed. As a result, the data can be viewed by anyone with basic computer skills, and expertise in GIS is not required to access the data. To view a theme, simply click on the Periwinkles Menu. A drop-down menu will appear. Select the topic of interest. Another menu will appear which shows a list of the themes available for that topic. Highlight the themes that you would like to add and click okay. You are now on your way to accessing the data held in the GIS. The various menus and toolbars are outlined below.

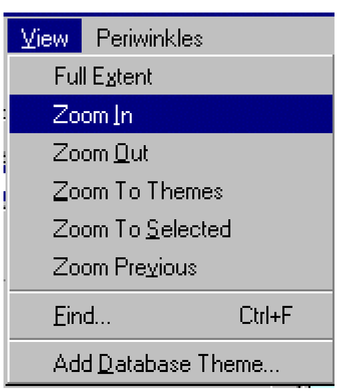
1. Menus

There are three main menus, which are primarily for viewing the maps at different scales, and adding and removing themes and topics. They are the Edit, View and Periwinkles menus.

The Edit Menu

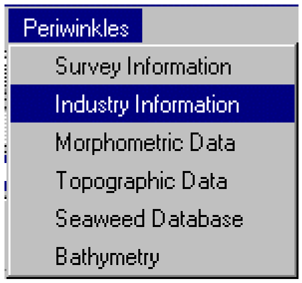
- to delete themes or to delete entire topics from the table of contents

The View Menu



- to view the full extent of the map
- to zoom in or out of specific areas of the map display
- to find a particular name on the map e.g. place name
- to add a new theme from an external database using SQL

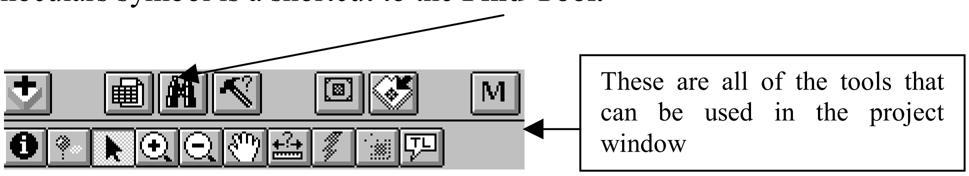
The Periwinkles Menu



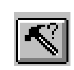
- to add a new theme to the table of contents. Themes are organised under the six topics described in table one.

2. Toolbars

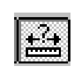
Toolbars provide shortcuts to many of the functions described above. For example, the binoculars symbol is a shortcut to the **Find Tool.**



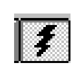
The **Query Builder** allows you to design your own queries of the data. By default, the query is contained within parentheses, but the parentheses may not be required, depending on the complexity of your query.



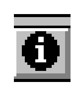
It is also possible to **Measure** the distance between one point on the map and another. A choice of units is available for display e.g. meters, miles, kilometres etc.



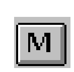
HotLinks let you access virtually any data or application directly from a view. For example, you can click on a site to display a photograph of the surveyed belts. A hot link is followed when you click on a feature in a theme with the HotLink tool.



The **Identify Tool** can be used to provide attribute values for an **Active Theme** (click on the theme in the table of contents to make it active; – notice that it will appear raised above the other themes).



The **Metadata Tool** provides background information on the origin of a selected data-point



Screenshots

The following screenshots provide an insight into how some of the data appears in the GIS.

- **Detailed large scale maps**

It is possible to zoom into a specific area for a more detailed view. Below is an example of the Donegal Coastline with themes containing information on seaweed coverage, coastal features, county boundaries and bathymetry. Results of a query on a seaweed coverage datapoint are shown in the 'Identify Results' dialogue box. The scroll down bar on the right of the table can be used to show the rest of the results.

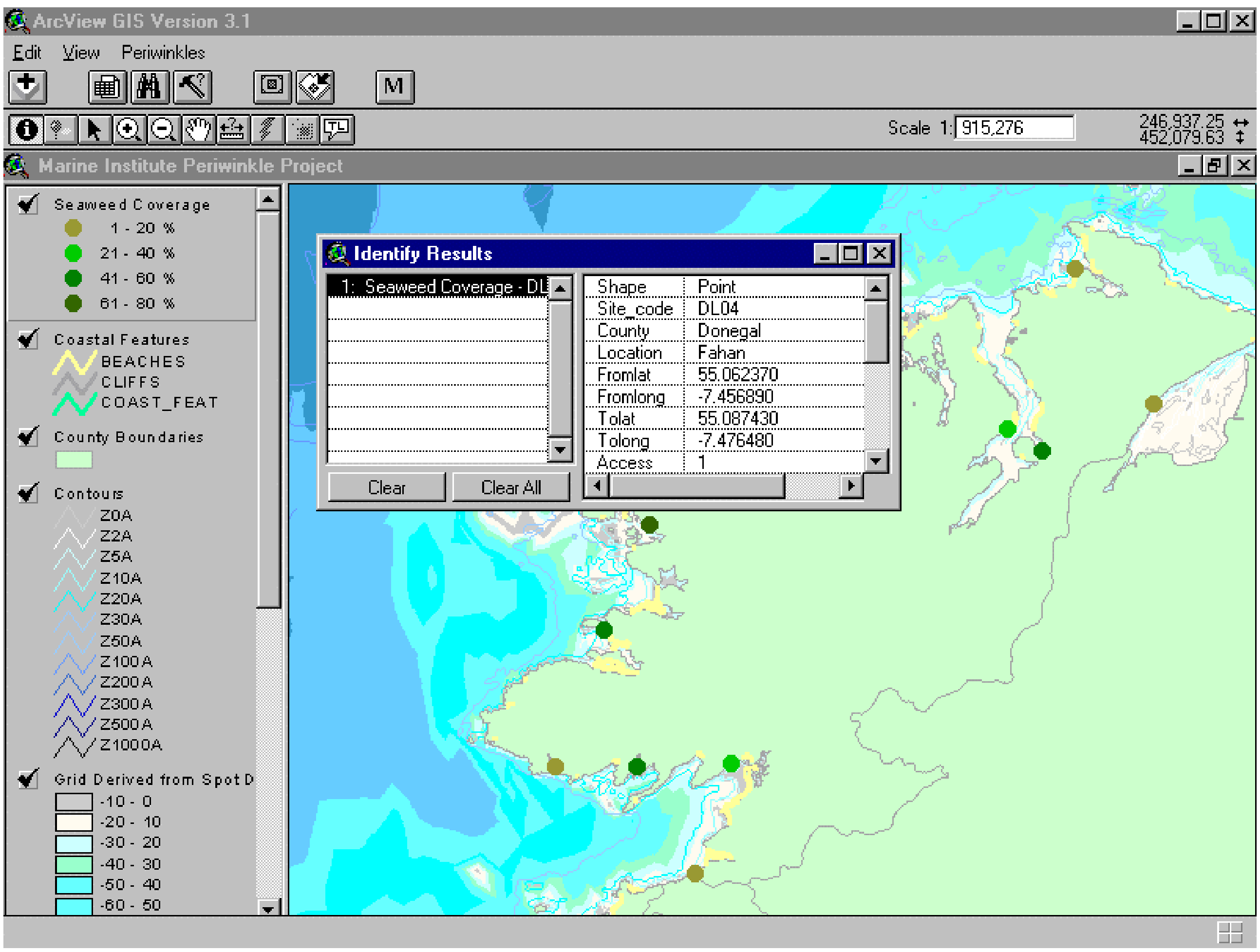


Figure 3. An example of a detailed large scale map.

- **Periwinkle density maps**

Polygons showing the length and bearing of each belt are colour coded to show periwinkle densities per zone. This information was reproduced to scale. In figure 4 the periwinkle densities are less than 40 per m^2 (shaded light pink) in all of zones A, B and C. The position of the start and end points of the shore are shown as red points.

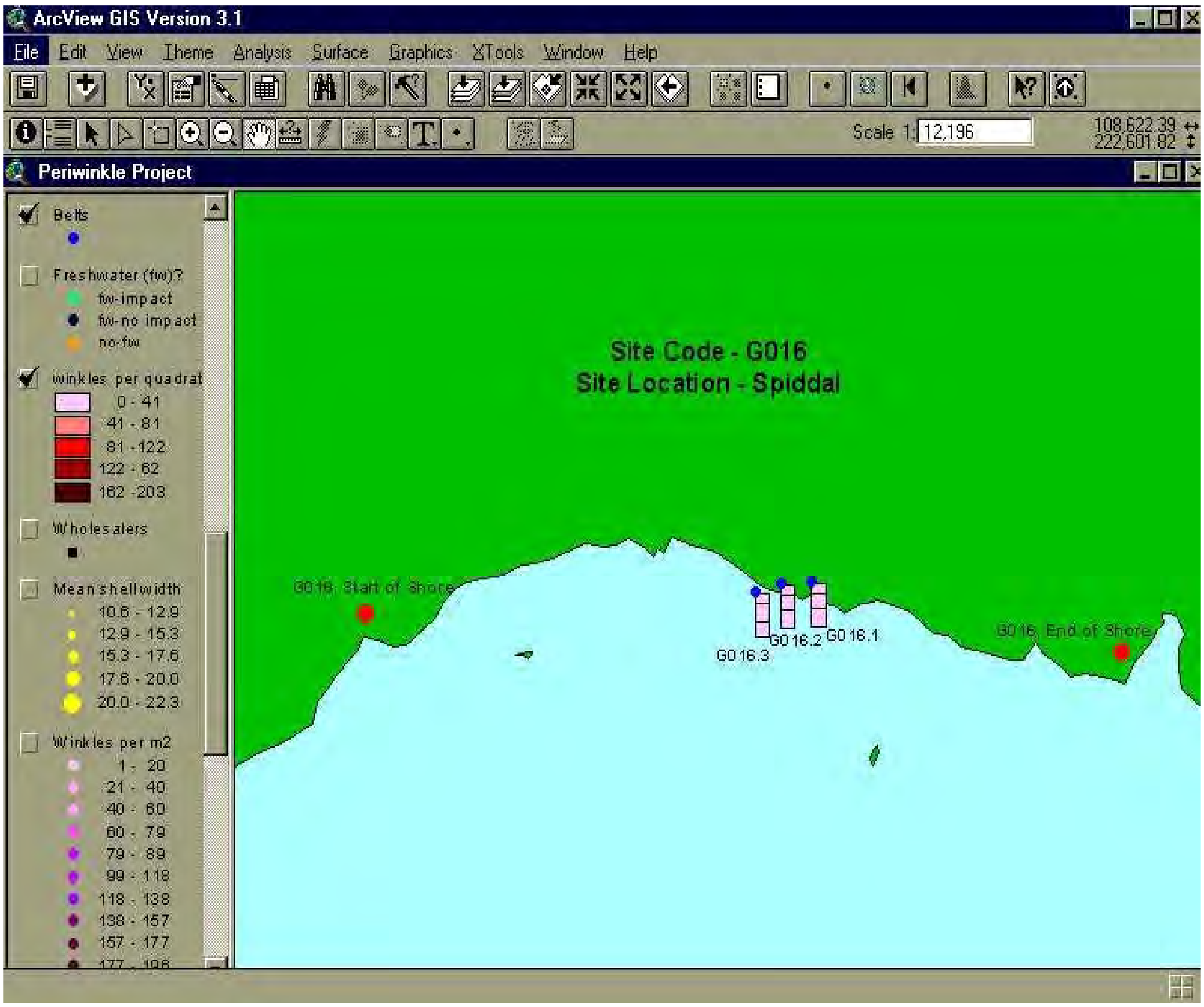


Figure 4. An example of a periwinkle density map.

The Project Window

Everything that has been described up until this point would have been viewed in the **VIEW WINDOW** mentioned earlier. Simply simply closing or minimising the View Window can access the PROJECT WINDOW. You will notice that a different set of menu bars will appear along the top. These menus are similar to those used in many Windows environments e.g. File - Close. There is also a **Help** option here, which provides information on all aspects of Arc View.

The layout of the **Table of Contents** will also look different. There will be a list of options including:Views, Tables, Layouts, Scripts and Dialogues. Only the **Views** and **Tables** options are needed here. Clicking on Views, highlighting Marine Institute Periwinkle Project and selecting Open will return you to the View Window. The Metadata Table can be viewed by selecting the Tables option. This is explained below.

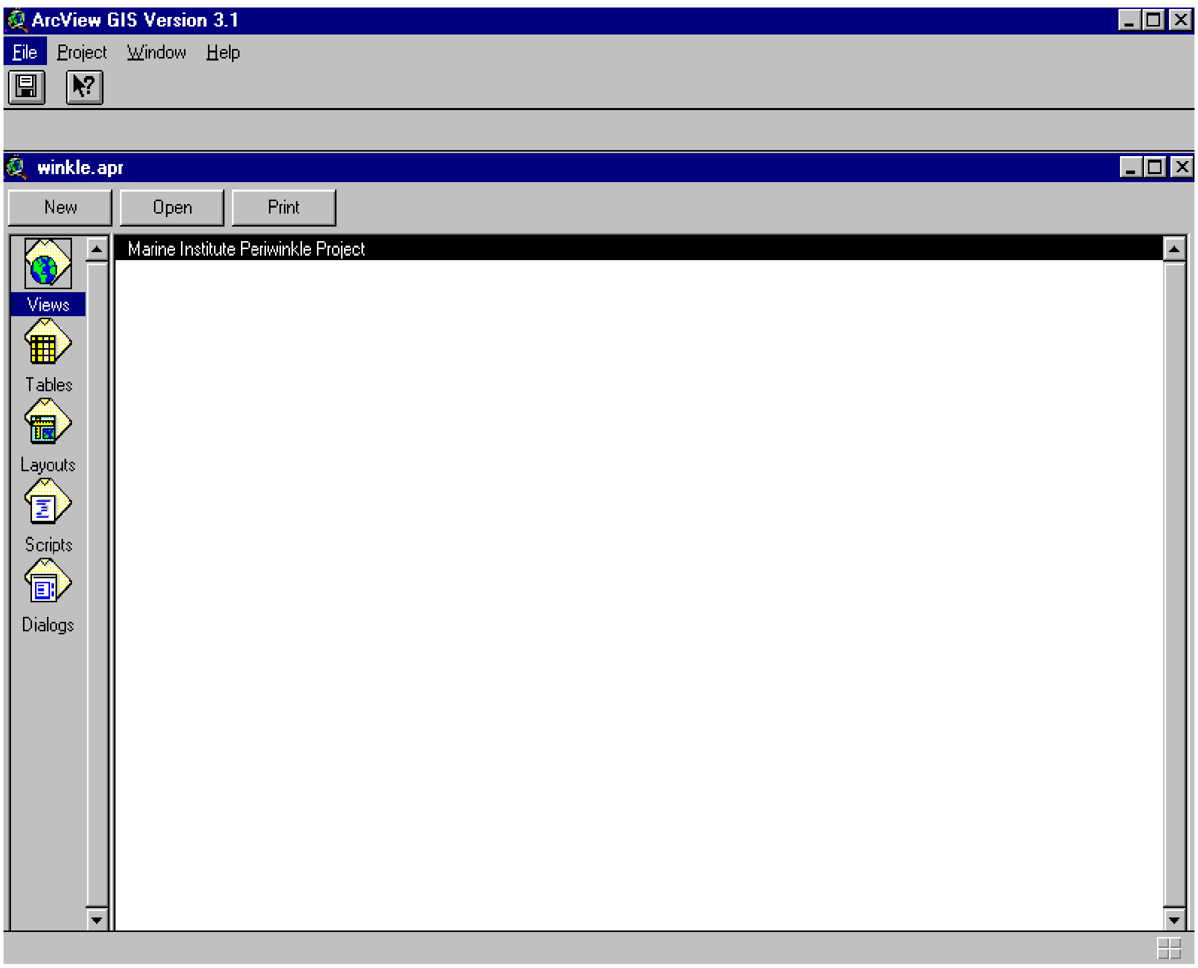
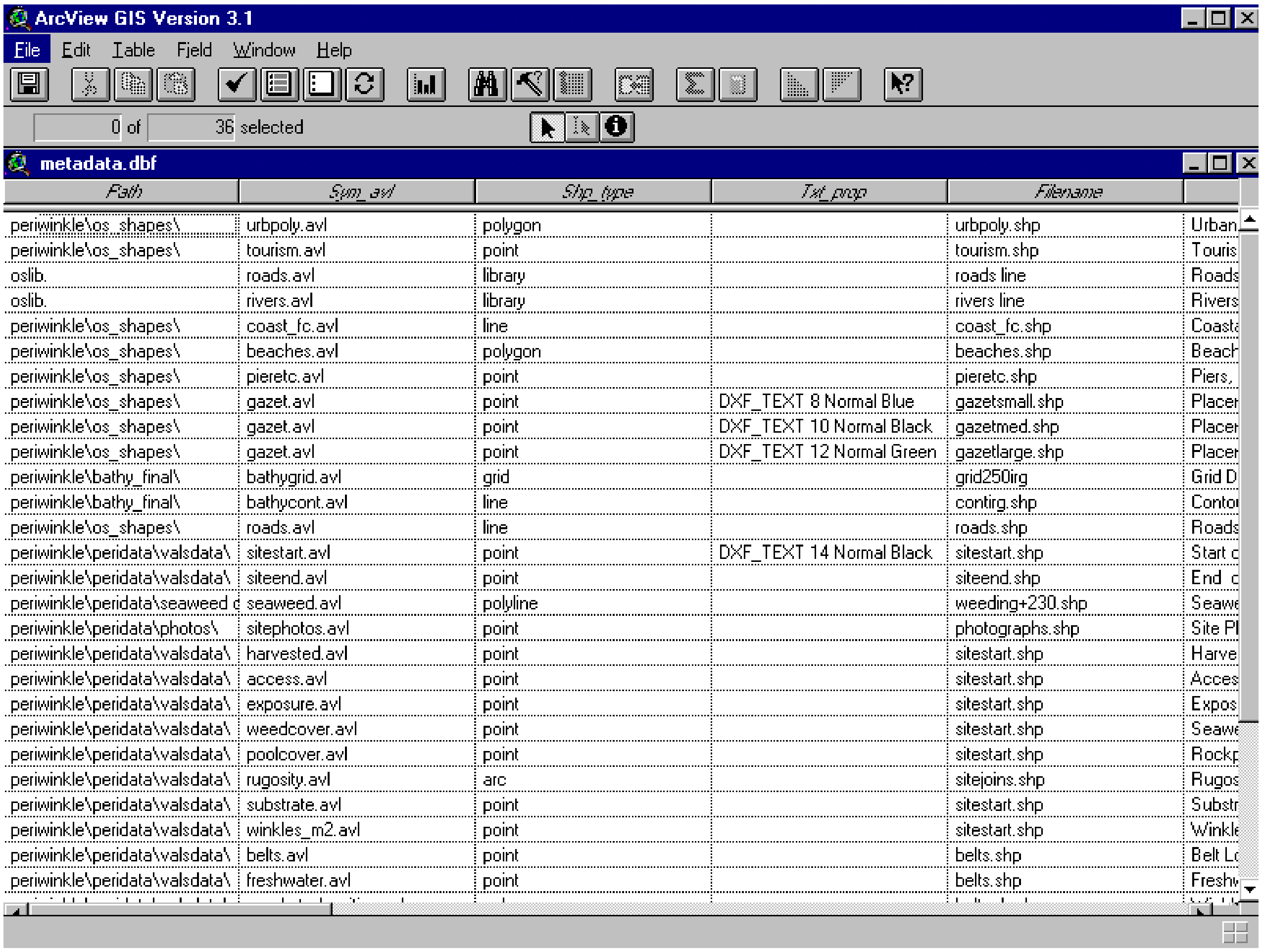


Figure 5. The project window.

The Metadata Table

To open the **Metadata Table**, click on **Tables** from the **Table of Contents** in the **Project Window**. The Metadata Table contains background information on individual files, such as the file path, the filename, the legend, copyright, scale, source etc.



Path	Sym_avl	Shp_type	Txt_prop	Filename	
periwinkle\os_shapes\	urbpoly.avl	polygon		urbpoly.shp	Urban
periwinkle\os_shapes\	tourism.avl	point		tourism.shp	Touris
oslib.	roads.avl	library		roads line	Roads
oslib.	rivers.avl	library		rivers line	Rivers
periwinkle\os_shapes\	coast_fc.avl	line		coast_fc.shp	Coast
periwinkle\os_shapes\	beaches.avl	polygon		beaches.shp	Beach
periwinkle\os_shapes\	pieretc.avl	point		pieretc.shp	Piers,
periwinkle\os_shapes\	gazet.avl	point	DXF_TEXT 8 Normal Blue	gazetsmall.shp	Placer
periwinkle\os_shapes\	gazet.avl	point	DXF_TEXT 10 Normal Black	gazetmed.shp	Placer
periwinkle\os_shapes\	gazet.avl	point	DXF_TEXT 12 Normal Green	gazetlarge.shp	Placer
periwinkle\bathy_final\	bathygrid.avl	grid		grid250irg	Grid D
periwinkle\bathy_final\	bathycont.avl	line		contirg.shp	Contoi
periwinkle\os_shapes\	roads.avl	line		roads.shp	Roads
periwinkle\peridata\valsdata\	sitestart.avl	point	DXF_TEXT 14 Normal Black	sitestart.shp	Start c
periwinkle\peridata\valsdata\	siteend.avl	point		siteend.shp	End c
periwinkle\peridata\seaweed d	seaweed.avl	polyline		weeding+230.shp	Seawe
periwinkle\peridata\photos\	sitephotos.avl	point		photographs.shp	Site Pl
periwinkle\peridata\valsdata\	harvested.avl	point		sitestart.shp	Harve
periwinkle\peridata\valsdata\	access.avl	point		sitestart.shp	Acces
periwinkle\peridata\valsdata\	exposure.avl	point		sitestart.shp	Expos
periwinkle\peridata\valsdata\	weedcover.avl	point		sitestart.shp	Seawe
periwinkle\peridata\valsdata\	poolcover.avl	point		sitestart.shp	Rockp
periwinkle\peridata\valsdata\	rugosity.avl	arc		sitejoins.shp	Rugos
periwinkle\peridata\valsdata\	substrate.avl	point		sitestart.shp	Substr
periwinkle\peridata\valsdata\	winkles_m2.avl	point		sitestart.shp	Winkle
periwinkle\peridata\valsdata\	belts.avl	point		belts.shp	Belt Lc
periwinkle\peridata\valsdata\	freshwater.avl	point		belts.shp	Freshw

Figure 6. The metadata table.

The Accuracy of the GIS

Positions of sites and belts were obtained using a handheld GPS, which is accurate to within 12m. The accuracy of a reading depends on the ability of the receiver to receive enough satellite signals to calculate a position. In some cases the belt positions will appear to overlap with the land. This is due to inaccuracies in the waypoints, and to minor discrepancies in the actual base map outlining the coastline.

Abbreviations used in the Data

Table headings are limited in character length in ArcView. As a result many headings were abbreviated. The abbreviations can be seen when looking at an Attribute Table or when looking at the results of an **Identify** Query.

Qu = Quadrat
S = Site
B = Belt
Z = Zone
H = Shell Height
Av_no_ZA = Average number of periwinkles in Zone A
Av_no_ZB = Average number of periwinkles in Zone B
Av_no_ZC = Average number of periwinkles in Zone C
Av_Qu_S = Average number of periwinkles per quadrat per site
Av_m2_S = Average number of periwinkles per m^2 per site
Fromlat = From latitude
Fromlong = From longitude
Tolat = To latitude
Tolong = To longitude
Max _l_s = Maximum periwinkle shell length per site
Mean_l_a = Mean shell length in zone A per site
Mean_l_b = Mean shell length in zone B per site
Mean_l_c = Mean shell length in zone C per site
Mean_l_s = Mean shell length per site
Mean_w_a = Mean shell width in zone A per site
Mean_w_b = Mean shell width in zone B per site
Mean_w_c = Mean shell width in zone C per site
Mean_w_s = Mean shell width per site
Mean_a_a = Mean shell aperture height in zone A per site
Mean_a_b = Mean shell aperture height in zone B per site
Mean_a_c = Mean shell aperture height in zone C per site
Mean_a_s = Mean shell aperture height per site
Mean_aw_a = Mean shell aperture width in zone A per site
Mean_aw_b = Mean shell aperture width in zone B per site
Mean_aw_c = Mean shell aperture width in zone C per site
Mean_aw_s = Mean shell aperture width per site

Additional Notes

Zoom in to a scale of a least 1:10,000 to see the belt locations clearly. The belts are recreated to scale (30m wide) which makes it necessary to zoom in to this extent to view them.

Acknowledgements

The project relied heavily on the co-operation and support of many people. The authors would particularly like to thank all the wholesalers who provided information and support for the project. Thanks also to those that assisted in the shore surveys including: David O Regan, Ana Periera, Mary O Connell, Mary-Jo Duncan Ryan, Sandra Leyzour, Magali Molla.

Thanks to the following who gave their time and provided valuable information: Gerry Gorman, Kevin Flannery, Dan Minchin, Andy Molloy, John and Flor Harrington, Shane Tobin, Ray Harty, Duncan Browne and Evelyn Moylan. Their assistance is gratefully appreciated.

The proposal for this project was written by Eddie O' Leary who provided helpful advice on many occasions. Sincere thanks also to Deirdre Tobin for her help with the GIS, to Michelle Cronin for help with the statistics and to Dr. Richard Fitzgerald who was an advisor on the project.

Finally, we would like to acknowledge Geoffrey O'Sullivan of the Marine Institute for his encouragement and assistance.

Evolution, 36(3), 1982, pp 561–580

ENVIRONMENTAL CHANGE AND THE EVOLUTIONARY HISTORY OF THE PERIWINKLE (*LITTORINA LITTOREA*) IN NORTH AMERICA

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How does a sexually reproducing species respond evolutionarily to irreversible changes in its environment? Does it remain morphologically unchanged for long periods of time, as believed by those who hold that innovations in form evolve only in small isolated populations at or just after the time of speciation (Eldredge, 1971; Eldredge and Gould, 1972; Carson, 1975; Vermeij, 1978; Stanley, 1979), or can change be brought about in large well-established populations?

To answer these questions, the following four points must be established: (1) there was an environmental change, which can be recognized independently from any phenotypic alteration in the species being studied; (2) the environmental change can be perceived by the organism; (3) adaptations to the change can be identified and measured; and (4) specimens spanning the interval of time over which the environmental change took place must be available in order to assess the phenotypic (or genotypic) response.

Several examples of historical change in phenotype (and presumably in genotype) are known in gastropods (Berry and Crothers, 1974; McLeod and Moore, 1978; Murray and Clarke, 1978; Wall et al., 1980). The interpretation that these changes were caused by natural selection is complicated by the fact that the selective agents which are believed to have been responsible were inferred a posteriori and could not be identified independently from the phenotypic data. In the present study, I attempted to discover whether the arrival of the predatory green crab (*Carcinus maenas*) on American shores north of Cape Cod was experienced by the common periwinkle (*Littorina littorea*) as an increase in the incidence of predator-induced sublethal shell damage, and whether the periwinkle responded to this change phenotypically with an increase in shell thickness.

Historical Background

Littorina littorea (L.) is native to Europe, where it is plentiful on rocky shores and in salt marshes from the White Sea to near Gibraltar (Bequaert, 1943). The occurrence of *L. littorea* in North America before 1840 was spotty and remains poorly known (Kraeuter, 1974; Vermeij, 1978; Carlton, unpubl.). The species was found in several post-Pleistocene archaeological sites in New Brunswick and Nova Scotia (Clarke, 1963). Bird (1968) recorded *L. littorea* from pre-Viking strata in Newfoundland, and Wagner (1977) found a single specimen in sediments dated at 40,000 years B.P. in Nova Scotia. If the periwinkle was indigenous to North America before the coming of European man, as is also suggested by weak genetic evidence (Berger, 1977), it seems to have been confined to eastern Canada, and did not begin its rapid spread southward until circa 1860. *Littorina littorea* soon became one of the most abundant snails in the intertidal and shallow subtidal zones on the Atlantic coasts of Canada and New England. It was found south of Cape Cod for the first time in 1875, and had reached Atlantic City, New Jersey, by 1891. Although in recent years *L. littorea* has been collected as far south as Watchapreag, Virginia, I have not collected it south of Indian River, Delaware. The periwinkle's northern limit is not well established, but appears to lie somewhere in southern Labrador.

The green crab *Carcinus maenas* (L.) is a well-known predator of *L. littorea* and of closely related species (Blegvad, 1914; Ropes, 1968; Pettitt, 1975; Heller, 1976; Menge, 1976; Hylleberg and Christensen, 1978; Lubchenco, 1978; Lubchenco and Menge, 1978; Rafaelli, 1978; Elner and Raffaelli, 1980; Hadlock, 1980). The eastern Atlantic range of *C. maenas* contains that of *L. littorea* and also extends to Iceland and the westernmost Baltic Sea (areas inhabited by *L. littorea* in the Pleistocene) as well as to Mauritania (Poulsen, 1949; Almaca, 1961, 1962, 1963; Christiansen, 1969). Before 1900, *C. maenas* in North America was known only from Cape Cod to New Jersey (Rathbun, 1887). In 1905, it was reported from the vicinity of Casco Bay, Maine, and from there the species spread gradually eastward and northward to Bar Harbor in the Frenchman Bay area (1926–30), Jonesport (1948, possibly as early as 1919), and Passamaquoddy Bay (1951) to southern Nova Scotia (1954) and the Minas Basin (1953) (Dow and Wallace, 1952; Scattergood, 1952; Bousfield, 1958; Bousfield and Leim, 1958; Welch, 1968). *Carcinus maenas* was found in Northumberland Strait and on the west coast of Cape Breton in 1960 (Bousfield and Laubitz, 1972), but the permanence of the green crab's populations in these frequently ice-clogged waters is in doubt (R. W. Elner, pers. comm.). Permanent populations of *C. maenas* are found throughout the Bay of Fundy and on the Atlantic coast of Nova Scotia as far east as 65 km beyond Halifax (Bousfield and Laubitz, 1972). Throughout its North American range, *C. maenas* is subject to large population fluctuations and is particularly sensitive to cold winters (Dexter, 1947; Welch, 1968; Wheeler, 1980). The important point from the perspective of this study is that *L. littorea* in New England and Canada maintained populations in the absence of *C. maenas* for 40 to more than 100 years, and still does so between Labrador and Northumberland Strait.

The northward spread of *C. maenas* is not known to have resulted in the extinction or population decline of other species. The lobster *Homarus americanus* Say, another predator of the periwinkle, suffered a substantial reduction in numbers and in average body size during the second half of the nineteenth century, when canneries were established on a large scale (Rathbun, 1887). Present evidence suggests that the arrival of *C. maenas* north of Cape Cod represented an increase in both the number of species and the abundance of shell-breaking predators of intertidal gastropods in that region.

Predation and Predictions

Carcinus maenas can impose selection for greater armor in its prey either by learning from prior experience (Elner, 1978, 1980; Elner and Hughes, 1979) or by making mistakes by attacking unsuitable prey (Hughes and Elner, 1979; Elner and Raffaelli, 1980; Hadlock, 1980). When it does the latter, the crab damages the outer lip of the shell, which is subsequently repaired by the snail. A scar on the shell's exterior records the stage of growth when the snail suffered sublethal lip damage (Fig. 1) (Heller, 1976; Raffaelli, 1978). Large (5 to 6 cm wide) green crabs from Rhode Island are capable of breaking and killing *L. littorea* of up to a length of 18 mm (Hadlock, 1980). J. Lubchenco (pers. comm.), using a 63 mm wide green crab from Massachusetts, established the upper limit of vulnerability of the periwinkle at 14 mm.

The incidence of breakage-induced scars is a measure of the intensity of sublethal shell breakage and of the opportunity for selection in favor of resistance to lethal breakage. If the incidence of repair is high, a large proportion of the population has been exposed to selection with respect to shell strength. Within species, an increase in the frequency of repair is usually associated with an increase in the contribution of lethal breakage to overall mortality (Vermeij, 1981). The lack of repair in a population implies either that shell-breaking agents are absent or that all at-

TABLE 1A. *Means and standard deviations of frequencies of repair in* Littorina littorea *in relation to shell size, region, and date of collection.*[1]

Size class and region	Frequencies of repair		
	Old samples	New samples	All samples
10 to 14 mm			
North of Nova Scotia	—	—	.088+-.073 (6)
Cape Cod to Nova Scotia	.069+-.048 (8)	.109+-.027 (6)	.086+-.044 (14)
South of Cape Cod	.153+-.169 (4)	.140+-.079 (10)	.143+-.105 (14)
Northern Europe	—	—	.038+-.074 (5)
Wadden	—	—	.071+-.085 (11)
Denmark	.050+-.057 (5)	.034+-.027 (4)	.043+-.045 (9)
Southern North Sea	.146+-.096 (6)	.216+-.147 (7)	.183+-.126 (13)
Southwest Europe	—	—	.064+-.065 (7)
15 to 19 mm			
North of Nova Scotia	—	—	.129+-.114 (7)
Cape Cod to Nova Scotia	.073+-.063 (11)	.074+-.053 (14)	.074+-.057 (25)
South of Cape Cod	.145+-.117 (4)	.174+-.155 (12)	.167+-.143 (16)
Northern Europe	.144+-.161 (5)	.102+-.104 (7)	.120+-.126 (12)
Wadden	—	—	.142+-.155 (10)
Denmark	.038+-.034 (9)	.019+-.027 (5)	.031+-.032 (14)
Southern North Sea	.170+-.109 (9)	.209+-.158 (13)	.192+-.139 (22)
Southwest Europe	—	—	.116+-.104 (10)
20 to 24 mm			
North of Nova Scotia	—	—	.085+-.067 (6)
Cape Cod to Nova Scotia	.118+-.089 (9)	.097+-.084 (26)	.103+-.085 (35)
South of Cape Cod	.123+-.077 (5)	.207+-.129 (10)	.179+-.119 (15)
Northern Europe	.121+-.142 (6)	.220+-.083 (4)	.157+-.129 (10)
Wadden	.243+-.134 (4)	.058+-.073 (4)	.150+-.140 (8)
Denmark	.097+-.098 (5)	.043+-.050 (7)	.066+-.075 (12)
Southern North Sea	.216+-.128 (6)	.099+-.072 (7)	.153+-.114 (13)
Southwest Europe	.158+-.123 (4)	.197+-.129 (6)	.181+-.121 (10)
Greater than 25 mm			
Cape Cod to Nova Scotia	.053+-.021 (4)	.106+-.061 (9)	.087+-.056 (13)
Northern Europe	—	—	.358+-.312 (4)
Denmark	.120+-.014 (4)	.027+-.026 (5)	.068+-.054 (9)
Southwest Europe	—	—	.219+-.107 (6)

[1] Number of samples is given in parentheses.

tacks by these agents result in the snail's death. (For further discussion see Vermeij, 1981.)

Shell thickness affects susceptibility to lethal breakage (Raffaelli, 1978; Vermeij, 1979; Dudley, 1980; Elner and Raffaelli, 1980). Thick-shelled littorinids reach immunity from lethal breakage at a smaller size than do thin-shelled individuals. Accordingly, I predict that there is a positive correlation in *L. littorea* between absolute shell thickness and the frequency of repair when shell size is held constant.

If the green crab affected the periwinkle, an increase in the frequency of repair and in shell thickness should be evident in museum collections of shells from Cape Cod to Nova Scotia, but not in shells from north of Nova Scotia, south of Cape Cod, or Europe. If the effect of *C. maenas* was minor or swamped by other factors, the history of *L. littorea* from Cape Cod to Nova Scotia should not differ from that in other parts of the North Atlantic.

Data on shell thickness and frequency of repair in *L. littorea* can be used to test hypotheses about geographical variation in the importance of shell breakage as a component of selection. The equatorward increase in the incidence and expression of breakage-resistant characteristics in gastropods implies that selection in favor

TABLE 1B. *Means and standard deviations of shell thickness of* Littorina littorea *in relation to shell size and region.*[1]

Size class and region	Shell thickness (mm)
10 to 14 mm	
North of Nova Scotia	.550+−.124 (5)
Cape Cod to Nova Scotia	.508+−.108 (12)
South of Cape Cod	.449+−.109 (11)
Northern Europe	—
Southern North Sea	.544+−.044 (5)
15 to 19 mm	
North of Nova Scotia	.695+−.055 (6)
Cape Cod to Nova Scotia	.582+−.093 (24)
South of Cape Cod	.576+−.117 (14)
Northern Europe	.602+−.067 (9)
Wadden	.580+−.072 (9)
Denmark	.481+−.051 (13)
Southern North Sea	.659+−.087 (21)
Southwest Europe	.798+−.341 (10)
20 to 24 mm	
North of Nova Scotia	.853+−.193 (6)
Cape Cod to Nova Scotia	.822+−.154 (31)
South of Cape Cod	.774+−.171 (12)
Northern Europe	.771+−.087 (10)
Wadden	.693+−.079 (7)
Denmark	.679+−.116 (10)
Southern North Sea	.864+−.137 (12)
Southwest Europe	.932+−.231 (10)
Greater than 25 mm	
Cape Cod to Nova Scotia	1.138+−.194 (11)
Denmark	.790+−.151 (9)
Southwest Europe	1.498+−.385 (6)

[1] Number of samples given in parentheses.

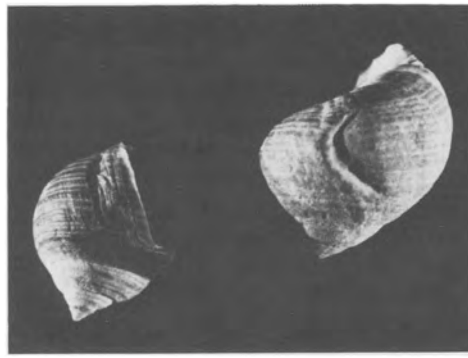

FIG. 1. *Littorina littorea* with a repaired injury. One of the specimens was still repairing the damage when the animal was collected. Specimens were taken in February, 1976, near Plymouth, Devon, England.

of armor intensifies toward lower latitudes (Vermeij, 1976, 1978; Vermeij and Currey, 1980; Vermeij et al., 1980). Accordingly, I predict that the frequency of repair and shell thickness in *L. littorea* should increase from north to south. This prediction would also accord with the pattern of diversity of predatory crab species. Intertidally, three predaceous crabs are known north of Cape Cod, and at least four occur further south (Peterson, 1979). In Europe, northern shores are inhabited by two, and southwestern shores by three or four species (Poulsen, 1949; Wolff and Sandee, 1971).

MATERIALS AND METHODS

This study was based on an analysis of over ten thousand shells, mostly in museum collections, from all parts of the range of *L. littorea*. Each sample was classified biogeographically as belonging to one of eight regions: (1) North America south of Cape Cod; (2) North America between Cape Cod and the northern limit of *C. maenas*; (3) North America north of the present distribution of *C. maenas*; (4) southwest Europe (Ireland, southern England, western Europe from Normandy south); (5) southern North Sea (extreme northern France, Belgium, and the Netherlands north to, but not including, Den Helder); (6) Wadden District (Den Helder to northwestern Germany, including the former Zuiderzee); (7) Denmark; and (8) northern Europe (Scotland, northern England, and Norway). The division at Cape Cod represents a well-known biogeographical discontinuity between a boreal and a more warm-temperate biota (Briggs, 1974; Bousfield and Thomas, 1975). In Europe, the divisions are more arbitrary. The transition from the typical warm-water biota of the Lusitanian Province to the more cold-temperate faunas of northern Europe is very gradual between the western end of the English Channel and southwestern Holland (den Hartog, 1959; Lewis, 1964; Wolff and Sandee, 1971). I have chosen to separate the southern North Sea from the biotically richer coasts of southwest Europe on the one hand, and

TABLE 2. *Product-moment correlation coefficients (r) between frequency of repair and shell thickness in four size classes of* Littorina littorea.

Region	Correlation coefficients in size classes 10–14 mm	15–19 mm	20–24 mm	25 mm
North of Nova Scotia	+.037	−.609	+.774*	—
Cape Cod to Nova Scotia	+.522*	−.160	+.078	−.076
South of Cape Cod	+.428	+.185	+.317	—
Northern Europe	—	+.588*	+.287	—
Wadden	—	+.849*	−.163	—
Denmark	—	+.411	+.304	+.758*
Southern North Sea	−.461	+.330	+.069	—
Southwest Europe	—	+.751*	+.276	−.056
All regions	+.247*	+.356*	+.224*	+.136

* Significant at or below the .05 level

from the more impoverished estuarine Wadden Sea coasts on the other. Because Danish populations of many species differ consistently from populations of the same species in the Wadden District (Poulsen, 1949; Rasmussen, 1973; Theisen, 1978), I have recognized Denmark as a distinct biogeographical region.

In order to test whether the frequency of repair and shell thickness increased in North American *L. littorea* as *C. maenas* spread north of Cape Cod, populations were classified as pre-*Carcinus* or post-*Carcinus,* based on dates of first discovery (Scattergood, 1952; Welch, 1968). In the regions where the green crab has always been present, changes in repair and thickness were assessed by comparing samples collected before and after 1930, the year halfway between the first appearance of *C. maenas* north of Cape Cod and the year when the green crab reached its present northern limit in North America. Samples of subfossil periwinkles were excluded from this analysis.

The frequency of breakage-induced shell repair was defined as the number of scars per shell. A scar can be distinguished from a "growth line" (interruption of shell growth) by its irregular, usually jagged trajectory. Scars were counted only on the last whorl. I assumed that periwinkles were collected randomly with respect to the presence of scars. Because many samples contained only large shells, no attempt was made to calculate a frequency of repair for the whole sample; instead, I calculated frequencies of repair for each of five predetermined size classes.

I measured thickness of the outer shell wall at a point about 1 mm from the edge of the outer lip. For each sample, I determined the mean shell thickness for each available size class. These mean shell thicknesses were used in geographical and temporal comparisons within size classes. Absolute thickness was chosen rather than relative thickness because shell strength is proportional to the square of absolute thickness (Vermeij and Currey, 1980).

RESULTS

Relation Between Repair and Thickness

Many gastropod species show great variation in the frequency of shell repair on both a local and a geographical scale (Vermeij, 1978, 1981; Vermeij et al., 1980). *Littorina littorea* is no exception, as the data in Appendix 1 (summarized in Table 1) demonstrate. Shell thickness (Table 1) is also highly variable from place to place. Linear correlation coefficients between the frequency of repair and mean shell thickness (Table 2) reveal a significant positive relationship at a level of .95 or higher in six of 23 cases. With all geographical regions combined, the correlation between repair and thickness, though low, is significantly positive in three of the four size classes. These data generally support the view that thicker shells have higher frequencies of repair than do thinner shells.

Additional evidence that thick shells provide better protection against breakage comes from comparisons within samples. Repaired shells were thicker than unrepaired shells of the same size in 13 of 22 comparisons (59%) involving eight scarred individuals from Cape May, New Jersey (1962). At Shark River, New Jersey (1962), five repaired shells were thicker than unrepaired shells in 67% of 12 comparisons.

Temporal Comparisons

Samples of *L. littorea* taken between Cape Cod and Nova Scotia before *C. maenas* became established were compared in one-tailed Mann-Whitney *U*-Tests to those taken after the appearance of the green crab. Frequencies of repair in the older samples were significantly lower than those in the newer samples in the 25–35 mm size class ($P < .05$) and perhaps in the 10–14 mm class ($P < .06$). Some shores north of the present northern limit of *C. maenas* are potentially available to this crab because they are comparatively ice-free in winter (Bousfield and Thomas, 1975). If samples from Nova Scotia to Newfoundland and Quebec are classified as pre-*Carcinus* along with the older samples from further south, the differences in the 25–35 mm and 10–14 mm size classes are significant at the .02 and .01 levels, respectively. No differences were found in the 15–19 mm and 20–24 mm classes whether the northern shells are included or not. There was no difference in shell thickness between samples taken before and after the arrival of *C. maenas*.

In other parts of the world, comparisons were made between samples collected before and after 1930. Frequencies of repair in older samples in the 10–14 mm size class from the southern North Sea were significantly lower than those of newer samples ($P < .02$), but there was no corresponding difference in shell thickness. Moreover, the trend in repair reverses in the 20–24 mm size class. In Denmark, there is a tendency for the post-1930 samples to have lower frequencies of repair than those collected before 1930 ($P < .001$ in the 25–35 mm class, $P < .06$ in the 15–19 mm class). Correspondingly, there is a tendency for the newer Danish samples to have thinner shells than the older ones ($P < .03$ and .04 in the 15–19 mm and 25–35 mm classes, respectively). No other temporal differences in repair or thickness appeared in any other region.

Analysis of repair frequencies in complete samples (shells of all sizes) yields similar results. The only significant temporal changes within regions are an increase in repair after the coming of the green crab north of Cape Cod ($P < .03$, 45 samples) and a reduction in repair after 1930 in Denmark ($P < .003$, 22 samples).

Regional Differences

The Kruskall-Wallis Test was used in the 10–14 mm, 15–19 mm, and 20–24 mm size classes to ascertain whether differences exist among seven areas (all North American samples from north of Cape Cod were treated as belonging to one region). For the frequency of repair, differences are significant at the .05, .01, and .05 levels, respectively. Denmark is the region responsible for most of these differences. A posteriori multiple comparisons tests (Hollander and Wolfe, 1973) show that frequencies of repair in Danish samples are significantly lower than those in the North Sea in the 10–14 mm and 15–19 mm classes, and lower than those in the Wadden District in the 10–14 mm class. These data point to a marked increase in repair from low values in the estuarine waters of Denmark and the Wadden Sea to higher values in the mostly marine southern North Sea. There is no trend in Europe for repair frequencies to increase southward (Table 1). In North America, samples collected south of Cape Cod have significantly higher frequencies than do those from north of Cape Cod. This trend is significant at the .04, .025, and .025 levels in the 10–14 mm, 15–19 mm, and 20–24 mm classes, respectively. Populations from Long Island Sound, an area of relatively low salinity, do not differ from populations at fully marine sites south of Cape Cod. The expected latitudinal

TABLE 3. *Number of samples of* L. littorea *in which the frequency of repair increases (+) or decreases (or remains constant) (−) in transitions from one size class to the next larger one.*

Region	Number of samples in adjacent classes: Classes 2–3	Classes 3–4	Classes 4–5	All transitions
North of Cape Cod	7+ 8−	13+ 8−	5+ 5−	25+ 21−
South of Cape Cod	3+ 5−	5+ 3−	2+ 1−	10+ 9−
Northern Europe	1+ 2−	3+ 5−	2+ 1−	6+ 8−
Wadden	5+ 3−	5+ 1−	2+	12+ 4−
Denmark	4+ 5−	5+ 4−	3+ 2−	12+ 11−
Southern North Sea	8+ 4−	6+ 5−	3−	14+ 12−
Southwest Europe	6+	5+ 1−	3+ 1−	14+ 2−

Size class 2: 10 to 14 mm.
Size class 3. 15 to 19 mm.
Size class 4 20 to 24 mm.
Size class 5: greater than 25 mm.

trend is thus found in North America but not in Europe.

Regional differences in shell thickness are significant at the .05 level in the 10–14 mm size class, and at the .01 level in the 15–19 mm and 20–24 mm classes (Kruskall-Wallis Test). Samples from estuarine regions (Denmark and to a lesser extent the Wadden District) stand out in having significantly thinner shells than do those from areas of more typically marine salinity in the southern North Sea, northern Europe, and southwest Europe. Comparisons among the last three regions reveal no latitudinal gradient in the 10–14 mm class, and only a modest increase in thickness toward the south in the 15–19 mm and 20–24 mm classes. The a posteriori multiple comparisons test shows that none of the differences among these three regions is significant. Nevertheless, by far the thickest *L. littorea* come from the coasts of southern England and Brittany in southwest Europe (see Appendix 1 and Table 1). In North America, samples from south of Cape Cod actually have somewhat thinner shells than do those collected further north. Although this difference is significant only in the 20–24 mm class ($P < .015$, two-tailed Mann-Whitney U-Test), it is opposite to the expected trend and opposite to the weak gradient in Europe. Estuarine populations from Long Island Sound do not differ in thickness from other populations in more saline areas south of Cape Cod.

The relationship between frequency of repair and shell size within samples differs from region to region. Normally, the frequency of repair is expected to rise as shell length increases, because larger shells are less susceptible to lethal breakage and have been exposed to destructive agents for a longer time than smaller ones. A reduction in the incidence of repair with increasing shell size means that agents of breakage are relatively weak or that they avoid attacking larger shells. Table 3 gives the number of samples which show an increase or a decrease in the frequency of repair from one size class to the next larger one. Instances of constant frequencies in adjacent classes within a sample were treated as decreases. Southwest Europe, and to a lesser extent the Wadden District, differ from other regions in having a preponderance of increases rather than an approximately equal number of increases and decreases. These data suggest that predators are stronger in southwest Europe, where shells are thick and reach a large size, than elsewhere.

DISCUSSION

The data on repair in *Littorina littorea* show clearly that this snail experiences one aspect of its environment (shell breakage) very differently from place to place and, in some areas, over the course of historical time. The incidence of repair, which is a measure of the intensity of unsuccessful shell breakage, generally increases from north to south on the east coast of North America, and from estuarine to more saline areas in Europe. Frequencies of repair in *L. littorea* have remained stable on a regional, if not a local, scale for the last 100 years or more in most of the eight regions studied here. Historical changes in repair were detected in one or more size classes in Denmark, the southern North Sea, and North America from Cape Cod to Nova Scotia. Surviving periwinkles experienced more unsuccessful shell breakage before 1930 than after that date in Denmark, and a reverse trend is evident in northern North America and (in one size class) in the North Sea.

My data suggest that a thick shell is effective as protection against shell-breaking agents. Although nothing is known about the heritability of shell thickness in *L. littorea,* thickness is known to have a strong genetic component in other snails (Struhsaker, 1968; Pollard, 1975). It is therefore reasonable to regard shell thickening as a partly genetic adaptation against lethal shell breakage. If this is so, and if shell-breaking predators are present everywhere in the periwinkle's range, why are shells of *L. littorea* thin in some regions and thick in others?

In Denmark, selection does not favor armor in *L. littorea* because that species may not have a size refuge from *Carcinus maenas,* which is the only shell-breaking predator on most Danish shores. Green crabs in Denmark reach a much larger size (94 mm in width) than they do in other parts of the North Atlantic (Rasmussen, 1973), and can kill even the largest periwinkles (Blegvad, 1914). I do not know why the low frequencies of repair before 1930 became even lower after that date. There is no hint in the literature of a reduction in numbers or of an increase in maximum body size of *C. maenas,* but these possibilities cannot be eliminated.

The frequency of repair in two out of four size classes of *L. littorea* from north of Cape Cod increased after the arrival of the green crab. This pattern was not duplicated elsewhere in the periwinkle's range except in the southern North Sea, but in that region the trend is inconsistent in the various size classes. Accordingly, the hypothesis that the arrival of the green crab contributed to an increased incidence of unsuccessful predation of boreal North American periwinkles remains plausible.

Why was the increase in repair not accompanied by the expected increase in shell thickness? First, if American periwinkles are recent immigrants from Europe, where their ancestors co-occurred with *C. maenas,* the time spent by American periwinkles without *C. maenas* may have been too short for any genetic thinning of the shell to have taken place. If, however, the populations in New England and further south came from an indigenous population, this excuse no longer applies.

Secondly, if American periwinkles are recent immigrants from Europe, they may be genetically impoverished. Berger (1977) suggested that *L. littorea* between Massachusetts and Prince Edward Island has less electrophoretically detectable variation than it does in Brittany. At several esterase loci, however, Vuilleumier and Matteo (1972) found slightly more variation in the New England populations than in those from Brittany. Not only are these data contradictory, but the geographical comparisons that were made are between North America and a part of Europe from which the purported ancestors of American periwinkles probably did not come. Moreover, Lande (1980) has emphasized that the loss of genetic variation as a result of the founder effect is small except if the founding population was extremely small (fewer than five individuals). With respect to shell thickness, between-sample variability north of Cape Cod is as great as, or greater than, that in all European regions except southwest Europe (Table 1). In fact, Bumpus (1898) perceived more variation in shell dimensions of American populations than in those from Great Britain. Although his work cannot be verified statistically and contains erosion-induced artifacts (Bigelow and Rathbun, 1903), the evidence suggests that genetic impoverishment and lack of phenotypic variation are unlikely explanations for the lack of adaptation by northern American periwinkles to the arrival of *C. maenas*.

A final possibility is that thick-shelled variants, once they arose, could not spread and become established in northern populations of the periwinkle. By the time *C. maenas* arrived north of Cape Cod, populations of the periwinkle were already large, and gene flow by dispersal of planktonic larvae was and is probably extensive. If predation varied along a gradient or in some other geographically systematic fashion, local genetic differentiation might take place even with considerable gene flow. In fact, some clinal variation in esterases has been reported for *L. littorea* in Maine and Massachusetts (Vuilleumier and Matteo, 1972), and Koehn et al. (1976) described populations of *Mytilus edulis* L. in Nova Scotia whose gene frequencies differed markedly at several loci from those of mussels elsewhere in eastern Canada. Unfortunately, nothing of the functional significance of the enzyme differences or of the environmental cues to which the snails are responding is known. Predation, however, is usually characterized by considerable local variation, with adjacent populations often experiencing very different levels of successful and attempted predation (Menge, 1976, 1978; Vermeij, 1978, 1980*a*). Such geographically haphazard variation coupled with extensive gene flow may act to prevent local genetic adaptation to differences in predation (Vermeij, 1978; Stanley, 1979). Studies of the evolutionary response of poorly dispersing species such as *Thais lapillus* (L.) should shed further light on these speculations.

American periwinkles depart from the expected trend in still another way. Compared to shells from north of Cape Cod, those south of the Cape have higher frequencies of repair, yet they are thinner. This phenotypic response would seem, on the face of it, to be counter-adaptive with respect to predation by shell-breakers. I suggest that this anomaly is due to the fundamental relationship between longevity, growth rate, shell thickness, and temperature. *Littorina littorea* may be like many other temperate shelled invertebrates (Newcombe and Kessler, 1936; Thorson, 1957; Wells and Gray, 1960; Vernberg, 1962; Gaillard, 1965; Choquet, 1968; Frank, 1975; Hughes and Roberts, 1980*a*) in having a shorter adult life-span in warmer waters. South of Cape Cod, periwinkles remain relatively small (maximum length 27 mm) and attain maximum ages of 3–5 years (Kraeuter, 1974), whereas north of the Cape and in Europe they usually exceed 35 mm in maximum length and attain an age of 10–20 years (Moore, 1937; Smith and Newell, 1955; Williams, 1964; Rasmussen, 1973; Guyomarc'h-Cousin, 1975; Daguzan, 1976; Hughes and Roberts, 1980*b*). In molluscs, great age is usually associated with slow growth and a thick shell, whereas a short life-span is usually correlated with rapid growth and a thin shell (Vermeij, 1980*b*). This tendency, which probably reflects a differential dependence of cell division and differentiation on temperature (Smith-Gill and Berven, 1979), can be modified through the action of selection (Berven et al., 1979). I believe that the thick-shelled, predation-resistant periwinkles of southern England and Brittany represent such selection in warm waters.

Why thick shells have not evolved among southern American *L. littorea,* or for that matter among southern populations of such native American bivalves as *Mytilus edulis* and *Mya arenaria* L. (Newcombe and Kessler, 1936; Wells and Gray, 1960), remains a mystery. Genetic contamination from populations north of Cape Cod by dispering larvae in the predominantly southward flowing ocean current cannot explain the phenomenon, because *M. edulis* (a planktonically dispersing species) shows changes in gene frequency at several loci between populations north and south of Cape Cod and between populations from Long Island Sound and adjacent less estuarine coasts (Koehn et al., 1976, 1980). Moreover, levels of unsuccessful predation, though variable, are higher on a geographical scale south of Cape Cod than north of the

Cape, so that local adaptation should be possible.

The native American *Littorina irrorata* (Say), which in the northern part of its range (New Jersey) co-occurs with *L. littorea* in salt marshes (Vermeij, 1973, 1978), also sustains a high incidence of sublethal injury and successful predation (Hamilton, 1976; Ackroyd et al., 1980), but its shell is substantially thicker and higher-spired than that of *L. littorea*. Like many other warm-water species, *L. irrorata* has evidently been able to build a thick shell and to attain a respectable longevity despite seasonally high temperatures (Bingham, 1972; Stiven and Kuenzler, 1979).

The apparent lack of morphological adaptation of American periwinkles to shell breakage may thus be explained by genetic mixing or by the tendency for fast growth at high temperatures to be associated with thin shells. I suspect that inadequacy of adaptation is common (see Stearns and Sage, 1980, for another example). This should not be construed as meaning that evolution does not occur or that natural selection is unimportant or ineffective. Instead, it points to the importance of understanding the genetic, physiological, and ecological reasons why adaptive change occurs in some populations and not in others.

Summary

In this study, I determined whether the arrival of the predaceous green crab (*Carcinus maenas*) on American shores north of Cape Cod was experienced by the common periwinkle (*Littorina littorea*) as an increase in the incidence of predator-induced sublethal shell damage, and whether the periwinkle responded to this change phenotypically with an increase in shell thickness. *Carcinus maenas* was first found north of the Cape in 1905, and reached its present northern limit in Nova Scotia in the 1950s. Comparisons of museum samples of periwinkles collected before and after the arrival of the green crab revealed that the frequency of repair (number of breakage-induced scars per shell) increased significantly in the 10–14 mm and 25–35 mm size classes but not in the two intervening classes. There was no corresponding increase in shell thickness despite the fact that thickness and the incidence of repair are correlated positively in *L. littorea*. In other parts of its range, *L. littorea* showed no temporal change in repair or thickness except in Denmark, where both showed a decrease.

The lack of an adaptive response among periwinkles between Cape Cod and Nova Scotia to increasing levels of unsuccessful shell breakage through time is unlikely to be the result of genetic or phenotypic impoverishment. Instead, extensive gene flow between areas of high and low predation may account for the stability of shell thickness through time. South of Cape Cod, where frequencies of repair are higher yet shells are thinner than north of the Cape, the widespread tendency for high summer temperatures to be associated with fast growth and thin shells may account for the absence of well-developed armor. Why populations in southwest Europe, where shells are thick and frequently scarred, could overcome this adaptive dilemma while American populations did not remains a mystery.

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NOTE ADDED IN PROOF. J. Carlton points out to me that St. Lunaire, a locality which I had placed on the north coast of Newfoundland (Appendix 1–2), probably refers to a village near St. Malo in France. The frequency of repair was anomalously high for a locality in northern North America but quite typical of sites in Southwest Europe. The relocation of St. Lunaire in France therefore strengthens the conclusions drawn in this paper.

APPENDIX 1. *Frequencies of repair and sample sizes of* Littorina littorea.

Locality and date	Frequencies of repair and sample sizes				
	5–9 mm	10–14 mm	15–19 mm	20–24 mm	≥25 mm
North of Nova Scotia					
Matamek, Qb., 1928	—	—	—	.050 20	0 12
Carleton, Qb., 1935	—	—	—	.067 15	—
Placentia Bay, Nf., 1947	—	—	.23 13	—	—
St. Lunaire, Nf., 1882	—	—	.30 10	.091 11	—
Long Pond, Nf., 1967	0 12	.038 55	—	—	—
Clark's Beach, Conception Bay, Nf., 1939	—	—	—	.10 30	.059 17
Arichat, N.Sc., 1910	—	0 14	0 23	—	—
Sidney, N.Sc., 1905	—	—	0 18	.20 10	—
Baddock Bay, N.Sc., 1938	—	—	.071 14	0 13	—
Point Aconi, N.Sc., 1967	—	.21 19	.17 24	—	—
Summerside Point, P.E.I., 1961	—	.080 25	—	—	—
Beach Wood, P.E.I., 1928	—	.078 13	.13 15	—	—
Cape Cod to Nova Scotia, old					
Isle au Haut, Me., 1897	0 8	.13 30	.067 15	0 12	.067 15
Islesboro, Me., 1895	0 17	.12 26	.096 31	.040 25	.056 18
Gloucester, Ma., 1878	.067 15	.045 67	.078 39	.10 30	—
Halifax, N.Sc., 1877	—	.051 39	.081 37	—	—
Bar Harbor, Me., 1907	—	.10 10	.21 19	.22 27	—
Salem, Ma., 1877	—	0 10	.070 57	.13 16	—
Southwest Harbor, Mount Desert, Me., 1921	—	.091 11	—	—	—
South Joggins, N.Sc., 1938	—	.017 58	0 25	—	—
Newcastle, N.H., 1877	—	—	—	.27 11	—
Beverly Farms, Ma., 1876	—	—	.059 17	.17 12	—
Flagg's Cove, Grand Manaan, N.B., 1898	—	—	—	—	.032 31
Halifax, N.Sc., 1850s?	—	—	0 11	.083 12	—
Lubec, Me., 1940	—	—	—	—	.078 13
Ten Pound Island, Ma., 1878	—	—	0 12	.045 22	—
Indian Harbour, N.Sc., 1950	—	—	.14 21	—	—
Cape Cod to Nova Scotia, new					
Hooke's Beach, Castine, Me., 1978	—	.083 12	.10 267	.12 67	—
Little Moose Pool, Me., 1978	—	—	—	.30 10	.11 27
Winter Harbor, Me., 1978	—	—	.030 65	.019 52	—
Castine, Me. (10 ft), 1980	—	—	—	.075 80	—
Gloucester, Ma., 1925	—	.071 14	.042 24	.078 13	—
Meadow Cove, Damariscotta River, Me., 1958	—	—	—	.18 17	.14 29
Chatham, Ma., 1957	—	—	—	.038 52	—
Nahant, Ma., before 1910	—	—	—	0 10	—
Isle au Haut, Me., 1936	—	—	—	.10 10	—
East Gloucester, Ma., 1960	—	—	—	0 13	—
Eastport, Me., 1980	—	—	—	—	.10 20
St. Andrews, N.B., 1981	—	—	—	.071 14	—
Bouteliers Point, St. Margaret's Bay, N.Sc., 1981	—	—	—	0 10	—
Bass Harbor, Me., 1931	—	—	.15 13	0 13	—
Nahant, Ma. (20 ft), 1967	—	—	—	—	.033 30
Gloucester, Ma., 1930	—	—	—	—	.071 28
St. Andrews, N.B., 1963	—	—	—	.10 30	.13 16
Weymouth, Ma., 1916	—	—	.074 29	.17 42	—
Biddeford, Me., 1938	—	—	.017 59	.18 22	—
Yarmouth, Ma., 1938	—	—	—	.071 14	—
Lynn, Ma., 1952	—	—	—	.083 12	—
Brewster, Ma., 1933	—	—	.12 60	.10 10	—
Cohasset, Ma., 1914	—	—	—	.30 10	—
Alma, N.B., 1960	—	.12 17	.12 25	—	—
St. Martins, N.B., 1960	—	.13 60	.030 66	—	—

APPENDIX 1. *Continued.*

Locality and date	Frequencies of repair and sample sizes				
	5–9 mm	10–14 mm	15–19 mm	20–24 mm	≥25 mm
Queensland, N.Sc., 1960	—	.11 28	.053 19	—	—
Peggy's Cove, N.Sc., 1960	—	.14 35	.18 50	—	—
St. Andrews, N.B., 1960	—	—	.042 24	0 14	—
Harboursville, N.Sc., 1960	—	—	.083 48	.17 41	—
Cheboque Point, N.Sc., 1960	—	—	—	.043 23	.078 13
Whale Cove, N.Sc., 1960	—	—	—	0 11	.24 25
Squirrel Island, Me., 1971	—	—	—	.12 25	.056 18
Chance Harbour, N.B., 1957	—	—	—	0 10	—
South of Cape Cod					
Vineyard Sound, Ma., 1878	—	.22 9	—	—	—
Atlantic City, N.J., 1891	—	—	—	.10 10	—
Guilford, Conn., 1968	—	—	.21 28	—	—
Barn Island, Conn., 1969	—	.15 13	—	.10 20	.29 14
Noank, Conn., 1969	—	.19 16	—	.032 31	—
Double Beach, Conn., 1969	—	—	.26 23	.11 19	—
Tuckerton, N.J., 1968	—	—	—	.18 11	—
Tuckerton, N.J., 1969	—	—	.083 12	.30 23	—
Woodmont, Conn., 1969	—	—	.15 2	0	—
Sayville, N.Y., 1953	—	.33 9	.11 88	—	—
Manasquan, N.J., 1952	0 14	.15 26		—	—
Lewes, Del., 1980	—	.081 37	.19 32	—	—
Indian River, Del., 1980	—	.10 10	—	—	—
West Haven, Conn., 1932	0 29	—	0 15	—	—
Point Judith, R.I., 1980	.091 11	.043 47	.12 86	.23 73	—
Vineyard Haven, Ma., 1901	—	.36 15	.10 30	.17 12	—
Tuckermuck, Nantucket, R.I., 1915	—	—	—	.078 13	—
Cape May, N.J., 1962	—	—	.59 17	.26 19	—
Shark River, N.J., 1962	0 12	.13 47	.26 43	.43 14	—
Jamaica, N.Y., 1913	—	—	—	.23 31	.30 10
Ocean City, N.J., 1945	—	—	—	.35 20	—
Fort Adams, R.I., 1899	—	0 10	—	—	—
Menemsha, Ma., 1980	—	.13 23	.043 23	.081 37	.071 14
Falmouth, Ma., 1955	—	.093 43	.074 27	—	—
Westerly, R.I., 1898	.059 17	.030 33	0 16	—	—
Branford, Conn., before 1918	—	—	.25 16	.038 26	—
Northern Europe					
Oslofjord, Norway, 1974	0 15	.017 59	0 44	—	—
Tromoy, Arendal, Norway, 1974	—	—	.20 15	.053 19	—
Skjeivik, Norway, 1920	—	—	.078 13	.13 15	—
Sjoonovaagen, Norway, 1920	—	—	.11 9	.078 39	.10 10
Sorfjorbottn, Norway, 1920	—	—	.11 9	—	—
Kvaroy, Luroy, Norway, 1920	—	—	—	.11 28	—
Bergen, Norway, 1931	—	0 11	0 9	0 27	—
Kilboghavn, Norway, 1920	—	—	0 8	0 24	—
Heroy, Helgeland, Norway, 1917	—	—	—	.20 15	—
Gjervalbottn, Norway, 1920	—	—	.42 12	—	
St. Andrews, Scotland, 1935	0 9	—	.067 15	.20 10	—
Deerness, Orkneys, 1966	—	0 11	.059 17	.13 24	.10 10
Scarborough, England, 1951	—	—	.28 43	.22 27	—
Molde, Norway, 1968	—	—	—	.33 15	.50 10
Hammerfest, Norway, 1881	—	—	—	—	.73 11
Uddevalla, Finland, fossil	—	0 14	—	—	—
Millport, Scotland, 1958	—	.17 24	.11 9	—	—
Oban, Scotland, 1850's	—	—	—	.042 24	—

APPENDIX 1. *Continued.*

Locality and date	Frequencies of repair and sample sizes 5–9 mm	10–14 mm	15–19 mm	20–24 mm	≥25 mm
Wadden					
Morsum, Sylt, 1951	.039 76	.11 47	—	—	—
List, Sylt, 1951	—	—	—	—	.31 13
Buiten Y, fossil	.045 22	.025 40	0 29	.083 12	—
Schiermonnikoog, dike, 1980	—	.12 60	.14 37	—	—
Schiermonnikoog, marsh, 1980	—	0 10	0 27	0 13	—
'T Horntje, Texel, 1980	.032 31	.030 33	.13 69	—	—
Harlingen-Zwarte Haan, 1951	—	.053 19	0 15	.083 12	.20 10
Groninger Wadden, 1941	0 68	.032 31	—	—	—
Den Oever, 1944	0 0	.068 44	.092 .76	0 15	—
Het Noorden, Texel, fossil	—	—	.063 16	.12 73	—
Lutjeswaard, 1926	—	—	.074 81	—	—
Den Helder, 1908	—	—	—	—	.17 12
Nieuwendiep, Den Helder, 1932	0 26	0 39	.034 117	.10 10	—
Nieuwendiep, Den Helder, 1915	—	—	.11 9	.25 8	—
Ulrum, 1938	—	.045 22	—	—	—
Den Helder, 1974	—	.30 10	.42 19	—	—
Oudeschild, Texel, 1950	—	—	—	.15 13	—
Wieringen, 1926	—	—	—	.20 10	—
Stavoren, 1920–1929	—	—	—	.42 12	—
Southern North Sea					
Wilhelminadorp, Zeeland, 1966	—	—	.14 22	—	—
Scheveningen, Z.H., 1909	—	—	.025 40	.087 23	—
Vrouwenpolder, Zeeland, 1916	—	—	.13 32	.27·15	—
Yerseke, Zeeland, 1946	—	—	.13 16	.033 61	—
Katwijk, Z.H., 1915	—	.083 12	.21 29	—	—
Katwijk, Z.H., 1916	—	0 12	—	—	—
Terneuzen, Zeeland, 1948	—	—	.091 11	.11 9	—
Yerseke, Zeeland, 1980	.10 40	.13 47	.25 93	.053 19	—
Strodorppolder, Zeeland, 1980	—	.22 23	.29 27	—	—
Wemeldinge-Kattendijke, Zeeland, 1980	—	—	.18 43	.18 17	—
Blankenberge, Belgium, 1980	—	.43 21	.44 25	—	—
Heyst-Blankenberge, 1890	—	.12 25	.087 23	—	—
Blankenberge, 1875	—	—	.071 13	—	—
Blankenberge, 1937	.14 14	.37 41	.41 37	—	—
Oostende, Belgium, 1904	.14 14	.26 19	.11 9	—	—
Oostende, 1967	—	.22 9	.50 12	—	—
Oostende, 1936–1937	.11 9	.14 42	.085 47	.14 21	—
Oostende, 1973	—	0 28	.14 35	.18 31	.038 26
Oostende, 1939	—	—	.059 17	—	—
Wimmereux, France, 1920	—	—	—	.17 24	.091 11
Wimmereux, 1914	—	.20 10	.30 43	—	—
Wimmereux, 1958	—	—	0 9	0 19	—
Vlissingen, Zeeland, 1892	—	.21 33	.30 86	.31 29	—
Vlissingen, 1918	—	—	.30 20	.39 103	.33 9
Denmark					
Flensborg, 1907	—	—	.071 56	—	—
Hornbaek, 1980	—	0 21	.037 54	.056 18	—
Gilleleje, 1980	—	—	—	.10 10	—
Humlebaek, 1888	—	.059 17	.060 50	.25 8	—
Dragörhavn, 1888	.059 17	0 24	.037 27	—	—
Grenaa, 1888	—	—	0 11	.11 19	.13 8
Frederikshavn, 1888	—	.14 22	.082 61	.10 59	.12 83
Gilleleje, 1888	—	.053 19	.017 59	.026 39	—

APPENDIX 1. *Continued.*

Locality and date	Frequencies of repair and sample sizes				
	5–9 mm	10–14 mm	15–19 mm	20–24 mm	≥25 mm
Hovsörhavn, 1916	—	0 48	0 28	—	—
Esbjerg, 1888	—	—	0 17	—	—
Frederikshavn, 1968	.042 24	.026 76	0 38	0 14	0 8
Hirsholm, 1887	—	—	—	—	.10 20
Hirsholm, 1924	—	—	—	—	.13 23
Hirsholm, 1969	—	—	—	0 12	.036 28
Frederikshavn, 1936	—	—	0 9	0 9	—
Hundested, 1962	—	—	—	.12 34	.065 31
Vellerup Vig, 1940	—	.063 32	0 65	—	—
Vellerup Vig, 1980	—	.045 22	.059 17	.025 121	—
Staffansbanke (12 m), 1961	—	—	—	—	0 10
Munkholm, 1964	—	—	—	—	.033 30
Hornbaek, 1888	—	—	.071 56	0 20	—
Southwest Europe					
Le Croisic, Brittany, 1887	—	0 10	.31 26	.15 39	.091 11
Plymouth, Devon, 1976	—	.18 28	.25 12	.27 11	.37 16
Dawlish Warren, Devon, 1976	—	—	.091 11	—	—
Killybego, Eyre, 1869	—	—	0 12	—	—
Downderry, Cornwall, 1961	—	—	0 18	.39 33	—
Arcachon, France, 1953	—	—	0 14	—	—
Santander, Spain, 1963	—	0 9	.050 20	—	—
Ile Oleron, France, 1964	—	0 10	—	—	—
Dafunda, Portugal, 1872	—	—	—	.18 40	.26 23
Ile d'Aix, France, 1973	—	—	.078 26	.098 61	.11 35
Roscoff, France, 1922	—	—	—	0 10	—
Granville, France, 1891	—	—	—	.30 10	—
Le Havre, France, 1946	0 10	.14 21	.19 16	.25 12	—
Lough Foyle, Eyre, 1959	—	—	—	.045 22	—
Menai Bridge, Wales, 1958	—	—	—	—	.28 40
Clorelly, Devon, before 1910	—	—	—	—	.20 10
Ilfracombe, Devon, 1896	—	.10 20	.12 17	—	—
Pobbles Beach, Gower Peninsula, Wales, 1979	—	.065 31	.071 42	.13 16	—

APPENDIX 2. *Mean shell thickness in size classes of* Littorina littorea.

