A SURVEY OF THE CURRENT STATUS OF THE FLAT OYSTER *OSTREA EDULIS* IN STRANGFORD LOUGH, NORTHERN IRELAND, WITH A VIEW TO THE RESTORATION OF ITS OYSTER BEDS

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ABSTRACT

Stocks of the flat oyster (*Ostrea edulis*) have declined throughout their entire geographical range, principally due to anthropogenic overexploitation. Strangford Lough in north-east Ireland supported a productive flat oyster fishery until the population crashed at the turn of the century. A survey of flat oyster resources in Strangford Lough has revealed that a small population still exists, although the origin of the stock is not apparent. Spatfall on natural cultch occurred at low levels in 1997. Natural recruitment of oysters in Strangford Lough may be limited by the availability of suitable substratum. Although the hydrographic conditions in the north of Strangford Lough are ideal for oyster bed reclamation, any development programme would require a large-scale accumulation of broodstock and suitable substratum.

Received 27 January 1999. Read 24 May 1999. Published 29 October 1999.

INTRODUCTION

The natural range of the European flat oyster (*Ostrea edulis*, Linne 1758) extends from the Fjords of Norway, south to Morocco and into the Mediterranean as far as the Black sea coast (Alcaraz and Dominguez 1985). Natural populations of native oysters formerly fringed much of this range (Yonge 1966). Although some beds still remained in various regions, including the West Coast of Ireland (Barry 1981) and the Limfjord region of Denmark (Korringa 1952), wild oyster populations had become scarce around Europe by the 1940s.

As a result, the European flat oyster industry is based on aquaculture but production has been eroded in recent decades by a succession of disease epidemics. In the late 1960s the French oyster sector was decimated by the parasitic micro-organism *Marteilia refringens* (Balouet and Chastel 1979). From the late 1970s the haplosporidian parasite, *Bonamia ostreae*, which induces bonamiasis disease, spread across Europe detrimentally affecting oyster cultivation in the process (McArdle *et al.* 1991). The disease is particularly pernicious within high density layings, and spreads rapidly between individuals. Consequently, commercial stocks have suffered severe losses and mortality levels of over 80% have been documented on commercial layings in France (Figueras 1991). Culture of *O. edulis* in many areas of Europe is now dictated by measures to counteract the threat of *B. ostreae*. Aquaculture remains viable only under a regime of reduced cultivation densities, prohibition of relaying oysters, rotation/fallowing of beds, cleansing of sites and fishing gear and culling lays in which infestation levels exceed 10% (Hugh-Jones 1994). In general the anxiety generated by *B. ostreae* has curtailed any real enthusiasm for cultivating flat oysters (Hugh-Jones 1994). Consequently, cultivation of the Pacific oyster *Crassostrea gigas* (Thunberg, 1793), which is not susceptible to bonamiasis and exhibits a faster growth rate than *O. edulis*, has become the major share of oyster production in Europe. Nevertheless market-place demand for native flat oysters remains strong and commercial demand has not been met fully because of the problems facing production.

Regeneration of indigenous oyster beds with the subsequent maintenance of a sustainable fishery could provide a natural means to facilitate flat oyster production. This strategy, which was used with success in Lough Foyle, Co. Donegal, alleviates the dangers of importing disease, which is associated with more intensive aquaculture because oyster movement is effectively a one-way process from the beds to the market.

The Lough Foyle oyster fishery is based exclusively on self-propagating spat production on natural beds. These were replenished in 1970 when 250,000 *O. edulis* spat were introduced by the

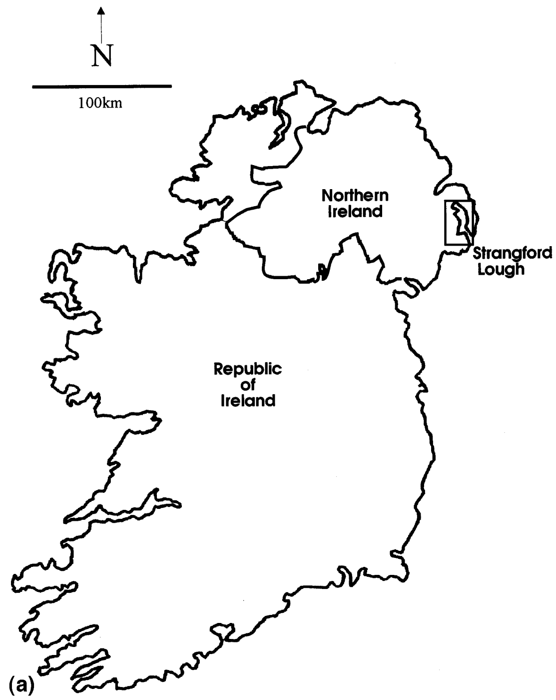

Fig. 1a—Geographical location of Strangford Lough in Ireland.

