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Voluntary management in an inshore fishery has conservation benefits

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SUMMARY

The management of fisheries in European Union (EU) waters has generally been regulated through government institutions and agreed quota allocations. This top-down management approach may have contributed to the continued decline of targeted fish stocks by forcing fishers to compete for limited resources without engendering a sense of resource stewardship. In attempting to reverse this decline, scientists and managers should examine management systems that do not solely depend on top-down approaches, and the Inshore Potting Agreement (IPA) is an example. The IPA is a voluntary fishery management system designed and operated by inshore fishers of south Devon, England. The IPA was conceived to reduce conflict between static-gear (pot and net) and towed-gear (trawl and dredge) fishers, and is regarded as a successful fisheries management regime by fishers and managers because it has effectively allowed fishers from both sectors to operate profitably on traditional fishing grounds. Another study determined that the IPA has incidentally protected benthic habitat complexity. Fishers from the static-gear and towed-gear sectors were interviewed to determine the evolution and function of the IPA, and to establish the factors that ensure the high level of regulatory compliance amongst fishers from both sectors. Towed-gear fishers gave significantly different responses to the same questions asked of static-gear fishers, and were generally less satisfied with the existence of the IPA. Multivariate analyses of the interview data suggested that fishers who thought the IPA was a good system also thought the system provided pot protection, but had experienced inter-sector conflict. Fishers who thought the IPA provided no personal benefit also thought that static-gear fishers should be more restricted, and that towed-gear corridors or more seasonal-use areas should be established within the existing IPA area. However, fishers from both sectors agreed that the IPA has maintained traditional practices of the local fishing industry, and that the system has conserved target finfish and scallop species. A number of factors were identified as critical to the success of the IPA. These included the voluntary nature of the agreement, the limited number of organizations representing fishers and very high level of membership of those organizations, and the simplicity of the system. Regulatory compliance is enhanced through the ability of fishers' organizations to respond rapidly to inter-sector conflict issues.

Keywords: fishery management, gear conflict, *Cancer pagurus*, marine protected areas

INTRODUCTION

It is widely accepted that fisheries globally are in decline. (FAO [Food and Agricultural Organization of the United Nations] 2000). It therefore must be considered that conventional fishery management practices, based on predictive models of stock dynamics and aimed at maximizing or optimizing fishery output in the long term, have not been working well (Acheson *et al.* 1998; Hofman & Powell 1998; Lauck *et al.* 1998). In an effort to prevent further stock failures, and to prevent the demise of traditional fisheries, it may be beneficial to study and use management systems that have been successfully applied at a local scale.

The present paper focuses on a voluntary fishery management system established off the south coast of Devon, England, known as the Inshore Potting Agreement (IPA), that has to date been the focus of political (Woodhatch & Crean 1998), behavioural (Hart 1998) and biological (Kaiser *et al.* 2000) studies. The IPA was conceived and established by fishers to reduce conflict between those that operated static gears (pots and anchored gill nets) and those that used towed gears (trawls and dredges). At present, there is no legal recognition of the system, though the IPA is generally well adhered to by fishers from both sectors of the industry, and is an excellent example of a management system that takes account of the social and economic forces that drive the exploitation of living resources. These forces have been identified as factors that should be considered in fisheries management if sustainable exploitation is to be achieved (Langton & Haedrich 1997; Charles 1998; Hanna 1998; Murray *et al.* 1999; Knudsen & MacDonald 2000).

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The IPA is regarded as a successful fishery management regime by fishers and managers because it has effectively allowed fishers from both sectors to operate profitably on traditional fishing grounds, and because it has continued to function for several decades. In order to understand the reasons for its continuity it is necessary to record the historical development of the fisheries within the local area and the technological and biological changes that eventually led to its creation. This paper evaluates the attitudes and perceptions of fishers from the static-gear and towed-gear sectors in regard of (1) what the IPA achieves; (2) the reasons for the continuity of the IPA; (3) the operation of exclusive-use zones and seasonal-use zones within the IPA; (4) existing intra-sector and inter-sector conflict issues; and (5) the potential for further development of the IPA or the possibility of the system breaking-down. In addition, we have sought to characterize key features of the IPA that may be adopted by fishery managers in other areas.

History and background of the IPA

Edible crabs (*Cancer pagurus*) have been harvested from the inshore waters of south Devon, England, for hundreds of years. Fishers from local communities with a strong crab-fishing tradition believe that the crab-fishing industry of the British Isles began in villages along the coastline of Start Bay (Fig. 1). Static-gear fishers that presently operate in Start Bay commonly maintain that they are at least third- or fourth-generation crab-fishers. Evidence for this history is available from the 1891 Census, which indicated that of the 104 men between the ages of 15 and 65 living in the coastal villages of Beeson, Beesands and Hallsands, 63 (60.6%) listed fishing as their occupation.

Before the expansion and modernization of the crab fishing industry in south Devon, static-gear boats were commonly launched and retrieved by hand from beaches in front of fishing villages. The wooden sailing and rowing boats used were typically 5–6 m in length, and fishers worked in crews of two or three per boat, lifting 60–100 pots per day by hand (Table 1). Pots were constructed to an inkwell design from withy (thin woven willow branches), and were usually laid in strings of up to five below each marker buoy (Fig. 2). Crab fishing continued in a similar manner until the 1930s, when inboard engines were first employed on inshore boats (Table 1). The number of pots routinely operated remained small, essentially because the withy pots would disintegrate within one year, thus preventing the number of pots used being added to at the beginning of each season. The size of boat used did not increase during the 1930s and boats continued to be operated either from village beaches or local ports.

In the early 1950s, the materials from which pots were constructed changed to steel wire woven around a cherry-branch frame (Table 1). The inkwell design essentially remained unchanged, though wire pots were dipped in a mix of tar and creosote to improve their longevity. These pots

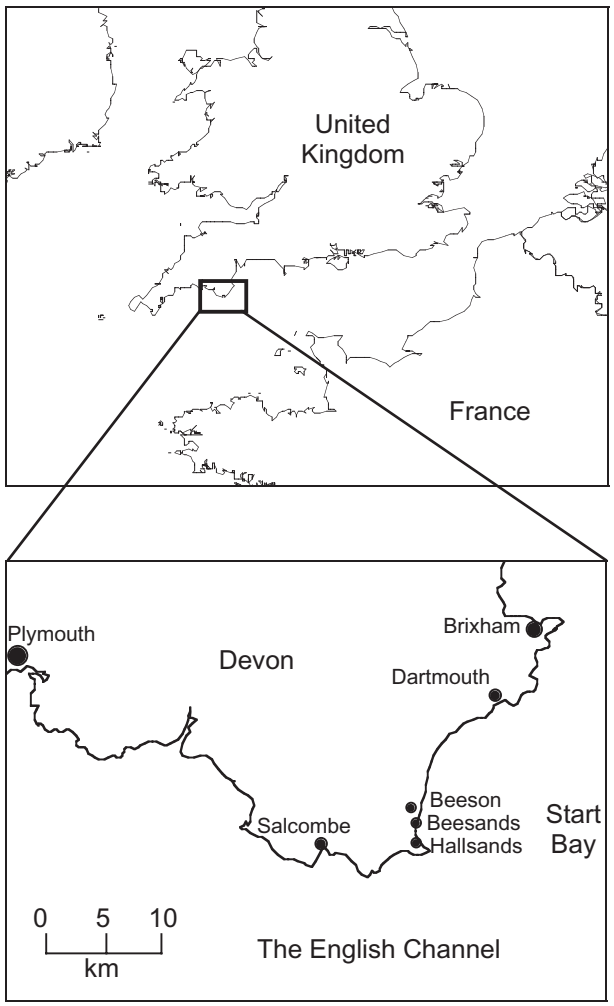

Figure 1 Fishing villages in South Devon, UK.

typically lasted from one to two years, allowing each boat to operate up to 200. However, a small number of crabbing companies employed pot-makers, thus allowing a greater number of pots to be fished. By the mid 1960s, no commercial beach-launched boats remained in use, and the crabbing sector operated exclusively from deep-water ports such as Salcombe and Dartmouth. Pots assembled from plastic frames and nylon netting were finally introduced in the early 1970s, and fishers used boats of 10–12 m length to typically operate up to 300 pots in strings of 30 per marker buoy (Table 1).

