


Recently, there has been increasing interest in releasing ("seeding") bivalves onto the seabed for purposes of aquaculture or population enhancement. The success of such enterprises has varied greatly and is related to the interactions between mortality, dispersal, and growth of the organisms. In this paper, we have constructed a stage-based matrix model for short-term population dynamics of seeded sea scallops (*Placopecten magellanicus*). Our goals were to predict scallop survival to commercial size and to determine the relative contributions of predation, dispersal, and growth to loss of scallops. Competing risk theory was used to account for predation by crabs and by sea sears, and for correlations between dispersal and predation (both of which depend on encounters with predators). Density dependence in the form of predator functional responses, seasonal variation, and a simple spatial structure were also incorporated into the model. The model was parameterized from the results of small-scale experiments and tested against independently observed population trajectories. Uncertainty analysis was used to determine the effect of parameter sampling error on model output. Sensitivity analysis indicated that variables affecting predation by crabs were important and that variables affecting intermediate-sized scallops (e.g., large juveniles) were more important than those affecting other size classes. Using perturbation analysis, we ranked alternative management scenarios for increasing final scallop survival from the most effective to the least effective as follows: reducing predator densities, increasing size of seeded scallops, changing the initial density of seeded scallops, increasing the dimensions of the site, and changing the season of seeding. Inclusion of seasonal variability in predator densities (thereby converting the deterministic model into a stochastic model) did not greatly change final scallop survival.


The efficiency and selectivity of spring-toothed scallop dredges was assessed using a concurrent depletion experiment and diver survey of dredge tracks on a north Irish Sea fishing ground. Two size classes of the scallop, Pecten maximus (L. 1758), were examined: below minimum legal landing size (MLLS), (90-109 mm shell length (SL)) and above MLLS (> 109 mm SQ. Estimates of efficiency from the depletion experiment (24.3% and 29.5% respectively) were consistently lower than those from the diver surveys (38.0% and 40.7% respectively). This difference appeared to be due to inherent variation in the efficiency of scallop dredges rather than bias from either technique. This emphasizes the need for error terms to be built into estimates of dredge efficiency. The diver survey also found that dredges were highly selective toward scallops greater than 90 mm SL, catching only 3.0% or less of individuals below this size. Consequently, the diver survey provided a much more accurate assessment of scallop size and age composition than dredge surveys. Dredge efficiency was also assessed for four species of benthic fauna commonly taken as by-catch in the local fishery.

Estimates of efficiency from the depletion experiment were found to include a considerable amount of indirect fishing mortality. When efficiency was defined as total mortality due to fishing (the combination of catch and indirect fishing mortality), estimates from the depletion experiment and diver surveys were in close agreement. For two species, Luidia ciliaris (Phillipi 1837) and Cancer pagurus (L. 1758), these efficiency or total mortality estimates were approximately 45% and 68% respectively, emphasizing the impact scallop dredging might have on non-target species. In summary, we recommend that if possible, depletion experiments should be combined with diver surveys when assessing scallop dredge performance. Diver surveys provided additional information on dredge selectivity along with an improved measure of the variance in dredge efficiency estimates.


Benthic community data collected between 1938 and 1950 by N.S. Jones were compared with modern samples from seven sites in the Irish Sea. Multivariate and univariate methods were used to compare community change over time and examine the possible impact of scallop dredging over the 60 year time period. A conservative approach to data analysis ensured that observed differences in faunal composition between time periods were not due to differences in sampling methodologies or taxonomic identification. The community composition changed at all sites, though to different degrees. The amount of change was related to how long a site had been fished, rather than fishing intensity. Mobile, robust and scavenging taxa have increased in abundance, while slow-moving or sessile, fragile taxa have decreased. Differences between historical and modern samples were greater than could be accounted for by the natural variability of the system (as indicated by spatial and temporal replication at three sites) and indicate real long-term change. This study emphasises that in the absence of good-quality data series and experiments, the use of 'fuzzy' historical data is often the only possible way to judge long-term change and can yield valuable results. (C) 2002 Elsevier Science B.V All rights reserved.


Gravelly sea-bed communities around the Isle of Man, Irish Sea, are very heterogeneous in terms of both epi- and infauna. This patchiness is found at a wide range of spatial scales. This paper reviews the results of a large study which investigates disturbance by scallop dredging from the large- (fishing grounds) to the small-scale (experimental plots).
Commercial dredging for scallops and queen scallops disturbs, and may be a factor in structuring, benthic communities on these gravelly substrata.

Community composition can be shown to be related to the intensity of commercial dredging effort; this is confirmed by dredging experiments in an area closed to commercial fishing.

