ECOLOGY OF LÆSØ TRINDEL – A REEF IMPACTED BY EXTRACTION OF BOULDERS

NERI Technical Report no. 757 2009

NATIONAL ENVIRONMENTAL RESEARCH INSTITUTE
AARHUS UNIVERSITETY

ECOLOGY OF LÆSØ TRINDEL – A REEF IMPACTED BY EXTRACTION OF BOULDERS

NERI Technical Report no. 757 2009

Karsten Dahl[1]
Claus Stenberg[2]
Steffen Lundsteen[1]
Josianne Støttrup[2]
Per Dolmer[2]
Ole Secher Tendal[3]

[1] National Environmental Research Institute, Aarhus University
[2] National Institute of Aquatic Resources, Technical University of Denmark
[3] Zoological Museum, SNM, University of Copenhagen

NATIONAL ENVIRONMENTAL RESEARCH INSTITUTE
AARHUS UNIVERSITY

Data sheet

Series title and no.: NERI Technical Report No. 757

Title: Ecology of Læsø Trindel - A reef impacted by extraction of boulders

Authors: Karsten Dahl[1], Claus Stenberg[2], Steffen Lundsteen[1], Josianne Støttrup[2], Per Dolmer[2] & Ole Secher Tendal[3]

Departments: [1] National Environmental Research Institute, Aarhus University; [2] National Institute of Aquatic Resources, Technical University of Denmark; [3] Zoological Museum, SNM, University of Copenhagen

Publisher: National Environmental Research Institute ©
Aarhus University - Denmark

URL: http://www.neri.dk

Year of publication: December 2009

Editing completed: December 2009

Referee: Else Marie Stamphøj, Agency for Spatial and Environmental Planning

Financial support: The project is carried out with contribution from the LIFE financial instrument of the European Community and the Danish Forest and Nature Agency.

Please cite as: Dahl, K., Stenberg, C., Lundsteen, S., Støttrup, J., Dolmer, P., & Tendal, O.S. 2009: Ecology of Læsø Trindel - A reef impacted by extraction of boulders. National Environmental Research Institute, Aarhus University. 48 pp. - NERI Technical Report No. 757. http://www.dmu.dk/Pub/FR757.pdf

Abstract: The reef Læsø Trindel is subjected to a major restoration in the coming years rebuilding the reef as a cavernous stable reef. The baseline study presented in this report documented that the seaweed forest on the reef was dominated by relatively low macroalgal biomasses compared to reef areas with many large stable boulders. The algal vegetation was dominated by small perennial species and fast growing opportunistic species. Bryozoans living on the algal leaves made up the vast majority of the fauna biomasses. The fish community was dominated by species from the wrasse family with only few commercially interesting species present. Lobsters were not caught within the project area but in few numbers outside the area. Gammaridae were the most important pray species in both the goldsinny wrasse and cod. Acoustic tagging of cods proved the importance of the reef as a feeding ground during night time in June.

Keywords: Reef, Natura 2000 network, baseline study, seaweed forest, hard bottom fauna, biodiversity, acoustic fish tagging, fish pray, restoration

Layout: Anne van Acker

Drawings: The authors

Cover photo: Cuckoo wrasse (female). Photo: Karsten Dahl

ISBN: 978-87-7073-145-4

ISSN (electronic): 1600-0048

Number of pages: 48

Internet version: The report is available in electronic format (pdf) at NERI's website http://www.dmu.dk/Pub/FR757.pdf

Supplementary notes: The report documents the result of the baseline study done in 2007 as part of the EU Life project Blue Reef - Rebuilding of marine cavernous boulder reefs in Kattegat. The Blue Reef project is run by the Danish Forest and Nature Agency in collaboration with the National Environmental Research Institute/Aarhus University, the National Institute of Aquatic Resources/Technical University of Denmark and Agency for Spatial and Environmental Planning.

Contents

[Blank page]

Summary

The aim of the 'Blue Reef' project is to improve the quality of the reef habitat at Læsø Trindel. The reef is part of the Natura 2000 area Læsø Trindel and Tønneberg Banke. The report describes the results of the baseline investigation carried out in the area to document the present biological components at the reef.

221 different species were found at Læsø Trindel, which was considered as a relatively high biodiversity. The biomasses on benthic macro algal vegetation were on the other hand rather small compared to reef areas dominated by large stable boulders and with the same depth. The biomasses were dominated by small members of perennial species or fast-growing species.

The fauna biomass was small and dominated by bryozoans growing on the algal leaves. Newly settled blue mussels (*Mytilus edulis*) were numerous but made up a small fraction of the overall biomass in June. Large blue mussels were not observed at all. There was a good positive correlation between the fauna biomass and the algal biomass in the samples.

The fish community was dominated by species from the wrasse family, whereas commercial species like cod (*Gadus morhua*) were few. Lobsters were not caught within the planned restoration area but in few numbers just outside on the deeper parts of the reef. Juvenile cod tagged with small acoustic transmitters used the reef area during night time in June indicating that the reef area is an important habitat.

Blue mussels and gammaridae were often found in the stomachs of goldsinny wrasse (*Ctenolabrus rupestris*) in the autumn, indicating that they are important pray items for this fish species. Gammaridae were also numerous in cod stomachs but a range of other pray species were also common indicating a more opportunistic pray preference.

The investigation indicated that the restoration of the reef most likely will result in a more developed seaweed forest with higher biomasses of both algal and fauna species. Such improvements of the biological components will most likely also result in better living conditions for fish and shellfish.

The project is carried out with contribution from the LIFE financial instrument of the European Community.

Sammenfatning

'Blue Reef'-projektets formål er at genoprette naturkvaliteten på stenrevet Læsø Trindel. Revet er en del af Natura 2000-området Læsø Trindel og Tønneberg Banke. Denne rapport beskriver resultaterne af den biologiske basisundersøgelse, der er gennemført i området for at dokumentere de biologiske strukturer på revet.

Undersøgelsen viste, at der var en relativ høj biologisk diversitet på Læsø Trindel. I alt blev der registreret 221 forskellige arter på revet. Biomassen af fasthæftede alger var derimod lille i forhold til det, der kunne forventes på et rev bestående at store stabile sten. Algebiomassen bestod hovedsalig af mindre (unge) flerårige planter eller hurtigtvoksende planter, såkaldte opportunister. De enkelte større sten, der var på revet, var derimod bevokset med typiske flerårige alger med væsentlig større biomasser.

Bundfaunabiomassen var generelt lille og bestod primært af mosdyr, der sad fasthæftet til algeplanterne. Nyligt bundslåede blåmuslinger var hyppige, men udgjorde en lille del af biomasserne i juni. Større blåmuslinger blev slet ikke observeret i prøverne. Biomassen af bunddyr korrelerede med biomassen af makroalger i de indsamlede prøver, således at der var flere dyr til stede, når der var større og tættere algedækning.

Fiskefaunaen var domineret af arter fra læbefiskfamilien, hvorimod kommercielle arter som torsk var fåtallige. Det samme var gældende for hummere, som kun blev truffet i tejner uden for den del af revområdet, hvor genopretningen skal finde sted. Mærkning med akustiske mærker viste, at juvenile torsk i sommermånederne havde en tydelig døgnrytme – søgte ind på revet før solnedgang og opholdte sig på revet til solopgang. Dette indikerer, at revet er et vigtigt habitat for juvenile torsk.

Fødeundersøgelser viste, at blåmuslinger og tanglopper udgjorde en betydelig del af kosten for havkarusser (*Ctenolabrus rupestris*) i efteråret. Torsk spiste også mange tanglopper, men havde generelt et større indslag af forskellige fødeemner i maven. Dette tyder på, at torsken er mere opportunistisk i sit fødevalg.

Undersøgelsen indikerede, at naturgenopretningen af revet kan føre til en øgning af revets tangskov og dens tilhørende fauna. En sådan forbedring af de biologiske forhold vil også betyde bedre livsbetingelser for fisk og skaldyr generelt, men også for områdets egnethed som opvækstområde for kommercielt vigtige arter.

Undersøgelsen er udført med støtte fra det Europæiske Fællesskabs finansielle instrument 'Life'.

1 Introduction

1.1 Background

Offshore boulder reefs have a high biodiversity and represent a rare and biologically important reef type at the national and European level. Reef habitats are one of the few marine habitat types that are included in the EU Habitats Directive and for this reason 51 reef areas are included in the Danish Natura 2000 network. In Denmark boulder reefs in shallow waters have been extensively exploited habitats targeted for their high concentration of easy-to-collect large boulders for constructing sea defences and harbour jetties. This has destroyed an important habitat with a high biodiversity including cave dwelling species. A cautious estimate is that at least 34 km² of boulders from predominantly shallow cavernous reefs have been extracted from Danish waters (*Dahl et al. 2003*). The Danish National Monitoring Programme indicates that only 5 ha of the total cavernous reefs are left untouched.

The reef at Læsø Trindel within the Natura 2000 site Læsø Trindel and Tønneberg Banke in the Northern part of Kattegat (*figure 1.1*) is one of the shallow water reefs severely affected by extraction of boulders.

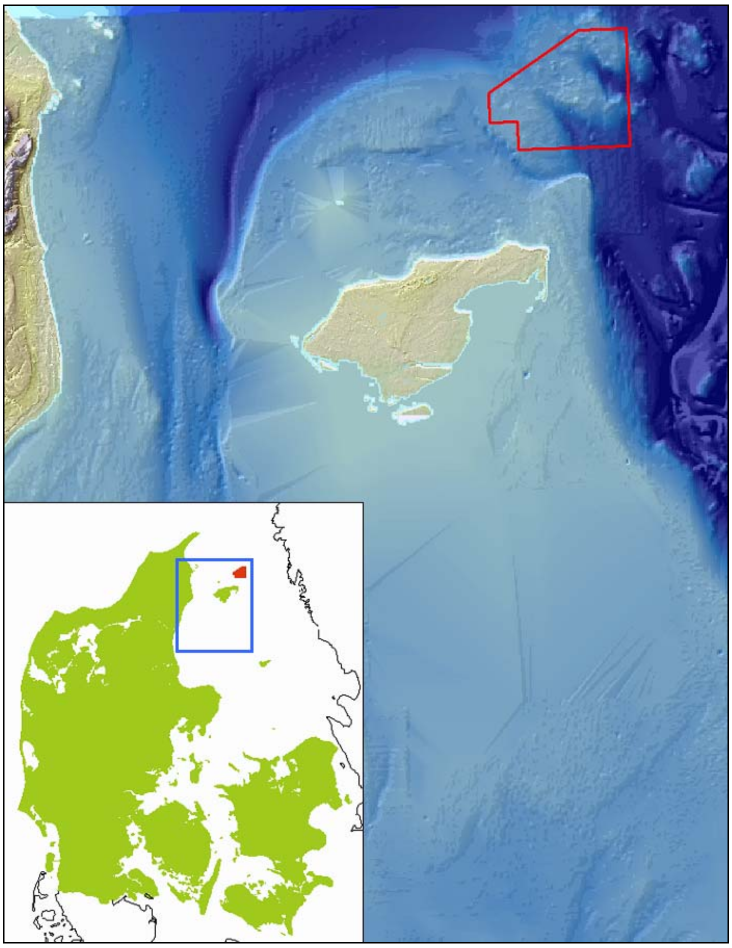


Figure 1.1. Location Læsø Trindel within the Natura 2000 site no. 168 'Læsø Trindel and Tønneberg Banke' in Kattegat. Map source GEUS.

The oldest available maps show that the water depth at Læsø Trindel was four feet equal to 1.25 m in the period from 1831 to 1911. In 1930 the first evidence exists of boulders removed from the reef top and later maps show a continuous increasing water depth at Læsø Trindel (*figure 1.2*) until approximately a depth of four m was reached in the 1970s.

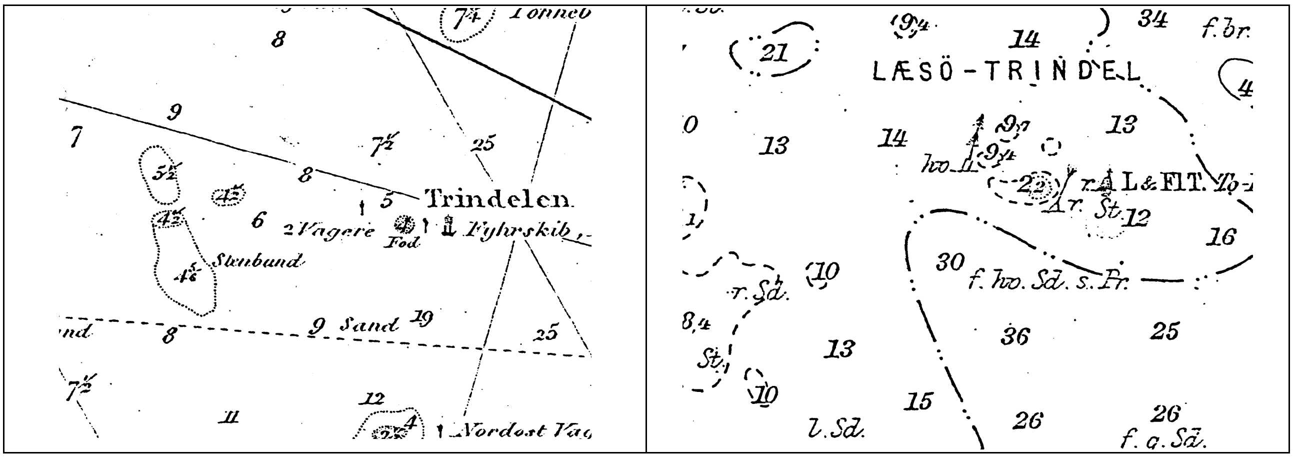


Figure 1.2. Old maps showing the water depth at Læsø Trindel. The left map is from 1831 showing that the top of the reef was just 4 feet (1.25 m) below the surface. The map to the right is from 1930 and at that time the top of the reef was 2.2 m below the surface.

Læsø Trindel was included as a monitoring site for macroalgal vegetation in the Danish National Marine Monitoring Program in 1991. The results of the monitoring clearly demonstrate that the present status of the reef is not satisfactory. The shallowest part of the reef is left with a vast majority of stones in the size class from 10-20 cm, and the biological components with dominance of opportunistic species indicate a fast turnover rate which is not common at other reefs with the same depth distribution and exposure. A continuous breakdown of the reef is indicated by yearly findings of larger algal species still anchored to stones that have tumbled down the reef slope to rest at 18 m's water depth at the foot of the reef (*figure 1.3*). The reef is obviously not in a stable condition due to the high physical stress caused by waves on this open water location compared to the relatively small size of stones left on the reef.

Figure 1.3. Laminaria plants anchored to small stones and transported to deep water at the foot of Læsø Trindel.
Photo: K. Dahl.

1.2 Aim

The 'Blue Reef' monitoring programme uses a 'BEFORE - AFTER' approach with monitoring activities before and after the restoration of the boulder reef. The report presents work from the baseline study programme of a selected number of key variables describing the overall quality of a reef habitat at Læsø Trindel today before the restoration projects began. In 2011 the area will be revisited using the same methodology and sampling programme.

To document the ecology and biodiversity status of Læsø Trindel in 2007, the following sampling was applied:

- On site diver surveillance to document physical stability and structure of the reef. This is a key indicator for assessing physical stability and structure of the reef.
- Suction sampling to collect fauna and flora specimens in order to estimate biomass, abundance and species diversity of bottom fauna and flora per m^2 on/over stable and unstable hard substrate. This is a key indicator for documenting the development of the biological community and provides a quantitative and qualitative estimate of biological diversity, which enables an evaluation of the biological structure and function of the restored reef area. It also provides data for comparison with the fish stomach analysis and documents the expected gain in physical and biological structure and function of the restored boulder reef.
- Fishing with scientific multi-meshed gillnet, supplemented with fish traps, to collect fish fauna. The gillnet consists of different mesh sizes ensuring unbiased fish catches of round and flatfish in a large size range. This provides information on the length distribution of fish species, fish biodiversity and their relative abundance and distribution.
- Fishing with lobster traps to sample European lobster (*Homarus gammarus*) and Brown crab (*Cancer pagurus*) to estimate abundance and distribution of these species. The population of European lobster was monitored as a key biodiversity indicator for species of cavernous reefs. It will also be used as a socio-economic indicator for the potential effect of restored reef areas for shellfish fisheries.
- In order to quantify the change in food-web dynamics, i.e. closer link between prey availability and food ingested by resident species, stomach content analyses were conducted on cod (*Gadus morhua*) and goldsinny wrasse (*Ctenolabrus rupestris*).
- Behaviour and migration studies of Atlantic cod (*Gadus morhua*) and European lobster by tagging with conventional t-bar tags and acoustic telemetry tags.