Locality and date	Shell thickness (mm)			
Size class	1	2	3	4
North of Nova Scotia				
Arichat, N.Sc., 1910	—	.70	—	—
Summerside Point, P.E.I., 1961	.56	—	—	—
Long Pond, Nf., 1967	.63	—	—	—
Point Aconi, N.Sc., 1967	.65	.65	—	—
Baddock Bay, N.Sc., 1938	—	—	.60	—
Cape Bald, N.B., 1957	.34	—	—	—
Clark's Beach, Nf., 1939	—	—	.87	1.15
Beach Wood, P.E.I., 1928	.57	.69	—	—
Matamek, Qb., 1928	—	—	.68	1.03
Carleton, Qb., 1935	—	—	.84	—
Sidney, N.Sc., 1905	—	.80	1.03	—
St. Lunaire, Nf., 1882	—	.68	1.10	—
Cape Cod to Nova Scotia, old				
Isle au Haut, Me., 1897	.62	.66	—	—
Ten Pound Island, Ma., 1878	—	.48	.87	—

APPENDIX 2. *Continued.*

Locality and date	Size class	Shell thickness (mm) 1	2	3	4
Halifax, N.Sc., 1877		.54	.63	—	—
Halifax, 1850's		—	.60	.85	—
Flagg's Cove, N.B., 1898		—	—	—	.84
Gloucester, Ma., 1878		.55	.68	.90	—
Salem, Ma., 1877		.40	.56	.87	—
Islesboro, Me., 1895		.50	.57	.77	1.38
Bar Harbor, Me., 1907		.70	.78	1.07	—
Lubec, Me., 1940		—	—	—	1.41
Newcastle, N.H., 1877		—	—	.85	—
Southwest Harbor, Me., 1921		.35	—	—	—
Beverly Farms, Ma., 1876		—	.53	.57	—
South Joggins, N.Sc., 1938		.35	.45	—	—
Indian Harbour, N.Sc., 1950		—	.65	—	—
Cape Cod to Nova Scotia, new					
Little Moose Island, Me., 1978		—	.65	.58	—
Winter Harbor, Me., 1978		—	.56	.78	—
Hooke's Beach, Castine, Me., 1978		.53	.64	.67	—
Biddeford, Me., 1938		—	.63	.78	—
Cohasset, Ma., 1914		—	—	1.00	—
Yarmouth, Ma., 1938		—	—	.87	—
Brewster, Ma., 1933		—	.53	.67	—
Whale Cove, N.Sc., 1960		—	—	—	1.15
Queensland, N.Sc., 1960		—	.73	—	—
Peggy's Cove, N.Sc., 1960		.45	.56	—	—
Harboursville, N.Sc., 1960		—	.53	.80	—
Cheboque Point, N.Sc., 1960		—	—	.85	1.26
St. Martins, N.B., 1960		—	.51	—	—
St. Andrews, N.B., 1960		.43	.52	—	—
Alma, N.B., 1960		.52	.62	—	—
Squirrel Island, Me., 1971		—	—	.97	1.23
Eastport, Me., 1980		—	—	—	1.23
St. Andrews, N.B., 1981		—	—	.76	—
Boutelier's Point, N.Sc., 1981		—	—	.72	—
Little Moose Pool, Me., 1978		—	—	.82	1.03
Castine, Me., 1980		—	—	.86	—
Weymouth, Ma., 1916		—	.58	.84	—
Gloucester, Ma., 1925		.86	.86	1.30	—
Meadow Cove, Me., 1958		—	—	.93	1.04
Chatham, Ma., 1957		—	—	.74	—
Nahant, Ma., before 1910		—	—	.96	—
Isle au Haut, Me., 1936		—	—	.91	—
East Gloucester, Ma., 1960		—	—	.86	—
Bass Harbor, Me., 1931		—	.46	.58	—
Nahant, Ma., 1967		—	—	—	1.20
Gloucester, Ma., 1930		—	—	—	.83
St. Andrews, N.B., 1963		—	—	.57	1.07
Chance Harbor, N.B., 1957		—	—	.86	—
South of Cape Cod					
Point Judith, R.I., 1980		.57	.76	—	—
Vineyard Sound, Ma., 1878		.47	—	—	—
Sayville, N.Y., 1953		—	.51	—	—
Manasquan, N.J., 1952		.53	—	—	—
Atlantic City, N.J., 1891		—	—	.93	—
Noank, Conn., 1969		.50	—	.80	—
Woodmont, Conn., 1969		—	.49	—	—
Barn Island, Conn., 1969		—	—	.73	.70
Double Beach, Conn., 1969		—	.58	.64	—

APPENDIX 2. *Continued.*

Locality and date / Size class	Shell thickness (mm) 1	2	3	4
Guilford, Conn., 1968	—	.57	—	—
Tuckerton, N.J., 1969	—	.48	.71	—
Indian River, Del., 1980	.39	—	—	—
Lewes, Del., 1980	.42	.66	—	—
Menemsha, Ma., 1980	.23	.38	.45	.95
West Haven, Conn., 1932	—	.54	—	—
Vineyard Haven, Ma., 1901	.60	.70	1.03	—
Tuckermuck, R.I., 1915	—	—	.88	—
Cape May, N.J., 1962	—	.71	.81	—
Shark River, N.J., 1962	.50	.55	.80	—
Jamaica, N.Y., 1913	—	—	.78	.86
Ocean City, N.J., 1945	—	—	.94	—
Falmouth, Ma., 1955	.33	.53	—	—
Westerly, R.I., 1898	.40	.72	—	—
Branford, Conn., before 1918	—	.43	.52	—
Northern Europe				
Tromoy, Norway, 1974	—	.60	.71	—
Skjeivik, Norway, 1920	—	.65	.78	—
Deerness, Orkneys, 1966	—	.55	.70	1.35
Sjoonovaagen, Norway, 1920	—	.68	.84	1.00
Oslofjord, Norway, 1974	.47	.49	—	—
Gjervalbottn, Norway, 1920	—	—	.68	—
Heroy, Norway, 1917	—	—	.76	—
Kvaroy, Norway, 1920	—	—	.83	—
Scarborough, England, 1951	—	.70	.81	—
Kilboghavn, Norway, 1920	—	.60	.60	—
Bergen, Norway, 1931	.57	.60	.74	—
Millport, Scotland, 1958	.50	.55	—	—
Oban, Scotland, 1850s	—	—	.77	—
St. Andrews, Scotland, 1935	—	.67	.90	—
Molde, Norway, 1968	—	—	.90	1.10
Hammerfest, Norway, 1881	—	—	—	.96
Wadden District				
List, 1951	—	—	—	.86
Schiermonnikoog dike, 1980	—	.60	—	—
Schiermonnikoog marsh, 1980	—	.53	.68	—
'T Hortnje, Texel, 1980	.50	.66	—	—
Harlingen-Zwarte Haan, 1951	—	—	—	1.06
Groninger Wadden, 1941	.37	—	—	—
Den Oever, 1944	.43	.60	.78	—
Het Noorden, fossil	—	.57	.71	—
Lutjeswaard, 1926	—	.57	—	—
Den Helder, 1908	—	.53	—	—
Den Helder, 1932	—	.53	—	—
Den Helder, 1974	—	.70	—	—
Ulrum, 1938	.50	—	—	—
Oudeschild, 1950	—	—	.80	—
Buiten Y, fossil	—	.46	.58	—
Wieringen, 1926	—	—	.62	—
Stavoren, 1920–1929	—	—	.68	—
Southern North Sea				
Wilhelminadorp, 1966	—	.68	—	—
Oostende, 1939	—	.47	—	—
Oostende, 1904	—	.74	—	—
Oostende, 1967	.60	.70	—	—
Oostende, 1936–1937	.57	.70	.79	—

APPENDIX 2. *Continued.*

Locality and date	Size class	Shell thickness (mm)			
		1	2	3	4
Oostende, 1973		—	.60	.62	1.03
Scheveningen, 1909		—	.67	.90	—
Vrouwenpolder, 1916		—	.70	1.12	—
Yerseke, 1946		—	.73	.93	—
Yerseke, 1980		.50	.62	.70	—
Katwijk, 1914		—	.60	—	—
Katwijk, 1916		.55	—	—	—
Terneuzen, 1948		—	.67	.98	—
Strodorppolder, 1980		.50	.58	—	—
Wemeldinge-Kattendijke, 1980		—	.53	.75	—
Blankenberge, 1980		.50	.76	—	—
Blankenberge, 1875		—	—	.84	—
Blankenberge, 1936–1937		—	.78	—	—
Heyst, 1890		—	.59	—	—
Wimmereux, 1920		—	—	1.07	—
Wimmereux, 1914		—	.84	—	—
Vlissingen, 1892		—	.63	.80	—
Vlissingen, 1918		—	.60	.74	—
Wimmereux, 1958		—	.63	.75	—
Denmark					
Vellerup Vig, 1980		.37	.57	.53	—
Hornbaek, 1980		.40	.43	.54	—
Gilleleje, 1980		—	—	.67	—
Flensborg, 1907		—	.53	—	—
Humlebaek, 1888		—	.51	—	—
Dragörhavn, 1888		—	.44	—	—
Grenaa, 1888		—	.44	.80	.77
Frederikshavn, 1888		—	.48	.90	.86
Frederikshavn, 1968		.30	.49	.58	.65
Frederikshavn, 1936		—	.41	.63	—
Gilleleje, 1888		—	.47	.60	—
Hovsörhavn, 1916		—	.51	—	—
Esbjerg, 1888		—	.53	—	—
Hirsholm, 1887		—	—	—	.85
Hirsholm, 1969		—	—	.80	.86
Hirsholm, 1924		—	—	—	1.08
Hundested, 1962		—	—	.61	.80
Vellerup Vig, 1940		—	.39	—	—
Staffansbanke, 1961		—	—	—	.56
Munkholm, 1964		—	—	—	.68
Southwest Europe					
Pobbles Beach, Wales, 1979		.47	.62	.61	—
Dawlish Warren, Devon, 1976		—	.56	—	—
Plymouth, Devon, 1976		.80	1.50	1.11	1.92
Menai Bridge, Wales, 1958		—	—	—	1.04
Clorelly, Devon, before 1910		—	—	—	1.79
Ilfracombe, Devon, 1896		.50	.60	—	—
Downderry, Cornwall, 1935		—	.76	1.03	—
Arcachon, France, 1953		—	.60	—	—
Santander, Spain, 1963		—	.67	—	—
Ile d'Aix, France, 1973		—	.73	1.10	1.40
Lough Foyle, Eyre, 1959		—	—	.66	—
Dafunda, Portugal, 1872		—	—	.80	1.07
Le Croisic, France, 1887		—	1.36	1.33	1.77
Granville, France, 1891		—	—	1.05	—
Roscoff, France, 1922		—	—	.90	—
Le Havre, France, 1946		—	.58	.73	—

1, 10–14 mm size class, 2, 15–19 mm size class, 3, 20–24 mm size class; 4, 25 mm size class.

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Influence of trematode infections on *in situ* growth rates of *Littorina littorea*

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The influence of various species of digenean trematodes on the *in situ* growth rate of *Littorina littorea* (Gastropoda: Prosobranchia) from different habitats was investigated. The main results showed: (1) that infections either reduced or had no significant effect on growth in comparison with uninfected snails; (2) that the same type of infection could have a differential effect on growth depending on the habitat/population from which the snails originated. These findings are consistent with the life history hypothesis expecting no or a stunting effect of trematode infections on the growth of longer-lived snails, but do also emphasize that growth rates following trematode invasion can be significantly modified by environmental conditions, such as, food availability.

INTRODUCTION

Since Wesenberg-Lund (1934) reported that trematode infected snails attained a larger size than uninfected specimens (gigantism), there has been much controversy regarding the effect of trematode infection on snail growth. Several studies have provided evidence of increased growth rates among infected specimens (Rothschild & Rothschild, 1939; McClelland & Bourns, 1969; Meuleman, 1972; Sluiters et al., 1980; Wilson & Denison, 1980; Mouritsen & Jensen, 1994; Gorbushin, 1997) whereas others have shown no or a stunting effect of trematode infections (Sturrock & Sturrock, 1970; Sousa, 1983; Crews & Yoshing, 1989; Fernández & Esch, 1991). In view of these discrepancies, Fernández & Esch (1991) have questioned that parasite-induced growth increment takes place *in situ* mainly because mark–recapture field studies have failed to show gigantism in infected specimens, and because laboratory studies on the same host–parasite association have reached contradictive conclusions. They suspect that evidence of parasite-induced gigantism from laboratory work is a result of providing the snails with *ad libitum* food supply. However, Mouritsen & Jensen (1994) argued that their laboratory evidence of gigantism in *Hydrobia ulvae* could be extrapolated to the field, supported also by Huxham et al. (1995). The decisive field evidence for gigantism in *H. ulvae* is, however, presented by Gorbushin (1997). In several populations from the White Sea, he was able to identify winter lines on the shells of *Hydrobia*, and could therefore measure directly and accurately annual growth rates of infected and uninfected specimens. This work shows that several species of trematodes do induce enhanced growth in *Hydrobia*, and hence, confirms that gigantism is a naturally occurring phenomenon.

However, it still remains to be clarified why many studies have reached contradictive results regarding the effect of parasites on snail growth. Sousa (1983) who reviewed the subject, suggested that whether or not gigantism evolves following trematode infection depends on the particular life history of the snail. Believing that gigantism is basically an energetic question, he expected that the obligatory castration of the infected snail released energy previously allocated to reproduction. Longer-lived iteroparous snail species may invest less energy in reproduction on an annual basis than shorter-lived semelparous species, and the latter should therefore develop gigantism because the castration would release enough energy for both parasites and additional growth. In the case of an iteroparous species, however, sufficient energy for both parasites and additional growth would not be released, and such snails might therefore experience no or stunting effect on growth if parasitized. Next to life history variation, other factors may also influence growth rates following parasitic invasion, such as the age of the snail and the species of trematode (e.g. Sousa, 1983; Fernández & Esch, 1991; Gorbushin, 1997). Mouritsen & Jensen (1994) also argued that the balance between energy intake or saving and the energy demand of the parasites following castration should affect growth rates. It was therefore expected that the growth rate of infected specimens is related to food availability within a given habitat, and hence, vary between populations.

It has not yet been clarified whether or not gigantism develops in trematode-infected *Littorina littorea* (L.) neither in the laboratory nor in the field. By using the method of measuring growth rates from growth interruption lines on the snails' shell, the present study aimed at testing two expectations: (1) trematode infection in *L. littorea* as a longer-lived iteroparous snail species have no or a stunting effect on growth, supporting the hypothesis of a life history dependent effect of the parasites; (2) the effect of trematode infection on growth differ between snail populations expected to experience different environmental conditions, including food availability.

MATERIALS AND METHODS

Sampling of snails

Specimens of *Littorina littorea* were collected from three different localities in Denmark, October 1995 (Figure 1). One hundred and fifty-four snails were collected on a west facing stone jetty at Rønbjerg Harbour, in the Limfjord (Rønbjerg population), 109 were collected on a west facing stony beach 3 km south of Rønbjerg Harbour (Trend population), and 164 were obtained from an east facing harbour entrance at Grenå Harbour, the easternmost point of Jutland (Grenå population). Mainly larger individuals were collected in order to maximize the probability of finding infected individuals. Following collection, the snails were immediately brought to the laboratory, measured, and dissected.

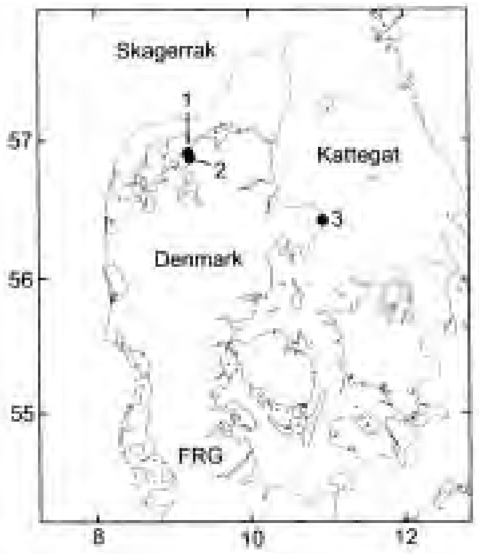

Figure 1. The sites of *Littorina littorea* collection (●): Rønbjerg (1), Trend (2), Grenå (3).

Measurements and dissection

Prior to dissection, the last growth interruption line (winter line) was identified on the shell of each specimen and the shell diameter at this point was determined to the nearest 0.1 mm (d_0; Figure 2). The growth of the shell from the winter line to the rim of the shell aperture was then determined in terms of angle increment with 2° accuracy ($\Delta\varphi$; Figure 2). Measurements were carried out under a stereomicroscope on the vertically orientated snail using an ocular micrometer provided with an angle meter.

Following measurements, the shells were crushed and the specimens sexed according to the presence or absence of a penis. Also the size of the penis was estimated by measuring the length from base to tip under the stereomicroscope. The abdominal soft parts of the specimens were subsequently dissected in order to verify the presence or absence of trematode infections. Parasites were identified to species or genus level according to Werding (1969).

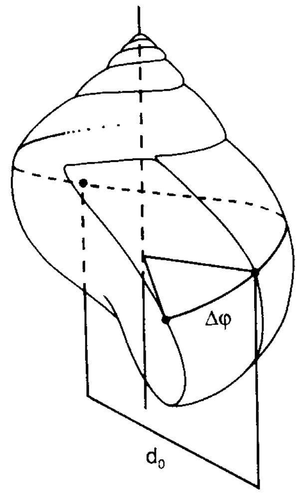

Figure 2. Diagram of shell measurements. d_0 denotes the shell width at the last growth interruption line, $\Delta\varphi$ denotes the angle increment in degrees from d_0 to shell aperture.

Data analysis

Since the growth rate decreases with snail size (see Results), comparison of growth rates between infected and uninfected specimens was carried out by applying a paired *t*-test on pairs of snails with similar shell diameter at the last winter line (d_0). Such pairs were chosen randomly from the data base using a computer algorithm. Where growth rates differed between sexes (the Trend population) only individuals with similar sex were paired, and even numbers of males and females were applied in the analysis of growth rates of uninfected snails.

Statistical analysis were carried out using SPSS (Statistical Package for the Social Science) (Norusis, 1993). Prior to the paired *t*-tests, the assumption of normal distributed differences in growth between pairs of snails was assured. Following Kruskal–Wallis test, *a posteriori* multiple comparisons compensating for experimentwise error-rate were performed according to Siegel & Castellan (1988).

Evaluation of the method

Because angle increment from an identified last growth interruption line on the shell as a measure of growth rate has been applied rarely on gastropods, it may be appropriate to comment on the advantages and disadvantages of this method. In comparison with the usually applied methods measuring changes in shell height (or width) during mark–recapture studies in the field or under controlled laboratory conditions, the present method has several advantages. (1) Measurements of angle increment is considerably more accurate than any measures of growth based on changes in shell height or width, especially when dealing with slow-growing species or specimens. (2) The method avoids artifacts due to parasite-induced shell deformation unrelated to actual growth rate but nevertheless affecting shell height or width (Wesenberg-Lund, 1934; Rothschild, 1936; Sturrock & Sturrock, 1970). (3) It avoids problems with spire erosion that might invalidate

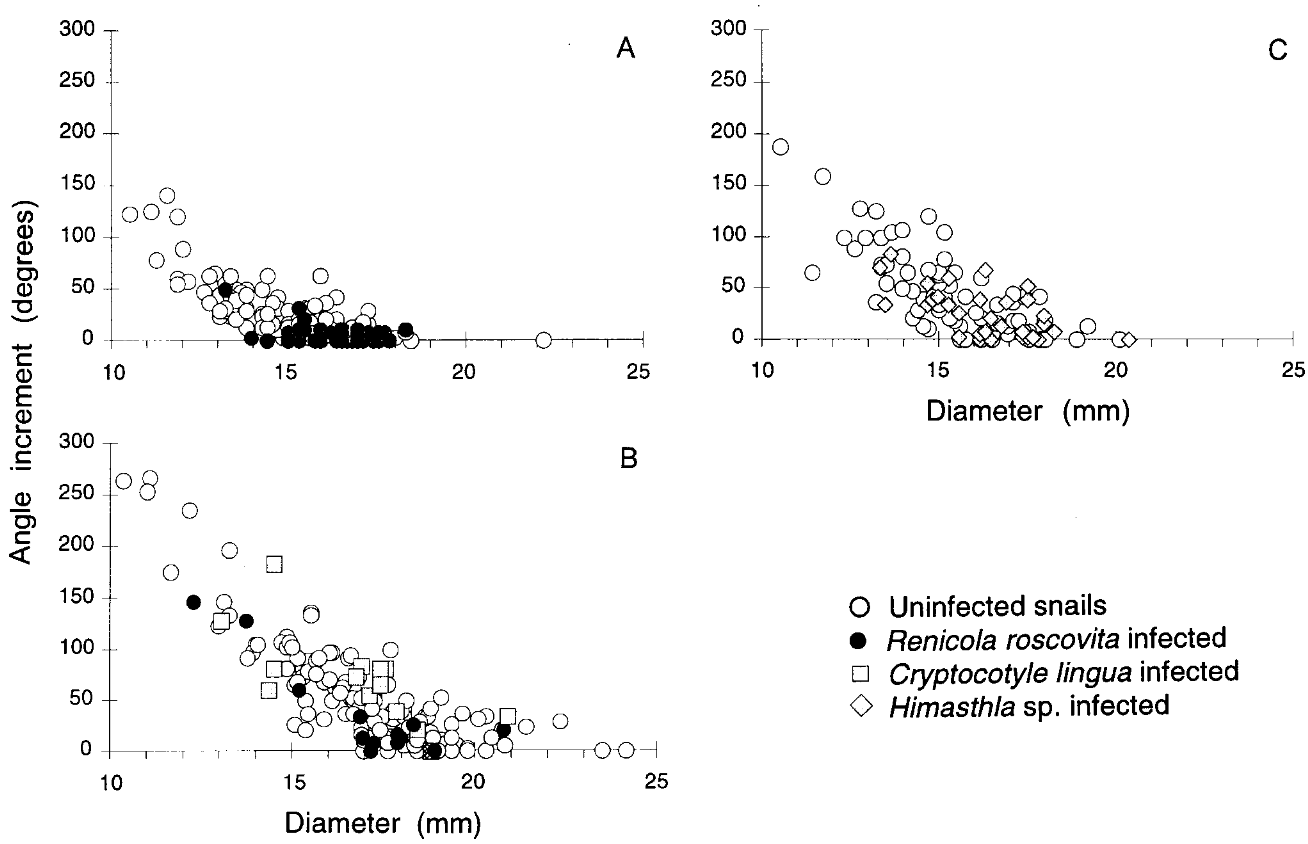

Figure 3. Angle increment ($\Delta\varphi$, degrees) as a function of shell diameter (d_0) for infected and uninfected *Littorina littorea* snails collected at Rønbjerg (A), Grenå (B), and Trend (C).

conclusions in mark–recapture studies where only shell height is measured (see for example Huxham et al., 1993). (4) Measurements of angle increment is easy and time saving, and there will be no problems with low rates of recapture usually experienced in mark–recapture studies. (5) In comparison with laboratory experiments the method benefits from its direct *in situ* approach thereby avoiding artefacts such as unrealistic availability of food (see for example Fernández & Esch, 1991).

Beside the above advantages a disadvantage should also be recognized. The method assumes that all measured specimens have been infected (or uninfected) throughout the period from the formation of the last growth interruption line. If this is not true, it may contribute to a higher variance among infected individuals, which, in turn, may reduce the possibility of demonstrating a significant difference between infected and uninfected snails. The problem is, however, only relevant when no statistical difference can be demonstrated. Regarding the *Littorina* specimens collected in the present study, having ages of usually more than 4 y (see Discussion), the above assumption is reasonable. In populations of longer-lived snails, the trematode-infections seem to accumulate only very slowly (Curtis, 1996), which minimizes the probability that new infections arise during a single growth season or period.

Finally, it should be emphasized that the identification of the last growth interruption line, which is the critical point in using the method of angle increment, has shown to be a reasonably easy task both on *Hydrobia* (Gorbushin, 1997) and *Littorina* shells. That these lines actually represent a period of growth interruption or at least a suitable starting point for growth estimates, is demonstrated by the observation of the overall decrease in angle increment with increasing shell size in both *Hydrobia* and *Littorina* (see Gorbushin, 1997 and Results). Such a negative relationship between growth rate and size is perhaps the most notorious observation in studies of gastropod growth.

RESULTS

Parasite location and host castration

Four different trematode species were encountered during the study. *Renicola roscovita*, *Cryptocotyle lingua*, *Microphallus pygmaeus* and *Himasthla* sp. However, only infections by *Renicola* from Rønbjerg and Grenå, infections by *Himasthla* from Trend, and infections by *Cryptocotyle* from Grenå occurred in sufficiently high frequencies to allow further analysis.

The parasite species were located in the gonad–digestive gland complex usually leaving only a minor part unaffected. One exception was infections by *Renicola*, where the distribution of the orange ball-like masses of sporocysts were often rather restricted leaving large parts of the gonads and the digestive gland free of larval trematodes. However, *Renicola* together with the other encountered trematode species, caused an at least partial

Table 1. Littorina littorea*: summary statistics of paired* t*-tests on the difference between the growth rate of trematode-infected and uninfected snails from the three investigated populations.*

		Growth ($\Delta\varphi$)					
Population	Trematode species	Infected	Uninfected	DIFF	t	df	P
Rønbjerg	*Renicola roscovita*	4.8	17.1	−12.3 ±2.0	6.09	45	<0.001
Trend	*Himasthla* sp.	25.7	32.8	−7.1 ±5.0	1.41	30	0.17
Grenå	*Renicola roscovita*	33.1	34.4	−1.3 ±5.6	0.23	13	0.82
	Cryptocotyle lingua	64.7	56.1	8.7 ±7.9	1.09	14	0.30

$\Delta\varphi$, mean angle increment in degrees (see Materials and Methods); DIFF, mean difference (±SE) in $\Delta\varphi$); t, test-value of the paired t-test; df, degrees of freedom; P, probability of no difference.

castration of the infected hosts in all populations studied, evidenced by significant smaller penis size among infected than among uninfected males (Student's t-test: $t>6.91$, $P<0.001$). Among Grenå snails the mean penis length of uninfected was almost twice the length of infected.

Trematode infection and growth

The growth rates of the snails decreased with increasing shell size in all three populations (Figure 3). The influence of infection on the snails' growth rates differed according to trematode species and snail population. In the Rønbjerg population invasion by *Renicola* caused a significant reduction in growth rates in comparison with uninfected specimens, whereas in the Grenå population this trematode species had no significant effect on growth (Table 1). Also *Cryptocotyle* had no significant influence on the growth of snails from the Grenå population, which applied to *Himasthla* infections from the Trend population as well (Table 1).

The conclusion that *Renicola* infections affect growth rates differently in snails from Rønbjerg and Grenå rests on the evaluation of the paired t-tests carried out on quite different sample sizes ($N_{\text{Rønbjerg}}=46$, $N_{\text{Grenå}}=14$). This imbalance makes it more likely to show a significant effect in the Rønbjerg population than in the Grenå population due to more statistical power in the test of the former. Hence, a type II error is risked by accepting H_0 (no difference) in the Grenå sample. However, a paired t-test carried out on the Rønbjerg sample embracing only 14 pairs as in the Grenå sample still arrives at a significant lower growth rate in infected than uninfected snails ($t_{13}=4.42$, $P=0.001$). Moreover, based on the observed difference (and attached variation) in growth between uninfected and *Renicola* infected Grenå snails (see Table 1), a sample size of 952 pairs of snails had to be included in the test before the effect of the infection can be considered statistically significant. Together, these considerations demonstrates that the observed differential effect of *Renicola* infections between snails from Rønbjerg and Grenå is notable.

Growth of uninfected snails

The growth rates of uninfected snails differed significantly among the three populations (Kruskal–Wallis test: $\chi^2=47.17$, $P<0.001$). Snails from Grenå showed considerably higher growth rates ($\varphi=42°$, 0–135° [median, range], N=101) than uninfected specimens from Trend ($\Delta\varphi=22°$, 0–118°, N=50), and especially, Rønbjerg ($\Delta\varphi=13°$, 0–62°, N=66) ($P<0.05$ for all possible *a posteriori* comparisons). The analysis was restricted to snails between 14 and 19 mm (d_0) where uninfected specimens were reasonably abundant in all three populations studied. The observed difference in growth rates cannot be explained by any difference in skewness of size-distributions within the applied size-class.

DISCUSSION

The life history hypothesis

The present results provides field evidence for the absence of parasite-induced gigantism in *Littorina littorea* by showing that trematodes have no or even a negative effect on the snails' growth rates from three different populations/habitats. The result forms a contrast to the evidence of gigantism in *Hydrobia* spp. infected by species of trematodes from the same genera (*Cryptocotyle* and *Himasthla*) and investigated by the same method (Gorbushin, 1997). Together, these two studies support the life history hypothesis initially presented by Sousa (1983) (see Introduction) who did not find evidence for gigantism in a mark–recapture study of the iteroparous marine snail *Cerithidea californica*.

The evaluation of Sousa's hypothesis strives for at least a reasonably accurate determination of snail longevity. As opposed to the situation in bivalves, direct age-determination of gastropods has so far proven to be difficult or rarely attempted (see Williamson & Kendall, 1981), and estimates of longevity are usually based on the analysis of size–frequency distributions. This may be adequate for the separation of annual and perannual life histories, but not appropriate for longer-lived species. In support of his hypothesis, Sousa (1983) mentioned *Hydrobia ulvae* as a semelparous short-lived species. Based on size–frequency analysis, *H. ulvae* has a longevity of 1–3 y depending on habitat (Chatfield, 1972; Fish & Fish, 1974; Wolff & de Wolff, 1977; Barnes, 1990; Mouritsen & Jensen, 1994). However, using the presence of winter interruption lines on the *Hydrobia* shell, Gorbushin (1997) arrived at longevities of 3 and 4 y in a Danish and a White Sea population, respectively. Hence, *H. ulvae* cannot be considered a semelparous species although its longevity is obviously much less than the 8–10 y given for *Cerithidea californica* in Sousa's study. Regarding the longevity of *Littorina littorea*, only little has been reported. Moore (1937) arrived at 5+ y in a population at Plymouth, in general agreement with Hughes & Answer (1982) mentioning 4.5+ y in a population from north Wales. In captivity specimens of *L. littorea* has attained ages of up to 20 y (Woodward, 1913). These numbers are generally in accordance with growth interruption lines found on the *Littorina* shell. In the White Sea, *Littorina* spp. are by routine aged according to such lines (see Sergievsky et al., 1991; Granovitch, 1992), and similar lines can be found on *L. littorea* also in the presently studied Danish populations. Our observations so far indicate that these growth interruption lines can be used in age-determination, and if applied, a major part of the snails collected in this study have ages of at least four (usually more) years. So, *L. littorea* as well as *H. ulvae* can be considered iteroparous species, the former having the largest longevity. Whether or not gigantism develops within a given snail species should therefore merely be viewed as a probability in the continuum between shorter-lived and longer-lived species. The former being more likely to develop gigantism when infected than the latter under the general assumption that longevity and annual energy investment in reproduction are negatively related.

Whereas the observations by Sousa (1983) on *C. californica* combined with ours on *Hydrobia* and *Littorina* support the life history hypothesis, the apparent absence of gigantism *in situ* in the semelparous freshwater snail *Helisoma anceps* (Fernández & Esch, 1991) is difficult to reconcile with this hypothesis. As discussed below, several factors may interfere with the potential growth rates of infected snails, and some of those could be relevant also to the mark–recapture study of *H. anceps*. Moreover, Miksys & Saleuddin (1987) found that castration actually accelerated growth rates in the closely related *H. duryi*, which suggests that the *H. anceps*-example may be a special case (see Gorbushin, 1997 for an alternative approach reconcilable with the *H. anceps*-example).

The effect of habitat

Snail life history is not the only factor that influences the growth rates of snails following trematode infection. Snails at different ages or infected by different trematode species may respond differently (Sousa, 1983; Fernández & Esch, 1991; Gorbushin, 1997), and food availability can also be expected to affect the growth rates of infected individuals (Fernández & Esch, 1991; Mouritsen & Jensen, 1994). The latter is now supported by Gorbushin (1997) showing that the growth of infected *Hydrobia* can be mediated by competitive interactions. Mouritsen & Jensen (1994) also argued that to the extent that food availability was important, the effect of parasites on growth rates might not be exclusively species-specific but also vary between subpopulations of the same species. This prediction has received support regarding *Hydrobia* (Gorbushin, 1997), and the importance of a habitat/population dependent effect is further evidenced by the present results showing that *L. littorea* infected by *Renicola roscovita* grew at a lower rate than uninfected snails at Rønbjerg, whereas no difference was found between *Renicola* infected and uninfected snails at Grenå.

Food seems to be a limited resource to *L. littorea*, that often subsist under intraspecific explorative competition (Hylleberg & Christensen, 1977a, who also studied the Rønbjerg population). Hence, the discrepancy between Rønbjerg and Grenå regarding the growth of infected snails could be due to differences in the abundance of food or in the time available for feeding. This is tentatively supported by the much higher growth rate at Grenå than at Rønbjerg of uninfected snails. Grenå and Rønbjerg are east and west facing habitats, respectively, and since the prevailing wind direction in Denmark is westerly, Rønbjerg is considerably more exposed to wind-induced wave-action than the more sheltered Grenå-habitat. Such environmental difference between habitats is likely to affect the time available for feeding in optimal microhabitats. On exposed shores *Littorina* snails regularly have to abandon optimal feeding sites in order to avoid wave-induced dislodgement (Boulding & Van Alstyne, 1993). On a seasonal basis this should produce growth rates below the potential for the habitat. It has to be acknowledged, however, that between-habitat differences in the growth of littorinoids are influenced by a number of factors other than just food availability (Hylleberg & Christensen, 1977b; Johannesson, 1986; Boulding & Van Alstyne, 1993; Reid 1996, and references therein). Additional studies are therefore necessary before it can be clarified whether food availability is a main reason for the differential effect of trematode infection on growth rates between different populations of *L. littorea*.

Future studies

Since it is documented that parasite-induced gigantism is a naturally occurring phenomenon and that growth rates following parasitic castration depend among other things on host species and habitat, further field studies may contribute only little to the evaluation of the validity of the life history hypothesis. The relative amount of energy allocated to growth and reproduction along the axis of snail longevity should within the frame-work of life history theory at least initially be genetically embodied (Stearns, 1992). Hence, the critical test of Sousa's hypothesis should show that, following parasitic castration, shorter-lived snails have an inherent ability to grow at a faster rate than longer-lived species under also optimal conditions. This is best done in the laboratory under controlled conditions (including access to *ad libitum* food) thereby excluding confounding effects of various environmental factors.

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Common periwinkle, *Littorina littorea*

Background

The common periwinkle, *Littorina littorea* (Linnaeus 1758*),* is one of about a dozen species of *Littorina* in the western Atlantic (Turgeon et al. 1998) and, together with *L*. *saxatilis* and *L*. *obtusata*, is among three species found in the northwest Atlantic north of New Jersey. *Littorina littorea* occurs in the eastern Atlantic as well, from northern Russia to northern Spain (Jackson 2005)*.* Not to be confused with the common periwinkle, *Vinca minor*, a creeping evergreen perennial vine with the same common name, *L*. *littorea* is also known as the wrinkle-winkle, edible periwinkle and European periwinkle (http://www.gso.uri.edu/maritimes/Text_Only/99Winter/text/carlton.htm). The latter name is in reference to the common assertion that this snail is of European origin, having been introduced by colonists and first reported in Nova Scotia about160 years ago (Morris 1975). It is documented that during this time period the periwinkle spread rapidly southward to southern New Jersey (Jacobson & Emerson 1971) and northward to Labrador (Morris 1975). However, sub-fossil and recent genetic evidence (Wares et al. 2002; Cunningham 2006) indicate that this species has been in continuous residence in North America for at least 8000 years and thus is not a result of human-mediated introduction. Rather, it is thought that ecological interactions of some type limited geographical distribution prior to the 19th century.

Today *L*. *littorea* is the most abundant of the three species occurring in New England and Canadian waters. Among these, it is also the largest one, attaining a height of up to 52 mm (Jackson 2005). Unlike the two other species, it is found at all intertidal levels on predominantly rocky shores (Brinkhurst et al. 1975). It also occurs subtidally but at increasingly lower densities to a depth of 40-60 m (Gowanloch and Haynes 1926, Jackson 2005). At least in the more northern areas of occurrence *L. littorea* tends to migrate up the shore as temperatures rise in spring and down the shore in fall to reduce exposure to sub-zero temperatures (Jackson 2005). *Littorina littorea* is an herbivore grazing on algae, favouring *Ulva lactuca* and *Enteromorpha intestinalis* and other foliose ephemeral green algae but rejecting others, such as the fucoid *Ascophyllum nodosum* (Watson 1985) favoured by *L*. *obtusata* (Trussell 1997).

Periwinkles reproduce sexually and fertilization is internal. Reproduction can take place throughout the year in parts of their range. However, the length and timing of the breeding period are heavily dependent on climatic conditions. Mating peaks in late spring or early summer. In contrast to the direct development of *L. obtusata* and *L. saxatilis*, individuals of *L. littorea* hatch from eggs that are shed directly into the sea on several separate occasions. Eggs are contained within capsules, each 1 mm capsule containing 2-9 eggs, 1-2 eggs being most common. Egg release is synchronized with spring tides (Fish 1979), with a maximum female fecundity of circa 100,000 eggs for a large female. Eggs of *L. littorea* hatch as a planktonic veliger larval stage (Fish 1979) that eventually settles on the bottom in late spring/early summer (Gardner 1987). The duration of the pelagic phase is primarily temperature dependent, lasting from 2-6 weeks and allowing a dispersal potential exceeding 10 km. Maturity is reached within 2-

3 years and the life span is estimated up to 5-10 years (Jackson 2005), with most living to 3 years and 20 mm shell height (Sharpe 1998). Males tend to mature earlier than females which mature at a smaller size (Jackson 2005).

Fishery

The common periwinkle is sold as a delicacy at fish markets primarily in Europe, but increasingly in North America (Jacobson & Emerson 1971). *Littorina littorea* can be found often at densities of 200-500 individuals per square meter in open coast and estuary habitats (Menger & Branch 2001). Considered a supplemental or casual fishery, specimens are obtained through hand gathering or mechanical harvesters and, depending on size, fetched between $1.76 and 1.00 per kg in Atlantic Canada in the late 1990's (Sharpe 1998). Within the area including Labrador to Cape Hatteras annual landings remained below 500 metric tons during the 1960's to early 1980's. However, this fishery has become increasingly important as harvesting approached 1500 tons in the late 1990's in Canadian waters alone (http://marvdc.bio.dfo.ca/pls/vdc/mwmfdweb.auth). Principal areas of fishery are the Gulf of Maine (NAFO area 5), coats of Bay of Fundy and southern Nova Scotia (NAFO 4X), and Gulf of St. Lawrence (NAFO 4S,4T). The common periwinkle is a considerable by-catch in the recently expanded rockweed fishery (Sharpe 1998).

Temperature limits

As an intertidal species *L. littorea* experiences dramatic temperature differences (Sandison 1967, Murphy 1979, Murphy & Johnson 1980, Chase & Thomas1995, Hamby 1975) from sub-zero temperatures to above 30ºC that can be experienced in upper shore rock pools (Jackson 2005). This is more or less confirmed by SST's based on the current northwest Atlantic distribution of *L. littorina*, that range from a February minimum of -2.1ºC to an August maximum of 25.8^{o}C. While the growth rate is reduced at temperatures above about 20ºC, the species is likely less affected by long term increases in temperature than most other species. Our overall sensitivity analysis correspondingly ranks this species as relatively invulnerable, only the limited mobility compared to fish preventing it from having the lowest sensitivity ranking. Similarly, a temperature sensitivity analysis (http://www.marlin.ac.uk/species/Adult_senexp_Littorinalittorea.htm#_Temp) indicates that adults of *L. littorea* are 'not sensitive' to changes in temperature, with only a 'low' 'intolerance' effect level that may reduce viability of a population but not kill it. That analysis also predicts 'immediate' recoverability when conditions improve. Compared to adults, the intolerance level of larvae is elevated to 'intermediate' status.

Impacts

When compared to other species in this investigation, sea surface temperature change associated with a 4ºC rise in global temperature will likely have a limited impact on the future distribution of *L. littorea* in the western Atlantic. Results from all four models under both scenarios agree in a predicted loss in the southern range of the species. All models predict a loss in thermal range at some distance south of Cape Cod, with only the GFDL model showing some loss north of Cape Cod in the Northumberland Strait area of the southern Gulf of Saint Lawrence. As there is little or no fishery south of Cape

Cod there is likely limited impact in that regard. However, a northern distributional shift will probably result in a shift of suboptimal fishery conditions of the common the periwinkle from south of Cape Cod to the adjacent Gulf of Maine, where there is harvesting today (http://marvdc.bio.dfo.ca/pls/vdc/mwmfdweb.auth). Thus the climate change scenario could result in a loss of this fishery in US waters. Conversely, all four models predict a northern distributional shift, with a range extension in Canadian waters from southern to northern Labrador that offsets the southern range loss. The habitat along these northern shores is predominantly rocky and thus well within the substrate preference of the species. However, as a predominantly intertidal species, the sea level rise associated with a 4ºC rise in global temperature is likely to have a considerable effect, as that habitat would be altered. The consequences of such habitat changes have not been explored here.

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Utkast til verneplan for våtmarksområder i Sør-Trøndelag fylke

Fylkesmannen i Sør-Trøndelag 1979

Utkast til verneplan for våtmarksområder i Sør-Trøndelag fylke

Fylkesmannen i Sør-Trøndelag

1979

FORORD

Arbeidet med «Utkast til verneplan for våtmarksområder i Sør-Trøndelag» startet i januar 1978. Planen er et ledd i Miljøverndepartementets serie av verneplaner for ulike naturtyper. Verneplanene blir utarbeidet fylkesvis og i regi av fylkesmannen.

Planen bygger på et omfattende registreringsarbeid fra institusjoner og enkeltpersoner, og en lang rekke ulike områder er vurdert. Planen omfatter de våtmarksområdene i Sør-Trøndelag som er av størst betydning for fuglelivet.

Det er holdt møter og befaringer hvor en har hatt kontakt med grunneiere, landbruksmyndigheter og kommuner. Disse kontaktmøtene har gitt verdifulle opplysninger om spesielle forhold i det enkelte område, og en har forsøkt å innpasse dette ved avgrensning av verneområdene og utarbeidelse av vernebestemmelsene for hvert av de aktuelle områdene — så langt dette har vært forenlig med verneformålet.

Konsulent Jon Suul har stått for arbeidet med verneplanen. Sør-Trøndelag fylkeskartkontor har vært behjelpelig med kartmaterialet. Miljøverndepartementet har dekt utgiftene til arbeidslønn og til trykking av planen, mens Sør-Trøndelag fylkeskommune har stilt kontorplass og skrivehjelp til rådighet.

Trondheim, august 1979

Einar H. Moxnes
fylkesmann

Ola Skauge
frilufts- og naturvernkonsulent

INNHOLDSFORTEGNELSE:

INNLEDNING

For 15—20.000 år siden var nesten hele Skandinavia dekket av is. Bare noen få plante- og dyrearter overlevde den siste istida ytterst ved kysten eller på de høyeste fjelltoppene. Etter hvert trakk isen seg tilbake og planter og dyr begynte å vandre inn fra omkringliggende områder. Ulike plantearter fant tilfredsstillende levevilkår i forskjellige områder avhengig av hvilke krav de stilte til jordbunnsforhold og klima. På denne måten ble det dannet løv- og barskoger, myrer og heier. Fugle- og dyrearter stilte ulike krav til terreng og vegetasjon i områder hvor de skulle leve. Dyrelivet kom derfor til å variere i takt med variasjonen i vegetasjon og naturforhold forøvrig.

I flere tusen år levde mennesker her i landet i og av naturen uten å foreta større, uomgjørlige endringer av landskapsbildet eller av plante- og dyrelivet. Etter hvert ble en del områder dyrket opp eller bebygd, men inngrepene i naturen var stadig forholdsvis små. Den tekniske utviklingen de siste hundre årene har imidlertid gitt vår generasjon nesten ubegrensede muligheter til totalt å omforme landskapsbildet og til å gjøre store og uopprettelige naturinngrep. Dette har fått skjebnesvangre følger for en lang rekke plante- og dyrearter. De artene som er knyttet til sjeldne naturtyper er særlig utsatt, mens andre arter får sine leveområder sterkt begrenset.

Samtidig som den tekniske utviklingen har gitt menneskene store muligheter, har den også gitt oss et betydelig og stadig økende ansvar for naturen og våre medskapninger der. I formålsparagrafen i naturvernloven av 19. juni 1970 heter det derfor:

> «Naturen er en nasjonalverdi som må vernes. Naturvern er å disponere naturressursene ut fra hensynet til den nære samhørighet mellom mennesket og naturen, og til at naturens kvalitet skal bevares for fremtiden. Enhver skal vise hensyn og varsomhet i omgang med naturen. Inngrep i naturen bør bare foretas ut fra en langsiktig og allsidig ressursdisponering som tar hensyn til at naturen i fremtiden bevares som grunnlag for menneskenes virksomhet, helse og trivsel».

I samsvar med dette vil det nå i all fysisk planlegging måtte settes forholdsvis klare krav om at det skal tas naturvernmessige hensyn. Dette er nødvendig både for å bevare spesielle naturtyper og for å gi planleggingen en bredde som tar rimelig hensyn til de langsiktige perspektivene i naturressursforvaltningen som naturvernloven forutsetter.

Det er enkelte naturtyper som det i dag er et særlig stort press på. Det er et tilsvarende stort behov for å få en oversikt over hvor store ressurser vi har av disse naturtypene og for å finne ut hvordan ressursene best kan forvaltes for framtiden. Blant disse naturtypene står i dag spesielt en del våtmarksområder i en særlig utsatt stilling.

Miljøverndepartementet har bedt fylkesmannen i Sør-Trøndelag om å foreta en registrering av våtmarksområdene i fylket og å prioritere de områdene i Sør-Trøndelag som bør bevares for ettertiden. Resultatet av arbeidet legges fram i dette verneplanutkastet.

VÅTMARKSOMRÅDER OG DERES VERDI

Våtmark er et nytt begrep i det norske språk og omfatter langt mer enn det vi umiddelbart forbinder med ordets oppbygning: våt mark. Ordet er oversatt fra det engelske «wetlands», jamfør også det svenske «våtmarker». Begrepet «våtmark» er definert som alle oversvømte eller vannmettede områder enten de er naturlige eller kunstige, permanente eller midlertidige, og om vannet er stillestående eller flytende, ferskt, brakt eller salt. Dette vil bl.a. omfatte naturområder som:

- myrer av alle slag
- elvedelta, elvemunninger og grunne og stilleflytende elvestrekninger
- strandenger, fjære- og gruntvannsområder i bukter, sund og laguner ved kysten og i skjærgården
- sumpområder, tjern og grunne småvatn
- grunne bukter og viker i større innsjøer

Ut fra topografiske, hydrologiske og biologiske kriterier er det derfor er uhyre uensartet utvalg av miljøer som her er stilt sammen. Den eneste fellesnevner er at vann i en eller annen form er til stede og i avgjørende grad preger miljøet. Vann er hovedkomponenten, og det er grunnlaget for det mangfoldige og ofte særpregede plante- og dyrelivet som forekommer i tilknytning til våtmarksområdene. Mange biologer har derfor oppfattet våtmarker som et noe kunstig begrep. I ornitoligisk sammenheng vil det på mange måter være svært hensiktsmessig å bruke, fordi en rekke fuglearter er gjennom hele sin livssyklus avhengige av våtmarker i videste forstand, selv om de gjennom året kan pendle mellom de mest forskjellige miljøer: hekkeplasser på myrer og ved skogstjern, rasteplasser under trekket i frodige mudderviker og sumper, overvintringsområder på eller langs sjøen. Derfor ser vi da også at våtmarksbegrepet er blitt benyttet særlig i forbindelse med ornitologi, selv om det etter hvert er i ferd med å gli inn også i andre sammenhenger.

Våtmarksområdene har mange og viktige funksjoner i naturen. Som eksempler kan nevnes at:

- de ofte har stor produksjon av plantemateriale som skaper grunnlag for et rikt og variert dyreliv
- de er voksested for en del særpregede eller sjeldne plantearter
- de er gyte-, oppvekst- og leveområder for en rekke fiskearter, amfibier og krypdyr

— de er hekke-, beite-, hvile-, raste-, myte-, trekk- og overvintringsplasser for en lang rekke fuglearter. Mange av disse er gjennom hele livet knyttet til våtmarksområder mens andre er knyttet til slike områder i perioder. De fugleartene som er særlig knyttet til våtmarksområder benevnes gjerne som vannfugler. Mange av artene er sjeldne og kravfulle. Vannfuglbegrepet omfatter bl.a. andefugl, vadefugl, lom, dykkere, storkefugler, riksefugler m.fl. (se også tabell 2)
— de er tilholdssteder for flere pattedyrarter — f.eks. kaste- og beiteplasser for sel, yngle- og leveområde for oter, beiteplasser for elg, leveområde for bever m.fl.
— de ofte har stor kapasitet til å lagre vann slik at de kan bidra til å jevne ut flomtopper
— de kan virke som naturlige renseanlegg
— de utgjør ofte vakre landskapselementer
— de kan være attraktive rekreasjonsområder
— de kan ha stor verdi for forskning og undervisning

Det kan være en rekke motiver for å ville verne våre våtmarker. Motivene kan deles inn i fire hovedgrupper:

A. De *økologiske* motivene tar utgangspunkt i våtmarkenes funksjon i naturen som helhet. Våtmarkene er vesentlige for naturens vannhusholdning og kan ha en betydelig renseeffekt. En reduksjon av våtmarksarealet kan derfor få uheldige og utilsiktede konsekvenser. Våtmarkene er ofte viktige produksjonsområder for plantemateriale. Dette utnyttes av planteetende dyr som igjen blir føde for kjøttetende dyr. Mange av disse plante- og dyreartene er spesielt tilpasset livet i forskjellige våtmarksmiljøer. Slike begrensede og spesielle miljøer kan ofte finnes innenfor et større og topografisk variert våtmarkssystem. Dersom våtmarksarealet innskrenkes, vil en del av disse spesielle miljøene kunne bli ødelagt. Dermed vil en del arter kunne forsvinne fra større eller mindre områder, kanskje endog bli utryddet.

   Når en art blir borte fra et område, vil ikke dens funksjon i naturen umiddelbart kunne erstattes av en annen. Vår kjennskap til de enkelte artenes funksjon i helhetsbildet er imidlertid begrenset. Det er derfor vanskelig å forutsi hvilke konsekvenser utryddelse av en art vil kunne få, men den balansen naturen selv har funnet fram til gjennom årtusener, vil kunne bli forrykket.

B. Til de *etiske* motivene hører spørsmålet om hvilken rett menneskene har til ikke bare å utnytte plante- og dyrearter, men også til å redusere deres mulighet for å overleve eller endog til å utrydde dem. Et annet spørsmål er med hvilken rett den nålevende generasjonen reduserer mangfoldet i den naturen som skal være de kommende generasjoners livsmiljø. Dagens mennesker kan neppe hevde å ha slike rettigheter. Dermed blir det en moralsk plikt for oss å sørge for at alle arter sikres muligheter for å overleve og å sørge for at naturens mangfold blir bevart i størst mulig utstrekning.

C. Til de *kulturelle* motivene hører erkjennelsen av at variasjon og mangfold i naturen bidrar til å øke menneskenes opplevelsesrikdom. Mange våtmarksområder, både sjøer, tjern og myrer, skaper liv i landskap som ellers er preget av store skog-, jord-eller fjellstrekninger og gjør disse områdene mer attraktive for rekreasjonsformål enn de ellers ville ha vært. Andre våtmarksområder er i seg selv naturperler som kan være inspirasjonskilde eller motiv for både kunstnere og andre. Naturen er med all sin variasjon og formrikdom egentlig en del av vår kulturarv som vi har et forvalteransvar for.

D. De *økonomiske* motivene kan være direkte eller indirekte. Til våtmarksområdene hører moltemyrer, tjern og sjøer med gode fiskebestander og myr- og strandstrekninger med ande- og vadefuglarter og annet jaktbart vilt. Den totale produksjonen i våtmarksområder kan ofte sammenlignes med utbyttet på dyrket mark målt i kilo kjøttvekt. Disse ressursene blir gjerne høstet over et stort område. Store våtmarksområder fungerer med andre ord både som «rugekasser» og «spisskamre» for småvilt, også for jaktbart vilt.

Våtmarksområder er en begrenset naturressurs. Inngrep i slike områder bør derfor bare foretas når dette synes riktig ut fra en langsiktig og allsidig ressursdisponering.

Rundt om i hele landet har mange våtmarksområder mistet mye av sin verdi på grunn av utfylling, tørrlegging, bebyggelse, forurensning, økende trafikk m.v. Også i Sør-Trøndelag har det vært en slik utvikling, og en del verdifulle områder er gått tapt. Imidlertid finnes det i fylket stadig en rekke ulike våtmarksområder, og flere av disse har betydelig verneverdi.

Arbeidet med å bevare de viktigste av disse våtmarksområdene har betydning langt utover den enkelte kommunes og fylkets grenser. Det er et ledd i et systematisk arbeid for å sikre et representativt utvalg av disse områdene for framtiden, og for å sørge for at planter og dyr som er knyttet til våtmarksområder skal kunne overleve. Dette arbeidet foregår på 3 nivåer:

a. Miljøverndepartementet arbeider for å bevare et representativt utvalg av karakteriske eller spesielt verdifulle våtmarksområder i Norge.

b. De nordiske lands naturvernmyndigheter samarbeider med sikte på å bevare et nett av våtmarksområder i Norden.

c. En internasjonal konvensjon om vern av våtmarksområder og vannfugl (Ramsarkonvensjonen) ble tilrådt av Norge i 1974. Konvensjonen forplikter de land som undertegner den til å sikre landets viktigste våmarksområder og til å forvalte disse ut fra allsidige og langsiktige hensyn.

De våtmarksområdene som kan bevares ved hjelp av fredning etter naturvernloven, vil utgjøre bare en meget liten prosentdel av landets våtmarksarealer. Det er derfor viktig at den enkelte grunneier og den enkelte kommune i sin arealdisponering tar hensyn til våtmarksområdene og de spesielle verdier som er knyttet til dem.

KLASSIFISERING AV VÅTMARKSTYPER

Med den store variasjon det er i våtmarkstyper kan det være nødvendig med en kort grovinndeling. Den følgende inndeling er også benyttet i tabell 5, når det gjelder vurderte våtmarksområder i fylket (jfr. NOF-våtm.utv. 1977).

A. *Våtmarker på fastlandet*

1. *Myr*
   Her inngår alle typer myrområder — både torv- og grasmyrer. Disse kan være vannrike og bløte og/eller tørre. Sumpområder og små dammer kan inngå.
2. *Elver/bekker*
   Her inngår alle typer. Viktigst i våtmarkssammenheng er stilleflytende, svingete («meandrenende») partier med loner og sumpområder.
3. *Næringsfattige vann og innsjøer*
   Ferskvann blir gjerne klassifisert gjennom det biologiske produksjonsnivå i en glidende overgang fra næringsfattige (oligotrofe) via middels næringsrike (mesotrofe) til næringsrike (eutrofe) innsjøer. Det er næringsgraden (trofigraden) som blir lagt til grunn, og oligotrof eller eutrof er derfor ikke eksakte begrep, men til en viss grad gjenstand for skjønn. Derfor er ikke begrepene i seg selv tilknyttet bestemte plantearter eller -samfunn, men mer til hvor mye plantemateriale som blir produsert. Næringsfattige vann er således karakterisert ved lav biologisk produksjon.
4. *Middels næringsrike vann og innsjøer*
   Jfr. pkt. 3.
5. *Næringsrike vann og innsjøer*
   Gjennom rik tilgang på næringssalter fra bunnmasser og omgivelser (kloakk og tilsig fra landbruksområder) er dette områder med særlig høy biologisk produksjon. I Sør-Trøndelag utgjør slike områder en sparsom naturtype.
6. *Myrvann*
   Dette er vann med lite eller ingen utskifting og med tilsig av sterkt brunfarget, humusrikt og surt myrvann. Typen kalles også dystrofe vann.

7. *Midlertidige vannansamlinger*
Selv om regnværsperioder og snøsmelting kan sette områder under vann for kortere eller lengre tid, er denne type våtmarker av relativt liten betydning i vårt land, sammenlignet med de store områder av midlertidige vannansamlinger som kan dannes i andre verdensdeler.

8. *Kunstige vannansamlinger*
Herunder inngår vannbassenger med relativt stabil vannstand (f.eks. vannreservoar) for vannforsyning, vannbassenger med store vannstandsvariasjoner (kraftverksmagasin o.l.), dammer og små bassenger (fiskedammer, mølledammer o.l.) og vannings- og dreneringssystemer. Disse har totalt sett liten betydning i våtmarkssammenheng i vårt land. De to sistnevnte kan imidlertid være av lokal betydning.

B. *Våtmarker ved kysten/i skjærgården og i lukkede farvann*

9. *Tidevannssonene*
Her inngår alle typer av havstrender fra sandstrand til svaberg og klipper. Området er sterkt påvirket av tidevannsvariasjonene. I tidevannssonen finner en noen av landets viktigste våtmarksområder. Totalt sett utgjør tidevannssonene store arealer i vårt land. Disse områdene har høy biologisk produksjon.

10. *Gruntvannsområdene*
Også de grunne kystområdene er viktige for den biologiske omsetningen i sjøen. I disse øvre områdene hvor lysintensiteten er god og strømningsforhold og tilgang på næring er gunstig, er det biologiske produksjonsnivået opp mot det høyeste en kjenner. De grunne sjøområdene langs Norskekysten er totalt sett vår viktigste og arealmessig største våtmarkstype.

11. *Dypere fjorder*
Områdene har begrenset betydning i våtmarkssammenheng.

12. *Grunne tidevannsbukter i lukkede farvann*
Her inngår grunne, beskyttede områder som tørrlegges ved lavvann. Områdene henger gjerne sammen med pkt. 13.

13. *Grunne bukter og våger i lukkede farvann*
Her inngår grunne, beskyttede områder som ikke tørrlegges ved lavvann.

14. *Ferskvanns- og brakkvannsbukter i lukkede farvann*
Der ferskvannstilførselen er stor, kan en få brakkvanns- og til dels ferskvannsbukter. Slike blandingssoner mellom ferskvann og saltvann kan ha meget store variasjoner innen de forskjellige miljøfaktorene i løpet av året og gjerne over korte tidsrom. Disse områdene kan være meget viktige i biologisk sammenheng.

15. *Grunne strømmer*
Herunder inngår grunne sund og strømmer som f.eks. forbinder større, åpne sjøområder eller fjorder med lukkede farvann. Disse områdene kan være svært produktive i biologisk sammenheng.

16. *Laguner*
Denne type er lite utbredt i Norge.

C. *Elvemunninger*

17. *Estuarier*
Dette er også en naturtype som bare finnes i beskjeden utstrekning i Norge. Med begrepet menes et delvis innestengt munningsområde for en eller flere elver hvor det foregår en gradvis uttynning av sjøvann. I de fleste tilfeller vil også tidevannsskiftninger spille inn. Løsmassene i de sentrale deler av et estuar består for en vesentlig del av mudder, og de markerte strømskiftningene som dels skyldes tidevannet, dels elvestrømmen, gjør at det i et estuar ikke bygges opp de markerte avsetningssoner som kjennetegner et delta. Et estuar får delvis tilførsel av næringsstoffer med elvevannet, dels via tidevannet fra sjøen, og dette skaper et meget fruktbart miljø. De kraftige vekslingene i forskjellige miljøfaktorer setter imidlertid store krav til de planter og dyr som skal kunne leve her, og den lavere fauna i et estuar er preget av liten artsvariasjon, men til sine tider meget stor individtetthet. Den biologiske produksjon i et estuar er beregnet å ligge opp imot det høyeste nivå en kjenner, 10—25 kg plantestoff pr. dekar og dag.

18. *Deltaområder*
Et delta er avsetningsområdet for løsmasser fra et vassdrag. Til forskjell fra et estuar foregår det her en kontinuerlig utbygging av landområder, og med markerte soneringer og sjiktninger av løsmassene i finere eller grovere materiale. Et aktivt delta er under stadig forandring, med oppbygging av ører og flate sand- og grusholmer, skifting av elveløp og etter hvert overgang til strandenger på de løsmasseavsetningene som kommer over det midlere høyvannsnivå. De ytre deler av deltaet er preget av langgrunne tidevannssoner og gruntområder

i sjøen. Også et delta må betraktes som et høyproduktivt område. I fjordbotnene langs Norskekysten var opprinnelig elvedeltaene et meget viktig landskapselement, de fleste heller små, men også en del store. Få andre våtmarkstyper har imidlertid vært så utsatt for inngrep fra menneskene, og i dag er en lang rekke av disse deltaområdene nedbygde og ødelagte. Dette kan illustreres godt ved situasjonen i Trondheimsfjorden. Av opprinnelig 6 større elvedelta i indre deler, med elvene Orkla, Gaula, Nidelva, Stjørdalselva, Verdalselva og Byaelva/Figgja, er det i dag bare Gaula som er intakt. Namsens utløp er også ødelagt. Det samme gjelder svært mange andre større norske elver.

D. *Landarealer langs sjøen*

19. *Holmer og skjær*
Selv om det på en del av disse områdene ikke foregår biologisk produksjon av betydning, og en del av områdene ikke kan klassifiseres som våtmark, kan de likevel være meget viktige våtmarkselementer i kraft av sin ofte intime sammenheng med produktive våtmarksområder (bl.a. er de gjerne hekkeplasser for flere arter vannfugler og sjøfugler, men fyller også andre funksjoner).

20. *Ulike strandsoneområder*
Dette omfatter landområder i umiddelbar tilknytning til tidevannssonen og delvis under direkte påvirkning av sjøvann under høyvannssituasjoner og under spesielle værforhold. Disse grensesonene mellom sjø og land får tilført en vesentlig del av næringsstoffer, bl.a. driftmateriale (tang, tare) som blir vasket på land og som gjennom nedbrytning skaper grunnlag for en meget høy omsetning i vegetasjonssonene på grensa mellom fastmark og åpen strand. På flate og mer beskyttede løsmassepartier finner en her de forskjellige strandengsamfunn, varierende fra fuktige strandsumper til tørrere enger, og gjerne med overgang til fukteng og ferskvannssump over springvannssonen. På mer eksponerte steder med løsmasser er det gjerne sandstrendene som dominerer, og om stranden ligger gunstig til for framherskende vindretninger og de rette plantearter er til stede, kan det dannes dynelandskap i bakkant av stranden der vegetasjonen fanger opp og binder sand som blåser opp fra stranden. Disse to strandsonetypene er likevel av mer beskjeden utstrekning i Norge. Dominerende over lange strekninger er her svaberg og knauser sammen med steinstrender av forskjellig slag.

VÅTMARKSAREALER I SØR-TRØNDELAG FYLKE

Konkrete talloppgaver over de ulike våtmarksområdenes areal i Sør-Trøndelag eller ellers i landet kan vanskelig framskaffes. Til det er kunnskapen om arealressursene i landet for dårlig i dag. Derfor kan en bare benytte grove angivelser.

Ved Landsskogstakseringen 1919—1939 ble det samlede myrarealet *under skoggrensen* beregnet til 2.346.000 da i Sør-Trøndelag, ved revisjonen 1954—64 ble myrarealet *under barskogsgrensen* beregnet til 1.171.800 da og ved Skogbrukstellingen 1967 ble myrarealet under barskogsgrensen beregnet til 1.233.834 da. Alle disse tall er beheftet med usikkerhetsmomenter, tallene fra 1919—30 ansees noe for høye og de sistnevnte fra 1967 som mest usikre blant fagfolk. I tillegg kommer myrarealet over skoggrensen som det ikke foreligger brukbare beregninger av, disse arealene er i Sør-Trøndelag ikke ubetydelige. Ifølge Miljøstatistikk 1978 utgjør ferskvannsarealet i Sør-Trøndelag fylke 956 km^2. Arealoppgaver over andre typer våtmarksområder forefinnes ikke. Tenker en på våtmarker på land vil disse totalt sett utgjøre små arealer i tillegg til det som inngår under myr og ferskvann. I tabell 1 har en antydet det samlede våtmarksareal på land i Sør-Trøndelag.

Tabell 1. *Totalareal og våtmarksarealer på land i Sør-Trøndelag fylke.*

Totalareal	18.831 km^2
Myrareal under skoggrensen	ca. 2.000—2.300 km^2
Myrareal over skoggrensen anslåes lavt til	ca. 800—1.000 km^2
Ferskvannsareal o.a.	ca. 950—1.000 km^2
Samlet	ca. 4.000 km^2

Når det gjelder våtmarksarealene langs kysten og i fjordene definerer Ramsar-konvensjonen våtmarksbegrepet slik at det omfatter gruntvannsarealer i sjøen ned til 6 meters dyp på fjære sjø. Også grunne sjøarealer på noe større dyp (ned til 20 meter og endog dypere) kan ansees som våtmark — særlig der disse henger sammen med større sammenhengende gruntvannsarealer/fjæreområder. Å komme fram til tallmessige arealoppgaver for disse våtmarksområdene er meget vanskelig. Fastlandet i fylket har en total strandlinje på 1164 km mens øyenes totale strandlinje med stort og smått utgjør hele 3890 km. Samlet 5054km. Utenfor denne lange strandlinje finnes ulike våtmarkskomponenter. Imidlertid berører de særlig viktige våtmarksområdene bare en liten del av den totale strandlinje.

VÅTMARKENE I SØR-TRØNDELAG OG DERES BETYDNING FOR FUGLELIVET

Våtmarksområder av ulike slag dekker totalt sett ca. 20 % (jfr. tabell 1) av Sør-Trøndelags landareal og i tillegg betydelige sjø- og fjærearealer langs kysten. Det er et stort antall fuglearter som benytter seg av disse områdene under hekking, trekk og overvintring, og som er avhengige av dem for å kunne overleve. I særlig grad gjelder dette ulike vannfuglearter. De særlig viktige våtmarksområdene utgjør en begrenset del av det totale våtmarksarealet, og de fungerer som:

— hekkeplasser
— beiteplasser for fugl som hekker i omgivelsene
— oversomringsplasser for ikke forplantningsmodne fugler
— hvile- og rasteplasser i trekktidene
— overvintringsplasser
— myteplasser for andefugler
— overnattingsplasser o.a.

Fuglenes trekk til og fra vinteroppholdssted har vært fortolket på ulike måter gjennom tidene og flere sider av fugletrekket er stadig uløste. Trekket kan beskrives som en trekkbevegelse og en snakker forenklet sett om trekkveier/trekkruter.

Langs kysten av Sør-Trøndelag går en viktig trekkvei for vannfugl o.a. fuglearter, denne trekkveien er en del av hovedtrekkåren langs Europas kyster fra/til hekkeområdene i nord til/fra overvintringsplassene i sør. En lang rekke fuglearter benytter det nett av viktige våtmarker som ligger langs denne trekkruten. I internasjonal sammenheng er flere av disse områdene gått tapt og andre er truet. Noen er sikret, og det arbeides i mange land med sikring av nye områder. F.eks. har bl.a. også Norge bidratt med økonomiske midler til innkjøp av det velkjente Marismasområdet i Sør-Spania hvor en del av den norske grågåsbestanden o.a. norske vannfugler overvintrer. De trekkende vannfuglene er en internasjonal naturressurs som ikke kjenner landegrenser. Det er derfor et internasjonalt ansvar å verne om dem, og det krever nasjonale tiltak for vern av arter og av områder (jfr. Ramsarkonvensjonen). De fylkesvise våtmarksplanene som nå utarbeides her i landet, er derfor å betrakte som et ledd i disse bestrebelsene.

Trekkveien langs kysten vår har en meget viktig sidegren som går langs Trondheimsfjorden fra/mot øst. Kysttrekkveien og denne knyttes sammen omkring Ørlandet.

Tabell 2. *Oversikt over antall fuglearter av ulike fuglegrupper som er registrert pr. 1/1-79 i Norge og i Sør-Trøndelag.*

Fugleorden	Funnet i Norge med Svalbard og Jan Mayen			Funnet i Sør-Trøndelag		
		Herav vannfugl			Herav vannfugl	
	Reg. tot.	tot.	hekkende	Reg. tot.	tot.	hekkende
Lommer	4	4	2	4	4	2
Lappedykkere	5	5	3	4	4	1(2?)
Stormfugler	8			4		
Pelikanfugler	5	1	1	3	1	1
Storkefugler	13	13	1	5	5	1
Flamingoer	1	1		1	1	
Andefugler tot.	44	44	31	35	35	19
herav gjess	10	10	7	7	7	3
ender	31	31	22	25	25	16
svaner	3	3	2	3	3	
Rovfugler	22	7	4	14	4	3(4?)
Hønsefugler	8			8		
Tranefugler tot.	12	10	6	6	6	4(6?)
herav traner	2	2	1	1	1	1
trapper	2					
rikser	8	8	5	5	5	3(5?)
Vade-, måse- og alkefugler tot.	87	62	35	59	41	26(27?)
herav vadere	52	52	29	35	35	22(23?)
måser	28	9	5	18	5	3
alker	7	1	1	6	1	1
Duefugler	7			5		
Gjøkfugler	3			2		
Ugler	12	1	1	9	1	1
Natteravner	1			1		
Seilere	3			1		
Råkefugler	4	1	1	3	1	
Spettefugler	8			8		
Spurvefugler	153	20	14	95	13	8
Totalt	400	169	99	267	116	66

I tillegg har en sekundære trekkveier langs de større dalførene fra Østlandet og nordover til Trøndelag, og fra det indre av Trøndelag langs dalførene ut til Trondheimsfjorden og kysten. Langs disse «dreneres» trekket til hovedtrekkrutene.

Mens det ved fjorden og langs kysten i særlig grad er fjære- og gruntvannsområder samt lavereliggende ferskvann som fungerer som hvile- og rasteplasser, er det mer næringsrike vatn, sumpområder og deltaområder som er særlig viktige i denne sammenheng i innlandet.

I trekkperiodene er der et meget stort antall fugl som passerer over Sør-Trøndelag. Det gjelder arter som hekker i fylket, og det gjelder arter som kommer langveis fra på vei sør- eller nordover til eller fra hekkeplassene i høyfjellet, i Nord-Skandinavia og Sibir eller i polarstrøkene.

Vel halvparten av de mange vannfuglene som er registrert i Sør-Trøndelag er påvist hekkende i fylket (se tabell 2). I hekkeperioden er ulike vannfugler avhengige av ulike våtmarksområder for skjul av reir, egg og unger og for å finne mat til seg og sitt avkom. Reirplass og beiteplass henger i flere tilfeller ikke sammen. Foreldrene søker ofte ut i våtmarker i omgivelsene for å finne næring. Hekketiden er en kritisk tid da mange forskjellige faktorer er avgjørende for formeringsresultatet.

Ved kysten av Sør-Trøndelag hekker mange vannfugler, og holmer og skjær i tilknytning til fjære- og/eller gruntvannsområder samt strandeng- og strandsumpområder kan være viktige hekkeområder. Ved kysten hekker vannfugler og sjøfugler gjerne sammen i kolonier (sjøfuglbegrepet overlapper vannfuglbegrepet noe), og flere av artene har hatt næringsmessig betydning og har vært en viktig del av kystkulturen.

I lavlandet ved kysten og fjordene og i nedre deler av dalførene er landskapet mest kulturpreget. I disse områdene er en del vegetasjonsrike ferskvann og sumpområder av særlig viktighet for hekkende vannfugler. De samme områdene vil gjerne også være viktig under trekktidene og før isen legger seg.

I innlandet og i fjellet har en rekke vatn, tjern og myrområder betydning som hekkeplasser. Særlig gjelder dette mer næringsrike vatn og sumpområder og varierte myrkomplekser rike på smådammer og sumpområder. I høgfjellet vil flere hardføre vannfuglarter finne hekkeplasser ved grunne sjøer og elveoser.

Etter hekketiden — hovedsaklig i slutten av juli — foregår fjærfellingen hos andefuglene. I denne myteperioden mister de armsvingfjærene og er da ikke fly-

Tabell 3. *Funksjonsmessig fordeling av vannfuglartene som utnytter våtmarksområdene i Sør-Trøndelag.*

Tegnforklaring: H = hekking, VT = vårtrekk, HT = høsttrekk, M = myting (andefugl), O = overvintring, R = regelmessig forekomst, U = uregelmessig eller sjelden forekomst.

Fuglegruppe	Antall arter reg.	Områdene utnyttes under: H		VT		HT		M	O	
		R	U	R	U	R	U	R	R	U
Lommer	4	2		4		4			3	1
Lappedykkere	4		1	2	2	2	2		2	2
Pelikanfugler	1	1		1		1			1	
Storkefugler	5	1		1	2	1	4		1	
Flamingoer	1				1					
Andefugler	35	16	3	21	8	21	10	14	13	9
herav gjess	7	2	1	3	2	3	3	2	1	2
ender	25	14	2	17	4	17	5	12	11	7
svaner	3			1	2	1	2		1	
Rovfugler	4	2	1	2	2	2	2		1	1
Tranefugler	6	2	2	2	4	2	4			2
herav traner	1	1		1		1				
rikser	5	1	2	1	4	1	4			2
Vade-, måse- og alkefugler	41	24	2	24	12	32	7		5	9
herav vadere	35	20	2	20	11	28	6		3	9
måser	5	3		3	1	3	1		1	
alker	1	1		1		1			1	
Ugler	1	1		1		1				1
Råkefugler	1						1			1
Spurvefugler	13	7	1	5	5	5	1		1	
Samlet	116	56	10	63	36	72	31	14	27	36

vedyktige. Flere arter samles i denne tiden på bestemte steder — gjerne i større flokker. Disse myteområdene ligger slik til at fuglene har god oversikt og eventuelt godt skjul og gode næringsmuligheter. Slike områder kjenner en både ved kysten og i innlandet. I Sør-Trøndelag gjelder det særlig større sammenhengende gruntvannsområder, større elveoser, flere ferskvann og større myrområder. I mytetiden er fuglene svært sårbare.

Mange av sommerens og trekktidens fuglearter forlater oss utover høsten og returnerer ikke før neste sesong. Imidlertid blir en del av artene tilbake om vinteren sammen med fugl som kommer ned fra høgfjellet og nordfra. Disse vannfuglene er avhengig av isfrie våtmarksområder hvor de kan finne føde i den vanskelige vintertiden. Da norskekysten ved Golfstrømmens «varme» vannmasser er isfri om vinteren, og det finnes gunstige oppholdsplasser som gir rikelig næringstilgang, utgjør en del våtmarksplassområder ved vår kyst viktige overvintringsplasser for en rekke vannfugler. Disse vil for en stor del falle sammen med viktige trekkområder, forskjellen er at områdene har betydning for ulike arter gjennom året. Områder i Trondheimsfjorden og utenfor kysten av Sør-Trøndelag har internasjonal betydning som overvintringsområder for flere arter.