The effect of scallop dredge disturbance on gravelly sea-beds may differ from that of bottom fishing on other soft sediments due to the extreme patchiness of animal distribution, greater abundance of epifauna and to the combined effect of the heavy, toothed scallop gear and stones caught in the dredges.

The underlying patchiness of gravelly bottom benthos necessitates the study of dredge disturbance on many spatial scales and with a high degree of replication.


A 2 km² area off the southwest coast of the Isle of Man (Irish Sea) has been closed to commercial fishing with mobile gear since March 1989. This area was heavily fished for Pecten maximus (Linnaeus, 1758) prior to closure, and the seabed immediately surrounding the closed area is still one of the most heavily dredged in the Irish Sea. Two methods have been used to study the effect of scallop dredging on the benthos in this closed area and adjacent fished areas. Firstly, twice-yearly grab sampling of experimental plots inside and outside the closed area since 1995 has enabled comparisons of the benthic infauna and epifauna of experimentally dredged plots, undredged control plots and plots exposed to commercial dredging. Secondly, divers have carried out visual transect surveys of P. maximus numbers regularly since closure. Communities of experimentally disturbed plots have become less similar to adjacent undisturbed control areas and more similar to commercially dredged areas. At each sampling date, similarity between dredged samples was greater than between undredged samples. Since 1989, there have been increases in the mean numbers of P. maximus in the closed area. The age structure of the closed area P. maximus population is also different to that outside, with a higher mean age due to the presence of large, old individuals. These results present strong evidence that scallop dredging alters benthic communities and suggest that the closure of areas to commercial dredging may allow the development of more heterogeneous communities and permit the populations of some species to increase. A common problem with studying fishing disturbance is the lack of good control sites and this work also demonstrates the value of closed areas to scientific studies of demersal fishing.


Brand, A. R. and K. L. Prudden (1997). The Isle of Man scallop and queen fisheries: past, present and future, Report to Isle of Man Department of Agriculture, Fisheries and Forestry by Port Erin Marine Laboratory, University of Liverpool


NOAA's State of the Coast Report. Silver Spring, MD, NOAA


The epibenthic fauna dredged in the channels of the Wadden Sea of Schleswig-Holstein is dominated by crustaceans. Mean species richness is lower in a southern region (7.6 +/- 2.2 species haul(-1)) which is part of the Elbe estuary and lacks protective barrier islands. A northern region is more marine and is protected by a seaward barrier of high sands and islands. Here mean species richness is 10.9 +/- 2.8. Within channels, there is no significant inshore-offshore gradient, and species number does not increase with depth. Stratified sampling near the island of SyIt revealed that abundance and diversity are high along the gentle upper slope (5 m depth) of channels when mussels are present, but low in the absence of mussels. Abundance and diversity are also low along the steeper slope below (at 10 and 15 m depth). In a channel with scattered stones and boulders, highest diversity (16.0 +/- 5.1) and dense epibenthic assemblages were encountered along the upper and middle slopes (5 and 10 m). Comparisons with historical surveys suggest that a decline of nearly fifty per cent of all epifaunal species within the last hundred years may be attributed to fishery disturbances.


Burnell, G. M. (1983). Growth and reproduction of the scallop Chlamys varia (L.) on the
west coast of Ireland, National University of Ireland, Galway.


A marked increase in scallop dredging has recently occurred in Jervis Bay, New South Wales, and implications made that the dredges destroy weed beds leaving a trail of dead or badly damaged scallops. Investigations were conducted by New South Wales State Fisheries biologists and it was found that damage to the seafloor was minimal and temporary. The scallop population structure seems unchanged compared with 1970-71 data. However, there is little doubt that some scallops are damaged by the passage of the dredges, but in some cases this is simply due to the dredges being towed too fast. The ratio of damaged to undamaged scallops is small.


Caddy, J. F. (1988). A perspective on the population dynamics and assessment of


The efficiency of fishing gear is assessed in relation to queens (Chlamys opercularis) behaviour. Divers observed queens' swimming behaviour during trawling and suggest that they are able to detect the approaching gear well in advance. They move in short bursts of swimming but after 7 or 8 bursts become exhausted.


Chícharo, L., J. Regala, M. Gaspar, F. Alves and M. A. Chícharo (2002). "Reburial time


The capture of immature fish in many commercial fisheries is controlled by restricting the use of fishing gears or elements of fishing gears that prevent the escape of immature fish. Improving the selective characteristics of fishing gear is based on the assumption that fish escaping are not seriously damaged and able to make a complete recovery. If fish escape and die as a direct result of stress and injuries or indirectly due to disease and predation associated with gear damage, then increasing the opportunity for escape by improving selectivity may result in an increased level of unaccounted fishing mortality. This paper identifies the main fishing gear types used for harvesting marine and freshwater fish, a range of injuries, stress reactions and mortalities that can occur during capture and escape. It is concluded that immediate and delayed mortalities can occur in fish escaping from fishing gears and that the high variation in mortality rates within experiments is associated with a lack of information on how fish condition is affected by various fishing stressors and the type and severity of physical damage received. Improving selectivity without reducing damage or stress incurred during capture and escape may not be the most appropriate way of protecting immature fish.