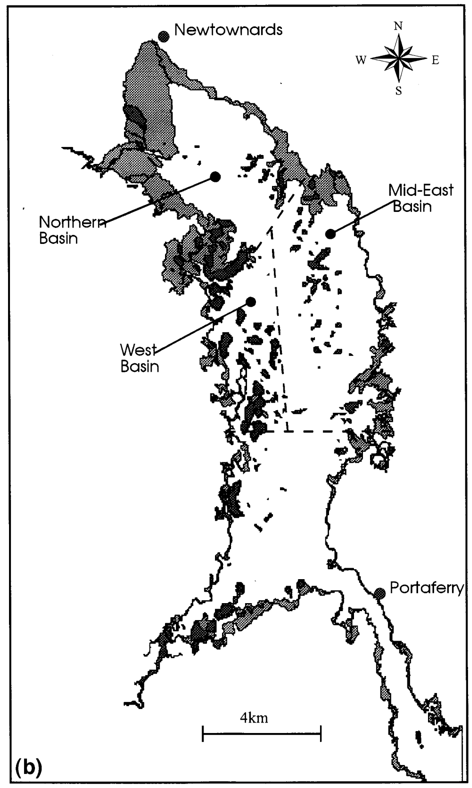

Fig. 1b—Flat oyster survey regions in Strangford Lough.

Department of Agriculture for Northern Ireland. The Foyle system presently enjoys a disease-free status, with an annual yield of 80–200 tons from five major beds on the western side of the Lough (McKelvey *et al.* 1996), although the fishery experienced a decline in landings over recent seasons (Lee 1996).

The suitability of Strangford Lough for flat oyster production seems promising. Historical information indicates that the system once supported a productive fishery with up to twenty boats employed in oyster dredging, although exact landing figures are not available (Brown 1818; Dickie 1857; Browne 1904; Went 1962). In more recent years, *O. edulis* specimens were recorded from various locations in the Lough. Sublittorally they were identified at Whiterock (Williams 1954; Nunn 1992). Native oysters revealed favorable growth rates in trials conducted in the Lough in the 1970s (Parsons 1974; Briggs 1979). Strangford Lough is a fully saline fjardic inlet of the Irish Sea (Boyd 1973) (Fig. 1a), a feature that would afford native oysters a degree of protection against the parasite *Marteilia refrigens*, which favours reduced salinity. Although the Lough has not been tested for *Bonamia*, any commercial stock retained in the Lough originates from Lough Foyle, which is *Bonamia* free (McKelvey *et al.* 1996).

This paper details the start of a study to assess the potential for restoration of the native oyster beds in Strangford Lough. The study focused on the northern half of the Lough as fishery data indicated that most former fishing activity for native oysters was concentrated in this region (Knox 1875). The abundance of bivalve shell (cultch) represents a vital consideration for the health of an oyster population since it determines the amount of potential settling substratum for recruiting oyster larvae (Mackenzie 1996). Consequently, cultch type and amount was also quantified at several sites. Recruitment of flat oyster spat onto natural cultch was quantified so as to understand the regenerative potential of the resident oyster population.

MATERIALS AND METHODS

OYSTER AND CULTCH DISTRIBUTION

In 1997 a baseline survey was conducted to establish the current status of *O. edulis* in the northern part of Strangford Lough. The Lough was divided into three discrete sections (Fig. 1b): the north region, the west region and the mid-east region. These three zones were further subdivided into littoral and sublittoral components giving a total of six designated survey regions. These regions were surveyed by means of 100m line transect survey units. Twenty-seven transects (sixteen sublittoral and eleven intertidal) were carried out during the survey (Fig. 2).