2 Material and methods

2.1 Physical environment

Data on the average salinity is available from nearby hydrographic sampling stations stored in the Danish national marine monitoring database MADS at the National Environmental Research Institute (NERI), Aarhus University. Furthermore, profiles of water column temperature, salinity and density (CTD) were carried out on transects intersecting the Læsø Trindel on surveys in April, June and October 2007.

Data on bathymetry were available from the Geological Survey of Denmark and Greenland (GEUS). In 2005 GEUS surveyed the area using a multibeam echo-sounder.

2.2 Sampling of macrophytes and benthic fauna

Sampling on the seabed for biomasses of macroalgae and benthic fauna and abundance of benthic fauna was conducted in the period from 29 June to 4 July 2007. The sampling was done using a suction sampler mounted with a 1 mm filter system operated by divers (*figure 2.1*).

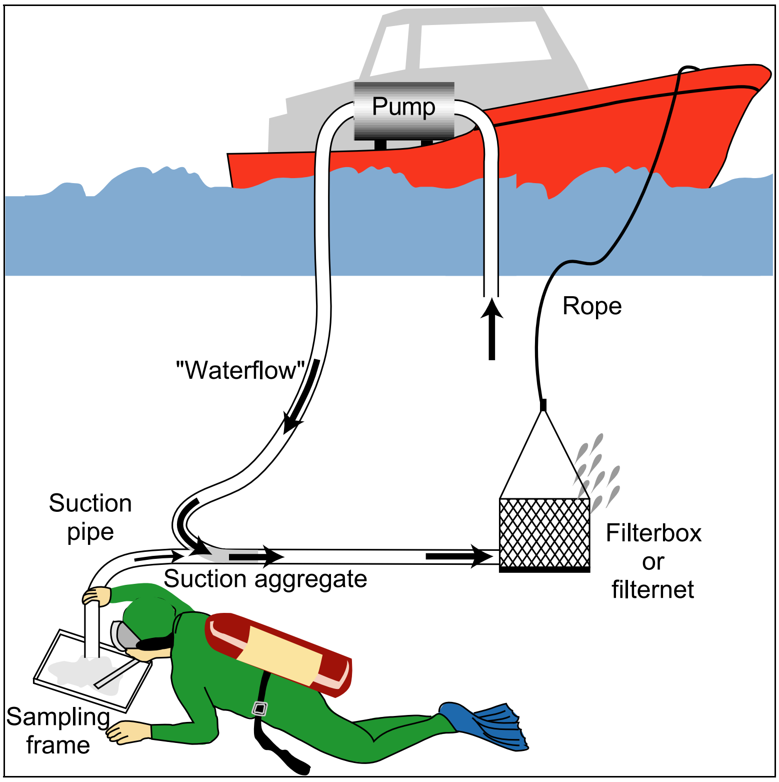


Figure 2.1. Suction sampling. The filter is either a box with 1 mm stainless mesh size used for sampling sand, gravel and small stones or a net made of plastic with the same mesh size used for sampling macroalgal vegetation and fauna scraped off from larger stones and boulders. Drawing by Britta Munter.

All samples were taken within areas where the restoration with boulders are planned to take place. Eight samples were taken at the western part of the reef at a depth of 9.6-9.9 m distributed on three anchor places. Six samples were taken at the middle part at a depth of 9.4-9.6 m distributed on two anchor places and 14 samples were taken near the eastern top of the reef at a depth of 5-6.2 m distributed on four anchor places. Information on the different samples is given in *table 2.1* and the geographic distribution is shown in *figure 2.2*.

Table 2.1. Sampling locations, positions and water depths at Læsø Trindel

Location	Anchor place	Position WGS-84		Station	Depth (m)
		Longitude	Latitude		
West	V1	5725.6638	1114.119	V1-1	9.9
				V1-2	9.9
	V2	5725.663	1114.1022	V2-1	9.8
				V2-2	9.8
				V2-3	9.8
	V3	5725.6819	1114.1648	V3-1	9.6
				V3-2	9.6
				V3-3	9.6
Mid	M1	5725.723	1114.53	M1-1	9.6
				M1-2	9.6
	M3	5725.6823	1114.443	M3-1	9.4
				M3-2	9.4
				M3-3	9.4
				M3-4	9.4
East	B1	5725.7245	1114.7425	B1-1	5.5
				B1-2	5.5
				B1-3	5.5
	B2	5725.679	1114.759	B2-1	5.9
				B2-2	5.4
				B2-3	5.5
				B2-4	5.2
	B3	5725.61	1114.761	B3-1	5
				B3-2	5
				B3-3	5.3
				B3-4	5.4
	B4	5725.7474	1114.7356	B4-1	6
				B4-2	6
				B4-3	6.2

The sampling was planned to focus on the seabed surface expected to be dominated by gravel/boulders, but at some sampling stations gravel was almost or totally missing and the seabed was dominated by rough sandy sediment. In those cases suction sampling included the upper few cm of the seabed.

Sampling took place within 0.1 m^2 frames dropped arbitrarily on the seabed on instructions by the dive operator while the diver was swimming over the seabed. Stones too big for the suction pipe (diameter ≥ 10 cm) were collected by hand and stored in the filterbox when suction was completed.

The samples were preserved in 4% formaldehyde buffered with borax.

In the laboratory the collected samples were sorted in five different fractions for further analysis and quantification: 1) large brown algal species,

2) other algal species, 3) smaller mobile animals from sediment and algae 1 mm - 1 cm, 4) large mobile animals > 1 cm, and 5) stones.

A subsample of 25% of the total weight of the moist sandy sediment was taken. Free living or loosely attached animals were collected in a 1 mm mesh.

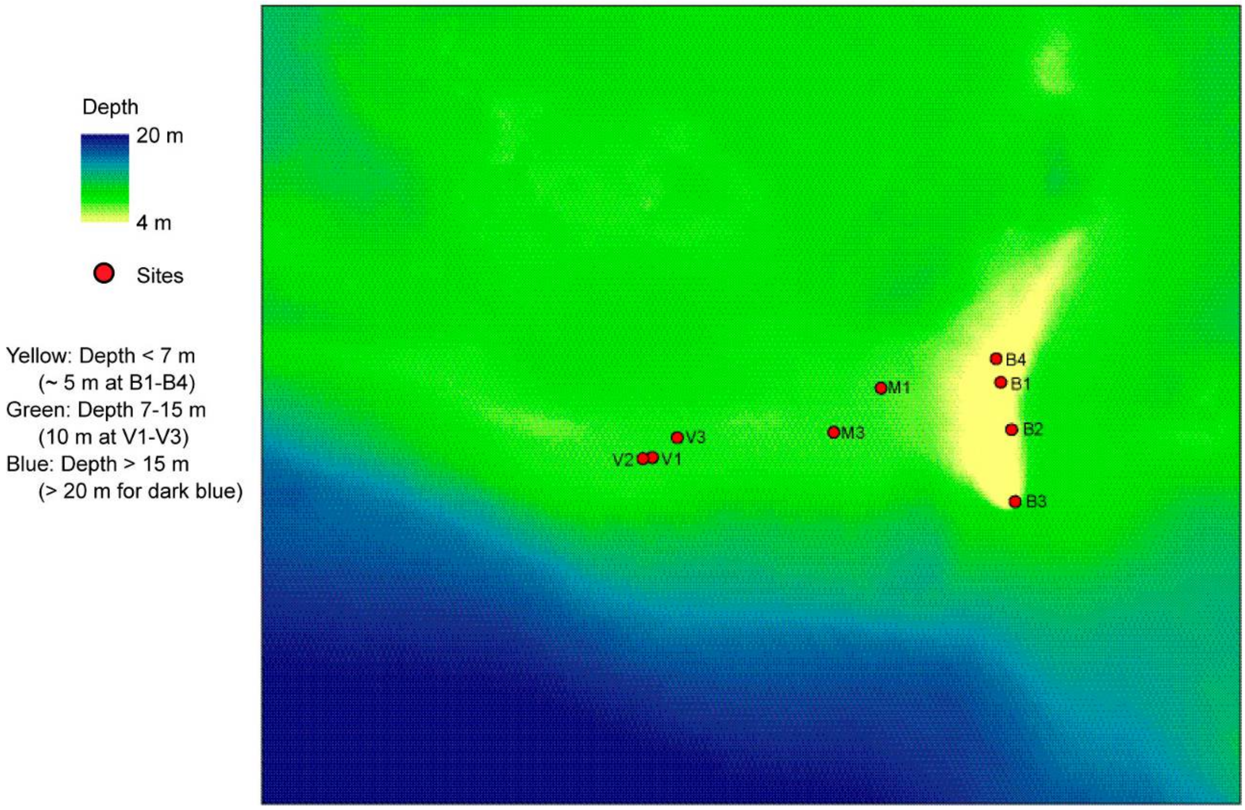


Figure 2.2. Bathymetry of Læsø Trindel and the surrounding seabed including suction sampling stations at Læsø Trindel. The map is based on multibeam data collected by GEUS.

1) Large brown algal plants were cut in pieces with a scissor, mixed and a subsample of 25% of the total wet weight was taken. In this process *Laminaria* holdfasts were also represented with 25% in the subsample. Epiphytic erect algal and animal species were identified and total ash-free dry weight of each species or higher taxonomic group in the subsample was measured with 0.0001 g accuracy. Free living or loosely attached animals were collected in a 1 mm mesh.

2) Small algal individuals were torn in smaller pieces, mixed and a subsample of 25% of the wet weight was taken. Algae and sessile animal species were identified and total ash-free dry weight of each species or higher taxonomic group in the subsample was measured with 0.0001 g accuracy. Free living or loosely attached animals were collected in a 1 mm mesh.

3) All free living or loosely attached animals identified from the sediment and algae were identified to taxa or as close to taxa level as possible. Abundance of each species or higher taxonomic group was counted and total ash-free dry weight of each species or higher taxonomic group in the subsample was measured with 0.0001 g accuracy.

4) All large mobile animals were identified to taxa or as close to taxa level as possible. Abundance of each species or higher taxonomic group was counted and total ash-free dry weight of each species or higher taxonomic group in the subsample was measured with 0.0001 g accuracy.

5) A subsample of 250 cm^2 surface area of the collected stones from each sample were studied using stereo microscope for identification of encrusting and tiny species generally not present in the other fractions. If stones were few, all available area was investigated. Species identified on stones were mainly used to give a fulfilling picture of the species diversity and were not included in the quantification of biomasses and species abundance.

To estimate the ash-free dry weight each species specific sample was first dried in an oven at 105 degrees Celsius for 24 hours, and then weight measured. Afterwards, the sample was burned at 505 degrees Celsius for 12 hours and the ash-free dry weight was calculated by subtracting the ash weight from the dry weight.

The total area of the two Bryozoan species *Electra pilosa* and *Membranipora membranacea* covering the algal vegetation was estimated. An area/ash-free dry weight ratio of 0.0020/cm^2 was estimated based on four subsamples. Weights of the two Bryozoan species were then estimated based on area covered in the samples. The estimated weight of the two Bryozoan species was then subtracted from the red and brown algal species on which they were growing.

In some cases selected species have been kept preserved and added to a species collection at NERI as reference material. In those cases their weights have been added up or estimated from specimens of similar size.

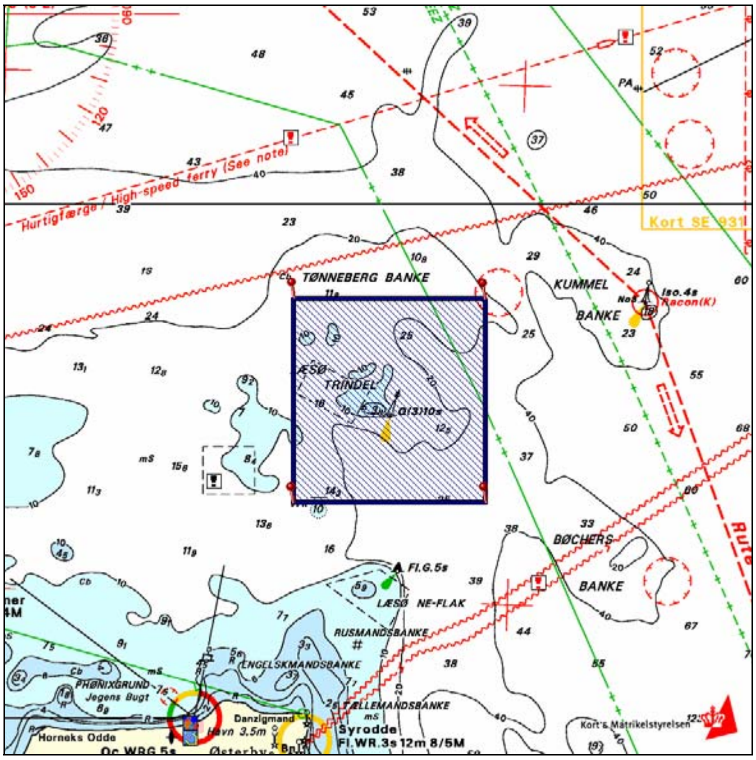
Ash-free dry weight and abundance of species were adjusted to 1 m^2 seabed.

2.3 Sampling of fish and shellfish fauna

Sampling of fish and shellfish was conducted from April to October 2007 but most intensive in the period 15 to 30 June.

The sampling design included a large area of 4 x 4 nautical mile around Læsø Trindel (*figure 2.3*) (outside the main Blue Reef project area) and a small area of the central Læsø Trindel. The small area was subdivided into a western area (A) with a depth of 6-10 m, a central area (B) with a depth of < 6 m and an eastern area (C) with a depth of 6-10 m (*figure 2.4*).

Figure 2.3. The 4 x 4 nautical mile area at Læsø Trindel. Area limits were N 57°27.800 - 57°23.800; E 011°18.800 - 011°11.400.



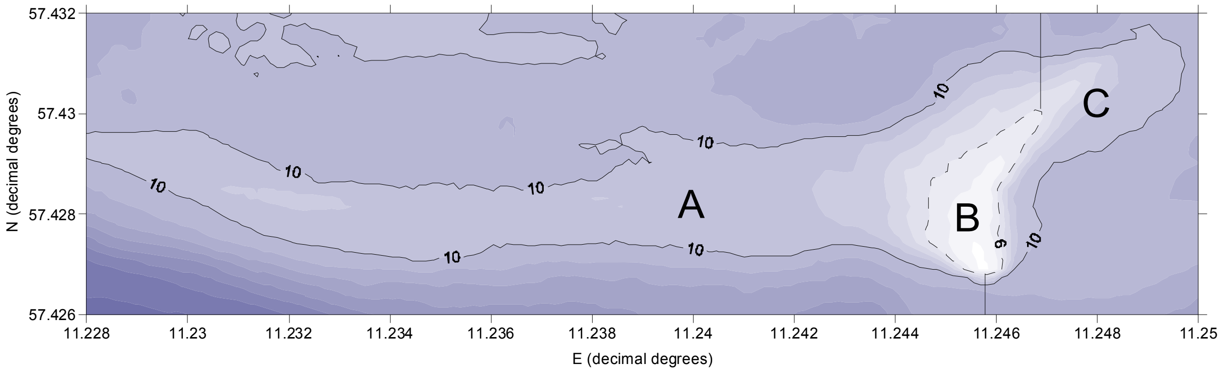


Figure 2.4. Area and depth stratification of central Læsø Trindel to the areas A (6-10 m), B (< 6 m) and C (6-10 m).

Distribution and abundance of fish were studied in two surveys in the periods 22-27 April and 15-30 June 2007.

The surveys were conducted from local fishing vessels in co-operation with local fishermen and from DTU Aqua's research vessel 'Havkatten'. In April, the large sized fish fauna with focus on adult cod (*Gadus morhua*) was assessed using single-meshed gillnets. A total of 23 stations were visited in the 4 x 4 nm area. In June, juvenile and adult fish fauna in general were assessed using multi-meshed gillnets and fish traps in the central Læsø Trindel area. A total of 12 stations were fished with the multi-meshed gillnets and 21 stations with fish traps.

The single meshed gillnet used in April was 70 mm and the multi-meshed gillnets used in June were 11, 14, 19, 24, 31, 41, 53 and 70 mm mesh size. Height was 1.5 m and length of 11, 14, 19, 24, 31, 41 mm nets 6 m, 53 mm net 12 m and 70 mm 52 m. Multi-meshed gillnets were combined at random and had a 1.8 m window between each mesh size panel.

Two types of fish traps were used: one with a mesh size of 8 mm, height of 65 cm and a 6 m lead (small mesh size trap), and one with a mesh size of 18 mm, height of 42 cm and a 6.5 m lead.