1. The effects of towed bottom-fishing gear on benthic communities is the subject of heated debate, but the generality of trawl effects with respect to gear and habitat types is poorly understood. To address this deficiency we undertook a meta-analysis of 39 published fishing impact studies.

2. Our analysis shows that inter-tidal dredging and scallop dredging have the greatest initial effects on benthic biota, while trawling has less effect. Fauna in stable gravel, mud and biogenic habitats are more adversely affected than those in less consolidated coarse sediments.

3. Recovery rate appears most rapid in these less physically stable habitats, which are generally inhabited by more opportunistic species. However, defined areas that are fished in excess of three times per year (as occurs in parts of the North Sea and Georges Bank) are likely to be maintained in a permanently altered state.

4. We conclude that intuition about how fishing ought to affect benthic communities is generally supported, but that there are substantial gaps in the available data, which urgently need to be filled. In particular, data on impacts and recovery of epifaunal structure-forming benthic communities are badly needed.


Data on growth of the black scallop Chlamys varia were obtained by tagging, raft cage rearing, reading winter growth rings, and analysis of length-frequency distributions. Von Bertalanffy growth curves were fitted to each set of data by least-square regression techniques involving no transformation of variates. The results obtained by the different methods are comparable except for those obtained by length-frequency distribution analysis. Length-frequency distribution analysis seems to be complicated by the presence of a biannual recruitment. Counting growth rings seems to be a more accurate and easier method for growth estimates. The sizes at rings are different for individuals born in spring and for those born in autumn; the growth curves derived for these two types of animals remain different throughout their whole life. The relative proportions of individuals originating from each of the two recruitment groups have remained remarkably homogeneous for the last five years. Comparative study of the allometric relationships between length and width of the shell of the animals from the two recruitment groups showed no significant difference.


Dare, P. J., D. Key, C. D. Darby and P. M. Connor (1993). The efficiency of spring-loaded dredges used in the western English Channel fishery for scallops, Pecten
Three experiments were conducted to measure the overall efficiency of commercial dredges used to survey scallop stocks. Marked animals were laid on four plots located in the Cornish fishery on inshore and offshore grounds ranging from smooth, sandy or muddy gravels to rougher, stony substrates. Efficiency at catching each 5mm size (shell height) class of scallop was estimated by comparing mean numbers of releases and recaptures per 1000m² of seabed.

The gear was highly size selective and of low efficiency overall with substrate-dependent variations. For these commercial dredges, with spring loaded tooth bars and 75mm belly and back meshes, mean efficiency at catching legally fishable (>90mm) scallops ranged from 6% (rough ground) to 41% (smooth muddy gravel). On the most widespread offshore ground type (sand and fine gravels) efficiency on two plots averaged 22%, but it fell rapidly with decreasing scallop size to 1.4% at 65mm and to only 0.2% at 45mm.

Dredge efficiency is the resultant not only of a two-stage selection and retention process (by toothbar and meshes) but of complex interactions between the gear, the seabed, hydrodynamic forces and the behaviour of the scallops themselves. Overall, spring loaded dreges retain rather few juvenile scallops and, although most effective on moderately soft grounds, their efficiency generally is low.


De Jonge, V. N., Van Der Berghs. (1987). "Experiments on the resuspension of


Activities.


In order to have a better understanding of recessing in great scallop, *Pecten maximus* and consequently the causes of mortality at reseeding, this study has monitored, at different seasons, the dispersion and recessing of different sizes of juveniles (about 15, 30 and 45 mm, called 'small', 'medium' and 'large') after seeding. Moreover, the aim was to see when small spat (15 mm) could be seeded, and thus reduce the costs of intermediate culture. Three monitoring approaches were used together: (1) continual observations by remote video camera, of a defined area (less than 1 m²) containing 10 scallops from each size group; (2) daily monitoring of behaviour with divers along three bottom lines, with 20 x 1 m² plots each and nine marked scallops per plot; and (3) the biochemical content of the muscle: adenylic energetic charge and storage of energy reserves (glucides, proteins, lipids). The video monitoring identified but did not quantify predator behaviour, particularly at night. The role and behaviour of spiny crab, *Maia squinado*, and of small predators has clearly been shown, such as: (a) small crustaceans, *Inachus* sp., breaking the edges of scallop valves; and (b) small gobies, *Pomatoschistus pictus*, pecking the tentacles of the scallop mantle. For the monitoring by divers, filtering appeared much too difficult to look at for it was very disturbed by divers, and anyway the resumption of filtering came immediately after seeding. On the other hand, diver monitoring of dispersal and recessing was quite easy to do with a minimum of practice. On the basis of dispersal, the best seasons for seeding appear to be spring or summer.
In autumn, two-thirds of 'small' and 'medium' juveniles are missing 3 days after seeding, but we could not observe whether they had been eaten by predators or had just moved and recessed farther. There was no experiment in winter owing to adverse conditions for scallop seedings. Biochemical analyses confirmed the unsuitability of autumn for scallop seeding, because of very low glucide content in this season. The adenyllic energetic charge in the smooth part of the muscle showed that stress before seeding (aerial exposure, handling), and post-seeding behaviour (swimming, recessing) have a high energetic cost for scallops. In summer and autumn, 3 days after seeding, none of the three size batches recovered their initial vitality.