The modern crab fishery

At present, inshore boats are typically 10–15 m in length, and are operated from deep-water ports by a skipper-owner and one to three crew. Up to 1600 pots are now worked from each boat, though the average number is 600–700 in strings of 40–60. The number of pots operated from each boat is no longer limited by the robustness of the pot construction, as modern pots constructed from man-made materials last many years, if routinely maintained. However, most skippers

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Table 1 Summary of the principle developments in South Devon fisheries.

Year	*Developments*
pre-1930	Static-gear fishers use wooden sailing and rowing boats of 5–6 m length, 60–100 withy pots and two or three fishers per boat. Pots in strings of up to five below each marker buoy. Beach boats hauled ashore by hand
1930–1950	Inboard motors introduced on beach boats early-1930s. Some larger boats (up to 10 m) with motorized capstans for hauling pots operated from deep-water ports by 1950. Beach boats hauled ashore using motorized capstans
1950–1960	Static-gear beach fishers began to move to larger deep-water port boats. Up to 200 cherry and wire pots operated from each boat, though sometimes more from port boats. Remaining beach boats equipped with motorized capstans for hauling pots
1960–1970	Beach boats no longer in use. Typical static-gear boat size 10–12 m. Improved gear designs and increasing engine power enabled towed-gear fishers to target rougher ground where only static-gear fishers had previously been able to operate
1970–1980	Plastic pots introduced. 300 pots in strings of up to 30 commonly used. Navigation aids (Decca) as well as additional gear and power improvements enabled towed-gear fishers to further push into rough ground areas. Seasonal scallop dredging by static-gear fishers abandoned late-1970s. Inshore Potting Agreement (IPA) established 1978
1980–1990	Increasing number of pots operated from each boat. Seasonal movement of pots within static-gear-only zones abandoned mid-1980s
post-1990	Typical static-gear boat size 10–15 m. Pot-locks and rubber skirts introduced on pots early-1990s. Up to 1600 pots operated from each boat, though average 600–700. Pots deployed in strings of 40–80

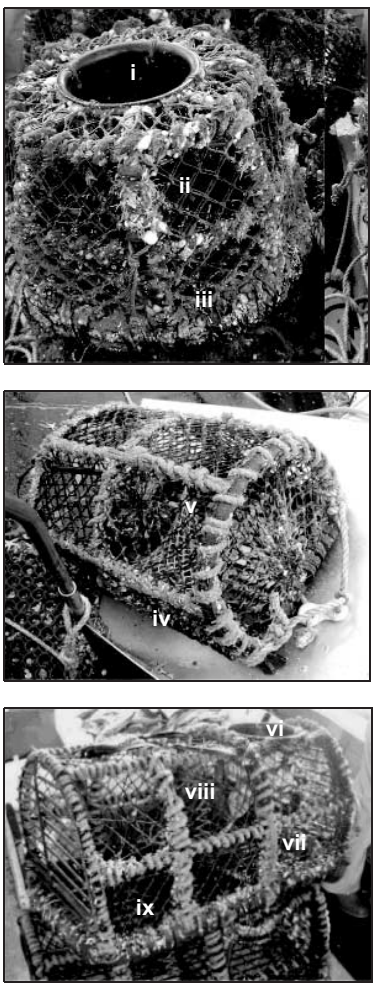

Figure 2 Different pot types used in the IPA. (*a*) Inkwell (diameter 65 cm). (*b*) Soft-eyed creel (length 90 cm). (*c*) Parlour (length 105 cm). i = rigid plastic top entrance, ii = location of rubber skirt used to slow escape of captured animals, iii = heavily weighted base, iv = side entrance, v = soft mesh non-return valve, vi = rigid plastic top entrance, vii = baited chamber, viii = soft mesh non-return valve exit to parlour, ix = parlour chamber.

continue to use the inkwell design, although many have experimented with more modern 'soft-eyed creels' or 'parlour pots', both designs featuring non-return entries to prevent the escape of animals after entry (Fig. 2). Despite this apparent advantage, on the softer seabed substrates where female (hen) crabs are targeted, fishers commonly state that inkwell pots are more efficient than designs featuring non-return entries. The only recent change to the inkwell design is that 'pot-locks' or rubber skirts were added to the funnels of the pots in the early 1990s, making it more difficult for captured animals to escape (Fig. 2). Fishers say that before these features were added, crabs would only stay in the pots for three to four days, or as long as bait remained. After this time, the crabs would climb out. Fishers believe that pot-locks or skirts slow the escape process, but state that even with these devices, few crabs will be caught unless pots are checked within seven to eight days of baiting. Lobsters are also generally believed to be able to climb in and out of inkwell pots, whether pot locks or skirts are used or not.

Conflict within the static sector

Pots were traditionally left in the water to fish over winter, though withy pots tended to rot and disintegrate by this point in the fishing season. However, wire pots were repaired as required, and because of their greater longevity, fishers were able to increase the amount of gear used. This increase created competition for space amongst static-gear fishers, such that gear had to be continuously left in favoured sites to prevent other fishers moving their gear to the location. In the IPA system, occupation of an area of the sea (and hence seabed) traditionally signifies the right to fish in that location, but only as long as gear is retained there.

The practice of leaving pots at sea over winter continues today. Space for additional static-gear within the IPA is very limited, and fishers wishing to enter the static-gear fishery are unable to do so unless they buy second-hand gear already positioned at sea. Vacant sites are also limited because some

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fishers leave weighted marker buoys in place to discourage other fishers from setting pot strings in unoccupied locations. As territories cannot be expanded, fishers can only create space for additional pot strings by moving existing strings closer together.

The towed gear sector

Towed bottom-fishing gears including otter trawls, beam trawls and dredges have been used in the inshore waters of south Devon for 500–800 years (Fox 2001). While some towed-gear boats were launched from beaches adjacent to villages, the majority operated out of deep-water ports such as Plymouth, Brixham, Dartmouth and Exmouth. There are now a small number of towed-gear fishers based in Salcombe and Dartmouth, but the towed and static sectors of south Devon tend to operate from different ports.

Historically, scallop dredging was conducted on a part-time basis by static-gear fishers from Christmas until the start of the crab-fishing season in April or May, when static-gear fishing restarted in earnest. Scallops rather than fish were targeted because the dredges used could be hauled by hand or with hand-operated capstans, while trawling required more specialized equipment. However, the use of towed-gear enabled static-gear fishers to 'make a living' over the winter when crab catches were low. In general, this practice stopped in the 1970s when scalloping became less profitable for part-time fishers and potting became more time intensive.

The inshore towed-gear sector now operates boats with dredges, beam trawls and otter trawls (for a review of towed gears, see Jennings *et al*. 2001). However, a local-area byelaw of the Devon Sea Fisheries Committee prevents non-local vessels greater than 15.24 m overall length operating within six miles of the Devon coastline. An annual closed season for scallops also occurs within the same area between July and September, and some boats seasonally use different towed gears to maximize potential earnings.

Conflict between sectors

Conflict between the towed and static sectors has long existed within the south Devon inshore fishery, but it was uncommon prior to the 1970s simply because towed gears could not be used effectively or safely on the mixed or rougher ground where pot fishers operated. Catches were probably sufficient such that there was little need for boats to stray into areas typically fished with other gear types. In addition, static-gear fishers historically moved gear from one location to another as they followed movements of crabs, which allowed other fishers access to the grounds they vacated.

The potential for conflict between towed-gear fishers and static-gear fishers has increased through time. As pots became constructed from more durable materials, static-gear fishers were able to operate more pots, and leave them in position year-round. The competition for space amongst static-gear fishers finally eliminated the traditional pattern of seasonal pot movement in the 1980s, and thus the towed-gear sector lost seasonal access to some sites. Most significantly, the development of towed gears such as rockhopper trawls and spring-loaded dredges, in conjunction with higher market prices for scallops and whitefish, meant that it became cost effective for towed-gear fishers to target rough ground.

It may seem strange that fishers are unable to avoid each other's gear. However, while towed-gear fishers may attempt to avoid pot strings, static-gear loss or damage is almost inevitable when towed and static gears are fished in close proximity. In particular, strong and complex inshore tidal streams make accurate towing difficult, so even when towed-gear fishers are aware of pot positions, interactions with gear can occur. The strong currents also pull marker buoys down-tide and away from the pot strings, or may even submerge them during peak flows, making the accurate location of gear difficult or impossible. In addition, in inshore areas pot strings may be tightly packed together, leaving very little room for towed-gear use, and towed gears must be towed between banks, where static-gear may also be positioned to avoid being buried by movement of bottom sediments.