Gillnets were deployed in the afternoon and retrieved the following morning (fishing time ~ 12 hours) while fish traps were deployed in the afternoon and fished for 2 days (fishing time ~ 48 hours).

Catch was identified to species and total length of each fish measured to nearest 0.5 cm below and weighed.

Figure 2.5. Local fisherman Jørgen Rulle is retrieving a fish trap during the June survey. Photo: Claus Stenberg.

Distribution and abundance of lobster (*Homarus gammarus*) and brown crab (*Cancer pagurus*) were assessed in the 4 x 4 nm area in May, July and September in co-operation with a local fisherman. A total of 163 stations were fished with baited (salted flounder) lobster/ crab traps.

The traps were the Scottish type lobster/crab trap with the dimensions 66 x 47 x 42 cm (*figure 2.6*).

Catch was identified to species, for lobster the thorax length and for crab the total width measured to nearest 0.5 cm below.

Figure 2.6. ‘Scottish type’ lobster/crab trap with dimensions 66 x 47 x 42 cm.
Photo: Claus Stenberg.

A feeding ecology study of two dominant fish species was scheduled to take place during the June survey but was cancelled due to bad weather. In order to fulfil the planned program, a new survey was set up and carried out from 23-25 October in co-operation with a local fisherman. Multi-meshed gillnets were set at the same stations that were studied for abundance and biomass of benthic fauna (‘Area B’ and ‘Area V-M’). Gillnets were deployed just before sunset and retrieved at sunrise. Cod and goldsinny wrasse (*Ctenolabrus rupestris*) were quickly sampled and put on ice to prevent stomach decomposition. Within 4 hours samples were frozen to minus 18^{o} C. In the laboratory fish were defrosted, length measured and wet weighed. The liver was removed and wet weighed. The gut (in cod defined as the digestive to the pylorus sacs, while for goldsinny wrasse defined as the entire digestive tract) was removed and conserved in 70% ethanol. Eviscerated fish and liver was dried at 60^{o} C for 72 hours and reweighed. Gut contents were examined under a binocular microscope and dietary items were identified to the lowest taxonomic group possible. Each dietary item for each individual was recorded and measured for total or partial length in an image analyzing system. Abundance of prey items in guts were cross correlated to available food items obtained by the benthic fauna sampling conducted in June to analyze feeding ecology and food web dynamics of the two species.

Behaviour and migration of dominant species were studied by catching fish and lobsters in traps and releasing them with conventional and acoustic telemetry tags. Conventional t-bar tags were used to tag 88 cod and 325 corkwing wrasses (*Symphodus melops*) in June. Acoustic coded tags (Type: Thelma LP9) were implanted in 17 cod and placed on 10 lobsters. 10 receivers (Type: Vemco VR2) were deployed in a grid covering the Læsø Trindel to detect the acoustic signals. Data were downloaded from receivers on 18 December 2007 and 3-4 June 2008.

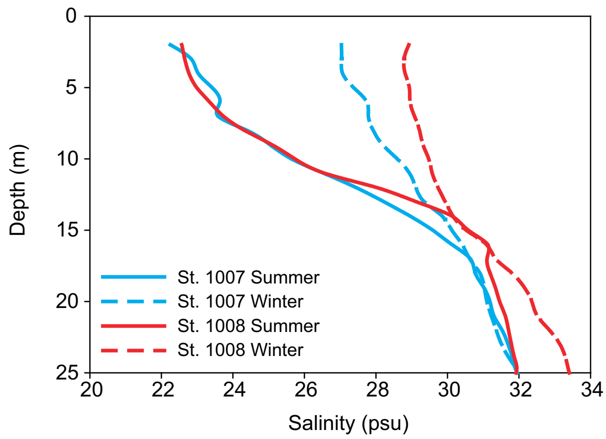
Figure 2.7. Acoustic tags are being implanted in cod (left picture) and attached to the claw of European lobster (right picture - see arrow). Photos: Claus Stenberg.

3 Results

3.1 Hydrographical conditions at Læsø Trindel

The average summer (June-September) and winter (November-February) salinities from the two nearby hydrographical monitoring stations 1007 and 1008 sampled as part of the Danish National Monitoring Programme are shown in *figure 3.1*. At a water depth of 6 m, the salinity varies from a summer average of around 23.5 psu to a winter average of approximately 28-29 psu. At 9 m's depth, the variation between summer and winter salinity is still pronounced. CTD profiles on the West-East transect intersecting Læsø Trindel also showed a depth gradient in temperature and salinity. At the surface, the temperature was 16-18 degrees and salinity 19 psu. At 10 m's depth, the temperature fell to 14-15 degrees and salinity increased to 30 psu. Surface water masses at the western part of the transect were 1-2° C warmer compared to the eastern part but otherwise water masses were relatively uniform across Læsø Trindel (*figure 3.2*).

Figure 3.1. Average summer and winter salinity profiles at the hydrographical station 1007 and 1008 sampled as part of the Danish national marine monitoring programme. The values are calculated based on a yearly sampling programme over 15 years from 1998.



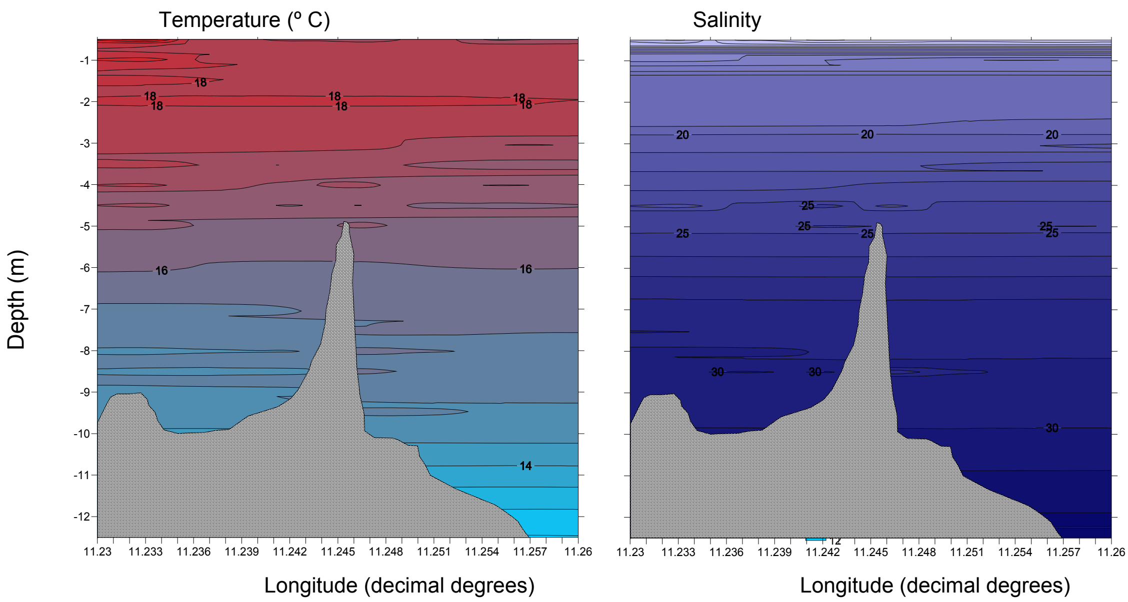


Figure 3.2. Temperature and salinity contour plots at the transect intersection Læsø Trindel obtained from CTD profiles on 20 June 2007.

3.2 Biological diversity

221 taxonomic distinct taxa were identified on parts of the reef where nature restoration is intended to take place. The majority of those taxa were identified to species level. Most taxa were found on the shallow part of the reef but 23% of the taxa were only identified on the deep stations at the middle and western part of the reef area (*table 3.1* and *figure 3.3*).

The species diversity in each of the samples collected by suction sampling was highly variable on the deep stations in the western and middle parts of the reef ranging from 60 distinct taxa per 0.1 m^2 to just 3. Half of the samples showed less than 10 taxa per 0.1 m^2. On the shallow stations the diversity ranged from 35 to 63 distinct taxa per m^2 and in half the samples between 50 and 57 taxa were identified (*Appendix 1*).

Table 3.1. Total number of identified distinct taxa from different taxonomic groups identified from the deep stations at the western and middle part of Læsø Trindel (M-V), the shallow stations (B) and in total for all sampling stations. Fauna taxa are separated in two groups: one representing strictly sessile living forms and the other representing organism with some motility (errant and sedentary forms).

	Living form	Taxonomic group	B	M-V	Total
Fauna	Sessile	Bryozoa	16	9	20
		Entoprocta	2	0	2
		Hydrozoa	14	7	15
		Porifera	1	1	1
	Motile	Bivalvia	6	6	10
		Cephalochordata	0	1	1
		Coelentarata	0	1	1
		Crustacea	23	24	30
		Echinodermata	2	2	3
		Gastropoda	8	8	13
		Nematoda	1	1	1
		Nemertea	1	1	1
		Oligochaeta	1	0	1
		Osteichthyes	28	29	34
		Polychaeta	18	19	29
		Polyplachophora	1	0	1
		Pycnogonida	0	1	1
Macrophytes		Chlorophyta	4	2	4
		Phaeophyta	13	11	15
		Rhodophyta	32	29	38
Total number			171	152	221

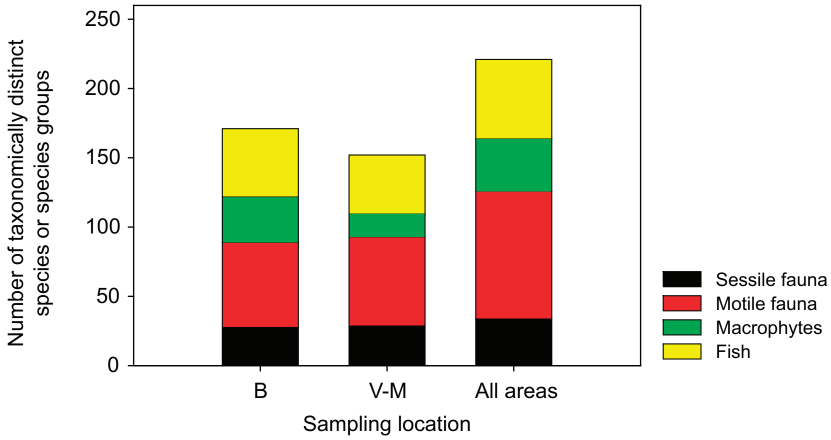


Figure 3.3. Total number of macroalgae, fish, sessile and motile fauna species per m^2 identified at the deep stations at the western and middle part of Læsø Trindel (V-M), at the shallow stations (B) and in total for all sampling stations.

3.3 Biomass and abundance of flora and fauna

3.3.1 Biomass

The group of red algae (Rhodophyta) and brown algae (Phaeophyta) made up the vast majority of the biomass at Læsø Trindel (*figure 3.4*). A complete list of biomasses distributed according to species for each sample is given in *Appendix 1*.

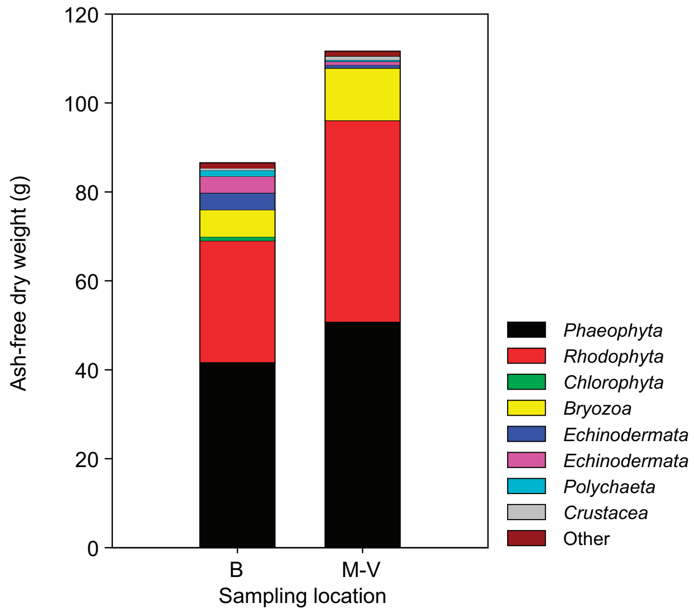


Figure 3.4. Average ash-free biomasses per m^2 sampled by suction-sampler at the two planned constructions at a depth of 9-10 m (M-V) and near the top of the present reef at a depth of approximately 5-6 m (B).

Opportunistic species like *Chorda filum* (*figure 3.5*), *Ectocarpus silicuosa* (*figure 3.6*) and fast growing epiphytic species like *Ceramium virgatum* and *Polysiphonia stricta* made up most of the biomass on the shallow stations. Juvenile *Laminaria* species were also present frequently. In some frames where one or a few large stable stones were present, large specimens of *Laminaria digitata/hyperborea* and *Desmarestia alata* were found together with other typical perennial species like *Delesseria sanguinea*, *Phyllophora pseudoceranoides* and *Ahnfeltia plicata*.

Figure 3.5. *Chorda filum* growing at Læsø Trindel at 6 m's depth. Photo: Karsten Dahl.

Figure 3.6. *Ectocarpus siliquosa* growing epiphytic on *Desmarestia aculeata* on smaller stones at Læsø Trindel 6 m's depth. Photo: Karsten Dahl.

Four of the investigated frames at the western part of the reef and three at the middle part of the reef were without any vegetation due to lack of suitable substrate and two more were nearly empty as well. The other samples all included vegetation and in two cases with high biomass due to presence of large stable boulders as substrate. In general, if vegetation was present at 9-10 m's depth, then it was almost without typical opportunistic species. In frames with good substrate conditions, species like *Desmarestia viridis*, *Desmarestia aculeata*, *Laminaria digitata/hyperborea*, *Laminaria saccharina*, *Phycodrys rubens*, *Phylophora pseudoceranoides*, *Delesseria sanguinea* and *Rhodomela confervoides* made up the vast majority of the algal biomass together with a small number of *Polysiphonia* species growing as epiphytes on other red algal species. *Figure 3.7* shows a typical community on a large boulder at a depth of 9.5 m at Læsø Trindel.

Figure 3.7. Large boulder with high biomasses of macroalgae. The species assemblage consists of *Laminaria digitata*/hyperborea, *Dilsea carnosa* (which was not sampled with the frames), *Delesseria sanguinea* and *Brongniatella byssoides*. The Bryozoan *Electra pilosa* covers large parts of the *Laminaria* and *Delesseria* leaves. Photo: Karsten Dahl.

Bryozoans dominated by *Electra pilosa* living epiphytic on the vegetation were the dominating fauna organism. High numbers of newly settled *Mytilus edulis* were present at all shallow stations (B), but due to their small size the biomass was low. The presence of starfish (*Asteriea rubens*) with higher biomass than *Mytilus edulis* at the same stations indicates that the presence of this mussel at the reef this summer was probably only for a short time.

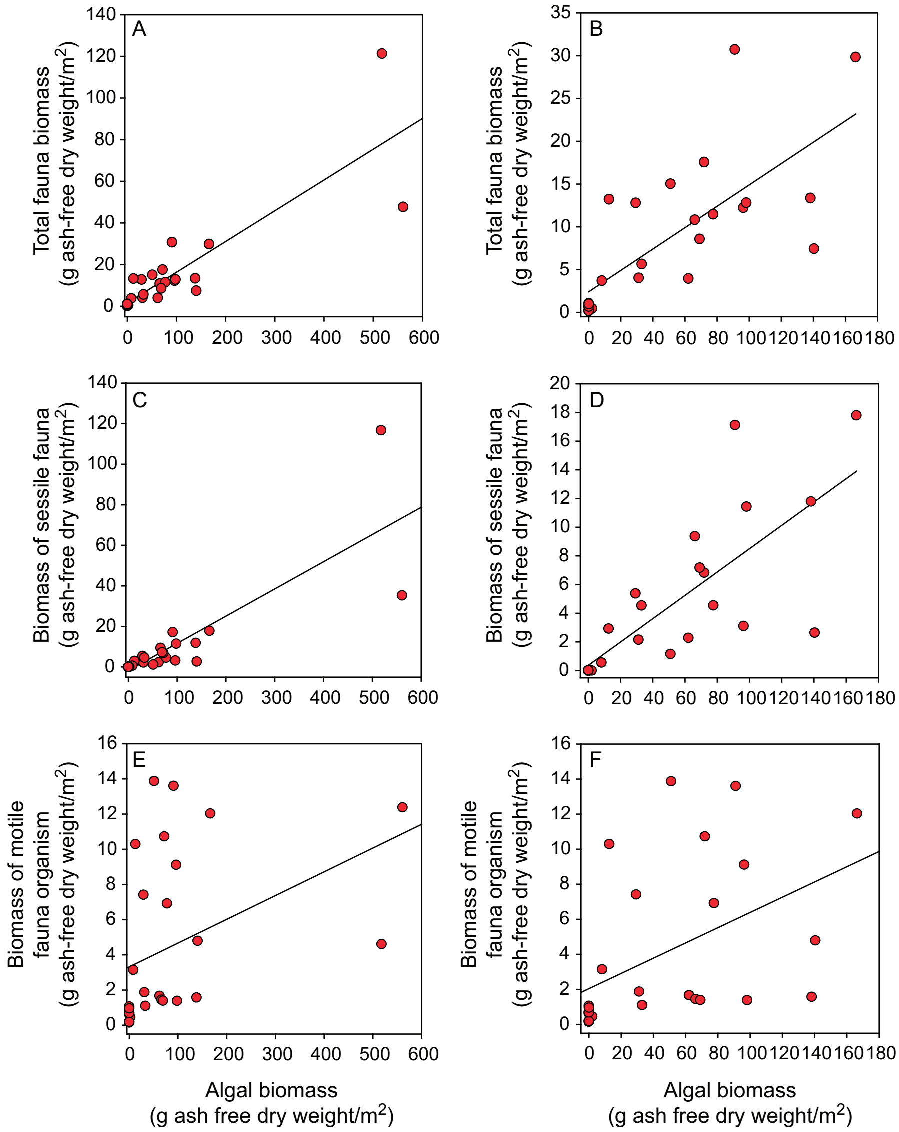
The Hydrozoans *Obelia geniculata* (*figure 3.8*) and *Obelia longissima* and Nematoda were also most often found at all shallow stations but more rarely at the deeper 9-10 m stations.