The scallop Chlamys varia was found associated with an enveloping epizoitic growth of the sponge Halichondria panicea. The bivalve was protected against predatory starfishes by the sponge which interfered with the attachment of tube feet and made the vulnerable byssal opening and valve margins inaccessible to the predator's gastric membranes. Protection was partial or complete depending upon the species of starfish and relative sizes of predator, prey, and epizoite. The effectiveness of the pectinid escape response was enhanced by the sponge which enabled the mollusc to dislodge attacking asteroids. The sponge benefited from an increased supply of suspended nutrients generated by the inhalant current of the host. The partnership is a commensal-protective mutualism of an unspecialized and probably facultative nature. The association has not been reported before although it may have a wide distribution, at least on the Atlantic coast of Ireland.


commercial fishing operations." Nature Conservancy Council.


Long-term monitoring of 2 benthic stations off the Northumberland coast, NE England, at 80 and 55 m depth, has been carried out since 1971. The 80 m station is located within a Nephrops norvegicus fishing ground, while the 55 m station is located outside of the main fished area. In this study we compare the fauna of the heavily fished site with that of the shallower site over a period during which fishing effort changed. Changes in macrofaunal abundance at the station outside the fishing ground reflected changes in organic input. This was also the case at the fished station except during the period of highest fishing activity when this relationship broke down. This suggests that the dynamics of the macrobenthos at this station were influenced by fishing activity. Individual taxa were categorised a priori, based on literature accounts of their response to fishing. At the site outside the fishing ground the proportion of individuals predicted a priori to increase and that predicted to decrease in response to the direct effects of fishing did not vary. At the heavily fished station the increase in fishing effort in the early 1980s did not alter the abundance of the taxa predicted to decline, but the abundance of individuals in taxonomic groups predicted to increase did change in the predicted direction. The differences in the dynamics of the 2 stations, which differed in their fishing intensity, provide some evidence for a role of direct effects of fishing in determining the abundance and composition of coastal macrofauna.


cytochemistry by a new technique " J Histochem Cytoch 14 291-302.


Maerl beds are little studied shallow marine habitats that have a patchy distribution around the British Isles. They are mixed sediment deposits built by a surface layer of slow growing coralline seaweeds that are of international conservation significance. Baseline information is provided on the high diversity and abundance of mollusc assemblages associated with Scottish maerl deposits. Commercial extraction and the use of towed demersal fishing gears kills the plants upon which survival of this habitat depends. The molluscan fauna of a site impacted by scallop dredging is compared with that of an unimpacted site. The need to conserve maerl habitats is highlighted as there is concern over the extent to which maerl beds are being disturbed in Europe and how activities such as scallop dredging affect the ecology of these fragile nearshore habitats.


Maerl beds are mixed sediments built by a surface layer of slow-growing, unattached coralline algae that are of international conservation significance because they create areas of high biodiversity. They are patchily distributed throughout Europe (to similar to 30 m depth around the British Isles and to similar to 120 m depth in the Mediterranean) and many are affected by towed demersal fishing. We report the effects of Newhaven scallop dredges on a previously unfished maerl bed compared with the effects on similar grounds that have been fished commercially in the Clyde Sea area; Scotland. Sediment cores were taken to assess the population density of live maerl thalli prior to scallop
dredging on marked test and control plots. These plots were then monitored biannually over a four-year period. Live maerl thalli were sparsely distributed at the impacted site, and experimental dredging had no discernible effect on their numbers. The previously unfished ground had dense populations of live maerl and scallops (both Aequipecten opercularis and Pecten maximus). While counts of live maerl remained high on the control plot, scallop dredging led to a >70% reduction with no sign of recovery over the subsequent four years. The vulnerability of maerl and associated benthos (e.g., the delicate bivalve, Limaria hians) is discussed in relation to towed demersal fishing practices. (C) 2000 International Council for the Exploration of the Sea.