The inshore potting agreement

In the mid-1970s, towed-gear fishers expanded the area over which they operated into areas where static-gear fishers had previously operated in isolation. Static-gear fishers suffered significant losses of pots as a result, which reduced catches and income, and necessitated the extra expense of gear replacement. In response to this, in 1978 the Ministry of Agriculture, Fisheries and Food was asked to mediate a meeting between representatives of the static and towed-gear sectors, the outcome of which was the Inshore Potting Agreement (IPA). It included areas designated for exclusive static or towed-gear use and for seasonal static and towed-gear use. The function of the agreement was to maintain the ability of static-gear fishers to operate on traditional grounds without the risk of losing gear to the towed sector (Fig. 3).

Subsequent to the creation of the first IPA, fishers suggested a number of modifications. In 1982 a new IPA was established, when temporal and spatial adjustments were made to reduce the complexity of the design, and the diamond-shaped seasonal zone outside the six-mile United Kingdom territorial limit was removed (Fig. 3). Further spatial and temporal adjustments were made in 1984 in response to requests for access to seasonal resources from towed-gear fishers, who gave up seasonal access rights in other areas as compensation (Fig. 3). The current version of the IPA was introduced in 1993, with further minor spatial and temporal changes (Fig. 3). There are now approximately 25 full-time static-gear boats that work within the IPA area, and approximately 15 towed-gear boats that regularly work in the vicinity of the IPA.

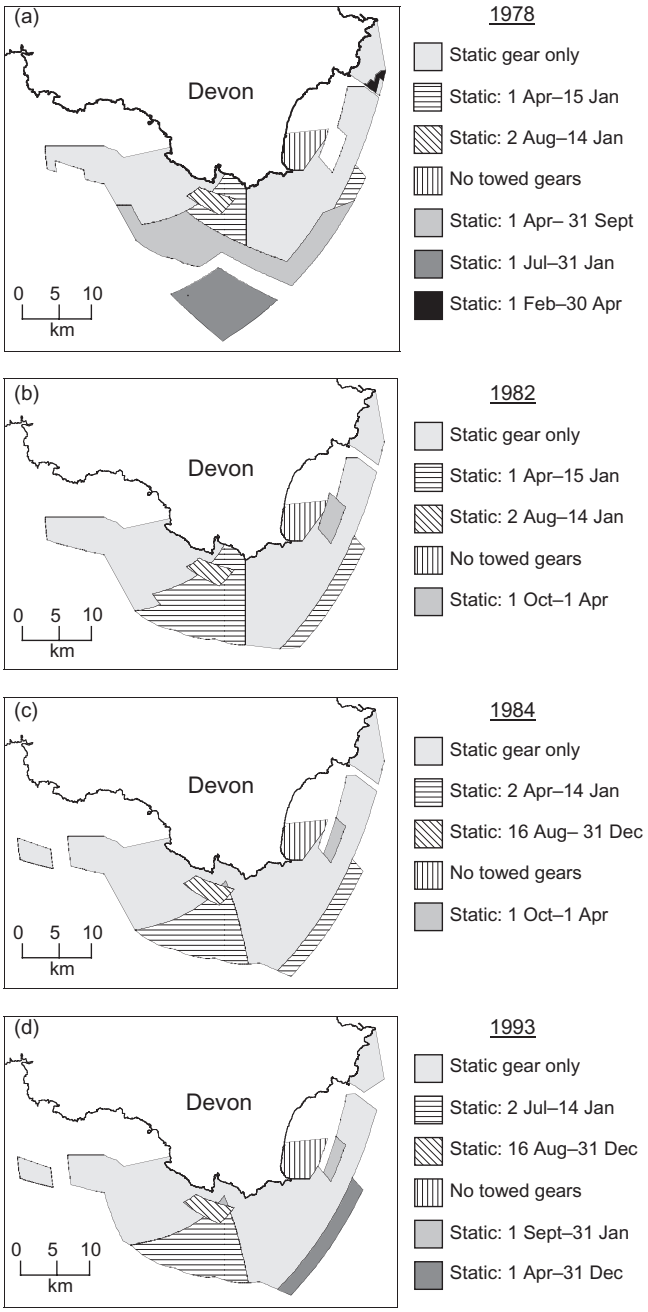

Figure 3 Inshore Potting Agreements for 1978, 1982, 1984 and 1993. 'No towed gears' refers to a Devon Sea Fisheries Committee local area byelaw banning the use of all towed gears in the area shown.

METHODS

Copies of the 1978, 1982, 1984 and 1993 IPAs were obtained from the South Devon and Channel Shellfishermen's Association. These were digitized using Arc View V.3.2, and the total area of exclusive-use and seasonal-access zones were determined using the British National Grid map projection. The areas of zones for seasonal static-gear use were calculated as ([total size of each seasonal zone] × [proportion of the year the zone was allocated for static-gear use]). Hence a zone of 50 km^2 available for static-gear use during six months of the year was calculated as $(50 \times 0.5) = 25\,km^2\,yr^{-1}$.

In order to conduct interviews, towed-gear and static-gear fishers of the IPA were approached via their respective fishers' associations, the South Western Fish Producers' Organization (SWFPO) and the South Devon and Channel Shellfishermen's Association (SDCSA). Meetings were organized to introduce the project to fishers, and interviews were subsequently carried-out at sea under normal working conditions. If on analysis gaps in the data were found, fishers were recontacted for additional questioning. Neis *et al.* (1999) stated that fisheries researchers can greatly strengthen the quality of data gathered by conducting interviews on the fishing grounds and combining them with observation and follow-up interviews. Interviewing at sea also allowed fishers to provide additional non-elicited information regarding aspects of the fishery that would have been missed had interviews been land based.

The interview process followed a semi-structured system. Each fisher was initially reinformed of the project aims, and what was to be achieved during the day. A series of questions were then posed to determine their position in the fishery, including age, experience, number of generations of fishers in their family and other socio-economic information. These included the value of the boat, types of gears used, number of crew, how much had been caught over previous seasons, where products were sold and from whom equipment or services were purchased. These questions not only served to establish each fisher's role within the fishery, but also began the questioning process on non-emotive issues.

Finally, more contentious issues were covered, including what services the IPA provided to each fisher, whether they felt the IPA served other fishing sectors, and any means by which the IPA could be improved. Fishers were also asked if they had had conflict interactions with fishers of other industry sectors, or conflict with fishers of the same sector. By asking these questions last, it was hoped that more responses would be elicited, and that any responses would be more likely to be honest. However, notes were taken earlier in the day if these issues were covered without prompting.

During the course of the project, interviews were conducted with the skippers of twelve static-gear boats and five inshore towed-gear boats. These represented approximately half of the full-time static-gear boats operating within the IPA area, and a third of the full-time towed-gear boats regularly operating in the vicinity of the IPA area. A member of the committee of the SDCSA, and two members of the committee of the SWFPO were also interviewed to elucidate the policy of each organization towards the IPA.

We undertook a multivariate analysis of fishers' responses to our interviews to ascertain whether there were any significant differences in the responses made by the two sectors and to ascertain whether different groupings of responses were linked to each other in a consistent fashion. We used the PRIMER software package to undertake cluster analysis on

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the responses to our interviews. Each interviewee was classed as a sample with their response to each question classed as either yes (1) or no (0). We used the Bray-Curtis index of similarity and the group average linkage technique to form a dendrogram of the relationship between the responses made by each interviewee. We performed an a priori one-way analysis of similarity (ANOSIM) test (a multivariate non-parametric version of ANOVA) for the differences that might occur between the different sectors that operate in the IPA (i.e. static versus mobile). We then repeated the cluster analysis, but on this occasion we examined the data for similarity between different questions. An a posteriori examination of the dendrogram indicated those questions that were answered in the most similar manner.

We further used the PRIMER software to undertake BIOENV analysis (Spearman rank correlation) to search for the combinations of the fishing sector, home port, age, experience and membership of local fishing or village committees that best matched the responses that fishers gave to interview questions.

RESULTS

Changes to the IPA

The total area of seabed covered by the first Inshore Potting Agreement (1978–1981) was 527.3 km^2 (Table 2). In 1982, the total area covered by the IPA was reduced to 470.7 km^2. The majority of the reduction resulted from the removal of a diamond-shaped seasonal-access zone outside the six nautical mile United Kingdom territorial limit. Despite the loss of this seasonal-access zone, and the reduction in the total area of the IPA, the area available for static-gear use increased slightly to 444.2 km^2 yr^{-1} because the static-gear-only area increased in size from 291 km^2 to 330.7 km^2.