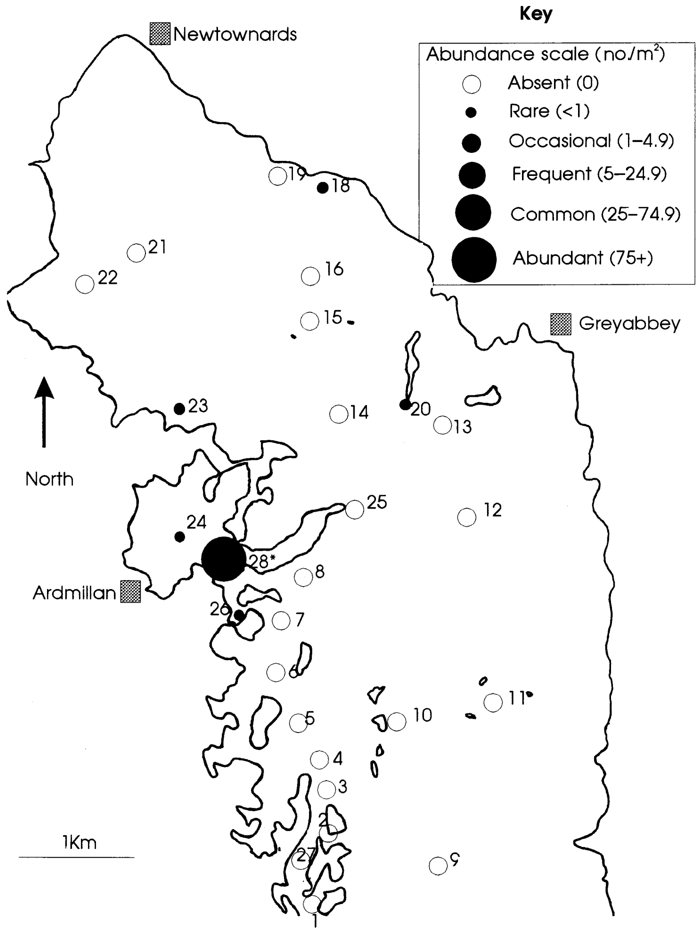

Fig. 2—Results of flat oyster surveys in Strangford Lough 1997. Sites 1–16 are sublittoral sites surveyed by diving and sites 17–27 are intertidal survey units: 1, Ringhaddy; 2, Castle Island i; 3, Castle Island ii; 4, Darragh; 5, Conly Island; 6, Braddock Rock; 7, Sketrick Island; 8, Lythe Rock; 9, Long Sheelah; 10, Drummond Island; 11, Bird Island; 12, North-Mid Channel; 13, Chapel Bay; 14, Duck Rock; 15, South Boretree; 16, North Boretree; 17, (Discontinued); 18, Newtownards Sailing Club; 19, Cunningburn Milltown; 20, Chapel Point; 21, West Rock; 22, Comber Estuary; 23, Paddies Point; 24, Reagh Bay; 25, Mahee Point; 26, Sketrick Shore; 27, Ringhaddy Shore; * 28, Additional site located on commercial oyster mats.

Sublittoral sites were surveyed by scuba diving and the intertidal stations were examined when uncovered during low spring tides. For subtidal surveys, a leaded 100m transect line was lowered to the sea bed from a boat. This line was weighed and buoyed at each end to facilitate deployment and retrieval. Each sublittoral transect was surveyed by two divers, each inspecting opposite sides of the line. Twenty-metre gradations were marked on the transect line with dayglo cord to enable the divers to establish distance along the sea floor. The divers dropped a 0.25m^2 quadrat randomly on the substratum three times at each 20m interval. This technique ensured replicated, random sampling along the entire length of the survey site. Quadrats were subdivided into 64 regular squares with bright orange twine to permit more accurate estimation of coverage by the divers. In total 36 quadrat areas were sampled along each transect, allowing a total of 9m^2 of substratum to be surveyed.

The total number of live oysters, as well as a range of other shellfish and potential oyster predators, was directly counted within each quadrat. The percentage coverage of the sea bed according to substratum type was determined within the bounds of the quadrat. Several substrate types were classified and measured including silty mud, fine sands, gravel and rock. The percentage of the seabed coverage by all types of shelly material was noted in addition to specific observations detailing the relative spatial coverage by oyster, horse mussel (*Modiolus modiolus*) and blue mussel (*Mytilus edulis*) shells. The total amount of suitable oyster substratum available at each transect unit was taken as the mean percentage area of the seabed covered by shelly material and rock. The mean amount of suitable substratum present per region was calculated by averaging the individual values generated from each transect within the region.