The great scallop Pecten maximus (Bivalvia: Pectinidae) supports a substantial European fishery with a recent history of declining catches caused by over-
exploitation. The sustainable exploitation of shellfish populations requires knowledge of the extent to which commercial grounds are reproductively self-sustaining or supplied with larvae originating from further afield. The degree of genetic differentiation between locations can provide important indirect evidence, reflecting the pattern and scale of effective larval dispersal. Pecten maximus were sampled from five locations around the Isle of Man, from Mulroy Bay (Ireland) and from Plymouth. Restriction-site variation was investigated in two PCR-amplified mitochondrial DNA fragments of 2 and 3 kb, respectively. Haplotype and nucleotide diversity within populations, and nucleotide divergence between populations, were calculated. Mean nucleotide sequence divergence was corrected for within-population polymorphisms and visualized by UPGMA cluster diagrams. Molecular analysis of variance (AMOVA) was carried out. Results showed low levels of population differentiation. Slight but significant differentiation between Isle of Man populations was revealed, with East Douglas appearing distinct from the remaining Manx locations. The analyses also indicated the distinction of Mulroy Bay from the other populations, and the lowest genetic variability was recorded from this enclosed habitat. This probably reflects the relative isolation of Mulroy Bay, whereas dynamic hydrographic conditions in the Irish Sea and the Channel may generally ensure extensive mixing of the planktonic larvae.

Heipel, D. A., J. D. D. Bishop, A. R. Brand and J. P. Thorpe (1998). "Population genetic differentiation of the great scallop Pecten maximus in western Britain investigated by randomly amplified polymorphic DNA." Marine Ecology Progress Series 162: 163-171. Randomly amplified polymorphic DNA (RAPD) banding patterns were compared between samples of the same year class of the scallop Pecten maximus (L.) from 5 locations (beds) within the commercial fishing grounds around the Isle of Man (UK). Phenotypic analysis of molecular variance (AMOVA) indicated that significant differentiation was present between these beds, although this accounted for only 2% of total variation, the remainder being between individuals within beds. As confirmed by multivariate analyses (PCOORD and UPGMA clustering), samples from the 2 northern Isle of Man beds resembled each other particularly closely, as did 2 southwestern beds, while the fifth, East Douglas, was relatively distinct. Comparison was extended to 2 samples taken outside the Irish Sea, from Mulroy Bay (Co. Donegal, Eire) and Plymouth (southwest England). Differentiation between the 3 regions was significant, accounting for 7% of total variation in a data set with balanced regional representation. A Mantel test on the whole data set revealed no significant correlation of phenotypic distance, based on RAPD banding pattern, with geographic distance. The potential correlation was largely destroyed by the marked differentiation of the population in Mulroy Bay, a semi-enclosed sea lough, and by the unexpectedly high phenotypic similarity between the Plymouth sample and the 2 northernmost Isle of Man samples. The RAPD data presented here provide the first evidence of population genetic structuring in exploited open-water stocks of this species, since previous allozyme studies of P. maximus have indicated genetic uniformity. Differentiation of the Mulroy Bay population from open-water stocks has been demonstrated previously in a study of mtDNA polymorphisms.


From 1946 to 1951 Dr N. S. Jones sampled the benthos around the south of the Isle of Man from over 200 sites. Multivariate methods have been used here to compare subsets of this historical data with recent data from the same locations: of these locations some have been subject to heavy scallop dredging over the intervening 40 plus years and some to little dredging. Clear changes were apparent regardless of scallop dredging intensity. Some of the changes in the heavily dredged areas were those expected to result from extreme physical disturbance-an increased polychaete mollusc ratio, loss of some fragile species, and an increase in the predominance of scavenger/predator species. However, changes in the lightly dredged areas also included the loss of a number of species including some potentially fragile tube-dwellers. Reasons for these changes were not apparent. (C) 1999 Academic Press.


disturbance in the Scotia-Fundy region, Industry Services and Native Fisheries Branch. Project Report No. 166