Figure 3.8. *Obelia geniculata* growing on Laminaria leaves at the nearby bubbling reef. Photo: Karsten Dahl.

Several fauna organisms registered at 9-10 m's depth, such as the Polychaete *Pisione remota,* belong to infauna communities. This is also the case for the species *Branchiostoma lanceolatum*, a very primitive fish that is typically found in rather course sand in the Kattegat. This species was identified from two rather close samples at 9-10 m's depth at the middle part of the reef.

There was good correlation between total fauna biomasses and macroalgal biomasses ($r^2 = 0.73$). Excluding the two samples with very high algal biomasses did not change the positive relationship ($r^2 = 0.55$) (*figure 3.9A* and *B*). Sessile fauna organisms or colonies showed, not surprisingly, a better correlation to algal biomasses (*figures 3.9C*, corr. = 0.68, and *3.9D*, corr. = 0.61) than mobile organisms (*figures 3.9E* and *3.9F*, corr. < 0.25).

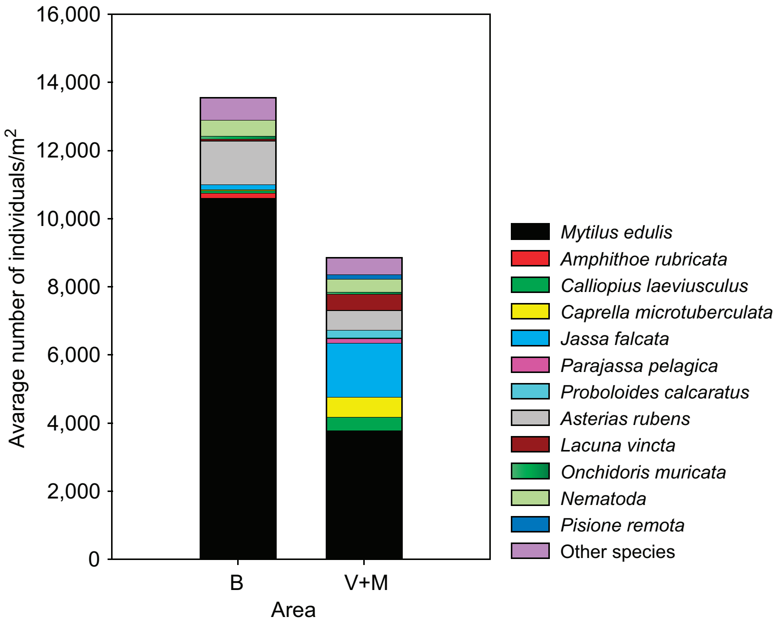
Figure 3.9. Total (A & B), sessile (C & D) and mobile (E & F) fauna organism as function of macroalgal biomasses. The right column (B, D and E) shows the correlation without the two samples with large biomass of algal.



3.3.2 Abundances

The average number of motile individual animals per m² was estimated to 13,550 at the shallow stations and 8,860 at the deeper stations (*figure 3.10*). A complete list of abundances of each motile species distributed on samples is given in *Appendix 2*. *Mytilus edulis* was the absolute dominating species at both water depths. *Asterias rubens* and nematodes were also numerous at both water depths. The crustaceans *Amphithoe rubricata* and *Calliopius laeviusculus* were found at the shallow stations but nearly missing at the deeper stations. On the other hand species like *Caprella microtuberculata*, *Jassa falcata*, *Parajassa pelagica*, *Proboloides calcaratus*, *Lacuna vincta* and *Posione remota* seemed much more numerous at the deeper stations compared to the shallow ones. These species were actually found in substantial numbers but only at a few stations.

Figure 3.10. Abundance of motile fauna organisms sampled by suction sampler at the two planned constructions at 9-10 m's depth (V+M) and near the top of the present reef at approximately 5-6 m's depth (B).



The total abundance of motile fauna species had a higher correlation with the algal biomasses than the macroalgal biomass (*figure 3.11*).

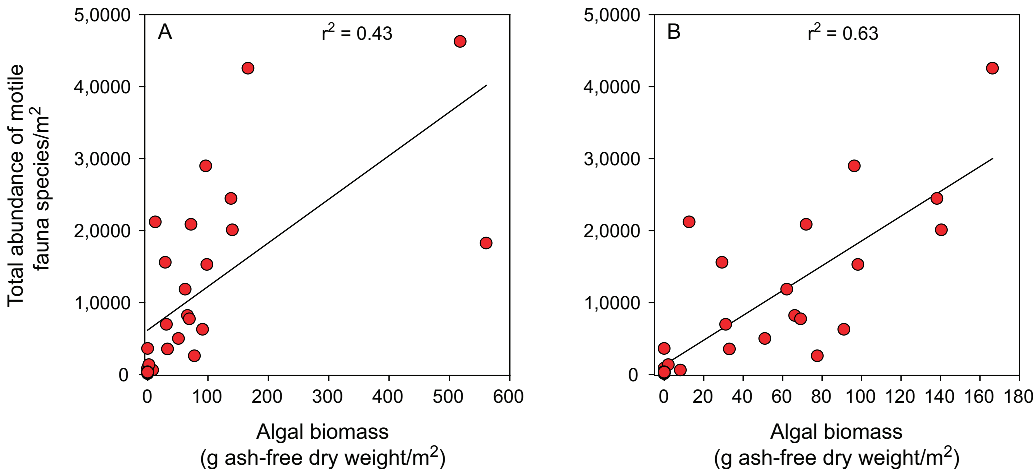


Figure 3.11. Total abundance of motile fauna organisms as function of macroalgal biomasses per m^2 on A) the total dataset and B) without the two samples with extraordinarily higher biomasses.

3.4 Abundances and distribution of fish and shellfish

In April abundance of target species cod was very low. A total of 6 cod were caught on 23 stations. The catch was dominated by ballan wrasse (*Labrus bergylta*), lumpsucker (*Cyclopterus lumpus*) and dab (*Limanda limanda*) (data not shown).

In June the three most abundant fish species at Læsø Trindel were rock cook (*Centrolabrus exoletus*), corkwing wrasse (*Symphodus melops*) and ballan wrasse (*Labrus bergylta*) (*figure 3.19*), while in terms of biomass it was rock cook, ballan wrasse and dab (*Limanda limanda*). Their relative abundance and biomass from gillnet and fish trap in the three areas of Læsø Trindel are illustrated in *figures 3.12* and *3.13*.). The maximum abundance and biomass of fish species in both types of fishing gear were found on the shallow area of the reef (area B). In the fish traps the brown crab in terms of biomass was much higher here. The A and C area had both similar abundance and biomass of fish. There was no significant difference in species composition in the three areas. Length distribution of the three most abundant fish species and cod are shown in *figure 3.14*. The wrasses had a modal total length around 10 cm while cod had no apparent modal length, but were between 17 and 40 cm in total length.

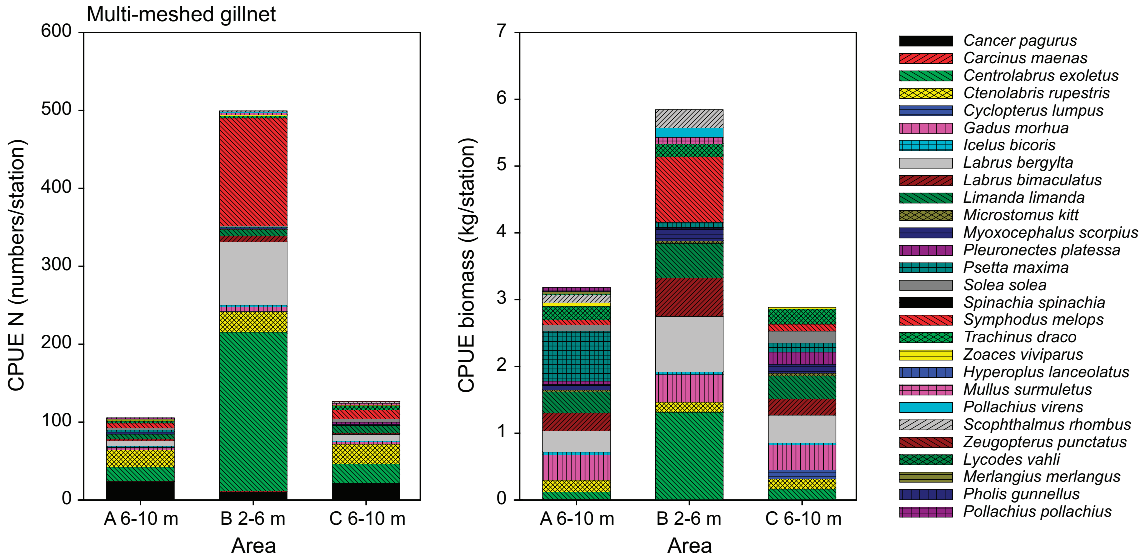


Figure 3.12. Multi-meshed gillnet CPUE in numbers and biomass (brown crab, *Cancer pagurus* is not included in biomass) at species level in the areas West, Mid and East from the June survey.

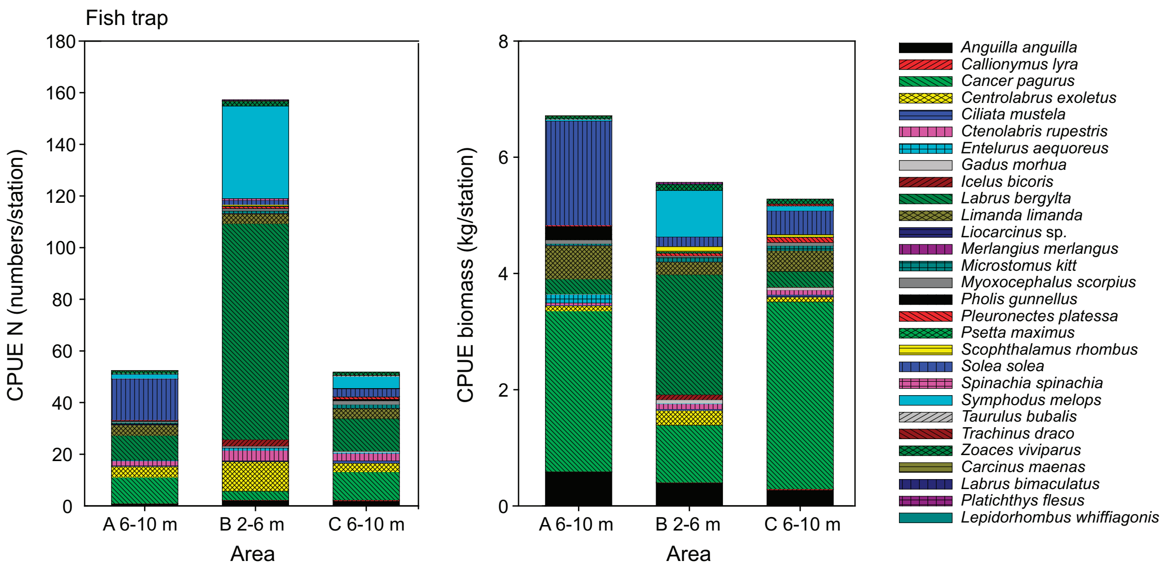
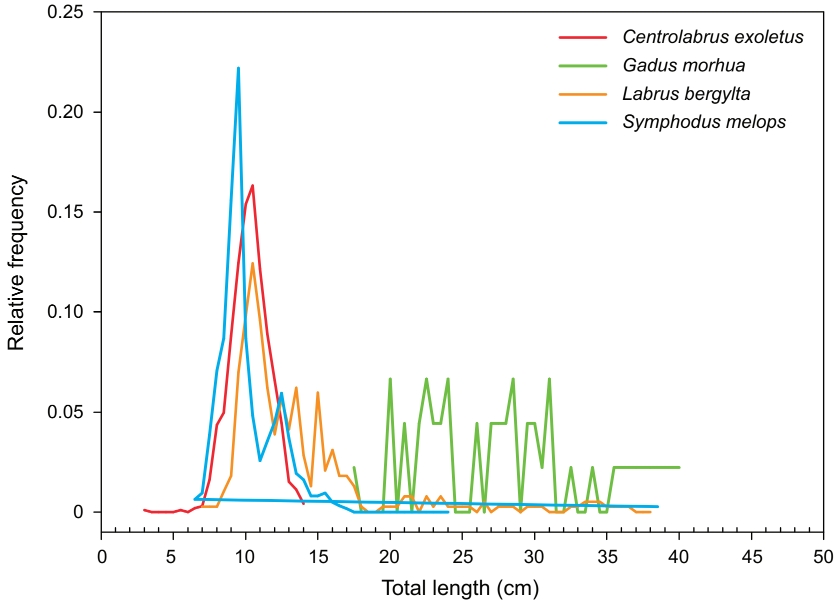


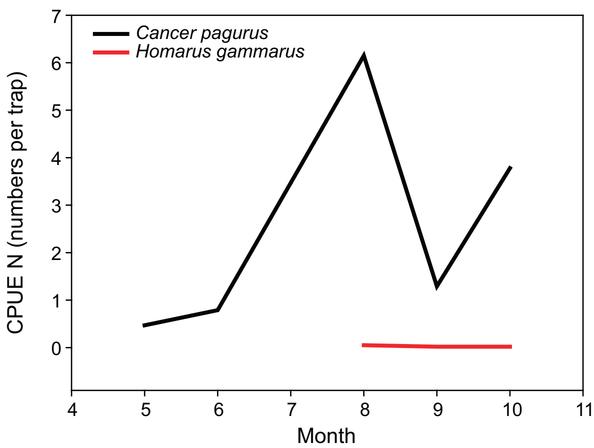
Figure 3.13. Fish trap CPUE in numbers and biomass at species level in the areas West, Mid and East from the June survey.

Figure 3.14. Length distribution of the three most frequently observed species and cod at Læsø Trindel in multi-mesh size gillnets.



European lobster and brown crab were surveyed monthly from May to October. Due to bad weather, the July survey was cancelled. Lobster was only caught in August and in low numbers. Mean CPUE N was 0.02 lobster per trap setting. Brown crab CPUE N varied between 0.7 and 7.5 in the period (*figure 3.15*). All lobsters were caught outside the central parts of the Læsø Trindel area, while brown crab was caught also at the central parts of Læsø Trindel (*figure 3.16*).

Figure 3.15. Mean monthly CPUE N in trap fishery for European lobster (*Homarus gammarus* and brown crab (*Cancer pagurus*).