In 1984 the total area of the IPA increased in size to 479.9 km^2, and the amount of ground exclusively available to static-gear fishers also increased to 357.1 km^2. The amount of seasonally-accessible ground was reduced to 90 km^2 yr^{-1}, which continued the general evolutionary pattern of increased exclusive access in exchange for reduced seasonal access for static-gear fishers within the IPA.

The current IPA has operated since 1993, and covers 478.4 km^2, with 349.7 km^2 reserved for static-gear use and 73.2 km^2 yr^{-1} retained for seasonal access. Most of the loss of seasonal access area from 1984 to 1993 resulted from alterations to the temporal rather than the spatial access to seasonal zones.

Table 2 Area of the IPA and static-gear zones 1978–1993.

Area	*1978*	*1982*	*1984*	*1993*
Total IPA area (km^2)	527.3	470.7	479.9	478.4
Static-gear-only zones (km^2)	291.0	330.7	357.1	349.7
Seasonal static-gear zones [area x % of year] (km^2 yr^{-1})	135.7	113.6	90.0	73.2
Total static-gear area [static only + seasonal] (km^2 yr^{-1})	426.7	444.2	447.0	422.9

Views of fishers

Cluster analysis of the responses to interview questions (Fig. 4*a*) indicated that the responses of the towed-gear sector were significantly different from those of the static-gear sector (ANOSIM, $r = 0.34$, $p < 0.001$). BIOENV analysis of the responses to interview questions determined that the industry sector of the interviewees provided the best correlation of demographic variable and response ($r_s = 0.323$), followed by a combination of sector and experience ($r_s = 0.320$), and then a combination of sector, experience and home port ($r_s = 0.318$). Other demographic variables or combinations of variables tested poorly represented the differences in responses observed ($r_s < 0.3$).

The analysis of similarity between different questions indicated some associations (Fig. 4*b*). For example, the state-

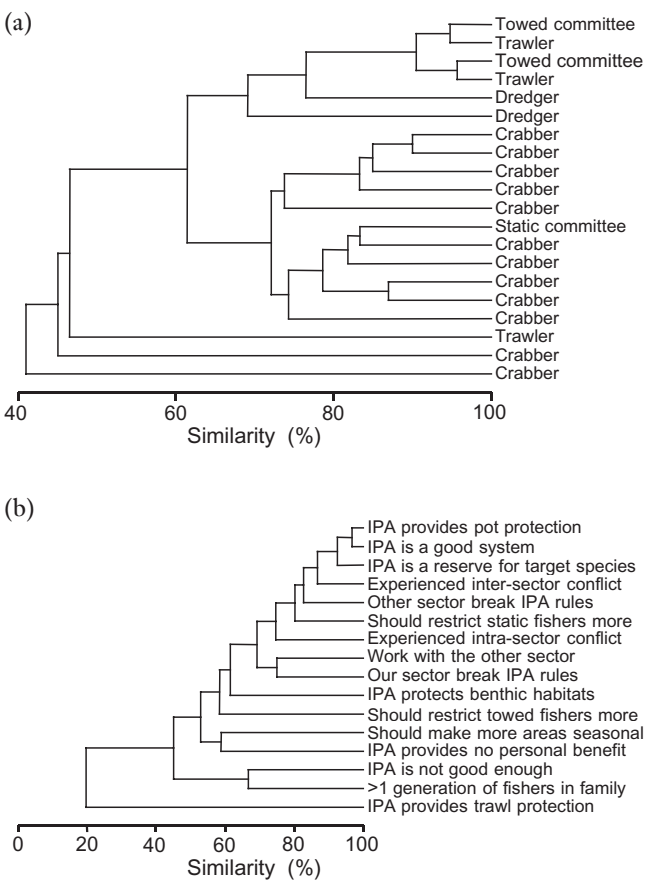

Figure 4 (*a*) Dendrogram showing the percentage similarity between the different fishers from the towed and static-gear sectors of the industry. Managers from each sector are also indicated. (*b*) A dendrogram of the same data analysed for the degree (percentage similarity) of association between different responses or opinions stated by all fishers.

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ment that 'the IPA is not good enough' was most strongly associated with fishers that confirmed that they had 'more than one generation of fishers in the family' and with the opinion that 'the IPA protects benthic habitats'. In contrast, the statement that 'our sector break IPA rules' was most strongly associated with the opinions that the IPA 'should restrict static-gear fishers more' and 'provides no personal benefit'. In addition, those that thought 'the IPA is a good system' also thought 'the IPA provides pot protection'.

Is the IPA a good system?

In response to the question 'Is the Inshore Potting Agreement a good system?', all but one of the static-gear fishers responded positively (Table 3). The exception was a fisher with gear positioned on the edge of the system (referred to as an 'edge' fisher in Tables 3–7) that stated that the IPA provided no personal benefit. This fisher reported that the IPA did little to stop towed-gear fishers from working in static-gear-only zones, and that he was forced to cooperate with towed-gear fishers by occasionally moving pot strings to allow them access to the ground that he fished. Other static-gear fishers, including those that operated on the interior of the system (i.e. had at least one other fisher's gear between their gear and any edge of the IPA; 'interior' in Tables 3–7) stated that although they received no personal benefit from the IPA, it had generally protected the ability of the static-gear sector to operate. Seven of the ten static-gear fishers who said the IPA was a good agreement also said that the IPA was not good enough and that more protection should be afforded to the static sector.

Of the five towed-gear fishers interviewed, three thought the IPA was a good system, and two thought it disadvantaged them unfairly. The general difference in opinion was due to some defending the right of the static sector to access fishery resources, while some objected to the overriding principle that static-gear fishers had property rights to the ground governed by the IPA. All members of the towed-gear sector raised the property rights issue, particularly in regard of one static-gear fisher who on retiring had advertised his boat for sale 'with gear and ground'. Towed-gear fishers objected strongly to the sale of fishing territories.

Gear protection

Almost all members of the static-gear sector interviewed stated that the IPA afforded a degree of pot protection they would not have in the absence of an agreement (Table 4). The two static-gear fishers who felt that the IPA did not provide protection for their gear stated that despite the IPA, the towed sector regularly fished in static-gear-only zones anyway, except in areas in which it was technically too difficult to operate.

Two towed-gear fishers agreed that the IPA afforded static-gear fishers some protection for their gear. However, other towed-gear fishers claimed that the degree of loss that the static-gear fishers suffered as a result of the activities of the towed sector was minimal, and was frequently exaggerated in order to create the maximum controversy. One towed-gear fisher stated that if the IPA static-gear-only zones were opened to the towed sector, static-gear fishers would benefit because any pots lost in the past would be quickly recovered.

Table 3 General function of the IPA. – = no strong opinion expressed or no comment.

Gear type	*Area*	*Person*	*Generations of fishers in family*	*The IPA is a good system*	*The IPA is not good enough*	*The IPA provides no personal benefit*
Static	Interior	1	4+	Agree	Agree	Agree
		2	1	Agree	–	–
		3	3+	Agree	Agree	–
		4	3+	Agree	Agree	–
	Edge	5	2	Agree	Agree	–
		6	1	Disagree	–	Agree
		7	1	Agree	Agree	–
		8	2	Agree	–	–
		9	3	Agree	–	–
		10	1	Agree	–	–
		11	3+	Agree	Agree	–
		12	No data	Agree	Agree	Agree
	Committee	13	1	Agree	Agree	–
Towed	Inshore	14	1	Agree	–	–
		15	1	Agree	–	Agree
		16	1	Agree	–	–
		17	1	Disagree	–	–
		18	No data	Disagree	–	–
	Committee	19	No data	–	–	–
		20	No data	Agree	–	–

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Table 4 Benefits of the IPA to fishers. – = no strong opinion expressed or no comment.