Våtmarkene i Sør-Trøndelag utfyller også andre funksjoner for vannfuglene — en kan nevne overnattingsplasser og vaskeplasser. Dessuten har områdene i skiftende grad betydning som beite-, hekke- og trekkplasser for andre fuglearter enn de som inngår under vannfuglbegrepet.

For å verne om vannfuglbestanden i Sør-Trøndelag vil det være nødvendig å sikre et utvalg av de viktigste våtmarksområdene i fylket. Dette vil også ha nasjonal og internasjonal betydning.

REGISTRERING AV VÅTMARKSOMRÅDER I SØR-TRØNDELAG

En fullstendig oversikt over alle forskjellige våtmarksområder i Sør-Trøndelag når det gjelder fysiske, biologiske og andre forhold er det umulig å sette sammen. Framskaffelse av en slik oversikt ville være meget arbeidskrevende og er umulig innen overskuelig framtid når en ser på tidsforbruk, kostnader og kvalifiserte fagfolk.

Likevel finnes det adskillig kunnskap innen forskjelligartede sektorer som geologi, hydrologi, botanikk og zoologi når det gjelder naturforhold i fylket. Det er også nær sammenheng mellom de ulike fagområdene — f.eks. mellom et områdes fysiske og biologiske forhold og mellom ulike biologiske faktorer. Det vil bl.a. være sammenheng mellom vegetasjon og fugleliv. Registreringer av fuglelivet i et våtmarksområde vil derfor også fortelle en del om området og dets vegetasjon. Når det gjelder våtmark er kanskje særlig fuglene gode indikatorer på den biologiske betydning de ulike områdene har. Nettopp registreringen av fuglelivet kan oftest gjennomføres enklere enn når det gjelder andre biologiske forhold. De fleste vannfuglene er av en viss størrelse og holder til i bestemte vannmiljø og er derfor lettere observerbare.

Totalt sett må det kunne sies at kunnskapen/datamengden når det gjelder våtmarker og vannfugl i Sør-Trøndelag, er god og bedre enn for andre naturtyper. Gjennom en årrekke har interesserte enkeltpersoner foretatt mer eller mindre regelmessige registreringer i ulike våtmarksområder i fylket. Denne virksomheten er blitt mer organisert etter hvert og utføres særlig av medlemmer av Norsk Ornitologisk Forening. I de senere årene er det blitt utført en rekke registreringsarbeider bl.a. som oppdrag fra Miljøverndepartementet, kommuner og andre institusjoner i samband med f.eks. generalplanarbeid, naturvernregistreringer for Landsoversikten for vern av naturvernområder og forekomster, vasskraftutbyggingsplaner, forskning m.v. I 1973 ble rapporten «Oversikt over viktige våtmarker i Norden» publisert for Nordisk Råd. Denne ga en oversikt over en del av de viktigste våtmarkene i Norden som til da var kjent. For Sør-Trøndelag ble der tatt med: Ørlands våtmarkssystem og Havmyrene på Hitra. Etter denne tid har det tilkommet adskillig kunnskap.

I samband med verneplanarbeidet i Sør-Trøndelag som startet i 1978 ble det samme år utført en rekke suplerende registreringer i områder som tidligere var dårlig dekt. Topografiske kart i målestokk 1:50.000 og flyfoto ble gjennomgått, og det samme ble tidligere materiale innsamlet i 1974 som grunnlag for «Vernekatalog 1976» utgitt av Sør-Trøndelag fylke. Dette er er rapport om frilufts- og naturvernområder registrert i fylket til da. Dessuten er all tilgjengelig litteratur gjennomgått, og det er tatt kontakt med lokalkjente personer rundt om i fylket. Data innsamlet i samband med NAVF-stipendiet: «Klassifisering og verdisetting av våtmarksområder» (Jon Suul) er benyttet, og det samme gjelder NOF avd. Sør-Trøndelags rapportarkiv.

Totalt er data for om lag 200 forskjellige — større og mindre — lokaliteter vurdert i sammenheng med dette planarbeidet. Det foreliggende registreringsmaterialet synes å gi et godt grunnlag for å foreta en prioritering av de mest verdifulle våtmarksområdene i fylket i dag.

I naturen foregår det stadig endringer, disse kan være naturlige eller påvirket av menneskets ulike inngrep og handlinger. Det er derfor mulig at enkelte våtmarker som nå har en relativt liten betydning for vannfuglene etter hvert kan få økende betydning — f.eks. ved en viss gjødsling av enkelte ferskvann.

VURDERING AV VÅTMARKSOMRÅDENES VERNEVERDI

Verdisetting av våtmarksområder er blitt foretatt på ulike områder gjennom forskjellige verneforslag og prosjekter. I internasjonal sammenheng er det utarbeidet kriterier for verdisetting av ulike våtmarker. Dette arbeidet har pågått over lengre tid og gjennom flere prosjekter. De internasjonale vernekriterier for våtmark er i hovedsak basert på kjennskap om og vurdering av vannfuglfaunaen (se bl.a. Szijj 1971, DOF 1975, Nilsson 1976 og 1978). I Norge hvor de fysiske og topografiske forhold er noe forskjellig fra resten av Europa og de sørligere land som fungerer som trekk- og vinteroppholdsplasser for mange av de nordlige vannfuglbestandene, vil de kriterier som legges til grunn for verdisetting og prioritering måtte justeres for våre forhold. De kriterier som er benyttet i denne planen er utarbeidet av Folkestad og Suul (in. prep.), og disse baseres på kjennskap om og vurdering av vannfugl og våtmarker i vårt eget land. I dette arbeidet har en vurdert verneverdi og prioritering av de ulike områdene ut fra:

1. *Artssammensetning/mangfoldighet:*
   — antall ulike fuglearter/hvilke arter som benytter området. Det bli lagt særlig vekt på vannfuglfaunaen (antall hekkende, trekkende, overvintrende, mytende arter)
   — antall individer av hver art og totalt for alle artene som benytter området til forskjellige tider av året

2. *Truede og representative arter og livsmiljøer:*
   — om kravfulle eller sjeldne fuglearter benytter området, dvs. arter med spesielle miljøkrav og/eller arter som bare finnes i små og ofte utsatte/sårbare bestander
   — om området består av en eller flere spesielle, sjeldne eller representative våtmarkstyper i landet, fylket eller sin del av fylket

3. *Andre kriterier:*
   — områdets *funksjoner,* i generell biologisk sammenheng og spesielt for vannfugl
   — områdets *størrelse* og geografisk *beliggenhet*
   — områdets *sammenheng* med andre våtmarker/våtmarkssystem
   — områdets *naturtilstand,* dvs. påvirkningsgrad av ulike inngrep og forstyrrelser

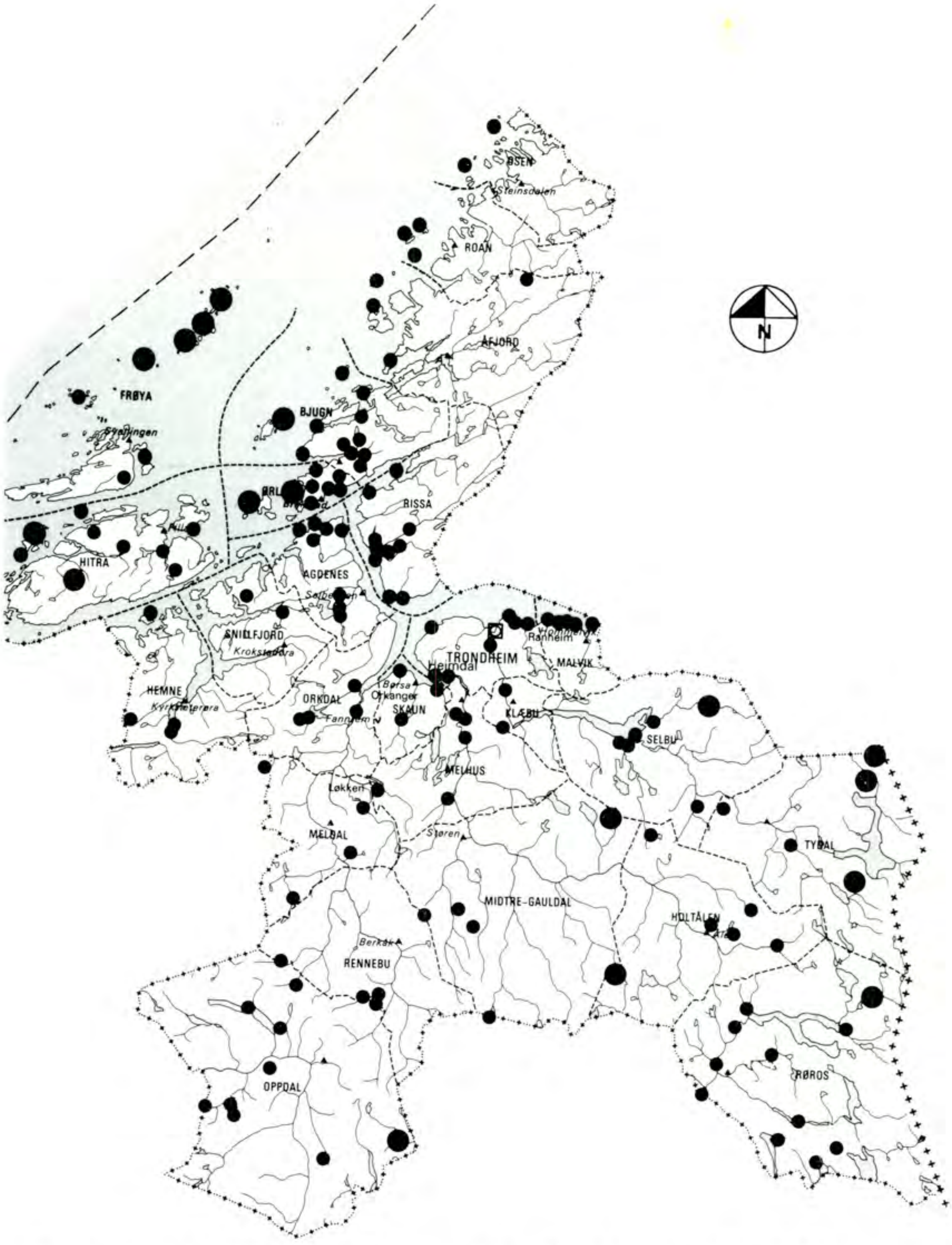
Alle disse momenter forteller noe om det aktuelle områdets naturtype, dets biologiske betydning og betydningen for vannfuglene i særdeleshet. Tallmessige oppgaver om fuglelivet spiller en vesentlig rolle ved verdivurderingene. Samlet gir disse data den kvalitative og kvantitative informasjon som gjør det mulig å prioritere de ulike områdene etter skalaen 1—5 som vist i tabell 4. I tillegg må nevnes at det ved vurderingen også i noen grad er lagt vekt på:

— andre naturfaglige verneinteresser i området
— områdets landskapsmessige verdi og egenart
— områdets kulturhistoriske verneinteresser
— om området har betydning som rekreasjonsområde.

Tabell 4. *Prioritering av områdene og forslag om tiltak*

Prioritet	Verdivurdering	Aktuelle tiltak
1	Svært verneverdig område, av internasjonal verneverdi	Vern i henhold til lov om naturvern: naturreservat
2	Meget verneverdig område, av nasjonal verdi	Vern i henhold til lov om naturvern: naturreservat, landskapsvernområde, fuglefredningsområde
3	Verneverdig område, av regional verneverdi (fylke/landsdel)	Vern i henhold til lov om naturvern: naturreservat, landskapsvernområde, fuglefredningsområde
4	Verneverdig område, av lokal verneverdi	Hensynstagen ved planlegging etter bygningsloven, skogvernloven, jaktloven etc.
5	Lite verneverdig område, uten verneverdi	Ingen

I tabell 5 finnes en oversikt over 139 ulike områder som er vurdert i samband med denne planen. Disse områdene er alle vurdert å tilhøre gruppene 1—4 i tabell 4. I tillegg er vurdert en rekke områder tilhørende gruppe 5 — se ovenfor. Tilsammen er omlag 200 områder vurdert.



Figur 1. *Oversikt over vurderte våtmarksområder i Sør-Trøndelag fylke — jfr. tabell 5.*

Tabell 5. *Oversikt over områder som er vurdert i sammenheng med våtmarksplanarbeidet i Sør-Trøndelag.*

Tegnforklaring:
Rubrikken «Naturtype(r)» følger inndelingen 1—20 beskrevet under kapittelet om klassifisering av våtmarkstyper (se side 11).

Funksjon for vannfugl:
H = Hekkeplass
T = Hvile-/rasteplass i trekktidene
O = Overvintringsplass
M = Myteplass

Andre verneinteresser:
A = Ferskvannsbiologiske (aquatiske) interesser
B = Botaniske interesser
F = Friluftsinteresser
G = Geologiske interesser
K = Kulturhistoriske interesser
L = Landskapsestetiske og naturtypeinteresser
P = Pattedyrinteresser (elg, oter, bever, sel)
S = Sjøfuglinteresser

Rubrikken «Prioritering» følger tabell 4:
1 = Internasjonal verneverdi
2 = Nasjonal verneverdi
3 = Regional verneverdi
4 = Lokal verneverdi

Nr.	Lokalitetsnavn	Kommune	Natur-type(r)	Funksjon for vannfugl	Andre verne-interesser	Priori-tering
1.	Røstøya	Hemne	9, 10, 19	THO	FL	4
2.	Gåsøran	Hemne	18	T		4
3.	Hyllvatna	Hemne	1, 3	H		4
4.	Stormyra	Hemne	1, 2	HT	B	4
5.	Jamtøya m.m.	Snillfjord	9, 10, 19	H	F	4
6.	Nesvatnet	Snillfjord	3/4	T		4
7.	Nervatnet	Snillfjord	4	H	L	4
8.	Mølnbukta	Agdenes	9, 10, 19	TO		4
9.	Utheim-Strand	Agdenes	9, 10	TO		4
10.	Litlvatnet	Agdenes	2, 5	THM	BAL	2

Nr.	Lokalitetsnavn	Kommune	Natur-type(r)	Funksjon for vannfugl	Andre verne-interesser	Priori-tering
11.	Storvatnet	Agdenes	3/4	HT	BAL	3/4
12.	Selvabukta	Agdenes	9, 10	TO		4
13.	Utnesvatnet	Agdenes	1, 4	HT		4
14.	Frostadvatnet	Agdenes	3/4	T		4
15.	Fiskløysa	Agdenes	4	HT	L	4
16.	Gjølmesørene	Orkdal	2, 9, 20	THO	B	3/4
17.	Melandsumpen	Orkdal	5	HT	BAL	4
18.	Svorkmyra	Orkdal	1, 2, 18	HT	BL	3
19.	Jakobsmyrene	Orkdal	1, 2, 3, 6	H		4
20.	Lomtjørna	Orkdal	1, 8	H		4
21.	Litlbumyran	Meldal	1, 2, 3, 8	HT	BLK	3
22.	Bjognan	Meldal	1, 2, 3, 6	H		4/3?
23.	Fossjøen	Meldal	3	HT		4
24.	Minilldalsmyra	Rennebu/ Oppdal	1, 2, 6	H	BL	3/4?
25.	Gisna	Rennebu/ Oppdal	2	HT		4
26.	Slettestjørna	Rennebu	1, 6	HT	BL	3
27.	Gryta	Oppdal	1, 2	H		4
28.	Stormyra	Oppdal	1, 2, 6	H	B	4/3
29.	Stangmyra	Oppdal	1	H		4
30.	Morkamyra	Oppdal	1	H		4
31.	Rauøra	Oppdal	2, 3	T	F	4
32.	N. Snøfjelltjørn	Oppdal	3/4	HT	ALK	2
33.	S. Snøfjelltjørn	Oppdal	3	H	L	4
34.	Dindalsvatna	Oppdal	3	HT	L	4
35.	Orkelkroken	Oppdal	1, 2, 3, 6	HT	L	3/4?
36.	Vetlevonene	Oppdal	1	H	L	4/3?
37.	Flonan	M. Gauldal	1, 6	HT		4
38.	Holtvatna	M. Gauldal	1, 2, 4	HT	BL	3
39.	Gåstjørnan	M. Gauldal	1, 3, 6	HT	GL	3
40.	St. Hiåsjøen m/omg.	M. Gauldal/ Tynset	1, 2, 3, 18	H		3?
41.	Hukkelvatna/ Flomyrene	M. Gauldal	1, 2, 3, 6	HT	BLK	3
42.	Fordalen	M.G./Holtål.	1, 2	HT	L	3?
43.	Nålsjøene	Holtålen	1, 2, 3, 6	HT		4
44.	Langtj. m.m.	Holtålen	1, 3	HT		3/4?

Nr.	Lokalitetsnavn	Kommune	Natur-type(r)	Funksjon for vannfugl	Andre verne-interesser	Priori-tering
45.	Holdsjødeltaet	Holtålen	2, 3, 18	H		3/4?
46.	Flangtjønna	Holtålen	6	HT		4
47.	Ormtjørnomr.	Holtålen	1, 2, 3, 6	H		3/4
48.	Gaulhåen	Holtålen	1, 2, 3	HT		3/4?
49.	Molinga	Røros	1, 2, 3, 18	HT	BL	2
50.	Glomma v/Glåmos	Røros	2	TO	P	3/4
51.	Glomma v/Sundet	Røros	2	T		4
52.	Havsjøen	Røros/Os	2, 3	T	L	4
53.	Grunnsjøen	Røros	3	HT		4
54.	Haugatjørnan	Røros	4	T	A	4
55.	Hyllingen m.m.	Røros	1, 2, 3, 6	HT	BGLK	2
56.	Stortj./Langen	Røros	1, 4	HT		4
57.	Stormyra	Tydal	1, 6	HT	B	4
58.	Kjølen	Tydal	1, 6	HT	B	3/4
59.	Sankkjølen	Tydal	1, 2, 6	H	B	4
60.	Rangledalen	(Tydal)/ Meråker	1, 2, 6	H	L	3/4
61.	Håen	Tydal	2	T		4
62.	Evsjøen	Selbu	1, 2, 3	HT		4
63.	Roltdalen	Selbu	1, 2	H	BL	4
64.	Stråsj./Prest-øyan/Kvern-fjellvatna	Selbu	1, 2, 3, 4, 6	HT	BLK	2
65.	Garbergøyene	Selbu	2, 18	HT	L	4
66.	Neaoset m.m.	Selbu	2, 18	TO	L	3/4
67.	Låen	Selbu	5	HTM	BL	3
68.	Fitjan	Selbu	2, 7, 18	HT	BL	3
69.	Målsjøen	Klæbu	4	HT	U	4/3
70.	Nidelva v/Tiller	Klæbu	2	TO		4
71.	Flatholmene	Malvik	9, 20	HTO	F	4
72.	Rota-Midtsand	Malvik	10	TO	F	4
73.	Storsand-Malvikodden	Malvik	10	TO	BF	4
74.	Malvikbukta	Malvik	10	TO	F	4
75.	Saksvikbukta	Malvik	10	HTO	F	4

Nr.	Lokalitetsnavn	Kommune	Natur-type(r)	Funksjon for vannfugl	Andre verne-interesser	Priori-tering
76.	Vikhamarbukta	Malvik	10	TO	F	4
77.	Værebukta	Trondheim	9, 10	TO	F	4
78.	Ranheimsfjæra	Trondheim	9, 10	HTO	F	4
79.	Grilstadbukta	Trondheim	9, 10	HTOM		3
80.	Leangenbukta	Trondheim	9, 10	HTO	BL	3
81.	Frøsetgrunnen	Trondheim	10, 19	TOM	F	4
82.	Steinshylla — N. Muhle	Trondheim	10	TO		4
83.	Deler av Nidelva	Trondheim	2	HTO	L	3
84.	Gaulosen	Trondheim/ Melhus	9, 10, 17, 18 19, 20	HTOM	BGL	2
85.	Svampan	Melhus	5	HT	BAL	4
86.	Hofstadkjela	Melhus	5	HT	BAL	4
87.	Skoldosen	Melhus	1, 2, 4, 18	HT	L	3/4
88.	Buvika	Skaun	9, 10	TO		3/4
89.	Mora-Laugen	Skaun	1, 2, 4, 18	HT	L	4
90.	Børsabukta	Skaun	2, 9, 10	TO		4
91.	Viggjabukta	Skaun	2, 9, 10	TOM		3/4
92.	Prestbukta	Rissa	2, 9, 10	TOM		3/4
93.	Grønningsbukta	Rissa	9, 10, 20	TOM	BL	3
94.	Strømmen	Rissa	14, 20	HTO	BLK	3
95.	Botn/Leira	Rissa	12	HT		3/4
96.	Kvithyll - Uddu	Rissa	9, 10	TO		4
97.	Deler av Skaua	Rissa	2	TO		4
98.	Omr. v/Fevåg	Rissa	9, 10	HTO		4
99.	Dørndalsvatnet	Rissa	3	HT		4
100.	Hovsfjæra — Brekstadfjæra	Ørland	2, 9, 10	TOM		2
101.	Flatnesfjæra	Ørland	9, 10	TOM		3
102.	Grandfjæra m/ Juldagene m.m.	Ørland	9, 10, 19, 20	HTOM	BLS	1
103.	Kråkvågsvaet m/ deler av Stor-fosen/Kråkvåg	Ørland	9, 10, 19	HTOM	BL	2
104.	Utstrand - Inn-strandfjæra	Ørland	9, 10	TO		3
105.	Flyplassumpen	Ørland	1	HT		4
106.	Rusasetvatnet	Ørland	1, 5	HTM	BAL	2

Nr.	Lokalitetsnavn	Kommune	Natur-type(r)	Funksjon for vannfugl	Andre verne-interesser	Priori-tering
107.	Eidsvatnet	Bjugn	4/5	HTM	L	3
108.	Brekkvatnet	Bjugn	4	HT	L	3/4
109.	Botngårdsfjæra	Bjugn	9	TO		4
110.	Kottengvatnet	Bjugn	¾	TO		4/3
111.	Neslandet	Bjugn	9, 10	TO		3/4
112.	Valsneset	Bjugn	9, 10	TO		3/4
113.	Været m.m.	Bjugn	9, 10, 19, 20	HTOM	BSL	2
114.	Sandnesvågen	Bjugn	12	TO		4
115.	Valtjørna	Bjugn	5	THM		4
116.	Lysøysundet	Bjugn	9, 10, 14	TO		4
117.	Asen	Bjugn	9, 10, 19	THOM	SL	3/4
118.	Lauvøya	Åfjord	9, 10	HTO	L	4
119.	Bingholmsråsa	Åfjord	9, 10, 14, 19	TO	L	3
120.	Slåttøy/Stemna	Åfjord	9, 10, 19	HTO	S	3/4
121.	Hosenøyene	Åfjord	9, 10, 18	HTO	S	4
122.	Morkestrand	Åfjord	2, 12	TO		4
123.	Momyrvatnet	Åfjord	1, 4	HT	B	4/3
124.	Måøya	Roan	9, 10, 19	HTOM	SL	4/3
125.	Almenningen	Roan	9, 10, 19	HTOM	SL	4/3
126.	Værøyområdet	Roan	9, 10, 19	HTOM	SL	4/3
127.	Utsiden av Buarøya m. fl.	Osen	9, 10, 19	HTOM	S	4/3
128.	Kårflesa - Grønskjæret	Osen	9, 10, 19	HTOM	S	4/3
129.	Froan	Frøya	9, 10, 19	HTOM	SBL	1
130.	Sula - Mausund	Frøya	9, 10, 19	HTO	S	4/3
131.	Hammarvatnet	Frøya	3/4	TO		4
132.	Grunnenen ved Uttian - Inntian	Frøya	9, 10, 19	TO	S	4/3
133.	Bispøyan	Hitra	9, 10, 19	HTOM	S	3/4
134.	Utsiden av Helsøya m.m.	Hitra	9, 10, 19	HTOM	S	3/4
135.	Utsiden av Dolmøy	Hitra	9, 10, 19	HTOM	S	3/4
136.	Havmyran	Hitra	1, 3, 6	HT	BL	1
137.	Lakselva	Hitra	2	TO		4
138.	Sørseterleiret	Hitra	9	HTO		4
139.	Brattåstjørna	Hitra	4	T		4

VERNEPLAN FOR VÅTMARKSOMRÅDER I SØR-TRØNDELAG FYLKE

Ut fra de registreringer som foreligger og de verdivurderinger og prioriteringer som er foretatt — se foregående avsnitt — foreslås et utvalg av våtmarker, dvs. de viktigste/høyest prioriterte områdene, vernet i medhold til lov om naturvern av 1970 (se tabell 6). Det gjelder 20 områder. I tillegg nevnes 9 andre prioriterte områder (se tabell 7) som av ulike grunner ikke medtas i planen. De 20 områdene som foreslås vernet omfattet totalt 87,17 km^2 landareal, ferskvann, brakk- og saltvann. Areal på land inkludert ferskvann omfatter 31,71 km^2 som tilsvarer ca. 0,75 % av det beregnede våtmarksarealet på land i fylket (se tabell 1) eller 0,17 % av fylkets totale landareal.

Tabell 6. *Prioriterte områder som foreslås vernet i våtmarksplanen for Sør-Trøndelag fylke (jfr. fig. 2)*

Nr.	Lokalitetsnavn	Prioritet	Verneform
1.	Bingsholmråsa, Åfjord	3	F
2.	Eidsvatnet, Bjugn	3	F
3.	Innstrandfjæra, Ørland	3	F
4.	Hovsfjæra, Ørland	2	F
5.	Grandfjæra, Ørland	1	N
6.	Kråkvågsvaet, Ørland	2	F
7.	Litlvatnet, Agdenes	2	N
8.	Strømmen, Rissa	3	F
9.	Grønningsbukta, Rissa	3	N
10.	Gaulosen, Melhus/Trondheim	2	N + L
11.	Svorkmyran, Orkdal	3	N
12.	Litlbumyran, Meldal	3	N
13.	Nordre Snøfjelltjørn, Oppdal	2	N
14.	Holtvatna, Midtre Gauldal	3	N
15.	Gåstjørnan, Midtre Gauldal	3	N
16.	Hukkelvatna, Midtre Gauldal	3	N
17.	Molinga, Røros	3	N
18.	Fitjan, Selbu	3	F
19.	Låen, Selbu	3	N
20.	Stråsjøen — Prestøyan, Selbu	2	N

Tegnforklaring: Prioritering følger tabell 5. Verneformer: F = fuglefredningsområde, L = landskapsvernområde, N = naturreservat (beskrivelse av disse verneformer se under kapittelet: Saksbehandling og forvaltning).

En del av de prioriterte verneobjektene blir av ulike årsaker ikke foreslått vernet i samband med våtmarksplanen for Sør-Trøndelag fylke.

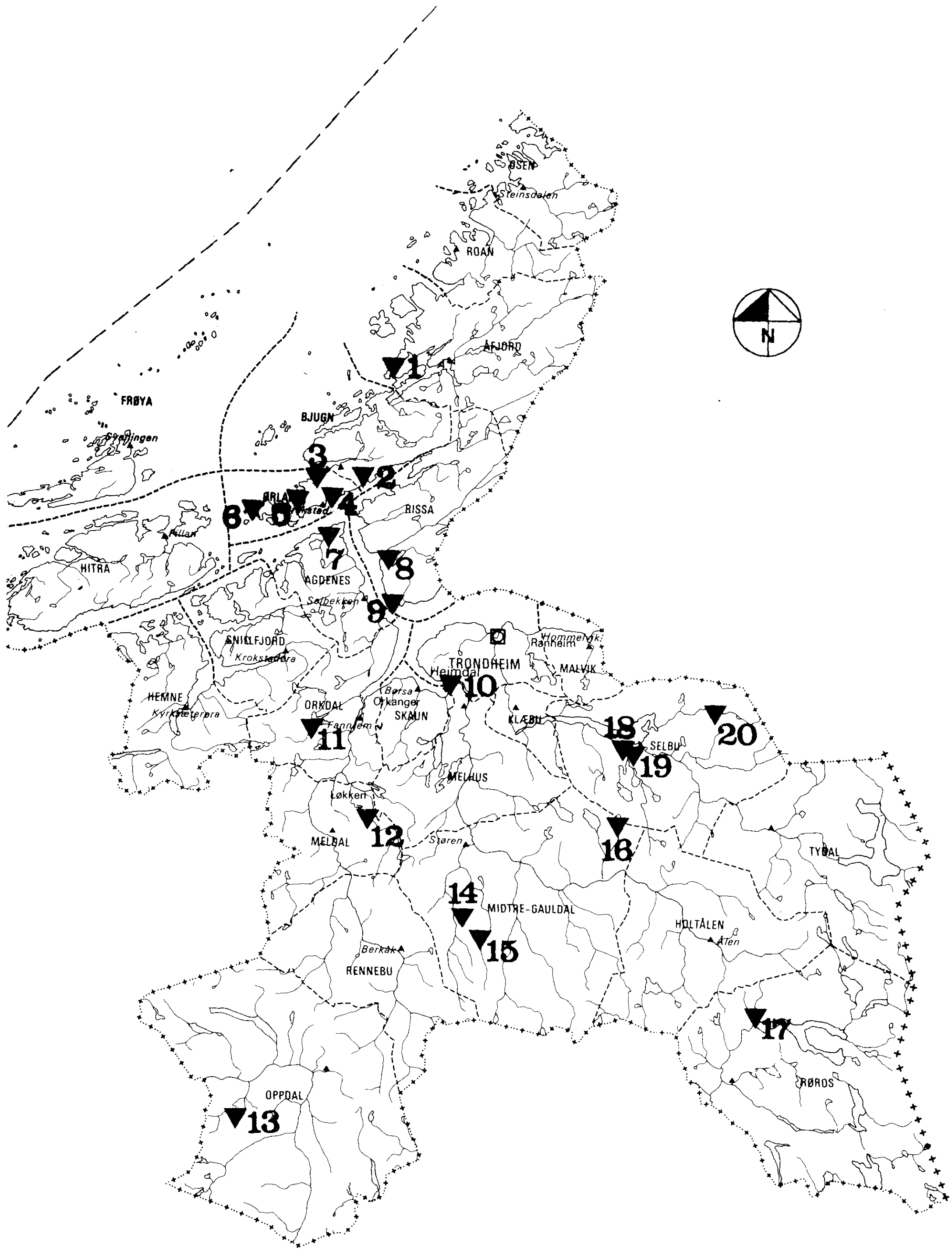
Tabell 7. *Prioriterte områder som ikke tas med i samband med våtmarksplanen for Sør-Trøndelag fylke.*

Nr.	Lokalitetsnavn	Prioritet
1.	Rusasetvatnet, Ørland	2
2.	Slettestjørna, Rennebu	3
3.	Froan, Frøya	1
4.	Havmyran, Hitra	1
5.	Været m.m., Bjugn	2
6.	Deler av Nidelva, Trondheim	3
7.	Leangenbukta, Trondheim	3
8.	Grilstadfjæra, Trondheim	3
9.	Hyllingen m.m., Røros	2

Av disse områdene er det tidligere fremmet verneforslag for Rusasetvatnet, Slettestjørna og Froan. Arbeidet med disse vernesakene er sluttført og endelig avgjørelse er nært forestående. Været i øygruppen Tarva, Bjugn er fredet ved Kgl. res. i 1973 som landskapsvernområde. Her er grensene for tiden under revisjon. Likesom Froan er også Været med omgivelser mer aktuell å nevne i samband med en kommende sjøfuglreservatplan enn i våtmarksplanssammenheng.

Både Havmyran på Hitra og Hyllingsdalen i Brekken, Røros er store naturområder med betydelige samlede verneinteresser. Vesentlige våtmarksinteresser inngår i disse. En vil foreslå at vern av disse områdene blir fremmet som enkeltsaker.

Leangenbukta, Grilstadfjæra og deler av Nidelva ligger innenfor tettbebyggelse og sentrum av Trondheim by. Likevel har områdene betydelig verdi i våtmarkssammenheng da områdene er viktige funksjonsområder for ulike vannfugler. Dessuten fungerer de sóm grønne lunger i byen, og er vakre landskapselementer. De er velegnet som studieobjekter for såvel skoleungdom som publikum i alle aldre som vil oppleve fuglelivet på nært hold ved storbyen. Leangenbukta er sikret ved regulering til friområde gjennom bygningsloven (1972). Deler av Nidelva og Grilstadbukta bør som Leangenbukta sikres gjennom reguleringsplaner. Dette er kommunens ansvar, og det er naturlig at kommunens planleggingsetat utarbeider de nødvendige planforslag i samråd med fylkets naturvernmyndigheter. I disse planene bør forholdene legges til rette slik at publikum bedre kan benytte det spesielle friluftstilbud som ligger i naturstudier i byens spesielle fuglebiotoper.



Figur 2. *Oversikt over de prioriterte våtmarksområder som foreslås vernet i verneplanen for våtmarksområder i Sør-Trøndelag fylke.*

ges til rette slik at publikum bedre kan benytte det spesielle friluftstilbud som ligger i naturstudier i byens spesielle fuglebiotoper.

I tillegg må det understrekes at det for noen få områder som er tatt med i vurderingene, ikke foreligger godt nok vurderingsmateriale på nåværende tidspunkt. Disse områdene er markert med 3? eller 3/4 — 4/3? og tatt med her p.g.a. at de må regnes å være av potensiell interesse i våtmarkssammenheng. Undersøkelser bl.a. i samband med Gaulavassdraget (10-årsvern av vassdrag-undersøkelsene) som er igangsatt fra 1978 og eventuelle andre registreringer, vil kunne gi grunnlag for videre vurderinger av disse og eventuelt andre områder som en i dag ikke måtte kjenne. I tilfelle enkelte av disse skulle være av vesentlig verneverdi, må forslag om vernetiltak reises separat senere, eventuelt i form av en suppleringsplan.

Ved siden av de områdene som er tatt med i tabell 5 og figur 2 har en i samband med denne planen vurdert en rekke andre våtmarksområder. Imidlertid ar disse av ulike årsaker vurdert å være av mindre betydning og de er derfor utelatt i oversiktstabellen — jfr. også tabell 4.

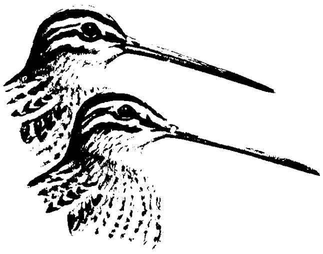
Tabell. *Skjematisk oversikt over hovedtrekkene i vann-, nærings- og vegetasjonsforholdene i de våtmarksområdene som foreslås vernet. X betyr et markant innslag av vedkommende type, (X) betyr et mer sparsomt innslag, mens — betyr at typen ikke finnes innen området.*

Lokalitetsnr. og navn	Hydrologi							Vegetasjon															
	Vanntype			Næringsforh. i ferskvann				Strandveg.			Vannveg.		Myrveg.				Krattveg.	Fukteng veg.	Sumpsk. veg.		Fastmark veg.		
													Torv		Gras								
	Salt	Brakk	Fersk	Rik	Middels rik	Fattig	Myrvann	Strandberg	Strandeng	Strandsump	Starr/snelle sump	Rørskog	Våt	Tørr	Våt	Tørr			Lauvskog	Barskog	Åpen hei	Lauvskog	Barskog
1. Bingsholmsråsa	X	—	—	—	—	—	—	(X)	(X)	—	—	—	—	—	—	—	—	—	—	—	X	—	—
2. Eidsvatnet	—	—	X	(X)	X	—	—	—	—	—	X	X	—	—	—	—	X	—	—	—	—	—	—
3. Innstrandfjæra	X	—	—	—	—	—	—	—	(X)	X	—	—	—	—	—	—	X	—	—	—	—	—	—
4. Hovsfjæra	X	—	—	—	—	—	—	(X)	(X)	X	—	—	—	—	—	—	(X)	—	—	—	—	—	—
5. Grandfjæra	X	—	—	—	—	—	—	(X)	X	X	—	—	—	—	—	—	(X)	—	—	—	—	—	—
6. Kråkvågsvaet	X	—	—	—	—	—	—	X	(X)	X	—	—	—	—	—	—	(X)	—	—	—	X	—	—
7. Litlvatnet	—	—	X	X	—	—	—	—	—	—	X	X	—	—	—	—	X	(X)	(X)	—	—	—	—
8. Strømmen	X	X	—	—	—	—	—	—	X	X	—	—	—	—	—	—	(X)	(X)	—	—	—	—	—
9. Grønningsbukta	X	—	—	—	—	—	—	—	X	X	—	—	—	—	—	—	—	—	—	—	—	—	—
10. Gaulosen	X	X	(X)	—	—	—	—	—	X	X	—	—	—	—	—	—	X	(X)	(X)	—	—	(X)	—
11. Svorkmyran	—	—	X	—	—	X	(X)	—	—	—	X	—	X	X	X	—	X	—	X	—	—	(X)	(X)
12. Litlbumyran	—	—	X	—	—	X	(X)	—	—	—	X	—	—	—	X	(X)	X	—	X	—	—	X	(X)
13. N. Snøfjelltjørn	—	—	X	—	—	X	—	—	—	—	X	—	—	—	—	—	—	—	—	—	X	—	—
14. Holtvatna	—	—	X	—	X	—	(X)	—	—	—	X	—	—	—	X	—	X	X	X	—	—	—	—
15. Gåstjørnan	—	—	X	—	—	—	X	—	—	—	—	—	X	X	X	—	X	—	—	X	—	X	X
16. Hukkelvatna	—	—	X	—	—	X	X	—	—	—	—	—	X	X	X	X	X	—	X	X	X	X	X
17. Molinga	—	—	X	—	—	X	(X)	—	—	—	X	—	X	X	X	X	X	X	X	—	—	(X)	—
18. Fitjan	—	—	X	—	—	X	—	—	—	—	X	—	—	—	—	—	X	X	X	—	—	X	—
19. Låen	—	—	X	X	—	—	—	—	—	—	X	X	—	—	—	—	X	X	X	—	—	—	—
20. Stråsjøen — Prestøyan	—	—	X	—	—	X	X	—	—	—	X	—	X	X	X	—	X	X	X	X	X	(X)	(X)

Tabell 9. *Oversikt over det samlede areal i dekar som foreslås vernet i verneplanen for våtmark i Sør-Trøndelag fylke.*

Nr.	Lokalitet	Landareal	Brakk-/saltvannsareal	Ferskvannsareal	Totalareal
1.	Bingsholmsråsa, Åfjord	160	6340		6500
2.	Eidsvatnet, Bjugn	20		650	670
3.	Innstrandfjæra, Ørland	140	1450		1590
4.	Hovsfjæra, Ørland	80	1295		1375
5.	Grandfjæra, Ørland	630	20370		21000
6.	Kråkvågsvaet, Ørland	1100	22900		24000
7.	Litlvatnet, Agdenes	100		430	530
8.	Strømmen, Rissa	130	205		335
9.	Grønningsbukta, Rissa	100	490		590
10.	Gaulosen, Melhus/Tr.heim	355	2410		2765
11.	Svorkmyran, Orkdal	495		350	815
12.	Litlbumyran, Meldal	1035		365	1400
13.	Nordre Snøfjelltjørn, Oppdal	2200		700	2900
14.	Holtvatna, Midtre Gauldal	105		40	145
15.	Gåstjørnan, Midtre Gauldal	2280		200	2480
16.	Hukkelvatna, Midtre Gauldal	11200		1300	12500
17.	Molinga, Røros	1175		525	1700
18.	Fitjan, Selbu	190		150	340
19.	Låen, Selbu	55		50	105
20.	Stråsjøen-Prestøyan, Selbu	4600		800	5400
Totalt		26150[1)]	55460[2)]	5560[3)]	87170

[1)] Heri medregnet alle sumpområder, oversvømmingsområder, øyer og holmer etc.
[2)] Heri medregnet fjæreområder nedenfor normalt flomål.
[3)] Heri medregnet alle ferskvannsområder med åpent vannspeil.



BESKRIVELSE AV DE ENKELTE OMRÅDENE SOM FORESLÅS VERNET

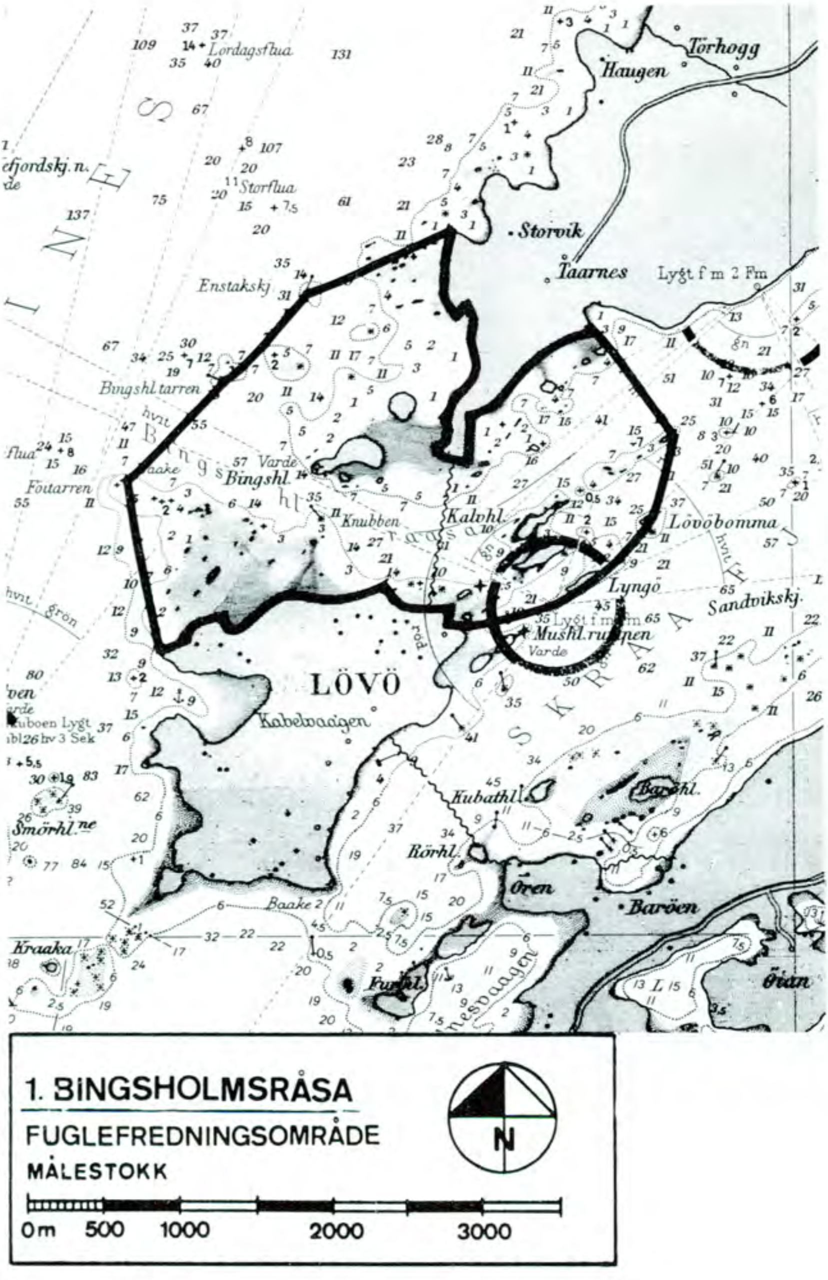
For hvert område gis det opplysninger om:

— forslag til avgrensning av et eventuelt verneområde
— områdets lokalitetsnummer
— områdets navn
— hvilke(n) kommune(r) området ligger i
— områdets beliggenhet i kommunen
— hvilke(t) kartblad i målestokk 1:50 000 (M 711-serien) området kan finnes på
— områdets UTM-koordinater (et sentralt punkt innen området)
— høyde over havet
— areal for det avgrensede området
— berørte eiendommer (gnr./bnr.)

For hvert område gis det videre:

— en kort områdebeskrivelse
— en kort beskrivelse av fuglelivet
— en kort beskrivelse av andre verneinteresser
— en kort omtale av formålet med å foreslå vern av området
— opplysninger om utførte inngrep
— opplysninger om kjente interessekonflikter
— anmerkninger om aktuelle skjøtselsbehov og andre merknader
— opplysninger om kilder og referanser

Målestokken er ulik på de forskjellige kartene


Lordagsflua
Storflua
Enstakskj
Bingshl.tarren
Bingshl.
Knubben
Foltarren
Storvik
Taarnes
Haugen
Törhogg
Kalvhl.
Lövöbomma
Lyngö
Sandvikskj.
Mushl.rumpen
LÖVÖ
Kabelvaagen
Kubathl.
Rörhl.
Baröen
Barhl.
Øren
Kraaka
Smörhl.
1. BINGSHOLMSRÅSA
FUGLEFREDNINGSOMRÅDE
MÅLESTOKK
0m
500
1000
2000
3000
N

LOKALITETSNUMMER: 1
LOKALITETSNAVN: Bingsholmsråsa
KOMMUNE: Åfjord

BELIGGENHET: Tårnes — Lauvøy
KARTBLAD: Bjugn 1522 I
UTM-KOORDINATER: 32V NR 460.910
HØYDE OVER HAVET: 0—21 meter
AREAL: Ca. 6500 da, herav ca. 6340 da vannareal

BERØRTE EIENDOMMER (GNR./BNR.):
3/1; 3/2; 3/3; 67/3; 67/5; 67/6; 67/12; 67/15; 67/16; 67/18; 67/35; 67/41.

KORT OMRÅDEBESKRIVELSE:
Bingsholmråsa er sundet mellom Tårnes og Lauvøy. Det består av større fjære/strandstrekninger og gruntvannsområder i tilknytning til disse. I sundet ligger det forøvrig en rekke større og mindre holmer, noen av disse blir knyttet til land ved fjære sjø. De største fjæreområdene ligger rundt Tårneset, og fjæreområdene består av flere elementer — fra mudder/leirbunn, hvor smådammer blir stående igjen ved fjære sjø, til sand-, grus- og mer rullesteinstrand. Nederst i fjæra er det store sammenhengende tangbelter. Holmene er dels lyngbevokst og dels grasbevokst. Spissen på Tårnes er flat og danner et mini-Ørland, landskapet er preget av jordbruk. Lauvøya er totalt sett mer variert og utgjør et vakkert kulturlandskap.

KORT ORNITOLOGISK BESKRIVELSE:
Fjære- og gruntvannsområdene i området er viktige for en rekke vannfugler, størst betydning har området som overvintringsplass og som hvile-/rasteplass i trekktidene. Tidligere var holmene i området viktige hekkeplasser for en rekke fugler, men i våre dager er det av flere årsaker mindre hekkende fugl her. Området er den eneste våtmarkslokalitet av denne type som skiller seg ut på kysten av Sør-Trøndelag når en ser bort fra Ørlands våtmarkssystem. Selv om lokaliteten ikke er særlig godt dekt når det gjelder ornitologiske registreringer, er hittil totalt 74 ulike fuglearter registrert i området. Av disse er 36 vannfuglarter, derav 3 lomarter, 2 dykkerarter, 11 andefuglarter og 15 vadefuglarter. Artsantallet er høyt, og det samme gjelder til sine tider individsantallet av enkelte arter. Flere spesielle vannfuglarter er registrert. Etter de kriterier som er benyttet er forekomsten av 9 vannfuglarter vurdert å være av regional interesse og 1 art av internasjonal interesse. Etter dette vurderes området å ha regional verneverdi. Området inngår som et viktig ledd i trekkruten for vannfugl langs kysten.

ANDRE VERNEINTERESSER:
Botaniske og marinbiologiske undersøkelser er ikke utført. Området ligger vakkert til.

FORMÅLET MED VERN:
Formålet er å sikre et spesielt våtmarksområde som fungerer som en viktig vannfuglbiotop. Området er et ledd i trekkveien langs kysten av Trøndelag.

UTFØRTE INNGREP:
Ingen vesentlige. Områdene på land på Tårnes er dyrket, og en vei fører helt ut på spissen. Her ute ligger en kirkegård, og området benyttes en del som utfartsmål uten at det kan sies å ha innvirkning på området.

KJENTE INTERESSEKONFLIKTER:
Ingen vesentlige.

AKTUELLE SKJØTSELSTILTAK/MERKNADER:
For tiden er det ikke aktuelt med direkte skjøtselstiltak i området.

KILDER/MERKNADER:
Litteratur: 1, 22, 42, 61.
Annet: 1, 6, 14.

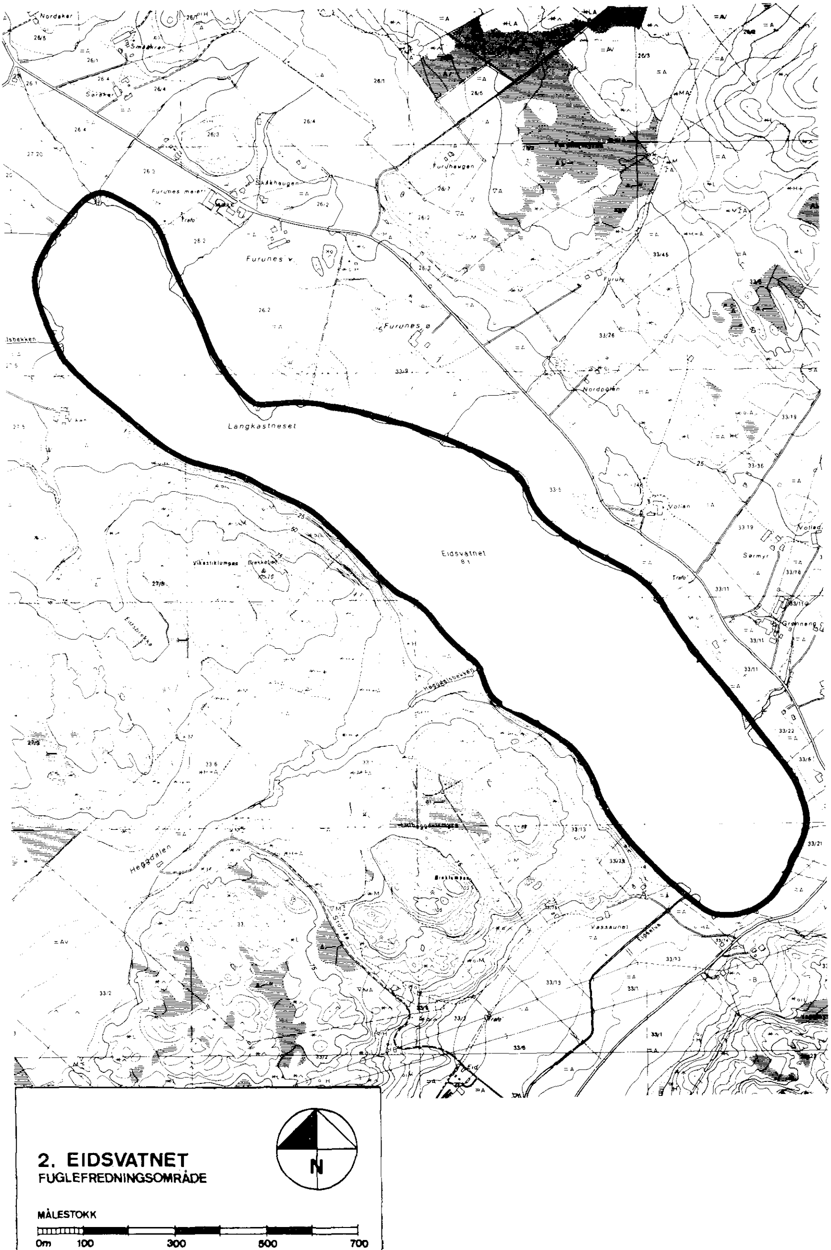
LOKALITETSNUMMER: 2
LOKALITETSNAVN: Eidsvatnet
KOMMUNE: Bjugn

BELIGGENHET: Mellom Botngård og Høybakken (Stjørna)
KARTBLAD: 1522 II Rissa
UTM-KOORDINATER: 32V NR 415.685
HØYDE OVER HAVET: 10 meter
AREAL: Ca. 670 dekar, herav ca. 650 dekar vannareal

BERØRTE EIENDOMMER (GNR./BNR.):
26/2; 26/3; 26/4; 27/1; 27/5; 27/7,8; 27/13,22; 27/20; 33/1; 33/2; 33/3; 33/5; 33/6; 33/9; 33/11; 33/13; 33/21; 33/22; 33/23; 33/24; 33/52; 33/79.

KORT OMRÅDEBESKRIVELSE:
Eidsvatnet er et vel 2,2 km langstrakt grunt vatn omgitt for en stor del av flat dyrket mark. På sørsiden er det bratte bergpartier med løvskog og furuskog. I selve strandsonen mot dyrket mark finnes et smalt belte med nesten sammenhengende kantskog bestående av or og vier. Rundt store deler av vatnet er det et takrørbelte som særlig i nordenden er bredt, tett og høyvokst. Innenfor takrørskogen finnes ofte et belte av elvesnelle, sumpsivaks, starr o.a. — dette er best utviklet i nordenden. Nettopp den nordre delen utgjør det grunneste parti i vatnet (1—3 meters dyp). Vatnet har utløp mot sørøst til Stjørnfjorden.

KORT ORNITOLOGISK BESKRIVELSE:
Eidsvatnet har sin viktigste funksjon som raste- og hvileplass for vannfugl i trekktidene, men området fungerer også som hekkeplass for en del arter. Dessuten benyttes området som beiteplass for arter som hekker i omgivelsene, som myteplass for en del ender og som vaskeplass for en del måsefugler. Tilsammen er hittil 85 ulike fuglearter registrert i/ved Eidsvatnet, herav 36 vannfuglarter. Canadagås er satt ut og hekker årvisst. Artsantallet er høyt, og det samme kan individantallet til sine tider være — særlig for enkelte arter. Artssammensetningen er karakteristisk for næringsrike lavlandsvatn i Midt-Norge. Flere kravfulle/spesielle vannfuglarter er registrert. Ut i fra de kriterier som er benyttet er forekomsten av 8 vannfuglarter av regional interesse (derav 2 hekkende) og 1 av nasjonal interesse. Eidsvatnet er en av de viktigste lokaliteter for sangsvane i fylket. Etter de tilgjengelige ornitologiske data vurderes Eidsvatnet å ha regional verneverdi. Det skiller seg klart i fra de mange andre vatn i lavlandet i Bjugn.



2. EIDSVATNET
FUGLEFREDNINGSOMRÅDE

ANDRE VERNEINTERESSER:
Det er ikke foretatt botaniske og ferskvannsbiologiske undersøkelser i området, og en har p.t. ikke tilgjengelige data for å vurdere andre biologiske verneinteresser enn de ornitologiske. Et visst fiske foregår i vatnet. Vatnet utgjør et vakkert element i kulturlandskapet i området.

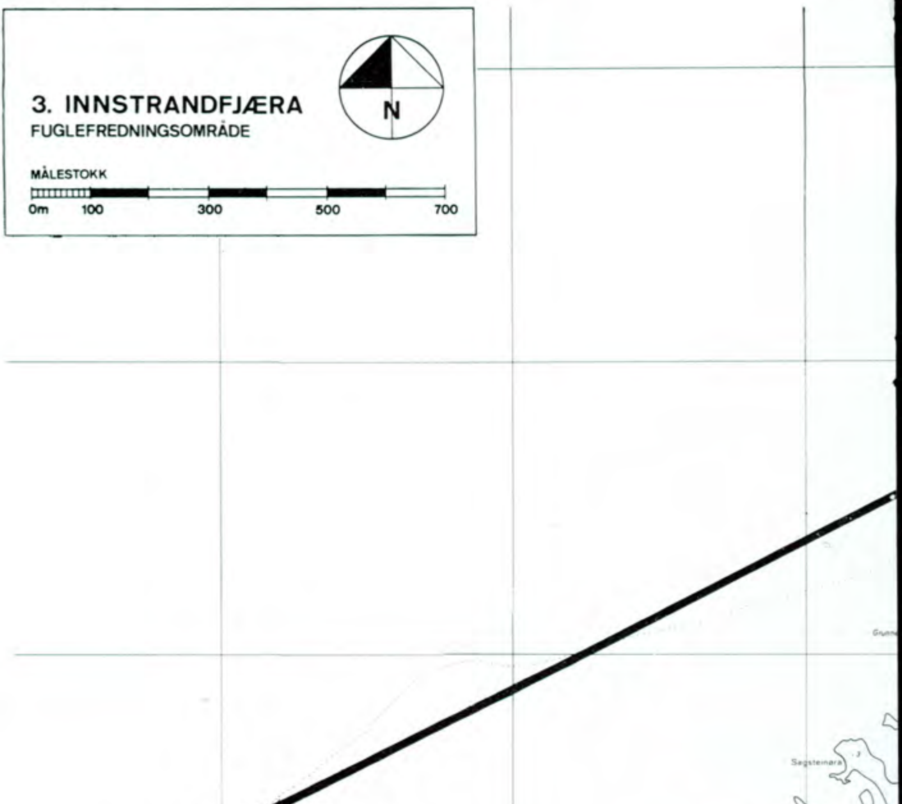
FORMÅLET MED VERN:
Formålet er å sikre en spesiell våtmarksbiotop av særlig viktighet for trekkende, men også enkelte hekkende vannfugler.

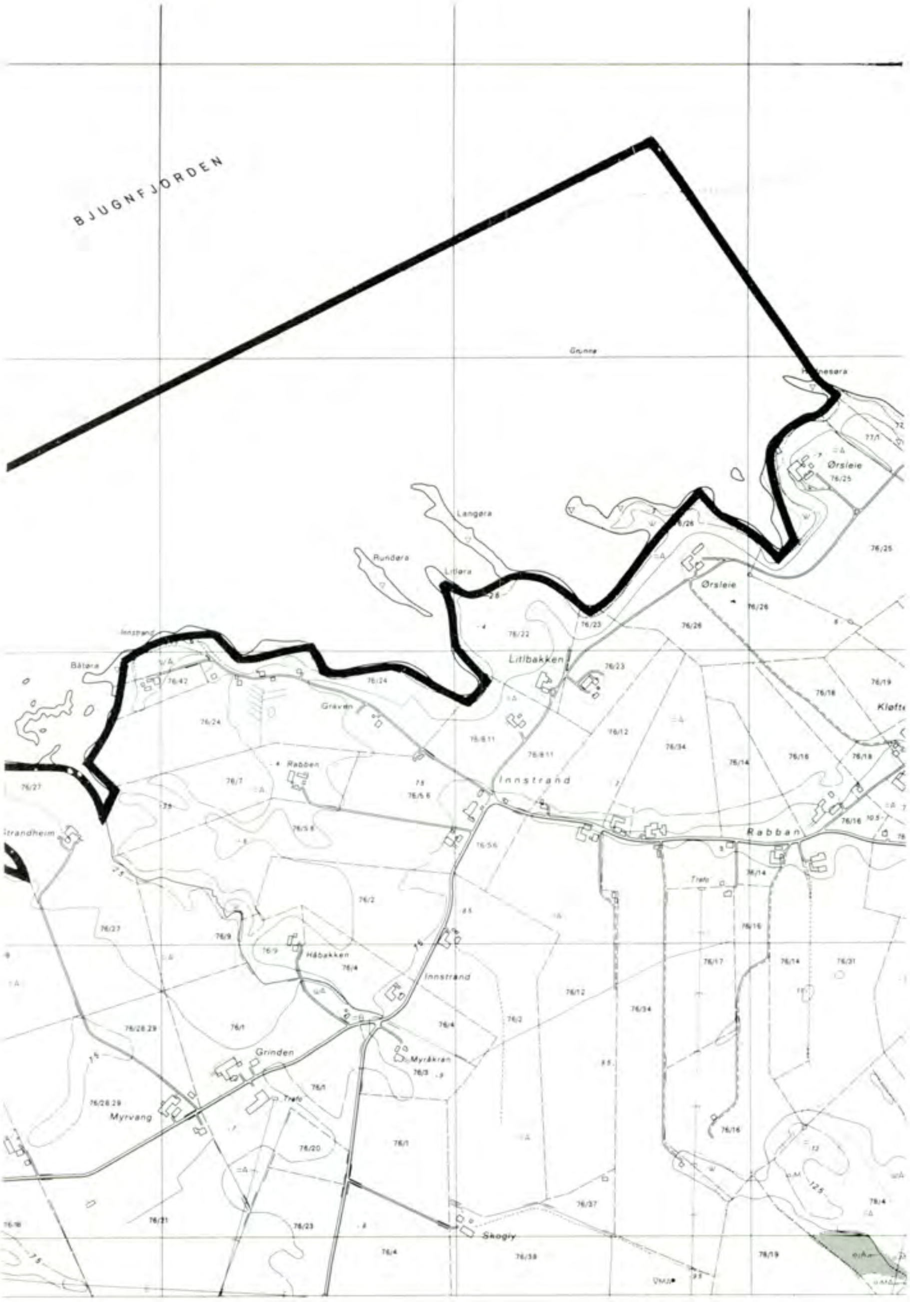
UTFØRTE INNGREP:
Eidsvatnet er senket to ganger, senest i 1948 (ca. 1,2 m). Da ble ca. 340 da sumpjord innvunnet. Vatnet er påvirket av næringstilførsel fra jordbruksområdene, og det er særlig i de senere årene at den frodige vannvegetasjpnen har utviklet seg. Tidligere var det utslipp fra et nærliggende meieri, men det er oppført etter at meieriet ble nedlagt. En høyspentlinje går ned til vatnet på østsiden og langs nordsiden.

KJENTE INTERESSEKONFLIKTER:
Eidsvatnet kan vanskelig senkes særlig mer p.g.a. vansker ved utløpet, men da tilgroingen bremser avrenningen ønskes opprensking av utløpet og grøfter ved jevnlige mellomrom. Dette ansees ikke som et problem, men ytterligere senking av normalvannstanden bør ikke skje. Det er ikke blitt gitt konsesjon for den først godkjente kraftlinjen som skulle krysse vatnet på en meget uheldig måte og som ville øke kollisjonsfaren for sangsvaner o.a. vannfugl betraktelig. Hensynet til kollisjonsfaren, landskapet og områdets verneverdi ble gitt prioritet. Jakttrykket er i dag ikke særlig stort, men noe andejakt pågår om høsten. De utsatte canadagjessene ansees som et problem på enkelte eiendommer p.g.a. nedtråkking og sterkt beite på åker og eng. Antallet har økt siden utsettingen.

AKTUELLE SKJØTSESLTILTAK/MERKNADER:
Utslippene/tilførselen av nærinfsstoffer til vatnet bør begrenses. Det er for tiden lite aktuelt med direkte skjøtselstiltak i området. Det vil være ønskelig med utfyllende biologiske undersøkelser i området.

KILDER/REFERANSER:
Litteratur: 19, 21, 22, 23, 61, 62, 69.
Annet: 2, 6, 14.


3. INNSTRANDFJÆRA
FUGLEFREDNINGSOMRÅDE
MÅLESTOKK
0m
100
300
500
700
N
Grunne
Grunne
Storkråka
Litlkråka
Kråkli
Leirosen
Rundøra
Sanden
Utstrand
Fjøsrabben
Bjellkuøya
Sagsteinøra
Sagsteinosen
Vollen
Haggan


BJUGNFJORDEN
Grunne
Langøra
Rundøra
Litløra
Ørsleie
Innstrand
Båtøra
Litlbakken
Gråven
Rabben
Strandheim
Håbakken
Grinden
Myråkran
Myrvang
Trafo
Skogly
Rabban

LOKALITETSNUMMER: 3
LOKALITETSNAVN: Innstrandfjæra
KOMMUNE: Ørland

BELIGGENHET: Uthaug — Døsvik
KARTBLAD: Ørland 1522 III
UTM-KOORDINATER: 32V NR 315.675
HØYDE OVER HAVET: 0—3 meter
AREAL: Ca. 1590 da, herav ca. 1450 da vannareal

BERØRTE GRUNNEIERE (GNR./BNR.):
75/1; 75/2; 75/5; 75/6; 75/7; 75/10; 75/36; 76/6; 76/7; 76/8,11; 76/22; 76/23; 76/24; 76/25; 76/26; 76/27; 76/35; 76/42; 77/11.

KORT OMRÅDEBESKRIVELSE:
Området er et fjæreområde bestående av ulike elementer. I de indre deler av fjæra finnes mudderbunnsområder, midt i fjæra er det store, flate sand-, grus- og leirområder med en del store steiner, og i dette området blir det stående igjen en del smådammer ved fjære sjø, ytterst i fjæra er det steingrunn med store tangbelter og utenfor mindre gruntvannsområder. Langs fastmarka er det en rekke innbuktninger — gjerne i tilknytning til mindre bekker og grøfter. Dette danner en avvekslende strandlinje. Ved Utstrand ligger en særegen brakkvannsdam (Kråka) og like ved en søppelplass som er i ferd med å ødelegge denne. Selve fjæresonen er ganske bred. De innenforliggende, flate områdene er preget av jordbruk.

KORT ORNITOLOGISK BESKRIVELSE:
Fjæresonen i området er variert i utforming, og deler av området er særlig av betydning for en rekke vannfuglarter. Området fungerer spesielt som en viktig hvile-/rasteplass i trekktidene for vadefugl og en del andefugl. Særlig viktig i så måte er områdene hvor det blir stående igjen vanndammer ved fjære sjø, her er det særlig under høsttrekket et ytende liv av vadefugl og andre vannfugl. «Kråka» er også en spesiell biotop, men området er sterkt påvirket og skjemmet av den nærliggende søppelplassen som forøvrig tiltrekker seg en del såkalte «søppelfugler». Områdene har også betydning for overvintrende vannfugl. Det utenforliggende gruntvannsområde har her mindre betydning som fuglelokalitet. Hittil er totalt 65 ulike fuglearter registrert. Fuglefaunaen domineres av vannfugl og 35 ulike vannfuglarter er registrert, derav 12 andefuglarter og 22 vadefuglar-

ter. Flere spesielle og kravfulle vannfugler er påvist. Artsantallet er høyt, og det samme gjelder individantallet av enkelte arter særlig i trekktidene. Etter de kriterier som er benyttet er forekomsten av 13 vannfuglearter vurdert å være av regional interesse, 1 av nasjonal interesse og 2 av internasjonal interesse. Etter dette vurderes lokaliteten separat å ha regional verneverdi. Området inngår som en viktig del av Ørlands våtmarkssystem og er et viktig ledd i trekkruten for vannfugl langs kysten.

ANDRE VERNEINTERESSER:
Botaniske og marinbiologiske undersøkelser er ikke utført.

FORMÅLET MED VERN:
Formålet er å sikre en spesiell vannfuglbiotop av særlig viktighet i trekktidene og et spesielt våtmarksområde som inngår som en viktig del av Ørlands våtmarkssystem.

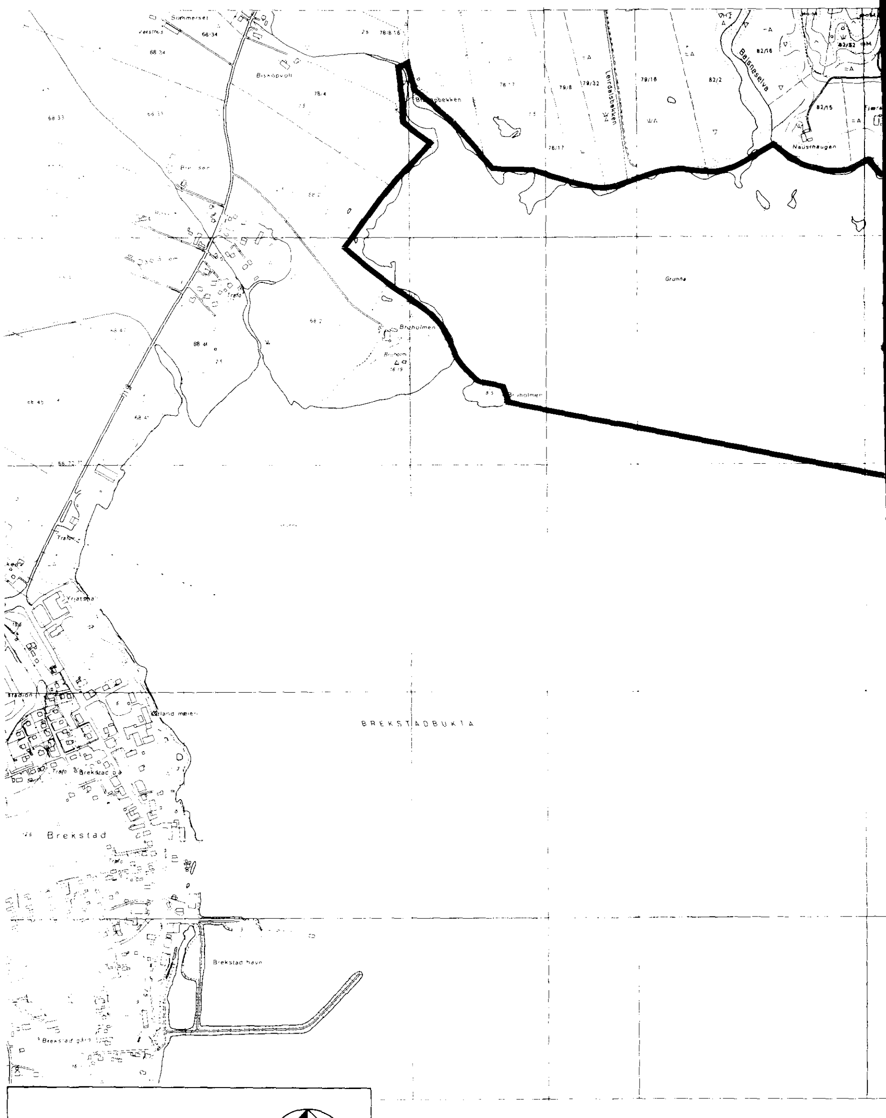
UTFØRTE INNGREP:
Fjæreområdene er lite påvirket utenom ved Kråka, hvor en søppeltømmingsplass forringer nærområdene og i særdeleshet den nærliggende brakkvannsdammen. Søppelavfall finnes spredt over et større areal. Søppelplassen er ikke formelt godkjent og visse interkommunale planer om en permanent løsning av søppelproblemene i Ørland/Bjugn er under drøfting.

KJENTE INTERESSEKONFLIKTER:
Eventuell videre «utbygging» av arealet søppeltømmingen foregår på. Det foregår noe jakt i området. Ca. 100 da kan innvies til jordbruksformål ved inndemming av et par bukter.

AKTUELLE SKJØTSELSTILTAK/MERKNADER:
Det er for tiden ikke aktuelt med direkte skjøtselstiltak i området. En opprydding rundt søppelplassen er imidlertid påkrevd.

Foruten de berørte eiendommene nevnt foran har flere andre grunneiere rettigheter til sand og tang på en del av disse eiendommene.

KILDER/REFERANSER:
Litteratur: 5, 19, 38, 61, 68.
Annet: 1, 2, 3, 6, 9, 17.


Sommerset
Biskopvoll
Bruholmen
Grunna
Naustaugen
B R E K S T A D B U K T A
Ørland meieri
Brekstad
Brekstad havn
4. HOVSFJÆRA
FUGLEFREDNINGSOMRÅDE
MÅLESTOKK
0m
100
300
500
700
N

Sørstrand
Fagerlund
Østlund
Fitjan
Fitjan hamnelag
82/75
82/77
82/73

LOKALITETSNUMMER: 4
LOKALITETSNAVN: Hovsfjæra
KOMMUNE: Ørland

BELIGGENHET: Brekstad — Austråt
KARTBLAD: Ørland 1522 III og Rissa 1522 II
UTM-KOORDINATER: 32V NR 345.640
HØYDE OVER HAVET: 0—2 meter
AREAL: Ca. 1375 da, herav ca. 1295 da vannareal

BERØRTE EIENDOMMER (GNR./BNR.):
68/2 (Staten); 78/11; 78/8,16; 78/17; 79/8; 79/16; 79/32; 82/1 (Sør-Trøndelag fylke); 82/2; 82/15; 82/16; 82/41; 82/32,40, 43; 82/71,76; 82/73, 82/75; 82/77; 82/80; 82/85.

KORT OMRÅDEBESKRIVELSE:
Hovsfjæra er i denne sammenheng benyttet som fellesbetegnelse for fjærestrekningen mellom Bruholmen og Austråt og omfatter: Bergsfjæra, Hovsfjæra, Balnesfjæra, Skalfjæra og Fitjan samt de grunne sjøarealene utenfor. Fjæreområdet er relativt langgrunt ved fjære sjø og sammensatt av flere typer. Øverst i fjæresonen finnes mudderbunnspartier — ofte med grunne smådammer. Midt i fjæra ligger et større område bestående av sand og grus, disse områdene er ved fjære sjø tørrere enn de innenforliggende. I nedre deler finnes et kraftig tangbelte, og spredt i hele fjæresonen finnes større og mindre steiner. I nær tilknytning til fjæresonen ligger noen sumppartier, men stort sett strekker dyrket mark og beiteland seg ned til flomålet. Utenfor fjæresonen ligger et større sammenhengende gruntvannsområde ned til 10—20 meters dyp. To større bekker — Biskopbekken og Balsneselva — samt noen mindre renner ut i fjæra. Innenfor fjæra er landskapet flatt og i dag for det meste preget av jordbruk.

KORT ORNITOLOGISK BESKRIVELSE:
Fjære-/gruntvannsområdene i Hovsfjæra har særlig betydning for en rekke ulike vannfugler, og området fungerer spesielt som hvile-/rasteplass i trekktidene og som overvintringsplass. Dessuten har området betydning som beiteplass for fugler som hekker i omgivelsene og som myteplass for andefugl. Ved vestlige og nordlige sterke vinder og dårlig vær betyr de mer avskjermede delene av Ørlands våtmarkssystem på innsiden av Ørlandet særlig meget for mange vannfugler. Dette ser en spesielt i den kritiske vintertiden. Området må funksjonsmessig

sees i sammenheng med Brekstadfjæra mellom Brekstad havn og Bruholmen. Dette området hører sammen med Hovsfjæra både funksjonsmessig og fysisk og utfyller de våtmarkselementer som finnes i Hovsfjæra. Hittil er totalt 108 ulike fuglearter registrert i området. Fuglefaunaen domineres av vannfugl, og 63 ulike vannfuglarter er hittil registrert, derav 3 lomarter, 2 dykkerarter, 19 andefuglarter og 23 vadefuglarter. Flere spesielle og sjeldne arter er påvist. Artsantallet er altså høyt, og det samme gjelder individantallet både for flere av artene og tilsammen. Spesielt under høsttrekket forekommer store ansamlinger av vadefugler, store antall andefugler forekommer store deler av året. Etter de kriterier som er benyttet er forekomsten av 17 vannfuglarter vurdert å være av regional interesse, 6 av nasjonal interesse og 3 av internasjonal interesse. Etter dette vurderes lokaliteten å ha nasjonal verneverdi. Området inngår som en viktig del av Ørlands våtmarkssystem, og det er et viktig ledd i vannfuglenes trekkvei langs kysten.