The shore-based survey technique was essentially identical to that employed sublittorally, except that the investigation was conducted on foot by a single individual working both sides of a 100m rope. An additional survey was employed to determine the quantity of adult oysters on commercial lays in Reagh Bay. These oysters were retained intertidally on large rectangular rubber mats to prevent the stock sinking into the adjacent soft sediments. As the oysters were raked out fairly evenly across these mats the population density was determined by direct counts within a pre-determined number (15) of randomly thrown quadrats (0.25m^2). The dimensions of each mat were found using a tape measure and from this the respective surface areas could be discovered. The total number of oysters held on each mat was then calculated from the population density and surface area estimates.

POPULATION ESTIMATES

The total number of oysters in the northern part of Strangford Lough was estimated using the following formula which has been adapted from Gunderson (1993),

$$P = \sum_{i=1}^{h} \left(\frac{Ri \cdot F}{a} \right) \bar{C}i. \qquad (1)$$

Here, the total population resident in the full survey area, P, is determined using an estimate of the area of each survey region in m^2, Ri. Surface areas for the survey regions were estimated from scaled maps of the Lough using Global Lab image analysis software, (Table 1). A proportionally weighted correction factor, F, was then applied to Ri to account for the amount of suitable oyster substratum present in the region, this factor was derived from survey results detailing percentage coverage by substratum type and was determined according to Equation 2. Value a, is a constant which refers to the area sampled within a single sampling unit ($9m^2$). The mean number of oysters observed per sampling unit in region i based on n_i samples, Ci, was determined according to Equation 3. Finally, h indicates the number of regions examined during the survey.

$$F = \frac{1}{ni} \sum_{j=1}^{ni} Sij, \quad (2)$$

in which Sij refers to the quantity of suitable oyster substratum observed in the jth sampling unit taken in region i, and

$$Ci = \frac{1}{ni} \sum_{j=1}^{ni} Cij, \quad (3)$$

in which Cij refers to the number of individuals observed in the jth sampling unit taken in region i.

SPAT COLLECTION

Recruitment of oyster spat onto natural substratum was investigated at nine sublittoral locations around Strangford Lough. A sample of cultch was procured from each site using a naturalists' hand dredge which was towed behind a small 50hp motor boat. The dredge had a mouth gape of 50cm × 15cm and was fitted with a collecting bag of 10mm mesh diameter. The contents of the dredge bag were transported to the laboratory for further examination. The total number of oyster spat attached to 100 bivalve shells randomly chosen from cultch, which consisted mainly of *Ostrea edulis*, *Aequipecten opercularis*, *Modious modiolus* and *Venerupis senegalensis* shells, was used as the basic data unit in this study. For each site, five replicates of 100 shells were examined. The number of *O. edulis* spat present on each shell was determined with the aid of a dissecting microscope.

RESULTS

POPULATION ESTIMATES

The results generated from the adult oyster survey are summarised in Fig. 2. No living specimens of *O.edulis* were detected at any of the sixteen sublittoral survey sites monitored during the survey. Live flat oysters were discovered at five out of the eleven intertidal stations, Reagh Bay, Sketrick, Paddies Point, Chapel Island and Newtownards Sailing Club (Fig. 2). Oyster abundances at all of these sites were categorised as rare; only single specimens, of valve diameter between 35mm and 66mm, were recorded from Chapel Island, Reagh Bay, Paddies Point and Sketrick Island. The majority of oysters found at most sites during the survey were attached to rocks and stones. This suggests that these oysters were recruits arising from the reproductive activity of adult stock somewhere in the Lough. Three individuals were detected at Newtownards Sailing club, although more living specimens were observed outside of the survey boundaries. The overall density of oysters at this site, although low ($0.334m^{-2}$), represented the highest density recorded during the survey. The specimen recorded from Sketrick Island appeared to be free living on mud, bearing no obvious attachment to the substratum. The presence of a commercial oyster producer (Cuan Sea Fisheries, Sketrick Island) adjacent to this site raises questions about the origin of this individual and suggests it may represent an escape from cultivated stock.

As oysters were discovered in only two survey regions, population estimates could only be attempted for two out of the six designated survey regions. The northern intertidal zone was estimated to have 101,818 individuals while the west intertidal region was estimated to have 8,157 (Table 2). These figures translate into densities of 0.0022 and 0.0005 oysters per square metre, respectively (Table 2). The stock estimates for the oysters held by Cuan Sea Fisheries within Reagh Bay are documented in Table 3.