Gear type	*Area*	*Person*	*The IPA provides pot protection*	*The IPA provides trawl protection*	*The IPA protects benthic habitats*	*The IPA acts as a reserve for target species*
Static	Interior	1	Agree	Agree	Agree	Agree
		2	Agree	–	Agree	Agree
		3	Agree	–	–	Agree
		4	Agree	–	Agree	Agree
	Edge	5	Agree	–	Agree	Agree
		6	–	–	–	–
		7	Agree	–	Agree	Agree
		8	–	–	Agree	Agree
		9	Agree	–	Agree	Agree
		10	Agree	–	Agree	Agree
		11	Agree	–	–	Agree
		12	Agree	–	Agree	Agree
	Committee	13	Agree	Agree	Agree	Agree
Towed	Inshore	14	–	–	Agree	Agree
		15	Agree	Disagree	Disagree	Agree
		16	Agree	Disagree	–	Agree
		17	–	Disagree	Disagree	Agree
		18	–	Disagree	Disagree	–
	Committee	19	Agree	Disagree	Disagree	Agree
		20	Agree	Disagree	–	Agree

There is also a gear protection aspect to the IPA for the towed sector, and in particular for those using otter trawls. Essentially, if pots are snagged while trawling then considerable damage may be done to the belly and cod-end of a trawl net. In this regard, two static-gear fishers commented that the IPA benefited the towed sector considerably because the static sector operated only within the limits of the IPA. All towed-gear fishers interviewed mentioned that trawls may be damaged by static gears, but said that because towed-gear fishers would always attempt to avoid pot strings, the IPA zoning system did not provide any additional trawl protection.

Table 5 Interactions between fishers of the same sector. – = no strong opinion expressed or no comment. n/a = not applicable.

Gear type	*Area*	*Person*	*Have had conflict within own sector*	*Our sector break IPA 'rules'*
Static	Interior	1	Agree	–
		2	Agree	–
		3	Agree	–
		4	–	–
	Edge	5	Agree	Agree
		6	Agree	–
		7	Agree	Agree
		8	Agree	Agree
		9	Agree	–
		10	Agree	–
		11	Agree	Agree
		12	Agree	Agree
	Committee	13	n/a	–
Towed	Inshore	14	–	Agree
		15	Agree	Agree
		16	–	Agree
		17	Agree	Agree
		18	–	Agree
	Committee	19	n/a	Agree
		20	n/a	Agree

Habitat protection

Nine of the twelve static-gear fishers stated that the IPA functioned to protect benthic habitats within the IPA area. This was in contrast to interviewees from the towed sector, where only one fisher suggested that the IPA functioned in this manner. With the notable exception of one scallop-dredge fisher, interviewees from the towed sector generally accepted that towed gears caused damage to the seabed. However, they also said that the IPA did not protect benthic habitats because static gears also caused damage, in particular when ropes dragged across the seabed during hauling. Static-gear fishers commonly considered these factors, but generally thought that the damage caused by static gears would be less significant than the damage caused by towed gears and so stated that the IPA functioned to protect the seabed.

Reserve function

There was almost uniform agreement amongst interviewees that the IPA functioned as a reserve for species targeted by the towed sector. Therefore it was felt that the IPA improved the long-term viability of the local fishing industry. Despite this view, towed-gear fishers protested that some static-gear

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Table 6 Interactions between fishers of different sectors. – = no strong opinion expressed or no comment.

Gear type	*Fishing area*	*Person*	*Other sectors violate the IPA*	*Cooperate with the other sector*	*Have had inter-sector conflict*	*Worst sector*
Static	Interior	1	–	–	–	–
		2	–	–	Agree	Scallop
		3	Agree	–	Agree	Scallop
		4	Agree	–	–	Scallop
	Edge	5	Agree	–	Agree	–
		6	Agree	Agree	Agree	Angling
		7	Agree	–	Agree	–
		8	–	Agree	Agree	–
		9	Agree	–	Agree	Scallop
		10	–	Agree	Agree	Scallop
		11	Agree	–	Agree	Scallop
		12	–	Agree	Agree	–
	Committee	13	Agree	Agree	–	–
Towed	Inshore	14	–	Agree	–	–
		15	Agree	Agree	Agree	Scallop
		16	Agree	Agree	Agree	–
		17	Agree	Agree	–	–
		18	–	–	–	–
	Committee	19	Agree	–	–	–
		20	Agree	–	Agree	–

fishers used anchored gill nets to catch demersal fish species that they felt were protected by the existence of the IPA. Fishers from both sectors felt that the potential reserve benefits were therefore lessened.

Intra-sector conflict

Almost all fishers from the static sector commented that they had conflict problems within their own sector, always as a result of competition for space (Table 5). The majority of these problems were said to have occurred as a result of newcomers entering the fishery, or with vessels that were fishing a large number of pots. The most commonly reported

Table 7 How can the IPA be improved? – = no strong opinion expressed or no comment.

Gear type	*Area*	*Person*	*Should give static-gear fishers more ground*	*Should limit static-gear fishers to pots only*	*Should put in corridors or seasonal areas*	*Should legalize the IPA*
Static	Interior	1	Agree	Agree	–	–
		2	–	Disagree	–	Agree
		3	–	–	–	Agree
		4	–	–	–	Agree
	Edge	5	–	Agree	–	Agree
		6	–	–	–	–
		7	Agree	Disagree	–	Agree
		8	–	Disagree	Agree	–
		9		–	–	–
		10	–	–	Agree	Agree
		11	–	Agree	–	–
		12	–	Agree	–	–
	Committee	13	–	Disagree	Disagree	Agree
Towed	Inshore	14	–	–	–	Disagree
		15	Disagree	Agree	Agree	Disagree
		16	Disagree	Agree	–	Disagree
		17	Disagree	Agree	Agree	Disagree
		18	Disagree	Agree	Agree	Disagree
	Committee	19	Disagree	Agree	Agree	–
		20	–	Agree	Agree	Agree

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periods for conflict interactions to occur were at the start of the static-gear season in spring when additional pots were put out at sea after over-winter repair, and when seasonal zones were reopened after a period of towed-gear use. At these times, territory boundaries between fishers were re-established, with the potential for ground to be acquired from neighbours.

Towed-gear fishers less commonly stated that they suffered conflict within their own sector, but two commented that they were forced to be secretive when fishing within static-gear-only zones, in case other towed-gear fishers noticed where they were working and began to operate in close proximity. Both these fishers admitted that they were passed detailed information on the location of static-gear by the pot fishers who operated in the area worked. Both also feared that their personal agreements would suffer if static-gear was damaged by other towed-gear fishers who had not been informed of the exact location of pot strings, but who attempted to fish nearby.

Inter-sector conflict

All of the towed-gear fishers interviewed admitted to fishing inside the IPA static-gear-only zones, though accusations of static-gear loss were generally denied. One scallop-dredge fisher accepted that he regularly caught pots, but also said that he replaced them whenever damage occurred.

A number of static-gear fishers that only used pots stated that the use of anchored nets by static-gear fishers represented a breach of the IPA. They commented that the IPA was established specifically to protect the right of pot fishers to operate, and that the use of nets was a considerable source of contention in dealings with the towed sector. All static-gear fishers who mentioned this issue thought the towed sector would be more likely to respect the IPA if anchored nets were not used inside the limits of the system. Two towed-gear fishers also commented that some static-gear fishers positioned gear outside the limits of the IPA (Table 6). One static-gear fisher confirmed that some fishers did place pots outside the IPA area, and a number of pot strings from another fisher were consistently found located outside the IPA during the period of the study.

Most static-gear fishers commented that they had experienced inter-sector conflict problems. The two exceptions were static-gear fishers with territories within the interior of the IPA. Despite this, only eight of the 13 interviewees from the static-gear sector felt that towed-gear fishers broke the spirit of the agreement by fishing in static-gear zones. Four static-gear fishers with conflict problems, including one who said he felt the other sector broke the IPA, still confirmed they worked with towed-gear fishers to allow them temporary access to the ground over which they worked.

Amongst those fishers who expressed an opinion with regard to which sector caused most conflict problems, there was almost universal agreement that scallop dredgers were most at fault. The exception was one fisher who stated that he had most problems with recreational anglers, as they frequently snagged ropes or pots while anchoring. Apart from dragging the pots away from their original location, which was said to reduce catches significantly, the interviewee claimed that the gear was almost inevitably cut off the anchors rather than untangled, thus making hauling the pots difficult and time consuming.

Can the IPA be improved?

Predictably, most members of the towed-gear sector were opposed to any suggestion that static-gear fishers should be given more ground (Table 7). However, two members of the static sector who admitted to cooperating closely with the towed sector said that this was a means to improve the IPA. There was disagreement between respondents from both sectors when additional restrictions were considered for static-gear fishers. Of the respondents from the static sector who expressed a strong opinion, half were in favour of limiting static-gear fishers to pots only, and half were against. Further input controls, including banning the use of non-return pot designs and limiting pot numbers according to size and power of the boat, or number of crew, were mentioned by four of the static-gear fishers and all but one member of the towed sector. Output controls recommended by static-gear fishers included a total allowable catch (TAC) system, a raised minimum landing size for male and female crabs or increased quality standards. However, it was accepted that crab buyers and processors would have to participate fully in any output control system.