ANDRE VERNEINTERESSER:
Det tidligere sump- og marsklandskapet langs fjæreområdene er forlengst oppdyrket, og verneinteressene er i det vesentligste konsentrert om arealet nedenfor flomålet. Marinbiologiske undersøkelser er ikke utført. Strandbergene på Bruholmen er av botanisk interesse. Bruholmen er av stor betydning for friluftslivet (bading/soling).

FORMÅLET MED VERN:
Formålet er å sikre et spesielt våtmarksområde av stor viktighet som trekk- og overvintringsplass for ulike vannfugler. Området inngår som en viktig del av Ørlands våtmarkssystem.

UTFØRTE INNGREP:
I selve fjæresonen er det i Hovsfjæra ikke utført vesentlige inngrep utenom visse kanaliserings- og forbygningsarbeider i områdene ved Balsneselva. Fjæreområdene tilføres en del næringsstoffer fra tilgrensende kulturmark, spesielt er Balsneselva og Biskopbekken forurenset. Tidligere lå større sumparealer på land ned mot fjæreområdene, disse arealene er forlengst oppdyrket med unntak av noen mindre områder.

KJENTE INTERESSEKONFLIKTER:
Brekstadbukta er planlagt utlagt til industriområde etter inndemming av området, og en reguleringsplan for området er under behandling. Bekken som renner ut i Brekstadfjæra vil bli overført til Hovsfjæra, og den bør eventuelt tilknyttes Biskopbekken. Bruholmen er et offentlig friluftsområde av særlig viktighet lokalt, friluftsinteressene kan ikke sies å medføre vesentlige problemer overfor et vern av Hovsfjæra. Det foregår noe jakt i området.

AKTUELLE SKJØTSELSTILTAK/MERKNADER:
Det er for tiden ikke aktuelt med direkte skjøtselstiltak i området.

Bruholmen er innkjøpt til friluftsformål og eies av staten.

Foruten de berørte eiendommene nevnt foran har flere andre grunneiere rett til å ta sand og tang på en del av disse eiendommene.

For Brekstadfjæra er en reguleringsplan for industriareal m.m. under behandling. Det er et meget viktig område for trekkende- og overvintrende vannfugl som går tapt ved utbygging av denne bukta, og tapet av området gjør at de resterende deler av Ørlands våtmarkssystem blir enda viktigere å bevare.

KILDER/REFERANSER:
Litteratur: 2, 5, 19, 22, 38, 61, 63, 68, 69.
Annet: 1, 2, 3, 6, 9, 17.

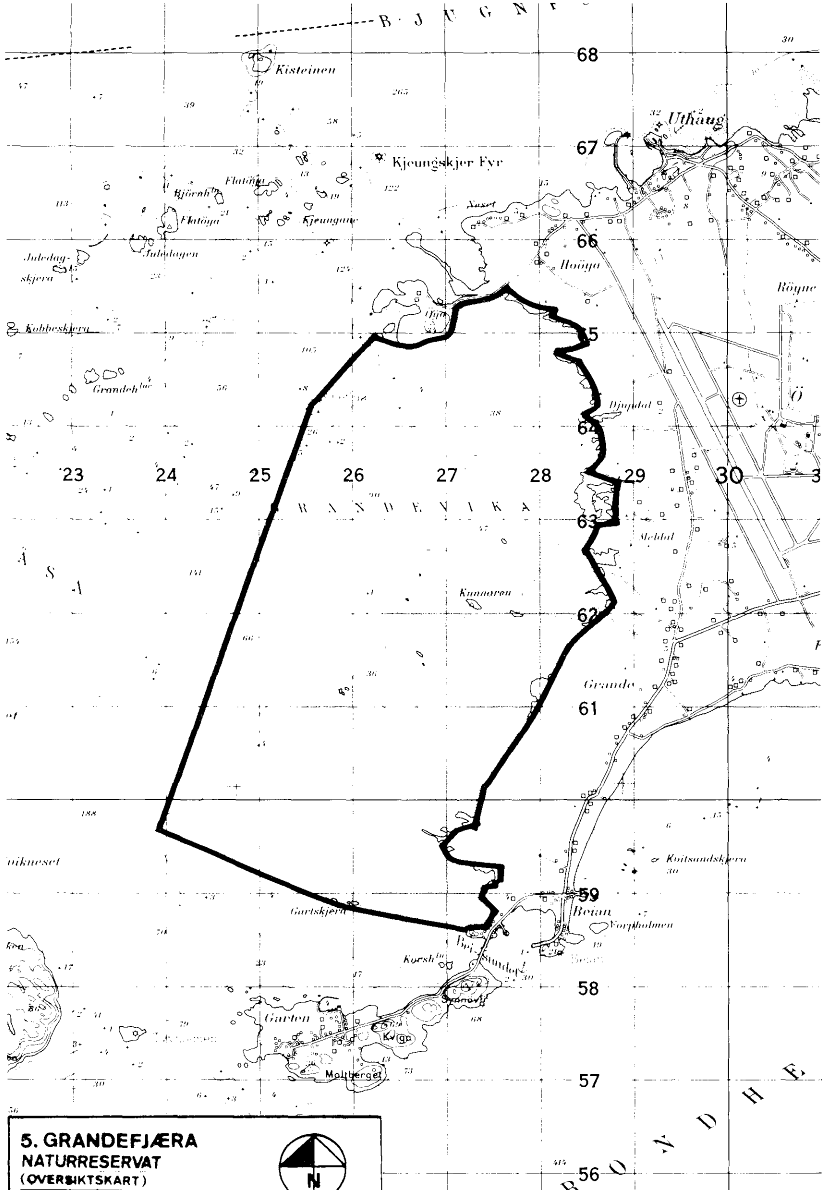
LOKALITETSNUMMER: 5
LOKALITETSNAVN: Grandfjæra
KOMMUNE: Ørland

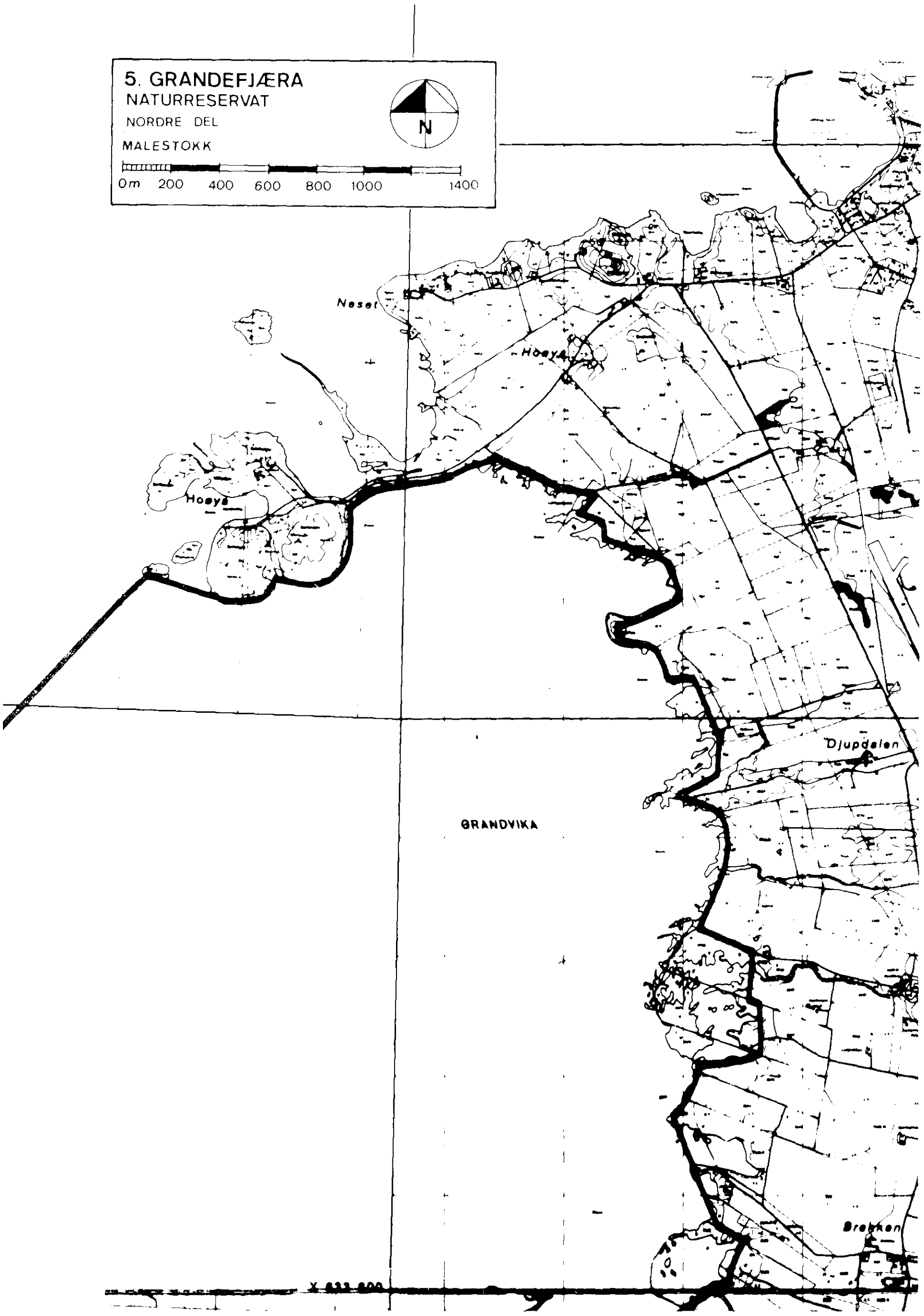
BELIGGENHET: Beian — Uthaug
KARTBLAD: Ørland 1522 III
UTM-KOORDINATER: 32V NR 270.620
HØYDE OVER HAVET: 0—5 meter
AREAL: Ca. 21.000 da, herav ca. 20.370 da vannareal

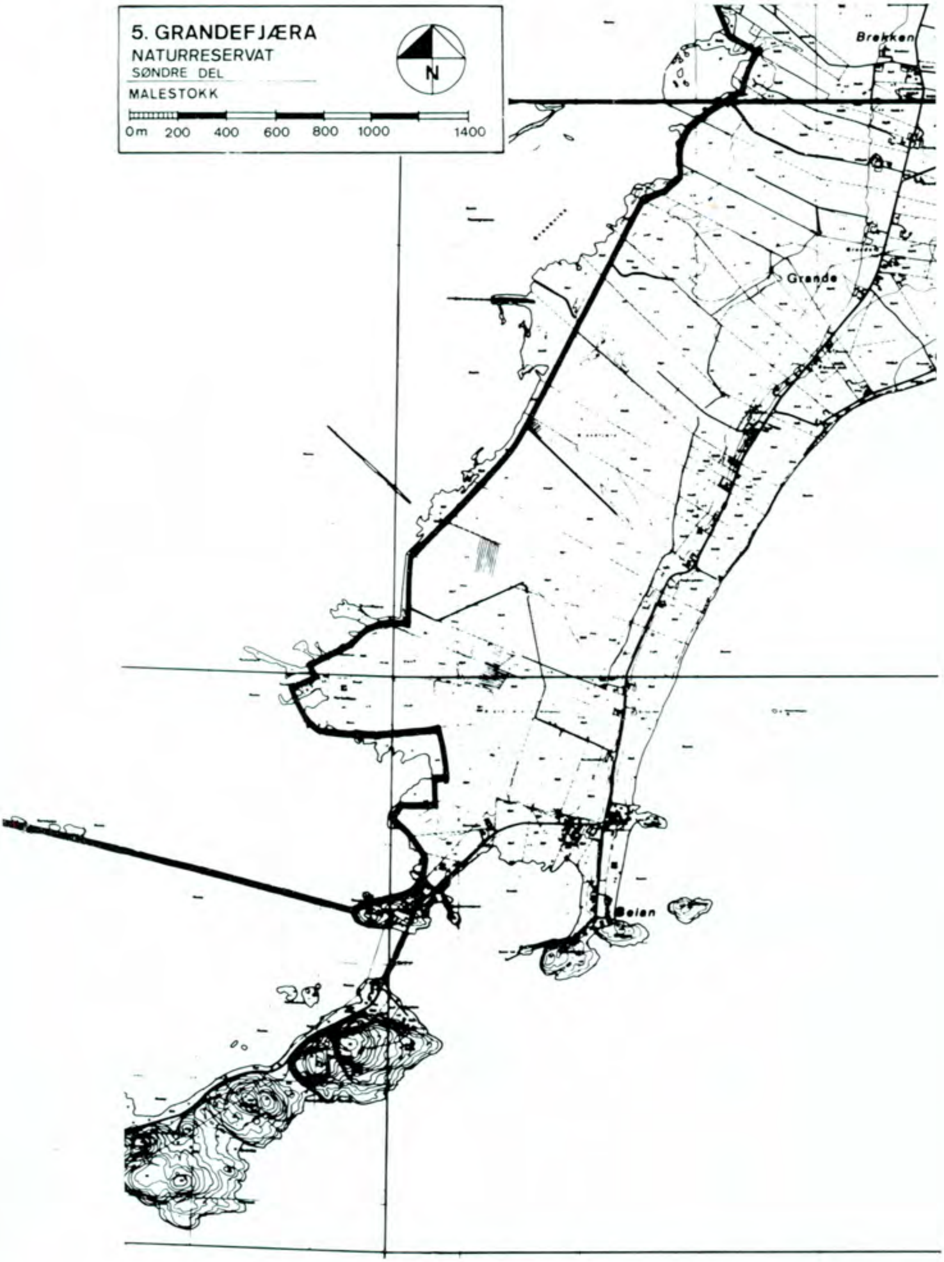
BERØRTE EIENDOMMER (GNR./BNR.):
62/1; 63/2; 63/3; 63/4; 63/6; 63/7; 63/8; 64/2; 64/3; 64/4; 64/5; 64/8; 64/9; 64/10; 64/13; 64/14; 64/15; 64/17; 64/22; 64/24; 64/26,51,52; 64/36; 64/37,41; 64/60; 64/62,71; 69/17; 69/44,83; 70/2; 70/23 m.fl.; 73/2; 73/3 m.fl.; 73/4; 73/5,19; 73/12; 73/13 m.fl. (Staten).

KORT OMRÅDEBESKRIVELSE:
Grandfjæra er den største sammenhengende fjærestrekning i fylket og består av en svært langgrunn fjære med store utenforliggende gruntvannsområder. Området strekker seg nesten 10 km fra Beian/Garten i sør til Hoøya i nord. Med i området kan en regne gruntvannsområdene i tilknytning til de mange småholmene ved Juldagene/Kistein m.fl. like nordvest for Hoøya. Innenfor fjæra lå det tidligere store sump- og marskområder og myrer, men av disse områdene er det bare små deler tilbake i dag. De gjenværende sumpområdene nord og midt i området er derfor av stor interesse. Ved fjære sjø blottlegges store fjæreområder, i den innerste del finnes en rekke partier hvor små dammer blir stående igjen, i den ytre del av fjæra ligger et stort tangbelte. Midt i fjæra ligger en mindre holme (Kunnaren) og helt sør i Gartskjæra. Landskapet innenfor selve fjæra er flatt åker- og beiteland.

KORT ORNITOLOGISK BESKRIVELSE:
Grandfjæra utgjør, p.g.a. den store næringstilgangen, den strategiske beliggenhet og arealets dimensjoner, et stort potensial for mange ulike vannfuglarter og andre trekkfuglearter. Størst betydning har området som hvile-/rasteplass i trekktidene. Gruntvannsområdene utenfor og sjøområdene ved holmene nordenfor er meget viktige også som myteplass for andefugl — i særlig grad ærfugl og sjøorre (totalt min. 5300 ind. er registrert i området). Området fungerer også som overvintringslokalitet, hekkeplass, oversomringsplass og som beiteplass for arter som hekker i omgivelsene. Funksjonsmessig henger området sammen med resten av Ørlands våtmarkssystem hvor det inngår som den viktigste del — vur-


5. GRANDEFJÆRA
NATURRESERVAT
(OVERSIKTSKART)
MÅLESTOKK
0m 500 1000 2000 3000
N
Kisteinen
Uthaug
Kjeungskjer Fyr
Flatöya
Bjørnh
Kjeungane
Juledag-skjera
Juledagen
Naset
Hoöya
Kobbeskjera
Grandeh
Djupdal
Meldal
RANDEVIKA
Kunnaren
Grande
Koitsandskjera
Gartskjera
Beian
Korsh
Garten
Kvign
Moltberget
BJUGN
TRONDHE
23
24
25
26
27
28
29
30
68
67
66
65
64
63
62
61
59
58
57
56


5. GRANDEFJÆRA
NATURRESERVAT
NORDRE DEL
MALESTOKK
0m 200 400 600 800 1000 1400
N
Neset
Hoeya
Hoeya
GRANDVIKA
Djupdalen
Brekken


5. GRANDEFJÆRA
NATURRESERVAT
SØNDRE DEL
MALESTOKK
0m 200 400 600 800 1000 1400
N
Brekken
Grande
Beian

derer en komponentene hver for seg. Hittil er totalt 107 ulike fuglearter registrert i området, fuglefaunaen domineres av vannfugl og hele 71 ulike vannfuglarter er registrert, derav 4 lomarter, 3 dykkerarter, 22 andefuglarter og 29 vadefuglarter, 13 vannfuglarter er funnet hekkende og 6 andre hekker trolig. Flere spesielle og sjeldne arter er påvist — noen av disse forekommer regelmessig. Artsantallet er meget høyt, og det samme gjelder individantallet for mange arter og totalt for vannfugl. Store antall vannfugl har tilhold i området store deler av året — bl.a. nevnes at min. 5500 andefugl og 5000 vadefugl er registrert samtidig i området. Etter de kriterier som er benyttet er forekomsten av 21 vannfuglarter vurdert å være av regional interesse, 16 av nasjonal interesse og 7 av internasjonal interesse. Etter dette vurderes området isolert sett å være av internasjonal verneverdi og et av de viktigste områdene for trekkende vannfugl langs Norskekysten. Området har lenge vært kjent for sitt rike fugleliv.

ANDRE VERNEINTERESSER:
Botanisk sett har deler av Grandefjæra høy verneverdi, da området har et stort spekter av typisk vegetasjon for strandenger i Trøndelag samtidig som her finnes innslag av sjeldne plantearter. Marinbiologiske undersøkelser er ikke utført. Landskapet har et særpreg som det vil være verdifullt å bevare.

FORMÅLET MED VERN:
Formålet er å sikre det største sammenhengende fjære-/gruntvannsområdet i fylket og den viktigste delen av Ørlands våtmarkssystem. Området er av særlig viktighet for mytende og trekkende vannfugl, og utgjør i denne sammenheng det viktigste enkeltområde i fylket.

UTFØRTE INNGREP:
I den sørlige del av området er det bygd et demnings- og kanalsystem for å innvinne landbruksjord, dette angår ca. ⅓ av strandstrekningen langs Grandfjæra. Storparten av Ørlandets myr-, sump- og marsklandskap er i dag oppdyrket, men noen rester finnes nordenfor demningen. Også deler av dette området kan det være aktuelt å søke oppdyrket. En del søppel, bilvrak etc. ligger spredt i fjæresonen.

KJENTE INTERESSEKONFLIKTER:
Det foreligger planer om ytterligere oppdyrkning (se foran) nordover fra den eksisterende kanalen. Disse planer kan, hvis de iverksettes, innvinne totalt ca. 400—500 da jordbruksland. Jakttrykket i området er høyt til Trøndelag å være.

AKTUELLE SKJØTSESLTILTAK/MERKNADER:
For tiden er det ikke aktuelt med direkte skjøtselstiltak i området utenom opprydding av søppel og bilvrak.

Foruten de berørte eiendommene nevnt foran har flere andre grunneiere rettigheter til sand og tang på en del av disse eiendommene.

KILDER/REFERANSER:
Litteratur: 2, 5, 15, 19, 21, 22, 24, 30, 38, 50, 51, 55, 61, 62, 67, 68, 69.
Annet: 1, 2, 3, 4, 6, 7, 9, 14, 17.

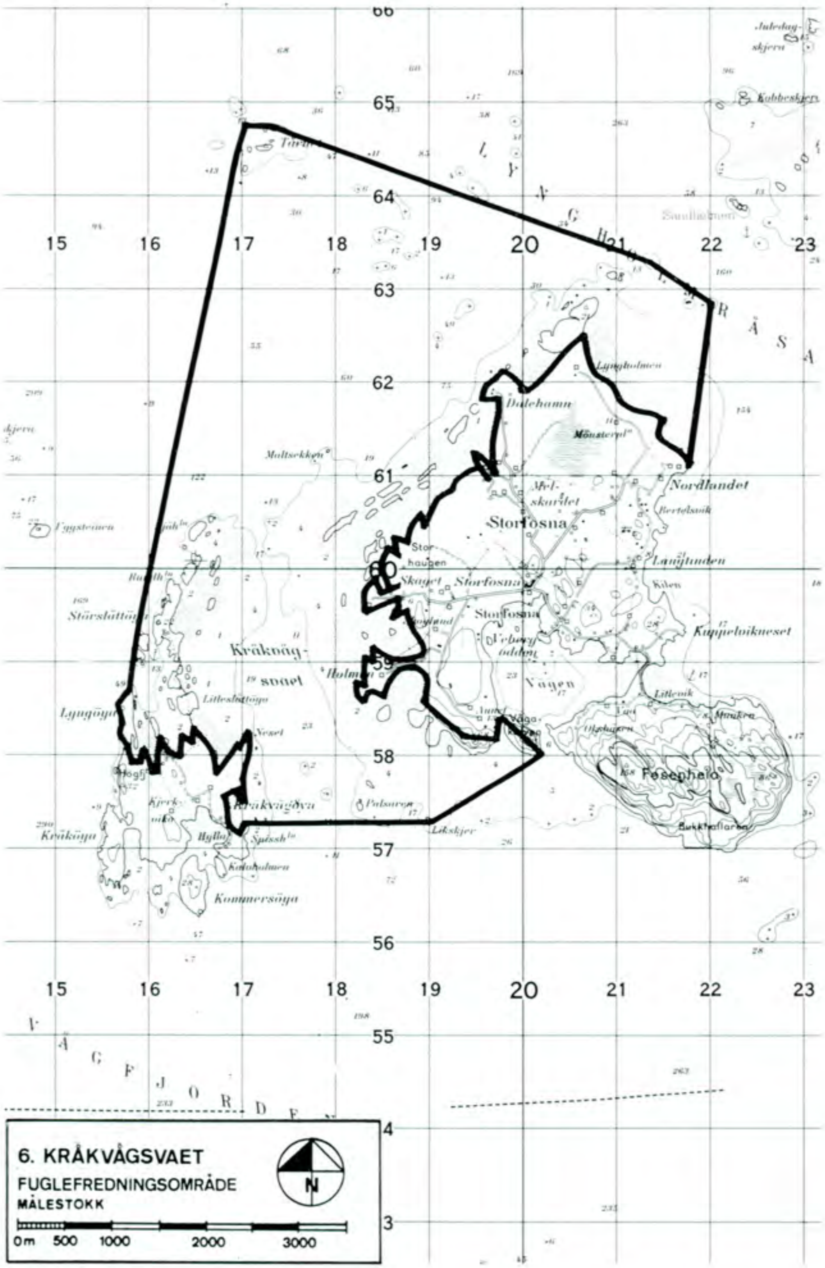
LOKALITETSNUMMER: 6
LOKALITETSNAVN: Kråkvågsvaet
KOMMUNE: Ørland

BELIGGENHET: Kråkvåg — Storfosen
KARTBLAD: Ørland 1522 III
UTM-KOORDINATER: 32V NR 180.610
HØYDE OVER HAVET: 0—21 meter
AREAL: Ca. 24.000 da, herav ca. 22.900 da vannareal

BERØRTE EIENDOMMER (GNR./BNR.):
59/1; 59/2; 59/3; 59/4; 59/5, 59/7; 60/1; 60/2; 60/4; 60/5; 60/6, 7; 60/8; 60/11; 60/12; 60/15 m.f.; 60/20; 60/27; 60/44, 103; 60/49; 60/52; 60/57; 60/67; 60/74; 60/76; 60/82; 60/101; 60/104; 60/109; 60/112.

KORT OMRÅDEBESKRIVELSE:
Kråkvågsvaet er sundet mellom øyene Kråkvåg og Storfosen med tilhørende fjære- og gruntvannsområder. Til området regnes her sjøarealet mellom hovedøyene nord til Tårnet og sør til Likskjæret samt holmene nord for Kråkvåg og holmene på nordvestsiden av Storfosen, og i tillegg et parti helt nord/nordøst på selve Storfosen. Kråkvågsvaet er meget grunt, og store deler av området er ikke dypere enn 5—10 meter. De største fjæreområdene ligger på vestsiden og på nordøstsiden av Storfosen. Landskapet på øyene er variert med flatt jordbruksland og en del knauser. På Storfosen er det en del løvskog samt barskogsplanting, og på det indre av øya et myrområde. Fosenheia er et markert landemerke (158 m.o.h.).

KORT ORNITOLOGISK BESKRIVELSE:
Fjære- og gruntvannsområdene i Kråkvågsvaet og ved Storfosen er viktige fuglelokaliteter, de fungerer i særlig grad som hvile-/rasteplasser i trekktidene og om vinteren for en lang rekke vannfugler og sjøfugler. Videre fungerer de som tilholdssted for en del ikkehekkende vannfugl om sommeren og som myteplass for andefugl — særlig for ærfugl og sjøorre (min. 1900 ind. er registrert i området). Holmene i området fungerer som hekkeplass for en del arter, og det eksisterer gamle tinglysninger om egg- og dunværsfredninger for disse. Antallet hekkefugl har imidlertid avtatt. Områdene inngår som en viktig del av Ørlands våtmarkssystem og henger på flere måter sammen med Grandefjæra og holmene nordenfor. Det er er viktig ledd i vannfuglenes trekkvei langs kysten. Hvis en regner


6. KRÅKVÅGSVAET
FUGLEFREDNINGSOMRÅDE
MÅLESTOKK
0m 500 1000 2000 3000
N
Storfosna
Nordlandet
Dalehamn
Kråkvåg-
svaet
Fosenhelo
Kråkvågøya
Kommersøya
Storhaugen

med Storfosen totalt, er det hittil registrert 122 ulike fuglearter i området, derav er 27 påvist hekkende og 23 andre sannsynlig hekkende. Av 55 registrerte vannfuglarter er 4 lomarter, 2 dykkerarter, 15 andefuglarter og 24 vadefuglarter, 12 vannfuglarter er påvist hekkende og 10 andre hekker sannsynlig. Artsantallet er høyt og det samme gjelder store deler av året individantallet, særlig dominerende er vannfuglfaunaen. Flere kravfulle og spesielle vannfugler er registrert, bl.a. er det registrert samtidig 37 lom, 3350 andefugl og 1400 vadefugl. Etter de kriterier som er benyttet er forekomsten av 19 vannfuglarter vurdert å være av regional interesse, 7 av nasjonal interesse og 2 av internasjonal interesse. Etter dette vurderes området separat å ha nasjonal verneverdi.

ANDRE VERNEINTERESSER:
Botaniske og marinbiologiske undersøkelser er ikke utført. Berggrunnen på deler av Storfosen består av en spesiell konglomeratbergart fra Devontiden som stedvis gir grunnlag for en særegen vegetasjon. Områdene utgjør vakre naturelementer i det spesielle landskapet en har her ute på øyene utenfor Ørland.

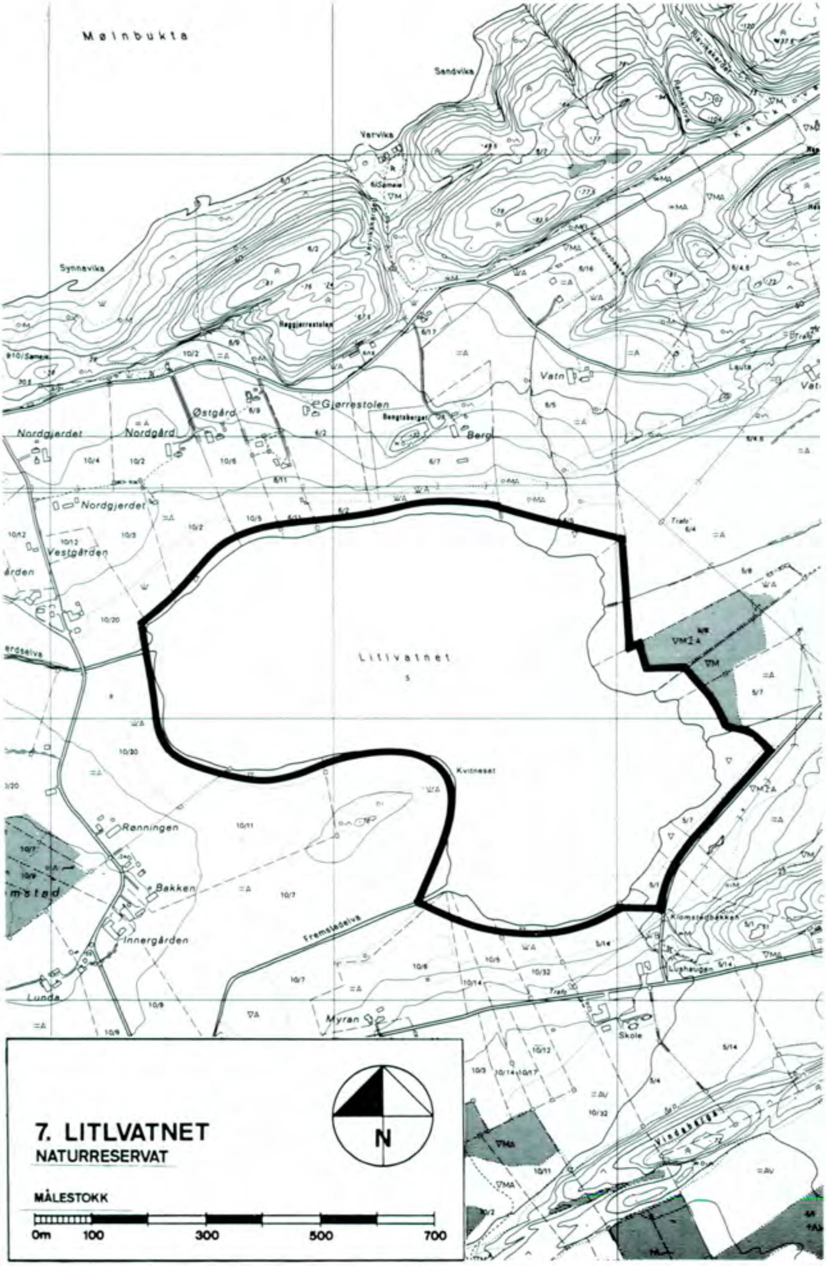
FORMÅLET MED VERN:
Formålet er å sikre et særlig viktig område for vannfugl, et spesielt våtmarksområde som inngår som en viktig del av Ørlands våtmarkssystem.

UTFØRTE INNGREP:
Ingen vesentlige.

KJENTE INTERESSEKONFLIKTER:
Økt ferdsel på holmene i hekketiden er et problem. Det drives en del jakt i området, og det kan reises tvil om denne aktiviteten foregår etter gjeldende regler. Hyttebygging i større omfang kan bli et problem. Økt småbåttrafikk og motorkapasitet kan medføre problemer.

AKTUELLE SKJØTSELSTILTAK/MERKNADER:
For tiden er det ikke aktuelt med direkte skjøtselstiltak i området. For holmene ved Storfosen og Kråkvåg er det aktuelt med ferdselsforbud i hekketiden for å beskytte hekkende fugler, reir, egg og unger.

KILDER/REFERANSER:
Litteratur: 2, 5, 13, 19, 22, 38, 39, 61, 62, 68, 69.
Annet: 1, 2, 3, 6, 7, 9, 17.



7. LITLVATNET
NATURRESERVAT
MÅLESTOKK
0m
100
300
500
700
N
Møinbukta
Sandvika
Varvika
Synnavika
Litlvatnet
Kvitneset
Nordgjerdet
Nordgård
Østgård
Gjerrestolen
Berg
Vestgården
Vatn
Rønningen
Bakken
Innergården
Lunda
Myran
Skole
Fremstadelva
Klomstadbakken

LOKALITETSNUMMER: 7
LOKALITETSNAVN: Litlvatnet
KOMMUNE: Agdenes

BELIGGENHET: Mølnbukt
KARTBLAD: Ørland 1522 III
UTM-KOORDINATER: 32V NR 329.545
HØYDE OVAR HAVET: 5 meter
AREAL: Ca. 530 da, herav ca. 430 da vannareal

BERØRTE EIENDOMMER (GNR./BNR.):
5/1; 5/6; 5/7; 5/8; 5/14; 6/2; 6/4; 6/5; 6/7; 6/11; 10/2; 10/3; 10/5; 10/6; 10/7; 10/11; 10/14; 10/20, 10/32.

KORT OMRÅDEBESKRIVELSE:
Litlvatnet ligger i et flatt kulturlandskap og er omsluttet av dyrket mark nesten rundt det hele. Utenom åker og beiteland er det noen løvskogspartier og bergknauser. Litlvatnet ligger på marine sedimenter og er gjennomgående meget grunt med gjennomsnittsdyp på 1—1,5 m, og største dyp på 3—3,5 m. Vannvegetasjonen er kraftig utviklet med tette takrørbelter og andre vannplanter. Vannvegetasjonen har forandret seg mye de siste 10—12 år. Naturlig tilgroing påskyndes delvis av den kunstige gjødselstilførsel. Nedslagsfeltet kan deles i to: a) omliggende åkerland og b) tilførselen fra det nærliggende Storvatnet gjennom Fremstadelva. Utløpet — Nordgjerdselva — er en 5—10 m bred kanal som når havet etter 6—700 m.

KORT ORNITOLOGISK BESKRIVELSE:
Litlvatnet er av særlig viktighet som hvile-/rasteplass i trekktidene og som hekkeplass for en del vannfugler. Dessuten fungerer vatnet som beiteplass for fugl som hekker i omgivelsene, som myteplass for en del andefugl og som vaskeplass for en del måsefugl. Andefuglene setter særlig sitt preg på fuglefaunaen. Litlvatnet kan funksjonsmessig sees i sammenheng med Storvatnet, og området kan også til en viss grad sies å henge sammen med Ørlandets varierte våtmarkssystem. Mellom Litlvatnet og Storvatnet foregår regelmessig utskiftning av en del vannfugl, det samme skjer mellom Litlvatnet og Ørlandet. Vatnet er et viktig ledd i trekkruten for vannfugl langs kysten. Hittil er 46 ulike vannfuglarter registrert i området, herav bl.a. 18 andefuglarter, 4 riksefuglarter og 13 vadefuglarter. Tilsammen er 105 ulike fuglearter registrert og av disse er det flere kravfulle og spe-

sielle vannfugler. Artsantallet er altså høyt, og til sine tider gjelder dette også individantallet (særlig i trekktidene). Artssammensetningen er spesiell og karakteriserer et spesielt næringsrikt ferskvatn. Litlvatnet utgjør bl.a. en av de viktigste hvile-/rasteplassene for sangsvane i fylket. Etter de kriterier som er benyttet, er forekomsten av 11 vannfuglarter (derav 3 hekkende) vurdert å være av regional interesse og 1 art av nasjonal interesse.

ANDRE VERNEINTERESSER:
Litlvatnet utgjør et spesielt vakkert landskapselement. De botaniske og ferskvannsbiologiske verneinteressene er sterke. Området er tidligere medtatt i Project Aqua. Et visst fiske foregår i vatnet, sjøaure går opp i vassdraget. Området er gjennom en årrekke blitt benyttet i undervisnings- og forskningsøyemed. De samlede verneinteressene tilsier at området har nasjonal verneverdi.

FORMÅLET MED VERN:
Formålet er å sikre et av de få eutrofe vatn i fylket og et av de fuglerikeste ferskvatn i landsdelen.

UTFØRTE INNGREP:
Litlvatnet er kulturpåvirket på flere måter. Vannstanden er senket flere ganger (senest i begynnelsen av 1960-årene) for å innvinne dyrkingsland, og vatnets opprinnelige størrelse er en god del redusert. En rekke grøfter fører ut i vatnet og tilsiget av næringsstoffer fra omliggende kulturmark er betydelig.

KJENTE INTERESSEKONFLIKTER:
Ytterligere senkinger av vannstanden for å innvinne mer jord er diskutert, men hvorvidt dette er gjennomførbart er ikke kjent. Jakttrykket er lite.

AKTUELLE SKJØTSELSTILTAK/MERKNADER:
Det er for tiden ikke aktuelt med direkte skjøtselstiltak i området.

KILDER/REFERANSER:
Litteratur: 3, 12, 17, 19, 21, 22, 24, 32, 55, 58, 61, 62, 68, 69, 70.
Annet: 1, 2, 6, 8, 13, 19.

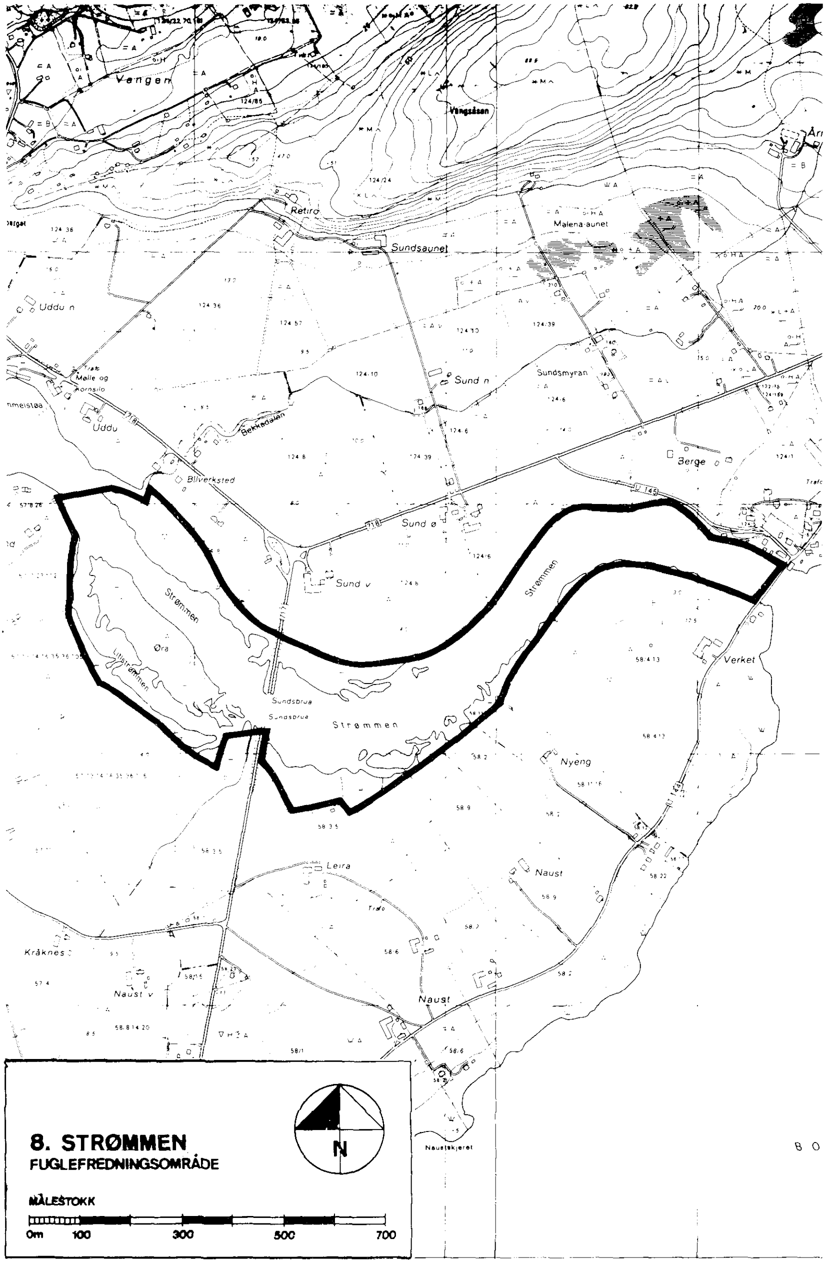
LOKALITETSNUMMER: 8
LOKALITETSNAVN: Strømmen
KOMMUNE: Rissa

BELIGGENHET: Rissa
KARTBLAD: Rissa 1522 II
UTM-KOORDINATER: 32V NR 467.504
HØYDE OVER HAVET: 0—3 meter
AREAL: Ca. 335 da, herav ca. 205 da vannareal

BERØRTE EIENDOMMER (GNR./BNR.):
57/7, 27, 112; 57/13, 14, 16, 35, 36, 105; 57/131, 133; 58/2; 58/3, 5; 58/4, 13; 58/9; 58/11, 16; 124/1; 124/6; 124/7; 124/8; 124/12; 124/14; 124/17.

KORT OMRÅDEBESKRIVELSE:
Strømmen i Rissa er forbindelsen mellom brakkvanns-/saltvannssjøen Botn og Trondheimsfjorden, et område hvor flo- og fjærevekslingene bestemmer strømforholdene. Området danner en S-slynge gjennom et vakkert kulturlandskap dominert av jordbruk og bebyggelse. To bruer går over området. Nedenfor Sundbrua deler Strømmen seg i to løp, men det søndre er svært grunt og blir bare fylt under storflo. Øra som ligger imellom løpene er vegetasjonsbevokst, det finnes noe løvetrekratt og strandeng/fuktengvegetasjon. Strandeng/fuktengvegetasjon finner en også ellers langs deler av Strømmen inn til dyrket mark. I Strømmen består bunnen av sand/grus og leire. I visse områder er det dannet store banker med blåskjell o.a., dette skal påvirke strømforholdene i området, og gjennomstrømningen skal ha minsket i forhold til tidligere.

KORT ORNITOLOGISK BESKRIVELSE:
Strømmen utgjør en viktig fuglebiotop, og området omtales for sine svaner allerede i 1729. Dets viktigste funksjon ligger i betydningen som hvile-/rasteplass i trekktidene og som overvintringsplass. Dessuten fungerer området som beiteplass for ikkehekkende fugl i sommerhalvåret og for fugl som hekker i omgivelsene. Tidligere hekket en del ærfugl i området, men i dag hører ikke arten med blant de som hekker her regelmessig. Strømforholdene gjør at området for det meste er isfritt i vinterhalvåret, og det gir en rekke vannfugler gode beitemuligheter. Vannfuglene dominerer fuglefaunaen i området. Hittil er totalt 77 ulike fuglearter registrert i Strømmen. Av disse er 41 vannfuglarter, derav 2 dykkerarter, 14 andefuglarter og 17 vadefuglarter. De fleste av vannfuglene er trekk- og



Vangen
Vangsåsen
Retiro
Sundsaunet
Malena-aunet
Uddu n
Mølle og kornsilo
Uddu
Bekkedalen
Sund n
Sundsmyran
Bilverksted
Berge
Sund ø
Sund v
Strømmen
Øra
Litlstrømmen
Sundsbrua
Verket
Nyeng
Leira
Naust
Kråknes
Naust v
Naustskjeret
8. STRØMMEN
FUGLEFREDNINGSOMRÅDE
MÅLESTOKK
0m
100
300
500
700
N

overvintringsgjester. Etter de kriterier som er benyttet er forekomsten av 10 vannfuglarter vurdert å være av regional interesse og 1 art av nasjonal interesse. Etter dette er lokaliteten vurdert å ha regional verdi. Området tilhører det nett av lokaliteter som samlet danner trekkveien for vannfugl langs Trondheimsfjorden.

ANDRE VERNEINTERESSER:
I området finnes velutviklet strandeng- og strandsumpvegetasjon som utgjør mer sjeldne vetetasjonstyper. Også i floristisk sammenheng har området betydelig botanisk verdi. Området er velegnet i undervisningssammenheng. Strømmen utgjør et vakkert og spesielt landskapselement. Området er det eneste av denne type våtmarker som inngår i planen, og denne type natur (grunne salt/brakkvannsstrømmer) er sjelden i landsdelen. Visse kulturverninteresser er knyttet til området.

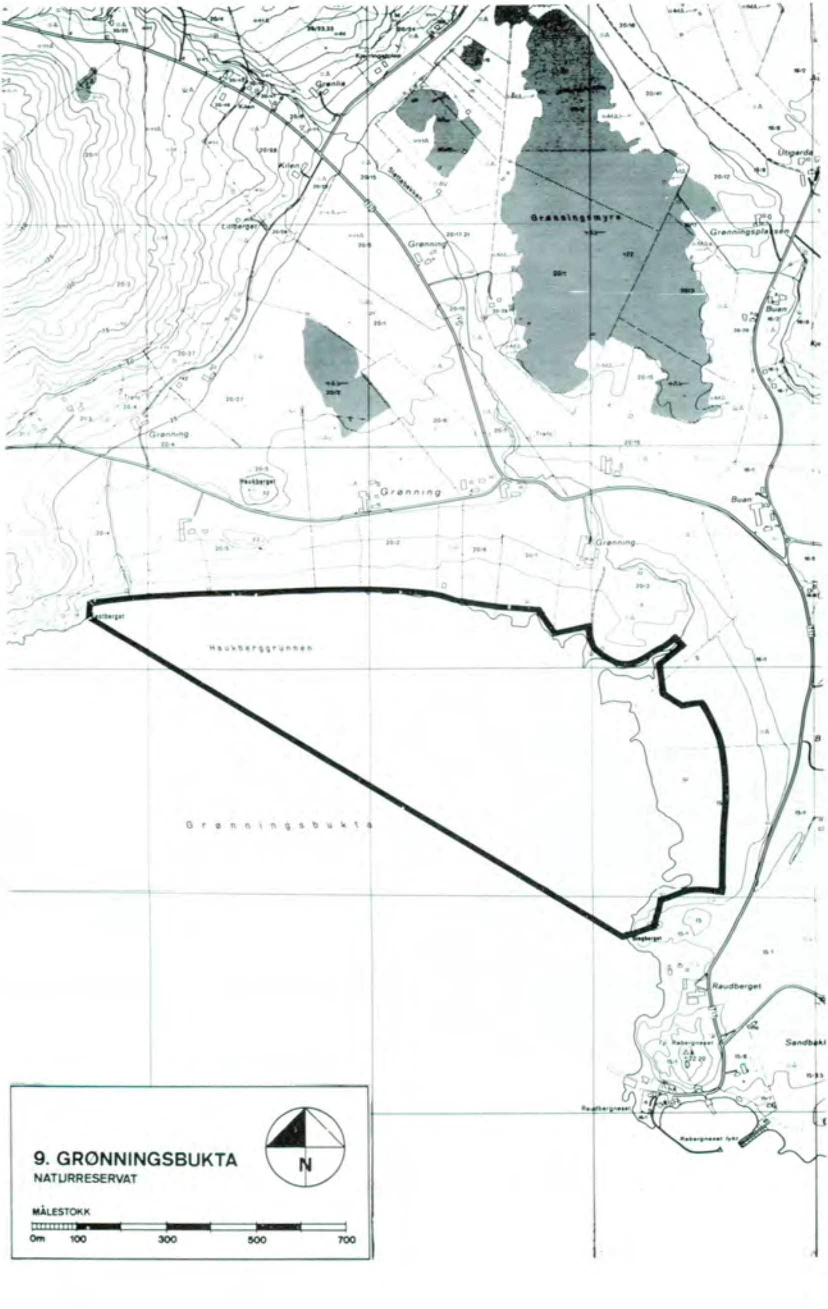
FORMÅLET MED VERN:
Formålet er å sikre et særegent våtmarksområde med et spesielt plante- og dyreliv.

UTFØRTE INNGREP:
Området er i dag totalt sett lite påvirket. To bruer går gjennom området, og dyrket mark og bebyggelse grenser opp til Strømmen. Ved Sundsbrua er det etablert et mindre verksted ved utfylling. Ved Uddu er det en naturlig havn for fiskebåter o.a., et havnemiljø med lange tradisjoner. I tidligere tider var det vanlig at fiskebåter kom inn i Strømmen langveis fra for å grave etter agningsemner (fjæremark og skjell). Deler av strandengområdene er noe beitepåvirket.

KJENTE INTERESSEKONFLIKTER:
Det har vært reist spørsmål om opprenskning av Strømmen for om mulig å bedre gjennomstrømningen for at forholdene i Botn skal kunne bedres. Konkrete planer foreligger imidlertid ikke. Hvorvidt en opprensking av Strømmen er ønskelig, kan en på nåværende tidspunkt vanskelig uttale seg om, men det er bl.a. avhengig av inngrepets art. Planer om oppdyrking av deler av strandengområdene kan bli aktuelt. Ny trasé og bru for R 717 kan skade området.

AKTUELLE SKJØTSELSTILTAK/MERKNADER:
Det er for tiden ikke aktuelt med direkte skjøtselstiltak i området.

KILDER/REFERANSER:
Litteratur: 9, 11, 16, 19, 22, 43, 61, 62, 68.
Annet: 1, 2, 6, 14.


9. GRØNNINGSBUKTA
NATURRESERVAT
MÅLESTOKK
0m 100 300 500 700
N
Grønningsbukta
Haukberggrunnen
Grønningsmyra
Grønningsplassen
Grønning
Haukberget
Raudberget
Raudbergneset
Buan
Grønlia
Kilen
Utgarda
Sandbakk

LOKALITETSNUMMER: 9
LOKALITETSNAVN: Grønningsbukta
KOMMUNE: Rissa

BELIGGENHET: Stadsbygd
KARTBLAD: Orkanger 1522 I
UTM-KOORDINATER: 32V NR 490.413
HØYDE OVER HAVET: 0—2 meter
AREAL: Ca. 590 da, herav ca. 490 da vannareal

BERØRTE EIENDOMMER (GNR./BNR.):
15/1; 16/1; 20/1; 20/2; 20/3; 20/4; 20/5; 20/6.

KORT OMRÅDEBESKRIVELSE:
Grønningsbukta er ei bukt på vestsiden av Røberg, det sørligste punkt på Fosenhalvøya. Området er et fjære- og gruntvannsområde med et innenforliggende strandengparti (ca. 85 dekar). Strandlinjen er ca. 1700 meter. Tidevannssonen er nederst dominert av steinfjære med et sammenhengende tangbelte. Over dette er det en del grus og grov sand. I størstedelen av bukta er det en driftvollsone. Innenfor denne ligger et lavereliggende, flatt sump- og strandengområde. Langs nordre del av stranda er det et smalt belte naturlig strand- og engvegetasjon mellom steinfjæra og åker og eng. Hele bukta er omsluttet av jordbruksmark. En åpen bekk renner ut midt i området.

KORT ORNITOLOGISK BESKRIVELSE:
Grønningsbukta og den nærliggende Prestbukta fungerer på flere måter sammen som et system. Områdets viktigste funksjon ligger i betydningen som raste-/hvileplass for vannfugl i trekktidene og om vinteren. Grønningsbukta fungerer også i noen grad som hekkelokalitet og benyttes om sommeren dessuten av en del ikke-hekkende fugl — bl.a. myter en del andefugl i området utpå sensommeren. For hele systemet er det hittil registrert 86 ulike fuglearter. Av disse er det funnet 18 andefuglarter og 22 vadefuglarter og tilsammen 53 vannfuglarter. Artsantallet er altså høyt, og det samme gjelder til sine tider individantallet — spesielt i trekktidene. Flere spesielle vannfuglarter er registrert. Artssammensetningen gjenspeiler et variert våtmarkssystem. Etter de kriterier som er benyttet er forekomsten av 12 vannfuglarter vurdert å være av regional interesse, 1 av nasjonal interesse og 1 av internasjonal interesse. Dette gjelder hele systemet Grønningsbukta — Prestebukta. I denne sammenheng vil en foreslå vern av den vik-

tigste delen av systemet — Grønningsbukta — som separat vurderes å ha regional verneverdi i ornitologisk henseende. Området er et viktig ledd i den trekkveien for vannfugl som går langs Trondheimsfjorden fra/mot øst.

ANDRE VERNEINTERESSER:
Ut fra botaniske kriterier er strandengområdet innerst i Grønningsbukta svært verneverdig og et av de fem strandengområdene i hele Trondheimsfjorden som er foreslått vernet. Området er velegnet til undervisningsformål. Grønningsbukta utgjør et vakkert landskapselement i nedre deler av Stadsbygd.

FORMÅLET MED VERN:
Formålet er å sikre et strand- og gruntvannsområde som utgjør en viktig trekk- og over-intringsplass for vannfugl, en spesiell våtmarkslokalitet med en sjelden vegetasjonstype.

UTFØRTE INNGREP:
Ingen vesentlige.

KJENTE INTERESSEKONFLIKTER:
Deler av området har blitt benyttet lokalt for uorganisert bading, og strandengene har blitt benyttet til beite, men disse bruksformer betraktes ikke å medføre konflikter i den målestokk dette har foregått i til nå. Søppeltømming bør unngås. Jakttrykket er lite.

AKTUELLE SKJØTSELSTILTAK/MERKNADER:
Det er for tiden ikke aktuelt med direkte skjøtselstiltak i området.

KILDER/REFERANSER:
Litteratur: 2, 11, 16, 19, 22, 61, 62, 68.
Annet: 1, 2, 6, 18.

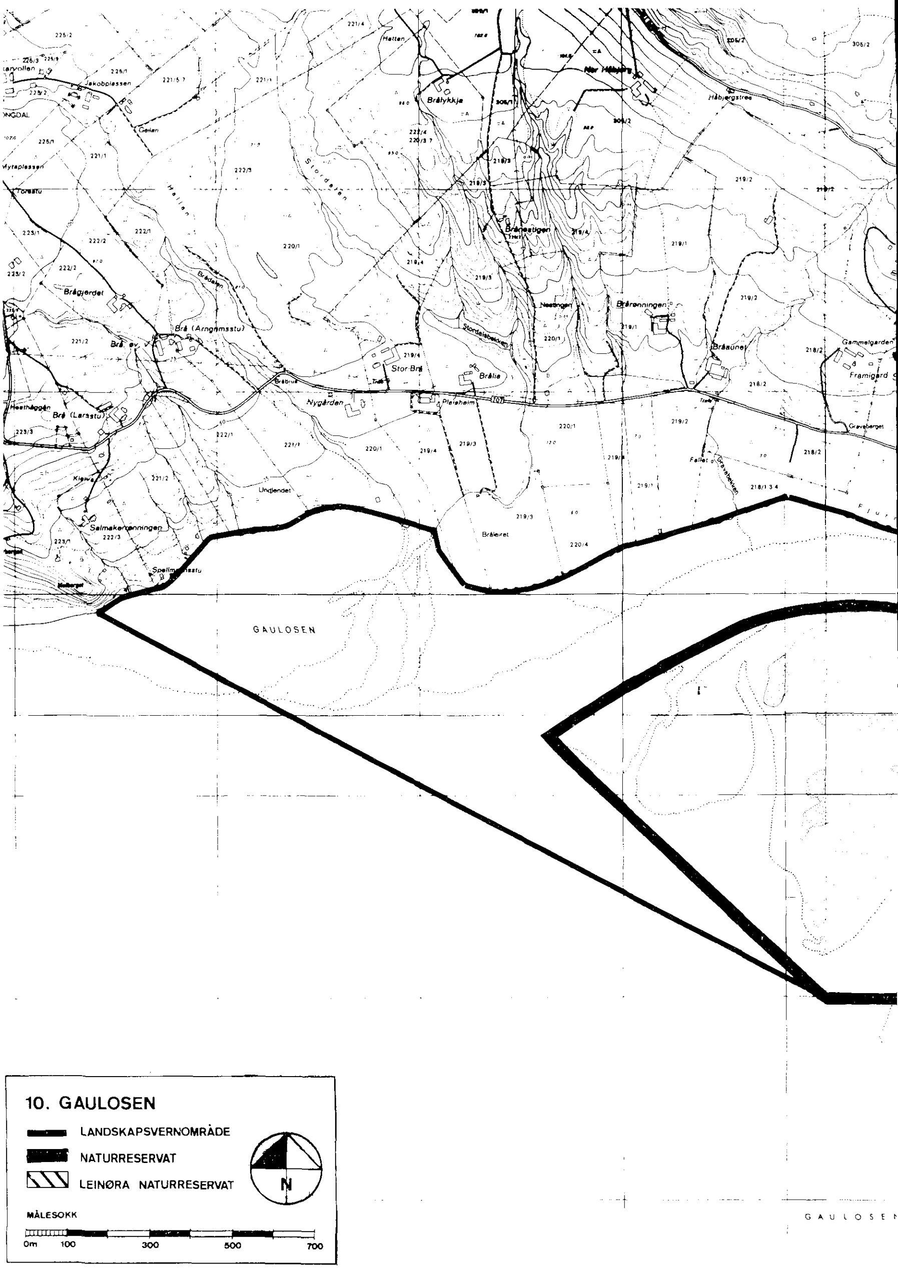
LOKALITETSNUMMER: 10
LOKALITETSNAVN: Gaulosen
KOMMUNE: Trondheim og Klæbu

BELIGGENHET: Øysand, Leinstrand/Byneset
KARTBLAD: Orkanger 1521 I og Trondheim 1621 IV
UTM-KOORDINATER: 32V NR 605.245
HØYDE OVER HAVET: 0—2 meter
AREAL: Totalt ca. 2765, herav ca. 2410 da vannareal

BERØRTE EIENDOMMER (GNR./BNR.):
Trondheim: 154/1; 154/2; 154/5 (Staten); 155/1; 157/2, 4; 218/1, 3, 4; 219/1; 219/2; 219/3; 219/4; 220/1; 220/4; 221/1; 221/2; 222/1; 222/3; 223/1. Melhus: gnr. 1/Øye sameie, 1/17; 1/19.

KORT OMRÅDEBESKRIVELSE:
Hovedkomponenten i området er elva Gaula som her renner ut i Trondheimsfjorden i det vakre kulturlandskapet som dannes bl.a. av Øysand og Byneslandet. Området består av selve elveløpet og et delta med større sand-, leir- og grussedimenter som har dannet ei elveør midt i utløpet. Denne deler utløpet i to. Hovedløpet går nord for øra (Storøra). På sørsiden av søndre løp ligger et større sump-og strandengparti og litt opp i elva ligger Leinøra med sumpmark, tindvedkratt og annen vegetasjon. Ved fjære sjø blottlegges større sammenhengende fjæreområder langs Byneslandet (Bråleiret m.m.), på Storøra og på Øysand. Gaula er grusførende og har endret noe på løpet gjennom tidene. Omgivelsene er preget av jordbruk.

KORT ORNITOLOGISK BESKRIVELSE:
Gaulosen fungerer som en meget viktig hvile-/rasteplass for vannfugl i trekktidene og om vinteren. Under trekket benyttes området også av en rekke andre fuglearter. En del arter hekker i området (særlig på Storøra og Leinøra). Videre fungerer området som beiteplass for fugler som hekker i omgivelsene, som myteplass for andefugl og hvileplass for måsefugl. En del fugler overnatter i området. Tilsammen er hittil 142 ulike fuglearter registrert i området, av disse er 4 dykkerarter, 21 andefuglarter, 28 vadefuglarter og tilsammen 65 vannfuglarter. Artsantallet er altså meget høyt, og det samme gjelder individantallet for flere arter eller grupper — f.eks. er det registrert 22 lom, ca. 1500 andefugl og ca. 600 vadefugl. En rekke spesielle og mer sjeldne vannfugler o.a. er registrert i området.



10. GAULOSEN
LANDSKAPSVERNOMRÅDE
NATURRESERVAT
LEINØRA NATURRESERVAT
MÅLESOKK
0m
100
300
500
700
N
GAULOSEN
GAULOSEN
Jakobplassen
Brålykkje
Håbjørgstrøa
Brågjerdet
Brå (Arngrimsstu)
Stor-Brå
Brålia
Pleieheim
Nygården
Brå (Larsstu)
Kleiva
Salmakerrønningen
Spellmannsstu
Undjendet
Bråeiret
Bråaunet
Brårønningen
Gammelgarden
Framigard
Gravaberget
Stordalen
Stordalsbekken
Brådalen
Hatten

G A U L A
Øysand
Lauvåsen
Sundsbakken
Skogly

Etter de kriterier som er benyttet er forekomster av 18 vannfuglarter vurdert å være av regional interesse og 14 av nasjonal interesse. Dette tilsier klart at området er av nasjonal verneverdi i ornitologisk henseende.

ANDRE VERNEINTERESSER:
Gaulas delta er det eneste intakte elveutløp av noen av de større midtnorske elvene. Området er av naturgeografisk og geologisk interesse. De botaniske verneinteressene er meget sterke og knyttet til strandengområdene på Storøra og på Øysandsiden samt til det spesielle tindvedkrattet som vokser på Leinøra. Gaula er en av de beste laks- og sjøaureelvene i landet.

FORMÅLET MED VERN:
Formålet med fredningen er å bevare et viktig våtmarksområde, ta vare på fuglelivet, verne om særlig artsrike og sammensatte strandenger samt å beholde Gaulosen som et vesentlig landskapselement og som eksempel på en tilnærmet urørt større elvemunning.

UTFØRTE INNGREP:
Det knytter seg store økonomiske interesser til grusen i Gaula, og grustekten har satt dype spor etter seg på Leinøra. Grus hentes også opp fra selve elveløpet ved oppsuging eller med båt i deltaet. I 1976 ble det anlagt en treningsbane for fotball på strandengene, dette og medfølgende biler og folk samt en del annen bilkjøring, søppeltømming/brenning og litt grustekt i sanddynene har påført strandengområdene en del skader (som kan rehabiliteres). Det foregår en del småbåttrafikk i området (har økt). På Melhussiden er det en del hyttebebebyggelse.

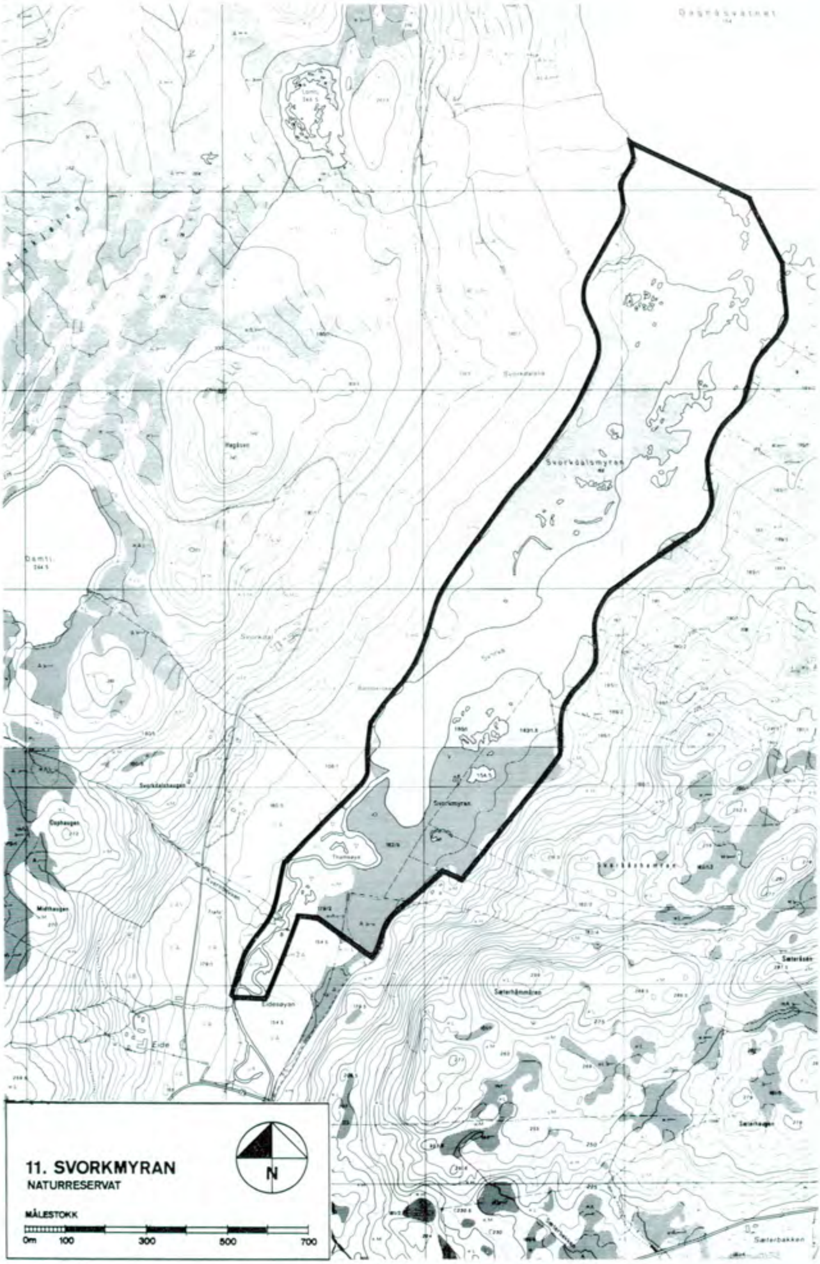
KJENTE KONFLIKTER:
Det foreligger ønsker om å ta grus på Storøra. Til det kreves det visse anlegg. Grushenting i elveløpet har hittil ikke vært noe problem. Området ligger opp til et av landsdelens viktigste badeplasser — Øysand. For stor trafikk i området ved Gaulosen er ikke ønskelig, men konflikten naturvern-friluftsliv er ikke særlig stor og skulle kunne løses. De få utfartsdagene om sommeren da tilstrømningen er særlig stor faller stort sett utenom den viktigste tiden for fuglene. Det foregår litt jakt i området (vesentlig av tilreisende).

AKTUELLE SKJØTSELSTILTAK/MERKNADER:
Området ble foreslått vernet allerede i 1965. En skjøtselsplan bør utarbeides hvor rehabilitering av de berørte strandengområdene inngår. Båttrafikken må reguleres. Det synes nødvendig med en form for inngjerding av strandengområdene på Øysand for å hindre bilkjøring.

På Leinøra ble det i 1971 opprettet et naturreservat (ca. 60 dekar) for å verne om tindvedkrattene. Dette reservatet er det første som ble opprettet i Sør-Trøndelag. Det kan være aktuelt med skjøtsel i reservatet. Omgivelsene bør også få en viss skjøtsel.

Det er utarbeidet en reguleringsplan for Øysandområdet hvor Gaulosen er avsatt som verneområde.

KILDER/REFERANSER:
Litteratur: 2, 4, 11, 14, 19, 20, 21, 22, 30, 52, 56, 57, 59, 60, 61, 62, 64, 68, 69.
Annet: 1, 2, 6, 7, 8, 19.


Svorkdalsmyran
Svorkmyran
Hagåsen
Damtj.
Svorkdalshaugen
Gophaugen
Midthaugen
Eide
Eidesøyan
Sæterhåmmåren
Sæteråsen
Sæterhaugen
Sæterbakken
11. SVORKMYRAN
NATURRESERVAT
MÅLESTOKK
0m 100 300 500 700
N

LOKALITETSNUMMER: 11
LOKALITETSNAVN: Svorkmyran
KOMMUNE: Orkdal

BELIGGENHET:
KARTBLAD: Snillfjord 1521 IV og Løkken 1521 III
UTM-KOORDINATER: 32V MR 310.144
HØYDE OVER HAVET: 153—160 meter
AREAL: Ca. 845 da, herav ca. 350 da vannareal

BERØRTE EIENDMMER (GNR./BNR.):
179/1; 179/2; 180/1; 180/5; 181/1; 182/1, 3; 182/2; 182/4; 182/5; 183/1; 188/1; 188/2; 189/1; 189/3; 190/1; 190/2; 191/1; 192/1; 192/2; 195/1; 195/2; 198/1.

KORT OMRÅDEBESKRIVELSE:
Området består av et flatt myr- og sumplandskap som elva Svorka slynger seg igjennom før den renner ut i Gangåsvatnet. Myrene utgjør et fint utviklet myrkompleks med nedbørsmyr og flatmyr med variert vegetasjon. Langs deler av elva vokser sammenhengende vierkratt. På østsiden av området er åsen dekt av granskog, vestsiden er stedvis brattere og her er skogen tettere og mer variert, søndre deler er preget av jordbruk.

KORT ORNITOLOGISK BESKRIVELSE:
Svorkmyrans varierte våtmarker fungerer først og fremst som hvile-/rasteplass i trekktidene og som hekkeplass for en del vannfuglarter o.a. Området fungerer også som beiteplass for arter som hekker i omgivelsene. Til tross for begrenset datadekning er det hittil registrert 31 ulike vannfugler i området, av disse 9 andefuglarter og 14 vadefuglarter, og 15 vannfuglarter er funnet hekkende. Canadagås er utsatt og hekker i området. Utfyllende registreringer vil ventelig komplettere og forsterke bildet av et fuglerikt våtmarksområde. Til sine tider kan individantallet av enkelte arter være høyt. Artssammensetningen er spesiell og karakteristisk for rikere våtmarksområder i indre skogsstrøk i fylket. Ut fra de kriterier som er benyttet vurderes lokaliteten å ha regional verneverdi.

ANDRE VERNEINTERESSER:
Ut fra botaniske kriterier vurderes Svorkmyran å være av nasjonal evt. landsdelsinteresse. Lavlandsmyrer i bunnen av daler som er såpass store, varierte og upåvirket av tekniske inngrep er sjeldne i Trøndelag, og myra er aktuell som re-

servat i myrreservatplanen. Området ligger meget vakkert til og utgjør et spesielt våtmarksområde. Ferskvannsbiologiske undersøkelser er ikke utført. Området er et viktig elgbeite. Et visst fiske foregår.

FORMÅLET MED VERN:
Formålet med vern av Svorkmyran er å sikre et vakkert og spesielt våtmarksområde intakt med en rik vannfuglfauna og spesiell vegetasjon.

UTFØRTE INNGREP:
Gangåsvatnet er regulert, og vannstanden i Svorka/Svorkmyran påvirkes i noen grad av dette. En vei går langs hele østkanten av myrene kloss opptil det aktuelle området. Det er bygd en del hytter i omgivelsene — enkelte helt inntil myrflaten.

KJENTE INTERESSEKONFLIKTER:
Ferdselen i området er økende (bl.a. sportsfiskere med småbåter). Jakt foregår i mindre omfang. Eventuell omlegging av riksvei 71 ved Svorka like sør for området bør skje uten at elveløpet blir flyttet.

AKTUELLE SKJØTSELSTILTAK/MERKNADER:
Det er for tiden ikke aktuelt med direkte skjøtselstiltak i området.

KILDER/REFERANSER:
Litteratur: 19, 21, 22, 31, 36, 61.
Annet: 2, 4, 6, 10.

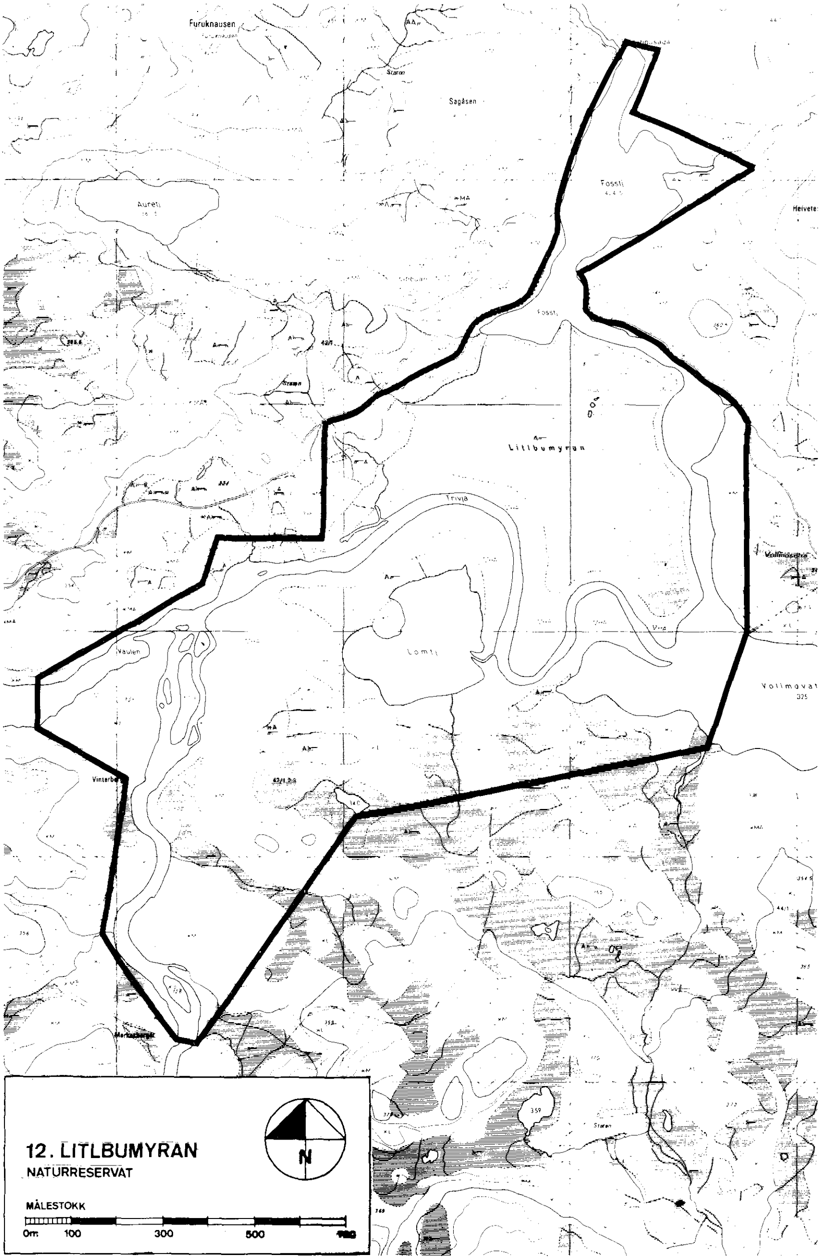
LOKALITETSNUMMER: 12
LOKALITETSNAVN: Litlbumyran
KOMMUNE: Meldal

BELIGGENHET: Ved Trivja, vest for Hølonda
KARTBLAD: Hølonda 1521 II
UTM-KOORDINATER: 32V NR 440.970
HØYDE OVER HAVET: 324—330 meter
AREAL: Ca. 1400 da, herav ca. 365 da vannareal

BERØRTE EIENDOMMER (GNR./BNR.):
Hele området (43/1 — Litlbuan; 42/1, 2, 3 — Storbuan; Vollmo Statsskog) eies nå av Staten etter at Thamseiendommen Storbuan ble innkjøpt (1976). Eiendommene inngår i Meldal Statsskoger og forvaltes av Statens skoger.