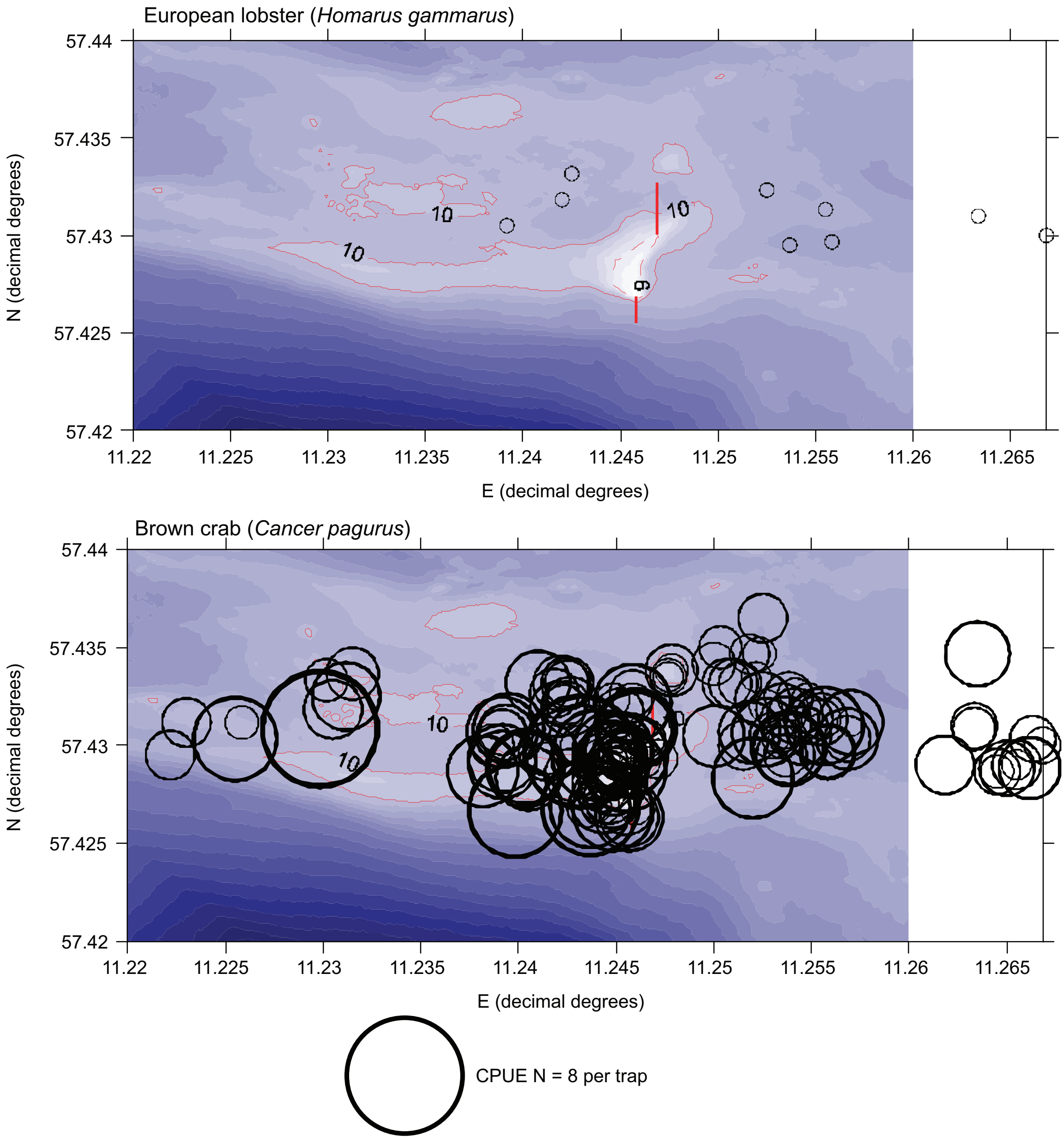


Figure 3.16. CPU N of European lobster (*Homarus gammarus*) and brown crab (*Cancer pagurus*) in all trap settings from May to October 2007.

3.5 Feeding ecology

A total of 199 goldsinny wrasses (*Ctenolabrus rupestris*) and 68 cod (*Gadus morhua*) were sampled for stomach analyses by multi-meshed gillnet fishing in October at the sites where benthic fauna were studied (area B and area V and M combined). Subsamples of 68 fish of each species were gut analyzed and prey items identified determined and size measured.

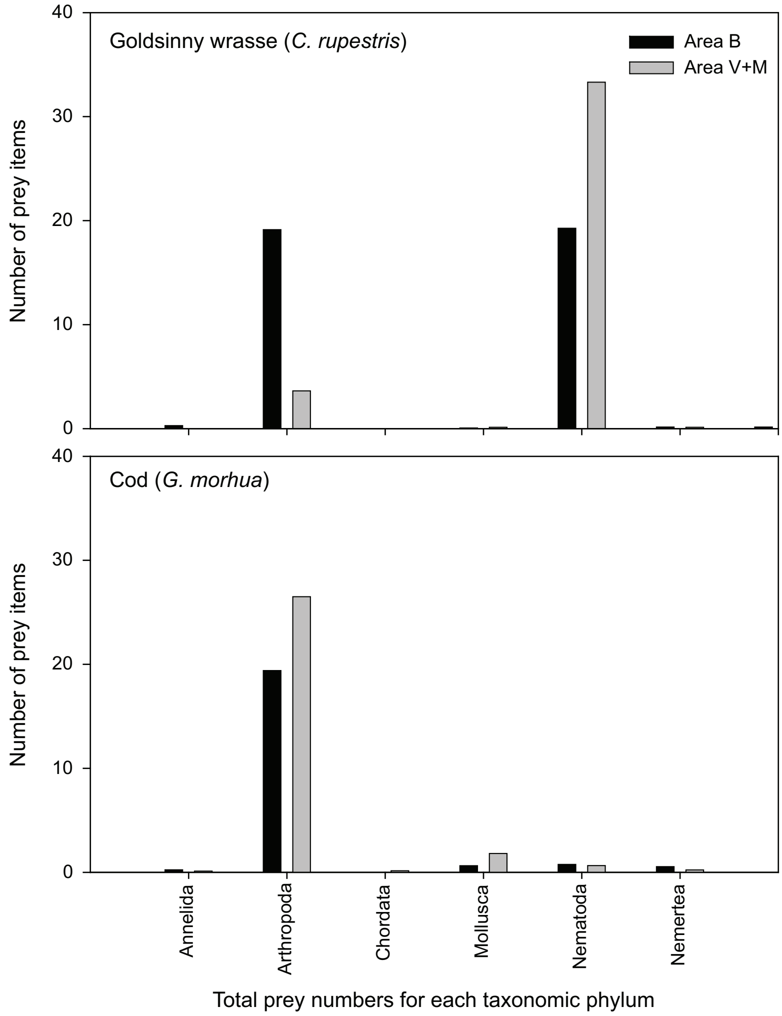
Goldsinny wrasses were eating a diverse group of taxonomic prey items. However, except for crustacean (Athropoda) and mollusks (Mollusca) the different prey items were only represented in very low numbers (*table 3.2*; *figure 3.17*). Different species of crustaceans (amphipods), mussels (*Mytilus edulis*) and snails together constituted 95-98% of the gut content in the goldsinny wrasses. When comparing the two investigated areas, a difference was especially seen between the occurrence of mussels and snails which were more abundant in areas V and M (~34 prey items/fish) compared to area B (~19 prey items/fish) (*table 3.2*; *figure 3.17*).

Cod were also eating a relatively large number of different taxonomic prey items. Even though crustaceans (amphipods) also constituted most of the prey items found in the gut, the relative share of other prey items was higher compared to the goldsinny wrasse (*table 3.2*; *figure 3.17*). This suggests cod to be a more opportunistic predator. A comparison of the cod diet in the two areas revealed no apparent differences (*figure 3.17*).

Table 3.2. Average number of prey items in areas B and V-M at lowest possible taxonomic level in goldsinny wrasse (*Ctenolabrus rupestris*) and cod (*Gadus morhua*) and their relative presence (in %) in examined individuals with stomach content. In total 68 specimens of each species were examined. Empty stomach was observed in one cod and eight goldsinny wrasse.

Fish species	Kingdom	Phylum	Subphylum	Class	Order	Suborder	Family	Genus	Species	Average number of items		Present in % of analysed individuals	
										Area B	Area V-M	Area B	Area V-M
C. rupestris	Plantae	Chlorophyta								0.02	0.19	2	6
		Phaeophyta								0.56		29	
		Rhodophyta								0.16	0.06	9	6
	Animalia									0.02		2	
		Annelida		Polychaeta						0.29		27	
		Arthropoda	Crustacea	Eumalacostraca	Isopoda	Valvifera	Idoteidae	Idotea	*Idotea granulosa*	0.07		4	
				Malacostraca	Amphipoda	Caprellidea	Caprellidae	Caprella	*Caprella linearis*	1.00	0.19	31	13
						Gammaridea				17.60	3.00	76	56
					Decapoda						0.06		6
						Caridea				0.16	0.19	13	19
						Pleocyemata				0.07	0.06	7	6
							Galatheidae	Galathea	*Galathea intermedia*	0.02	0.06	2	6
							Porcellanidae	Pisidia	*Pisidia longicornis*	0.07		7	
					Isopoda	Peracarida	Idoteidae	Isopoda		0.09	0.06	4	6
									Idotea granulosa	0.07		4	
		Cnidaria								0.04		2	
				Hydrozoa	Hydroida		Campanulariidae	Leomedea	*Laomedea flexuosa*		0.13		6
		Echinodermata	Eleutherozoa	Echinoidea	Echinoida					0.02		2	
		Mollusca		Bivalvia						0.04		2	
					Mytiloida		Mytilidae	Mytilus	*Mytilus edulis*	10.00	19.19	69	88
				Gastropoda						9.22	14.13	29	19
		Nematoda								0.16	0.13	11	13
		Nemertea								0.16	0.19	11	19
		Chordata		Actinopterygii						0.04		2	
	Other	Stone								0.76	0.06	20	6
	Total number of prey items per individual fish									*40.62*	*37.69*		
G. morhua	Plantae	Phaeophyta								0.14	0.19	12	15
		Rhodophyta									0.04		4
	Animalia	Annelida		Polychaeta						0.21		21	
					Phyllodocida	Aphroditoidea	Aphroditidae	Aphrodita	*Aphrodita aculeata*	0.02	0.12	2	12
		Arthropoda	Crustacea	Malacostraca	Amphipoda	Caprellidea	Caprellidae	Caprella	*Caprella linearis*	0.19	1.04	2	8
						Gammaridea				16.05	21.96	69	62
					Decapoda	Brachyura	Cancridae	Cancer	*Cancer pagurus*	0.12	0.50	5	31
						Caridea				1.33	0.96	69	62
							Crangonidae	Crangon		0.02		2	
									Crangon crangon	0.05		5	
							Hippolytidae	Hippolyte	*Hippolyte varians*		0.08		8
						Pleocyemata				0.26	0.69	17	38
							Galatheidae	Galathea	*Galathea intermedia*	0.90	0.38	55	23
								Munida	*Munida rugosa*	0.07	0.19	5	12
							Pinnotheridae	Pinnotheres	*Pinnotheres pisum*	0.05		2	
							Porcellanidae	Pisidia	*Pisidia longicornis*	0.24	0.12	14	8
							Portunidae	Liocarcinus	*Liocarcinus depurator*	0.12	0.58	7	27
		Mollusca		Bivalvia							0.12		8
					Mytiloida		Mytilidae	Mytilus	*Mytilus edulis*	0.50	1.54	33	27
				Gastropoda						0.14	0.15	10	15
		Nematoda								0.76	0.65	33	35
		Nemertea								0.55	0.23	31	15
		Chordata		Actinopterygii							0.15		8
	Other	Stone								0.33	0.81	17	31
	Total number of prey items per individual fish									*22.07*	*30.50*		

Figure 3.17. Average numbers of prey items for taxonomic phylum in areas B and V-M for goldsinny wrasse (*Ctenolabrus. rupestris*) and cod (*Gadus morhua*).



Stomach weight was used as a proxy for fullness of the stomach. Analyses of wet weight of stomach showed that the average weight was around 0.5 g for goldsinny wrasse and 1.5 g for cod. There was no significant difference between the two areas (ANCOVA; $p > 0.05$).

Table 3.3. Wet weight of stomach in goldsinny wrasse (*Ctenolabrus rupestris*) and cod (*Gadus morhua*). Standardized mean stomach weight found by analysis of covariance (ANCOVA) with fish length as covariate. P is statically probability of difference between areas.

	Area	**Standardized mean stomach wet weight (g)**	**N**	**P**
Ctenolabrus rupestris	B	0.40	199	0.06
	V + M	0.49		
Gadus morhua	B	1.54	68	0.85
	V + M	1.57		

Size analyses of prey and fish showed that prey size in goldsinny wrasse in general did not increase size with fish size while this was the case for cod (*figure 3.18*). For cod the increase was statistically significant for all prey items pooled (linear regression, $p < 0.006$) and also within the crusteceans (Malacostrca) ($p < 0.001$) and polychaetes (Polychaeta) ($p < 0.03$).

Figure 3.18. Prey length (for crustaceans thorax length, for other groups total length) versus predator length.

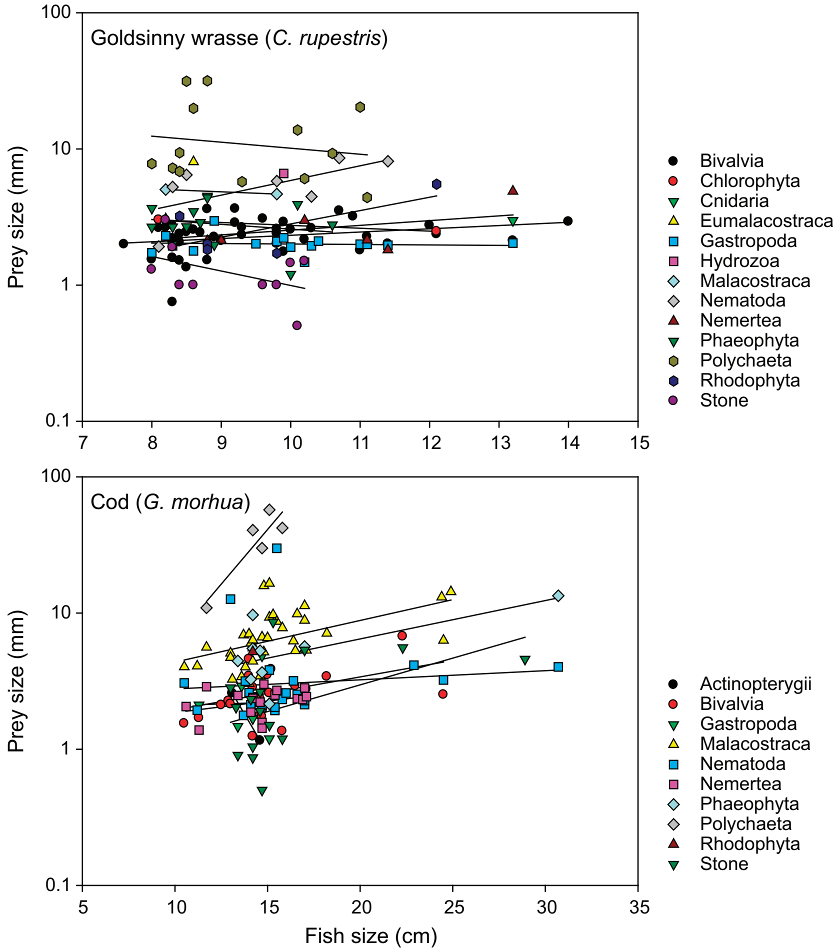


Figure 3.19. Three of the typical fish species at Læsø Trindel: corkwing wrasse (*Symphodus melops*), goldsinny wrasse (*Ctenolabrus rupestris*) and rock cook (*Centrolabrus exoletus*). Photo: Line Reeh.

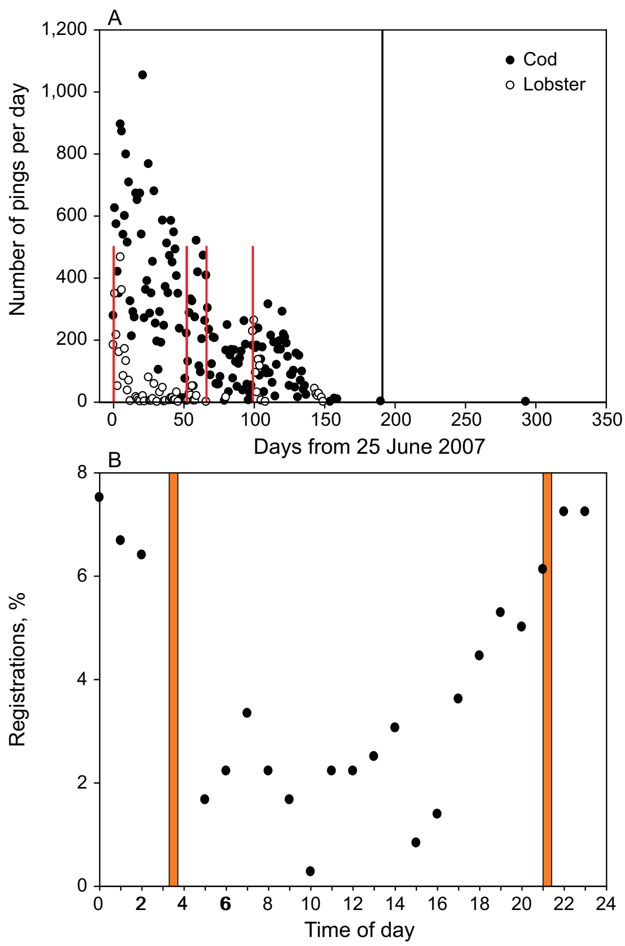
3.6 Behaviour and migration

88 cod and 325 corkwing wrasses (*Symphodus melops*) were marked with conventional t-bar tags in June 2007. At present only few tags returns have been obtained. It is therefore not yet possible to evaluate this part of the tagging program.