Table 1—Spatial dimensions of the survey regions (surface area).

Region	*Intertidal area in m^2 ($\times 10^6$)*	*Subtidal area in m^2 ($\times 10^6$)*	*Total area in m^2 ($\times 10^6$)*
North	19.644	26.816	46.460
West	5.438	9.789	15.227
Mid-East	4.509	32.318	36.828
Total	29.592	68.924	98.516

CULTCH DISTRIBUTION AND COMPOSITION

Dead oyster shell was discovered in relatively small quantities at 22 of the 27 survey sites (Table 4). The percentage cultch cover varied from 0.08% at Mahee Point (intertidal) and South Boretree (sublittoral) to 8.76% at Conly Island (sublittoral). No oyster shell was found at Darragh, Ringhaddy, Pawle Bay or North-Mid Channel. The quantity of cultch at most of the survey stations was low. North-Mid channel and North Boretree (both subtidal) were proven exceptions to this general situation, exhibiting percentage cultch cover of 73.61% and 67.33%, respectively. The majority of this material was composed of queen scallop (*Aequipecten opercularis*) shell.

The relative percentage makeup of the total cultch complement by shell type for each survey site is illustrated in Fig. 3. The west coast sites of Castle Island, Conly Island, Braddock, Sketrick Island, Lythe Rock, Long Sheelah and Drummond did not exhibit a great abundance of shell cultch, but the great majority of the total cultch complement at these localities was composed of oyster shell. Sites in the sublittoral central channel (Bird Island, Duck Rock, South Boretree and North Boretree) tended to possess the greatest quantity of cultch; queen scallops and *Venerupis senegalensis* dominated this material. The shore-based sites featured a predominance of blue mussel shell in the total cultch make-up (Fig. 3).

SPATFALL ON NATURAL CULTCH

In Ireland *O. edulis* generally spawns between late June and mid-September, and so young oyster spat may be observed from late summer onwards. Live oyster spat were detected at only three subtidal sites during a preliminary survey conducted in April 1997 (Fig. 4a). These spat resulted from the 1996 spawning season. Spatfall resulting from the 1997 breeding season was evident at five out of the nine sampling stations (Fig. 4b). The density of setting was not particularly high at any site; peak spat numbers were recorded at Reagh Bay where two spat were recorded per 100 cultch shells; this represents a settlement of 0.02 spat per cultch shell. Across all the survey stations, mean setting density of 0.0017 oysters per cultch shell was calculated during April 1997 and a mean density of 0.0052 oysters per shell was found during October 1997.

DISCUSSION

Wild flat oyster populations in Strangford Lough appear to be relatively insignificant. No natural oyster beds have been reported for over 100 years and only one fragmented, low density bed was detected during the present survey. This population is composed of relatively few, often isolated individuals attached to rocks and stones. The total wild oyster population estimate for the northern half of Strangford Lough is 109,975 individuals. This figure is insignificant when compared to figures reported for other oyster populations, such as the Spanish Mar Menor, which has been estimated to contain over 100 million flat oysters (Cano and Rocamora 1996). Similarly, the mean density of adult oysters in Strangford Lough was

Table 3—Population estimates of oysters held by commercial enterprises at Reagh Bay, Strangford Lough.

Mat no.	*Mat surface area (m^2)*	*Total no. of native oysters ($\times 10^3$)*	*Density (no./m^2)*
1	300	20.80	66.33
2	300	23.36	77.87
3	300	30.24	100.8
4	300	27.36	91.2
5	300	23.52	78.4
Mean	300	25.06	83.52
Total	1500	125.28	–

Table 2—Oyster population and density estimates in survey regions of Strangford Lough.

Region	*Intertidal population ($\times 10^3$)*	*Intertidal density (no./m^2)*	*Subtidal population ($\times 10^3$)*	*Subtidal density (no./m^2)*	*Total population ($\times 10^3$)*	*Total density (no./m^2)*
North	10.18 c.f. 0.056	0.0052	0 c.f. 0.234	0	10.18	0.0022
West	8.16 c.f. 0.027	0.0015	0 c.f. 0.019	0	8.16	0.0005
Mid-East	0 c.f. 0.236	0	0 c.f. 0.236	0	0	0
Total	10.99	0.0037	0	0	10.99	0.0011

c.f., correction factor for substrate type.

low (approx. 0.0011 per m^2). This figure compares poorly with the densities recorded in other wild flat oyster fisheries, for example in Bertrabouy Bay in south west Ireland densities of 4.8 oysters per m^2 were recorded (Minchin 1975). The commercial stock of flat oysters oversummered in Strangford Lough was estimated at 125,280 individuals. This transient population may actually represent a more significant broodstock than the wild population within the Lough.