Bottom trawling causes chronic and widespread disturbance to the seabed in shallow shelf seas and could lead to changes in the trophic structure and function of benthic communities, with important implications for the processing of primary production and the wider functioning of the marine ecosystem. We studied the effects of bottom trawling on the trophic structure of infaunal and epifaunal benthic communities in 2 regions (Silver Pit and Hills) of the central North Sea. Within each region, we quantified long-term (over 5 yr) differences in trawling disturbance at a series of sites (using sightings data from fishery protection flights), and related this to differences in the biomass and trophic structure of the benthic community. There were 27- and 10-fold differences in levels of beam trawl disturbance among the Silver Pit and Hills sites respectively, and we estimated that the frequency with which the entire area of the sites was trawled ranged from 0.2 to 6.5 times yr\(^{-1}\) in the Silver Pit and 0.2 to 2.3 times yr\(^{-1}\) in the Hills. The impacts of fishing were most pronounced in the Silver Pit region, where the range of trawling disturbance was greater. Infaunal and epifaunal biomass decreased significantly with trawling disturbance. Within the infauna, there were highly significant decreases in the biomass of bivalves and spatangoids (burrowing sea-urchins) but no significant change in polychaetes. Relationships between trophic level (estimated using nitrogen stable isotope composition, delta N-15) and body mass (as log(2) size classes) were rarely significant, implying that the larger individuals in this community did not consistently prey on the smaller ones. For epifauna, the relationships were significant, but the slopes or intercepts of the fitted linear regressions were not significantly related to trawling disturbance. Moreover, mean delta N-15 Of the sampled infaunal and epifaunal communities were remarkably consistent across sites and not significantly related to trawling disturbance. Our results suggest that chronic trawling disturbance led to dramatic reductions in the biomass of infauna and epifauna, but these reductions were not reflected in changes to the mean trophic level of the community, or the relationships between the trophic levels of different sizes of epifauna. The trophic structure of intensively trawled benthic invertebrate communities may be a robust feature of this marine ecosystem, thus ensuring the efficient processing of production within those animals that have sufficiently high intrinsic rates of population increase to withstand the levels of mortality imposed by trawling.


Effects of scallop dredging on gravelly seabed communities.


Fish move in rapidly. Feed on damaged animals AND scavenging invert species.


The passage of a beam trawl across the seabed leads to the direct mortality, or indirect mortality through subsequent predation, of some benthic species. In addition, animals retained in, or those that pass through, the cod end may also die as a result of the fishing process. The extent of this additional mortality needs to be quantified to calculate total mortality of non-target species associated with this type of fishery. Hence, we investigated the survival of animals caught by a 4 m beam trawl, in order to identify those species most sensitive to capture. Starfishes, hermit crabs and molluscs were highly resistant to the effects of capture (>60% survived in all cases). Fishes (except dogfish), sea urchins and swimming crabs suffered higher mortality after capture. Generally, the majority of the animals that passed through the meshes of the cod end survived. Experimental investigation of the cause of damage to certain species concluded that the chain matrix fitted to the gear.
was largely responsible for the injuries sustained. The types of injuries and their extent were species-specific, and were related to the fragility and physical characteristics of each species. Our experiments revealed that while some species are highly sensitive to capture, others are capable of surviving the effects of capture.


Labbé (1983). Contribution à l'étude de la dynamique d'exploitation du stock de
The feeding successes of four species of crabs (Crustacea: Brachyura) which are potential predators of the scallop *Pecten maximus* (L.) were studied under laboratory conditions. When provided with scallops of 4 and 5 cm shell height, *Liocarcinus depurator* (L.) did not consume any scallops whereas *Liocarcinus puber* (L.), *Carcinus maenas* (L.) and *Cancer pagurus* (L.) ate both size groupings but with varying success. The differences in the number of scallops eaten paralleled crab size such that *C. pagurus*, the species with the largest individuals (ca. 10.4 cm carapace width), ate the most, and small crabs (<5.5 cm carapace width), irrespective of species, ate none or very few scallops. Further experiments with *C. pagurus* and a wider size range of scallops (3-9 cm shell height) revealed the following trends: as prey size increased, the proportion of crabs feeding decreased and there was minimal predation on scallops >=7 cm shell height; male and female crabs showed similar predatory behaviour; and marine fouling on shells had no significant impact on crab feeding (X^2_2 test, P > 0.05). These findings are discussed in relation to the potential for bottom culture of *P. maximus*.
of new grounds and to depletion of the downstream population respectively.


Mason, J. and J. S. Colman (1955). Note on a short-term marking experiment on the scallop Pecten maximus (L.) in the Isle of Man, University of Liverpool. 67

Mattei, N. and M. Pellizzato (1997). Mollusk fisheries and aquaculture in Italy, NOAA.129,3


Causes of natural mortality include summer water temperatures too low for spawning or for larval development, flushing of basins by "tropic tides", lethal saltations in summer water temperature, predators and shell pests. Mass mortalities due to pathogenic micro-organisms are not known. Causes of fishing mortality include bottom damage by dragging, damage by turbulence in drags, dumping on deck, culling, shovelling, air exposure and shucking. Fouling of beds by discarded rims, and pressure changes, probably are not causes of mortality. Natural mortality has been estimated as 10% for adult scallops but there is no reliable figure. Present methods destroy 10% of discards (scallops returned to bottom) off Digby, Nova Scotia, and 2-20% on Georges Bank due to practices resulting in long air exposure and much mechanical damage. Dickie (1955) estimated that 20% of the scallops off Digby were removed each year by fishing (dragging). There is no satisfactory estimate of direct fishing mortality for Georges Bank.