The acoustic coded tagging of 17 cod and 10 lobsters were followed for a one-year period (June 2007 to June 2008). Results are shown in *figure 3.20*. The tagged cod were frequently logged in the summer months but after 150 days (late September) they disappeared from the area. A single tagged cod was registered again on 13 April 2008 but besides this specimen, there seemed to be no return to the Læsø Trindel area in spring (*figure 3.20A*). The tagged lobsters were only observed sporadically and mainly just after being released. Hereafter they were only rarely observed and with relatively long time intervals.

Most of the cod showed a strong diurnal migration pattern from June to September. An example of a typical diurnal migration pattern is show in *figure 3.20B* where a juvenile cod of 30 cm was tracked on 5-6 July 2007. A few hours before sunset, the log frequency at the receivers at Læsø Trindel increased two to threefold and stayed at this high level throughout the night. All registrations during day time were from receivers placed at deeper boundary stations. Juvenile cod thus seemed to migrate to the central reef area in the evening and utilize this area until dawn. During the day they sought deeper waters at the shelf of the reef area.

Figure 3.20. Acoustic tagging of cod (*Gadus morhua)* and lobster (*Homarus gammarus*). When a marked individual was present at central Læsø Trindel, a ping was received. A) Total pings (transmitted every three minute) per day per species. Small vertical lines in red show release days of lobster. All cod were marked on 25 June 2007 (day 0). Large vertical line in black shows 1. January 2008. B) Example of diurnal migration patterns from a 30 cm cod on 5 to 6 July 2007 expressed as percent of total pings in the period. Sunrise and sunset are illustrated by orange bars. Time is in GMT + 1.



4 Discussion and conclusion

The biodiversity in terms of species identified at Læsø Trindel at its present state is not judged as poor, although a comparison with a reference dataset is impossible due to lack of data sampled in this area and with the same gear. The diversity of fish species is more or less as expected on a reef area. The number of benthic fauna and flora species sampled by the suction sampler is somewhat smaller compared to another investigation at Mejl Flak in the Belt Sea area (*Dahl et al. 2005*). The investigation at Mejl Flak included sampling at both boulders and sandy-gravel seabed using the same sampling gear and approximately the same number of samples in the depth interval 4-8.5 m. Despite the less saline water at Mejl Flak, 52 distinct macroalgae and 156 distinct fauna taxa were identified compared to 57 and 130 taxa in this investigation. The presence of scattered, large, stable boulders in the area most likely secure the relatively high species number.

The biomasses sampled at Læsø Trindel varied and was depending on the presence of hard, stable substrate within the sampling frame. In two cases sampling took place on small but stable boulders at 9-10 m's water depth and this was clearly reflected in biomasses equal to > 600 g ash-free dry weight/m^2. At Mejl Flak the estimated average biomasses at boulders varied from 1,123 g at 4 m's depth to 1,915 g at 8 m's depth.

On most occasions algal vegetation within the frames was dominated by quick-growing opportunistic species or smaller individuals of perennial algal species. This indicates a reef with unstable structure preventing perennials to develop and remaining in a state of constant renewal.

The fauna biomasses were dominated by *Electra pilosa*, a bryozoan species living as an epiphyte on the algal vegetation. Newly settled *Mytilus edulis* were very abundant, especially on the shallow stations. The mussels had settled within the algal vegetation but the biomasses were negligible. The relatively large representation of starfish *Asterias rubens* indicated poor chances for young *Mytilus edulis* to survive as also observed on other reef locations investigated as part of the Danish National Monitoring Programme.

The fish fauna was in terms of numbers as expected, dominated by members of the wrasse family (Labridae) whereas more commercially important species like cod were only observed in low numbers. Highest fish abundance and biomass were seen on the shallow part of Læsø Trindel. The fish community structure and number of taxa were comparable with findings on hard bottom habitats in the Kattegat region off west Sweden (*Pihl & Wennhage 2002*). However, especially the abundance of gadoids was smaller at Læsø Trindel compared to hard bottom habitats in west Sweden (*Anonymous 2007*; *Pihl & Wennhage 2002*). Tagging of juvenile cod with acoustic tags did, however, show that they were using the reef area at central Læsø Trindel in the summer and early autumn. This indicates that Læsø Trindel even at its present status functions as an important habitat for gadoids at their juvenile stage.

European lobsters were only seen in very low numbers and only caught outside the central Læsø Trindel area. The overall catch rate of 0.02 lobster/trap was a factor 10 lower than catch rates at artificial and natural reefs in the west Swedish archipelago (*Anonymous 2007*). Acoustic tagged lobsters were only rarely logged at the reef area and never took permanent residence here. Other studies using the same technique have documented that lobsters migrate to reefs in the summer and do diurnal inter-reef movements here (*Smith et al. 1998*). However, laboratory experiments have also shown that lobsters show high selectivity for the size of shelters available - either directly or that could be created between the rocks and the bottom by excavating under the rocks (*Miller et al. 2006*). This suggests that Læsø Trindel's reef habitat at present does not have the structural complexity and shelter for lobsters.

The feeding ecology of cod and goldsinny wrasses, with amphipods being one of the most important food items and cod having a more opportunistic prey utilisation, is in line with other studies of the two species (*Hillden 1978*, *Fjøsne & Gjøsæter 1996*, *Link & Garrison 2002*, *Stål et al. 2007*). The positive correlation between algae biomass and total fauna biomass suggest that an increase in algae biomass, as expected to occur after the reef have been restored, would increase the food availability for fish in general but especially for the more opportunistic species like cod.

Overall this investigation documented that the biological community present at Læsø Trindel in general is less developed with few species and considerably low biomasses and abundances than expected at a reef in northern Kattegat at 5-10 m's depth.

The present conservation status of the reef at Læsø Trindel in the Natura 2000 site cannot be regarded as favourable. The restoration of the reef with large stable boulders is expected to result in considerably higher biomasses of macroalgae and subsequently to higher biomasses of benthic fauna and fish/shellfish. The restoration of the reef is also expected to improve the structure of the reef system with increased complexity due to presence of a more developed seaweed forest. The function of the reef is also expected to be improved due to higher biomasses (production) of seaweed, higher biomasses of fauna and better conditions for fish and shellfish.

5 Acknowledgement

A lot of people have been involved in this project. Thanks to all of you. Special thanks go to the two local fishermen Jørgen Rulle and Poul Olsen for incredible help with surveys and logistics. We are indebted to colleagues at DTU Aqua: Kerstin Geitner for help with GIS maps and data; Morten Sichlau Bruun for the operation of cod; Nidia Graf for the stomach analysis; Lars T. Thomsen and Jesper Knudsen for participation on surveys; Ole Norden Andersen, Locus, for help with fauna identification and Jan Damgaard Nielsen, NERI and Jens Larsen, University of Copenhagen for the dives to collect the acoustic receivers.

6 References

Anonymous 2005: Hummerrevsprojektet. Konstige rev i Göteborgs skärgård. Slutrapport år 2007. - Report No. 2007: 40, Länsstyrelsen, Västra Götalands Län.

Dahl, K., Lundsteen, S. & Helmig, S.A.: 2003: Stenrev - havbundens oaser. Danmarks Miljøundersøgelser. - Miljøbiblioteket 2, 104 s.
http://www2.dmu.dk/1_viden/2_Publikationer/3_miljobib/rapporter/MB02.pdf

Dahl, K., Lundsteen, S. & Tendal, O. S. 2005: Mejlgrund og Lillegrund. En undersøgelse af biologisk diversitet på et lavvandet område med stenrev i Samsø Bælt. Danmarks Miljøundersøgelser & Århus Amt, Natur & Miljø. 87 s. - Faglig rapport fra DMU nr. 529.
http://www2.dmu.dk/1_viden/2_Publikationer/3_fagrapporter/rapporter/FR529.pdf

Fjøsne, K. & Gjøsæter, J. 1996: Dietary composition and the potential of food competition between 0-group cod (*Gadus morhua* L.) and some other fish species in the littoral zone. - ICES Journal of Marine Science 53(5): 757-770.

Hillden, N.O. 1978: On the feeding of the goldsinny, *Ctenolabrus rupestris* L. (Pisces, Labridae). - Ophelia 17: 195-198.

Link, J.S. & Garrison, L.P. 2002: Trophic ecology of Atlantic cod *Gadus morhua* on the northeast US continental shelf. - Marine Ecology Progress Series 227: 109-123.

Miller, R.J., Sharp, G.J. & O'Brien, E.M. 2006: Laboratory experiments on artificial reefs for American lobsters. - Journal of Crustacean Biology 26: 621-627.

Pihl, L. & Wennhage, H. 2002: Structure and diversity of fish assemblages on rocky and soft bottom shores on the Swedish west coast. - Journal of Fish Biology 61 (Supplement A): 148-166.

Smith, I.P., Collins, K.J. & Jensen, A.C. 1998: Electromagnetic telemetry of lobster (*Homarus gammarus* (L.)) movements and activity: preliminary results. - Hydrobiologia 371/372: 133-141.

Stål, J., Pihl, L. & Wennhage, H. 2007: Food utilisation by coastal fish assemblages in rocky and soft bottoms on the Swedish west coast: Inference for identification of essential fish habitats. - Estuarine, Coastal and Shelf Science 71: 593-607.

Appendix 1 - Biomasses of species distributed on suction sample stations

	Species	B1-1	B1-2	B1-3	B2-1	B2-2	B2-3	B2-4	B3-1	B3-2	B3-3	B3-4	B4-1	B4-2	B4-3
Macrophytes															
Chlorophyta	Bryopsis plumosa	0.0		0.0	0.0	0.3	0.0	0.4	3.7	0.0	0.1	0.1	0.6	0.0	0.4
	Chaetomorpha melagonium														0.0
	Enteromorpha indet.			0.1		0.0	0.0		1.3	1.5	0.0	0.3	0.0		
	Spongomorpha aeruginosa	0.0		0.2	0.0	0.2	0.0	0.2	1.8	1.6	0.0	0.1	0.0		
Phaeophyta	Brown crust	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0
	Chorda filum			1.3	1.4	3.1	2.3	0.1	70.6	25.2	1.7	62.3	0.8		
	Chordaria flagelliformis								0.1						
	Desmarestia aculeata	2.9	9.0	37.4	1.3	0.7		0.0	6.0	2.3	2.9	2.6	10.9	25.4	0.0
	Desmarestia viridis		8.5	6.0	0.0	0.1	0.6	1.0		0.0		0.0	2.3	5.2	
	Ectocarpus siliqulosus	1.9	0.2	1.5	2.1	1.5	13.0	0.5	50.6	13.9	2.9	11.3	0.8	1.6	0.1
	Fucus indet.						0.0								
	Halidrys siliquosa														
	Hincksia ovata	0.0				0.0		0.0	0.0	0.0		0.0	0.0	0.1	0.0
	Laminaria dig/hyp	9.4	7.4				51.0	0.6						33.1	0.3
	Laminaria juvenil	0.1	1.0	8.7	17.1	5.4	1.6	0.0	0.2	0.3	0.1	0.0	8.4	2.8	0.0
	Laminaria saccharina												2.2		
	Lithosiphon pusillus			0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0			
	Petalonia fascia						0.2								
	Sphacelaria caespitula	0.8	0.1	0.5	0.3	0.6	0.5	3.0	4.5	5.1	0.4	0.6	5.1	0.0	4.4
	Sphacelaria cirrosa	0.0	11.4	0.0	0.0								0.0	0.0	
	Sphacelaria indet.								0.3						
	Sphacelaria plumosa														
Rhodophyta	Acrochaetium hallandicum														
	Acrochaetium moniliforme	0.0													
	Acrochaetium secundatum		0.0		0.0				0.0						
	Aglaothamnion byssoides														
	Aglaothamnion hookeri		0.1										0.0		
	Aglaothamnion indet.														
	Ahnfeltia plicata	0.1	2.2	0.1	0.2	1.5	1.7	0.6	0.2				0.1	6.6	9.5
	Audouinella efflorescens								0.0						
	Audouinella membranacea								0.0	0.0					
	Bonnemaisonia hamifera		0.0		0.0	0.0	0.0	0.0					0.0	0.0	0.0
	Brongniartella byssoides	0.0	5.4			0.0	0.2								
	Callithamnion corymbosum														
	Ceramium virgatum	1.4	32.1	0.5	1.0	2.0	8.0	0.3	0.2	0.0		0.0	20.6	5.7	2.3
	Chondrus crispus													0.1	
	Coccotylus/Phyllophora				0.1		0.0								
	Colaconema daviesii								0.0						
	Colaconema indet.	0.0			0.0										
	Colaconema nemalionis										0.0				
	Cystocloneum purpureum		1.5		0.0				0.0		0.0		3.2	0.8	1.9
	Delesseria sanguinea		2.5				0.4				0.0			23.9	0.0
	Dilsea carnosa														
	Erythrotrichia carnea														
	Erythrotrichia indet.	0.0													

	Species	B1-1	B1-2	B1-3	B2-1	B2-2	B2-3	B2-4	B3-1	B3-2	B3-3	B3-4	B4-1	B4-2	B4-3
	Gloiosiphonia capillaris			0.1		0.4			0.1	0.0	0.0			0.0	
	Goniotrichum alsidii														
	Lomentaria clavellosa														
	Membranoptera alata	0.2	0.8		0.0								0.1	0.1	2.9
	Palmaria palmata				0.1										
	Phycodrys rubens	0.0	1.0		0.0	0.0	3.4			0.0			0.2	0.0	0.0
	Phyllophora pseudoceranoides		17.7				1.3						3.7	9.3	
	Plumaria plumosa	0.0											0.0	0.1	2.1
	Polysiphonia elongata			0.0					0.0	0.1					
	Polysiphonia fibrillosa	1.7	3.0	4.1	0.5	2.3	1.9	1.3		0.1	0.0		2.0	5.5	8.0
	Polysiphonia fucoides	0.7	2.4	0.0	0.3	3.5	2.5	0.2	0.3	0.1	0.0	0.1	4.1	3.0	0.2
	Polysiphonia indet.												0.0		
	Polysiphonia stricta	11.8	27.8	0.1	41.0	7.4	2.5	3.7	0.2	0.1	0.0	0.1	2.4	38.5	0.2
	Porphyra indet.			0.0											
	Pterothamnion plumula														
	Red calcified crust		0.0	0.0	0.0	0.0		0.0					0.0	0.0	0.0
	Red crust		0.0										0.0		
	Rhodochorton purpureum		0.0		0.0		0.0	0.0					0.0	0.0	0.0
	Rhodomela confervoides		2.8	1.3	0.4	0.1		0.6	0.3	0.4	0.0	0.0	3.8	4.3	0.5
	Spermothamnion repens	0.1	1.2		0.1		0.0						0.4	0.1	0.1
Sessile fauna organisms															
Bryozoa	Aetea truncata								0.0		0.0	0.0	0.0		
	Alcyonidium aff. gelatinosum		0.0		0.0	0.0	0.0	0.4		0.0	0.0	0.1	0.5		0.0
	Alcyonidium albidum											0.0			
	Alcyonidium hirsutum														
	Callophora aurita	0.0	0.0	0.0					0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Callophora craticula											0.0			
	Callopora lineata														
	Celleporella hyalina								0.0			0.0			
	Cribrilina cryptooecum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
	Cribrilina punctata					0.0		0.0	0.0			0.0			
	Crisia eburnea														
	Cryptosula pallasiana	0.0	0.0												0.0
	Electra crustulenta									0.0					
	Electra pilosa	1.8	11.5	2.2	9.0	5.0	12.8	2.4	1.9	0.5	0.4	3.2	5.8	14.0	4.4
	Escharella immersa	0.0	0.0		0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Escharella indet.			0.0					0.0						
	Eudendrium indet.				0.0										
	Membranipora membranacea	0.3			0.2	0.1	4.0				0.0		0.1	3.7	
	Plagioecia patina				0.0					0.0					
	Schypha ciliata														
	Scruparia ambigua			0.0											
Crustacea	Balanus balanus										0.0				0.0
	Balanus crenatus														0.0
	Verruca stroemia				0.0										
Hydrozoa	Bougainvillia ramosa			0.0					0.0	0.0		0.0	0.0		0.0
	Bougainvilliidae indet.											0.0			
	Campanulina lacerata		0.0	0.0						0.0	0.0	0.0			0.0
	Clava multicornis													0.0	
	Clytia gracilis									0.0	0.0	0.0			
	Clytia hemisphaerica	0.0	0.0									0.0	0.0		
	Corydendrium dispar										0.0				