Eight of the 13 members of the static sector interviewed, and one member of the South Western Fish Producers' Organization (SWFPO) committee recommended that the IPA should be legalized to prevent towed-gear fishers operating in static-gear zones. All active fishing members of the towed sector rejected legislation however, as they claimed that it would do little or nothing to prevent towed fishers from breaking the IPA. In fact, fishers from both sectors commented that legislation could seriously harm the IPA, as towed fishers respected the agreement only because of its voluntary nature. It was considered that legislative intervention would be counterproductive.

Interviewees from the towed sector most commonly suggested the IPA should be altered by the introduction of corridors through static-gear zones, or the implementation of further seasonal access arrangements in existing exclusive static-gear zones. The exception was one fisher who operated a small trawler, and regularly towed in pockets of open ground within the static-gear-only zones. He said he preferred the existing system because he would lose his advantage if larger vessels from the towed sector were to be allowed into restricted zones. The towed-gear fishers in favour of greater seasonal access commented that the static fishers commonly abandoned their gear at sea over winter to avoid losing the site to other static-gear fishers, but that this prevented towed-gear boats from operating in these areas.

Essentially, the right of all fishers to go fishing was accepted by every interviewee, but the suggestion that static-gear fishers held property rights over territories within the IPA was strongly condemned by every towed-gear fisher. In contrast, one member of the SWFPO committee and one towed-gear fisher commented that the area of ground within the IPA was tiny in comparison to the area available to towed-gear fishers who work in the English Channel.

DISCUSSION

Fishery benefits

Fishers perceived that the Inshore Potting Agreement serves a number of functions, and primarily that it limits conflict between the towed-gear and static-gear sectors. Though almost all fishers stated that they suffered conflict interactions, it was commonly considered that inter-sector conflict would be worse without the IPA. A typical comment was 'It works 90% of the time. It isn't perfect, but whatever is done, it isn't going to be perfect'.

By limiting conflict, it is likely that the IPA has served to protect a large portion of the pot fishing industry of south Devon, and fishers from the static and towed-gear sectors are able to operate effectively and profitably in relative harmony. In comparison, fishers from both sectors described a pot fishery that historically operated in the 'Exeter Roughs', a nearby area to the east of that of the IPA, which disappeared after scallops (*Pecten maximus*) were discovered there by dredge fishers in the mid-1980s. The substratum was composed of biogenic, coralline reef, but within a short period it was reported that the seabed had been flattened and the pot fishery ended. However, it was also reported that the scallop fishery had been very short lived, and that there was little sign of a recovery in the substratum, or crab or scallop fisheries.

Scallop dredges are considered to be among the most damaging towed bottom-fishing gears (Dayton *et al.* 1995; Collie *et al.* 2000), though the use of other towed gears may also lead to long-term changes in benthic community structure (Bradstock & Gordon 1983; Kaiser & Spencer 1996; Collie *et al.* 1997; Jennings & Kaiser 1998; Kaiser *et al.* 1998; Auster & Langton 1999; Norse & Watling 1999). In this study, even towed-gear fishers generally accepted that damage occurred as a result of their fishing activities. However, the argument that the IPA does not protect benthic habitats because static gears also cause damage to the seabed is difficult to support. Studies by Kinnear *et al.* (1996) and Eno *et al.* (1996) indicated that potting caused little incidental damage to epibenthic fauna. A study by Kaiser *et al.* (2000) also determined the species diversity within IPA static-gear-only zones was higher than in seasonal-access zones, which in turn was higher than in areas outside the IPA system where towed-gear fishers were able to operate year-round. Importantly, biogenic fauna such as soft corals and hydrozoans were also more prevalent in exclusive static-gear use areas of the IPA.

Larvae of *Cancer pagurus* tend to be less selective of seabed characteristics at settlement than those of crustacean species of lower fecundity (Robinson & Tully 2000). However, other studies have shown that post-settlement survival of some sub-tidal crustacean species is higher in more complex habitats (e.g. Pile *et al.* 1996; Palma *et al.* 1998; Stevens & Kittaka 1998; Robinson & Tully 2000). Towed bottom fishing gears physically damage crustaceans (Hill *et al.* 1996; Kaiser & Spencer 1996), and a number of studies determined that crustacean densities decreased with increased towed-gear use (Eleftheriou & Robertson 1992; Veale *et al.* 2000). Pot fishers commonly maintained that if towed gears were occasionally worked near but not alongside or over their gear, then catch rates could increase, as crabs were attracted to dead or dying by-caught animals. The rapid attraction of scavenging megafauna, including *C. pagurus*, to dredge tracks has been well documented (Caddy 1973; Kaiser & Spencer 1994). However, pot fishers also stated that it took several months for catch rates to recover when towed-gear boats had worked repeatedly around their gear, and concluded that this was because the seabed had been damaged extensively. However, we found no published evidence to support this.

Of the species targeted with towed bottom fishing gears, scallops in particular may benefit from increased benthic heterogeneity within the IPA system. The presence of filamentous flora and fauna was identified as a critical factor in spat settlement in the scallop, *Pecten maximus* (Dare & Bannister 1987; Minchin 1992), giant scallop, *Placopecten magellanicus* (Stokesbury & Himmelman 1995) and Iceland scallop, *Chlamys islandica* (Harvey *et al.* 1993). As sessile emergent epifauna are at risk from towed gears (Collie *et al.* 1997; Sainsbury *et al.* 1998; Moran & Stephenson 2000), limits on towed-gear use within the IPA may have important implications for spat settlement and later recruitment of adults to nearby fisheries. In addition, spat or undersized scallops may be damaged when in direct contact with towed gears (Caddy 1973; Brand *et al.* 1980).

Spat may preferentially settle on structures to avoid being smothered by sediment (Brand *et al.* 1980; Thouzeau 1991; Harvey *et al.* 1993), and high concentrations of suspended silt have been shown to cause mortality in larvae and spat of different scallop species (Naidu & Scaplen 1979; Stevens 1987). Trawling may be a significant contributing factor to sediment resuspension in shelf seas (Churchill 1989; Piskaln *et al.* 1998; Auster & Langton 1999; Hall 1999), and consequently the reduction in sediment resuspension by trawlers inside the IPA may also benefit scallop recruitment. Furthermore, the possibility exists that some commercially important scallop beds are self-seeding, with only occasional spatfalls originating in other areas (Sinclair *et al.* 1985; Darby & Durance 1989; Brand 1991; Young *et al.* 1992). For example, Buestal *et al.* (1979) determined that the scallop (*P. maximus*) spat settlement in the Bay of Saint-Brieuc reflected the status of the local parent stock. Therefore, if a scallop bed is fished to commercial extinction, there may only be limited potential for its resettlement and rejuvenation, and a reserve

of mature scallops within the IPA could be vital to the continuation of the local scallop-fishing industry. Moreover, significant increases in scallop biomass have been clearly demonstrated in other closed area systems (see Turner *et al.* 1996; Brocken & Kenchington 1999; Murawski *et al.* 2000).

Most interviewees thought the IPA had functioned to improve the long-term viability of the towed-gear sector, though it was almost always in regard of protecting populations of demersal fish species such as rays (*Raja* spp.), turbot (*Scophthalmus maximus*) and anglerfish (*Lophius piscatorius*) rather than scallops. The possibility that the IPA may act as a reserve for fish species is uncertain. Fishery benefits in areas adjacent to reserves have been demonstrated infrequently, and it has been questioned whether a limited access system of only 480 km^2 would protect a population of mobile demersal fish such that any net benefits would result (Horwood 2000). However, much smaller reserves have proved to be beneficial for some relatively mobile species in both temperate and tropical systems (see Dugan & Davis 1993; Roberts & Hawkins 1997; Roberts *et al.* 2001). In the case of the IPA, the benefits for demersal fish species of preventing towed-gear fishing may be limited because these fish are taken within the system in anchored nets and by recreational anglers. However, most fishers in the towed sector believed that the system protected valuable and scarce target species and wanted access to the restricted ground within the IPA; for example, fishers reported that unusually large rays (*Raja* spp.) are caught on banks within the IPA by both anglers and commercial netters.