KORT OMRÅDEBESKRIVELSE:
Litlbumyran ligger på en flate i et ellers kupert barskogsterreng, elva Trivja kommer sørfra og bukter seg gjennom området. Elva er oppdemt for tidligere tømmertransport og danner Fosstjørna i nordre del av området. Myrflaten henger i øst sammen med Vollmovatnet som igjen er knyttet til Kalvhågåvatnet. I vest er Buvatnet knyttet til Trivja. Lomtjørna ligger på den søndre del av myrflaten som deles i to av elva. De store flatmyrene i dalbunnen har regelmessig vært neddemt til etter siste krig, og fortsatt oversvømmes store deler i flomperioder. Vegetasjonen bærer preg av å være i rask endring. Langs elve-/bekkekantene skyter det opp kratt som brer seg ut over de tørrere deler av myra. Vegetasjon og flora er rik. Omgivelsene er preget av barskog og blandingsskog. Plassene Litlbuan og Vollmo er i dag nedlagt.

KORT ORNITOLOGISK BESKRIVELSE:
Litlbumyrans betydning som fuglelokalitet ligger hovedsaklig i områdets funksjon som hvile-/rasteplass i trekktidene og som hekkeplass for en rekke vannfugler o.a. Dessuten benyttes området som beiteplass for arter som hekker i omvelsene. Hekkesuksessen har vært noe betinget av vårflommens komme da store deler av myrene kan bi dekt med vann. Hittil er det registrert 36 ulike vannfuglarter i området — av disse 11 andefuglarter og 15 vadefuglarter, 16 vannfuglarter er konstantert hekkende og ytterligere 5 hekker sannsynligvis. Flere spesielle arter er registrert. Artsantallet for dette begrensede området er altså høyt, og det samme gjelder stundom individantallet for flere av artene. Artssammensetningen er høyst spesiell og gjenspeiler et variert og særegent våtmarksom-


Furuknausen
Sagåsen
Aureti
Fossli
Heivete
Litlbumyran
Trivja
Lomtj
Vaulen
Vinterbe
Vollmovat
325
Staren
359
N
12. LITLBUMYRAN
NATURRESERVAT
MÅLESTOKK
0m
100
300
500

råde. Fuglefaunaen i området har gjennomgått en del endringer i løpet av de siste 10 årene. Etter de kriterier som er benyttet er lokaliteten vurdert å være av regional verneverdi i ornitologisk henseende.

ANDRE VERNEINTERESSER:
Området er et godt elgbeite. Det knytter seg sportsfiskeinteresser til området. Selv om området er under forvandling vegetasjonsmessig har det en viss botanisk interesse da en lang rekke spesielle plantearter finnes her. Området utgjør et særlig vakkert landskapselement. Den gamle veien mellom Hølonda og Meldal er av kulturhistorisk interesse.

FORMÅLET MED VERN:
Formålet er å sikre en særegen våtmarkslokalitet med spesiell flora og fauna.

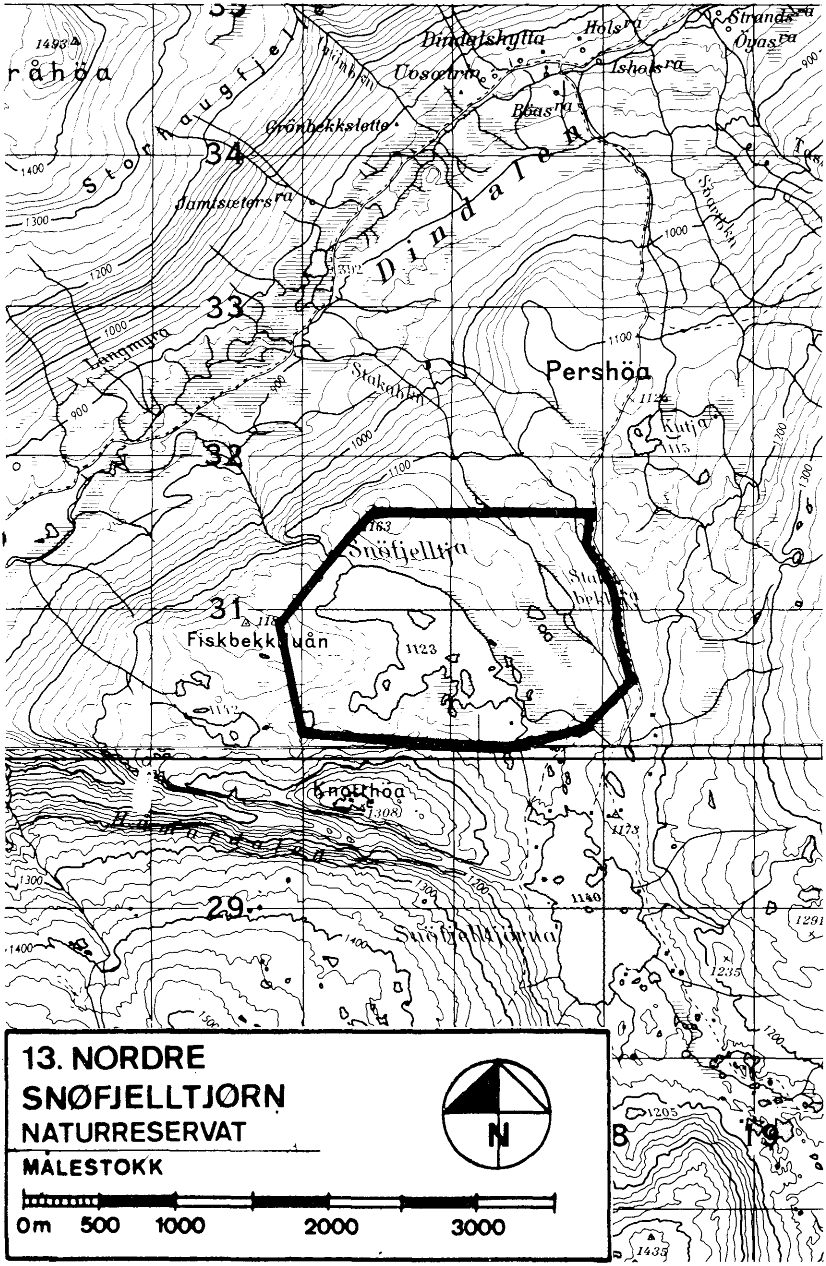
UTFØRTE INNGREP:
Det er oppført en demning i elva nord for Fosstjørna til bruk for tidligere tiders tømmerfløting, denne påvirker vannstandsnivået i området. Ved elva nedenfor Litlbuan ser en ennå rester etter den gamle brua som førte over elva etter den gamle veien mellom Meldal og Hølonda. Deler av denne veien benyttes i dag som skogsbilvei og som utfartsvei i friluftssammenheng.

KJENTE INTERESSEKONFLIKTER:
Ingen vesentlige. Jakttrykket er lite. Sportsfisket er sterkt økende og bør reguleres. Biltrafikken langs veien bør også reguleres.

AKTUELLE SKJØTSELSTILTAK/MERKNADER:
Visse skjøtselstiltak for å regulere for sterk gjengroing av løvkratt kan være aktuelt. Damanlegget bør istandsettes slik at vannstandsforholdene kan sikres og justeres etter ønske. Den gamle veitraséen bør ryddes slik at den ikke forsvinner. Det bør settes en bom på veien ved Storbuan for å hindre unødig biltrafikk i området, denne kan f.eks. åpnes for almenheten i bærtiden. Det økende fritidsfiske i området kan ha negative følger for hekkefuglene, og det bør vurderes å innføre tidsbegrenset fiske i området.

Plassen Litlbuan er istandsatt på en meget vellykket måte som skogstue av Statens Skoger. Denne utgjør et meget gunstig utgangspunkt for oppsyn og eventuelle undersøkelser i området.

KILDER/REFERANSER:
Litteratur: 19, 21, 22, 27, 30, 44, 45, 61, 63.
Annet: 2, 4, 6, 13, 15.


13. NORDRE
SNØFJELLTJØRN
NATURRESERVAT
MÅLESTOKK
0m 500 1000 2000 3000
N
Dindalshytta
Holsra
Strandsra
Øyasra
Uosætra
Ishoksra
Gronbekkslette
Jamtsætersra
Storhaugfjell
Dindalen
Pershöa
Kutja
Snöfjelltja
Stakabkn
Langmyra
Fiskbekkhuån
Knotthöa
Snöfjelltjörna
1493
1123
1163
1308
1173
1140
1205
1235
1291
1435

LOKALITETSNUMMER: 13
LOKALITETSNAVN: Nordre Snøfjelltjørn
KOMMUNE: Oppdal

BELIGGENHET: Dindalen
KARTBLAD: Oppdal 1520 III
UTM-KOORDINATER: 32 V NR 171.309
HØYDE OVER HAVET: 1125 meter
AREAL: Ca. 2900 da, herav ca. 700 da vannareal

BERØRTE EIENDOMMER (GNR./BNR.):
Oppdal Bygdealmenning og Dindal sameie

KORT OMRÅDEBESKRIVELSE:
Området ligger i høgfjellet mellom Dindalen og Åmotsdalen og dreneres til Grøvuvassdraget (Møre og Romsdal). Det ligger på et ganske flatt platå mellom noen mindre høydedrag. Området består av flere større og mindre tjern hvorav Nordre Snøfjelltjørn er det største og dominerende. Nordre Snøfjelltjørn er et grunt vatn med flat mudder- og sandbunn, største dybde er 3 m, men det meste er grunnere enn 1,5 m. Særlig på sør- og vestsiden er det store starrsumpområder, en del sumpmark finnes også i tilknytning til et par småtjern litt østenfor. Omgivelsene er for det meste preget av snaufjell med forblåste rabber og noe blokkmark. Sør for området ligger Søndre Snøfjelltjørn som i noen grad kan sees i sammenheng med de nordenforliggende tjern.

KORT ORNITOLOGISK BESKRIVELSE:
Tar en beliggenheten i betraktning må området karakteriseres å ha et enestående rikt fugleliv. Områdets viktigste funksjon ligger i dets betydning for hekkelokalitet for en rekke vannfuglarter med tilknytning til høgfjellet. Dessuten fungerer området som beiteplass for fugler som hekker i omgivelsene og for fugler på trekk. Flere vannfugler som hører hjemme i lavlandet er registrert, det samme gjelder flere kravfulle og spesielle arter. Hele 30 ulike vannfuglarter er hittil registrert i området, derav 7 andefuglarter og 14 vadefuglarter, 15 vannfuglarter er påvist hekkende. For en høgfjellslokalitet er artsantallet spesielt høyt, det samme må sies om individantallet av enkelte arter. Fuglelivet gjenspeiler de særlig gunstige forholdene på stedet. Etter de kriterier som er benyttet er forekomsten av 5 arter vurdert å være av nasjonal interesse og flere andre av regional interes-

se. Området vurderes etter dette å være av nasjonal verneverdi, og må regnes som det viktigste kjente enkeltobjekt når det gjelder betydningen for vannfugl i høgfjellet i Sør-Trøndelag.

ANDRE VERNEINTERESSER:
Området er hittil ikke undersøkt i botanisk og ferskvannsbiologisk sammenheng, men må antaes å være av interesse. Området ligger vakkert til. Ved området finnes gamle dyregraver av kulturhistorisk interesse.

FORMÅLET MED VERN:
Formålet er å sikre et spesielt viktig våtmarksområde for vannfugl i høgfjellet. Dette er det eneste våtmarksområde i høgfjellet som inngår i planen.

UTFØRTE INNGREP:
Nært opptil området er det oppført en del buer som særlig benyttes under villreinjakten. En turiststi fører forbi. Traktortrafikk foregår inn til hyttene. Disse ting har ingen direkte innvirkning, men buene og traktortrafikkens spor forskjønner ikke omgivelsene.

KJENTE INTERESSEKONFLIKTER:
Ingen vesentlige utenom garnfiske som hvert år tar en del andefugl og deres unger. På Dindal sameie er garnfiske forbudt (½-parten av Nordre Snøfjelltjørn).

AKTUELLE SKJØTSELSTILTAK/MERKNADER:
På en slik høgfjellslokalitet med det særlig rike fuglelivet som finnes, er det nødvendig å unngå garnfiske i hekketiden og i den tiden andeungene/ungfuglene har tilhold her før de flytter ned i lavereliggende områder.

KILDER/REFERANSER:
Litteratur: 19, 22, 25, 26, 61, 66.
Annet: 2, 6, 12.

LOKALITETSNUMMER: 14
LOKALITETSNAVN: Holtvatna
KOMMUNE: Midtre Gauldal

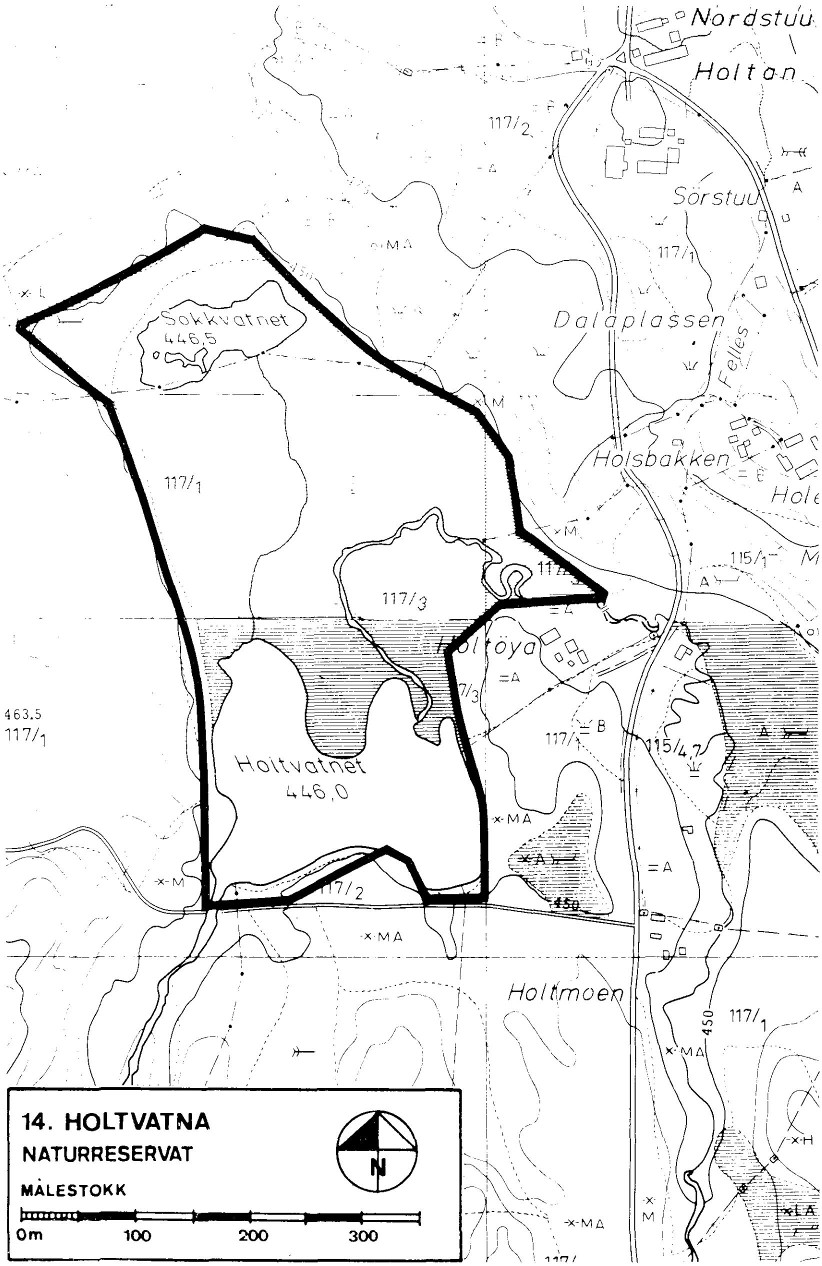
BELIGGENHET: Sørbygda, Soknedal
KARTBLAD: Budal 1620 IV
UTM-KOORDINATER: 32V PQ 632.743
HØYDE OVER HAVET: 446 meter
AREAL: Ca. 145 da, herav ca. 40 da vannareal

BERØRTE EIENDOMMER (GNR./BNR.):
117/1; 117/2; 177/3.

KORT OMRÅDEBESKRIVELSE:
Holtvatna ligger i en flat nedsenkning i et kupert landskap dominert av barskog, blandingsskog og jordbruksland. Området er lite, men variert og består av flere små tjern med omliggende starrsumpområder, rike fukteng-/myrflater og Byåa som snor seg gjennom området omgitt av vierkratt. På nord- og østsiden støter dyrket mark inn til området, mot vest gran- og blandingsskog og mot sør går en vei tett inntil området. Tjernene er meget grunne og ut på sommeren dekkes store deler av vannspeilet med vannvegetasjon. Området dreneres til Stavilla.

KORT ORNITOLOGISK BESKRIVELSE:
Både når det gjelder vegetasjon og fauna skulle en tro at lokaliteten lå i lavlandet. Som fuglebiotop har området særlig betydning som hvile-/rasteplass i trekktidene og som hekkeplass for en del vannfugler. Dessuten fungerer området som beiteplass for en del arter som hekker i omgivelsene og i noen grad som myteplass for andefugl. Tranene samles her om våren. Selv om lokaliteten er liten, er det registrert en variert fuglefauna med bl.a. 25 vannfuglarter til tross for liten datadekning. Av disse er hittil 11 konstantert hekkende innen området. Ytterligere registreringer vil ventelig bidra til å forsterke inntrykket av en spesiell fuglebiotop. Etter de kriterier som er benyttet vurderes området å være av regional verneverdi i ornitologisk henseende.

ANDRE VERNEINTERESSER:
Området er avgjort av botanisk interesse. Ferskvannsbiologiske undersøkelser er ikke utført. Området utgjør et vakkert landskapselement.



14. HOLTVATNA
NATURRESERVAT
MÅLESTOKK
0m
100
200
300
N
Nordstuu
Holtan
Sörstuu
Dalaplassen
Felles
Holsbakken
Sokkvatnet
446,5
Holtvatnet
446,0
Holtøya
Holtmoen
117/1
117/2
117/3
115/1
115/4,7
463.5
450

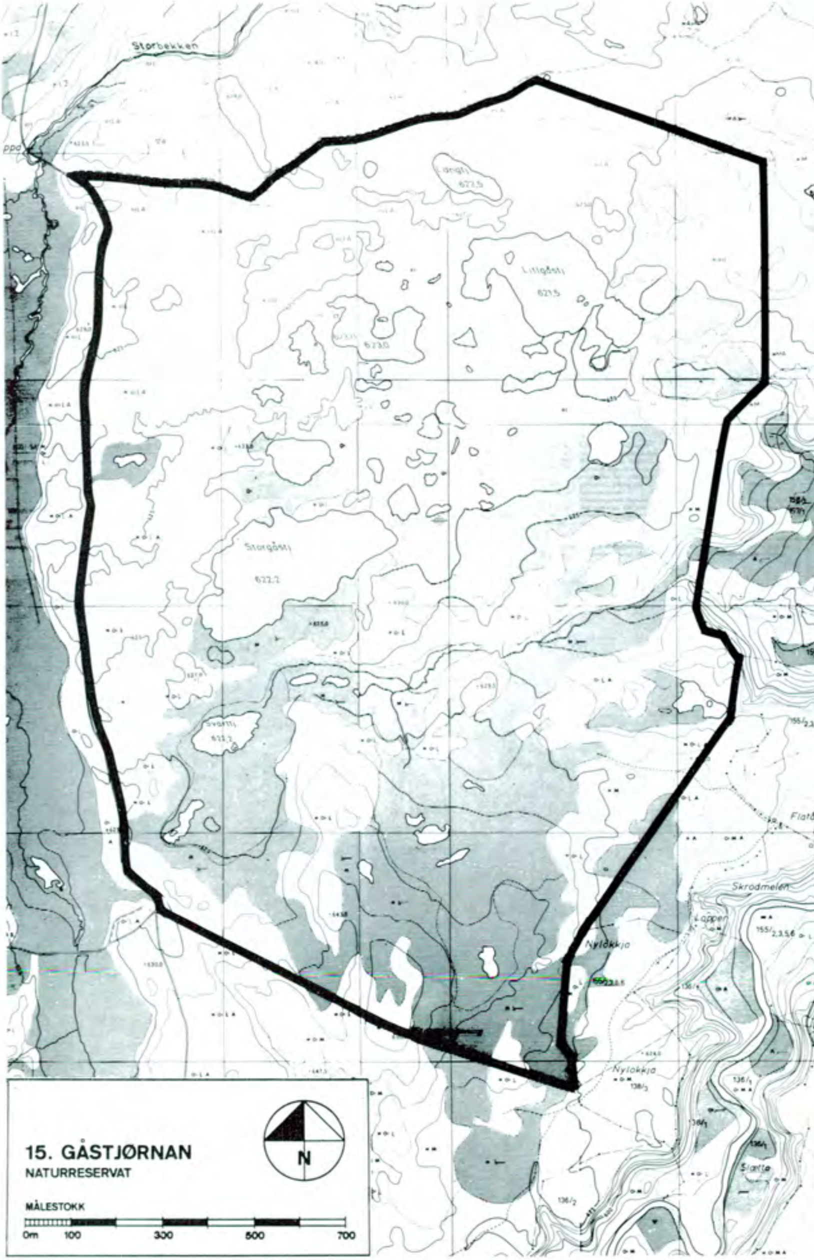
FORMÅLET MED VERN:
Formålet er å sikre et særegent lite våtmarksområde med rik flora og fauna. Området representerer en «lavlandsbiotop» i indre deler av fylket.

UTFØRTE INNGREP:
Ved ombygging av brua over Byåa ved utløpet fra Holtvatna ble det foretatt en senkning av løpet (1973) som har redusert vannstanden i området ca. 70—80 cm. Dette har bedret dreneringen fra tilstøtende, lavtliggende jordbruksjord. Området gjødsles noe ved tilsig fra omliggende jordbruksområder. Et lite, men stygt grustak er åpnet på sørsiden mellom veien og kloss inntil området.

KJENTE KONFLIKTER:
Det kan være aktuelt med ytterligere senking av vannstanden. Jakttrykket er uvesentlig.

AKTUELLE SKJØTSELSTILTAK/MERKNADER:
Det er for tiden ikke aktuelt med direkte skjøtselstiltak i området.

KILDER/REFERANSER:
Litteratur: 22.
Annet: 3, 6.


Storbekken
Lillgåstj
621,5
Storgåstj
622,2
Svarttj
Flatås
Skrodmelen
Nylokkja
Slætta
15. GÅSTJØRNAN
NATURRESERVAT
MÅLESTOKK
0m
100
300
500
700
N

LOKALITETSNUMMER: 15
LOKALITETSNAVN: Gåstjørnan
KOMMUNE: Midtre Gauldal

BELIGGENHET: Soknedal (Hauka)
KARTBLAD: Budal 1620 IV
UTM-KOORDINATOR: 32V PQ 685.715
HØYDE OVER HAVET: 640—660 meter
AREAL: Ca. 2480 da, herav ca. 200 da vannareal

BERØRTE EIENDOMMER (GNR./BNR.):
Soknedal Statsalmenning

KORT OMRÅDEBESKRIVELSE:
Hovedingrediensene i området er selve Storgåstjørna samt en del mindre tjern og dammer, en del mer eller mindre sammenhengende myrpartier og skog som er dominert av furu med innslag av bjørk og gran. Landskapet er for en stor del flatt med svak helning og noen mindre høydedrag. Gåstjørnan ligger på et platå som er skapt av de tykke kvartærgeologiske avsetningene som finnes i området og som gir hele området med omgivelser et spesielt preg. Omgivelsene består for det meste av tilsvarende skog, noe bebyggelse og kulturmark (setre og gårdsbruk) samt myrområder (spesielt nevnes Kakukjølen vest for Gåstjørnan).

KORT ORNITOLOGISK BESKRIVELSE:
Området fungerer både som hekkeplass og som hvile-/rasteplass i trekktidene for en del vannfugl og andre fuglearter. Dessuten fungerer det i noen grad som beiteplass for arter som hekker i omgivelsene. Hittil er tilsammen 21 vannfuglarter registrert i området, derav 6 andefuglarter og 9 vadefuglarter. Trekkende kortnebbgås sees regelmessig trekkende forbi, og området er trolig av en viss betydning som hvileplass for arten. Området er mangelfullt dekt når det gjelder ornitologiske registreringer. Etter de kriterier som er benyttet er området vurdert å ha lokal betydning i ornitologisk sammenheng, og det er hovedsaklig p.g.a. naturtypebetraktninger at lokaliteten vurderes å ha regional verneverdi.

ANDRE VERNEINTERESSER:
Landskapstypen i området er svært spesiell og preget av de tykke kvartærgeologiske avsetninger som finnes her. Området ligger innenfor et større område av kvartærgeologisk interesse. Botaniske registreringer foreligger ikke.

FORMÅLET MED VERN:
Formålet er å sikre et spesielt våtmarksområde som også er av en viss ornitologisk verdi. Denne våtmarks-/landskapstype blir ikke representert av noen av de andre områdene som inngår i planen.

UTFØRTE INNGREP:
Mot nordøst er det i utkanten av området foretatt noe oppdyrking, området er omkranset av vei og skogsbilveier, og skogområdene rundt er noe preget av skogsdrift. Det er ikke utført vesentlige inngrep i området rundt selve Gåstjørnan.

KJENTE INTERESSEKONFLIKTER:
Eventuelle skogsdriftsplaner, nydyrking og nye skogsbil/traktorveier.

AKTUELLE SKJØTSELSTILTAK/MERKNADER:
For tiden er det ikke aktuelt med direkte skjøtselstiltak innen området.

KILDER/REFERANSER:
Litteratur: 22, 61, 65.
Annet: 3, 6, 19.

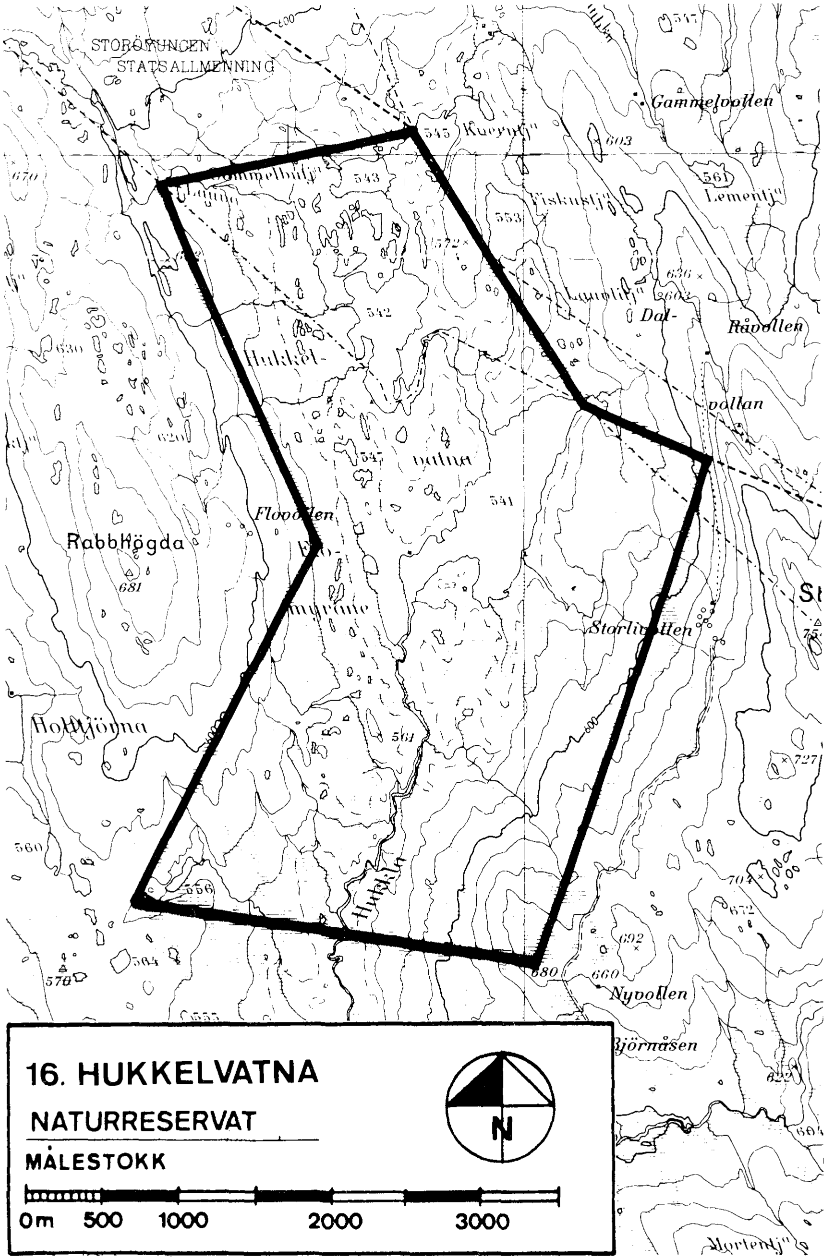
LOKALITETSNUMMER: 16
LOKALITETSNAVN: Hukkelvatna
KOMMUNE: Midtre Gauldal

BELIGGENHET: Singsås
KARTBLAD: Selbu 1621 II
UTM-KOORDINATER: 32V NQ 965.935
HØYDE OVER HAVET: 540—572 meter
AREAL: Ca. 12.500 da, herav ca. 1300 da vannareal

BERØRTE GRUNNEIERE (GNR./BNR.):
Rabslått og Seterås Statsskog; Sørungen Statsalmenning.

KORT OMRÅDEBESKRIVELSE:
Dette området er et av de største i planen, og omfatter en rekke naturtyper. Området ligger i den brede dalsenkningen mellom Rabbhøgda (681 m.o.h.) i vest og Storlifjellet (754 m.o.h.) i øst og består av slakke lier og en bred, flat dalbunn. Liene har en veksling av skog og bakkemyrer mens dalbunnen har en rekke større og mindre tjern og vatn i veksling med myr. Det forekommer et rikt spekter av myrtyper — både m.h.t. utforming og vegetasjon. Flomyrene vest i området utgjør det største sammenhengende myrkomplekset innen området. Store arealer har rik vegetasjon, og området har rik flora. Det har tidligere blitt drevet slått på myrene. Flere seteranlegg finnes i omgivelsene. De samlede våtmarksarealene representert ved myr, sump og vatn utgjør store deler av det aktuelle området.

KORT ORNITOLOGISK BESKRIVELSE:
Området fungerer som hekkelokalitet for en del vannfugler og en rekke andre fuglearter, det har også betydning som hvile-/rasteplass i trekktidene. Spillplasser for et par spesielle fuglearter finnes i området. Området er mangelfullt dekt når det gjelder ornitologiske registreringer — likevel er hittil 25 vannfuglarter registrert i området, derav 9 andefuglarter og 12 vadefuglarter. I tillegg kommer en rekke arter som først og fremst er knyttet til andre naturtyper som finnes i området. Blant de registrerte vannfuglartene er bl.a. et par spesielle arter funnet hekkende, forøvrig benyttes trolig området i noen grad av trekkende gjess (kortnebbgås?). Etter de kriterier som er benyttet vurderes området å ha regional verneverdi i ornitologisk henseende.


STATSALLMENNING
Gammelvollen
Rabbhögda
Hukkel-
vollan
Rävollen
Nyvollen
Björnåsen
16. HUKKELVATNA
NATURRESERVAT
MÅLESTOKK
0m 500 1000 2000 3000
N

ANDRE VERNEINTERESSER:
Ut fra botaniske kriterier er myrene i området vurdert å være av nasjonal verneverdi. De er undersøkt i samband med Landsplanen for myrreservater. Andre biologiska registreringer er hittil ikke utført i området. Området utgjør et lite påvirket, vakkert og variert naturlandskap.

FORMÅL MED VERN:
Formålet er å sikre et større sammenhengende naturlandskap med spesiell vegetasjon og fauna. Tilsvarende våtmarkselementer blir ikke representert i de andre lokalitetene i planen.

UTFØRTE INNGREP:
Helt sør i området er det et lite inntaksmagasin i elva Hukla som fører ut av området. Magasinet inngår i Samsjøreguleringen, og vannet overføres i tunnel dit. Ellers er området lite påvirket, i omgivelsene ligger noen seteranlegg, en traktorvei fører inn til Storlivollen fra Singsås. Deler av området har tidligere vært benyttet til beite og slått.

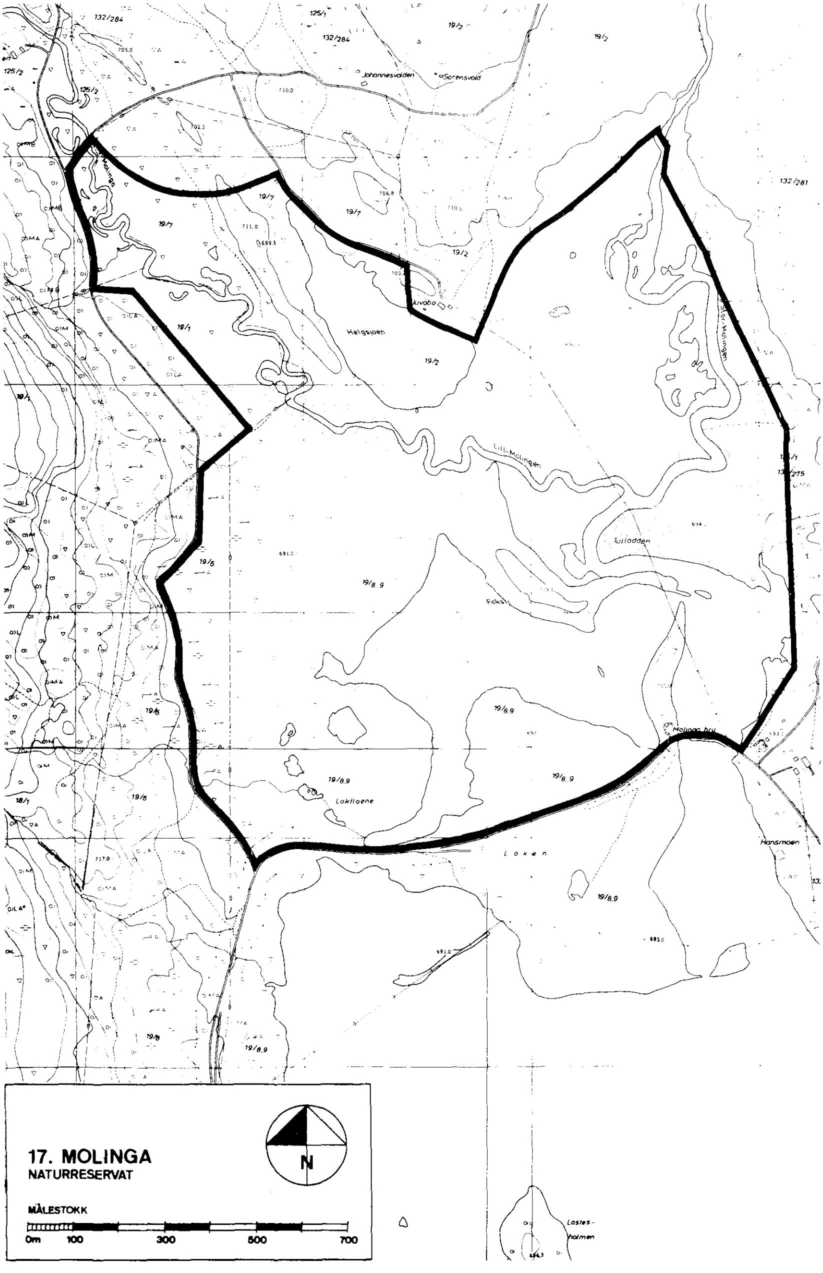
KJENTE INTERESSEKONFLIKTER:
Ingen kjente.

AKTUELLE SKJØTSELSTILTAK/MERKNADER:
Det er for tiden ikke aktuelt med direkte skjøtselstiltak i området, men skjøtsel med rydding og slått bør eventuelt vurderes senere for noen mindre områder av særlig botanisk interesse.

Områdene ved Hukkelvatna er foreslått vernet tidligere, og for noen år siden utarbeidet Statens naturverninspektør for Midt- og Nord-Norge et grenseforslag for området (1976). En har i denne planen stort sett valgt å følge dette grenseforslaget selv om det omfatter en del mer enn våtmarksområdene i området. Dette skyldes de samlede verneinteressene i området.

Det bør taes hensyn til området ved utnyttelse av tilstøtende områder på andre siden av kommunegrensen — i Selbu kommune. Her ligger områder som fysisk og funksjonsmessig hører sammen med Hukkelvatna/Flomyrene. En bør her unngå hyttebygging og skogsbilveier.

KILDER/REFERANSER:
Litteratur: 22, 28, 29, 35, 36, 48, 61, 65.
Annet: 2, 4, 6, 13, 19.



17. MOLINGA
NATURRESERVAT
MÅLESTOKK
0m 100 300 500 700
N
Johannesvolden
Sorensvold
Molinga
Helgsjoen
Juvabo
Lill-Molingen
Stor-Molingen
Tulladden
Lokkloene
Molinga bru
Hansmoen
Loken
Lastes-holmen

LOKALITETSNUMMER: 17
LOKALITETSNAVN: Molinga
KOMMUNE: Røros

BELIGGENHET: Glåmos, ved Aursunden
KARTBLAD: Røros 1720 III
UTM-KOORDINATER: 32V PQ 262.545
HØYDE OVER HAVET: 690—700 m.o.h.
AREAL: Ca. 1700 da, herav ca. 525 da vannareal

BERØRTE EIENDOMMER (GNR./BNR.):
19/1; 19/2; 19/6; 19/7; 19/8, 9; 125/2; 124/1—132/275; 132/281.

KORT OMRÅDEBESKRIVELSE:
Molingaområdet ligger i tilknytning til Aursunden. Elvene Lille og Store Molinga snor seg ned gjennom området og flyter sammen ut i Aursunden. Landskapet er nesten helt flatt — bare avbrutt av en morenerygg som går gjennom området. Arealet består av et sammenhengende våtmarksområde med myrområder, større sumpmarker, fuktengområder, grunne småtjern og elveloner. Vannstandsforholdene i Aursunden påvirker området. Omgivelsene er for det meste preget av bjørkeskogslier med myrdrag.

KORT ORNITOLOGISK BESKRIVELSE:
Molingaområdet utfyller flere funksjoner i ornitologisk sammenheng, viktigst er området som hvile-/rasteplass i trekktidene og spesielt om våren, men området byr også på gunstige hekkeplasser for en del vannfuglarter. Videre fungerer området som beiteplass for arter som hekker i omgivelsene, i noen grad som myteplass for andefugl og som spillplass for et par spesielle arter. Flere kravfulle og spesielle vannfuglarter er registrert. Hittil er 39 vannfuglarter registrert i området, av disse er 12 andefuglarter og 16 vadefuglarter, 16 vannfuglarter er konstantert hekkende mens 12 andre hekker sannsynlig eller har trolig hekket. Artsantallet er altså stort, det samme kan til sine tider gjelde individantallet av enkelte arter. Etter de kriterier som er benyttet er forekomsten av 9 arter vurdert å være av regional interesse og 1 art av nasjonal interesse. Ut fra de foreliggende data vurderes lokaliteten å ha regional verneverdi. Området skiller seg i ornitologisk henseende ut fra mange andre våtmarksområder i søndre deler av indre Sør-Trøndelag.

ANDRE VERNEINTERESSER:
Det foreligger ikke botaniske eller ferskvannsbiologiske registreringer fra området. Området utgjør et viktig elgbeite og et meget vakkert landskapselement.

FORMÅLET MED VERN:
Formålet er å sikre et spesielt våtmarksområde av spesiell viktighet for en rekke vannfugler.

UTFØRTE INNGREP:
Aursunden er regulert og vannstanden i sjøen påvirker vannstandsforholdene av Molingaområdet. Flere veier (fylkesvei og skogsbilveier) går i utkantene av området. Et hytteanlegg ligger ned til området og en kraftlinje fører fram dit tvers over området. Det er tatt ut noe grus et par steder.

KJENTE INTERESSEKONFLIKTER:
Det foreligger visse planer om omlegging av fylkesveien. Dette kan ikke skje på nordsiden av eksisterende trasé uten at det vil få vesentlige følger for områdets verneverdi. Nydyrking er ikke gjennomførbart innen det aktuelle området. Jakttrykket er lite.

AKTUELLE SKJØTSELSTILTAK/MERKNADER:
Det er for tiden ikke aktuelt med direkte skjøtselstiltak i området. På sikt kan det tenkes å være aktuelt med tiltak for å stabilisere vannstanden noe innen området.

KILDER/REFERANSER:
Litteratur: 19, 21, 22, 36, 61, 65.
Annet: 2, 4, 6, 11.

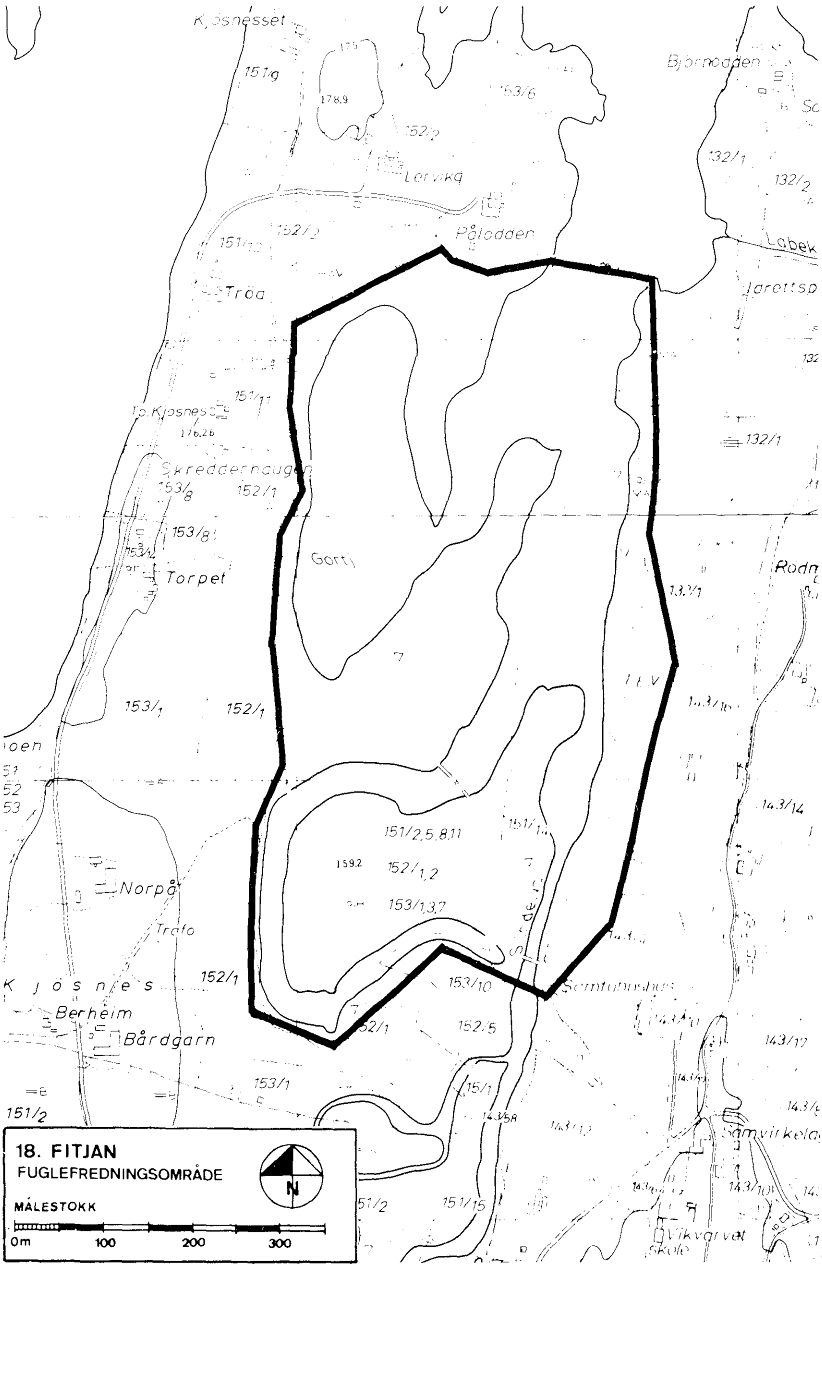
LOKALITETSNUMMER: 18
LOKALITETSNAVN: Fitjan
KOMMUNE: Selbu

BELIGGENHET: Vikvarvet
KARTBLAD: Selbu 1621 II
UTM-KOORDINATER: 32V NR 985.110
HØYDE OVER HAVET: 157—160 meter
AREAL: Ca. 340 da, herav ca. 150 da vannareal

BERØRTE EIENDOMMER (GNR./BNR.):
143/53; 151/2, 5, 8, 11; 151/14; 152/1; 152/2; 152/5; 153/1, 3, 7; 153/10.

KORT OMRÅDEBESKRIVELSE:
Området ligger i et flatt landskap og dannes av Gullsetelvas utløp i Selbusjøen. Det består av elveløpet med elveslynger, et grunt tjern (Gorrtjørna) og tilhørende sumpmarksområder med fuktenger. Vannstanden varierer i takt med Selbusjøen, og området er noe utsatt for flom om våren. Langs elveløpet vokser en del tett løvkratt. Omgivelsene er preget av jordbruk og jordbruksbebyggelse.

KORT ORNITOLOGISK BESKRIVELSE:
I ornitologisk sammenheng er funksjonen som hvile-/rasteplass i trekktidene den viktigste. Spesielt om våren blir området benyttet av mange vannfugler. Dessuten hekker en del arter i området — både vannfugl og andre fuglearter — og en del fugl som hekker i omgivelsene benytter området som beiteplass. Området kan funksjonsmessig i noen grad sees i sammenheng med Låen (jfr. lokalitetsnummer 19) som ligger like ved. Det foregår en viss utskiftning av fugl mellom disse lokalitenene særlig i trekktidene, blir fugl skremt fra det ene området, kan de fly over i det andre. Da begge områdene er av svært begrenset størrelse, er dette av betydning for fuglelivet i området da områdene til en viss grad utfyller hverandre. Hittil er totalt 97 fuglearter registrert i Fitjanområdet, herav er 16 funnet hekkende og 22 antas å hekke, 39 vannfuglarter er registrert og av disse er 13 andefugler og 18 vadefuglarter. Artsantallet er høyt, og det samme kan gjelde individantallet av enkelte arter. Etter de kriterier som er benyttet er forekomsten av 10 vannfuglarter vurdert å være av regional interesse. Lokaliteten vurderes etter dette å ha regional verneverdi.


18. FITJAN
FUGLEFREDNINGSOMRÅDE
MÅLESTOKK
0m
100
200
300
N
Kjosnesset
Lervika
Pålodden
Tröa
Skreddernaugen
Torpet
Gortj
Norpå
Trafo
Kjøsnes
Berheim
Bårdgarn
Bjørnodden
Labek
Rødn
Vikvarvet
Skole
151/2,5,8,11
152/1,2
153/1,3,7
153/10
152/5
153/1
151/2
151/15
152/1
153/1
153/8
132/1
132/2
143/14
143/12

ANDRE VERNEINTERESSER:
Området er av botanisk interesse da rike fuktenger og sumpområder av denne størrelse er sjelden i lavereliggende deler av Trøndelag. Reguleringen av Selbusjøen og kulturpåvirkning reduserer imidlertid de botaniske verneverdiene. Området ligger vakkert til i kulturlandskapet.

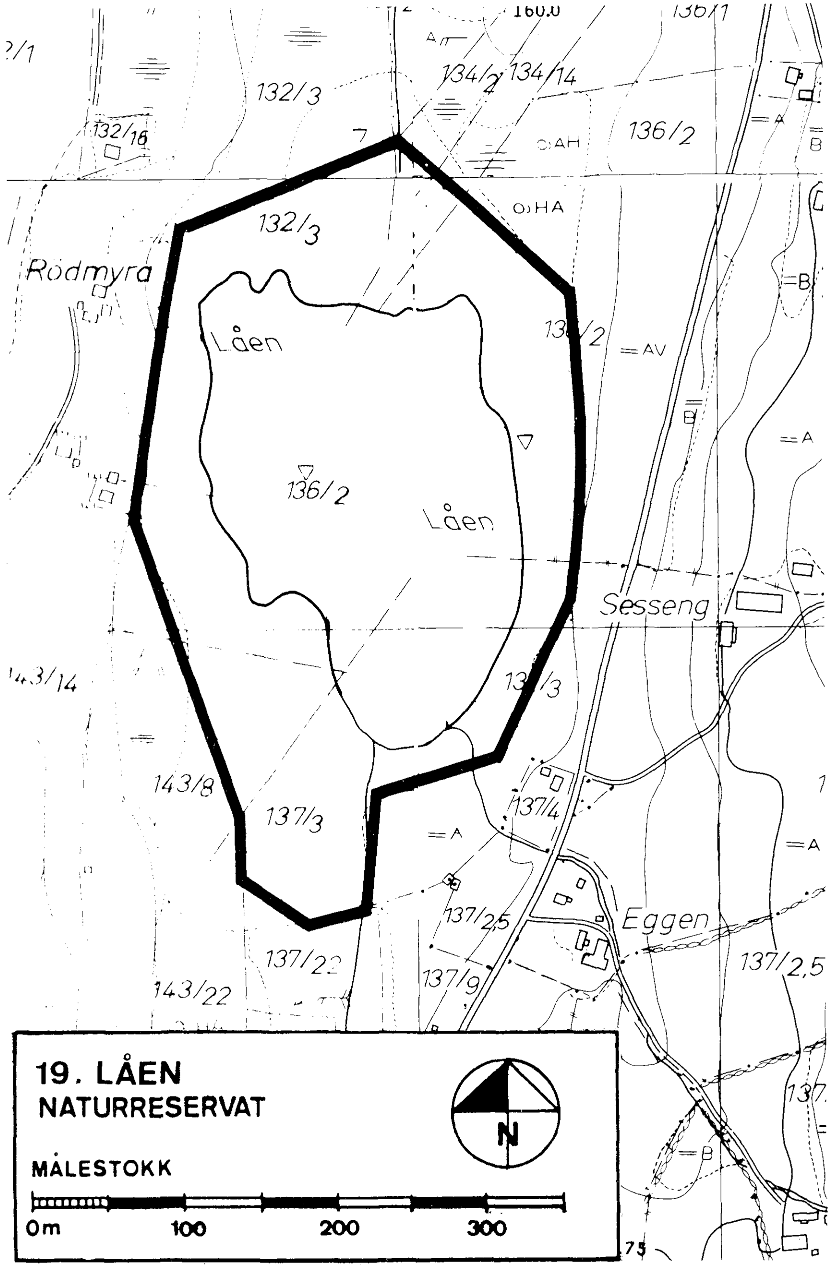
FORMÅLET MED VERN:
Formålet er å sikre et spesielt våtmarksområde med et rikt plante- og dyreliv.

UTFØRTE INNGREP:
Selbusjøen er som nevnt regulert og påvirker vannstanden i området, ved utløpet er det bygd en «molo». Elva er delvis kanalisert i samband med reguleringene. I elveløpet er det en del rester etter anlegg fra tømmerfløtningen. Området er delvis sterkt beitepåvirket. Deler av det opprinnelige fuktengområdet er oppdyrket.

KJENTE INTERESSEKONFLIKTER:
Ytterligere dyrkning i området kan muligens være aktuelt i visse deler. Eventuell omlegging av elveløpet p.g.a. nye reguleringer kan muligens bli aktuelt. Jakttrykket er lite.

AKTUELLE SKJØTSELSTILTAK/MERKNADER:
For tiden synes ikke direkte skjøtselstiltak aktuelle, på sikt kan muligens tiltak for å stabilisere vannstanden noe innen området være ønskelig.

KILDER/REFERANSER:
Litteratur: 19, 22, 28, 46, 48, 61, 62, 65, 68.
Annet: 2, 4, 6, 16.


19. LÅEN
NATURRESERVAT
MÅLESTOKK
0m
100
200
300
N
Rödmyra
Låen
Låen
Sesseng
Eggen
132/3
132/3
132/16
134/2
134/14
136/2
136/2
137/3
137/4
137/2,5
137/2,5
137/22
137/9
143/14
143/8
143/22

LOKALITETSNUMMER: 19
LOKALITETSNAVN: Låen
KOMMUNE: Selbu

BELIGGENHET: Vikvarvet
KARTBLAD: Selbu 1621 II
UTM-KOORDINATER: 32V NR 992.108
HØYDE OVER HAVET: 160 meter
AREAL: Ca. 105 da, herav ca. 50 da vannareal

BERØRTE EIENDOMMER (GNR./BNR.):
132/3; 134/2; 134/14; 136/2; 137/3; 143/8; 143/14.

KORT OMRÅDEBESKRIVELSE:
Låen er et lite, næringsrikt tjern som har utløp til Selbusjøen gjennom en smal bekk/kanal (Låbekken). Det ligger i en senkning i det småkuperte landskapet ved Selbusjøen og omgis av kulturmark. Rundt tjernet vokser tett løvskogskratt, vannvegetasjonen dekker store deler av vannflaten, og et tett takrørbelte dominerer det meste av strandsonen. Vannspeilet blir delvis dekt av nøkkeroser utpå sommeren. Vannstanden varierer og påvirkes noe av Selbusjøen. Området gjødsles fra omliggende jordbruksområder.

KORT ORNITOLOGISK BESKRIVELSE:
Selv med sitt meget begrensede areal er Låen en meget viktig fuglebiotop. Området fungerer som hekkeplass, hvile-/rasteplass i trekktidene, natteplass, myteplass for en del andefugl og som beiteplass for arter som hekker i omgivelsene. Viktigst er området som trekklokalitet og som hekkeplass for spesielle vannfuglsarter. Funksjonsmessig henger Låen sammen med Fitjan (lokalitetsnummer 18). Det foregår utveksling av fugl mellom de to nærliggende lokalitetene som på mange måter utfyller hverandre. Totalt er 71 arter hittil registrert i området — et meget høyt artsantall for en så liten biotop, 32 vannfuglarter er registrert — av disse 10 andefuglarter og 12 vadefuglarter, 12 vannfuglarter er konstantert hekkende og ytterligere 5 hekker sannsynlig. Flere kravfulle og spesielle vannfuglarter er registrert. Også individantallet kan for en del arter være høyt. Artssammensetningen gjenspeiler et særlig viktig våtmarksområde. Etter de kriterier som er benyttet er forekomsten av 9 vannfuglarter (herav 3 hekkende) vurdert å være av regional interesse og 1 art (hekkende) av nasjonal interesse. Ut fra dette vurderes lokaliteten å være av regional verneverdi i ornitologisk sammenheng.

ANDRE VERNEINTERESSER:
Området er av botanisk interesse. Ferskvannsbiologiske undersøkelser er ikke utført. Tidligere var det et rikt fiske i Låen.

FORMÅLET MED VERN:
Formålet er å sikre en spesiell våtmarksbiotop med et spesielt fugleliv. Områder av denne type er meget fåtallige i Trøndelag.

UTFØRTE INNGREP:
Vannstanden i Låen er senket ved at kanalen har blitt utgravd, noe som har bedret dreneringen fra jordbruksområdene rundt Låen.

KJENTE INTERESSEKONFLIKTER:
Enkelte av de tilstøtende områder kan muligens tenkes oppdyrket. Jakttrykket er lite.

AKTUELLE SKJØTSELSTILTAK/MERKNADER:
Det er for tiden ikke aktuelt med direkte skjøtselstiltak utenom at grøftene/kanalene bør opprenskes for å hindre større oversvømmelser. Slik opprenskning bør skje skånsomt.

KILDER/REFERANSER:
Litteratur: 14, 19, 22, 28, 46, 48, 61, 62, 65, 68, 69.
Annet: 2, 4, 6, 16.

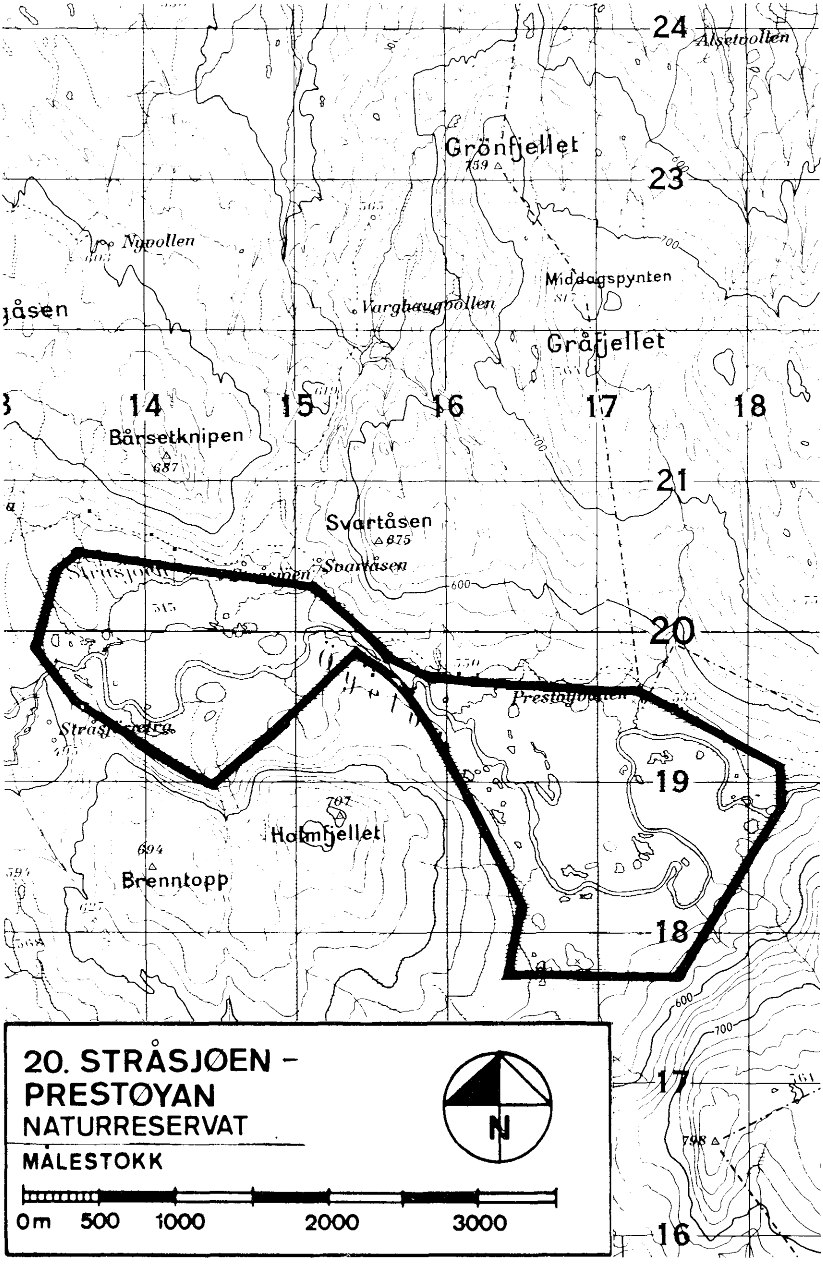
LOKALITETSNUMMER: 20
LOKALITETSNAVN: Stråsjøen—Prestøyan
KOMMUNE: Selbu

BELIGGENHET: Garbergelvvassdraget
KARTBLAD: Flornes 1721 III
UTM-KOORDINATER: 32V PR 145.200/170.190
HØYDE OVER HAVET: 515—540 meter
AREAL: Ca. 5400 da, herav ca. 800 da vannareal

BERØRTE EIENDOMMER (GNR./BNR.):
49/10; 50/11; 50/13; 51/6; 52/5, 67/13; 76/11 (eies alle av Trondheim Elektrisitetsverk), 54/6 (Trondheim kommune), 67/1 (Staten v/Selbu prestegård), 193/1 (Selbu lensmannsbestilling), 50/1; 50/2; 52/1; 67/38; 76/3, 4; 89/1; Roltdal Statsalmenning.

KORT OMRÅDEBESKRIVELSE:
Området ligger ved Garbergelva og består av to platåer med en høydeforskjell på ca. 25 meter. Elva renner stille i store slynger (tilsammen 8—9 km) gjennom hvert av platåene og danner Svartåsfossen mellom dem. Den meget grunne Stråsjøen ligger på det nedre platået og er forbundet til elva gjennom en liten kanal. Større sammenhengende flatmyrområder og sumpmark omslutter Stråsjøen og deler av elveløpet, flere smådammer finnes spredt i området. Det øvre platå — Prestøyan — har en anne karakter, terrenget er noe mer kupert og myrflatene er tørrere, men også her finnes en del smådammer og bløtere parti. Langs elva på begge platå vokser frodig kantskog av bjørk og vier. Omgivelsene er preget av åser med blandingsskog og bakkemyrer, og rester etter seterdrift kan ennå sees. Området utgjør det største sammenhengende våtmarksområde i innlandet i fylket som er tatt med i denne planen, og det representerer det eneste området i fylket som i noen grad kan erstatte det store våtmarksområdet i Nedalen i Tydalen. Nedalsmyrene er som kjent neddemt ved vasskraftregulering til tross for tidligere naturfredning.

KORT ORNITOLOGISK BESKRIVELSE:
Våtmarksområdene i Stråsjøen—Prestøyan utgjør en kompleksitet av ulike våtmarkselementer som kan dekke en rekke vannfugler og andre fuglearters miljøkrav. Av størst betydning er områdenes funksjon som hekkeplass og som hvile-/rasteplass for en rekke vannfugler i trekktidene. Dessuten fungerer området som beiteplass for arter som hekker i omgivelsene og som spillplass for et par spesielle vannfuglarter. I de senere år er det utført årlige registreringer i området,


20. STRÅSJØEN - PRESTØYAN
NATURRESERVAT
MÅLESTOKK
0m 500 1000 2000 3000
N
Grönfjellet
Nyvollen
Middagspynten
Vargbaugvollen
Gråfjellet
Bårsetknipen
Svartåsen
Alsetvollen
Holmfjellet
Brenntopp
24
23
21
20
19
18
17
16
14
15
16
17
18

og hittil er 76 fuglearter registrert, herav 21 arter er påvist hekkende og 21 andre er antatt å hekke. Totalt er 36 vannfugler registrert, herav 11 andefuglarter og 16 vadefuglarter, 9 vannfuglarter er påvist hekkende og 11 andre er antatt å hekke. Artsantallet må sies å være høyt, og det samme gjelder individantallet av enkelte arter. Flere spesielle og sjeldne vannfuglarter er registrert. Etter de kriterier som er benyttet vurderes området samlet å ha nasjonal verneverdi.

ANDRE VERNEINTERESSER:
Både botaniske og ferskvannsbiologiske undersøkelser er utført, og disse gir klare konklusjoner om at områdets verneverdi er høy. De landskapsestetiske verneverdiene i området må også nevnes, områdene utgjør svært vakre landskapselement. Områdene ligger i et betydningsfullt friluftsterreng.

FORMÅLET MED VERN:
Formålet er å sikre et større sammenhengende, særegnet og variert våtmarksområde med spesiell vegetasjon og fauna. Området er det største våtmarksområde i innlandet i fylket som blir fremmet i planen.

UTFØRTE INNGREP:
Utover en del hyttebebyggelse i omgivelsene — hvorav et par ligger særlig uheldig til — og en sti langs nordøstsiden av myrområdene, er områdene så godt som uberørte. Tidligere var det en del slått og setring i området.

KJENTE INTERESSEKONFLIKTER:
Garbergelva er foreslått medtatt blant 10-års vern av vassdragene, men er truet av kraftutbygging. Ytterligere hyttebygging i omgivelsene vil medføre sterkere ferdsel. En eventuell ny turiststi gjennom disse deler av Selbus fjellområder kan ved uheldig trasévalg influere negativt på området. Det foregår noe småviltjakt i området.

AKTUELLE SKJØTSELSTILTAK/MERKNADER:
Det er for tiden ikke aktuelt med direkte skjøtselstiltak i området.

Området bør sees i sammenheng med resten av vassdraget hvor også Kvernfjellvatna ovenfor Stråsjøen/Prestøyane er viktige kompnenter.

KILDER/REFERANSER:
Litteratur: 19, 22, 28, 47, 48, 49, 61, 65.
Annet: 2, 4, 5, 6, 16.

SAKSBEHANDLING OG FORVALTNING

Det framgår foran at 29 av de i alt ca. 200 vurderte våtmarksområdene i Sør-Trøndelag har en slik naturvernmessig betydning i internasjonal, nasjonal og/eller regional sammenheng at det er ønskelig med særlige vernetiltak etter lov om naturvern. Av disse 29 områdene er et allerede vernet innenfor Været landskapsområde og tre andre sluttbehandlet som enkeltsaker av Miljøverndepartementet. Et område er sikret ved reguleringsbestemmelser, mens to andre som ligger i Trondheim by bør sikres på samme måte. To større områder med en rekke ulike verneinteresser foreslås fremmet som enkeltsaker i medhold av lov om naturvern.

Det skal her redegjøres nærmere for hva eventuelle vernetiltak for de gjenstående 20 forekomstene innebærer i praksis.

Vern av spesielle naturområder og naturforekomster skjer i Norge i medhold av lov om naturvern av 19.6.1970. Det er der gitt hjemmel for opprettelse av flere ulike vernekategorier:

— Nasjonalparker	(Store områder av tilnærmet urørt natur som i det vesentlige ligger på statens grunn).
— Landskapsvernområder	(Egenartede natur- eller kulturlandskaper, der tradisjonell virksomhet (jordbruk/skogbruk) fortsatt skal kunne tillates).
— Naturreservater	(Tilnærmet urørte naturområder av særlig verdi (ofte av mindre omfang) som gis forholdsvis strenge vernebestemmelser).
— Naturminne	(Geologiske, botaniske eller zoologiske forekomster som fredes p.g.a. høy vitenskapelig eller historisk interesse).
— Fuglefredningsområde	(Naturområder av særlig verdi for fuglelivet som gir noe mildere vernebestemmelser).
— Plante- og dyrelivsfredning	(Arter eller samfunn av planter og dyr som er sjeldne eller truete).

Aktuell verneform for de forannevnte 20 våtmarksområdene er naturreservater, fuglefredningsområder og et område hvor en foreslår en kombinasjon av naturreservat og landskapsvernområde.

Vedtak om opprettelse av naturreservater, landskapsvernområder og fuglefredningsområder treffes av Kongen etter naturvernlovens §§ 5, 6, 8, 9, 10 og 14.

§ 5.

«For å bevare egenartet eller vakkert natur- eller kulturlandskap kan arealer legges ut som landskapsvernområde. I landskapsvernområde må det ikke iverksettes tiltak som vesentlig kan endre landskapets art eller karakter. Fylkesmannen avgjør i tvilstilfelle om et tiltak må anses å ville endre landskapets art eller karakter vesentlig.

§ 6.

Vedtak om å legge ut et areal som landskapsvernområde treffes av Kongen, som kan fastsette nærmere bestemmelser om området, dets skjøtsel og bruken av det.

§ 8.

Områder som har urørt, eller tilnærmet urørt natur eller utgjør spesiell naturtype og som har et særskilt vitenskapelig eller pedagogisk netydning eller som skiller seg ut ved sin egenart, kan fredes som naturreservat. Et område kan totalfredes eller fredes for bestemte formål som skogreservat, myrreservat, fuglereservat e.l.

§ 9.

I område som har vesentlig betydning for planter eller dyr som blir fredet i medhold av § 13 eller § 14, kan utbygging, anlegg, forurensninger og andre inngrep forbys for å bevare deres livsmiljø.
Det samme gjelder område for planter eller dyr som er eller blir fredet i eller i medhold av annen lovgivning.

§ 10.

Vedtak i medhold av §§ 8 og 9 treffes av Kongen som kan fastsette nærmere bestemmelser om områdene og deres skjøtsel.

§ 14. 2. ledd

I et område som har særlig betydning som tilholdssted for en rekke arter kan pattedyr og fugler fredes.» (Dette gjelder også hi, reir og egg).

Før en fredning blir det gjort et omfattende forarbeide. Den prosedyren for saksbehandling som Miljøverndepartementet følger i slike saker vil normalt omfatte følgende:

1. Registrering av aktuelle forekomster/områder.
2. Dokumentasjon/grovavgrensning av de registrerte områdene.
3. Prioritering av de registrerte områdene med hensyn til verneverdi.
4. Fylkesmannen foretar en detaljutredning hvorunder kommunene og grunneierne m.fl. kontaktes før fylkesmannen fremmer fredningsforslag til Miljøverndepartementet. Forslaget inneholder som oftest utkast til avgrensning, fredningsbestemmelser, oversikt over grunneierforholdene og eventuelle åpenbare konflikter mellom verneinteressene og andre interesser som knytter seg til hvert område.
5. På grunnlag av fylkesmannens detaljutredning vurderes forslaget av departementet som eventuelt sender de aktuelle fredningsforslag til uttalelse til alle berørte parter.
6. Verneforslagene sluttbehandles i Miljøverndepartementet på bakgrunn av innkomne uttalelser.
7. Departementets sluttvurdering legges fram for Regjeringen som forslag til Kongelig resolusjon.

Det arbeidet som hittil er utført ved framleggelsen av denne oversikten, kan sies å omfatte punktene 1—4 foran. Det gjenstående arbeid vil omfatte punktene 5—7. Av dette vil det framgå at de organer og enkeltpersoner som kan bli berørt av en eventuell fredning vil få anledning til å uttale seg, før de endelig fredningsforslag blir utarbeidet. Det vises for øvrig til naturverlovens § 18, der det heter:

> «Før det treffes vedtak om vern eller fredning i medhold av denne lov, skal eiere,brukere eller andre som blir berørt av tiltaket, varsles og gis anledning til å uttale seg innen en nærmere angitt frist. Skulle det hende at vansker med å nå hver enkelt blir for stor, kan det gis varsel gjennom kunngjøring i Norsk lysingsblad og en eller flere aviser i distriktet om at dokumenter vedrørende det påtenkte tiltak er utlagt på formannskapets kontor med anmodning om uttalelse innen en frist som ikke må settes kortere enn 6 uker fra kunngjøringen i Norsk lysingsblad. Berører saken interesser som hører under fylkeslandbruksstyret, fylkesskogrådet, fylkesfriluftsnemnda, jordstyret, skogrådet, friluftsnemnda eller andre sakkyndige organer, bør disse få høve til å uttale seg. Det samme gjelder vedkommende kommuner og fylkeskommuner. Departementet kan på forhånd treffe vedtak om midlertidig vern eller fredning som nevnt i første ledd inntil saken er avgjort.»

Som nevnt innebærer opprettelsen av et naturreservat relativt strenge vernebestemmelser. Vernebestemmelsene for landskapsvernområder og fuglefredningsområder er mildere. Vernebestemmelsene skal ha til formål å verne de naturverdier som utgjør formålet med fredningen.

Ved utformingen av vernebestemmelsene må naturlig nok de spesielle forhold og interesser som knytter seg til det enkelte område vurderes.

For hvert av de foreslåtte verneområdene i denne planen er det utarbeidet konkrete forslag til vernebestemmelser. Disse følger som vedlegg til planen.

Når området er fredet, vil området bli oppmerket og det vil eventuelt bli sørget for oppsyn med området. Det vil videre bli sørget for oppslag om gjeldende fredningsbestemmelser, og i enkelte tilfeller gitt informasjon om natur, planteliv, dyreliv o.l. i området.

Forvaltningen av fredede våtmarksområder kan tillegges naturvernmyndighetene på fylkesplan. Utgifter ved skjøtselstiltak og oppsyn betales av Miljøverndepartementet.

Spørsmål som gjelder det videre arbeid med disse saker kan rettes til: Fylkesmannen i Sør-Trøndelag, v/frilufts- og naturvernkonsulenten, c/o Sør-Trøndelag fylkeskommune, Munkegt. 10, 7000 Trondheim, tlf. 075/26 000.

ØKONOMISKE ERSTATNINGER VED FREDNING

Spørsmål om staten har plikt til å betale erstatning i forbindelse med fredning av naturvernområder, er vanskelig. Mange forhold vil kunne få betydning for avgjørelsen. Ifølge naturvernlovens § 20 skal imidlertid erstatningsspørsmålet avgjøres i samsvar med alminnelige rettsgrunnsetninger:

> «Økonomisk tap som følge av vedtak i medhold av denne lov kan i samsvar med alminnelige rettsgrunnsetninger kreves erstattes av staten. Med mindre annet blir avtalt, avgjøres spørsmålet ved rettslig skjønn etter begjæring av en av partene innen ett år etter at vedtaket er kunngjort. Når en eiendom som helt eller delvis omfattes av vedtak som nevnt i første ledd ikke lenger kan utnyttes på regningssvarende måte, kan eieren kreve den innløst av staten. Med mindre annet blir avtalt, avgjøres spørsmålet om vilkårene for innløsning er til stede ved rettslig skjønn som fastsetter erstatningen.»

Staten var lenge tilbakeholden med å innrømme plikt til å betale erstatninger ved fredning. Spørsmålet om erstatning ved rådighetsinnskrenkinger ble vurdert av Høyesterett i forbindelse med den såkalte strandlovdommen fra 1970. Bakgrunnen var at en grunneier ble nektet dispensasjon fra forbudet mot å bygge hytter. Staten ble den gang enstemmig frifunnet for grunneierens krav om erstatning.