	Species	B1-1	B1-2	B1-3	B2-1	B2-2	B2-3	B2-4	B3-1	B3-2	B3-3	B3-4	B4-1	B4-2	B4-3
	Coryne indet.											0.0			
	Eudendrium ?arbusculum														
	Eudendrium indet.				0.0					0.0					
	Gonothyraea loveni		0.0		0.0				0.0	0.0	0.0	0.0			0.0
	Obelia dichotoma												0.0		
	Obelia geniculata	0.0	0.2		0.1	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0
	Obelia longissima	0.1	0.0	0.1	0.1	0.1	0.1	0.1	0.7	0.6	0.1	1.2	0.3	0.1	0.1
	Perigonimus indet.									0.0					
	Sertularella rugosa					0.0									
	Sertularia cupressina														
Polychaeta	Pomatoceros triquerter														0.0
Porifera	Porifera indet.		0.0												
Entoprocta	Barentsia gracilis				0.0					0.0					
	Pedicellina indet.												0.0		
Mobile fauna organisms															
Bivalvia	Cultellus pelucidus														
	Dosinia lupinus									1.6					
	Hiatella arctica			0.0	0.0			0.0	0.0	0.0			0.0	0.0	
	Musculus discors								0.0						
	Mya truncata									0.0			0.0	0.0	
	Mysella bidentata	0.0												0.0	
	Mytilus edulis	0.2	0.5	0.3	0.5	0.6	0.8	0.8	0.9	0.1	0.0	0.1	0.7	1.8	0.3
	Spisula elliptica														
	Tellina pygmaea														
	Thracia indet.														
	Thracia papyracea														
Cephalochordata	Branchiostoma lanceolatum														
Coelentarata	Edwardsia indet.														
Crustacea	Ampelisca typica														
	Amphithoe rubricata	0.0	0.2	0.1	0.0	0.5	0.0	0.1		0.0			0.4	0.3	0.1
	Aora typica									0.0					
	Apherusa bispinosa														0.0
	Apherusa jurinei													0.0	0.0
	Balanus improvisus			0.1		0.1							0.0		
	Bathyporeia elegans														
	Calliopius laeviusculus	0.0	0.1			0.0	0.0		0.1	0.1			0.1	0.1	0.0
	Caprella microtuberculata		0.0			0.0				0.0				0.0	
	Corophium bonelli				0.0				0.0	0.0					0.0
	Dexamine spinosa		0.1	0.0		0.0	0.0	0.0	0.1	0.0			0.0	0.1	0.0
	Dexamine thea														
	Galathea indet.								0.0						
	Galathea strigosa												2.0		
	Gammarellus homari			0.2				0.1					0.1	0.2	
	Gammarus indet.								0.0						
	Hippolyte indet.(pelagisk)														
	Idothea indet.		0.0											0.0	
	Jassa falcata	0.0	0.1		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0
	Macropipus arcuatus														
	Microdeutopus gryllotalpa								0.0						
	Parajassa pelagica		0.0												
	Proboloides calcaratus														0.0
	Synchelidium intermedium														

	Species	B1-1	B1-2	B1-3	B2-1	B2-2	B2-3	B2-4	B3-1	B3-2	B3-3	B3-4	B4-1	B4-2	B4-3
	Xantho pilipes														0.1
Echinodermata	Asterias rubens	1.0	0.2	0.7	0.2	2.4	4.4	6.7	2.8	11.3	3.1	6.7	5.5	7.8	0.2
	Echinoidea														
	Psammechinus miliaris														
	Strongylocentrotus droebachiensis						0.0								
Gastropoda	Bittium reticulatum	0.1		0.0		0.1		0.1	0.1	0.0			0.1	0.1	0.0
	Dendronotus frondosus														
	Doto indet.														
	Hydrobia ulvae							0.0							
	Lacuna vincta		0.0			0.0		0.0	0.0				0.0	0.1	0.0
	Lunatia catena		0.2												
	Lunatia montagui														
	Onchidoris muricata	0.1	0.1	0.1		0.0			0.1	0.1		0.0	0.1	0.0	
	Onoba semicostata														0.0
	Polycera indet.														
	Rissoa albella		0.0												
	Rissoa indet.								0.1						
	Rissoa membranacea														
	Rissoa parva								0.0						
Polychaeta	Autolytus edwardsi														
	Capitela capitata						0.1								
	Chaetozone setosa														
	Eulalia viridis		0.0												
	Eusyllis blomstrandi														
	Goniadella bobretzkii														
	Harmothoe imbricata	0.3				0.5	0.6	0.1	0.3	0.2			0.4	0.7	
	Harmothoe impar			0.1											0.0
	Harmothoe indet.		0.0			0.1			0.1	0.1		0.0		0.0	
	Heteronereis indet.							0.1		0.1					
	Kefersteinia cirrata	0.0					0.1								
	Lagisca extenuata												0.1		
	Lepidonotus squamatus					0.2									
	Malmgrenia glabra						0.1								
	Nephtys cirrosa														
	Nephtys kersivalensis														
	Nephtys pulchra														
	Nereidae											0.1			
	Nereimyra punctata					0.0									
	Nereis indet.							0.1		0.1	0.0			0.0	
	Nereis pelagica				0.5	2.5	7.4	2.0	0.0				1.1	0.1	0.2
	Ophelia limacina														
	Phyllodoce maculata														0.0
	Pisione remota														
	Polydora ciliata					0.0									
	Polydora cornuta							0.0							
	Proceraea cornuta	0.0				0.0							0.0	0.0	
	Protodorvillea kefersteini					0.1									
	Pseudomystides limbata														
	Spio filicornis				0.1									0.0	
	Spionidae														
	Streptosyllis websteri														
Polyplachophora	Tonicella marmorea												0.1		

	Species	B1-1	B1-2	B1-3	B2-1	B2-2	B2-3	B2-4	B3-1	B3-2	B3-3	B3-4	B4-1	B4-2	B4-3
Pycnogonida	Anoplodactylus exiguus														
Nematoda	Nematoda	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0			0.0	0.1	0.0
Nemertea	Nemertea			0.1				0.0							
Oligochaeta	Oligochaeta				0.0								0.0		0.0
Total biomass		**35.2**	**151.6**	**66.1**	**77.0**	**42.1**	**121.8**	**25.8**	**147.9**	**66.0**	**11.9**	**89.1**	**89.5**	**196.2**	**38.7**

	Species	M1-1	M1-2	M3-1	M3-2	M3-3	M3-4	V1-1	V1-2	V2-1	V2-2	V2-3	V3-1	V3-2	V3-3
Macrophytes															
Chlorophyta	Bryopsis plumosa														
	Chaetomorpha melagonium														
	Enteromorpha indet.	0.0								0.0					
	Spongomorpha aeruginosa														0.0
Phaeophyta	Brown crust														
	Chorda filum	0.3													
	Chordaria flagelliformis														
	Desmarestia aculeata	59.0	6.4				2.1	9.9	17.1	3.6					
	Desmarestia viridis		23.2					20.0	0.2						
	Ectocarpus siliqulosus	0.5	0.9					0.0	1.3	0.0					
	Fucus indet.														
	Halidrys siliquosa		0.1												
	Hincksia ovata	0.1						0.1	0.1	0.0					
	Laminaria dig/hyp	6.0						112.7							
	Laminaria juvenil	0.1	0.1					0.6	0.1	0.1					
	Laminaria saccharina		443.3												
	Lithosiphon pusillus														
	Petalonia fascia														
	Sphacelaria caespitula	0.0	1.0												0.0
	Sphacelaria cirrosa	0.7	0.1					1.5	0.7	0.4					
	Sphacelaria indet.														
	Sphacelaria plumosa														0.0
Rhodophyta	Acrochaetium hallandicum	0.0													
	Acrochaetium moniliforme	0.0													
	Acrochaetium secundatum														
	Aglaothamnion byssoides							0.1							
	Aglaothamnion hookeri														
	Aglaothamnion indet.								0.0						
	Ahnfeltia plicata		6.4					0.3	0.2	23.1					
	Audouinella efflorescens														
	Audouinella membranacea														
	Bonnemaisonia hamifera		0.0					29.0	0.1	0.1					
	Brongniartella byssoides	1.3	1.1						8.6	0.4					
	Callithamnion corymbosum	0.0	0.0					0.0							
	Ceramium virgatum	0.0	0.1					4.8	0.1						
	Chondrus crispus	0.1	0.2					0.5							
	Coccotylus/Phyllophora	0.1													
	Colaconema daviesii														
	Colaconema indet.	0.0													
	Colaconema nemalionis								0.0						
	Cystocloneum purpureum	0.1	2.5					0.4	0.3	25.9					

	Species	M1-1	M1-2	M3-1	M3-2	M3-3	M3-4	V1-1	V1-2	V2-1	V2-2	V2-3	V3-1	V3-2	V3-3
	Delesseria sanguinea		35.0					21.7		31.4					
	Dilsea carnosa								0.2						
	Erythrotrichia carnea	0.0													
	Erythrotrichia indet.	0.0							0.0						
	Gloiosiphonia capillaris														
	Goniotrichum alsidii								0.0						
	Lomentaria clavellosa	0.1	0.0					0.3							
	Membranoptera alata		3.3					0.9	0.0						
	Palmaria palmata								0.7	9.6					
	Phycodrys rubens	17.1	16.6					40.5	0.1	3.0					
	Phyllophora pseudoceranoides	6.0	11.2					266.6	0.1						
	Plumaria plumosa		0.3					0.2	0.8						
	Polysiphonia elongata	4.0							0.0						
	Polysiphonia fibrillosa	0.7	0.1					3.3							
	Polysiphonia fucoides		0.0					0.0	5.7	0.0					
	Polysiphonia indet.														
	Polysiphonia stricta	0.0	6.0					1.5	7.0	0.5					
	Porphyra indet.														
	Pterothamnion plumula	0.0	0.0					3.0							
	Red calcified crust				0.0		0.0		0.0						
	Red crust														
	Rhodochorton purpureum														
	Rhodomela confervoides		2.7						25.7	0.0					
	Spermothamnion repens	0.0	0.4					0.1	0.1						
Sessil fauna organisms															
Bryozoa	Aetea truncata														
	Alcyonidium aff. gelatinosum	0.2													
	Alcyonidium albidum														
	Alcyonidium hirsutum							0.7							
	Callophora aurita														
	Callophora craticula														
	Callopora lineata		0.0												
	Celleporella hyalina		0.0					0.0							
	Cribrilina cryptooecum														
	Cribrilina punctata														
	Crisia eburnea		0.1					0.0	0.1	0.0					
	Cryptosula pallasiana														
	Electra crustulenta														
	Electra pilosa	2.4	29.3					109.8	5.9	10.6					
	Escharella immersa														
	Escharella indet.														
	Eudendrium indet.														
	Membranipora membranacea	0.5	0.0					4.5	0.0	0.6					
	Plagioecia patina														
	Schypha ciliata							0.0							
	Scruparia ambigua	0.0	0.0												
Crustacea	Balanus balanus														
	Balanus crenatus														0.0
	Verruca stroemia														
Hydrozoa	Bougainvillia ramosa														
	Bougainvilliidae indet.														
	Campanulina lacerata														

	Species	M1-1	M1-2	M3-1	M3-2	M3-3	M3-4	V1-1	V1-2	V2-1	V2-2	V2-3	V3-1	V3-2	V3-3
	Clava multicornis														
	Clytia gracilis														
	Clytia hemisphaerica							0.0	0.0	0.1					
	Corydendrium dispar														
	Coryne indet.														
	Eudendrium ?arbusculum	0.0	0.0					0.0							
	Eudendrium indet.														
	Gonothyraea loveni														0.0
	Obelia dichotoma														
	Obelia geniculata	0.0	0.0						0.0	0.0					
	Obelia longissima		0.0						0.0	0.0					
	Perigonimus indet.														
	Sertularella rugosa		0.0					0.0		0.1					
	Sertularia cupressina		5.8					0.1	1.0						
Polychaeta	Pomatoceros triquerter														
Porifera	Porifera indet.							1.5	0.0	0.0					
Entoprocta	Barentsia gracilis														
	Pedicellina indet.														
Mobile fauna organisms															
Bivalvia	Cultellus pelucidus													0.0	
	Dosinia lupinus														
	Hiatella arctica		0.0												
	Musculus discors														
	Mya truncata														
	Mysella bidentata														
	Mytilus edulis	0.2	0.5		0.1		0.1	0.8	0.8	0.3					
	Spisula elliptica													0.1	
	Tellina pygmaea			0.0											
	Thracia indet.					0.0									
	Thracia papyracea														0.5
Cephalochor-data	Branchiostoma lanceolatum				0.0	0.1									
Coelenterata	Edwardsia indet.					0.0									
Crustacea	Ampelisca typica														0.0
	Amphithoe rubricata							0.1							
	Aora typica		0.0						0.0						
	Apherusa bispinosa	0.1	0.1					0.0	0.0	0.1					
	Apherusa jurinei														
	Balanus improvisus		0.1												
	Bathyporeia elegans										0.1				
	Calliopius laeviusculus	0.5	0.1					0.4							
	Caprella microtuberculata	0.5	0.1				0.0	0.4		0.1					
	Corophium bonelli		0.0												
	Dexamine spinosa	0.2	0.1					0.0	0.1	0.1					
	Dexamine thea		0.0												
	Galathea indet.														
	Galathea strigosa														
	Gammarellus homari								0.1						
	Gammarus indet.														
	Hippolyte indet.(pelagisk)													0.0	
	Idothea indet.														
	Jassa falcata	1.0	0.2				0.0	1.2	0.0	0.1					
	Macropipus arcuatus	5.1													

	Species	M1-1	M1-2	M3-1	M3-2	M3-3	M3-4	V1-1	V1-2	V2-1	V2-2	V2-3	V3-1	V3-2	V3-3
	Microdeutopus gryllotalpa				0.0										
	Parajassa pelagica	0.2						0.1							
	Proboloides calcaratus	0.1	0.0					0.1							
	Synchelidium intermedium					0.0									
	Xantho pilipes														
Echinodermata	Asterias rubens	0.2	9.9				0.0	0.1	0.2	0.1	0.0				
	Echinoidea													0.0	
	Psammechinus miliaris		0.0						0.0						
	Strongylocentrotus droebachiensis														
Gastropoda	Bittium reticulatum	0.0							0.0						
	Dendronotus frondosus	0.0													
	Doto indet.		0.0												
	Hydrobia ulvae														
	Lacuna vincta	0.2	0.5					0.1	0.1	0.1					
	Lunatia catena														
	Lunatia montagui					0.1									
	Onchidoris muricata	0.1	0.1							0.1					
	Onoba semicostata														
	Polycera indet.		0.4												
	Rissoa albella														
	Rissoa indet.	0.1	0.1												
	Rissoa membranacea							0.0							
	Rissoa parva														
Polychaeta	Autolytus edwardsi	0.0													
	Capitela capitata														
	Chaetozone setosa			0.1											
	Eulalia viridis	0.0	0.1					0.1							
	Eusyllis blomstrandi	0.0						0.1		0.1					
	Goniadella bobretzkii												0.0		0.1
	Harmothoe imbricata							0.1							
	Harmothoe impar							0.1							
	Harmothoe indet.	0.1	0.0												
	Heteronereis indet.														
	Kefersteinia cirrata														
	Lagisca extenuata														
	Lepidonotus squamatus														
	Malmgrenia glabra														
	Nephtys cirrosa					0.2									
	Nephtys kersivalensis												0.4		
	Nephtys pulchra											0.1		0.2	
	Nereidae														
	Nereimyra punctata														
	Nereis indet.	0.0													
	Nereis pelagica	0.1	0.1					0.3							
	Ophelia limacina			0.0	0.5	0.1	0.1			0.5		0.0	0.4		0.3
	Phyllodoce maculata														
	Pisione remota	0.1		0.0	0.1	0.0	0.0				0.0	0.1	0.1	0.0	0.0
	Polydora ciliata														
	Polydora cornuta	0.1													
	Proceraea cornuta				0.0										
	Protodorvillea kefersteini	0.0		0.0			0.1						0.1		
	Pseudomystides limbata				0.0										