Following termination of commercial fishing pressure on the Strangford Lough oyster resource it is unclear why a recovery in stocks did not ensue. A general revival may be unattainable by a natural population following a protracted period of over-exploitation for a variety of reasons. Once the population falls beneath a certain threshold level the total reproductive effort in terms of larval production may not be heavy enough to offset the 'normal' losses associated with a planktonic recruitment phase (Korringa 1976). In addition, fertilisation rates have been shown to decrease as the oyster population falls (Rothschild *et al.* 1994). Mean communication distance between compatible individuals increases and rising dilution factors diminish the stochastic element associated with syngamy (Galtsoff *et al.* 1930).

The demise of flat oyster fisheries around the British Isles was not caused solely by overfishing pressure. Of the grounds suitable for oyster production around the English coast only those in Essex, Kent, The Isle of Wight, Devon and Cornwall were still capable of producing oysters in the 1950s (Knight-Jones 1952; Cole 1956; Shelbourne 1957; Waugh 1957; Utting *et al.* 1991). The decline in many former fisheries was due in part to a series of unusually cold winters in the 1930s and 1940s, which resulted in severe oyster mortalities, especially on North Sea coasts (Orton 1940). Declining water quality due to municipal and industrial pollution also had a detrimental impact on oyster stocks (Cole 1956). The introduction of exotic pests created additional problems in many oyster-producing regions. The slipper limpet (*Crepidula fornicata*) was particularly harmful on oyster grounds on the East Coast of England, the invader competing voraciously with the indigenous oysters

Table 4—Percentage coverage of the sea bed by various cultch types at the survey stations.

Site	*Native oyster*	*Blue mussel*	*Horse mussel*	*Other*	*Total*
Ringhaddy	0	0	0	0	0
Castle Island i	0	0	0	0	0
Castle Island ii	0.22	0	0	0.22	0.44
Darragh	0	0	0	0	0
Conly Island	8.76	0	0.04	0.95	9.75
Braddock Rock	2.69	0	0	1	3.69
Sketrick Island	0.78	0.04	0.08	0.08	0.98
Lythe Rock	0.65	0.04	0.04	0.26	0.99
Long Sheelah	2.21	0.04	1.38	0.56	4.19
Drummond Island	5.73	0.04	0.87	2.21	8.85
Bird Island	0.35	0.04	0	7.34	7.73
North-Mid Channel	0	0	0	73.61	73.61
Chapel Bay	0.13	0.65	0	0.22	1.00
Duck Rock	0.69	0	0.02	9.42	10.13
Boretree South	0.09	0.24	0.04	19.36	19.73
Boretree North	2.52	0.48	0.02	64.58	67.33
Sailing Club	2.21	0	0	0	2.21
Cunningburn Milltown	0.61	1.48	0.04	0.26	2.39
Chapel Point	0.87	1.04	0	2.26	4.17
West Rock	1.82	10.33	0	1.38	13.53
Comber Estuary	0.47	0	0	5.47	5.94
Paddies Point	0.35	3.29	0	0.26	3.9
Reagh Bay	0.26	1.56	0	0.08	1.9
Mahee Point	0.08	0.61	0	0.52	1.21
Sketrick Shore	0.52	1.91	0.09	0.95	3.47
Ringhaddy Shore	1.65	1.56	0	1.3	4.51