De typiske fredningssakene skiller seg imidlertid fra saker om dispensasjon etter strandloven på flere måter. Etter hvert som en utover i 1970-årene fikk flere fredningssaker med aktuelle interessekonflikter mellom grunneiere og stat, meldte behovet for en avklaring seg derfor for fullt.

Rettspraksis hadde gitt liten veiledning i hvordan fredningssaker burde avgjøres når det gjaldt erstatningsspørsmålet. Derfor ble flere saker av prinsipiell betydning brakt inn for domstolene.

I løpet av de senere år har det skjedd en viss avklaring for bestemte typer av fredninger, og det vises ofte i denne forbindelse til saken om fredning av et 60 dekar stort edellauvskogreservat — Bogslunden edellauvskogsreservat i Rygge i Østfold. Dette området var en del av en eiendom på i alt ca. 1000 dekar innmark og 40 dekar skog. Av de 60 dekar var 40 dekar dyrkingsjord av beste kvalitet. Staten hevdet erstatningsfrihet bl.a. fordi de 40 dekar med god dyrkingsjord måttes anses som en lite vesentlig del av eiendommen. Staten fikk ikke medhold i de to instansene som sto for skjønnet. Erstatningen ble fastsatt til kr. 120.000. Grunnlaget for beregningen var netto oppdyrkingsverdi av jordstykket. Saken ble anket til Høyesterett, men staten trakk anken tilbake og overskjønnets kjennelse ble rettskraftig.

Etter at dette erstatningsspørsmålet ble avklart, trakk Miljøverndepartementet tilbake også andre saker som skulle behandles av domstolene og hvor de erstatningsrettslige forholdene var noenlunde de samme som i Bogslund-saken.

Den avklaring som hittil har skjedd gjennom utvikling av en rettspraksis i noen typer av saker vil i større grad gjøre det mulig på flere felter å løse eventuelle erstatningsspørsmål ved minnelige ordninger.

FORKLARING AV EN DEL ORD OG UTTRYKK

Alkefugler: Omfatter alle alker (7 arter hos oss inklusive geirfuglen som er utryddet). En art (teist) regnes som vannfugl.

Andefugl: Omfatter alle ender, gjess og svaner. Alle regnes som vannfugl.

Art: Grunnenhet ved klassifisering av planter og dyr. De individer som tilhører en art har stort sett samme ytre og indre karakter og gir ved innbyrdes krysning fruktbare avkom.

Biologi: Læren om livet og livsformene.

Biotop: Et noenlunde ensartet område som er levested for et bestemt samfunn av dyr eller planter.

Botanikk: Læren om plantene.

Ekskursjonsområde: Naturområde egnet for naturstudier for studenter, skoleungdom og publikum.

Flamingoer: Omfatter alle flamingoer (1 art funnet spontant hos oss). Alle regnes som vannfugl.

Lappedykkere: Omfatter alle dykkere (5 arter hos oss). Alle regnes som vannfugl.

Lommer: Omfatter alle lommer (4 arter hos oss). Alle regnes som vannfugl.

Myting: Fjærfelling. Andefuglene er flyveudyktige i mytetiden p.g.a. myting av armsvingfjærene.

Måsefugl: Omfatter alle joer, måser og terner. Noen måser og terner regnes som vannfugl.

Naturvernloven: Lov om naturvern av 19. juni 1970 er loven som hjemler vern/fredning av ulike naturområder/forekomster og arter på forskjellige måter.

Ornitologi: Læren om fuglene.

Pelikanfugler: Omfatter alle pelikaner, suler og skarver. Noen regnes som vannfugl.

Ramsarkonvensjonen: Den internasjonale konvensjon for vern av våtmarker og vannfugl. Navn etter byen Ramsar i Iran. Norge har tiltrådt i 1974.

Referanseområde: Naturvernområde som er intakt og som derfor kan benyttes i sammenlignende studier av tilsvarende områder som er utsatt for inngrep (eller studier av andre intakte naturområder).

Riksefugler: Omfatter alle rikser og vannhøns. Alle regnes som vannfugl.

Sjøfugl: Fuglearter i hele eller vesentlige deler av livet er avhengige av næring fra havet. Det er en viss overlapping med vannfugl.

Storkefugler: Omfatter alle hegrer, ibiser og storker. Alle regnes som vannfugl.

Søppelfugler: Fuglearter som i særlig grad treffes ved søppel- og avfallsplasser: kråke, ravn, svartbak, gråmåse m.fl.

Vadefugl: Omfatter alle tjelder, brokkfugler, sniper, avosetter, svømmesniper, trieler og ørkenløpere. Alle regnes som vannfugler.

Vannfugl: Fuglearter som i vesentlig grad er knyttet til ulike våtmarksområder.

Zoologi: Læren om dyrene.

Økologi: Læren om forholdet mellom organismene og deres miljø.

Økosystem: Samling av plante- og dyresamfunnene i et område og det totale miljø disse samfunn lever i (f.eks. våtmark).

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13. Fhv. naturverninspektør Kristen Krogh, Trondheim.
14. Lærer Odd Rygh, Å i Åfjord.
15. Lærer Åge Røe, Krokstadøra.
16. Stud.real. Jostein Sandvik, Trondheim.
17. Bankmann Rolf Skogstad, Brekstad.
18. Cand.real. Ole Reitan, Stadsbygd.
19. Stud.techn. Erling Vikan, Trondheim.

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An Assessment of the Potential for the Sustainable Development of the Edible Periwinkle, Littorina Littorea, Industry in Ireland

Article · January 2002

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An Assessment of the Potential for the Sustainable Development of the Edible Periwinkle, *Littorina littorea*, Industry in Ireland

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Final Report

2002
(Survey completed 2000)

Valerie Cummins[1], Susan Coughlan[2], Orla McClean[1], Niamh Connolly[1], John Mercer[2], Gavin Burnell[3]

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TABLE OF CONTENTS

SECTION 1 - INTRODUCTION

1 Background to the Study and Project Objectives

The edible periwinkle *Littorina littorea* (L.) has been exploited as a food source in Ireland since the stone age (Woodman, Anderson and Finlay, 1999). Today there is a large market for the edible periwinkle on the continent, principally in France. Pearson (1994) estimated that the Irish periwinkle industry was worth approximately €6.34 million (£5 million) in exports per annum. The edible periwinkle industry remains a fishery of economic and sociological importance in peripheral coastal communities. It is particularly important as an additional source of income in areas where few other employment opportunities exist.

According to the Department of Marine and Natural Resources (DoMNR), 2,635 tonnes of periwinkles were exported in 1998. However, this is considered by some to be a gross underestimate of the size of the industry. Unofficial figures provided by a wholesaler at the 1997 Shellfish Association AGM, suggested that, at the time, closer to 7,000 tonnes were exported per annum.

The difficulty in assessing the true scale of the Irish periwinkle industry lies in its black market nature. In addition, periwinkles are a "non-pressure stock" species which means that the fishery is completely unregulated. Indeed, many wholesalers claim that over-harvesting of the resource is jeopardising the recruitment of periwinkles on our shores.

Prior to this study, there was little or no scientific information available on the state of Irish periwinkle stocks, nor was there an accurate estimate of the scale and value of the Irish industry. This project aimed to redress this situation.

The main objectives of the project were:

- To establish the distribution and abundance of the edible periwinkle populations along the Irish coast and to provide a benchmark against which subsequent studies could be compared.

- In reviewing the Irish periwinkle industry, to assess its socio-economic impact on Irish coastal communities and to determine the potential impact of developments within this sector.

- To incorporate the resultant data into a Geographical Information System (GIS). The GIS would then be used as a decision making tool in developing a management strategy for the industry.

Primary field workers were Ms. Valerie Cummins and Ms. Orla McClean (both from the Coastal and Marine Resources Centre, National University of Ireland, Cork), and Ms. Susan Coughlan (from the Shellfish Research Laboratory, National University of Ireland, Galway). Ms. Cummins took over from Ms. McClean in June 1999. Field sites along the coast were arbitrarily split in two, with the Shannon estuary as the point of division. Ms. Coughlan was responsible for sampling and interviewing relevant individuals north of this point (i.e. County Clare to County Donegal), and Ms. Cummins and Ms McClean south and east of this point (i.e. County Kerry to County Louth), including regular sampling of Bullens Bay in

County Cork. Regular meetings were scheduled to ensure continuity of methods and exchange of ideas. Several other research assistants were employed at various stages of the project to aid with sampling and measurement of animals.

Plate 1. The edible periwinkle, *Littorina littorea.*

SECTION 2 - OVERVIEW OF PERIWINKLE BIOLOGY

2 Overview of Periwinkle Biology

2.1 Anatomical description

The edible periwinkle, *Littorina littorea* (Linnaeus, 1758), is a Prosobranch gastropod of the Family Littorinacea. It is one of the most common, and one of the largest, shore Gastropods of the Irish coast. It can attain a height of approximately 35cm. The head and tentacles of the animal are covered with dense transverse black lines; in some individuals, the head and tentacles are uniformly black. Sexes are separate and easily distinguished (at least when the animals are ripe) by the presence of a penis on the right hand side of the male and a whitish ovipositor in the equivalent area of the female. Under certain conditions, including the presence of the anti-fouling pollutant tributyltin (TBT), females may show abnormal development of a penis (pseudohermaphroditism) (Casey, *et al*., 1996).

Mature shell height ranges from approximately 10.6mm – 52.8mm (Reid, 1996). The shell is usually dark brown, and can appear almost black when wet. Other shell colours such as pale cream and orange occur occasionally. The outer lip of the aperture is defined by brown lines. The columella is white (except in old animals, where it may discolour to a darker cream). Juvenile *L. littorea* are more difficult to identify. They have a crenulated shell, and may be mistaken for the rough periwinkle, *Littorina rudis.* A particularly distinguishing feature of *L. littorea* is the alternate light and dark banding on the outer lip of the shell (Fish and Fish, 1989).

2.2 Distribution

L. littorea is distributed from the White Sea (and perhaps Spitzbergen) to Southern Portugal in the eastern Atlantic, and in the western Atlantic from Labrador to Virginia. The rapid spread of *L. littorea* along the northwestern Atlantic coast, following human settlement in North America in the nineteenth century, provides one of the most well documented examples of the dispersal of marine species (Reid, 1996).

The species is common around the coast of Ireland, Britain, the Outer Hebridies, Orkneys and Shetland Islands (Smith and Newell, 1955; Reid, 1996). However, it is rare on certain small offshore islands, including the Isles of Scilly (Smith & Newell, 1955), Lundy and St Kilda (see Reid, 1996). This has been attributed to probable low rates of colonization by planktotrophic larvae from mainland populations, and the difficulty in maintaining populations where endogenous larvae may be swept away by currents (Reid, 1996).

L. littorea is typically found on rocky shores, where its vertical range extends from high water neap tide level to extreme low water spring tide level (Moore, 1937). Occasionally it may occur sub-littoraly to depths of approximately 60m (Fretter and Grahame, 1960). The vertical level at which periwinkles may be found on the shore is variable and depends on factors such as exposure and weed cover (Lubchenco, 1983). Food scarcity appears to set the upper limit to the vertical distribution of *L. littorea* (Yamada and Mansour, 1987). While *L. littorea* is found mainly on semi-exposed to sheltered coasts, it is also tolerant of estuarine conditions and great exposure (Boulding and Alstyne, 1993; Fish, 1972; Williams, 1964).

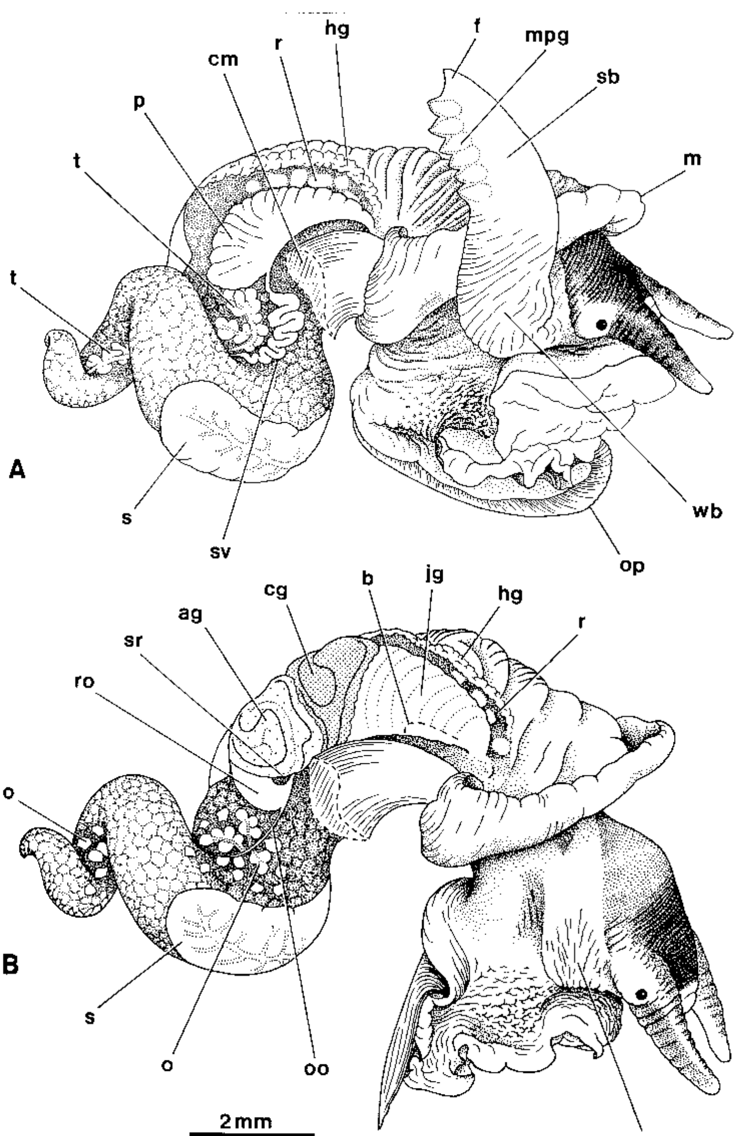


Figure 1. **A mature male (A) and female (B) of a representative littorinid (*Littorina compressa*) the anatomy of which closely resembles that of *L. littorea*.** This diagram from **Reid (1996)** is more accurate and representative than the diagram from Fretter and Grahame (1968). The animals are removed from their shell and undissected. Abbreviations: ag albumen gland, b, copulatory bursa (visible by dissection); cg, capsule gland; cm, insertion of columelllar muscle on shell; f, filament of penis; hg, hypobranchial gland; jg, jelly gland; m, mantle edge; mamillliform penial gland (visible by transparency); o, ovary (ramifying in digestive gland); oo, ovarian oviduct; op, operculum; ovipositor; prostate gland; rectum; ro, renal oviduct; s, stomach; sb, smooth region of penial base; sr, sv, seminal vesicle; t, testis (ramifying in digestive gland); wb, wrinkled region of penial base.

2.3 Spawning and development

Gastropods living on rocky shores exhibit a wide range of reproductive strategies and patterns of embryonic and larval development (Underwood and McFayden, 1983). Within the Family Littorinacea, different species show different methods of reproduction, ranging from direct development in benthic egg capsules (e.g. *L. mariae*, Fretter and Graham, 1962), to ovoviviparity (e.g. *L. saxatilis,* Berry, 1961), to pelagic eggs and planktotrophic larvae (e.g. *M. neritoides,* Lebour, 1935; *L. unifasciata*, Underwood and Chapman, 1989).

A detailed account of the male and female reproductive systems of *L. littorea* has been given by Linke (1933), and is summarised by Fretter and Graham (1962). Williams (1964) distinguished five development stages (which he described for each sex): immature virgin, maturing individuals/recovering spents, fully mature and spawning, partially spent, and spent (Table 1). This method has been adopted by several authors to enable comparison between different populations (Fish 1972; O Sullivan 1977; Doyle 1993).

Maturity is thought to occur 12-18 months after settlement once a shell height of approximately 11mm has been reached (Williams, 1964). Populations of *L. littorea* vary in their time of spawning. Even at the same latitude; maturation, copulation and spawning times show wide local variations depending on food availability and exposure (Fish, 1972). Breeding and spawning in Irish and UK populations occurs from January to June, (Tattersall, 1920; Moore, 1937; Williams, 1964; Fish 1972, 1979). A fortnightly rhythm of egg release related to the tidal cycle was suggested by Grahame (1975), and conclusively demonstrated by Alifierakis & Berry (1980), following experiments in the UK.

Fertilisation is internal, after which, the females release planktonic egg capsules. These egg capsules are pelagic, asymmetrically biconvex with a flat peripheral rim. The egg capsules contain a maximum of nine eggs (Linke, 1933); more commonly, they contain one to three (Thorson, 1946; Fish, 1979). Upon release, the egg capsules swell osmotically and burst after five to six days. Each egg hatches into a free-swimming veliger larva and remains in this planktonic stage for six to seven weeks. This planktotrophic development stage results in widespread dispersal and genetic uniformity. Metamorphosis may be delayed if conditions are not suitable. This results in considerable variation of settlement times, with larvae settling on the shore throughout several months of the year.

Table 1. Female and male development stages of *L. littorea* (after Williams, 1964).

Females

Stage	**Ovipositor**	**Gonad**	**Caps gland/ albumen gland**	**Covering gland**
Stage I Immature	Heavily pigmented	No trace	Vestigial	Vestigial
Stage II Maturing	Lightly pigmented	Diffuse light pink areas	Small but distinct	Small but distinct
Stage II Recovering	Lightly pigmented	Extensive light pink areas	Large, often swollen, yellow-brown	Dark brown
Stage III Ripe	Lightly pigmented and well defined	Very extensive light pink areas	Very swollen, white	Dark brown
Stage IV Partially spent	Lightly pigmented	Extensive; dark pink/red	Slightly swollen, yellow-cream	Very dark brown
Stage V Spent	Heavily pigmented	Scarce, red or red/brown areas	Poorly developed, Dark yellow brown	Poorly developed, yellow brown

Males

Stage	**Penis**	**Vas deferens**	**Prostate**	**Gonad**
Stage I Immature	Minute	No trace	Faint trace	No trace
Stage II Maturing	Very small	Lightly coiled, possibly with some sperm	Distinct	Scattered yellow areas
Stage II recovering	Quite well developed	Lightly coiled, possibly with some sperm	Distinct	Extensive light yellow
Stage III Ripe	Large	White, much coiled, swollen; full of sperm	Well developed, cream-white	Very extensive, light yellow
Stage IV Partially spent	Well developed	Much coiled, not swollen, sperm in lower coils	Distinct, yellow-brown	Extensive, yellow-brown
Stage V Spent	Very small	Gently coiled, dark brown	Small, dark brown	Poorly developed, localised dark brown areas only

2.4 Diet and feeding

L. littorea is an omnivorous grazer. However, it is highly selective in favour of the foliose ephemeral green algae *Ulva lactuca* and *Enteromorpha intestinalis*. The fucoid *Ascophyllum nodosum* and *Coralinia officinalis* are rejected even after prolonged periods of starvation. These algae are not readily digestible; the latter species is heavily calcified and presents a physical barrier to grazing. In addition, drift algal material is frequently exploited as a food source (Watson and Norton, 1985), especially at higher shore levels (Woodbridge, 1978).

Feeding activity is influenced by tidal cycle and season. The animals are stimulated to feed when immersed by the tide and when damp conditions prevail (Newell, 1958; Moore, 1936; Williams, 1964). The grazing activity of periwinkles can have a habitat modifying impact on a shore. The grazing process removes sediment from hard substrates which precludes the development of an algal canopy (Bertness, 1984). At high densities, *L. littorea* can clear shores of *Enteromorpha* sp. and can inhibit settlement of barnacles *Balanus* sp. (Petratis, 1983).

2.5 Growth

Growth rate is defined as the change in body mass or weight over time. *L. littorea* shows considerable variation in growth rate for the first four years of its life. Shell height is the commonly employed measure of growth. Fretter and Graham (1962) describe shell formation in two major phases: 1) cellular processes of ion transport, protein synthesis, and secretion, and 2) a series of photochemical processes in which crystals of Calcium Carbonate (CaCo3) are nucleated, orientated, and grow in intimate association with a secreted organic matrix. Through growth, mineralised granules form rounded flattened crystals, each covered by a delicate organic membrane. The layering of the crystals appear as striations to the naked eye. Each spiral grows around and partly conceals the surface of the previous whorl. Thus, the most recently secreted part of the shell is that by the mouth. Where the inner sides of the spirally coiled whorls are brought into contact with on another, there results a more or less solid pillar, the columella, around which the whorls of the shell rotate (Fretter and Graham, 1962).

A shell height of approximately 8-9mm is achieved by the end of the first year (Williams, 1964). This increases to about 16mm by the end of the third year. A pattern in growth rates was observed by Lambert & Farley (1968), and by Gardener and Thomas (1987). The general trend was for growth rates to increase from May to early July, followed by a decrease in growth rates from mid-July to mid-August. Growth rates were observed to increase again in early September, before declining in the winter months. Although *L. littorea* are capable of breeding all year round, periods of shell growth are interrupted when conditions are favourable for reproduction (Williams, 1964). For example, Williams (1964) observed active shell growth on a shore in Wales, from July to October, which corresponded with a period when mature animals were fully spent. Growth rates decreased when gonad maturation began again the following November. However, Fretter and Graham (1960) observed a looser growth cycle, when, on reaching sexual maturity a cessation in growth occurred in correspondence with a period of maximum sexual activity.

The growth rate decreases rapidly with age (Fretter and Grahame, 1960) and absolute growth rate is affected by food availability and habitat (Moore 1937; Williams, 1964, Griffin, 2000).

Parasite infection and predation also affect growth and survival. Population density can affect growth rates in natural populations, with competition for resources acting to limit growth at higher values. Griffin, (2000) found exceptionally high growth rates (K = 0.0277 per 21 day period), on a high density, semi-exposed shore in Southern Ireland. The mid-shore region exhibited the highest growth rate. The lowest growth rates were found on the lower shore. Griffin (2000) concluded that periwinkles have an opportunistic growth strategy, which is attributed to competition, food availability and quality. High population densities can also prevent re-settlement of a food source. At high densities, *L. littorea* can clear shores of *Enteromorpha* sp. and can inhibit settlement of barnacles *Balanus* sp. (Petratis, 1983).

2.6 Migration

Gendron (1977) showed some evidence for a seasonal migration on a shore in North America. The periwinkle population density at the uppermost station established during his study showed a decrease in density between October and January, while an increase at the same station occurred during early summer. Gendron (1977) attributed this change in density to a shoreward spring migration. Williams and Ellis (1975), recorded similar patterns for a population in Yorkshire; however, Smith and Newell (1955), while studying a shore in Kent, suggested that periwinkles tend to remain at the beach level they adopt during the first year of life after larval settlement. *L. littorea* also show evidence of a "homing instinct", whereby dislodged individuals have the ability to find their way back to the zone from which they were displaced (Newel, 1958). Wave action is considered to be the most likely stimulus by which the animals orient themselves (Gendron, 1977).

2.7 Life span and maximum size

Periwinkles are capable of a long life as shown by Woodward's (1913) record of an individual that had reached more than 20 years in an aquarium. The largest recorded specimen came from Scotland and was 52.8mm in height (Reid 1996).

SECTION 3 - RESOURCE ASSESSMENT

3.1 Introduction

High density *L. littorea* shores are attractive sites for periwinkle harvesting activities. The harvesting of this gastropod provides a valuable source of income to rural coastal communities (Pearson, 1994). However, little is known about the impact of such harvesting activities on periwinkle populations. Wholesalers and pickers have reported problems of over-picking in the past on several shores around the country (T. Tobin, *pers. comm.,* 2000), leading to fears that the sustainability of the industry may be in jeopardy. Up until now, there was no scientific information on the distribution or density of *L. littorea* populations in Ireland.

Data collected for this study from 1998 to 2000 are examined in this chapter with a view: to describing the distribution and abundances of *L.littorea* on Irish shores; to describing the size and dynamics of periwinkles within these populations; and to providing a benchmark against which subsequent studies could be compared. Studies were also undertaken to identify some of the factors that impact on both individuals and populations of *L. littorea.*

Bullens Bay is situated on the north-westerly corner of the Old Head of Kinsale, on the County Cork coastline. It is harvested throughout the year by approximately five local pickers, however, harvesting activities are most intensive during the winter period there. The site was selected as a re-survey site to observe temporal changes in population dynamics of *L. littorea.* Bullens Bay is a sheltered site, protected from the prevailing south-westerly winds. The intertidal zone extends downwards over a gently sloping gradient. It is largely a rocky foreshore, with a small sandy beach that is exposed during low tide. Observed fauna during surveys included typical rocky foreshore species, the major components being the limpet *Patella vulgata*, the flat periwinkle *Littorina littoralis*, the dog whelk *Nucella lapillus*, and the topshells *Monodonta lineata* and *Gibbula umbilicalis*. The main source of food of the browsing species is provided by large algae, (such as *Fucus* sp. and *Ascophyllum nodosum*), as well as various microscopic algae.

3.2 Research Methods

3.2.1 Materials and methods for shore surveys

A total of 124 shores around the coast were surveyed during the project. Survey sites were selected (after consultation with wholesalers, fisheries officers and harvesters), on the basis that they provide suitable habitats for harvestable quantities of periwinkles; these were usually sheltered or semi-exposed shores. Other sites were selected (e.g. exposed coasts) for comparative purposes. In the present study, a survey site is described as an area of coast with homogenous shore type with respect to rock form, seaweed cover, exposure etc. This sometimes led to discrete sites existing along a lengthy section of shoreline.

All shores were surveyed on spring tide. At each site three belts of approximately 30m width, chosen randomly, were divided into three biologically defined zones representing upper, middle and lower shores: (i) *Fucus spiralis* to *Ascophyllum nodosum*; (ii) *A. nodosum* to *F. serratus;* (iii) *F. serratus* to the low water level.

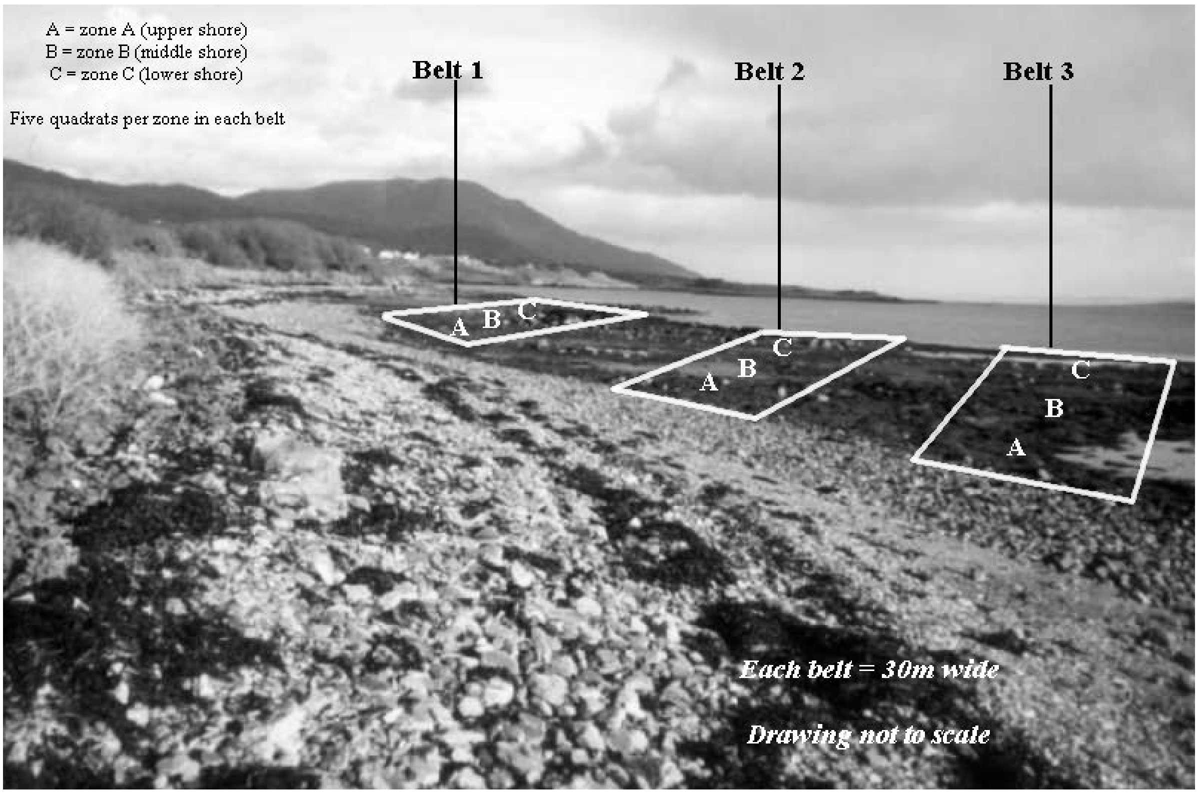


Figure 2. Example of the sampling procedure used on the shore. At each site, three belts of approximately 30m width, chosen randomly, were divided into three biologically defined zones representing upper, middle and lower shores: (i) *Fucus spiralis* to *Ascophyllum nodosum*; (ii) *A. nodosum* to *F. serratus;* (iii) *F. serratus* to the low water level.

The length of each of the three belts was measured. The bearing of each belt was also recorded. A handheld Global Positioning System (GPS) was used to mark the starting point of each belt, in addition to the start and end point for each site. This, and other relevant data were subsequently added to a Geographical Information System (GIS). GIS software facilitates the storing, manipulating and displaying of a wide range of temporal and spatial data. The maps used for this report were produced using Arcview GIS software. On completion of the study a copy of the Periwinkle Project GIS was made available to the Marine Institute in Dublin (Appendix B).

Exposure of sites was rated on a scale of one to five, after Lewis (1964) (Appendix A). One represents very exposed sites, and five represents very sheltered sites. In some cases, the exposure scale was subdivided to allow more flexibility in describing shores. As a result, there were ten possible degrees of exposure i.e. 1, 1.5, 2, 2.5 etc. (a modified version of the Lewis (1964) scale). Five quadrats ($0.25m^2$) were placed randomly within each zone and all *L. littorea* within the quadrat were counted, removed, and placed in labelled polythene bags. The samples were returned to the laboratory and frozen to preserve them for further analysis.

The percentage cover of rockpool, seaweed, bedrock, rock, stones, gravel, sand and mud was also recorded from each quadrat. Any influx of freshwater into the belt, or any other potential impact from sewage or shellfish culture was noted.

A comparison was made between the numbers of *L. littorea* on different substrate types, as recorded during the surveys, using the Chi-squared test. Substrate types included bedrock, rock, stone, gravel, sand and mud.

3.2.2 Temporal variation in density at Bullens Bay in County Cork

Bullens Bay in County Cork was selected for several re-surveys in order to assess temporal variations in periwinkle distributions on the shore. The survey method used was the same as the method described in Section 3.2.1. Table 2 shows when surveys were undertaken. Eleven re-surveys were undertaken at Bullens Bay.

Table 2. Survey dates at (a) Bullens Bay, County Cork

Date	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1998			x					x			x	
1999	x			x				x		x	x	
2000				x				x			x	

3.2.3 Shell measurements of L. littorea

In order to investigate shell morphometry and the effects of environmental variables on shell shape at various sites, frozen samples collected from surveyed shores were measured to 0.1mm using vernier callipers. Periwinkles less than 5mm were recorded as such and were not measured. This was due to the physical difficulty of handling such small animals and due to the increased significance of any errors of measurement at such sizes (Crothers, 1992). Three measurements of each shell were taken: shell length (SL), shell width (SW), aperture length (AL). Aperture width (AW) was also measured for a number of samples. In total 6,056 periwinkles were measured for shell height, width and aperture height. In addition, 1,795 periwinkles were measured for aperture width.

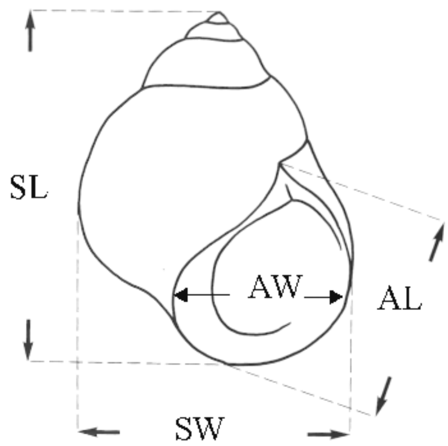


Figure 3. Morphological measurements recorded from shells. SL= Shell length; SW = Shell Width; AL = Aperture Length; AW = Aperture Width. After Reid (1996).

All statistical analysis was carried out using SPSS version 9.0. Graphs were plotted using SPSS or Excel 5.0. Error bars on all graphs where mean data is presented represent the 95% confidence interval. Non-parametric statistical tests were applied due to the bi-modal nature of the data. Spearman rank correlations were used to determine what, if any, relationships exist between the physical/ biological parameters studied and shell shape. The main factors examined for associated effect with shell morphometry in this study were:

1. Exposure
2. Vertical position on the shore (i.e. zone).

While only two factors are considered in this analysis, it is very likely that many other factors also impact on various aspects of shell shape, particularly predation (Robertson, 1992) and salinity (Reid, 1996).

3.2.4 Length frequency histograms

Histograms of shell length/frequency were plotted with the aim of investigating patterns in recruitment, growth and various aspects of population dynamics. Forty-seven sites were used for this purpose and measurements from all periwinkles >5mm shell length were used. Periwinkles <5mm shell height were excluded due to the difficulty of measuring aperture length accurately on very small shells. (However, measurements of shell height were taken from (n= 12) shells <5mm, prior to the methodology being finalised, the results of which were included in this analysis).

Bullens Bay, County Cork, was selected as a re-survey site to observe temporal changes in the length frequency distribution of the population. Bullens Bay was surveyed 11 times (Table 2). Measurements were taken from data collected from six of the 11 visits due to time constraints in measuring all of the samples. The six visits covered the period from November 1998 to August 2000. The months selected represent the months of November, January, April, August (twice) and October. Size frequency histograms were plotted from this data. The measurement data were used to examine changes in growth rates.

3.3 Results

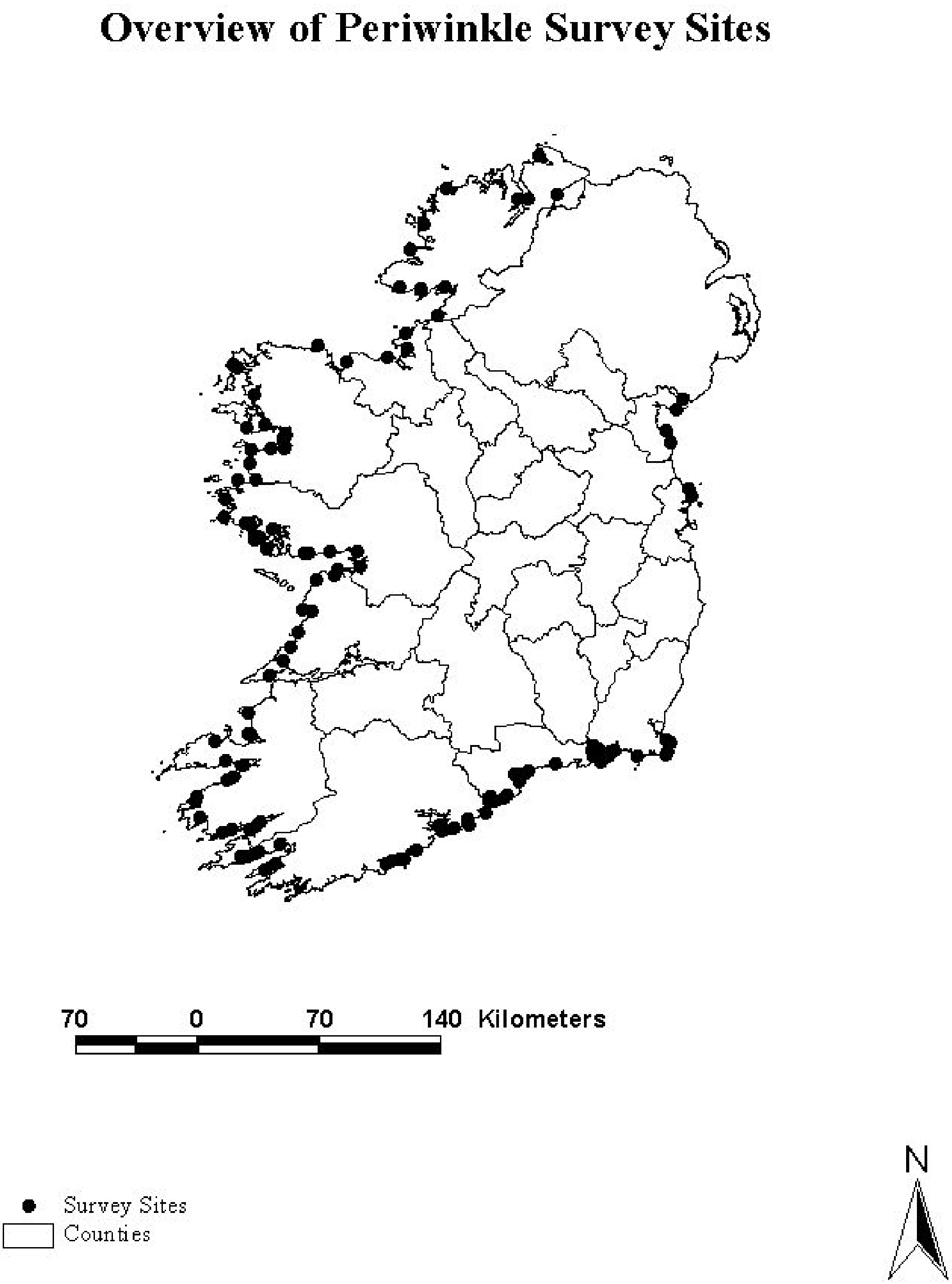


Figure 4. Overview of locations of periwinkle survey sites.

3.3.1 Results of shore surveys

Table 3. Mean periwinkle densities per m^2 at all survey sites. Exposure is based on the modified Lewis (1964) scale.

Site	County	Exposure	Mean periwinkle density per m^2
Bullens Bay	Cork	4	63
Oysterhaven	Cork	4	94
Howes Strand	Cork	1	58
Roches Point	Cork	3	69
Garrettstown	Cork	3	23
Ballycotton Island	Cork	3	31
Ballycotton	Cork	3	64
Knockadoon	Cork	3	161
Whitegate Bay	Cork	5	37
Broadstrand	Cork	4	110
Dinish Island	Cork	4	39
Ballyshane strand	Cork	2	112
Trabolgan	Cork	3	47
Youghal Town	Cork	2	8
Ardnahinch	Cork	3	104
Ballynakilla	Cork	4	52
Rocks NE of Fort Point	Cork	4	86
Aghabeg	Cork	5	48
Seal Harbour	Cork	3	121
Rocks NE of Reen Point	Cork	4	89
Reenabulliga	Cork	4	116
Kilcrohane	Cork	2	124
Whiting Bay	Waterford	3	50
Whiting Bay 2	Waterford	3	196
Ardmore Strand	Waterford	3	182
Clonea strand	Waterford	3.5	180
Helvick head - N side	Waterford	3.5	71
Ballynacourty - E side	Waterford	3	47
Youghal-East	Waterford	4	45
Ardmore East	Waterford	3	115
Dungarvan West	Waterford	5	16
Dungarvan East	Waterford	5	16
Dungarvan - Abbeyside	Waterford	4	75
Dunmore East	Waterford	5	93
Passage East	Waterford	5	38
Passage East 2	Waterford	5	26
Boatstrand	Waterford	2.5	1
Duncannon	Wexford	3	26
Duncannon 2	Wexford	3	22
Netherton	Wexford	2.5	15
Kilmore Quay	Wexford	3	15
Grange Strand	Wexford	3	24
Carnivan Bay	Wexford	3	9
Fethard Quay	Wexford	4	10

Site	County	Exposure	Mean periwinkle density per m^2
Bannow	Wexford	4	26
Patricks Bay	Wexford	2.5	69
Crossfintan Point	Wexford	3	26
Rosslare Harbour	Wexford	4	74
Greenore Point	Wexford	2	49
Ormonds Island	Kerry	4	91
Fenit 1	Kerry	4.5	26
Cromane	Kerry	4	9
Anascaul	Kerry	2.5	116
Fenit 2	Kerry	5	53
Ballyheige	Kerry	2.5	46
Fermoyle	Kerry	4	11
Glanlough	Kerry	4	38
Cove Harbour	Kerry	4	58
Ballinskelligs	Kerry	2	78
Doulus Bay	Kerry	3	49
Rossbeigh	Kerry	3	34
West of Rossbeigh	Kerry	3	47
Knightstown	Kerry	4	10
Tuosist Castle	Kerry	3	42
Loughaunacreen	Kerry	3	47
Eyeries	Kerry	2	74
Carlingford Lough	Louth	5	70
Rathcor	Louth	3	54
Corstown Bridge	Louth	2	73
Near Clogher Head	Louth	2	106
Skerries	Dublin	1.5	70
Rush	Dublin	2.5	124
Quilty	Clare	3.5	5
Fanore	Clare	2	3
Ballyvaughan	Clare	4.5	9
Doonbeg	Clare	4	19
Poulnasherry	Clare	5	6
Rehy	Clare	4	20
Lehinch	Clare	3	9
Haggs Head	Clare	2.5	19
Finavara Point	Clare	4	17
Murrisk	Mayo	5	1
Achill Sound	Mayo	4	3
Gubinwee	Mayo	3.5	15
Mullranny	Mayo	3	16
Louisburg	Mayo	2.5	22
Salleen Bay	Mayo	4	30
Roonagh Point	Mayo	2.5	31
Claggan Cove	Mayo	4.5	8

Table 3 contd. Mean periwinkle densities per m^2 at all survey sites. Exposure is based on the modified Lewis (1964) scale.

Site	County	Exposure	Mean periwinkle density per m^2
Bunlough Point	Mayo	3	26
Carrowholly	Mayo	4.5	5
Ballycastle	Mayo	2.5	35
Outer Belmullet	Mayo	2.5	19
Shellfish Laboratory, Carna	Galway	5	16
Mweenish	Galway	3	26
Loughaconeera	Galway	5	8
Letterard	Galway	4	53
Ervallagh	Galway	3	28
Finish (inside island)	Galway	4	16
Garumna Island	Galway	3.5	16
Inveran	Galway	3.5	34
Bundoran	Donegal	3.5	21
Fahan	Donegal	4.5	13
Rossbeg	Donegal	3	29
Rathmullan	Donegal	3.5	17
Meenlaragh	Donegal	3	34
Burtonpoint	Donegal	4.5	7
Doagh Isle	Donegal	2	2
Lough Foyle	Donegal	4.5	17
Kilcar	Donegal	3	62
Iniscrone	Sligo	3	14
Aughris Head	Sligo	4	39
Rosses Point	Sligo	4.5	8
Pollmolasha	Sligo	2.5	48

Table 3 contd. Mean periwinkle densities per m^2 at all survey sites. Exposure is based on the modified Lewis (1964) scale.

- Substrate data

Bedrock and stones were the most common substrate types found to occur on the surveyed shores (total percentage coverage of bedrock was 41%, percentage coverage of stones was 18%) (Figure 5). A comparison of the substrate data from different sites showed a significant relationship between gravel and periwinkle numbers, with higher numbers of periwinkles occurring on gravel sites than on other substrate types (Chi-sq value 26.67, $P<0.001$). Thus, in tests for comparisons of densities of *L. littorea* from replicated gravel sites, results indicated that the presence of gravel can have a significant influence on the densities of *L. littorea* on a shore. Results from the other Chi-squared tests were not significant. The resulting values were: *bedrock P = .817; rock P = .133; stone P = .051; sand P = .891.*

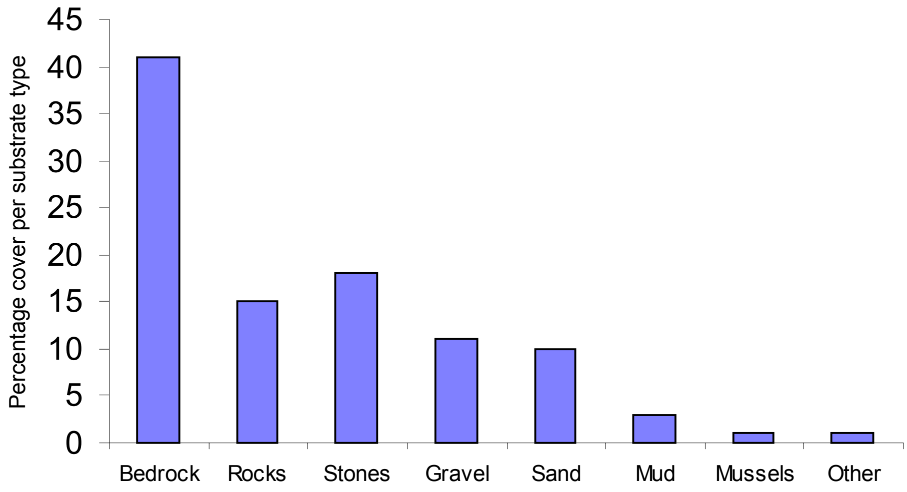


Figure 5. Total percentage cover of different substrate types recorded during the survey.

- Density and exposure

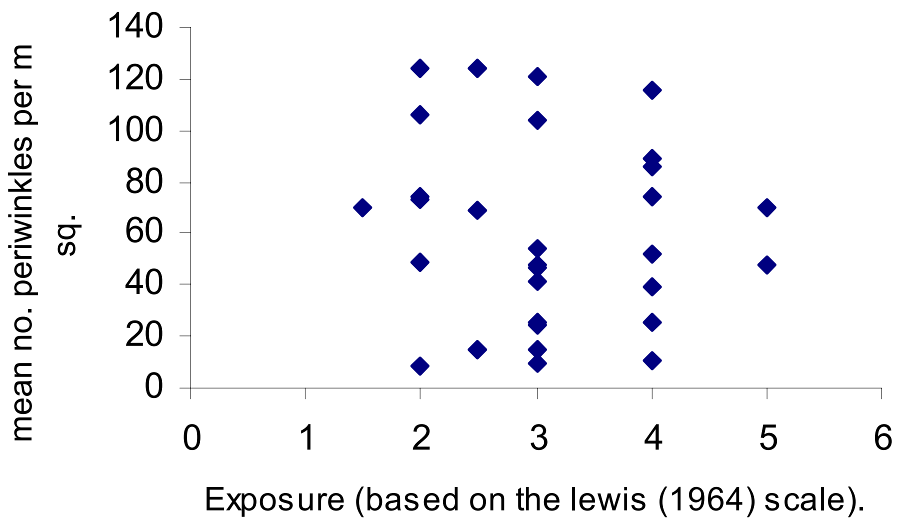


Figure 6. The relationship between density and exposure in *L. littorea* based on the mean number of perwinkles per site. The sites have different exposure levels classified according to the Lewis (1964) scale of exposure.

An examination of periwinkle densities at the study sites, indicate that in general the greatest densities of *L. littorea* occurred on shores of exposure 2-4 as defined by the Lewis (1964) scale (Figure 6). It should be noted that density decreases at the extremes of the exposure scale.

- Shoreline distributions

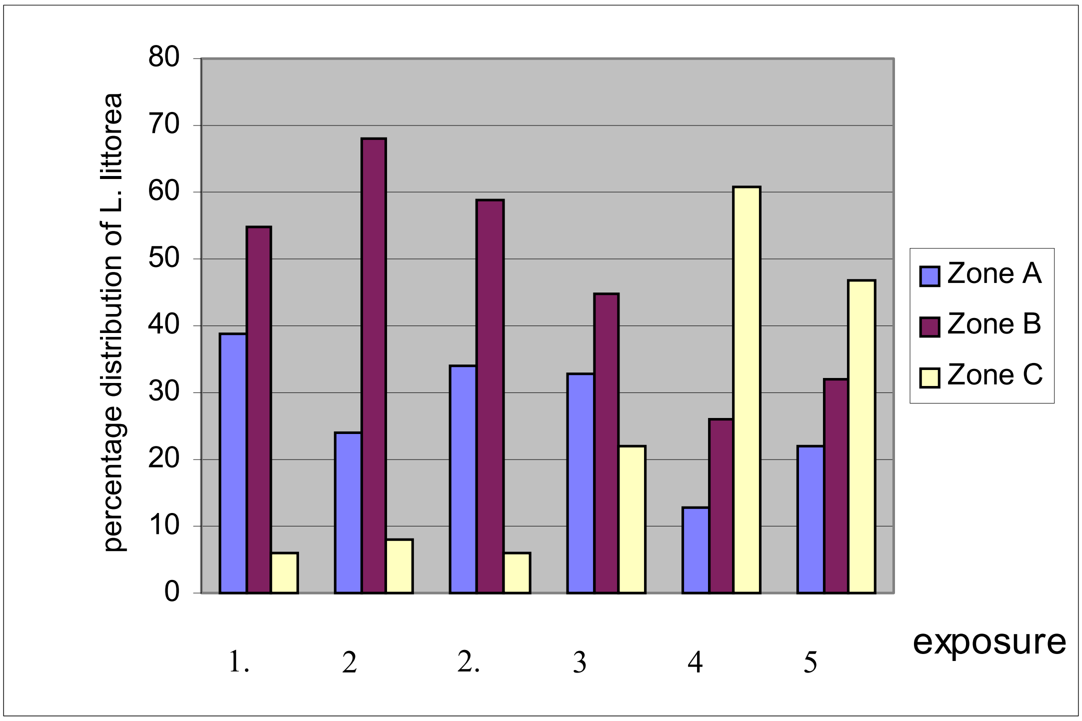


Figure 7. Percentage distribution of *L. littorea* on different levels of the shore in relation to exposure (using the modified Lewis scale).

L. littorea appear to show marked changes in preferred tidal height with exposure. This trend was noted during sampling. A graph of distribution at various exposures is presented in Figure 7. There is a reasonably consistent increase in relative density at higher shore levels on more exposed coasts. This is particularly clear in Zone C, which is the lowest of the three vertical divisions, where the percentage distribution falls from between 50% and 60% on extremely sheltered and sheltered shores, to less than 10% on exposed shores (2.5 to 1.5 on the Lewis (1964) scale of exposure).

3.3.2 Temporal variation in density at Bullens Bay in County Cork

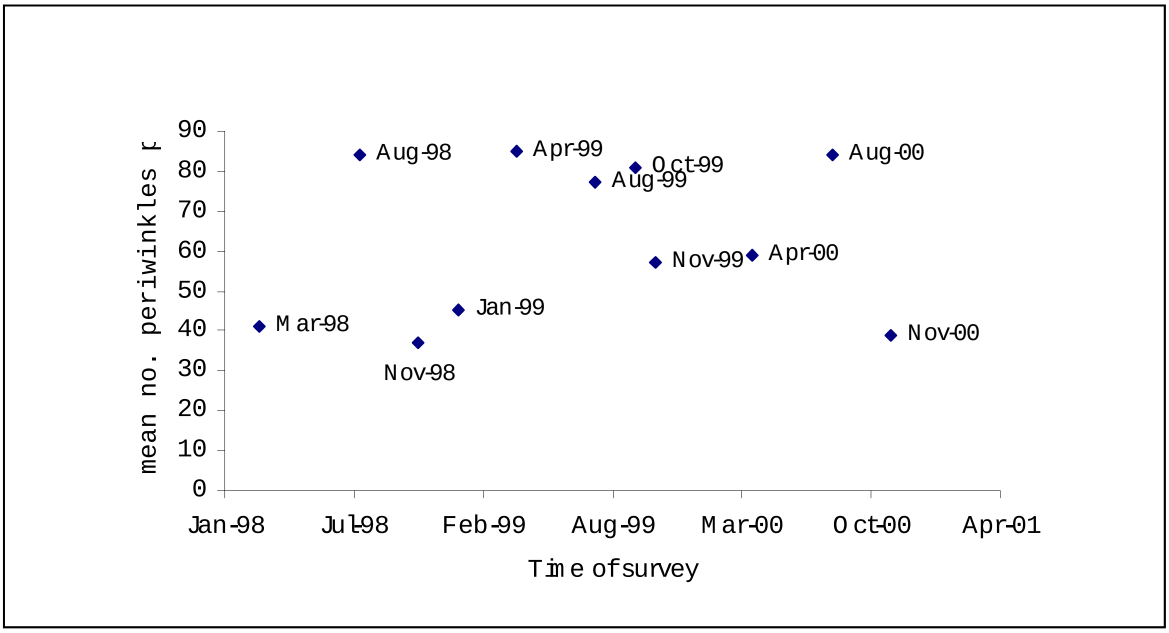


Figure 8. Changes in the mean numbers of periwinkles per m^2, over a three year period, at Bullens Bay, as recorded at different sampling times.

The shore at Bullens Bay was observed to have a mean density of *L. littorea* over the study period, of approximately 63 per m^2. There were sizeable differences in density at Bullens Bay between the sampling times, with a definite rise in densities between April and October in all three years (Figure 8). The numbers of *L. littorea* on the shore fell by over 50% between August and November in 1998 and in 2000. In 1999, periwinkle densities fell from a mean number of 81 periwinkles per m^2 in October, to 57 periwinkles per m^2 in November.

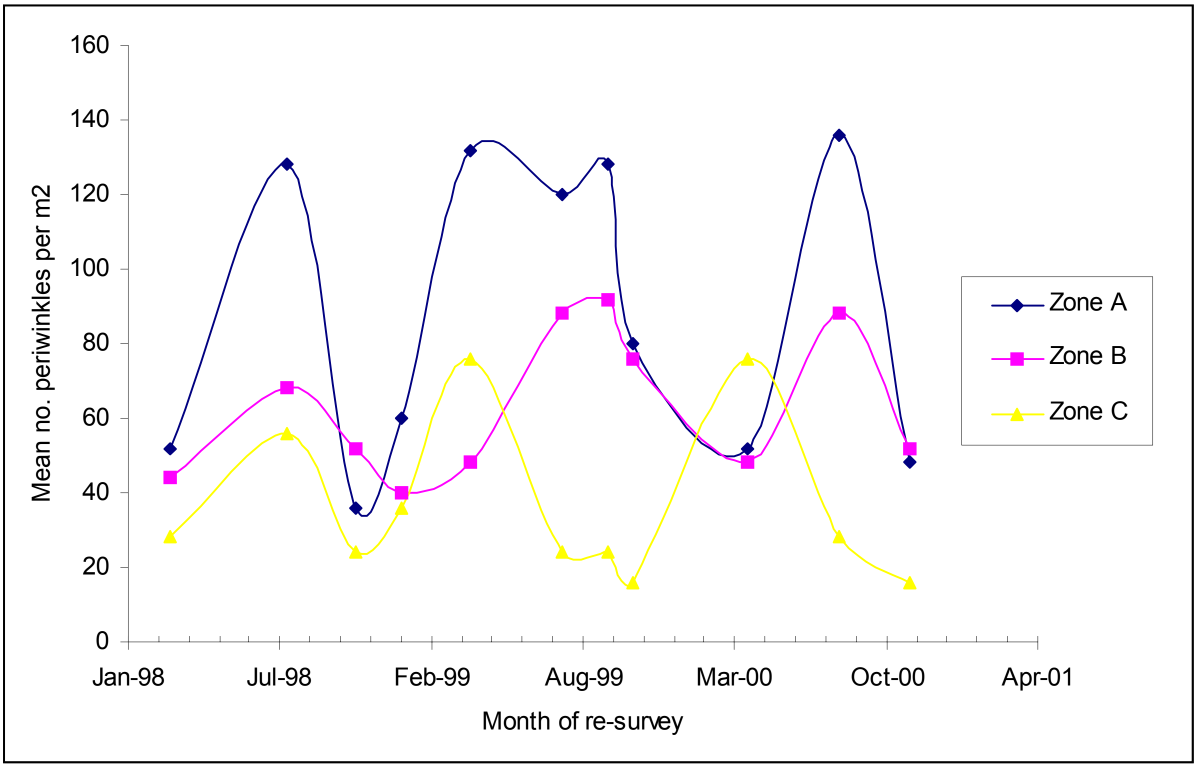


Figure 9. Mean densities of *L. littorea* on the upper, middle and lower shore at Bullens Bays over a three year period.

Densities of *L. littorea* per zone over the three year sampling period are shown in Figure 9. It can be seen from this graph that the highest numbers of periwinkles were found at the upper shore levels (zones A and B). April 1999 and April 2000 were the only periods when the number of periwinkles at the lower shore level (zone C) were observed to be higher than the number of periwinkles higher up the shore.

3.3.3 Shell measurements of L. littorea

- Exposure and shell morphometry

Results from a Spearman rank correlation show a weak correlation between shell length and exposure ($P>0.05$). The correlation between shell width and exposure is significant ($P<0.05$). These relationships are presented graphically in Figures 10 and 11.

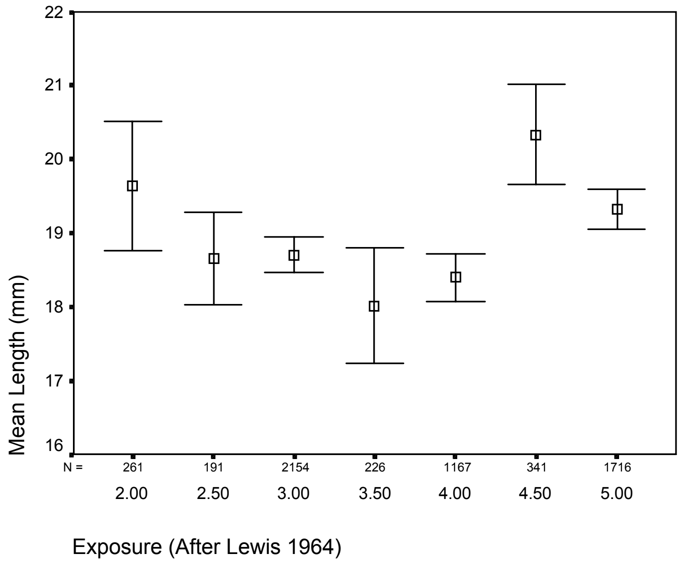


Figure 10. Relationship between mean shell length and exposure in *L. littorea*. Error bars represent the 95% confidence interval.

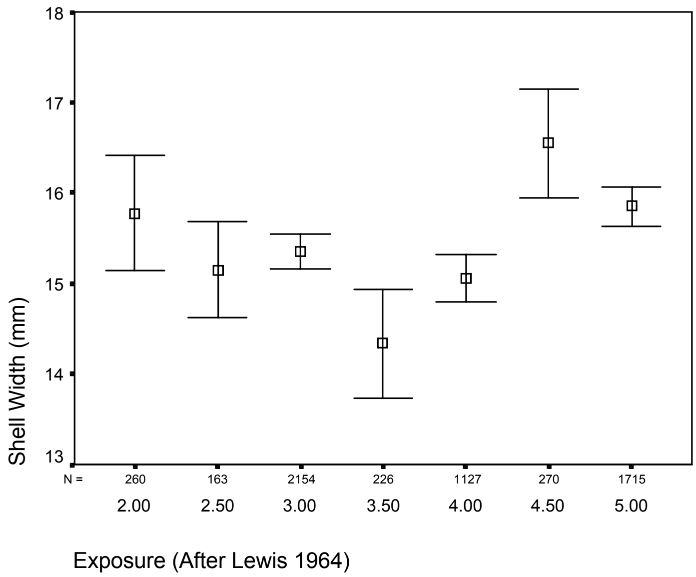


Figure 11. Relationship between mean shell width and exposure in *L. littorea*. Error bars represent the 95% confidence interval.

The relationship between exposure and mean shell height/ aperture height ratio is significant($P<0.01$). The relationship between mean shell height to aperture height ratio and exposure is shown graphically in Figure 12.

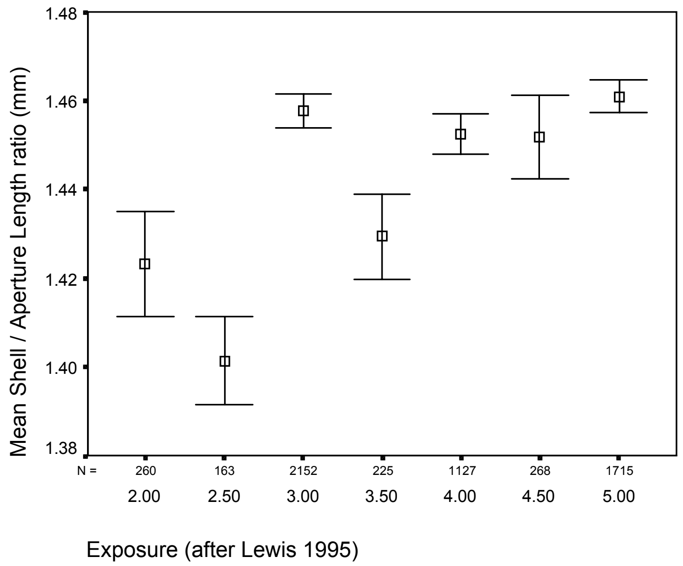


Figure 12. Relationship between mean shell height/ aperture height ratio and exposure in *L. littorea*. Error bars represent the 95% confidence interval.

- Vertical position (zone) and shell morphometry

Zone A represents the upper shore, zone B represents the middle shore and zone C represents the lower shore. The Spearman rank correlations between zone/height, zone/width and zone/aperture height/shell height ratio are significant at the 0.01 level for each parameter. It can be seen from Figure 13 that there is a distinct increase in shell height at lower shore levels. Figure 14 shows that relative aperture height decreases at lower shore levels.

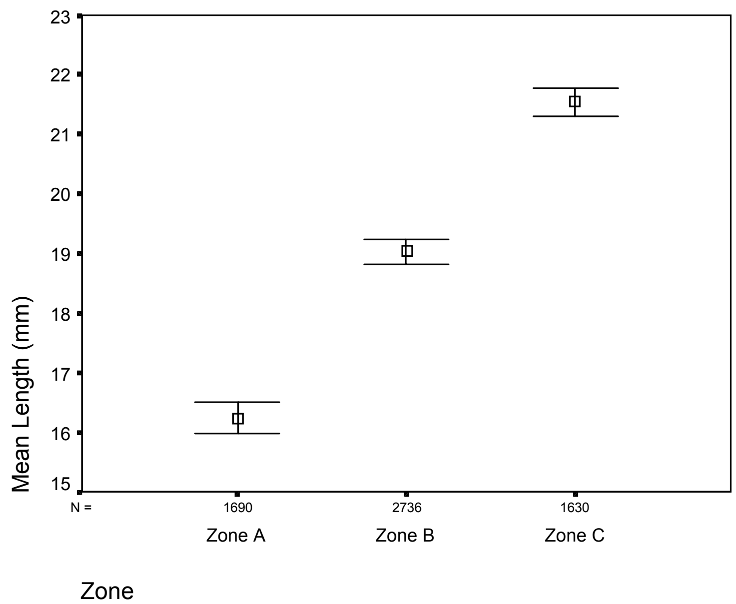


Figure 13. Relationship between shell height and zone in *L. littorea*. Error bars represent the 95% confidence interval.

3.3.4 Length frequency histograms

Length frequency distributions for 47 measured sites were plotted (Figure 14) in order to determine time of recruitment and to identify different cohorts as indicated by discrete peaks on the histogram. The mean shell height varies considerably from shore to shore, ranging from 13.0mm at Doulus Bay, County Kerry to 28.6mm at Burtonpoint County Donegal. Reports in the literature for mature shell height in *L. littorea* range from 10.6mm to 52.8mm (Reid, 1996). The largest speciman of *L. littorea* measured in this study was 37.0mm in shell height. It was found at Netherton, County Wexford.

In Bullens Bay, where seasonal variation in shell size was observed over a three year period, the mean shell length recorded was 18.3mm ± 6.2. The largest shell size attained in Bullens Bay, measured as a maximum length, was 34.1mm. The length frequency distributions for Bullens Bay varied according to the time of year the sites were surveyed. The population structure of *L. littorea* from November 1998 to August 2000 is shown in Figure 15. The population was generally bimodal during this period.

Figure 14. Length/frequency histograms from shores of varying exposure based on the modified Lewis scale. Graphs are presented in order of exposure, beginning with exposure 2 and ending with exposure 5. Site codes relate to the county where the survey was conducted , e.g. DL09 is site no. 9 in Donegal. (SO- Sligo, MO- Mayo, CE- Clare, K- Kerry, C- Cork, WD- Waterford, WX- Wexford, DN- Dublin, LH- Louth)

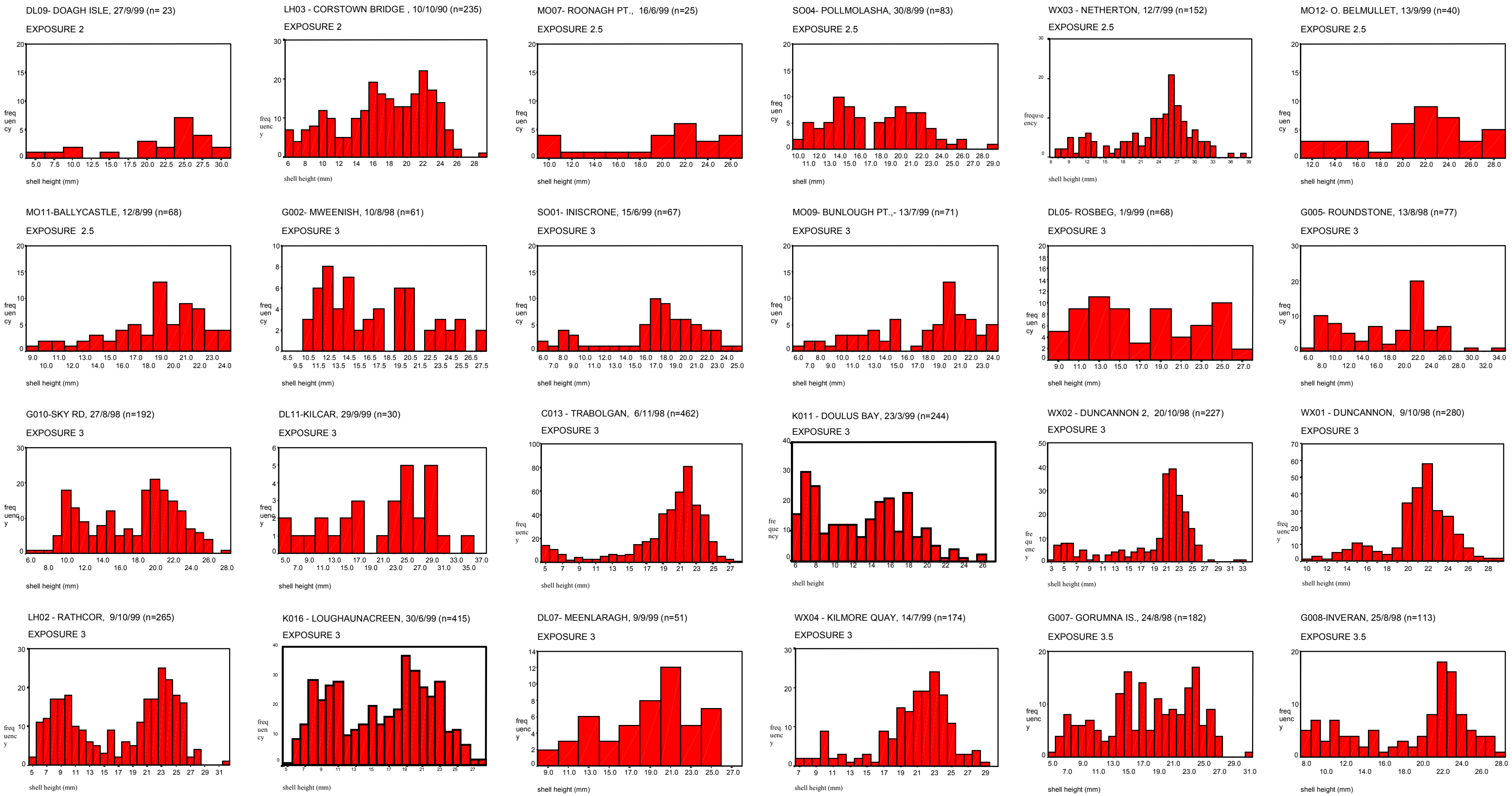
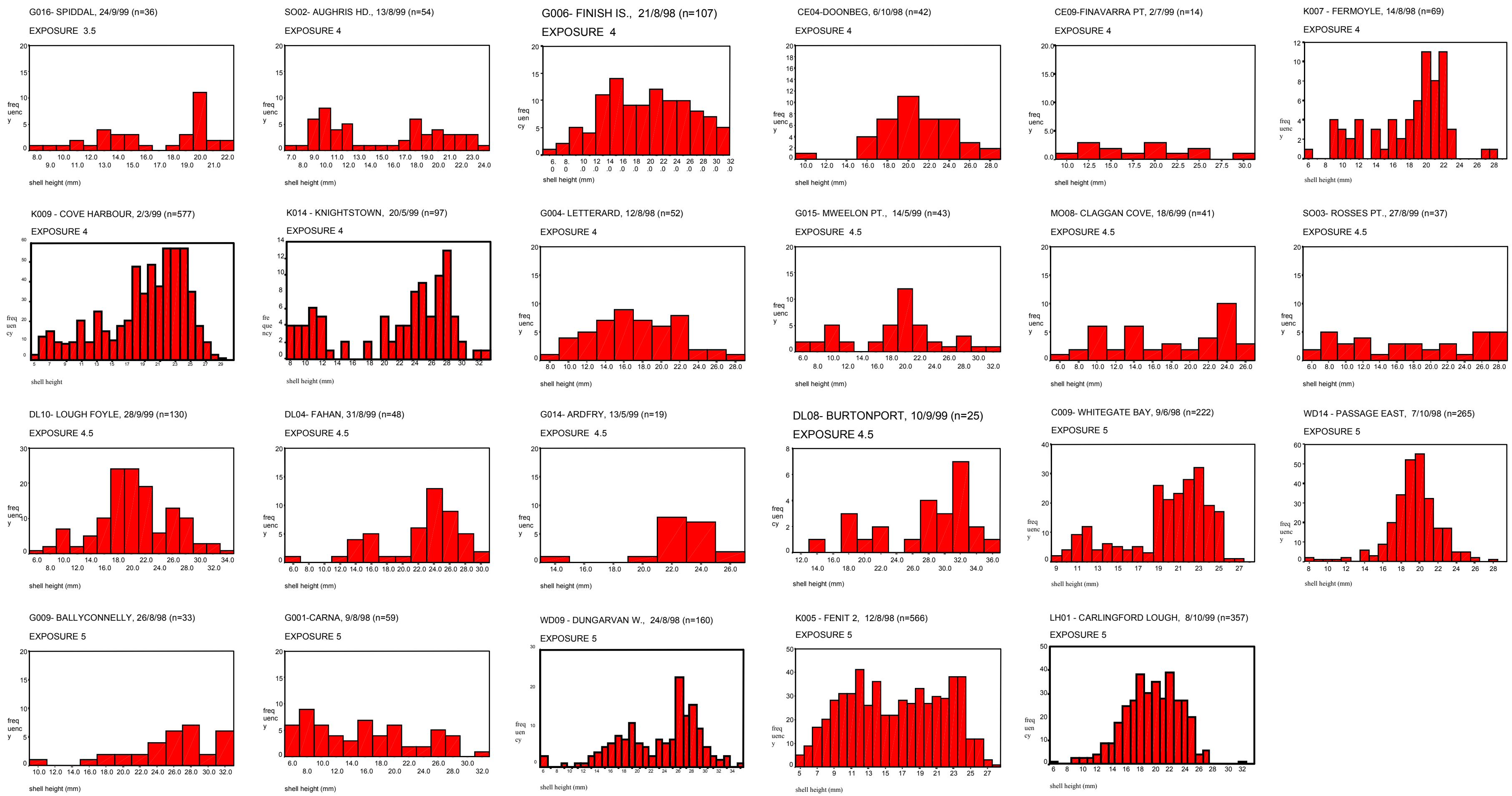


Figure 14 contd'. Length/frequency histograms from shores of varying exposure based on the modified Lewis scale. Graphs are presented in order of exposure, beginning with exposure 2 and ending with exposure 5. Site codes relate to the county where the survey was conducted , e.g. DL09 is site no. 9 in Donegal. (SO- Sligo, MO- Mayo, CE- Clare, K- Kerry, C- Cork, WD- Waterford, WX- Wexford, DN- Dublin, LH- Louth)



BULLENS BAY DATA

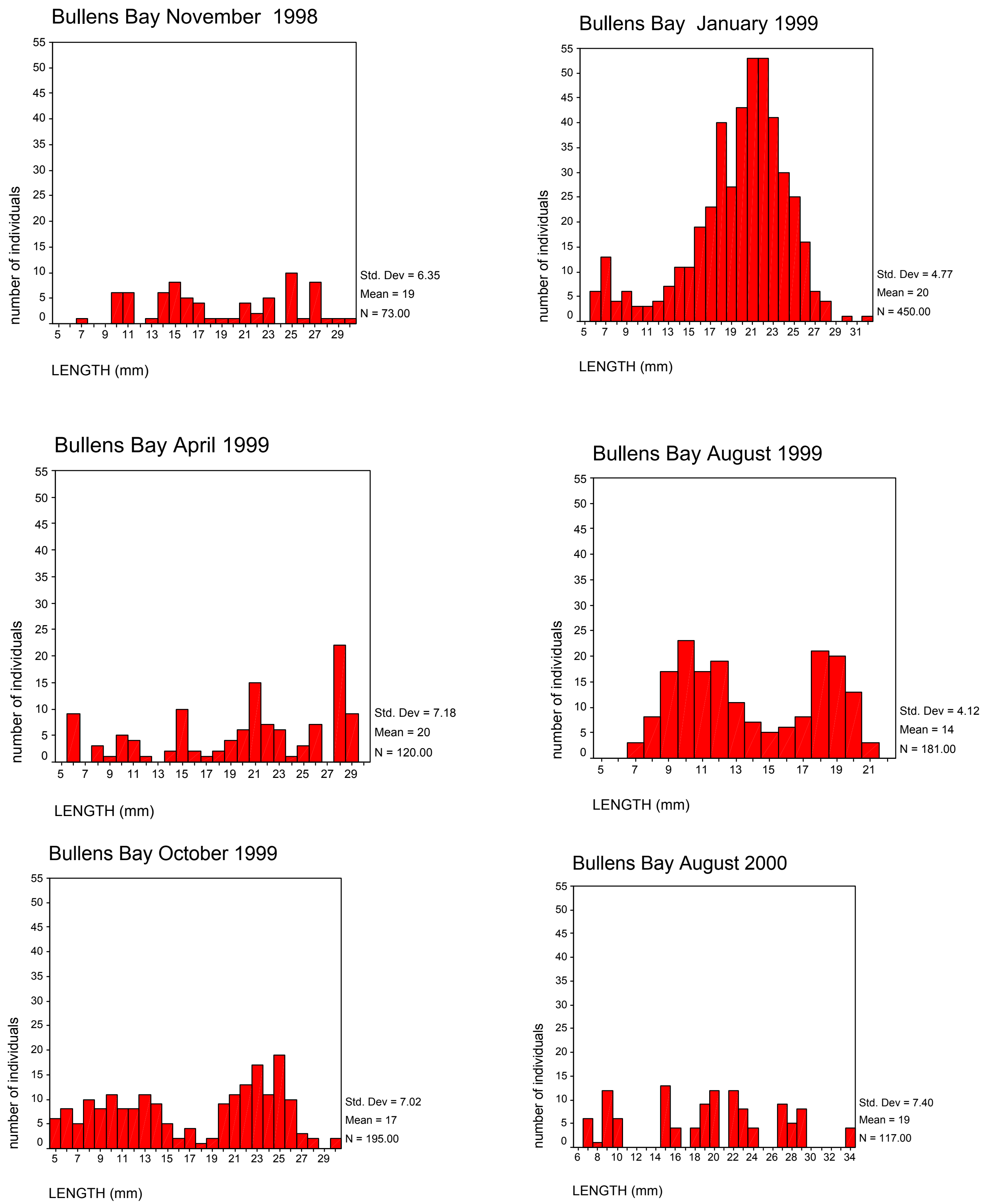


Figure 15. Length frequency distribution graphs of measurements of *L. littorea* taken from one site at Bullens Bay, County Cork. Data were collected over a three year period. Bullens Bay is a sheltered site.