	Species	**M1-1**	**M1-2**	**M3-1**	**M3-2**	**M3-3**	**M3-4**	**V1-1**	**V1-2**	**V2-1**	**V2-2**	**V2-3**	**V3-1**	**V3-2**	**V3-3**
	Spio filicornis			0.0											
	Spionidae											0.0			
	Streptosyllis websteri							0.1							
Polyplachophora	Tonicella marmorea														
Pycnogonida	Anoplodactylus exiguus	0.1						0.0							
Nematoda	Nematoda	0.2	0.0	0.0			0.0	0.1							
Nemertea	Nemertea			0.0	0.0		0.1	0.1					0.1	0.3	0.0
Oligochaeta	Oligochaeta														
Total biomass		**108.5**	**608.7**	**0.2**	**0.7**	**0.6**	**2.5**	**639.3**	**77.7**	**111.0**	**0.1**	**0.2**	**1.1**	**0.7**	**1.0**

Appendix 2 - Abundance of benthic fauna on suction sample stations

Group	Species	B1-1	B1-2	B1-3	B2-1	B2-2	B2-3	B2-4	B3-1	B3-2	B3-3	B3-4	B4-1	B4-2	B4-3
Bivalvia	Cultellus pelucidus														
	Dosinia lupinus									40					
	Hiatella arctica			80	40			40	40	80			120	80	
	Musculus discors								40						
	Mya truncata									40			40	40	
	Mysella bidentata	40												40	
	Mytilus edulis	4880	22560	8160	6160	11440	4280	18400	15720	3040	260	1240	15240	34720	2540
	Spisula elliptica														
	Tellina pygmaea														
	Thracia indet.														
	Thracia papyracea														
Cephalochordata	Branchiostoma lanceolatum														
Coelentarata	Edwardsia indet.														
Crustacea	Ampelisca typica														
	Amphithoe rubricata	40	160	240	40	160	120	200		40			320	440	150
	Aora typica									40					
	Apherusa bispinosa														10
	Apherusa jurinei													40	50
	Balanus improvisus			160		200							80		
	Bathyporeia elegans														
	Calliopius laeviusculus	40	360			80	40		160	80			80	320	20
	Caprella microtuberculata		80			80				40				80	
	Corophium bonelli				40				160	40					10
	Dexamine spinosa		40	200		40	80	80	200	40			120	240	70
	Dexamine thea														
	Galathea indet.								40						
	Galathea strigosa												40		
	Gammarellus homari			80				40					40	120	
	Gammarus indet.								40						
	Hippolyte indet.(pelagisk)														
	Idothea indet.		40											80	
	Jassa falcata	40	480		80	440	40	40	200	40	40	80	40	600	60
	Macropipus arcuatus														
	Microdeutopus gryllotalpa								40						
	Parajassa pelagica		40												
	Proboloides calcaratus														20
	Synchelidium intermedium														
	Xantho pilipes														10
Echinodermata	Asterias rubens	1200	360	2560	320	1520	800	1200	2160	675	300	1120	3360	1840	430
	Echinoidea														
	Psammechinus miliaris														
	Strongylocentrotus droebachiensis						80								
Gastropoda	Bittium reticulatum	320		40		120		280	200	40			160	320	30
	Dendronotus frondosus														
	Doto indet.														
	Hydrobia ulvae							40							

Group	Species	B1-1	B1-2	B1-3	B2-1	B2-2	B2-3	B2-4	B3-1	B3-2	B3-3	B3-4	B4-1	B4-2	B4-3
	Lacuna vincta		40			80		80	120				40	280	80
	Lunatia catena		40												
	Lunatia montagui														
	Onchidoris muricata	120	120	160		40			240	160		80	160	200	
	Onoba semicostata														10
	Polycera indet.														
	Rissoa albella		40												
	Rissoa indet.								40						
	Rissoa membranacea														
	Rissoa parva								40						
Nematoda	Nematoda	40	40	80	1400	840	200	400	360	80			640	2480	10
Nemertea	Nemertea			40				40							
Oligochaeta	Oligochaeta				40								40		10
Polychaeta	Autolytus edwardsi														
	Capitela capitata						400								
	Chaetozone setosa														
	Eulalia viridis		40												
	Eusyllis blomstrandi														
	Goniadella bobretzkii														
	Harmothoe imbricata	160				200	120	40	160	80			160	320	
	Harmothoe impar			40											10
	Harmothoe indet.		5			120			40	80		40		120	
	Heteronereis indet.							40		80					
	Kefersteinia cirrata	40					5								
	Lagisca extenuata												40		
	Lepidonotus squamatus					40									
	Malmgrenia glabra						40								
	Nephtys cirrosa														
	Nephtys kersivalensis														
	Nephtys pulchra														
	Nereidae											40			
	Nereimyra punctata					40									
	Nereis indet.							160		280	10			40	
	Nereis pelagica				40	50	70	70	80				50	10	10
	Ophelia limacina														
	Phyllodoce maculata														10
	Pisione remota														
	Polydora ciliata					40									
	Polydora cornuta							40							
	Proceraea cornuta	40				40							40	80	
	Protodorvillea kefersteini					5									
	Pseudomystides limbata														
	Spio filicornis				40									40	
	Spionidae														
	Streptosyllis websteri														
Polyplachophora	Tonicella marmorea												40		
Pycnogonida	Anoplodactylus exiguus														
Total number		**6960**	**24445**	**11840**	**8200**	**15575**	**6275**	**21190**	**20080**	**4995**	**610**	**2600**	**20850**	**42530**	**3540**

Group	Species	M1-1	M1-2	M3-1	M3-2	M3-3	M3-4	V1-1	V1-2	V2-1	V2-2	V2-3	V3-1	V3-2	V3-3
Bivalvia	Cultellus pelucidus													40	
	Dosinia lupinus														
	Hiatella arctica		40												
	Musculus discors														
	Mya truncata														
	Mysella bidentata														
	Mytilus edulis	1400	7480		2680		800	20800	5960	13840					
	Spisula elliptica													40	
	Tellina pygmaea			40											
	Thracia indet.					40									
	Thracia papyracea														40
Cephalochordata	Branchiostoma lanceolatum				10	40									
Coelentarata	Edwardsia indet.					80									
Crustacea	Ampelisca typica														40
	Amphithoe rubricata							120							
	Aora typica		80						80						
	Apherusa bispinosa	40	80					160	40	120					
	Apherusa jurinei														
	Balanus improvisus		120												
	Bathyporeia elegans										40				
	Calliopius laeviusculus	2800	40					2680							
	Caprella microtuberculata	4160	440				40	3640		40					
	Corophium bonelli		80												
	Dexamine spinosa	160	80					120	40	40					
	Dexamine thea		40												
	Galathea indet.														
	Galathea strigosa														
	Gammarellus homari								40						
	Gammarus indet.														
	Hippolyte indet.(pelagisk)													40	
	Idothea indet.														
	Jassa falcata	9720	960				40	10920	40	320					
	Macropipus arcuatus	40													
	Microdeutopus gryllotalpa				40										
	Parajassa pelagica	880						1120							
	Proboloides calcaratus	1160	120					2200							
	Synchelidium intermedium					40									
	Xantho pilipes														
Echinodermata	Asterias rubens	960	4800				40	840	920	480	40				
	Echinoidea													40	
	Psammechinus miliaris		40						120						
	Strongylocentrotus droebachiensis														
Gastropoda	Bittium reticulatum	40							40						
	Dendronotus frondosus	120													
	Doto indet.		40												
	Hydrobia ulvae														
	Lacuna vincta	1200	2680					2040	440	280					
	Lunatia catena														
	Lunatia montagui					40									
	Onchidoris muricata	240	560							80					
	Onoba semicostata														
	Polycera indet.		200												

Group	Species	M1-1	M1-2	M3-1	M3-2	M3-3	M3-4	V1-1	V1-2	V2-1	V2-2	V2-3	V3-1	V3-2	V3-3
	Rissoa albella														
	Rissoa indet.	80	40												
	Rissoa membranacea							40							
	Rissoa parva														
Nematoda	Nematoda	4600	120	80			80	320							
Nemertea	Nemertea			40	40		40	80					40	40	40
Oligochaeta	Oligochaeta														
Polychaeta	Autolytus edwardsi	40													
	Capitela capitata														
	Chaetozone setosa			40											
	Eulalia viridis	40	40					200							
	Eusyllis blomstrandi	80						360		40					
	Goniadella bobretzkii												40		40
	Harmothoe imbricata							40							
	Harmothoe impar							200							
	Harmothoe indet.	40	120												
	Heteronereis indet.														
	Kefersteinia cirrata														
	Lagisca extenuata														
	Lepidonotus squamatus														
	Malmgrenia glabra														
	Nephtys cirrosa					5									
	Nephtys kersivalensis												40		
	Nephtys pulchra											5		5	
	Nereidae														
	Nereimyra punctata														
	Nereis indet.	40													
	Nereis pelagica	160	50					160							
	Ophelia limacina			40	80	80	40			40		40	80		40
	Phyllodoce maculata														
	Pisione remota	40		480	680	80	160				40	320	40	40	120
	Polydora ciliata														
	Polydora cornuta	40													
	Proceraea cornuta				40										
	Protodorvillea kefersteini	80		120			120						40		
	Pseudomystides limbata				40										
	Spio filicornis			40											
	Spionidae											5			
	Streptosyllis websteri							40							
Polyplachophora	Tonicella marmorea														
Pycnogonida	Anoplodactylus exiguus	800						160							
Total number		**28960**	**18250**	**880**	**3610**	**405**	**1360**	**46240**	**7720**	**15280**	**120**	**370**	**280**	**245**	**320**

NERI **National Environmental Research Institute**
DMU Danmarks Miljøundersøgelser

National Environmental Research Institute, NERI, is a part of Aarhus University.

At NERI's website www.neri.dk you'll find information regarding ongoing research and development projects.

NERI undertakes research, monitoring and consultancy within environment and nature.

Furthermore the website contains a database of publications including scientific articles, reports, conference contributions etc. produced by NERI staff members.

Further information: www.neri.dk

National Environmental Research Institute
Frederiksborgvej 399
PO Box 358
DK-4000 Roskilde
Denmark
Tel: +45 4630 1200
Fax: +45 4630 1114

Management
Department of Arctic Environment
Department of Atmospheric Environment
Department of Environmental Chemistry and Microbiology
Department of Marine Ecology (main address)
Department of Policy Analysis (main address)

National Environmental Research Institute
Vejlsøvej 25
PO Box 314
DK-8600 Silkeborg
Denmark
Tel: +45 8920 1400
Fax: +45 8920 1414

Department of Freshwater Ecology
Department of Marine Ecology
Department of Terrestrial Ecology

National Environmental Research Institute
Grenåvej 14, Kalø
DK-8410 Rønde
Denmark
Tel: +45 8920 1700
Fax: +45 8920 1514

Department of Policy Analysis
Department of Wildlife Ecology and Biodiversity

NERI Technical Reports

NERI's website www.neri.dk contains a list of all published technical reports along with other NERI publications. All recent reports can be downloaded in electronic format (pdf) without charge. Some of the Danish reports include an English summary.

Nr./No.	2009
759	Control of Pesticides 2008. Chemical Substances and Chemical Preparations. By Krongaard, T. 25 pp.
758	Oplandsmodellering af vand og kvælstof i umættet zone for oplandet til Højvads Rende. Af Grant, R., Mejlhede, P. & Blicher-Mathiesen, G. 74 s.
755	Historisk udbredelse af ålegræs i danske kystområder. Af Krause-Jensen, D. & Rasmussen, M.B. 38 s.
754	Indicators for Danish Greenhouse Gas Emissions from 1990 to 2007. By Lyck, E., Nielsen, M., Nielsen, O.-K., Winther, M., Hoffmann, L. & Thomsen, M. 94 pp.
753	Environmental monitoring at the Seqi olivine mine 2008-2009. By Søndergaard, J., Schiedek, D. & Asmund, G. 48 pp.
751	Natur og Miljø 2009 – Del B: Fakta. Af Normander, B., Henriksen, C.I., Jensen, T.S., Sanderson, H., Henrichs, T., Larsen, L.E. & Pedersen, A.B. (red.) 170 s. (også tilgængelig i trykt udgave, DKK 200)
750	Natur og Miljø 2009 – Del A: Danmarks miljø under globale udfordringer. Af Normander, B., Jensen, T.S., Henrichs, T., Sanderson, H. & Pedersen, A.B. (red.) 94 s. (også tilgængelig i trykt udgave, DKK 150)
749	Thick-billed Murre studies in Disko Bay (Ritenbenk), West Greenland. By Mosbech, A., Merkel, F., Boertmann, D., Falk, K., Frederiksen, M., Johansen, K. & Sonne, C. 60 pp.
747	Bunddyr som indikatorer ved bedømmelse af økologisk kvalitet i danske søer. Af Wiberg-Larsen, P., Bjerring, R. & Clausen, J. 46 s.
746	NEC-2020 emission reduction scenarios. Assessment of intermediary GAINS emission reduction scenarios for Denmark aiming at the upcoming 2020 National Emission Ceilings EU directive. By Slentø, E., Nielsen, O.-K., Hoffmann, L., Winther, M., Fauser, P., Mikkelsen, M.H. & Gyldenkærne, S. 216 pp.
745	NuukBasic. Conceptual design and sampling procedures of the biological programme of NuukBasic. By Aastrup, P., Nymand, J., Raundrup, K., Lauridsen, T.L., Krogh, P.H., Schmidt, N.M., Illeris, L. & Ro-Poulsen, H. 70 pp.
744	Danish Emission Inventories for Stationary Combustion Plants. Inventories until year 2007. By Nielsen, M., Nielsen, O.-K., Plejdrup, M. & Hjelgaard, K. 216 pp.
743	Dioxin og biologisk effektmonitering i ålekvabbe i kystnære danske farvande. Af Strand, J., Bossi, R., Dahllöf, I., Jensen, C.A., Simonsen, V., Tairova, Z. & Tomkiewicz, J. 66 s.
742	Vildtbestande og jagttider i Danmark: Det biologiske grundlag for jagttidsrevisionen 2010. Af Noer, H., Asferg, T., Clausen, P., Olesen, C.R., Bregnballe, T., Laursen, K., Kahlert, J., Teilmann, J., Christensen, T.K. & Haugaard, L. 288 s.
741	Biodiversity at the Ecosystem Level – Patterns and Processes. Proceedings of the 2nd DanBIF conference, 26-27 April 2009. By Balslev, H. & Skov, F. (eds.). 44 pp.
739	Emission Inventory for Fugitive Emissions in Denmark. By Plejdrup, M.S., Nielsen, O.-K. & Nielsen, M. 47 pp.
738	Økologisk risikovurdering af genmodificerede planter i 2008. Rapport over behandlede forsøgsudsætninger og markedsføringssager. Af Kjellsson, G., Damgaard, C., Strandberg, M., Simonsen, V. & Krogh, P.H. 48 s.
737	Environmental monitoring at the former lead-zinc mine in Maarmorilik, Northwest Greenland, in 2008. By Schiedek, D., Asmund, G., Johansen, P., Rigét, F., Johansen, K., Strand J., & Mølvig, S. 70. pp.
736	Naturtilstand på terrestriske naturarealer – besigtigelser af § 3-arealer. Af Fredshavn, J.R., Nygaard, B. & Ejrnæs, R. 46 s.
735	Naturtilstand i habitatområderne. Habitatdirektivets lysåbne naturtyper. Af Fredshavn, J.R. & Ejrnæs, R. 76 s.
734	Undervandsplanter som indikatorer for vandkvalitet i søer. Af Søndergaard, M., Johansson, L.S., Jørgensen, T.B. & Lauridsen, T.L. 48 s.

ECOLOGY OF LÆSØ TRINDEL – A REEF IMPACTED BY EXTRACTION OF BOULDERS

The reef Læsø Trindel is subjected to a major restoration in the coming years rebuilding the reef as a cavernous stable reef. The baseline study presented in this report documented that the seaweed forest on the reef was dominated by relatively low macroalgal biomasses compared to reef areas with many large stable boulders. The algal vegetation was dominated by small perennial species and fast growing opportunistic species. Bryozoans living on the algal leaves made up the vast majority of the fauna biomasses. The fish community was dominated by species from the wrasse family with only few commercially interesting species present. Lobsters were not caught within the project area but in few numbers outside the area. Gammaridae were the most important pray species in both the goldsinny wrasse and cod. Acoustic tagging of cods proved the importance of the reef as a feeding ground during night time in June.

ISBN: 978-87-7073-145-4
ISSN: 1600-0048