Scallops (Pecten maximus) held within lantern nets, at depths exceeding 16 m for 35-129 days in two deep water bays, spawned when raised near the sea surface in June or July. All four attempts produced spawning scallops following a 1.1-2.4 degree C rise in temperature.


The adult populations of the scallop (Pecten maximus) and of flame shells (Lima hians) have declined in the North Water of Mulroy Bay on the north coast of Ireland. Settlements of these and some other bivalve species either failed or
were reduced. These events relate well to the first introduction and subsequent increased use of organotin net-dips on salmonid farms in this Bay. The last use of these net-dips was during the spring of 1985. In 1986 there was a good settlement of scallops, and settlements of other bivalves were recorded except for flame shells. Levels of TBT in adult scallop tissue in the North Water are high, 0.7 μg g⁻¹ wet wt; levels determined in other species were much lower.


Workshop, Aberdeen, Scotland.


selection in alternate-haul experiments." *Fisheries Research* 27(1-3): 113-129.


Ecodredge References.enl


1. Man has increased the input of carrion to marine communities worldwide through the practice of discarding fisheries-derived material. A large proportion of discarded material sinks to the sea bed and becomes available to benthic scavengers. Carrion from fisheries discards will subsidize marine food webs, which can sometimes result in the enhancement of consumer populations. 2. This study examines the benthic scavengers that feed on fisheries discards in three habitats in the Irish Sea. We investigated the relationship between the abundance of scavengers feeding on carrion in terms of numbers of each species and the density of those scavenger species in the surrounding area. 3. Observations with baited time-lapse cameras at a site offshore From Anglesey showed that the hermit crab Pagurus bernhardus was attracted to carrion in greatest abundance and aggregated at densities of up to 330 m(-2). At Red Wharf Bag, a wider range of species was observed: starfish Asterias rubens, hermit crabs P. bernhardus, whelks Buccinum undatum and swimming crabs Liocarcinus spp. There was relatively little scavenging activity at the Walney Island site where the edible crab Cancer pagurus appeared to consume the greatest proportion of the carrion. 4. Numbers of each scavenger species at the bait were only partially related to the background population density of each species at each site. The rate of consumption of carrion varied between sites and could be related to the abundance of different scavenger species at the bait. 5. Baited traps were used to investigate those benthic scavengers that were too small to be observed by time-lapse photography. The traps caught a variety of amphipod and isopod species. Some species were habitat-specific, whereas others were ubiquitous, but specialized in eating a particular type of carrion; for example, Orchomene nanus, which was only caught in traps baited with crab. 6. The results demonstrated that the responses of scavengers to fisheries discards varied between different habitats. The responses of hermit crabs, P. bernhardus, were particularly variable, with large aggregations of individuals occurring at one site but not at others, despite similar background population densities.


Five populations of C. varia, on the west coast of Ireland were sampled by diving. Growth in trays was investigated and an experiment was performed on the artificial collection of spat. Population density differed between sites and greatest length occurred where densities were lowest. Growth in trays at Ballynakill Harbour could be approximated by the Bertalanffy model. The growth curve estimated from checks on shells from the natural population at the same site was comparable with that obtained from the tray experiment. Spat were successfully collected on monofilament nylon held off the bottom in onion bags.
Best results were obtained in enclosed bays and their appear to be 2 major spatfalls during the summer.


Rolfe, M. S. (1973). Notes on queen scallops and how to catch them. Shellfish Information Leaflet 27., Ministry of Agriculture Fisheries and Food


Rudders, D. B., W. D. Du Paul, J. D. Lange Jr and K. D. Goff (2001). Survey methodology for the evaluation of the sea scallop Placopecten magellanicus population in the mid atlantic closed areas. ICES Working Group on Fishing Technology and Fish behaviour, Seattle, USA, ICES.


A rock rake or drag is used inshore off the coast of Maine to commerciallt harvest sea scallops, *Placopesten magellanicus* (Gmelin). The gear is designed for use in rocky habitat. In Swans Island conservation Area, recently closed to commercial dragging, scallop habitat is extremely variable with respect to substrate type. Tests tows showed the drag fished differently in response to catch weight, tow direction, and less than 25% changes in tow speed and scope of the warp. Incidental damage was significantly higher on rock than sand substrate; 25.5% vs 7.7% in 1988 experiments. The dominant types of damage were chipped shell margins and separated hinges. The severity of damage may be related to catch weight and number of tows impacting an individual. No relationship was observed between scallop shell size and incidental damage rate.


sediment-water exchange of phosphate in North Sea continental margin sediments."