Development of the IPA

Few regulations exist to control the level of fishing effort exerted on crustacean stocks in European waters. Crab fisheries are yet to come under a total allowable catch (TAC) or quota system, and currently catches are only restricted by a minimum landing size and subjective quality assessment. There is also no statutory limit on the number of pots that a fisher may use, and the only effective limits on effort are the number of pots that a fisher is able to operate, and the space on the seabed in which the pots may be placed. The establishment of the IPA, and subsequent changes to its shape and size over time resulted from proposals originating from users of the inshore system. Fishers were driven to form the IPA because of significant conflicts and the system has worked effectively to maintain the ability of fishers from both the towed and static sectors to operate. However, the diamond-shaped seasonal access zone outside the United Kingdom territorial limit was less likely to have functioned successfully because there are few access restrictions for fishers from the European Union to waters beyond the six-mile limit. In the absence of statutory protection, or without enforcement of fishery regulations, any part of the IPA that operated outside the six-mile limit could only function with the consent of other fishers within the European Union. This consent would be open to accidental abuse through lack of knowledge of the system, or deliberate intent. However, healthy fish stocks are a collective good, and in most common property situations it is difficult to exclude people from such goods (Jentoft *et al.* 1998). Hence, without conventional fishery management measures such as the six-mile territorial limit, or power and effort limitations on towed-gear use within six miles of the coastline where the bulk of the IPA exists, it is unlikely that the IPA would have survived.

Property rights refer to the entire range of rules, regulations, customs and laws that define rights over appropriation, use and transfer of goods and services (Kula 1992). Acheson *et al.* (1998) and Walters (1998) suggested that property rights must be established before any other fishery management regulation can be successfully applied. Towed-gear fishers were vehemently opposed to an official system of territory ownership within the IPA, and maintained that access should be equal for all fishers. However, informal ownership arrangements do exist between static-gear fishers. These arrangements have allowed static-gear fishers to reduce the risk of operating in an open-access system, though because of the number of pots fished, ensuring access to seasonal grounds is problematic. One informant maintained that pots were historically fished close inshore early in the season, when male crabs were targeted on rough ground. During this period, towed-gear vessels would cover ground further offshore. Over the summer and autumn, pots were moved further offshore onto softer ground to target female crabs, enabling the towed-gear fleet to fish any suitable ground inshore. The informant stated that the system operated successfully because it allowed both sectors to cover all areas. In addition, when the pots became degraded or were removed from the water over the winter period, towed boats were further able to target areas normally fished with static-gear.

The movement of pots between sites probably worked in the past because effort was limited. It is likely that the reduction in the amount of seasonal access ground from 1978 to 1993 resulted from two factors, namely the difficulty that static-gear fishers have in reacquiring ground when areas are seasonally reopened, and the difficulty of ensuring regulatory compliance in seasonal access zones. Not only is it logistically difficult to move a large number of pot strings from one place to another, there is also little to prevent a fisher from positioning gear in a site occupied by another the previous season. Occupying a territory continually prevents an annual race to position gear at the start of the season. It is also easier to manage and enforce a single use system than a multiple-use, seasonally-changing system. Enforcement is a key factor leading to successful fishery enhancement from reserves (Roberts *et al.* 2001).

Importantly, as a voluntary agreement, the IPA is based on goodwill, and the use of anchored nets by static-gear fishers to target demersal fish species has the potential to affect the long-term viability of the IPA adversely. Essentially, this is because the towed-gear sector perceived only limited benefits of abiding by the IPA. Towed-gear

fishers stated that they did not feel trawl protection was achieved through the IPA, and that beam trawls and scallop dredges were in any case not damaged when they came into contact with pots. Further, because fishers of the different sectors do not generally use the same home ports, there is little social advantage for one fisher in avoiding conflict with another fisher of a different sector when there is no possibility that they will have to tie up alongside each other in port. However, towed-gear fishers stated that the benefit of the IPA to their sector was that the area acted as a reserve for demersal fish species. When static-gear fishers used anchored gill nets within the IPA area, towed-gear fishers felt that the benefit to them of adhering to the IPA was reduced, goodwill between sectors inevitably suffered, and the potential for the further development of the IPA also diminished.

Wider application

A number of authors have proposed that rather than attempt to manage a fishery or fish stock in isolation, managers should take into consideration the ecosystem within which the fishery exists. Proponents suggest that if an ecosystem is sustainably managed as a whole, the individuals within will also be sustainably managed (Sherman, 1991; Botsford *et al.* 1997; Langton & Haedrich 1997; McGlade *et al.* 1997; Jennings & Kaiser 1998; Hofmann & Powell 1998; Pitcher & Pauly 1998). Essentially, it may be critically important to include the management of fishers in the management of marine ecosystems, and it may be that the maximum long-term fishery production will be more easily achieved by controlling 'how' fishing is undertaken, rather than 'how much' is caught. The shift in emphasis towards non-technical fishery management measures stems in part from the failure of existing management programmes to meet biological goals (Murawski 2000).

The IPA represents an interesting example of how fishing should be undertaken. Furthermore, the system has evolved in modern society, despite the increasing pressures of lower catches but higher expectations of earnings and living standards. Probably the most noteworthy features of the IPA are that it was conceived relatively recently and has the general backing of both fishery sectors, but has protected the traditional practices of the local fishing industry, and benthic habitats that have been recognized as important to the long-term maintenance of some marine fisheries. Because of these features, fishers and managers should be commended for the creation and function of the IPA, and characteristics of the system that may be successfully adopted in other locations may be noted. These are:

(1) Management may be more successful if all existing uses of the managed area are taken into account. The IPA is an agreement between fishers over a fishing ground that historically had been used for the same purposes as it is today.
(2) Management may be more successful if all existing users of the managed area are taken into account. The IPA has been reduced in size to lie mostly within the six-mile territorial limit of the UK, thus reducing potential conflict with non-local fishers not party to the management system.
(3) When existing use of the seabed permits, exclusive-use zones have the greatest potential for management success. It is easier to enforce exclusive-use systems, and reallocating seasonal territories has the potential to create conflict within sectors. Further, exclusive-use zones may allow the effects of management strategies to be more easily quantified and related to changes in fishery use, and may provide the basis for adaptive management experiments, the results of which could be applied to a wider region.
(4) Seasonal limitations on gear types have the potential to work effectively, as different fishing sectors may wish to target the same areas at different times of the year. However, seasonal changes in use should not be overly complex in time or space. Care may also be required to ensure that on reopening an area to a sector, fishers that previously occupied sites are able to subsequently return to the same sites.
(5) Within a management zone, long-term regulatory compliance may be more likely if users are restricted in their ability to switch methods to take advantage of increases in abundance of species targeted by other fishing sectors, but protected and enhanced by the change in management. The use of anchored nets by static-gear fishers has reduced the potential for long-term viability of the IPA.
(6) If gear types and effective effort are limited at the inception of a new system, conflict between users is less likely to develop. In the present case, conventional fishery management regulations exist such that within six miles of the United Kingdom coast, towed-gear fishers are limited to 12 dredges and power of no greater than 300 hp. This has prevented large or non-United Kingdom vessels from fishing inside the IPA.
(7) Regulatory compliance is more likely to result when managers are able to meet regularly to discuss events occurring in a fishery, and when management is flexible and adaptable. When features of the IPA were found to be unworkable, changes were quickly made.
(8) Conflict avoidance and regulatory compliance is more likely if negotiation can be between bodies that represent fishers *en masse*. Two fishers' associations represent all of the static-gear fishers and most of the towed-gear fishers operating in the IPA. Information is rapidly disseminated within associations and peer group control may be applied.

ADDENDUM

The Department for Environment, Food and Rural Affairs (DEFRA) created national legislation to protect the IPA in March 2002. The maximum fine for breaking this legislation is £50 000. Whilst this may seem to be a retrograde step after

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advocating the benefits of voluntary management in the IPA, the system of legislation that was created still allows fishers to determine the rules of the fishery. Managers and representatives of all fishing sectors impacted by the IPA are required to meet on a management panel once every three months. At each panel meeting, fishers can submit requests for changes to the IPA. Any recommendations for change that are decided by the panel are then submitted to DEFRA annually. Importantly, whilst the IPA can change, the IPA that is protected by the legislation is then the one depicted by a chart of the system that hangs in the office of the Chief Fisheries Officer of the Devon Sea Fisheries Committee.