3.4 Discussion

3.4.1 Abundance and distribution of L.littorea

There was a noticeable trend in periwinkle densities between the east and the west coasts, with the lowest densities consistently occurring on the west coast. It is possible that this trend is a consequence of the varying geology around the coast, which gives rise to different types of substratum. The lowest densities of *L. littorea* on harvestable shores were observed to occur around Galway Bay. The sheltered granite shores of Galway afford few crevices and are likely to provide a less suitable habitat for large numbers of *L. littorea.* Some of the highest densities of periwinkles were recorded along the eastern shoreline of County Cork and County Waterford (e.g. 196 per m^2 Whiting Bay, 182 per m^2 Ardmore Strand and 180 per m^2 Clonea Strand). Much of this inter-tidal area is composed of finely stratified mudrock and shale, which when weathered leads to an abundance of small sheltered crevices, ideal habitats for periwinkles.

L. littorea are reported to congregate in hundreds or thousands in depressions and small gullies, especially where algal debris occurs (Lewis, 1964). A significant relationship was noted between periwinkle densities and gravel as a substrate type. Small gullies in which gravel can aggregate so that the substratum is in fact quite stable, provide ideal settlement conditions for larvae; firstly, by providing a large surface area for settlement, and also by providing protection from desiccation, dislodgement and predation (Atkinson and Newbury, 1984). The presence of gravel offers similar advantages to older animals, in particular as a source of protection from dislodgement and predation.

Williams (1964) found very high densities of *L. littorea* on a moderately exposed shore at Craig-y-Wylfa, Wales. This trend is in accordance with the findings of the present study. Moderately exposed shores supporting large populations of *L.littorea* have been described in other studies (Ballantine, 1916; Graham and Mill, 1992; Hylleberg & Christensen, 1977; Lewis, 1955; Stephenson & Stephenson, 1972).

There is a general trend for the number of periwinkles per unit area to drop as one moves from the upper shore (Zone A), to the lower shore (Zone C). This was found to be the case for example in Bullens Bay, Kilcrohan, Carnivan Bay and Patricks Bay. This is in accordance with the documented research on periwinkle ecology (Crothers, 1992; Williams, 1964). However, there were a number of sites where the density incline appeared to be reversed e.g. Carlingford Lough and Aghabeg. These two shores were the only shores with a classification of 1 (extremely exposed) on the Lewis (1964) scale of exposure. It has been suggested that the degree of wetting on an exposed upper shore allows periwinkles to extend their range upwards (Moore, 1940). Perhaps the opposite is true for an extremely sheltered shore; further studies would have to be undertaken with more sampling locations to conclude this with certainty. In addition, there were a number of sites where the highest density of *L. littorea* occurred in Zone B, the middle shore. This was most notable on the east coast around Wexford, (e.g. Netherton; Crossfintan

Point; Rosslare Harbour), Dublin (e.g. Skerries; Rush), and Louth (e.g. Rathcor; Corstown Bridge; Clogher Head). The coastline on the east coast is generally flat and not as rugged as on the south and southwest coast. As a result, zonation is not as pronounced as it is on rocky, rugged shores. This could be the reason why higher densities of *L. littorea* appear to occur on the middle shore, in particular on the east coast. It was also noted during sampling that periwinkles on exposed shores were largely confined to rockpools, thereby avoiding much of the dessication effect associated with living high on the shore. Food availability may also be a factor in shoreline distribution, as most algae on the sampled exposed coasts were found in rockpools.

Environmental conditions such as temperature and input of freshwater were observed during the surveys. Freshwater inputs were observed at some sites (e.g. North East of Fort Point, Cork), in the form of streams flowing to the sea. However, these did not appear to have any impact on *L. littorea* populations at particular sites, even though an abundance of *Ulva lactua* was often associated with the streams. It is impossible to draw any conclusions from the recordings of temperature that were made, as most of the surveys were done between June and September, with no significant variation in temperature recorded during those months. Seasonal variation in periwinkle densities, observed at Bullens Bay, where samples were collected at different times over a three year period, may be attributed to many factors. These include population dynamics, as well as external factors such as storminess, degree of wetting, variation in collection rates by pickers etc. Temperature is one of many factors that may potentially influence the variation in population densities.

Finally, periwinkles are never uniformly distributed and shorelines are never uniform in nature. The methodology adopted for this study was designed to ameliorate these features; however, it is very difficult to represent an entire shoreline on one visit, in just three 30m belts. In conclusion, it is unlikely that the density of populations of *L. littorea* is determined by a single factor, but rather from a combination of many acting together, to provide optimal conditions where adults can thrive in large numbers, and where optimal settlement may occur and hence maintain a high density. Several factors were examined (exposure, topography of the shore, and algal cover). However, other factors are likely to be involved, which were not taken into consideration, such as the absence or scarity of important competitors (especially limpets); settlement conditions; intraspecific competition for food; intraspecific competition for space; and tidal range and emersion periods. Exposure and substratum of a shore, however, are likely to be amongst the most important factors.

3.4.2 Temporal variation in density at Bullens Bay in County Cork

At Bullens Bay, where temporal variation in density was observed, it appears that lowest densities of periwinkles occur during the winter period. This may be a consequence of natural mortality, or increased harvesting activity, as this shore is intensively picked during the winter. Another possibility for the reduced densities in winter could be a result of a sub-tidal migration. Sub tidal winter migrations may minimise exposure to freezing temperatures at this time of the year (Gendron, 1977). The effect of temperature extremes created by daily tidal immersions would also be minimised due to reduced periods of exposure. It is unlikely that periwinkle harvesting is responsible for the reduced numbers of *L. littorea* on the upper and mid shore regions during the winter period, as picking tends to be concentrated on the lower shore, where the largest periwinkles are to be found. It is possible that settlement of new juveniles (assuming that settlement occurs in early January/February in Bullens Bay) is responsible for the apparent increase in the density of periwinkles observed on the shore in late spring. Gendron (1977) working on a population of *L. littorea* in North America, found that the largest decrease in the density of periwinkles occurred between October and January. A similar pattern of change is apparent in the results from Bullens Bay.

3.4.3 Shell measurements of L. littorea

Intensive over-picking of a shore can have an impact on shell height as many of the larger animals are removed. However, no clear relationship between shell height and over-picking was identified from the data collected from one off site visits in this study. The intensity of the picking effort varies considerably from shore to shore and will often depend on current market prices and the time of year. In addition the mean shell height obtained for a shore does not reflect the number of very large or small periwinkles found in a population. Due to the extended planktotrophic larval stage in *L. littorea*, which leads to a relatively genetically heterogenous population, most observed morphometric variation is considered to be a result of natural selection and/ or the ability to adapt to the surrounding environment (Crothers 1992, Reid 1996).

In an examination of the relationship between shell measurements and exposure, the correlation between shell height and exposure was weak, however, the correlation between shell width and exposure was significant. While it is clear that the periwinkles from the most sheltered shores are larger than those from shores of intermediate exposure, the pattern is not one of consistent increase in size with decreasing exposure. This may be a consequence of small sample size, as measurements were only taken from seven shores with exposures greater than 3 on the Lewis scale of exposure.

L. littorea have been observed to adapt their shell morphometry, particularly their shell shape ratio, in relation to exposure. An increase in the value of the shell shape ratio corresponds to a decrease in aperture height. In *L. littorea* a smaller aperture, more characteristic of sheltered shores, is believed to be an advantage in avoiding predators (such as birds and crabs), which feed more effectively on sheltered shores (Crothers 1985, Robertson 1992). The larger aperture of animals from more exposed coasts is believed to allow for a larger foot and consequently a stronger hold on the substrate; this pattern was shown for other Littorinids by Raffaelli (1982). Crothers, 1992 also suggested a relationship between shell length and exposure. A lower spire reduces drag and hence provides an advantage on exposed shores. Exposure was shown to have a demonstrable effect on relative aperture height with significant correlation between exposure and shell height/aperture height ratio. In this case, an increase in the value of the shell height/ aperture height ratio corresponds to a decrease in aperture height, so a positive correlation points to a reduced aperture height on sheltered shores.

The effects of vertical position (zone) on the shore are quite distinct. Shell height is very strongly correlated with zone i.e. shell height increases down the shore. This agrees with the findings of other authors in studies of the influence of shore height on shell length in *L. littorea* (Vermeji, 1972; Gendron, 1977). The relationship between vertical position (zone) and shell morphology may indicate a seaward migration of older animals, or perhaps it is only on the lower shore that periwinkles achieve the largest sizes. McQuaid (1981) suggests that the greater tenacity of adults allows a gradual downshore migration of growing animals in response to gradients of food availability. This could be explained by the greater availability of food on the lower shore, where algal densities are higher. In addition *L. littorea* are stimulated to feed when immersed by the tide and when damp conditions prevail (Newell, 1958; Moore, 1937; Williams, 1964). Thus, the larger animals found on the lower shore have greater opportunities for feeding due to the regular influence of the tidal cycle on immersion rates.

3.4.4 Population structure of L. littorea

Sites favoured for settlement seem to be shores of moderate exposure (Lewis scale 3-4) with rocky and/or gravel substrates e.g. Rosbeg County Donegal (DL05), Kilcar County Donegal (DL11), Sky Road County Galway (G010), and Mweenish County Galway (G002). Three possible reasons for this pattern are outlined:

1. Sheltered sites are favoured by juvenile periwinkles for settlement purposes;
2. Mortality rate of newly settled juveniles on sheltered shores is considerably greater;
3. Growth rates are less on exposed shores.

While it is likely that growth on more exposed shores is slower, this does not explain the low levels (or absence) of juveniles on very sheltered shores, for example, at Ardfry, County Galway (G014), Ballyconnelly County Galway (G009), and Passage East, County Waterford (WD14). One explanation for this pattern put forward by Crothers (1992), involved what he described as the “whiplash effect” of dense fucoid algae which sweep away newly settled juveniles. Once juveniles survive early settlement, animals grow rapidly and may live for many years. In contrast, on an exposed shore, while conditions for settlement may be favourable, especially on barnacle covered rocks, few individuals survive winter storms (Crothers, 1992).

Large numbers of small periwinkles were observed at the Carna site (G001), however, this site was not as muddy as many sheltered sites and consisted of large areas of gravel and small stones. Seaweed cover is sparse in areas where the substrate is unstable, which would reduce whiplash effect. Water flow was also greater than would be expected due to considerable influx of freshwater and run-off from a tidal lagoon. A site in County

Kerry, Fenit 2 (K002), also does not conform to this pattern, proving that each shore is unique and many environmental parameters may affect settlement.

The shell height of cohorts will vary according to the time of year the site was surveyed and the time of settlement at the site. Spawning times are known to vary geographically; in addition, *L. littorea* has an extended spawning time (Fish, 1972). These factors may confuse the interpretation and comparison of length frequency histograms. However, it is usually possible to determine size/age classes from within an individual shore. Many of the histograms from exposed or semi-exposed shores show evidence of 2-3 size classes e.g. Rosbeg, County Donegal (DL05), Meenlaragh, County Donegal (DL07), Loughaunacreen, County Kerry (K016) and Corstown Bridge, County Louth (LH03). The smallest size class would, if a spring spawning were to be presumed, represent that year's settlement. It is rarely possible to decipher more than three age-classes, probably a result of a slowing of growth with age and maturity.

In sheltered shores, where there appears to be less recruitment, periwinkles appear to be larger and this is borne out by statistical analysis. In terms of population dynamics, it makes more sense that recruitment is highest where mortality is highest. This may also indicate that sheltered shores, where the largest periwinkles occur, are more susceptible to the effects of over-picking.

3.4.4.1 Population structure of L. littorea at Bullens Bay

In general, the length frequency distribution for the sampled population of *L. littorea* at Bullens Bay appears to be bi-modal. The data for periwinkles measured in November 1998 represent a low number of samples, for periwinkles less than 10mm. The cohort with a modal height of 7mm in January 1999 appears to have reached a shell length of 10mm by August 1999, and a shell length of 15mm by August 2000. Assuming that settlement occurs in late spring (May), the snails with a shell length of 10mm in August 1999 could be up to 15 months old. It could be said that the animals that obtained 14mm in August 2000 were approximately 27 months old. In November 1998, there was a high density of *L. littorea* at a modal height of 15mm. By August 2000, this cohort appears to have achieved a length of 20mm. Thus, it could have taken 21 months to grow from 15mm to 20mm. This would indicate that animals with a shell length of 20mm could be up to 4 years old. Previous studies have shown that a shell length of approximately 8mm is achieved at the end of the initial year of growth, increasing to about 16mm in length by the end of the third year (Williams, 1964; Hughes & Answer, 1982; Crothers, 1992). The findings at Bullens Bay are in keeping with these approximations of growth. However, Moore (1937) suggested faster growth rates in a study on *L. littorea* in Plymouth, for example, *L. littorea* has been shown to grow to 14mm shell length in December of its first year and reach a shell length of over 27mm by its fifth year.

L. littorea shows considerable variation in growth rate for the first four years of its life (Moore, 1937; Williams, 1964). The results from Bullens Bay indicate variable growth rates (approximately 8 months to grow from 0.5mm to 7mm; 7 months to grow from 7mm to 10mm; 12 months to grow from 10mm to 14mm). These figures assume that settlement occurs in early summer (Smith & Newell, 1955; Williams, 1964), and that *L. littorea* settle at a shell height of approximately 0.5mm (Smith & Newell, 1955). They do not take into account possible spurts in growth at productive times of year. A pattern in growth rates of *L.littorea* was observed by Lambert and Farley (1968) and by Gardener and Thomas (1987). The general trend was for growth rates to increase from May to early July, followed by a decrease in growth rates from mid-July to mid-August. Growth rates were observed to increase again in early September, before declining in the winter months. Periods of shell growth are interrupted when conditions are favourable for reproduction (Williams, 1964). Williams (1964) observed active shell growth on a shore in Wales, from July to October, which corresponded with a period when mature animals were fully spent. Growth rates decreased when gonad maturation began again the following November. Fretter and Graham (1960) observed a looser growth cycle, when, on reaching sexual maturity a cessation in growth occurred in correspondence with a period of maximum sexual activity. Maturity is thought to occur 12-18 months after settlement once a shell length of approximately 11mm has been reached (Williams, 1964). However, analysis of specimens collected from a shore in Galway during this study, showed the age of first maturity as approximately 15mm for males, and slightly higher for females; the smallest ripe female had a shell length of 17mm (Unpublished PhD data, Shellfish Research Laboratory, Carna). Taking this into account, it is unlikely that observed variable growth in animals less than 14mm in August 2000 can be attributed to sexual activity. Factors such as temperature, food availability, exposure, predation, competition and salinity also have an impact on growth (Pertraitis, 1982, 1987; Crothers, 1992; Reid, 1996; Robertson, 1992). It is possible that these factors have a greater impact on growth in periwinkles less than 14mm in Bullens Bay. The mean density on the shore was found to be high, approximately 63 periwinkles per m^2. Thus, competition could be an important factor limiting growth of the periwinkles on the shore in Bullens Bay.

There were considerable variations in the numbers of periwinkles >25mm shell length on the shore in Bullens Bay over the sampling period. This pattern could be attributed to harvesting pressure, as the largest periwinkles are the most desirable on the market. For example, in November 1998, a cohort with a modal height of 26mm was identified. By August 1999 no periwinkles >21mm were observed in the samples. However, by October 1999 a peak at a modal height of 25mm re-appeared. It is questionable if this same group grew to the observed shell length of 28mm in August 2000, as growth rate has been shown to decrease rapidly with age. Very little research has been carried out on growth rates in larger animals, although it is known that periwinkles >25mm must be several years old. The largest animal measured from Bullens Bay was 34.1mm in shell length.

A difficulty arises in using a harvested shore, such as Bullens Bay for studying the population structure of *L. littorea* as one of the main factors influencing such population structure will be harvesting itself. Temporal variation in periwinkle harvesting at Bullens Bay leads to difficulty in the interpretation of the impact of this activity, however, it is likely that harvesting has an impact on the population structure of *L. littorea* at this site, and that this impact extends to periwinkles that are greater than 14mm in shell length. In addition, the lack of measurements of periwinkles <5mm shell length meant that variations in recruitment patterns could not be observed. Nevertheless, it has been possible to suggest a model of growth in Bullens Bay.

SECTION 4 - INDUSTRY REVIEW

4.1 Introduction

Littorina littorea is collected in large quantities for human consumption. Collection is usually carried out by part time fishermen and by women (O Sullivan, 1977). Wright (1936) states that in the Blackwater Estuary, Essex, commercial quantities of periwinkles were dredged from sublittoral channels; however, gathering in Ireland is carried out by hand. Periwinkle harvesting is done during spring tides. Periwinkles are easier to harvest during this period as the lower shores, where the largest periwinkles are found, are more accessible. Some picking is done during periods of neap tides, but the quantity harvested is considerably less (T. Tobin, Youghal, pers. comm., 2000). When demand for periwinkles on the continent is high, and when prices are good, there is an increase in the number of people picking, and in the quantity of periwinkles exported. Extra demand for periwinkles at Christmas drives the price up from approximately £1,400 to £2,200/tonne, making Christmas one of the busiest times for periwinkle pickers and wholesalers. Some harvesters only pick at this time of the year, as the higher prices make it more worthwhile, and the extra cash is often needed. There is a subsequent post Christmas lull in the demand for periwinkles; demand increases again around Easter (K. Flannery, Dingle, pers. comm., 2000). Demand for periwinkles in the summer months has increased in recent years attributable to the increased volume of trade experienced in France by restaurants at that time of year.

Traditionally, the price obtained for periwinkles varied throughout the year, in accordance with the demand from foreign markets, (Wright, 1936). Seasonal trends in price still occur today. Price also depends on the size of the periwinkles, and whether they are graded or not. Wholesalers can also have an impact on the price a picker can get. Some wholesalers keep the price artificially high; this ensures the loyalty of the pickers when there is competition amongst wholesalers for stocks, and also encourages pickers to harvest in the run up to Christmas. Generally speaking, a picker could receive as little as 80p per kilo, but this can increase to around £1.50/kg at Christmas time. Wholesale prices are in the region of £2.10/kg for periwinkles less than 13mm, and about £2.50/kg for periwinkles greater than 15mm. Periwinkles are usually exported with other shellfish, and transport costs vary from 12p/kg plus VAT, to 22p/kg plus VAT for groupage.

The market price plays a major role in the number of people picking at any one time (McKay and Fowler, 1997). Market prices were very good in 1999, but they were subsequently affected by the oil tanker (the *Erika*) accident off the Brittany coast in December 1999. There is a demand for Irish periwinkles from French oyster farmers who use them to graze the algae that fouls the oyster bags. As a result, any impact on the French oyster industry, such as an oil spill, has a knock-on effect on the Irish periwinkle market.

There are no regulations in place to control the quantities of periwinkles harvested per year. Periwinkle picking is very much a ‘free for all’ situation; establishing oneself as a picker requires little more than a bucket. Despite the evident lack of regulatory control, all periwinkles collected in Ireland must meet the end product standards outlined in the European Community Directive on Shellfish Hygiene 91/492/EEC. This requires all shellfish harvesters to maintain a Harvester Book, which should log details of the species gathered, time and location of harvesting, quantity collected and destination of the shellfish. Rigid implementation of the harvesters book system is difficult to ensure in this industry. These regulations also require that wholesalers operate from a registered dispatch centre, which has been allocated a veterinary inspection number. This number is necessary in order to obtain an export licence. It also confirms that the premises has passed the required standard in terms of hygiene. These controls are enforced by the Department of the Marine and Natural Resources.

Historically, the only information on the Irish periwinkle industry has been compiled by the Department of Marine and Natural Resources (DoMNR). Up until now, no effort has been made to examine the periwinkle industry in Ireland as a discrete entity. In this section, an attempt has been made to estimate the true size and nature of the periwinkle industry in Ireland. The research methods and results are presented below.

Plate 2. Bags of harvested periwinkles, *Littorina littorea,* awaiting collection from a shore in Galway.

4.2 Research Methods

A confidential questionnaire, directed at periwinkle wholesalers, was designed to obtain information on the periwinkle industry. Twenty-six wholesalers were identified nationally, all of whom responded to the questionnaires, which were distributed between between June 1999 and January 2000. This represents the majority of periwinkle exporters in the country. However, periwinkles are sometimes purchased directly by French and Belgian buyers, which makes it extremely difficult to account for all of the exports. The aim of the questionnaire was to assess the quantity of periwinkles exported from different areas, and to obtain an impression of any changes in the supply of periwinkles from pickers to wholesalers over the last five years. Wholesalers were also asked their opinions about potential management strategies that might contribute to the future sustainability of the industry.

In addition to questionnaires, meetings were organised with as many wholesalers as possible. This was particularly advantageous when visiting a stretch of coastline for the first time, as wholesalers could pinpoint harvested sites for future surveys. Individuals with knowledge of the industry, while not actively partaking in commercial dealings in periwinkles (for example, fisheries officers), were also consulted.

Fisheries landing data was sought from the Department of the Marine and Natural Resources (DoMNR), the responsible authority for maintaining sea fisheries statistics. Periwinkle statistics are collected by Sea Fishery Officers and are then processed by the Department.

Eight seafood restaurants, six in Cork and two in Galway, were contacted by telephone to document the perception of periwinkles as a restaurant food in Ireland, and whether there might be potential to develop the home market further.

4.3 Results

The information obtained from the questionnaires is presented by dividing the coastline into five areas, which represent the main wholesaling areas in the country (Figure 16).

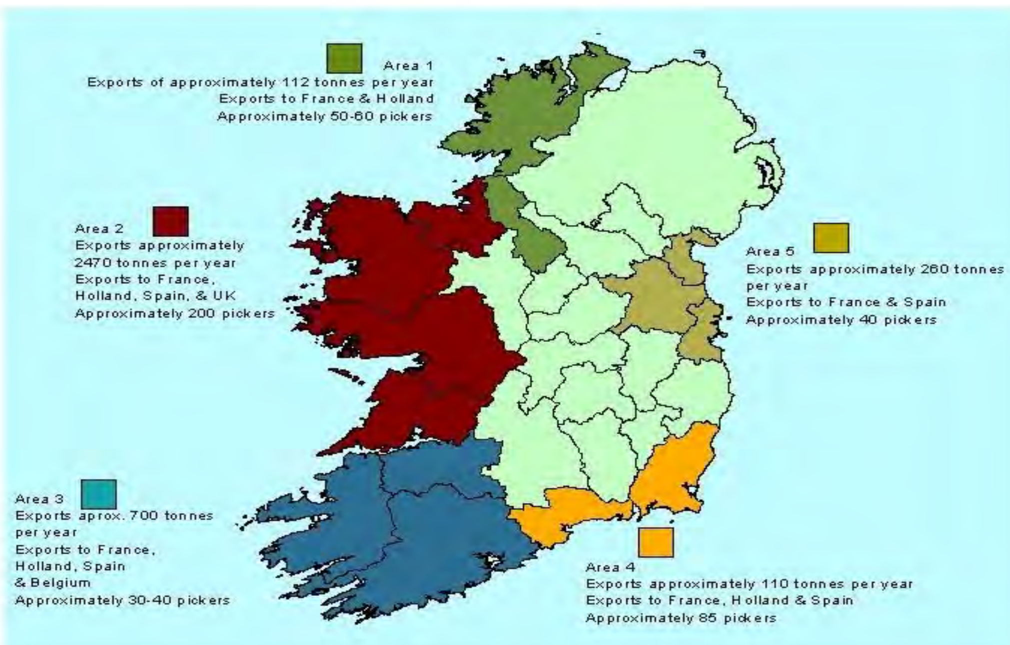


Figure 16. Industry review areas and summary of periwinkle industry activities

4.3.1 Area 1

This coastal area stretches from Rathmullan in County Donegal to Rosses Point in County Sligo. There is one major wholesaler operating from here, as well as two known agents who supply a large percentage of the picked periwinkles to wholesalers in Area 2. Results from questionnaires and interviews indicate that approximately 112 tonnes are exported directly from here per year. The exports are shipped to markets in France and

Holland. Each interviewee claimed that there was a decrease in the quantity of periwinkles being supplied to them; they attributed this to over-picking, picking during the breeding season, and pollution. They also said that regulations need to be put in place to conserve stocks, and mentioned closed seasons and minimum harvesting size as the best options for control. There are an estimated 50 to 60 pickers in Area 1. Periwinkles are exported to France and Holland from this area.

4.3.2 Area 2

This stretch of coastline extends from Rosses Point to Kilrush in County Clare. Seven wholesalers and agents were interviewed in this area, which includes some of the biggest wholesalers operating in the country. These wholesalers export approximately 2,470 tonnes per year. Two individual wholesalers account for over half of this total. All of the wholesalers said that they had experienced a decrease in the quantity of periwinkles they were receiving. While overpicking was cited as the major cause of the decrease by three of the wholesalers and agents, some additional factors, such as a shortage of labour, less picking effort, and pollution were listed as other potential explanations for the decrease in periwinkle supplies. This area contains the largest number of pickers, as there is an extensive area of suitable coastline. Based on wholesaler information, there are an estimated 200 pickers here. Periwinkles from Area 2 are exported to France, Holland, Spain and Britain. A proportion of this harvest is also retained for sale on the domestic market. However, this accounts for less than one percent of the total. Beach front vendors in Kilkee County Clare have operated a seaside business there for over a century. Sales of periwinkles in Ireland are also to be found further up the coast in the seaside town of Lahinch (County Clare) and in County Donegal at Killybegs. All of the interviewees said that regulations should be enforced to help the future sustainability of the industry. They suggested that minimum harvesting size and closed seasons would be the most practical way of achieving this.

4.3.3 Area 3

Area 3 extends from Tarbert in North Kerry to the coastal town of Youghal in East Cork. This area produces a conservative estimate of approximately 700 tonnes per year and there are at least 11 wholesalers operating from here. Periwinkles from this area are exported to France, Holland, Belgium and Spain. All of the wholesalers in this area noticed a decrease in the number of periwinkles made available to them by pickers. They also noticed a decrease in the average size of the periwinkles picked. Over-picking was listed as a major factor in the decline of periwinkle stocks, while less picking effort also featured as a possible cause. In 1998, the North West Kerry Shellfish Co. Ltd., under proposals for the conservation of inshore stocks of shellfish, submitted to the Minister for the Marine and Natural Resources, a proposal that a minimum size should be introduced for periwinkles harvested and that a closed season should also be introduced. No action was taken on behalf of the government at the time on this issue. Several exporters, pickers and people associated with the industry have expressed a genuine concern for the sustainability of the industry in this area. There are approximately 100 people reliant on income derived from periwinkle picking in this part of the country. Estimates vary according to which wholesaler is providing the information, but there is general agreement amongst the wholesalers that the number of pickers is declining. Many attribute this to the fact that fewer young people are involved in the industry, as there are now more attractive sources of employment elsewhere. One set of figures provided by a wholesaler, showed a decrease in the number of harvesters in an area in east Cork from 30-40 pickers ten years ago, to 7-8 full time pickers today.

One of the wholesalers interviewed in Area 3 said that the average size of the periwinkles being supplied to him had *increased* in recent years. On further questioning, he said that in the early 1990s, he used to purchase undersize periwinkles to sell to oyster-farmers in Brittany (mesh size of less than 13mm). These periwinkles were required to graze the algae in oyster bags. The on-grown periwinkles were then sold to the local markets by the oyster farmers. This practice ceased in 1993 when the French oyster production suffered problems with disease. As a result, the market for seed, small and medium periwinkles gradually decreased.

4.3.4 Area 4

This area consists of the coastline from Youghal to Rosslare, and includes the sheltered Dungarvan Bay, where much of the periwinkle picking takes place. Approximately 110 tonnes of periwinkles are exported annually from this area. There are three major wholesalers operating from here, two of whom rely on agents from other parts of the country to supply additional stocks when the demand is high. Shipments are made through the port at Rosslare, and the periwinkles go to France, Spain and Holland. All of the wholesalers in this area stated that the quality of the periwinkles, in terms of size, was good, and that the quantity being supplied to them remained stable. The largest of these wholesalers stopped accepting undersize periwinkles a number of years ago, and he attributes the recent prevalence of very big periwinkles to this practice. Nevertheless, all of these wholesalers said that regulations should be introduced to control the industry nation-wide, and they all favoured closed seasons and minimum sizes as the best methods of control. There are approximately 40 regular pickers from Dungarvan to Passage East in County Waterford, and a further 45 pickers from Arthurstown to Rosslare Harbour in Wexford. Some of this harvesting is reportedly done by ‘New Age Travellers’ who have been harvesting periwinkles in the region in recent years. Locals have commented on seeing groups of up to ten 'New Age Travellers' work a stretch of shore for the duration of a spring tide, and then move on to the next stretch of coastline. Several of the locals that were interviewed in the area were worried about the impacts of this intense harvesting method on the local periwinkle stocks.

4.3.5 Area 5

The coastline north of Rosslare to Dublin is largely made up of sandy, muddy foreshores, so periwinkle harvesting does not occur on a commercial scale in this region. Consequently, Area 5 extends from the North Dublin coast as far as Carlingford Lough in County Louth. There is one wholesaler from the Republic operating in this area. He also collects periwinkles from north of the border. He stated that fewer people are picking periwinkles in the region now than before, and that over-picking is not a problem. His volume of trade has increased in the past few years due to other wholesalers relinquishing their business. There are about 20 pickers between Clogher Head and Carlingford Lough that pick all year round. This number increases to approximately 30-35 people in the winter season (November to March). There are a similar number of harvesters that work the coast between Clogher Head and Rush. These are all local people; up to 90% of the picking is done by men.

4.3.6 General results

During meetings with the wholesalers, it became apparent that many would be interested in exploring the potential for on-growing. On-growing would involve taking seed and small periwinkles and maintaining them in an aquaculture system until they were of commercial size.

There is little, if any, post harvest processing. Some wholesalers provide special 10kg collection bags for the pickers to fill. These bags are collected, given quick inspection for general size of the periwinkles, and packed for immediate export. In the country of import, the periwinkles are usually separated into small 5kg bags. These are then placed into one large 40kg or 50kg bag, and sold to shops and restaurants. The 5kg bags are convenient for restaurants with large turnovers, as the periwinkles can be 'boiled in the bag'. Alternatively, the periwinkles are packaged loosely into 5kg polystyrene boxes. These boxes can be stored in the fridge, and the required quantity of periwinkles can be removed and cooked as desired. The periwinkles will remain fresh for several weeks in the fridge.

Ten of the 24 wholesalers said that they grade the periwinkles prior to export. The larger periwinkles command a higher price, making the process worthwhile. Grading is achieved by riddling the periwinkles using a bar or mesh riddle. The bar or mesh spacings vary in size and sort the periwinkles into undersized (to be discarded), medium, large, or jumbo. Most wholesalers classify a periwinkle passing through a mesh size of >15mm as being large. Wholesalers may also have to discard periwinkles that are covered in barnacles, as these are unmarketable. Periwinkles that are not graded in this country are usually graded by the importer on their arrival at their country of destination.

A further value adding technique, practiced by four of the wholesalers, involves allowing the periwinkles to crawl up vertical sheets of Perspex (a practice known as 'crawling'). Using this method, weak and dead periwinkles can be identified and removed prior to packaging. Buyers will pay more for this higher quality product.

One individual wholesaler investigated cooking and freezing the periwinkles so that they could be vacuum-packed and supplied to the market year round. He tried introducing the product at several trade fairs in France, but quickly realised that there was little demand.

Plate 3. Ungraded periwinkles photographed at a wholesalers premises in County Mayo.

Plate 4. A periwinkle grading machine.

4.3.7 Analysis of official fishery statistics

Annual reported catches of periwinkles can be seen from the sea fish landings by species, collated by the Department of Marine and Natural Resources. These figures are based on information provided by the wholesalers to the DoMNR's Sea Fisheries Officers. The wholesalers are under no statutory obligation to do this, thus the reliability of the data can often depend on the level of trust built up between the two groups.

Annual reported catches of periwinkles since 1973 are given in Figure 17. This data indicates that an average of about 2,370 tonnes per year were landed in the 1970s, with a peak of 2,995 tonnes in 1975. There was a decrease in the catch during the 1980s when the average figure was 1,604 tonnes per year, and landings fell to 1,198 tonnes in 1981. Periwinkle landings have gradually risen again since then, and in the most recent years for which data are available, catches have remained higher than the 1970s average. This is in direct contrast to the information derived from the questionnaires, which indicates that wholesalers have experienced a general decline in the quantity of stocks handled by them since 1995.

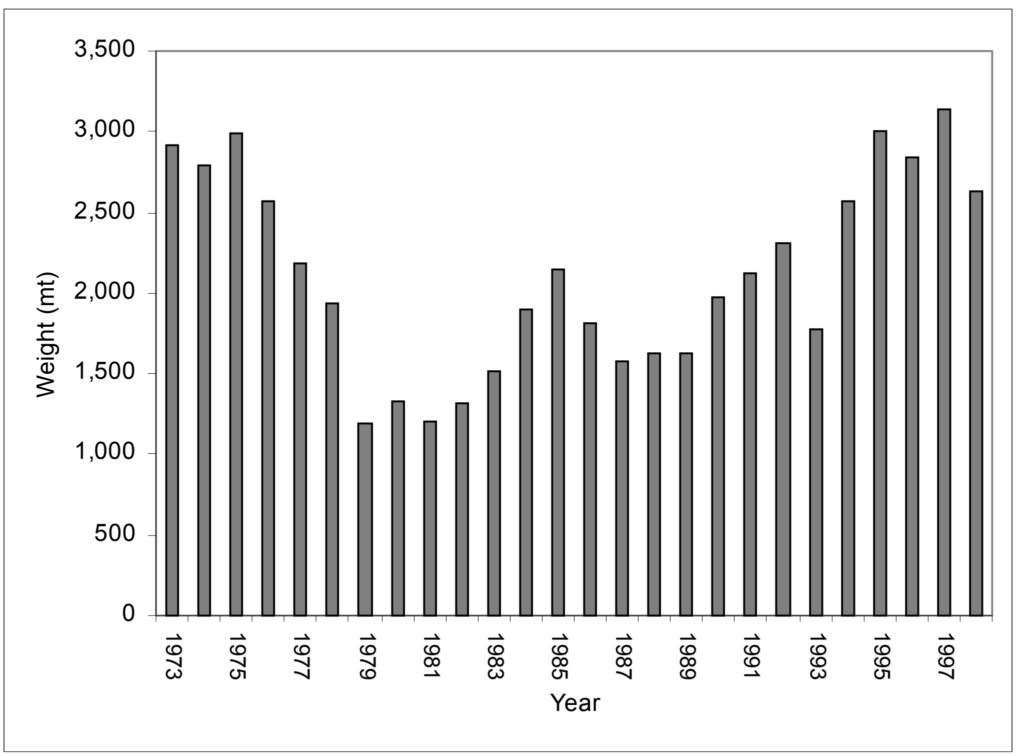


Figure 17. Catches of periwinkles in Ireland 1973 to 1998.
Source: Department of Marine and Natural Resources.

4.3.8 Feedback from seafood chefs

Three out of the eight restaurants contacted had periwinkles on their menu at one time or another. Two of these restaurants stopped serving periwinkles, due to the lack of demand. The general opinion of all of the chefs interviewed, was that periwinkles are tedious to eat and people are not practised in extracting them from the shell. There are also limitations on how they can be cooked and presented. One chef thought that the modern trend for convenience foods had made people reluctant to put effort into extracting the snail from the shell. On the other hand, the chef of a French seafood restaurant thought that this aspect of the food source was one of the attractions.

In general older people, in the 50 plus age bracket, eat periwinkles; traditionally in Ireland periwinkles were boiled in milk with onions. Irish people living in the coastal counties are more inclined to eat periwinkles than are their inland counterparts.

Three of the chefs stated lack of familiarity with the supply chain as a reason for not using periwinkles. Fear of contamination was also stated by two of the chefs as a reason for not using them.

When asked if there would be any potential for increasing the quantity of periwinkles being used in Irish restaurants, the replies were positive from six of the eight chefs questioned. The general opinion was that Irish people were experimenting more with the types of food they eat. The increasing popularity of mussels and oysters over the last 10 years was given as an example of this change. It was observed that if periwinkles were well marketed, there could be a change in attitude towards eating periwinkles, either as bar food, or as part of a seafood platter.

The main potential for selling more periwinkles on the Irish market comes from the increasing numbers of tourists visiting Ireland each year, especially the French and the English. Five of the chefs said that they would consider putting periwinkles on their menus (if they could find suppliers), during the tourist season; one of the chefs, who already does so, said that periwinkles were popular with his customers.

4.4 Discussion

Many of the results presented in this section of the report are based on the opinions of wholesalers. Due to the difficulty in identifying harvesters willing to discuss their involvement in the industry, the wholesalers themselves were also reluctant to provide detailed information on the sources of their supplies, to protect those individuals who may also claim unemployment and other social welfare benefits. As a result, the findings presented here reflect the difficulty in obtaining a clear picture of what is happening in this 'black economy' type industry.

In other ways, the wholesalers were very forthcoming with regard to how they operated their businesses. However, many of the export figures provided are thought to be an underestimate of the true quantity of periwinkles landed. The figure of approximately 3,650 tonnes exported per annum, obtained from the results of the questionnaires, is likely to be a conservative estimate of the true quantity of periwinkles actually harvested. This may be due to a reluctance to reveal figures for periwinkles that are exported unreported. In addition to this, there are cases around the coast, where pickers have built up contacts with importers in Belgium and France, and export their harvest directly. It is also difficult to estimate the quantity of periwinkles taken out of the country by French buyers who bypass the Irish wholesalers. As a result, it would be reasonable to estimate that the true quantity of periwinkles exported from Ireland may be closer to over 4,000 tonnes per year. Using these figures and current market prices, it is estimated that in excess of £7 million worth of periwinkles are exported from Ireland annually.

There appear to be approximately 500 part-time pickers employed by the industry, although this figure fluctuates depending on the time of year. While this is thought to be a fairly accurate reflection of the current situation, the number of pickers is very much dependant on the economic climate of the day and on the market price for periwinkles abroad.

Further research into the feasibility of **on-growing** could have an impact on the future of the industry. The main aim of this process would be to maximise growth rates so that the periwinkles would be marketable within a profitable time period. On-growing has never been tested on a commercial basis here in Ireland, although research trials conducted in Bantry Bay (Griffiths, 1996) and in Scotland (Cashmore and Burton, 1998) both concluded that benefits may be gained from this type of operation. Development of an artificial diet is something to consider for any large-scale aquaculture activity. An artificial pellet was tested in the Bantry Bay on-growing trials, but it was concluded that several changes would have to be made before this diet would be suitable for periwinkle culture (Griffiths, 1996). Observed problems with the diet included leaching, and lack of palatability. For small scale on-growing of periwinkles, costs would have to be kept to a minimum to ensure profitability of operations. Periwinkles are a low value species in comparison to some other farmed shellfish (such as oysters and abalone). William Connolly's Redmills Ltd. is currently developing Abalone diets, but these will market at £500 - £600 per tonne. For this reason, it might be better to feed the periwinkles on a natural diet of seaweed gathered from the shore. The development of aquaculture facilities suitable for intensive rearing also requires consideration. Such facilities may include a pump-ashore system where environmental parameters could be manipulated to ensure optimal feeding and growth rates. More work needs to be carried out to determine factors such as seasonal changes in growth, the benefits of providing supplementary feed, and the effects of parasitism.

Polyculture is another option for on-growing small periwinkles. This involves growing the periwinkles to a marketable size with another cultivated species. This practice is commonly used by French oyster farmers. The advantage of this procedure is that the periwinkles are very effective at keeping the oyster bags clean of fouling algae. In France, many oysters are grown in intertidal ponds, or parcs, which are ideal for confining the periwinkles with the oysters. Although parcs are not used in Ireland, one oyster farmer in Dungarvan successfully incorporates periwinkles in with his oyster bags as a method of biological control of fouling organisms. Surprisingly, it is not common practice among other oyster growers (R. Harty, pers. comm., 1999).

Post harvest processing of the periwinkles could also be suggested as an area for future focus. The current practice of packaging the periwinkles in 10kg bags keeps the costs down, however it does not ensure a quality product for the buyer. One exporter practising this technique has had non-payment for goods due to the large proportion of undersized periwinkles in some bags. Some pickers have also been known to add weight to the bag by adding stones to the middle. Despite this, many wholesalers believe that minimal handling is the most economically viable strategy. However, there seems to be little room for development in the area of post harvest processing; the greater majority of periwinkles are consumed fresh, either as an appetiser or as a minor part of a seafood platter. Potential seems to exist for selling more periwinkles to Irish restaurants, particularly during the tourist season. Picking during the summer to provide for the home market is unlikely to have any major impact on periwinkle stocks, as the potential size of the market is small.

Grading. As a large number of periwinkles are exported without being graded, it must be assumed that many undersize periwinkles end up in the market place, or that the importers dump them. This trade in undersize periwinkles is of particular importance at a time when so many of the wholesalers have expressed concerns about the resource. On the other hand, each of the wholesalers that employ sorting techniques said that they either return the undersize periwinkles to the shore, or make use of them in some other way. For example, one wholesaler relays them in oyster-bags where they graze the fouling algae from the trestles. Another wholesaler in Kerry uses them to clean his lobster tanks as the periwinkles feed on fouling macro and microalgae. While the return of undersized periwinkles to the shore must be welcomed, its unclear how well the animals recover. However, they obviously fare better than those periwinkles that (as has been suggested) are buried to prevent harvesters from re-picking them.

A number of wholesalers blamed **pollution** for a reduction in periwinkle stocks in certain coastal areas. It is known that *L. littorea* are affected by TBT based antifoulants, which were commonly used on vessels, primarily on leisure craft, until a partial ban was introduced in Ireland in 1997. A study in the UK, on *L. littorea* populations in the estuary of the river Crouch (Essex), showed that the numbers of *L. littorea* eggs and veliger larvae progressively increased following the ban on TBT-based anti-foulings on small boats by the UK government in 1987 (Matthiessen *et al*, 1995). This suggests that TBT may have impaired periwinkle reproduction and/or survival of the eggs and larvae. Another effect of TBT on *L. littorea*, termed imposex, causes formation of male sexual characteristics in females. The effects of imposex on periwinkles in Cork Harbour were studied by Casey and Burnell (1998). Imposex is not fatal and affected populations do not exhibit a male dominated population structure (Baur *et al*., 1995). Also, due to dispersal during the pelagic larval stage of *L. littorea,* populations do not necessarily become extinct as a result of imposex. The majority of harvested shores are located away from harbour areas where TBT might still be present in the sediment, making it unlikely that TBT plays a major role in the availability of the resource at present. However, it may have had a more significant role on the impact of periwinkle populations prior to the introduction of the ban. The other major pollution threat to populations of *L. littorea* is from oil spills; however, these usually have a localised impact, and there has not been a significant spill in Irish coastal waters in recent years.

The official landing statistics from the Department of the Marine and Natural Resources show that there has been a steady rise in the number of periwinkles landed throughout the 1990s (Figure 17). This can be misleading when presented out of context. It is unlikely that this rise is due to increased picking effort, but to a combination of other factors. The introduction of EC Directive 492, which defines end product standards for shellfish, led to improved accountability within the industry. This has had a substantial impact on landing figures since 1991. In addition, the DoCMNR has increased the number of sea fishery officers, so that more accurate information has been collected in recent years. Furthermore, landing figures for the early 1970s (when landing data would have been much more difficult to obtain) are roughly the same as figures for the late 1990s. The figures from the 1970s are likely to be an underestimate; if this is the case, this supports the conclusion that picking effort may be in decline.

Finally, the **overexploitation** of the resource in some locations has been outlined by the wholesalers, but at the same time many of them have noticed a decrease in the number of periwinkles made available to them by pickers. Part of this could be attributed to a reduction in the number of people becoming involved in harvesting. The age profile of harvesters indicates that a shortage of pickers may become a problem in the near future (Section 5). Only 18.5% of pickers interviewed were under the age of 40. Young people perceive periwinkle picking as intensive work, with very little financial return for the effort involved (Section 5).

Based on the feedback from wholesalers, it appears that localised over-picking does occur. The action taken by the North West Kerry Shellfish Co. Ltd. in submitting a proposal for conservation to the Minister for the Marine reflects the level of concern about over-picking in that area. Harvested shores are characterised by easy access, both to the site and to the bottom of the shore. As a result, intensive collecting tends to occur in these areas. This can reduce the overall numbers and size of animals in a population. However, in the absence of a comparable study, it is difficult to determine whether this is a large-scale problem. In addition, *L. littorea* is less vulnerable to the long term effects of over-exploitation than many other species due to its very long planktonic stage and its consequent ability to disperse and re-seed in over-picked areas. As a result, it appears that the major threat to the future of the industry may not be from over-picking, but from the decline in the number of people engaged in harvesting. Section 5 shows that there has been a decline in the number of people involved in picking periwinkles in recent years. The current strong economy in Ireland offers people of all ages a wider range of job opportunities than ever before, and entices them to abandon traditional sources of income. It could be said that the current shortage of periwinkle pickers will provide periwinkle stocks with the opportunity to regenerate themselves, and that it is perhaps the survival of the *periwinkle picker* over the *periwinkles themselves* that we must consider in the future. This reduces the immediate need for regulations to be implemented and should be taken into account before a management strategy is considered.

Regulations to ensure the sustainable development of the periwinkle resource would be welcomed by those who are worried about the conservation of periwinkle stocks. Several exporters, pickers and people associated with the industry have expressed a genuine concern for the sustainability of the periwinkle industry, and were very anxious that regulations are put into place in the near future. A closed season and a minimum harvesting size were the most widely supported regulations presented to harvesters and wholesalers alike.

Closed season. It appears that the motivation behind some of the support for a summer-closed season may be for reasons other than concern for the species. One of the main advantages of a closed season is that it would be easy to enforce. It seems many wholesalers would rather not handle periwinkles during the summer months, when prices are low and periwinkles are difficult to keep. One of the main reasons for continuing to sell periwinkles at this time of year is to maintain foreign customers who might acquire a different wholesaler or agent (perhaps from Scotland) if supplies were not forthcoming. Among pickers, the support for a closed season stems from the fact that few people pick during the summer anyway. A closed season at this time of year would suit those pickers who work on fishing boats or on farms during the summer. As a result, a closed season during the summer, when harvesting is at its lowest, makes little sense. The proposed timing however, makes little biological sense as *L. littorea* appears to spawn in the late winter and spring, and a summer closed season would not protect the animal during this time.

A closed season spanning the months of January to possibly April would best protect spawning periwinkles (pending conclusive research that this is the spawning season for most Irish populations). However, it is unlikely that pickers and wholesalers would support a closed season at any time of the year other than during the summertime. A closed season outside of the summer period could result in a serious loss of income for pickers and wholesalers, due to the closure of the fishery at a time when prices for periwinkles are likely to be high.

Minimum harvesting size. One of the classic signs of imminent problems for a fishery is the increase in sub market size individuals in the catch. The demand for undersize periwinkles by French oyster farmers undoubtedly had a negative impact on Irish periwinkles stocks on certain shores. However, many tonnes of periwinkles continue to be wasted every year because the size of the periwinkles gathered by the pickers is unacceptable for the market. Grading eliminates much of this waste, but it is likely that a large number of periwinkles are dumped, rather than returned to the shore.

The main advantage of the introduction of a minimum landing size therefore would be to force pickers to avoid shores where a large proportion of sub market size periwinkles occur. The majority of the wholesalers questioned suggested 13mm (shell height) as the minimum landed size that should be introduced. This corresponds with the smallest sized periwinkle that would be acceptable on the general market, but fails to take age/size of maturity into consideration. It must be noted that in Galway Bay at least, periwinkles do not mature until they are 15-17mm shell height, (Unpublished work, Shellfish Research Laboratory, Carna), which means that the minimum size advocated by the wholesalers might not protect the species as desired.

The introduction of a minimum landing size would be more difficult to enforce than closed seasons, as a number of wholesalers export periwinkles without grading them. Ideally, the pickers should be held accountable for any sub market size animals in a catch. However, due to the difficulty of identifying pickers, the wholesalers would have to be made responsible for failure to comply with this regulation. The enforcement of this regulation would mean that small exporters would have to buy grading equipment which, possibly, they could not afford. It would also be impossible to ensure that the graded, undersized periwinkles are returned to the shore to allow them to grow to a marketable size.

SECTION 5 -SOCIO-ECONOMIC IMPACTS OF THE IRISH PERIWINKLE INDUSTRY

5.1 Introduction

The aim of the socio-economic study was to evaluate the impact of the Irish periwinkle industry on coastal communities. This section gives an overview of the socio-economic issues derived from the study. These are closely linked with the nature of the periwinkle industry, as outlined in Section 4.

5.2 Research Methods

5.2.1 Questionnaires

A questionnaire was developed to collect information about the socio-economic aspect of the periwinkle industry. Originally, it was intended that the harvesters' questionnaire would be filled out by the harvester in the presence of the picker. However, it became evident that pickers were slightly intimidated by this, thus, a more informal approach was adopted, where questionnaires were filled out after a meeting with a picker. The age, occupation, and gender of the picker was recorded, together with their opinions on prospective regulations and the state of the industry.

5.3 Results

Fifty-four harvesters were consulted during the course of sampling. Of these, 81% were male and only 7.5% were not local to the area. The age profile showed that only 18.5% of pickers were under the age of 40. Most of the pickers interviewed relied on farming/fishing for their main source of income (60% from farming /fishing background: 25% farming and 35% fishing). While picking is almost exclusively used as an income supplement, at least one picker encountered in County Cork makes a reasonable living out of picking alone. There appears to be a real culture of periwinkle picking (often extending back through several generations) as an income supplement in small fishing/farming communities such as Carna, County Galway, and Kilkee, County Clare.

A few pickers took the fishery for granted commenting that "the periwinkles would always be there". However, there was widespread belief that there was a decline in periwinkle numbers in the recent years; many pickers (39%) suggested that this may be a consequence of overpicking; other pickers (15%) suggested that summer picking was the primary cause of decline.

It was impossible to ascertain the precise income of the interviewees. In some instances pickers were so reluctant to talk that even introducing such a question would have made the individual suspicious and unlikely to answer further questions. In many cases, other pertinent questions could not be asked. However, it would be reasonable to assume that most of those interviewed were on a comparatively low income. Many wholesalers and others who have knowledge of the industry claim that pickers rely heavily on social welfare payments, and that this would account for some of their unwillingness to be interviewed.

5.4 Discussion

The industry on the island of Inis Meain, County Galway, (one of the Aran Islands), has been studied by Evelyn Moylan and Paul Cashburn of Taighde Mara Teo. There are 16 harvesters on the island; eight pickers are seasonal workers and only pick in winter when demand is greatest. One interesting demographic to emerge was that most pickers were single men; only two of the 16 pickers were married. It is believed that the industry is worth around £17, 000 per annum to the islanders.

At one point, attempts were made to develop the industry on the island, it was initially hoped to conduct on-growing experiments and to develop a value added brine-pickled product. These projects were aimed at getting local women involved in natural resource based employment. The intended target market was the summer tourist trade. However, those involved became embroiled in arguments over foreshore rights (where certain pickers believed themselves to have the right to pick a certain area, and only that area). The pickers lack of co-operation eventually proved to be an insurmountable obstacle. The periwinkle population on Inis Meain is thought to be heavily overpicked. The area with exploitable quantities of periwinkles is very small and pickers have complained that "Jumbo" sized animals have disappeared. However, there appears to be little understanding that this has, most likely, resulted as a consequence of overpicking (Moylan, E., pers.comm. 1999).

It is of interest to compare the current socio-economics of the industry with those of the periwinkle industry in the early 1900s. The scope and dynamics of the industry were outlined in a study by Browne (1903) and this report provides evidence for a significant decline in the dependence on the fishery in the last 100 years. Browne's report states that around 300 to 400 people were involved in the industry in the early 1900s in the Belmullet (County Mayo) area alone; in 1998 a picker interviewed claimed that only two to three individuals now pick regularly in the area.

Many interviewed said that young people perceived periwinkle picking as being hard work for little return and that well paid work was now easier to come by. The age profile of harvesters may reflect the increasing age profile of many rural areas. Fewer young people now remain in traditional occupations such as fishing and farming (where quotas and regulation have made earning a living increasingly difficult) rather heading for more profitable work in towns and cities. The increase in third level attendance over the last twenty years may also have had an effect. Research carried out by the ERSI in 1999 showed that 6,000 people left all the Gaeltacht areas (traditionally areas with a high level of harvesting) in the past five years, 40% of whom were under 25 years of age. 50% percent of those leaving had third level qualifications (cited in Ireland on Sunday 16/1/00). This decline in the numbers picking regularly was mentioned by several wholesalers. Many complained that pickers were simply dying out and the age profile of pickers seems to confirm that this is the case. During the Christmas season, at least one wholesaler keeps the price paid to the harvesters artificially high in order to provide an incentive to pick and hence ensure continuity of supply. Other notable changes since the turn of the century include a shift from the mainland UK (particularly London) to European markets as the focus for export.

The recent high price of periwinkles has made them more attractive to pickers, thereby increasing the pressure on this fishery. The average price per tonne has risen steadily in the last few years;- from £569 in 1991 to £788 in 1996 (Central Statistics Office, 1999). This high price has removed some of the stigma attached to periwinkle harvesting that has existed in the past when periwinkle picking was considered a menial occupation.

SECTION 6 - CONCLUSIONS AND RECOMMENDATIONS

6.1 Summary and Conclusions

6.1.1 Resource Assessment

- The survey of harvestable shores showed geographic variation in the abundance of *L. littorea*. These variations may be a consequence of the varying geology around the coast. The highest densities of *L. littorea* per area on harvestable shores, as indicated by the present study, occur along the coasts of County Cork (east) and Waterford. Much of the inter-tidal area along the eastern shoreline of County Cork and County Waterford is composed of finely stratified mud rock/shale, which, when weathered leads to an abundance of small sheltered crevices, ideal for periwinkles.

- The lowest densities of *L. littorea* on harvestable shores, as recorded by the survey, were shown to occur around Galway Bay. The sheltered granite shores of Galway afford few crevices and are likely to provide a less suitable habitat for large numbers of *L. littorea.*

- The highest densities of periwinkles, occur on semi-exposed shores, (as recorded on shores such as Knockadoon and Ardnahinch, East Cork), with lower densities at both very sheltered (e.g. Ardfry and Mweelon Point, County Galway) and very exposed sites, (e.g. Fanore, County Clare).

- A large variance in population densities of *L. littorea* existed at the different survey sites. It is unlikely that the density of a population is determined by a single factor, but rather from a combination of many factors acting together. Migration, recruitment and harvesting have an impact on periwinkle densities on a shore. Exposure and substratum of a shore, are also likely to have considerable impact on population densities.

- Exposure has an effect on zonation on the shore. Periwinkles on exposed coasts were found higher on the shore than those on sheltered shores.

- It was found that the highest densities of *L. littorea* tend to occur on moderately exposed shores, 2-4 on the Lewis (1964) scale of exposure.

- There was a significant relationship between gravel as a substrate type and periwinkle densities; gravel can provide significant protection from dislodgement and predation.

- The largest periwinkles were found on the most sheltered shores; however, no consistent pattern of increase in size with decreasing exposure was detected.

- Aperture height is smaller in animals from sheltered shores, this is in accordance with the findings of other authors.

- There is a strong correlation between periwinkle size and position on the shore. Most large animals being found at the lowest inter-tidal levels.

- Aperture size of larger individuals is generally relatively smaller than that of small animals. This may be due to the fact that most large animals were found on sheltered shores, or that the selection pressure for a large foot is not as great for large/ lower shore animals.

- Minimum densities of *L. littorea* occurred during the winter period at Bullens Bay, which may be a result of natural mortality, harvesting pressures or sub tidal migration. Further observations could be carried out in this area to investigate migration patterns.

- It appears that localised over-harvesting of periwinkles occurs in certain coastal areas; however, with a lack of historic scientific data, it is difficult to determine whether this is a large scale problem. The resource assessment carried out for this project provides a bench-mark to which subsequent studies can be compared for evidence of overpicking.

- Harvesting almost certainly has an impact on population structures in Bullens Bay, and that this impact extends to periwinkles that are greater than 14mm in shell length.

6.1.2 The Irish periwinkle industry

- Results from questionnaires indicate that approximately 3,651 tonnes of periwinkles are exported from Ireland per annum. However, it would be reasonable to estimate that the true quantity of periwinkles exported is higher, due to the black market nature of the industry. Using this figure and current market prices, it is estimated that in excess of £7 million (approx €8.9 million) worth of periwinkles are exported from Ireland annually.

- There were approximately 500 part-time pickers working in the industry in the study area in 1998/1999. This figure is based on estimates provided by the wholesalers. The number of people involved in periwinkle picking at any one time is very much dependent on the economic climate of the day and the market price for periwinkles abroad.

- The age profile of pickers indicates that a shortage of harvesters may become a problem in the near future. Only 18.5% of pickers met with on the shore were under the age of 40.

- Young people perceive periwinkle picking as difficult, labour intensive work, with very little financial return for the effort involved. Within the current economic climate, alternative, better paid work is easier to come by.

- Sixty percent of the pickers interviewed came from a fishing (35%) or farming (25%) background.

6.1.3 Management Options

- Several exporters, pickers and people associated with the industry have expressed genuine concern for the sustainability of the periwinkle industry. They were very anxious that the findings of this project would result in regulations being put into place in the near future. However, there is no conclusive evidence to suggest that stocks are over-picked. In addition, the decrease in the number of people picking reduces the immediate need for regulations to be implemented.

- A closed season and/or a minimum landing size were both discussed as potential regulations to control over-picking. When asked, pickers and wholesalers were in favour of a summer closed season. This coincides with the time of year when there is little harvesting, as prices are low, and pickers become involved in fishing, farming or tourist related industries. However, a closed season during the summer would be of little benefit to periwinkle stocks. A closed season that coincides with the spawning period of *L. littorea* (possibly January to April, pending conclusive research that this is the spawning period for most Irish populations) would appear to be one of the best options for ensuring the protection of periwinkle populations. It is less likely that pickers and wholesalers would support a closed season at any time of the year other than during the summer.

- If the implementation of regulations becomes necessary in the future, a closed season would be the best management option to consider.

- Over the duration of this project, larval rearing trials were carried out at the Shellfish Research Laboratory, Carna. During the course of this work, it was found that the spawning season at Carna, County Galway extends from January to April/May. The spawning season is known to vary geographically, so further research needs to be carried out to establish the spawning season for Irish *L. littorea* populations.

- A minimum landing size of 13mm was suggested by many of the wholesalers. This corresponds with the smallest sized periwinkle that would be acceptable on the general market, and fails to take age/size of maturity into consideration. It must be noted that, in Galway Bay at least, some periwinkles do not mature until they are 15-17mm shell height. This means the minimum size advocated by wholesalers might not protect the species as desired.

- Widespread reports of over-picking must be considered in the context of the decline in the number of commercial harvesters involved in the industry, and this should be taken into account before any consideration is given to introducing regulations.

6.1.4 The future of the industry

- The future of the periwinkle industry in Ireland may be heavily dependent on the future economic climate of the country. If economic growth continues or at least stabilises at its present level, then the main threat to the industry will be the lack of harvesters to ensure a continuity of supply.

- The lengthy planktotrophic stage of *L. littorea* makes it less subject to the effects of localised overexploitation than species without such ability to disperse. Where populations of large periwinkles are removed from one area, larvae can be recruited from more distant shores, and so, in time, over-picked areas may be re-seeded. The periwinkle fishery in Ireland has withstood the test of time and has almost certainly come through periods of very intense picking pressure in the past (as shown by periwinkle landing data from the 1903 Browne Report).

- The potential for adding value to exports by post harvest processing appears to be limited. A fresh live periwinkle is the product most sought after on the continent, especially France.

- At certain times of the year, the demand for periwinkles is so high that the supply does not satisfy the demand from foreign markets. During periods of peak market demand, Irish wholesalers could export greater quantities of periwinkles if more periwinkles were picked or available. Developments in on-growing and polyculture could provide areas of future growth for the industry. In the future if prices should rise as a consequence of a decline in supply, ongrowing and polyculture may become economically viable. There is also potential for selling more periwinkles to Irish seafood restaurants, particularly during the tourist season.

6.2 Recommendations

- It must be appreciated that this report is a baseline study of the periwinkle industry carried out over a short time frame. Thus it would be unwise to make any immediate long term predictions or assumptions or to precipitate untimely protective measures without the benefit of ongoing data to demonstrate or validate their necessity.

- On the basis of this study no immediate action appears to be required in regard to protective legislation for periwinkles either by closed season, catch or size limitations or closed/protected areas.

- Periwinkle stock status should be continually reviewed and updated from strategically located key sites where calibrated sampling should be structured to include estimates of natural and fishing mortality, catch per unit effort, (CPUE), as well as overall trends in population composition. Thus, in the event of any untoward alteration in any of these parameters, rapid remedial action could be decided based on the updated predictive model. Such data could be used to counteract long-term effects due, for example, to overfishing, poor recruitment etc. by carefully selected legislation.

- Complementary investigations should also be undertaken to determine seasonality in spawnings for populations around the coast, as well as development of methods to predict yield per recruit, and thus determine relative year class strengths as a component for long term yield predictions. Also without such knowledge it is impossible to identify closed seasons in the event they might be necessary to protect adults during the spawning season.

- It may be that inaccessible periwinkle populations have historically acted as a reservoir to ensure regular recruitment into exploited areas of the fishery. If fishing pressure increase significantly it is suggested that an extended protection of such areas may be a logical management option which would be more readily supported by the industry than other alternatives.

- Should a requirement emerge in the short term requiring protective measures relating to season or size, these would have to be unilateral as any such local regulations would prove very difficult to enforce due to the movement patterns of post harvest stock.

- Developments in on-growing and polyculture could provide areas of future growth for the industry. Interest in these was expressed during the survey and it is recommended that government agencies take a more pro-active role in encouraging feasibility trials in this area, as there is currently little support or expertise available on the subject.

- There is potential for selling more periwinkles to Irish seafood restaurants, particularly during the tourist season. Fears about the safety of eating periwinkles contaminated by pollution need to be allayed and seafood chefs need to be made aware of where to obtain local supplies.

- It should be noted that the periwinkle may be well suited to demonstrate the operation, practices and benefits which can derive from understanding the biology and population dynamics of a species. It might be an appropriate case study as an example for other inshore commercial species and additionally could provide opportunities for and benefit from post graduate research as well as "hands on" experience and training in applied fisheries practices.

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Appendix A. The Lewis Biological Exposure Scale Defined (Lewis, 1964)

1. Very Exposed Shores

i. A very wide *Verrucaria* belt *entirely* above tidal level, and reaching perhaps 40-60ft. or more above the barnacle line.
ii. *Littorina neritoides* abundant throughout the lower *Verrucaria* zone; density varying greatly with substrate but not less that 1 per 5 $cm.^2$ on open surface, or 5-10 per sq. cm. in crevices.
iii. *Porphyra*/Myxophyceae belts well developed above the barnacle line persisting throughout the summer in the north, especially on flatter slopes.
iv. *Fucus distichus anceps,* and *F.sp*. f. *nanus* present (in the north and west).
v. *Lichina pygnaea* locally abundant (especially on verticals and in the south) and covering 20-40% of surface at level of maximum density.
vi. Eulittorial zone dominated by barnacles and limpets (with minimum densities of 100-150 per 5 $cm.^2$ and 50-100 per sq. metre respectively), or by *Mytilus*/Rhodophyceae communities which cover at least 50% surface in levels of maximum density.
vii. *Patella aspera* the dominant limpet in the middle and lower shores
viii. A belt of lithothamnia/*Corallina* and other Rhodophyceae usually present above the *Alaria* zone when the midshores lack *Mytilus*/Rhodophyceae communities.
ix. The upper sublittoral zone dominated by *Alaria*/lithothamnia and *P. aspera* and rising to M.L.W.N or above.

2. Exposed Shores

i. A *verrucaria* belt 10-30 ft. wide, largely above tidal levels.
ii. *Littorina neritoides* abundant, some *L. saxatilis* present.
iii. Some development of *Porphyra*/Myxophyceae belts (especially in north).
iv. *Lichina pygmaea* abundant (especially in the south).
v. Midshores dominated by barnacles and limpets alone, or by barnacles, limpets and *F.v.* f. *linearis* in flatter areas; the latter ranging from scattered solitary plants (especially in the south) to 50% cover or more (especially in the north).
vi. *Mytilus*/Rhodophyceae communities local, rarely dominant; most common in north and west.
vii. *Patella aspera* abundant in lower shore.
viii. *Thais lapillus* abundant; groups of several hundreds, or a scattered density not less than 10-20 per sq. metre.
ix. Well-developed belt of *Himanthalia* and /or Rhodophyceae (*Gigartina, Corallina* especially).
x. Some *Balanus perforatus* possible in S.W. England and *Bifucaria* in S.W. England and Ireland.
xi. The upper sublittoral zone dominated by *Alaria* in north, *Alaria* and *Laminaria digitata* in south.

3. Semi-Exposed Shores

i. *Verrucaria* belt about 4-10 ft. deep, partly within reach of the tides.
ii. *Littorina saxatilis* dominant, astride lower limit of *Verrucaria; L. neritiodes* becoming scarce especially in north.
iii. Distinct belts of *Pelvetia* upshore and/or *Fucus serratus* downshore (especially on flatter surfaces).
iv. *Chthamalus stellatus* becoming scarce (in north-west and west).
v. *Lichina pygmaea* present but zone barely detectable.
vi. Midshores of mixed barnacles, limpets and short *Fucus vesiculosus.*
vii. *Monodonta lineata* and *Gibbula umbilicalis* present (in south and west); 1-5 per sq. metre, more locally, especially near pools.
viii. *Thais* present and *L. littorea* appearing but local density varying greatly with topography.
ix. *Fucus serratus* belt associated with or surmounted by Rhodophyceae *(Laurencia* spp., *Gigartina, Rhodymenia, Lomentaria*); locally replaced by *Balanus perforatus* especially on verticals or in shade.
x. *Patella aspera* present but largely confined to lower littoral and sublittoral zone, or to lithothamnia pools.
xi. *Laminaria digitata* and lush growths of small algae dominate the sublittoral; *Saccorhiza polyschides* locally abundant in south and west.

4. Sheltered Shores

i. *Verrucaria* zone narrow and within reach of waves.
ii. *L. saxatilis* abundant (50-100 per sq. metre at least) when upper fucoids scarce.
iii. Full sequence of fucoid zones *(Pelvetia, F. spiralis, Ascophyllum* and/or *F. vesiculosus, F. serratus*), but cover not sufficiently dense to exclude barnacles completely.
iv. Barnacles, usually large, thinly scattered or patchy except on verticals.
v. Abundance of *Littorina littorea* and *L. obtusata* on all coasts, and of *Monodonta* and *Gibbula umbilicalis* in south and west.
vi. *Patella vulgata* abundant; *P. aspera* scarce or absent.
vii. *Laminaria digitata* dominate in the upper sublittoral zone.

5. Very Sheltered Shores

i. Extreme compression of *Verrucaria* zone to a 1-3 ft. belt lying *entirely* within reach of spring tides.
ii. Complete dominance of fucoids, and especially of long fronded *Ascophyllum* (4-12 ft. or more).
iii. Extreme scarcity of barnacles, except on some verticals, and their upper limit usually below M.H.W.N. (especially in *Balanus* areas).
iv. A well-developed *Catenella/Bostrychia*/Myxophyceae belt (especially in south and west).
v. The sublittoral zone dominated by *L. saccharina/Halidrys* with a *Chondrus/Furcellaria*

Appendix B. Periwinkle GIS Operations Manual for the Marine Institute

Contents **Page**

Background to the Periwinkle Project

The edible periwinkle *Littorina littorea* has been exploited as a food source in Ireland since the stone age (Woodman, Anderson, Finlay, 1999). Today there is a large market for the edible periwinkle on the continent, principally in France. The edible periwinkle industry remains a fishery of socio-economic importance in peripheral coastal communities. It is particularly important as an additional source of income in areas where few other employment opportunities exist.

Prior to this study, there was little or no scientific information available on the state of Irish periwinkle stocks, nor was there an accurate estimate of the scale and value of the Irish industry. This project aimed to redress this situation significantly.

The main objectives of the Periwinkle Project were:

- To establish the distribution, size and age distribution of the edible periwinkle populations along the Irish coast.

- In reviewing the Irish periwinkle industry, to assess its socio-economic impact on Irish coastal communities and to determine the potential impact of developments within this sector.

- **To incorporate the resultant data into a Geographical Information System (GIS). The GIS would then be used as a decision making tool in developing a management strategy for the industry.**

Further details on the Periwinkle Project can be obtained from:

The Marine Institute
80 Harcourt Street
Dublin 2

Information is also provided on:
www.cmrc.ucc.ie/pages/research

This section provides an overview of the GIS database that was completed for the project. Operation of the GIS is explained within the context of this document.

Introduction to (GIS)

GIS stands for Geographical Information Systems. GIS has been compared to the high tech equivalent of the map. The first GIS, which emerged in the early 1980s, allowed for the basic overlaying of geographically referenced data onto digital maps. Since then, these computer systems have developed rapidly in functionality, and can now facilitate the assembling, storing, manipulating, and displaying of a wide range of spatial and temporal data. The capabilities of GIS can broadly be categorised as follows: map production, data retrieval, data warehousing, report generation, data modelling, data integration, data transformation to a common projection and data overlays. There are several different types of GIS software packages available. MapInfo, GeoMedia and ArcView are amongst some of the more popular GIS packages used in this country. ArcView was the package used for this project as this software was already in place in the Coastal Resources Centre, UCC, where there is a large amount of expertise in using this system for the mapping of natural resources and other coastal data.

Data Capture Methods

During the project, 124 shore surveys were carried out. The bulk of the data held in the GIS originates from these surveys. Survey sites were selected on the basis that they provide suitable habitats for harvestable quantities of periwinkles; these were usually sheltered or semi-exposed shores. Other sites may have been selected (e.g. exposed coasts) for comparative purposes.

Three belts of approximately 30m width were divided into three biologically defined zones representing upper, middle and lower shores. (i) *Fucus spiralis* to *Ascophyllum nodosum*; (ii) A. *nodosum* to *F. serratus;* (iii) *F. serratus* to the low water level. Exposure was rated on a scale of one to five (after Lewis, 1964); one represented extremely exposed sites, and five represented very sheltered sites. In some cases, the exposure scale was subdivided to allow more flexibility in describing shores. As a result, there were ten possible degrees of exposure i.e. 1, 1.5, 2, 2.5 etc. Five quadrats ($0.25m^2$) were placed randomly within each zone and all the edible periwinkles, *L. littorea,* within each quadrat were counted, removed, and placed in labelled polythene bags. The samples were returned to the laboratory and kept in freezers to preserve them for further analysis.

The percentage cover of rockpool, seaweed, bedrock, rock, stones, gravel, sand and mud were also recorded from each quadrat. Any influx of freshwater into the belt, or any other potential impact from sewage or shellfish culture was noted.

The length of each of the three belts was measured and the bearing of each was also noted. A handheld Global Positioning System (GPS) was used to mark the starting point of each belt, in addition to the start and end point for each site. This, and other relevant data were subsequently added to a Geographical Information System (GIS).