Smaal, A. C. and J. Widdows (1994 ). The scope for growth of bivalves as an
integrated response parameter in biological monitoring. . Biomonitoring of coastal


Gear on the Sea Floor of New England., Boston, Massachusetts, Conservation Law
Foundation.

Summary: This paper is a brief review of five major gear types used in New
England that contact the sea floor during their operation: bottom trawls, scallop
dredges, gill nets, hooks, and lobster traps. Each gear type is outlined in terms
of technical evolution, bycatch, selectivity, and management issues. The review
emphasizes how the gear interacts with bottom habitat and the possible impacts
of this interaction. The paper concludes that cumulative fishing impacts of each
gear type need to be identified in order to define appropriate fishing
levels/strategies.

Proceedings of the World Symposium on Fishing Gear and Fishing Vessel Design, St.

no litoral Norte da costa portuguesa nos meses de Maio/Junho e Outubro de 1986."
Relatórios Técnicos e Científicos do INIP, Lisboa nº17: 15p.

Veneto. Piano per il rilevamento delle caratteristiche qualitative e quantitative dei corpi
idrici della Regione Veneto. III: 7-12.

(Bivalvia) with comparative notes on four allied species, University of Liverpool.


responses of Macoma balthica to copper pollution in the Baltic." Oceanol. Acta. 22:
431-439.


and biomass: a field test in a non-boreal intertidal habitat." Marine Ecology Progress Series 100: 103-109.


Proceeding of the 3º Symposium on the Iberian Atlantic Continental Margin, Faro, Ciacomar, Universidade do Algarve.


The impact of demersal fishing gears on benthic habitats and species has been the subject of much attention recently, and suggestions have been made that scavenging epifaunal species may benefit at the population level from the additional food source provided by discards. This paper investigates some aspects of this process, including the relative attractiveness to predators of different discard species, and the role of damage in scavenger attraction. A time-lapse video system with a 1000 m long cable was positioned in an area closed to fishing, adjacent to the most heavily fished scallop (Pecten maximus) ground in the Irish Sea. A variety of undamaged and damaged by-catch animals were positioned in front of the camera, and the subsequent predator aggregations investigated. Densities of scavenger species up to 200 times that
of the background population were observed, and aggregations of some species persisted for up to 3 days. The most frequently recorded scavengers, and therefore presumably those species most likely to benefit from discards as a food source, were: Asterias rubens L., Astropecten irregularis (Pennant), Liocarcinus spp Stimpson, Pagurus spp Fabricius and Callionymus lyra L. Predator attraction to apparently undamaged queen scallops, Aequipecten opercularis (L.), was almost as high as to damaged A. opercularis. Of all the prey species studied, queen scallops were the most attractive to scavengers. A directional relationship was found between the ambient water current and the arrival of the starfish, Asterias rubens. (C) 2000 Elsevier Science B.V. All rights reserved.


This paper examines spatial differences in the distribution of by-catch assemblages from the scallop [Pecten maximus (L.) and Aequipecten opercularis (L.)] fishing grounds in the North Irish Sea, during 1995. The sites examined have been exposed to differing known levels of fishing disturbance by scallop dredging, based on unusually high-resolution data extracted from fishermen's logbooks. Uni- and multi-variate techniques have been used on a production dataset (a value which incorporates both abundance and biomass figures), as well as abundance and biomass data individually. The original species list was reduced to higher taxonomic groupings in line with the theory that the latter is more appropriate for detecting anthropogenic change. Species diversity and richness, total number of species, and total number of individuals all decrease significantly with increasing fishing effort. Species dominance increases with effort. Total abundance, biomass and production, and the production of most of the major individual taxa investigated decrease significantly with increasing effort. Multivariate analysis reveals a significant relationship between fishing effort and by-catch assemblage structure. The taxa most responsible for the differences are the echinoids and cnidarians, but prosobranch molluscs and crustaceans also contribute to the differences. By-catch assemblage structure is more closely related to fishing effort than any other environmental parameter investigated, including depth and sediment type. We observed an approximately linear decrease in diversity with increasing fishing disturbance, and suggest this is primarily due to selective removal of sensitive species and, more importantly, habitat homogenisation. These results were interpreted in the light of ecological theories relating disturbance to community structure. The argument that invertebrate scavenger populations benefit from prolonged exposure to fishing disturbance was also examined, but no supporting evidence was found.


time and metabolic parameters as stress indices in sea mussels exposed to cadmium or polychlorinated biphenyls." Arch. Environ. Contam. Toxicol. 20: 259-265.


Wilson, U. A. W. (1994). The potential for cultivation and restocking of Pecten maximus (L.) and Aequipecten (Chlamys) opercularis (L.) on Manx inshore fishing grounds, University of Liverpool.