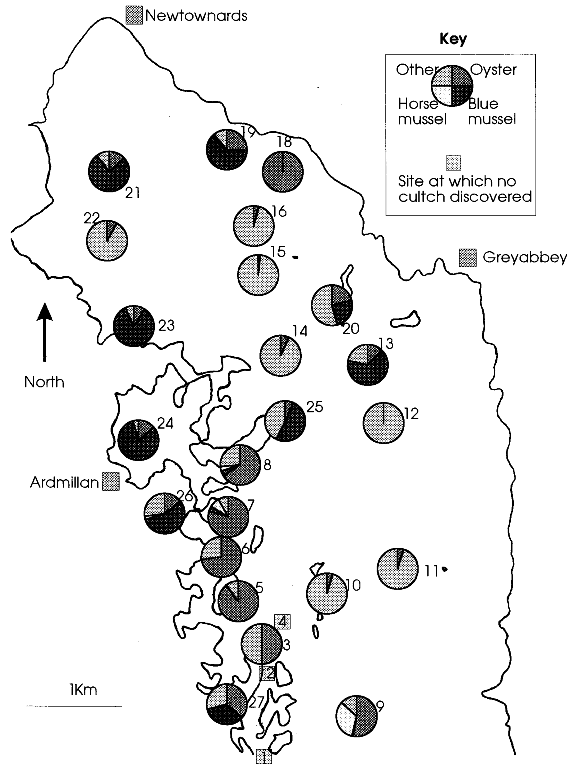

Fig. 3—The relative percentage makeup by shell type of the total cultch complement at each oyster survey site. (For sites, see Fig. 2.)

for space and planktonic food (Cole 1952; Walne 1956).

Large quantities of old oyster shell still carpet the sea bed locally in certain areas along the west coast of Strangford Lough. This finding indicates the importance of flat oysters in the benthos of these regions at that time and substantiates the historical records that show the importance of the Western shoreline for flat oyster production. These aggregations of old cultch indicate regions formerly inhabited by an oyster stock, but as with many other Irish flat oyster fishery regions, no recruitment has been observed on this material for a considerable length of time. Although cultch deposits may indicate areas that were inhabited by oysters, they provide no indication of former productivity levels. Many oyster populations exhibited low productivity and were incapable of tolerating the increased pressures caused by fishing, disease, pollution and competitors, thus leading to the virtual extinction of the flat oyster from many coastal areas (Dalido 1948; Barry 1981).

Oyster populations follow an allee type demographic pattern; the population realises optimum recruitment when a fairly high density of resident oysters are evident (Odum 1989). The growth rim of the adult oyster provides the best setting surface for recruiting spat (Korringa 1946). Consequently, the removal of too many mature oysters makes population revival difficult due to the lack of optimum settling substratum.

Oyster spatfall in Strangford Lough is evident, albeit at a comparatively low level (approx. 0.0052 per cultch shell). It is not clear, however, whether this settlement is due to a naturally reproducing wild oyster population or from the commercial oyster stocks in Reagh Bay. Even with the benefit of this limited spatfall, it is unlikely that Strangford Lough oyster stocks could be restored without intervention. Derelict oyster beds rarely develop if left unattended (Millar 1968). The deposition of fresh, unfouled cultch onto areas experiencing consistent spatfall has been shown to enhance recruitment in oyster fisheries (Abbe 1988; Burtol 1994; Mackenzie 1970; Street *et al.* 1973) as the number of larvae that can set is directly proportional to the available area of clean shell surface (Mackenzie 1983). Supplemental shell planting cannot generate increased yields in fisheries where spatfall is too slight (Sieling 1950) due to inadequate broodstock density (Haven and Fritz 1985). To achieve the reclamation of Strangford Lough oyster beds, it may prove necessary to import large quantities of seed oysters in order to build up a large enough central spawning stock as indicated by Orton, (1946). Mackenzie (1970) suggested that the size of spawning beds of disease-resistant oysters need not exceed 20m^2 in order to generate successful local rehabilitation, although this gives no idea of the total numbers of adult oysters needed. Korringa (1946) stated that at least 10 million mother oysters were required to produce an adequate spatfall during an 'average' summer spawning season in the Dutch Oosterschelde, an area of similar size to Strangford Lough. The minimum spawning stock size needed to facilitate acceptable spatfall levels (one spat per planted shell; Korringa 1976) in Strangford Lough is unclear because no descriptive relationship between broodstock size and setting intensity has ever been established (Mackenzie 1996). Oyster spatfall success fluctuates widely between seasons, even when spawning stock levels are similar (Loosanoff 1966). Low spatfall will often accompany a large adult biomass, whereas heavy setting can occasionally result from a small spawning stock (Dekshenieks and Hofmann 1993; Chauvaud *et al.* 1996). The lack of correlation between broodstock size and spatfall success implies that larval survival is at least as important as adult abundance in determining the viability of a localised oyster population. Whitlatch and Osman (1994) demonstrated that the size of adult eastern oyster (*Crassostrea virginica*) stocks was more sensitive to changes in larval survival than adult survival or fecundity.