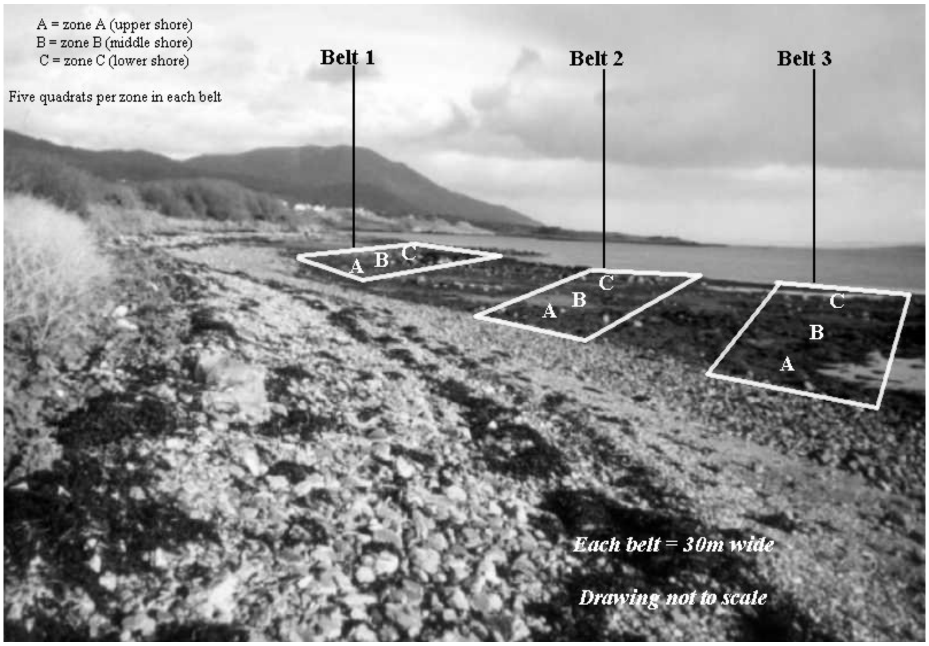

Figure 1. Sampling procedure carried used on the shore

Overview

The results from the shore surveys identify the areas of our coastline that are currently harvested for periwinkles. Results show periwinkle densities at these locations, and the average size of periwinkles measured at selected sites, taken from nearly 22,000 measurements of shell size. Additional data collected from individual sites were also included. The GIS facilitated the production of resource maps at various scales, with colour coded labels for additional attributes. These maps were used in the production of the final report.

Additional data layers were also added to the GIS from other sources. For example an outline of the coastline of Ireland, plus the county boundaries provide the backdrop for most of the information. Data from the Ordnance Survey 1:50,000 digital maps, such as roads, car parks and urban areas, were also added. This was obtained from the Marine Access Project, (completed by the Coastal Resources Centre for the Marine Institute), which contains the location of piers and jetties all around the country.

A project to map and assess the seaweed resources (*Ascophyllum nodosum, Laminaria spp.*) off the West Coast of Ireland was conducted in 1998 (Hession, Guiry and Joyce, 1998). This database was also incorporated into the Periwinkle Project GIS as another data layer.

The Periwinkle Project GIS can be interrogated to provide information on all aspects of the industry as described above. The flexibility of these computer systems means that future data can easily be incorporated, thus providing decision-making bodies with a powerful management tool.

Getting Started

Insert the CD entitled "Periwinkle Project GIS". The project information is stored on the CD in the D drive, in the 'winkle' folder. Select the 'winkle' folder, copy it, and paste it to your C drive. It is preferable that the periwinkle GIS is installed as C:\winkle. If it is installed under a different path, then you will need to make changes to your startup settings in Arc View[1].

Open ArcView by going to Start – Program – Esri – ArcView GIS. When ArcView has loaded, go to file and click on open project. Select C:\winkle\winkle.apr (this is the project file). Wait for a couple of seconds for the project to open. The project will open in a **VIEW WINDOW**. An outline of the Irish Coast and County Boundaries will become visible in the **map display**. These are **themes** and the visible themes are listed in the **table of contents** to the left of the map display. These themes are **ticked** to show that they are turned **on**.

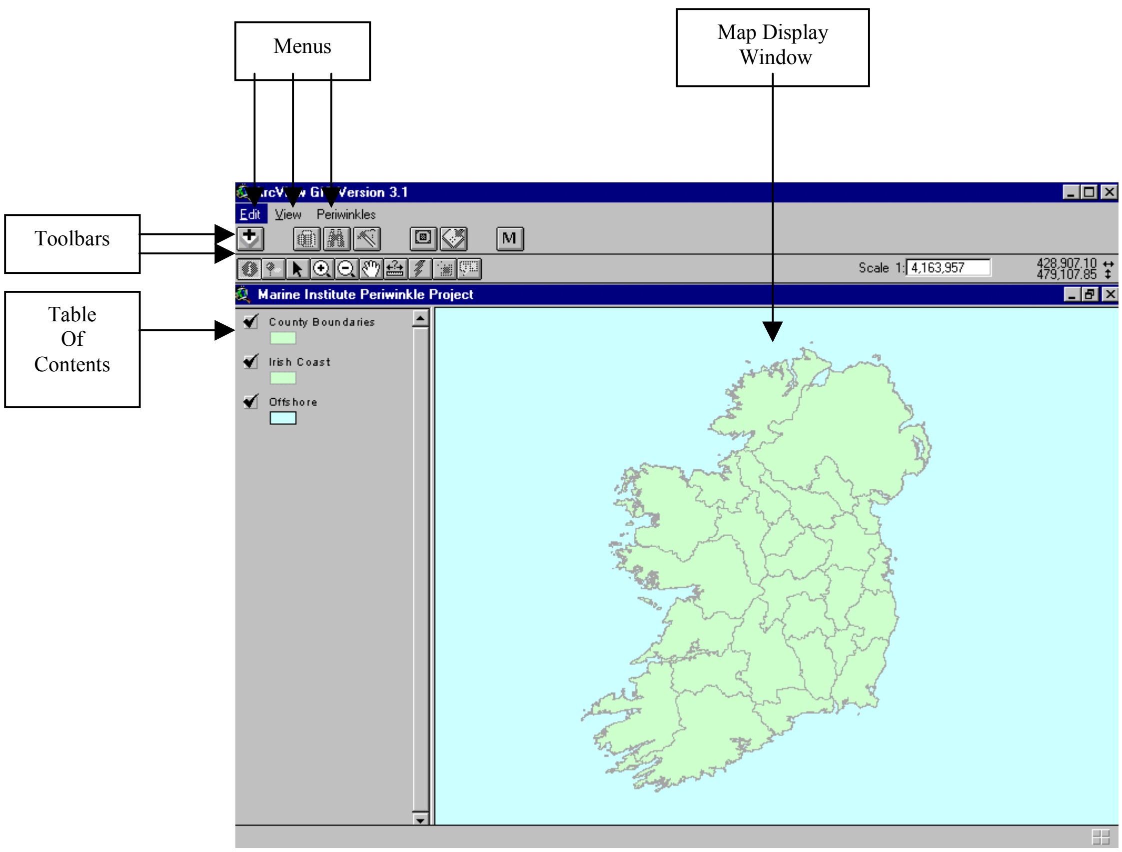

Figure 2. Overview of the first view to open in the periwinkle GIS.

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[1] To install the periwinkle GIS under an alternative path to C:\winkle, go to C:ESRI\AV_GIS30\ARCVIEW\ETC\Startup. Select the Startup File (not the PS File). Open this file in Wordpad. Scroll down to the bottom of the text, to where it says: System.SetEnvVar("DATADRIVE","C:\winkle\"). Change the datadrive details to the new path where the periwinkle GIS will be installed.

Structure of the GIS - (Themes and Topics)

The data was grouped into six different **topics**, which made up six different data layers on the GIS. The topics are basically the subject areas into which the data are divided. The topics are: survey information, industry information, morphometric data, topographic data, seaweed data, bathymetry. Each of these topics contains a range of **themes**, which can be added to the table of contents and viewed in the map display where they will be displayed as lines, points or polygons, depending on the type of data. Table 1 shows a breakdown of each topic and theme.

Topic	*Sub Heading*	*Theme*
Site Information	Survey Information	Access to Sites
		End of survey site
		Exposure
		Harvested sites
		Rockpool coverage
		Rugosity
		Seaweed coverage
		Start of survey site
		Substrate type
		Winkles per m2
	Belt Data	Belt locations
		Freshwater impact
		Winkles per quadrant
	Site Photographs	Site photographs
Industry Information		Wholesalers
Morphometric Data	Shell Measurements	Maximum shell height
		Mean aperture width
		Mean shell height
		Mean shell width
Topographic Data	OS 1:50,000 Discovery Series	Beaches
		Coastal features
		High water mark
		Low water mark
		Piers, slips, jetties
		Place-names
		Rivers
		Roads
		Tourist features
		Urban areas
Seaweed Database		Seaweed data
Bathymetry	Admiralty Chart Data	Contours
		Grid derived from spot depths

Table 1. Themes and Topics in the GIS

Viewing the Data

The Periwinkle Project GIS was saved into a customised version of ArcView, with many of the more advanced functions removed. As a result, the data can be viewed by anyone with basic computer skills, and expertise in GIS is not required to access the data. To view a theme, simply click on the Periwinkles Menu. A drop-down menu will appear. Select the topic of interest. Another menu will appear which shows a list of the themes available for that topic. Highlight the themes that you would like to add and click okay. You are now on your way to accessing the data held in the GIS. The various menus and toolbars are outlined below.

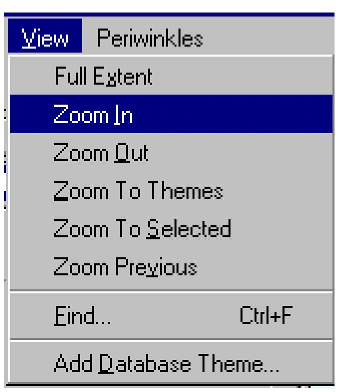
1. Menus

There are three main menus, which are primarily for viewing the maps at different scales, and adding and removing themes and topics. They are the Edit, View and Periwinkles menus.

The Edit Menu

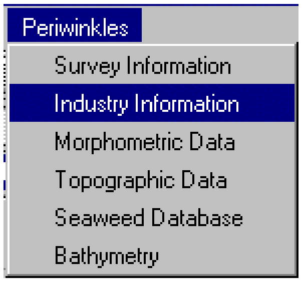
- to delete themes or to delete entire topics from the table of contents

The View Menu



- to view the full extent of the map
- to zoom in or out of specific areas of the map display
- to find a particular name on the map e.g. place name
- to add a new theme from an external database using SQL

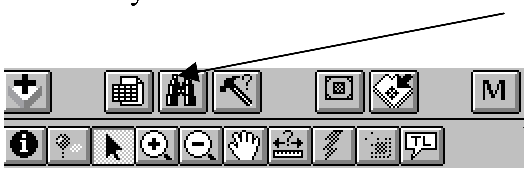
The Periwinkles Menu



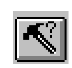
- to add a new theme to the table of contents. Themes are organised under the six topics described in table one.

2. Toolbars

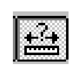
Toolbars provide shortcuts to many of the functions described above. For example, the binoculars symbol is a shortcut to the **Find Tool.**



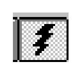
These are all of the tools that can be used in the project window



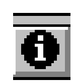
The **Query Builder** allows you to design your own queries of the data. By default, the query is contained within parentheses, but the parentheses may not be required, depending on the complexity of your query.



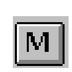
It is also possible to **Measure** the distance between one point on the map and another. A choice of units is available for display e.g. meters, miles, kilometres etc.



HotLinks let you access virtually any data or application directly from a view. For example, you can click on a site to display a photograph of the surveyed belts. A hot link is followed when you click on a feature in a theme with the HotLink tool.



The **Identify Tool** can be used to provide attribute values for an **Active Theme** (click on the theme in the table of contents to make it active; – notice that it will appear raised above the other themes).



The **Metadata Tool** provides background information on the origin of a selected data-point

Screenshots

The following screenshots provide an insight into how some of the data appears in the GIS.

- **Detailed large scale maps**

It is possible to zoom into a specific area for a more detailed view. Below is an example of the Donegal Coastline with themes containing information on seaweed coverage, coastal features, county boundaries and bathymetry. Results of a query on a seaweed coverage datapoint are shown in the 'Identify Results' dialogue box. The scroll down bar on the right of the table can be used to show the rest of the results.

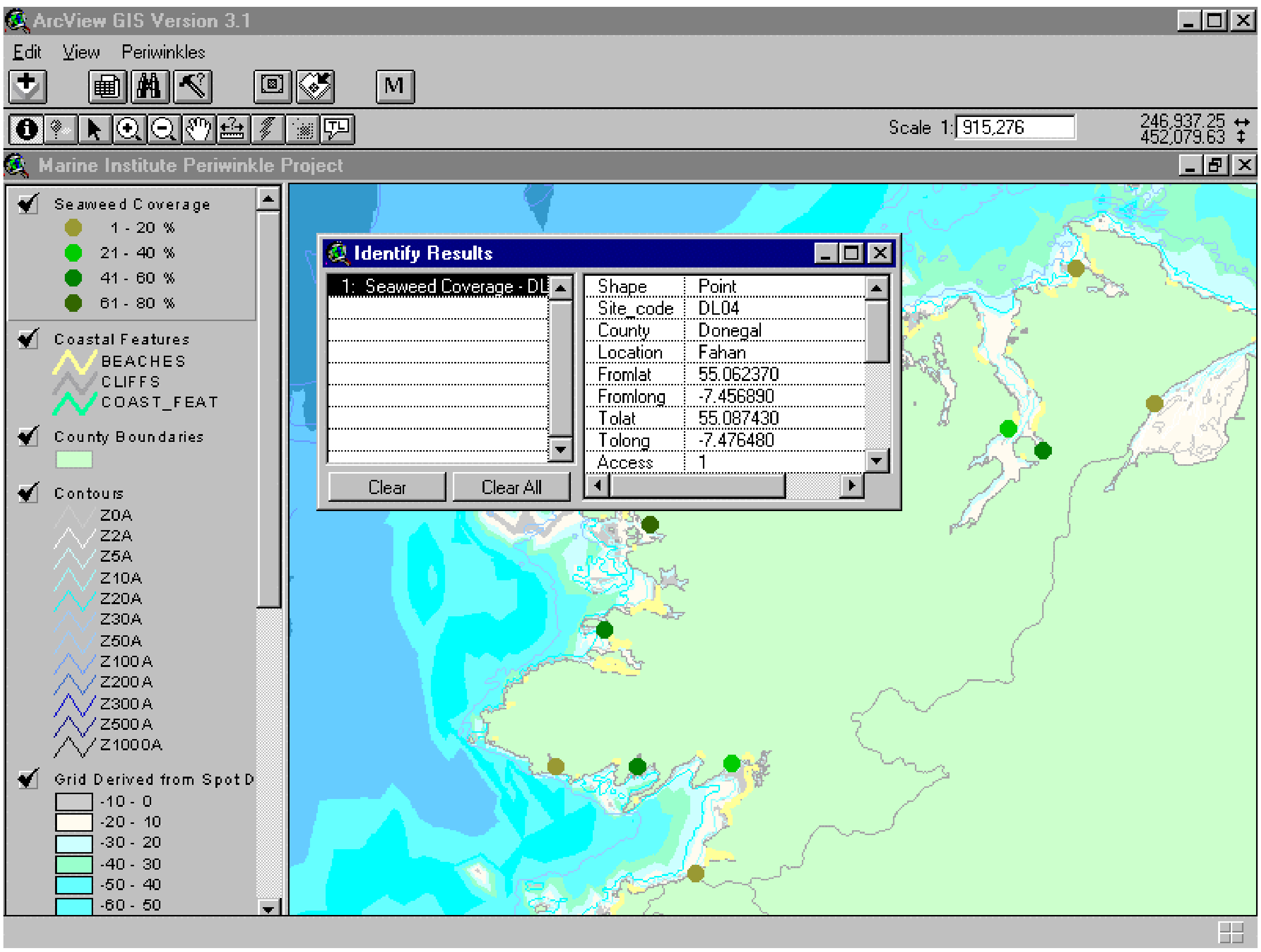


Figure 3. An example of a detailed large scale map.

- **Periwinkle density maps**

Polygons showing the length and bearing of each belt are colour coded to show periwinkle densities per zone. This information was reproduced to scale. In figure 4 the periwinkle densities are less than 40 per m^2 (shaded light pink) in all of zones A, B and C. The position of the start and end points of the shore are shown as red points.

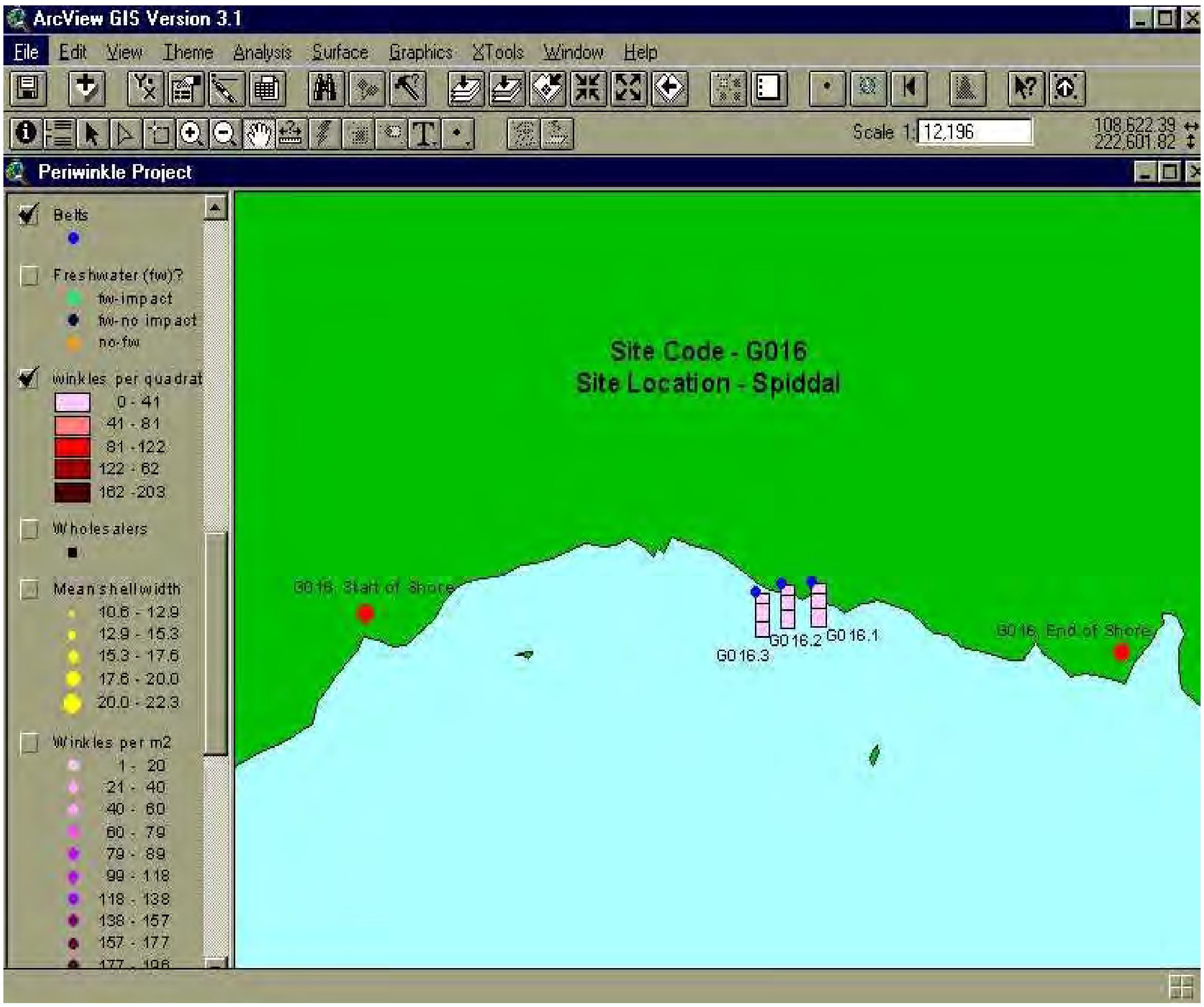


Figure 4. An example of a periwinkle density map.

The Project Window

Everything that has been described up until this point would have been viewed in the **VIEW WINDOW** mentioned earlier. Simply simply closing or minimising the View Window can access the PROJECT WINDOW. You will notice that a different set of menu bars will appear along the top. These menus are similar to those used in many Windows environments e.g. File - Close. There is also a **Help** option here, which provides information on all aspects of Arc View.

The layout of the **Table of Contents** will also look different. There will be a list of options including:Views, Tables, Layouts, Scripts and Dialogues. Only the **Views** and **Tables** options are needed here. Clicking on Views, highlighting Marine Institute Periwinkle Project and selecting Open will return you to the View Window. The Metadata Table can be viewed by selecting the Tables option. This is explained below.

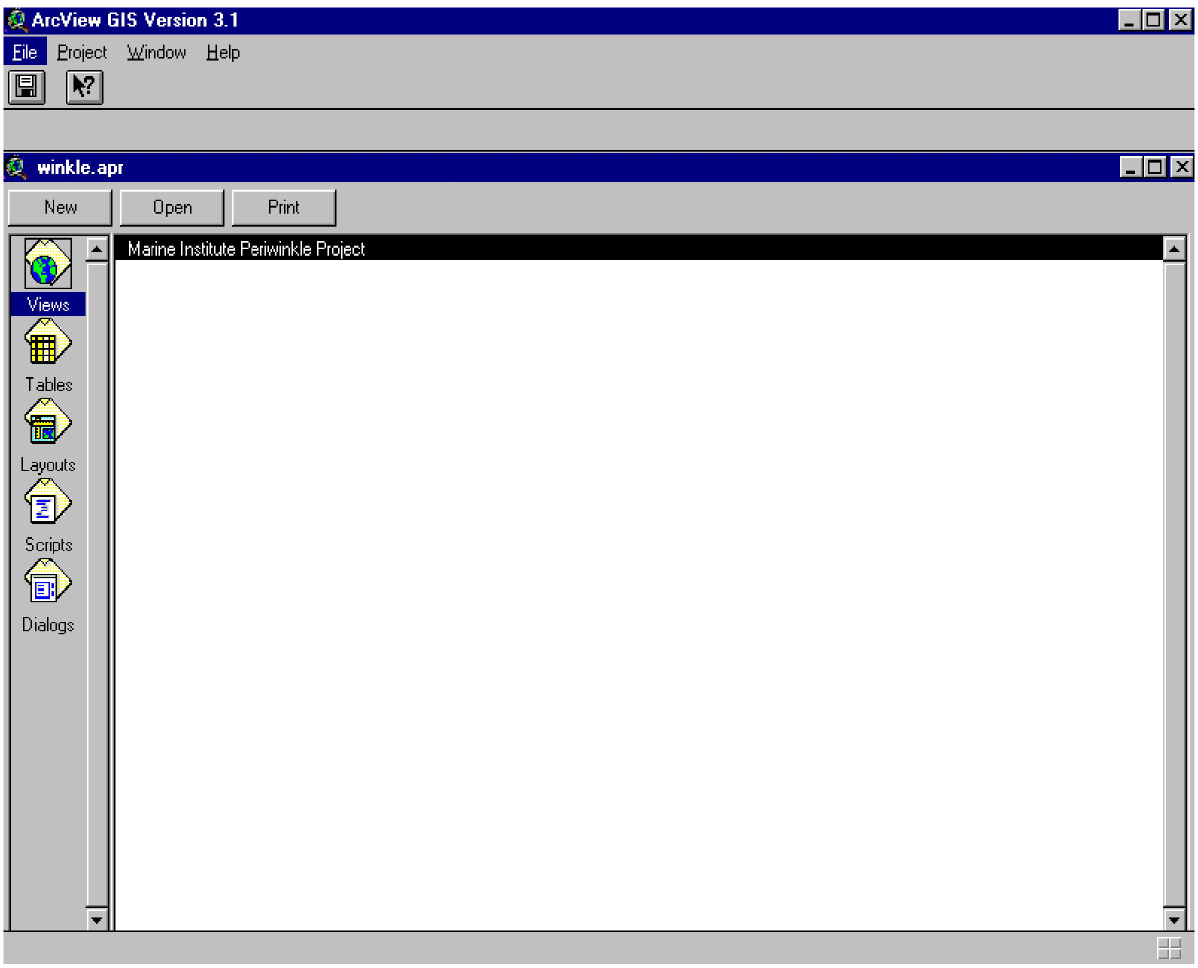
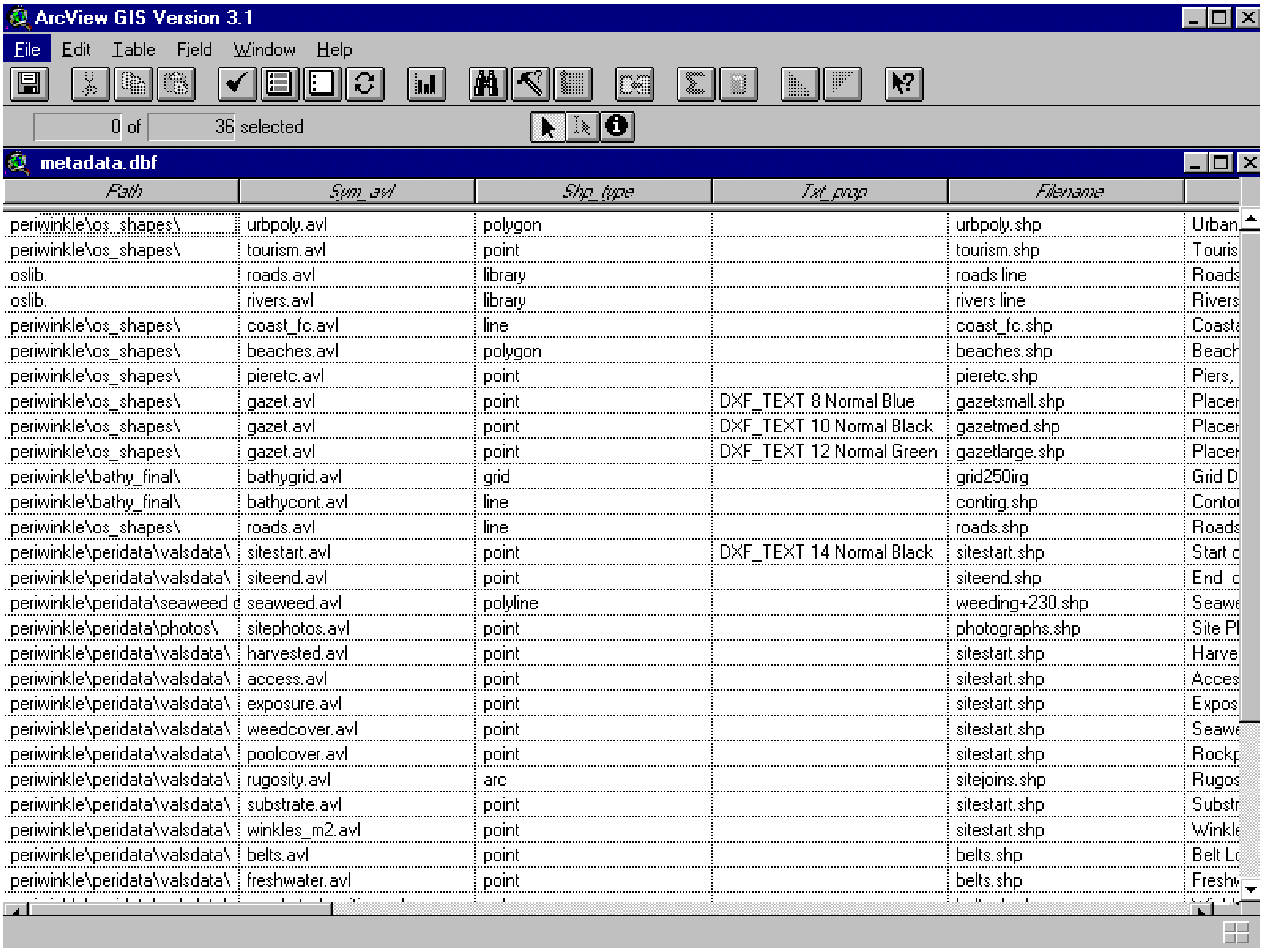


Figure 5. The project window.

The Metadata Table

To open the **Metadata Table**, click on **Tables** from the **Table of Contents** in the **Project Window**. The Metadata Table contains background information on individual files, such as the file path, the filename, the legend, copyright, scale, source etc.



ArcView GIS Version 3.1

File Edit Table Field Window Help

0 of 36 selected

metadata.dbf

Path	Sym_avl	Shp_type	Txt_prop	Filename	
periwinkle\os_shapes\	urbpoly.avl	polygon		urbpoly.shp	Urban
periwinkle\os_shapes\	tourism.avl	point		tourism.shp	Touris
oslib.	roads.avl	library		roads line	Roads
oslib.	rivers.avl	library		rivers line	Rivers
periwinkle\os_shapes\	coast_fc.avl	line		coast_fc.shp	Coast
periwinkle\os_shapes\	beaches.avl	polygon		beaches.shp	Beach
periwinkle\os_shapes\	pieretc.avl	point		pieretc.shp	Piers,
periwinkle\os_shapes\	gazet.avl	point	DXF_TEXT 8 Normal Blue	gazetsmall.shp	Placer
periwinkle\os_shapes\	gazet.avl	point	DXF_TEXT 10 Normal Black	gazetmed.shp	Placer
periwinkle\os_shapes\	gazet.avl	point	DXF_TEXT 12 Normal Green	gazetlarge.shp	Placer
periwinkle\bathy_final\	bathygrid.avl	grid		grid250irg	Grid D
periwinkle\bathy_final\	bathycont.avl	line		contirg.shp	Contor
periwinkle\os_shapes\	roads.avl	line		roads.shp	Roads
periwinkle\peridata\valsdata\	sitestart.avl	point	DXF_TEXT 14 Normal Black	sitestart.shp	Start c
periwinkle\peridata\valsdata\	siteend.avl	point		siteend.shp	End c
periwinkle\peridata\seaweed d	seaweed.avl	polyline		weeding+230.shp	Seawe
periwinkle\peridata\photos\	sitephotos.avl	point		photographs.shp	Site Pl
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periwinkle\peridata\valsdata\	access.avl	point		sitestart.shp	Acces
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periwinkle\peridata\valsdata\	poolcover.avl	point		sitestart.shp	Rockp
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periwinkle\peridata\valsdata\	winkles_m2.avl	point		sitestart.shp	Winkle
periwinkle\peridata\valsdata\	belts.avl	point		belts.shp	Belt Lo
periwinkle\peridata\valsdata\	freshwater.avl	point		belts.shp	Freshw

Figure 6. The metadata table.

The Accuracy of the GIS

Positions of sites and belts were obtained using a handheld GPS, which is accurate to within 12m. The accuracy of a reading depends on the ability of the receiver to receive enough satellite signals to calculate a position. In some cases the belt positions will appear to overlap with the land. This is due to inaccuracies in the waypoints, and to minor discrepancies in the actual base map outlining the coastline.

Abbreviations used in the Data

Table headings are limited in character length in ArcView. As a result many headings were abbreviated. The abbreviations can be seen when looking at an Attribute Table or when looking at the results of an **Identify** Query.

Qu =	Quadrat
S =	Site
B =	Belt
Z =	Zone
H =	Shell Height
Av_no_ZA =	Average number of periwinkles in Zone A
Av_no_ZB =	Average number of periwinkles in Zone B
Av_no_ZC =	Average number of periwinkles in Zone C
Av_Qu_S =	Average number of periwinkles per quadrat per site
Av_m2_S =	Average number of periwinkles per m^2 per site
Fromlat =	From latitude
Fromlong =	From longitude
Tolat =	To latitude
Tolong =	To longitude
Max _l_s =	Maximum periwinkle shell length per site
Mean_l_a =	Mean shell length in zone A per site
Mean_l_b =	Mean shell length in zone B per site
Mean_l_c =	Mean shell length in zone C per site
Mean_l_s =	Mean shell length per site
Mean_w_a =	Mean shell width in zone A per site
Mean_w_b =	Mean shell width in zone B per site
Mean_w_c =	Mean shell width in zone C per site
Mean_w_s =	Mean shell width per site
Mean_a_a =	Mean shell aperture height in zone A per site
Mean_a_b =	Mean shell aperture height in zone B per site
Mean_a_c =	Mean shell aperture height in zone C per site
Mean_a_s =	Mean shell aperture height per site
Mean_aw_a =	Mean shell aperture width in zone A per site
Mean_aw_b =	Mean shell aperture width in zone B per site
Mean_aw_c =	Mean shell aperture width in zone C per site
Mean_aw_s =	Mean shell aperture width per site

Additional Notes

Zoom in to a scale of a least 1:10,000 to see the belt locations clearly. The belts are recreated to scale (30m wide) which makes it necessary to zoom in to this extent to view them.

Acknowledgements

The project relied heavily on the co-operation and support of many people. The authors would particularly like to thank all the wholesalers who provided information and support for the project. Thanks also to those that assisted in the shore surveys including: David O Regan, Ana Periera, Mary O Connell, Mary-Jo Duncan Ryan, Sandra Leyzour, Magali Molla.

Thanks to the following who gave their time and provided valuable information: Gerry Gorman, Kevin Flannery, Dan Minchin, Andy Molloy, John and Flor Harrington, Shane Tobin, Ray Harty, Duncan Browne and Evelyn Moylan. Their assistance is gratefully appreciated.

The proposal for this project was written by Eddie O' Leary who provided helpful advice on many occasions. Sincere thanks also to Deirdre Tobin for her help with the GIS, to Michelle Cronin for help with the statistics and to Dr. Richard Fitzgerald who was an advisor on the project.

Finally, we would like to acknowledge Geoffrey O'Sullivan of the Marine Institute for his encouragement and assistance.

NÅR MILJØET ER I UBALANSE

Chrysocromulina polylepis – algen som skremte Norge våren 1988

Foto: E. Dahl

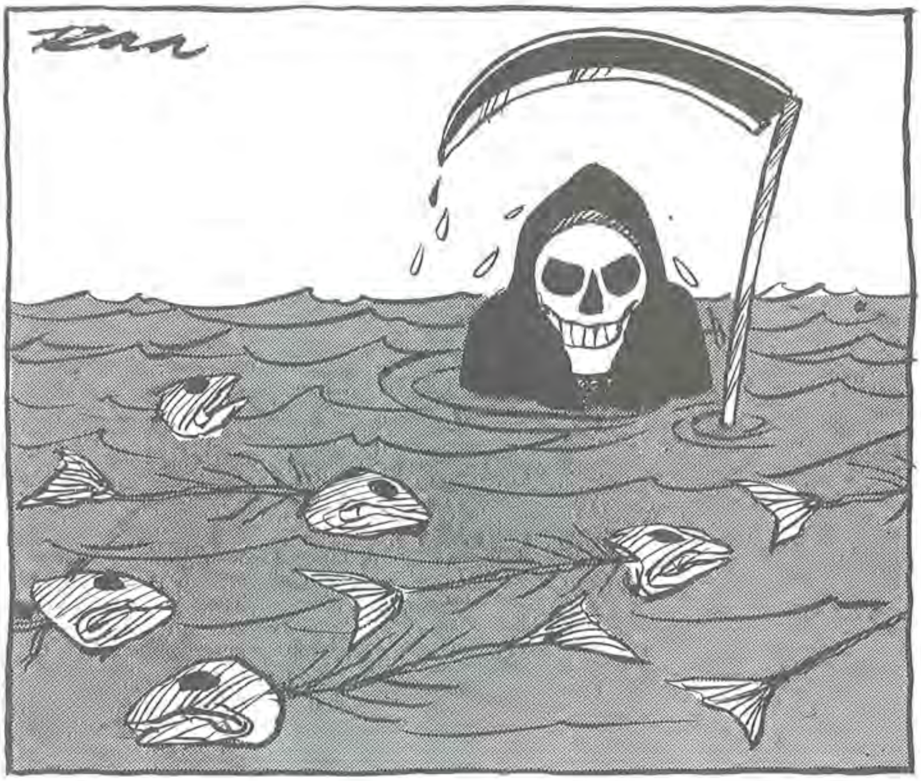
HAVFORSKNINGSINSTITUTTET VOKTER LIV OG MILJØ I HAVET RUNDT I NORGE

Planktonalger er mikroskopiske planter som driver i sjøen og er næring for andre dyr.
Våren 1988 begynte en lite kjent alge å formere seg over alle grenser.
Algen kvelte alt konkurrerende liv der den dukket opp.
I løpet av kort tid drev den inn i kyststrømmen med kurs for de store oppdrettsanleggene på Vestlandet.
Hva var det som skjedde?
Hvorfor skjedde det?

Hva gjorde Havforskningsinstituttet da det oppsto en giftig

ALGEOPPBLOMSTRING

HAVFORSKNINGSINSTITUTTET – ET MODERNE FORSKNINGSINSTITUTT



Algene kommer!
(Tegning: Raa Bergens Tidende)

«DEN TAUSE MORDER»

Våren 1988 ble algen med det imponerende navnet *Chrysochromulina polylepis* toppoppslag i aviser og TV. «Århundrets naturkatastrofe» ble den kalt.

Som en havets gresshoppesverm i et utrolig antall av opptil 100 millioner individer pr. liter vann, invaderte den Skagerrak, Kattegat og hele kystområdet fra Øresund til Bergens-regionen.

Algen viste seg å være giftig. Dyr som kom i direkte kontakt med store algekonsentrasjoner kunne dø i løpet av få minutter. Dyr og planter i det angrepne området som ikke var store eller mobile nok til å kunne flykte, ble drept. I enkelte havområder fant man kun *C. polylepis* og døde sjødyr. Oppdrettsfisk i de aktuelle områdene døde i tusenvis.

«Alger» ble toppoppslag på avisenes forsider og i TV-nyhetene.

Man fikk inntrykk av at «Den tause morder» truet alt liv i havet.

ALGER BETYR LIV!

Etter at algeinvasjonen var over, satt mange mennesker igjen med inntrykk av at alger er identisk med dødbringende forurensning. Detter er heldigvis fundamentalt galt.

Tvertimot er alger en forutsetning for livet i havet.

LIVETS MOLEKYLER

Livet i havet starter med at karbonatomer fra oppløst kulldioksyd. Sammen med atomer og molekyler av nitrogen, fosfor, oksygen og hydrogen organiserer de seg i ringer, kjeder og forgrenete rekker, til livsmolekyler som proteiner, karbohydrater og ensymer.

Plantene er de eneste organismer som klarer å bygge slike livsmolekyler uten å ta næring fra andre levende vesener. Underverket kalles «fotosyntese» fordi byggeprosessen henter den nødvendige energi fra lysets «fotoner».

Planter på landjorden kalles gress, trær, busker etc. De fleste landplanter er lett synlige.

De fester seg til et fast punkt på jorden med røtter. For å vokse trenger de sollys, vann og «gjødsel» i form av f.eks. nitrater og fosfater.

DRIVENDE MINIPLANTER

Plantene i havet kalles alger. Som på jorden finner vi både store og små planter i sjøen. Tang og tare er eksempel på store, fastsittende alger som er bygd opp av millioner av celler.

99% av alle algene i havet består imidlertid bare av en eneste celle. Derfor er de så små at de ikke kan sees med det blotte øyet. Typisk diameter for en algecelle er rundt 1/100 mm. Til gjengjeld er det til sine tider enormt mange av dem.

For å vokse må algene holde seg i de øvre vannlag der det er sollys. De finner næring ved å ta til seg nitrater, fosfater og silikater fra vannet de driver i. De lever ikke på noe fast sted. Tvertimot driver de viljeløst rundt med havstrømmene. Slike drivende miniplanter kalles **planktonalger.**

PLANKTONALGER – HAVETS MATPRODUSENTER

En planktonalge kan oppfattes som en ørliten gjennomsiktig pose som inneholder fargestoffet klorofyll og enkelte tilleggsfarger. Tilleggsfargestoffene gir hver algeart en karakteristisk farge.

Det finnes to hovedtyper av alger:

Kiselalger (diatomeer) som har stive posevegger av silisium, og

Flagellater som har myke posevegger av cellullose eller kitin.

Algenes viktigste oppgave i naturen er å få til fotosyntese.

Under fotosyntesen, som kjemisk sett er så komplisert at det nærmer seg miraklet, blir energifattig karbondioksyd fra sjøvannet trukket inn posen med klorofyll. Karbondioksydgassen består av karbonatomer som henger fast i oksygenatomer. Karbonatomene blir deretter dradd løs fra oksygenet og istedet sydd inn i algens egenproduserte molekyler. «Algemolekyler», som f.eks. sukker og stivelse, er konsentrert næring som kan fordøyes av dyrelivet i havet. Det frigitte oksygenet returneres til hav og atmosfære til beste for alle dyr som trenger oksygen til sin respirasjon.

ENORM PRODUKSJON

Den primære matproduksjon som alle verdens alger tilsammen står for, er enorm. Det er regnet ut at det årlig overføres mer enn 30 tusen millioner tonn karbonatomer fra energifattig karbondioksyd til energirike karbohydrater. Det tilsvarer ca. 100 tonn karbohydrater for hvert menneske på jorden.

PRIMÆRPRODUSENTENE SOM MÅ DØ

Algene kalles **primærprodusenter** fordi de er de første organismer som produserer spiselig mat av næringsstoffene. Ingen dyr må dø for at plantene i havet skal kunne leve.

Derimot må algene dø for at dyrene i havet skal kunne leve. De fleste alger blir nemlig spist av dyreplankton like etter «fødselen». Dyreplanktonet spises deretter av småfisk, som siden blir spist av større fisk høyere opp i næringskjeden.

Den energien som algene henter fra solen, og deretter binder til organiske molekyler, representerer derfor den samlete matrasjon for alt liv i havet.

Skulle algenes produksjon minke, vil derfor produksjonen av fisk, sjøfugl og sjøpattedyr også uvegerlig måtte avta. Algene er derfor ingen dødelig forurensning. Tvert imot representerer de livet. De er simpelthen **forutsetningen** for at mennesker og dyr kan høste mat fra havet.

HVA ER EN ALGEOPPBLOMSTRING?

Vannet inneholder «gjødsel» i form av karbondioksyd, nitrater, fosfater, silikater og andre kjemiske stoffer som enten er skylt ut i sjøen fra land eller hvirvlet opp fra havbunnen eller fra dypere vannmasser.

Dersom det er rikelig med næringsstoffer og samtidig tilstrekkelig med lys, vil algene vokse ved at de deler seg i to. Under ideelle forhold kan denne fordoblingsprosessen gjenta seg hver dag. Vi sier da at det skjer en oppblomstring og at det kommer «groe» i sjøen.

I våre farvann er det oppblomstringer hver vår. Under oppblomstringer kan det ganske fort bli så mange alger at store havområder tar farge av deres karakteristiske fargestoff.

NØDVENDIG MED LITT FLAKS!

Skal en algeart lykkes med å formere seg i stor stil, må den ha klaff på fire områder samtidig:

1. Den må ha passende oppdrift slik at den holder seg i det belyste vannlaget.
2. Lysets farge og styrke må passe for akkurat de fargestoffene som algene inneholder.
3. Algene må kunne vokse fort med de næringsstoffene som foreligger.
4. Sjansen for at algene spises umiddelbart etter «fødselen» må være liten.

UGRESS I ALGEHAGEN

Oppblomstring av bestemte algearter under vår og høst er både naturlig og ønskelig.

Der finnes imidlertid over tusen algearter som alle konkurrerer om de samme næringsstoffene. Sjansen for at akkurat en art skal ta «matfatet» alene over et stort havområdet er derfor minimal. Det normale er at algene opprettholder en slags balanse der flere arter lever side om side. Overraskelsen var derfor stor da den praktisk talt ukjente og høyt uønskete algarten *Chrysochromulina polylepis* plutselig overtok kommandoen i mai 1988. Det var kommet ugress i algehagen!

HEKTISK I FISKERIDIREKTORATETS «KRISESENTER».
Forskere fra Havforskningsinstituttet, Universitetet i Bergen, Universitetet i Oslo og fra Nansensenteret i Bergen arbeidet natt og dag med å vokte algenes bevegelser slik at de kunne utarbeide «algevarsler» til kystens fiskeoppdrettsanlegg. Her viser forsker Jan Aure ved Havforskningsinstituttet hvor algefronten befant seg den 28. mai 1988.

NATURENS LUNE ELLER MENNESKENES DÅRSKAP?

Drama i 5 akter

Når menneskene slipper store mengder med næring ut i havet, kan mye skje! Våren 1988 ble det målt uvanlig høye nitratkonsentrasjoner i Skagerrak/Kattegat området. Dette ga antakelig *C. polylepis* sjansen til å tilrive seg hovedrollen i et gigantisk naturkriminaldrama som ennå ikke er helt oppklart.

Der foreligger imidlertid indisier på at følgende kan ha skjedd:

1. I mars/april startet alle algeartene i området sin normale våroppblomstring. Etter en tid ble det slutt på silikatet, og diatomeene, som er avhengig av silisium til det stive skallet sitt, måtte trappe ned produksjonen.

2. Siden det fremdeles var rikelig med nitrater i vannet kunne flagellatene som ikke trenger silisium fortsette veksten. *Chrysochromulina polylepis* og andre flagellater i området fikk formere seg uten å måtte konkurrere om maten med diatomeene. Flagellatenes antall økte sterkt.

3. Lysforholdene i sjøen bestemt av skyforhold og vannets gjennomskinnelighet var trolig ideelle for *C. polylepis* sitt fargestoff. I alle fall startet denne algen en eksplosiv vekst.

4. Fosfatinnholdet i sjøen tok slutt. *C. polylepis* tok frem et hittil ukjent trumfess. Den kunne snylte fosfor fra levende planter og dyr! Når den støtte på en naboorganisme med tynn nok hud, etset den små hull og suget i seg fosforholdig vevsvæske. Naboplankton og tilfeldige sjødyr med tynnveggete gjeller fikk millioner av «algestikk». Sjøvannet og vevsvæske rant inn og ut gjennom hullene. Ionebalansen brøt sammen og ofrene døde.

5. Nitratinnholdet i sjøen tok slutt. *C. polylepis* fikk næringsmangel.

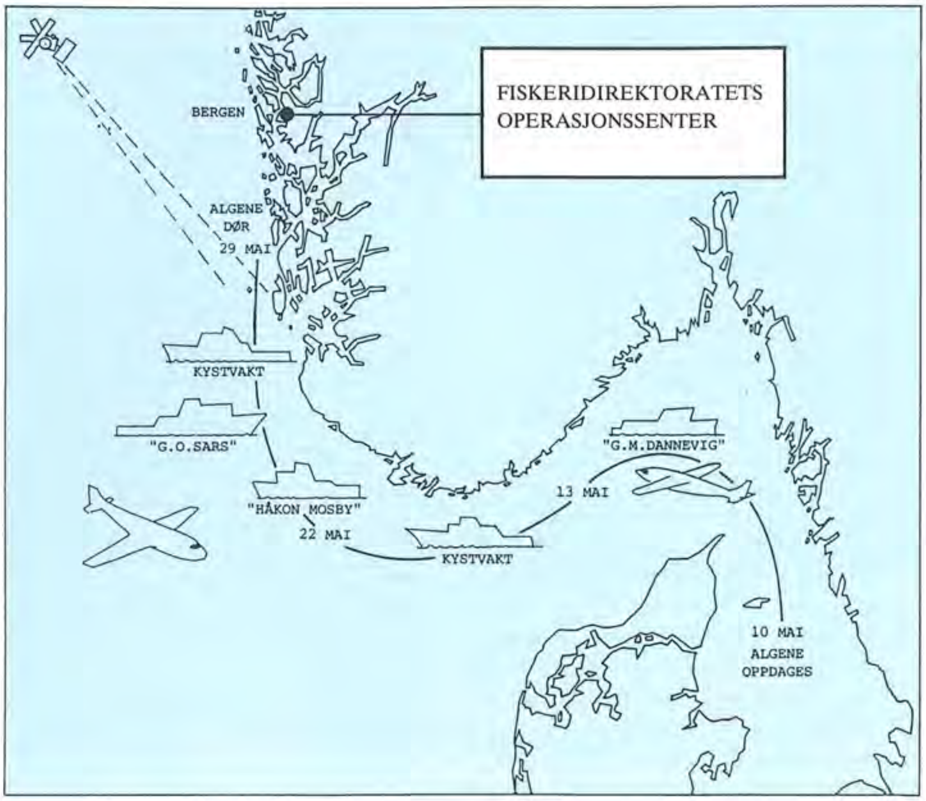
Massedød av alger inntrådte. I løpet av få dager døde milliarder av dem. Snart kunne den bare observeres i enkelte næringsrike lommer. Spillet var slutt!

HVA GJORDE HAVFORSKNINGS-INSTITUTTET

Algeinvasjonen våren 1988 kom overraskende. Den tilgjengelige kunnskap om algen var liten. Det var vanskelig å finne ut hvorfor dyr som kom i kontakt med algen døde. Tok man alger opp fra sjøen for å utforske deres biologi i laboratoriet, sprakk de som såpebobler.

Trass vanskene klarte en samarbeidsgruppe fra Havforskningsinstituttet, Universitetene i Oslo og Bergen og fra Nansensenteret ganske raskt i å finne en sikker måte å identifisere og telle algene på. Det ble også utviklet en formel for hvor

ALGEINVASJONEN DAG FOR DAG
Algene ble oppdaget utenfor Lysekil 10. mai. Deretter ble de fulgt fra skip, fly og satellitt inntil de rundt 29. mai bukket under for næringsmangel ved Karmøy. Algen gjorde stor skade på livet i havet fordi den drepte andre dyr og planter for å dekke sitt eget fosfatbehov.



stor algekonsentrasjon forskjellige fiskearter kunne tåle. Denne var avhengig av vannets saltholdighet. Jo ferskere vann, dess flere alger tålte fisken.

Denne informasjonen kom til nytte for den rådgivningsstab av oseanografer og biologer som Fiskeridirektoratet satte ned for å rettlede fiskeoppdretterne langs kysten.

Algene drev nemlig inn i Kyststrømmen som med stor hastighet sendte dem nordover mot kysten av Sør- og Vestlandet.

Algefrontenes posisjoner ble nå overvåket natt og dag fra forskningsfartøy, fly og satellitt. Det ble utarbeidet varsler for når og hvor algene ville innfinne seg langs hele den truete kystlinjen. Oppdrettere på utsatte steder ble varslet, og evakuering av truete lokaliteter ble satt i gang.

Oppdrettsfisken ble berget, men store deler av dyrelivet langs Sørlandets strandsone var midlertidig utradert. Kanskje mistet vi en hel årsklasse av kysttorsk!

HVEM ER SKYLDIG?

Gode kriminaldrama avsluttes med at den skyldige blir avslørt og straffet. Hvem var det som slapp *Chrysochromulina polylepis* løs i våre farvann? Forskerne er enig om at det var den unormalt store nitratmengden som ga flagellatene et fortrinn i livskampen. Dette kan skyldes unormal mild vinter 1987/88, ekstra kraftig utstrømning fra Østersjøen og økt avrenning av gjødselstoffer fra landbruk og industri. Det siste momentet er antakelig det viktigste.

I de siste årene har det skjedd en kraftig økning av næringsutslipp fra landene rundt Nordsjøen. Spesielt fra de land som ligger lengst syd. Dette har forskjøvet den naturlige likevekten mellom næringsstoffene der, slik at sjansen for nye ubalanserte kjempeoppblomstringer i fremtiden dessverre har økt. Kanskje ligger nytt ugress allerede i startgropen? Europas mennesker er altså hovedsynderne!

HVA NÅ?

Skal vi hindre at giftige algeoppblomstringer blir en årviss hendelse i fremtiden, trengs der en strengere håndhevelse av de gjeldende internasjonale miljølover. Om nødvendig må nye, bindende lover og regler mot utslipp utarbeides og vedtas. Havforskningsinstituttet er gjennom sine internasjonale kontakter engasjert i dette arbeidet.

Vi håper alle at situasjonen som oppsto i mai 1988 aldri gjentar seg. Skulle imidlertid så galt skje, er Havforskningsinstituttet klar til en ny intensiv overvåknings- og varslingsinnsats!

A.S JOHN GRIEG

Statsnail AS
Postboks 2
7159 BJUGN

Trondheim, 28.04.2017

Deres ref.:	Vår ref. (bes oppgitt ved svar):	Saksbehandler:
[Deres ref.]	2017/2407	Line Løvås

Avgjørelse i klagesak – Søknad om høsting av strandsnegl i Grandefjæra våtmarksreservat i Ørland kommune, Sør-Trøndelag

Miljødirektoratet opphever Fylkesmannen i Sør-Trøndelags vedtak av 30.01.2017. Høsting/plukking av strandsnegl er tillatt etter verneforskriften for Grandefjæra våtmarksreservat. Miljødirektoratet vil likevel anmode Statsnail AS om å avvente plukking av strandsnegl i Grandefjæra inntil de kjenner effekten av fjorårets høsting utenfor verneområdene, og ellers utøve stor varsomhet ved utøvelse av sin virksomhet i naturreservatet av hensyn til verneformålet og verneverdiene.

Miljødirektoratet viser til brev datert 16.02.2017 fra Statsnail AS. Brevet gjelder klage på Fylkesmannens vedtak av 30.01.2017 vedrørende avslag på søknad om høsting av strandsnegl i Grandefjæra naturreservat i Ørland kommune. Klagen ble oversendt fra Fylkesmannen i Sør-Trøndelag til direktoratet i brev av 13.03.2017. Viser også til øvrige dokumenter vedlagt søknaden og klagen, samt til deres brev datert 15.03.2017 hvor Statsnail AS kommenterer fylkesmannens oversendelsesbrev til direktoratet. Endelig vises til møte om saken den 05.04.2017, og utfyllende informasjon til klagen i denne sammenheng.

Bakgrunn
Statsnail AS startet med kommersiell høsting av strandsnegl i Sør-Trøndelag i 2016. Sneglene eksporteres som mat til Frankrike. I sin første sesong høstet bedriften strandsnegl i langgrunne fjæreområder langs kysten av Sør-Trøndelag. Nå ønsker bedriften å høste strandsnegl i verneområder med tilsvarende langgrunn fjære. Fylkesmannen og Statsnail AS hadde i løpet av høsten 2016 dialog vedrørende høsting av strandsnegler i verneområder i Sør-Trøndelag. Fylkesmannen mener at høsting av strandsnegler i verneområder er søknadspliktig, mens Statsnail AS mener at aktiviteten er å anse som fiske slik at det er direkte tillatt etter verneforskriften. Som følge av dialogen med fylkesmannen søkte Statsnail AS i brev av 04.01.2017 om å få høste strandsnegl i Grandefjæra naturreservat.

Søknaden
Statsnail AS anfører at høstingen utføres på en skånsom og miljøvennlig måte, og at aktiviteten ikke

forstyrrer fuglelivet i området. Høstingen foregår slik at fire personer skal snorkle/dykke i området og plukke strandsnegler for hånd i en egenutviklet plukkesele. Plukkingen skjer utenfor blæretangbeltet, på ca. 2 meters dybde, og de berører ikke havbunnen utover selve plukkingen. I møte med direktoratet den 05.04.2017 anslår bedriften at de vil plukke ca. 11 tonn strandsnegl i Grandefjæra naturreservat, men presiserer at dette kun er et anslag. Total mengde vil avhenge av hvor mye strandsnegl som finnes i området, samt størrelsen på dem. Bedriften opplyser at aktiviteten vil utføres ca. 6 timer pr. dag, ca. 2-3 timer før og etter maks. fjære. Hele strandområdet dekkes, de snorkler fram og tilbake langs stranda i den tiden de er der. Statsnail AS finner det vanskelig å anslå hvor lenge de vil være i Grandefjæra naturreservat, ettersom plukkingen vil utføres så lenge det er lønnsomt for dem. I klagen anslås at Grandefjæra er et område hvor man typisk vil kunne høste med fire mann i en periode på 3-4 måneder hvert år. Statsnail AS understreker at de er en miljøvennlig og ansvarsbevisst bedrift. Bedriften mener at virksomheten ikke vil forstyrre fuglelivet, og viser til at fuglene oppfatter dykkerne som ufarlige sjøpattedyr i vannet. De ønsker å ta hensyn til fuglelivet og vil derfor ikke starte høstingen før etter 15. juni. Statsnail AS peker på at strandsneglen har et enormt reproduksjonspotensiale, og mener at bestanden raskt vil komme tilbake til tilsvarende nivå som før de startet høstingen. De viser til at strandsnegl er en meget tallrik og vellykket art som tåler godt å bli høstet. Videre anføres at vesentlig, alvorlig eller irreversibel skade på strandsneglebestanden eller habitatet strandsneglen lever i vil være usannsynlig med omsøkte høstemetode. Bedriften skal tilbake på samme steder som de plukket forrige sesong, og er spente på om mengden strandsnegl er den samme i år som i fjor. De plukker kun store snegler, ca. 20-25 mm i diameter. Statsnail AS mener at disse ikke er viktig mat for fugl, da de er for store til å passere gjennom fordøyelseskanalen til fuglene, og skallet er for hardt til å knuses. Statsnail AS har gitt utfyllende informasjon om strandsneglenes økologi, og har lagt ved flere vitenskapelige artikler ved søknaden som underbygger deres argumentasjon. For nærmere beskrivelse vises til søknaden med vedlegg i sin helhet.

Fylkesmannens vedtak
Fylkesmannen avslo søknaden i vedtak av 30.01.2017. Fylkesmannen viser til at det er forbudt med aktiviteter som kan endre de naturgitte forhold, jf. kap. IV nr. 3 i verneforskriften for Grandefjæra naturreservat. I sin begrunnelse viser fylkesmannen til at høsting av strandsnegl som omsøkt vil være i strid med verneformålet for naturreservatet. Fylkesmannen mener at høsting av bløtdyr ikke var tema under verneprosessen, og at det derfor ikke kan likestilles med høsting av fisk i verneforskriften for Grandefjæra. Høsting av bløtdyr var ikke en aktivitet som eksisterte i området under verneprosessen på 1980-tallet, eller som man forventet skulle bli aktuell. Fylkesmannen opplyser at Grandefjæra naturreservat har en viktig funksjon for fuglelivet hele året, både under vår- og høsttrekket, men også som myte- og overvintringsområde. Fylkesmannen viser til at bakgrunnen for vern av Grandefjæra var, av hensyn til fuglelivet, å sikre et stort og sammenhengende fjære-/gruntvannsområde som er den viktigste delen av Ørland våtmarkssystem. Videre viser fylkesmannen til at Grandefjæra fikk status som Ramsar-område 24. juli 1985, og utgjør "Ørlandet våtmarkssystem" sammen med Krågvågsvaet fuglefredningsområde, Innstrandfjæra fuglefredningsområde og Hovsfjæra fuglefredningsområde. At området har fått Ramsarstatus innebærer at Norge internasjonalt har forpliktet seg til å ta spesielt vare på og beskytte leveområder for vannfugl, og forvalte områdene på bærekraftig vis. Fylkesmannen peker på at massiv høsting av strandsnegl neppe er noen trussel for arten strandsnegl, men at høstingen lokalt kan ha negative konsekvenser ved at det kan skapes endringer i fjærefaunaen og økosystemet i strandsonen. Fylkesmannen mener at det er svært lite sannsynlig at plukkingen ikke vil medføre

noen form for forstyrrelser, og mener at konsekvensene av en storstilt og systematisk høsting vil være sterkt negativt og klart i strid med vernet av Grandefjæra.

Klagen
Statsnail AS påklaget fylkesmannens vedtak i brev av 16.02.2017. Statsnail AS er uenig i fylkesmannens vurdering, og gjentar at de mener at plukking av strandsnegl er å anse som fiske som er direkte tillatt etter verneforskriften. I anledning klagen har bedriften innhentet en vurdering fra Fiskeridirektoratet om hva som er å anse som fiske etter fiskerilovgivningen. Det vises til brev av 02.02.2017 og 13.03.2017 fra Fiskeridirektoratet. Statsnail AS peker videre på at det også pågår annet fiske i Grandefjæra naturreservat, blant annet etter taskekrabbe, hummer og kongesnegl, i tillegg til fisk. Bedriften mener at verneforskriften ikke bare er begrenset til fiske etter fisk.

Forberedende klagesaksbehandling
Fylkesmannen i Sør-Trøndelag har ikke funnet grunn til å endre sin vurdering som følge av klagen fra Statsnail AS, og har sendt saken til Miljødirektoratet for endelig avgjørelse. Fylkesmannen ser at det kan være grunnlag for bærekraftig høsting av strandsnegl, ettersom strandsnegl er en vanlig forekommende art i Norge, men stiller spørsmål ved hvor dette bør tillates og i hvilket omfang. I og med at strandsnegl er en viktig del av økosystemet mener fylkesmannen at høsting av strandsnegl ikke bør forekomme i verneområder. Fylkesmannen mener at det bør finnes mange andre egnede høstelokaliteter utenfor verneområdene i Ørlandsområdet. Fylkesmannen fastholder at høsting av bløtdyr ikke var tema under verneprosessen, og at bestemmelsen i kap. V nr. 6 er relatert til fiske av fiskebestander.

Øvrige merknader og møte
Statsnail AS ga i brev av 15.03.2017 kommentarer til fylkesmannens forberedende klagesaksbehandling, og la også ved brev av 13.03.2017 fra Fiskeridirektoratet hvor Fiskeridirektoratet redegjør for at høsting av strandsnegl er omfattet av begrepet fiske etter fiskerilovgivningen. Kommentarene gjelder i hovedsak fylkesmannens tolkning av verneforskriften, og det framgår at Statsnail AS er sterkt uenig i denne vurderingen. For nærmere detaljer vises til brevet i sin helhet.

Statsnail AS ba om et møte med direktoratet før direktoratet behandlet klagen. I møte den 05.04.2017 deltok Jon Eirik Brennvall fra Statsnail AS, og Line Løvås og Egil Roll fra Miljødirektoratet. Statsnail AS presenterte sin virksomhet og ga utfyllende opplysninger til søknaden og klagen. Brennvall opplyste at sekkene med strandsnegl vil bli lagret i sjøen inntil de blir hentet en dag pr. uke, og transportert til et mottak i Åfjord. Dette skjer enten ved at sekkene bæres i land og losses på en varebil på nærmeste parkeringsplass, eller ved direkte lossing i båt. Brennvall gjentok at man er uenig i fylkesmannens tolking av verneforskriften, og understreket at bedriften driver sin virksomhet på miljøvennlig og bærekraftig vis. Bedriften opplyste at de dekket de fleste aktuelle områder utenfor verneområdene i Ørlands-området i fjor, og at de vil fortsette sin virksomhet i de samme områdene i år. I tillegg ønsker de å plukke i Grandefjæra naturreservat, fordi de vet at det er store forekomster av store strandsnegler der. Brennvall opplyste at de er spente på å se effekten av plukkingen de gjorde i fjor. I fjor var bedriftens første sesong, og sesongen i år vil gi svar på om forekomstene av strandsnegler er like god som i fjor og om sneglene er like store. Brennvall sa at de ikke kjenner langtidseffektene av høstingen, og årets sesong er derfor svært spennende for dem. Brennvall understreket at de ønsker samarbeid og god dialog med vernemyndigheten i forbindelse med sin virksomhet.

Rettslig grunnlag
Grandefjæra naturreservat ble vernet ved Kongelig resolusjon 23.desember 1983, se Forskrift om fredning for Grandefjæra våtmarksreservat, Ørland kommune, Sør-Trøndelag (heretter omtalt som verneforskriften). Formålet med fredningen er "å bevare et internasjonalt viktig våtmarksområde med vegetasjon, fugleliv og annet dyreliv som naturlig er knyttet til området", se punkt III i verneforskriften.

For reservatet gjelder at "All vegetasjon i vann og på land er fredet mot enhver form for skade og ødeleggelse", se punkt IV nr. 1. Videre angir punkt 2 i samme bestemmelse at "Alt vilt, inkludert sjøpattedyr, herunder deres hi, reir og egg fredet mot enhver form for skade, ødeleggelse og unødig forstyrrelse, jf. viltlovens § 3. Jakt, fangst, bruk av skytevåpen, samt slipp av hund er forbudt." I reservatet må det "ikke iverksettes tiltak som kan endre de naturgitte forhold", jf. punkt IV nr. 3. Bestemmelsen lister opp en rekke tiltak som eksempel på dette.

Verneforskriften angir at bestemmelsene i punkt IV ikke er til hinder for "fiske etter det til enhver tid gjeldende lovverk og forskrifter gitt i medhold av dette", se punkt V nr. 6. Denne bestemmelsen står sentralt ved vurderingen av denne saken.

Miljødirektoratet er klageinstans i saken, jf. forvaltningsloven § 28. Som klageinstans kan Miljødirektoratet prøve alle sider av saken, og herunder ta hensyn til nye omstendigheter. Direktoratet kan treffe nytt vedtak, eller oppheve vedtaket og sende saken tilbake til fylkesmannen til helt eller delvis ny behandling, jf. forvaltningsloven § 34. Klagen er framsatt innen klagefristen og tas til behandling, jf. forvaltningsloven § 29.

Miljødirektoratets vurdering
Klagen gjelder fortolkingen av punkt V nr. 6 i verneforskriften. Spørsmålet er om plukking av strandsnegl kan anses som fiske etter bestemmelsen i verneforskriften. Statsnail AS mener at plukking av strandsnegl er å anse som fiske som er direkte tillatt etter verneforskriften. Fylkesmannen i Sør-Trøndelag mener at plukking av strandsnegl ikke omfattes av denne bestemmelsen, og mener aktiviteten er i strid med verneformålet i reservatet.

Verneforskriften er bygd opp slik at den angir forskriftens virkeområde og formål, og har bestemmelser om hva som er forbudt i verneområdet, jf. punkt IV. Deretter gjør forskriften unntak for bestemte aktiviteter og tiltak som vil være direkte tillatt, jf. punkt V. Verneforskriften angir i punkt V at bestemmelsene i punkt IV ikke gjelder for virksomhet og aktiviteter som er nevnt i punkt V, jf. ordlyden "Bestemmelsene i punkt IV er ikke til hinder for…". Dette innebærer at det under verneprosessen er foretatt en interesseavveining mellom hensynet til vern og ønsker om bruk og tiltak, hvor man har kommet til at disse bestemte aktivitetene skal være direkte tillatt uavhengig av forbudene i punkt V. Fiske er således tillatt etter punkt V nr. 6.

Det sentrale vurderingstemaet i denne saken er om "fiske etter det til enhver tid gjeldende lovverk og forskrifter gitt i medhold av dette" i bestemmelsen i punkt V nr. 6 omfatter høsting/plukking av strandsnegl.

Fylkesmannen mener at man ikke kan sammenligne høsting av bløtdyr med høsting av fisk, idet høsting av bløtdyr ikke var noe tema i verneprosessen, mens høsting av fisk var det. Fylkesmannen viser til at høsting av strandsnegl ikke var en aktivitet som eksisterte i området på 1980-tallet når verneprosessen pågikk, og at man heller ikke forventet at det ville bli aktuelt i området på vernetidspunktet. Fylkesmannen viser til at det i utkastet til verneplan kun var snakk om fiskebestander og jaktbart vilt som var aktuelt på vernetidspunktet. Fylkesmannen mener at høsting av strandsnegl faller inn under forbudsbestemmelsen i punkt IV nr. 3, og dermed er søknadspliktig. Miljødirektoratet vil bemerke at ordlyden er det naturlige utgangspunktet for tolkingen av verneforskriften. Som det fremgår i Miljødirektoratets veileder M106-2014 Rundskriv om forvaltning av verneforskrifter (se s. 6), må rekkevidden eller betydningen av ord og uttrykk blant annet vurderes med bakgrunn i alminnelig forståelse og bruk av uttrykket på vernetidspunktet. Dersom ordlyden er uklar, kan forarbeidene til vernevedtaket ha betydning for tolkingen av ulike bestemmelser i verneforskrifter. Forarbeidene kan være viktige kilder om det faktiske grunnlaget for vernevedtaket og hvilke interessekonflikter som har vært vurdert.

Ofte er det slik fylkesmannen anfører, at man ved vurderingen av hva som menes med et begrep, et tiltak eller en aktivitet som reguleres i verneforskriften, legger til grunn den aktivitet eller virksomhet som eksisterte på vernetidspunktet. Fylkesmannen viser til at det i utkastet til verneplan fremgår at aktiviteten i området før vernevedtaket gjaldt fiskebestander og jaktbart vilt. Miljødirektoratet kan ikke se at dette er nærmere beskrevet eller spesifisert i Foredraget til kongelig resolusjon 23. desember 1984. Det fremgår imidlertid i de generelle kommentarene til verneplanen at Fiskerisjefen i Trøndelag har uttalt at "fredningsbestemmelsene ikke må være til hinder for yrkesfiskernes næringsvirksomhet", og at Miljødepartementet i sin kommentar til merknadene uttalte at "Departementet er enig i fylkesmannens positive vurdering av mulighetene til å gi dispensasjon for Teledirektoratet og yrkesfiskernes virksomhet". Særskilt for Grandefjæra naturreservat fremkommer det at Uthaug fiskarlag og Sør-Trøndelag fiskarlag i sine merknader til vernet uttalte at "fredningsbestemmelsene ikke må bli til hinder for motorbåttrafikk, fiske, tang- og tareskjæring", og Fiskerisjefen i Sør-Trøndelag anmodet om at fiskarlagenes synspunkter ble tatt hensyn til. Fylkesmannen og Miljøverndepartementet svarte ut det som gjaldt tang- og tareskjæring, men fiske ble ikke særskilt kommentert utover det som fremgår i de generelle merknadene til verneplanen, som referert til ovenfor. Resultatet ble verneforskriften som ble vedtatt 23.12.1984.

Miljødirektoratet mener at ordlyden i punkt V nr.6 er nokså klar, slik at den utfra en alminnelig forståelse og bruk av denne typen formuleringer, henviser til "fiske" slik det defineres i lovgivningen som regulerer fiske. Uten at det finnes klare holdepunkter for at "fiske" i verneforskriften skal begrenses til å omfatte kun fiske av fiskebestander, finner direktoratet det vanskelig å legge noen annen fortolkning til grunn enn den som følger av ordlyden. Fiskeridirektoratet har i brev av 13.03.2017 redegjort for at begrepet "fiske", etter både på vernetidspunktet gjeldende saltvannsfiskelov og någjeldende havressurslov, innbefatter høsting av strandsnegl. Dette innebærer at når forskriften åpner for "fiske etter det til enhver tid gjeldende lovverk", må også høsting av strandsnegl være tillatt.

Konklusjon
Statsnail AS må etter dette gis medhold i at høsting av strandsnegl er å anse som "fiske etter det til enhver tid gjeldende lovverk" i verneforskriften punkt V nr. 6, og dermed er tillatt i Grandefjæra naturreservat. Fylkesmannen har da ikke hjemmel for å nekte tiltaket gjennomført. Fylkesmannens vedtak må derfor oppheves

Miljødirektoratet vil understreke at vår avgjørelse kun gjelder plukking av strandsnegl i Grandefjæra naturreservat. Avgjørelsen innebærer ikke at aktiviteten er tillatt i alle verneområder. Hver verneforskrift er utformet konkret for sitt verneområde. Hvis Statsnail AS vurderer plukking av strandsnegl i andre verneområder, må det derfor vurderes ut fra hver enkelt verneforskrift. Dette må avklares med forvaltningsmyndigheten for verneområdet.

Selv om Statsnail AS nå har fått medhold i sin klage, vil Miljødirektoratet likevel henstille bedriften om å avvente utøvelse av sin virksomhet i Grandefjæra naturreservatet, eller i det minste utøve stor varsomhet. I likhet med fylkesmannen er direktoratet bekymret for påvirkningen som denne typen aktivitet vil kunne ha på verneverdiene. Direktoratet er enig i fylkesmannens vurderinger knyttet til forstyrrelse på fuglelivet, og er usikker på hvilken effekt høsting av strandsnegl som planlagt vil ha for fjærefaunaen og økosystemet i strandsonen. Statsnail AS har gitt en grundig søknad og klage, og har vist at de har god kunnskap om strandsnegl. Likevel har bedriften vært åpne på at de ikke kjenner effekten av et så stort uttak av snegler som de har foretatt, og at de er spente på hvordan tilstanden er i områdene de høstet fra i fjor. Statsnail AS ønsker å drive sin virksomhet på en bærekraftig måte, og direktoratet vil sterkt oppfordre Statsnail AS om å avvente høsting av strandsnegl innen Grandefjæra naturreservat inntil man har sett langtidseffekten av høsting av strandsnegl utenfor verneområdene. I denne sammenheng viser direktoratet til føre-var-hensynet i naturmangfoldloven § 9 og bestemmelsen i havressursloven § 7 hvor det fremgår at

> "Ved forvaltninga av dei viltlevande marine ressursane og det tilhøyrande genetiske materialet skal det leggjast vekt på
> a) ei føre-var-tilnærming i tråd med internasjonale avtalar og retningslinjer
> b) ei økosystembasert tilnærming som tek omsyn til leveområde og biologisk mangfald, …"

Av hensyn til verneverdiene vil direktoratet også oppfordre bedriften til å søke etter andre egnede høstelokaliteter utenfor verneområdene.

Dersom Statsnail AS velger å ikke følge direktoratets oppfordring og anbefaling, og likevel velger å plukke standsnegl i Grandefjæra naturreservat, håper direktoratet at bedriften kan søke å tilpasse virksomheten sin av hensyn til fuglene (f.eks. redusere antallet timer pr. dag, sammenhengende dager, eller total mengde). Dere må gjerne gå i dialog med forvaltningsmyndigheten vedrørende dette.

Vedtak
Klagen fra Statsnail AS tas til følge. Miljødirektoratet opphever Fylkesmannen i Sør-Trøndelag sitt vedtak av 30.01.2017, jf. forvaltningsloven § 34 fjerde ledd.

Miljødirektoratets vedtak er endelig, og kan ikke påklages, jf. forvaltningsloven § 28 tredje ledd.

Hilsen
Miljødirektoratet

Dette dokumentet er elektronisk godkjent og har derfor ingen signatur

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Ørland kommune	Boks 401	7129	Brekstad
Statens naturoppsyn	Postboks 5672 Sluppen	7485	TRONDHEIM

Hei!

Viser til tlf.

Sender som avtalt oversikt over fangst av skalldyr og bløtdyr i område 0725 i de siste 3 år + hittil i 2017.

Fangst av skalldyr/bløtdyr i 2014 -2015 - 2016 og hittil i 2017:

Rundvekt					
Radetiketter	**2014**	**2015**	**2016**	**2017**	**Totalsum**
0725 Frohavet/Lyngholmråsa/Kråkvågfjorden	626015,6	753516,7	837684,8	6477,1	2223694,2
HUMMER	390,3	379,9	363,4		1133,6
KAMSKJELL	1293		1418		2711
KONGESNEGL		212	3798	5260	9270
SJØKREPS	2123,3	1700,8	4972,9	1149,1	9946,1
TASKKR HAN	184824,5	220740,5	248544,5		654109,5
TASKKR HO	437384,5	530483,5	578588		1546456
OSKJELL				68	68

Mvh

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