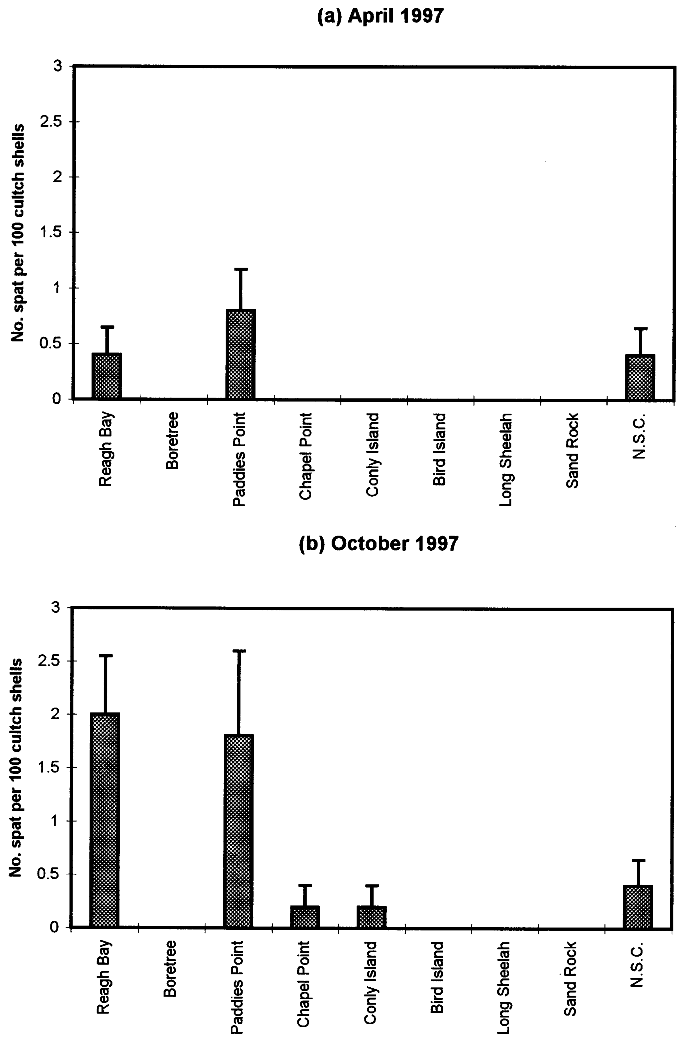

Fig. 4—The number of oyster spat setting per 100 natural cultch shells sampled (a) before and (b) after the 1997 spawning season. Bars show one standard error around the mean.

Oyster bed rehabilitation has been actively addressed in Chesapeake Bay in the United States, in direct response to recent declines in oyster landings (Rothschild *et al.* 1994). Replenishment programmes focusing on extensive cultch planting and supplementation of adult broodstock have increased the concentration of planktonic oyster larvae and subsequent spatfall intensity within the system (Burtol 1994). A revival of the native oyster beds in Strangford Lough may also be attainable through a large scale reclamation process. The hydrographical conditions in the Northern Strangford basin are ideal for such a project. A high degree of water retention is experienced over each tidal cycle (Boyd 1973), ensuring a restricted dispersal of oyster larvae from the local system. The establishment of a large broodstock should be a major focus for any proposed reclamation programme. However millions of broodstock may be required to produce satisfactory spatfall levels. A great deal of work is required to discern the potential amount of supplementary stock required to stimulate revival and the subsequent influence of hydrodynamics on any resultant progeny. In addition, large quantities of fresh cultch would need to be planted at various locations on the sea bed, determined by the local hydrodynamics, to provide suitable substratum for the larvae to colonise. The impact of fouling organisms on the effectiveness of planted cultch for oyster setting must also be addressed in spatio–temporal terms.

ACKNOWLEDGEMENTS

Sincere thanks go to the staff of the Centre for Marine Resources and Mariculture, Portaferry, especially to P. Heath and D. Rodgers. The authors would also like to thank the Portaferry scientific divers. Special acknowledgement is extended to J. Parsons of Cuan Sea Fisheries for his expert opinion. Thanks are also extended to the fishermen of

Strangford Lough, chiefly Malcom Carter and David Clarke. This work was supported by a European Social Fund grant.

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