Though the IPA is no longer a voluntary system, static-gear fishers have initially responded positively to the introduction of legislation, and few losses of static gear have been reported. Towed-gear fishers also report being satisfied with the legislation, highlighting the parity that is now present in the IPA for all fishers of their sector, and the benefits of having a forum in which they may have requests for changes to the IPA heard.

The longer-term impact of this legislation is difficult to envisage, but it is hoped that it will provide the potential for enforcement of the IPA, whilst maintaining the ability of fishers to manage the fishery.

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References

Acheson, J.M., Wilson, J.A. & Steneck, R.S. (1998) Managing chaotic fisheries. In: *Linking Social and Ecological Systems: Management Practices and Social Mechanisms for Building Resilience,* ed. F. Berkes & C. Folke, pp. 390–413. Cambridge, UK: Cambridge University Press.

Auster, P.J. & Langton, R.W. (1999) The effects of fishing on fish habitat. *American Fisheries Society Symposium* **22**: 150–187.

Botsford, L.W., Castilla, J.-C. & Peterson, C.H. (1997) The management of fisheries and marine ecosystems. *Science* **277**: 509–515.

Bradstock, M. & Gordon, D.P. (1983) Coral-like bryozoan growths in Tasman Bay, and their protection to conserve commercial fish stocks. *New Zealand Journal of Marine and Freshwater Research* **17**: 159–163.

Brand, A.R., Paul, J.D. & Hoogesteger, J.N. (1980) Spat settlement of the scallops *Chlamys opercularis* (L.) and *Pecten maximus* (L.) on artificial collectors. *Journal of the Marine Biological Association of the United Kingdom* **60**: 379–390.

Brand, A.R. (1991) Scallop ecology: distributions and behaviour. In: *Scallops: Biology, Ecology and Aquaculture,* ed. S.E. Shumway, pp. 517–584. Amsterdam, the Netherlands: Elsevier Science Publishers BV.

Brocken, F. & Kenchington, E. (1999) A comparison of scallop (*Placopecten magellanicus*) population and community characteristics between fished and unfished areas in Lunenburg County, NS, Canada. Unpublished report, Department of Fisheries and Oceans, Bedford Institute of Oceanography, Dartmouth, Nova Scotia, Canada: 33 pp.

Buestal, D., Dao, J.C. & Lemaire, G. (1979) Collecte de naissain de pectinidés en Bretagne. *Rapports et Procés-Verbaux des Réunions du Conseil International pour l'Exploration de la Mer* **175**: 80–84.

Caddy, J.F. (1973) Underwater observations on tracks of dredges and trawls and some effects of dredging on a scallop ground. *Journal of the Fisheries Research Board of Canada* **30**: 173–180.

Charles, A.T. (1998) Beyond the status quo: rethinking fishery management. In: *Reinventing Fisheries Management.* ed. T.J. Pitcher, P.J.B. Hart & D. Pauly, pp. 101–111. London, UK: Kluwer Academic Publishers.

Churchill, J.H. (1989) The effect of commercial trawling on sediment resuspension and transport over the Middle Atlantic Bight continental shelf. *Continental Shelf Research* **9** (9): 841–864.

Collie, J.S., Escanero, G.A. & Valentine, P.C. (1997) Effects of bottom fishing on benthic megafauna of Georges Bank. *Marine Ecology Progress Series* **155**: 159–172.

Collie, J.S., Escanero, G.A. & Valentine, P.C. (2000) Photographic evaluation of the impacts of bottom fishing on benthic epifauna. *ICES Journal of Marine Science* **57** (4): 987–1001.

Darby, C.D. & Durance, J.A. (1989) Use of the North Sea water parcel following model (NORSWAP) to investigate the relationship of source to recruitment for scallop (*Pecten maximus*) stocks of England and Wales. ICES Council Meeting 1989 Collected Papers. Copenhagen, Denmark: ICES: 19 pp.

Dare, P.J. & Bannister, R.C.A. (1987) Settlement of scallop, *Pecten maximus*, spat on natural substrates off south-west England: the hydroid connection (Abstract). In: The Sixth International Pectinid Workshop, ed. A.R. Beaumont and J. Mason. International Council for the Exploration of the Seas, Menai Bridge, Wales: 31 pp.

Dayton, P.K., Thrush, S.F., Agardy, M.T. & Hofman, R.J. (1995) Environmental effects of marine fishing. *Aquatic Conservation: Marine and Freshwater Ecosystems* **5** (3): 205–232.

Dugan, J.E. & Davis, G.E. (1993) Applications of marine refugia to coastal fisheries management. *Canadian Journal of Fisheries and Aquatic Sciences* **50**: 2029–2042.

Eleftheriou, A. & Robertson, M.R. (1992) The effects of experimental scallop dredging on the fauna and physical environment of a shallow sandy community. *Netherlands Journal of Sea Research* **30**: 289–299.

Eno, N.C., MacDonald, D. & Amos, S.C. (1996) A study on the effects of fish (Crustacea/Mollusc) pots on benthic habitats and species. Unpublished report, Studies contract 94/076, European Commission Directorate General DG XIV: 43 pp.

FAO (2000) The state of world fisheries and aquaculture (SOFIA) 2000. Rome, Italy: FAO: 142 pp.

Fox, H. (2001) *The Evolution of the Fishing Village: Landscape and Society along the South Devon Coast, 1086–1550.* Oxford, UK: Leopard's Head Press: 208 pp.

Hall, S.J. (1999) *The Effects of Fishing on Marine Ecosystems and Communities.* Oxford, UK: Blackwell Science: 296 pp.

Hanna, S. (1998) Institutions for marine ecosystems: economic incentives and fishery management. *Ecological Applications* **8** (1, Supplement): 170–174.

Hart, P.J.B. (1998) Enlarging the shadow of the future: avoiding conflict and conserving fish. In: *Reinventing Fisheries Management,* ed. T.J. Pitcher, P.J.B. Hart & D. Pauly, pp. 227–238. London, UK: Kluwer Academic Publishers.

Harvey, M., Bourget, E. & Miron, G. (1993) Settlement of Iceland scallop *Chlamys islandica* spat in response to hydroids and filamentous red algae: field observations and laboratory experiments. *Marine Ecology Progress Series* **99**: 283–292.

Hill, A.S., Brand, A.R., Wilson, U.A.W., Veale, L.O. & Hawkins, S.J. (1996) Estimation of by-catch composition and the numbers of by-catch animals killed annually on Manx scallop fishing grounds. In: *Aquatic Predators and their Prey*, ed. S.P.R. Greenstreet & M.L. Tasker, pp. 111–115. Oxford, UK: Fishing News Books.

Hofmann, E.E. & Powell, T.M. (1998) Environmental variability effects on marine fisheries: four case histories. *Ecological Applications* **8** (1, Supplement): 23–32.

Horwood, J.W. (2000) No-take zones: a management context. In: *Effects of Fishing on Non-target Species and Habitats – Biological, Conservation and Socio-economic Issues,* ed. M.J. Kaiser & S.J. de Groot, pp. 302–312. Oxford, UK: Blackwell Science.

Jennings, S. & Kaiser, M.J. (1998) The effects of fishing on marine ecosystems. *Advances in Marine Biology* **34**: 203–354.

Jennings, S., Kaiser, M.J. & Reynolds, J.D. (2001) *Marine Fisheries Ecology*. Oxford, UK: Blackwell Science: 417 pp.

Jentoft, S., McCay, B. & Wilson, D.C. (1998) Social theory and fisheries co-management. *Marine Policy* **22** (4–5): 423–436.

Kaiser, M.J. & Spencer, B.E. (1994) Fish scavenging behaviour in recently trawled areas. *Marine Ecology Progress Series* **112**: 41–49.

Kaiser, M.J. & Spencer, B.E. (1996) The effects of beam trawl disturbance on infaunal communities in different habitats. *Journal of Animal Ecology* **65**: 348–358.

Kaiser, M.J., Edwards, D.B., Armstrong, P.J., Radford, K., Lough, N.E.L., Flatt, R.P. & Jones, H.D. (1998) Changes in megafaunal benthic communities in different habitats after trawling distrubance. *ICES Journal of Marine Science* **55**: 353–361.

Kaiser, M.J., Spence, F.E. & Hart, P.J.B. (2000) Fishing-gear restrictions and conservation of benthic habitat complexity. *Conservation Biology* **14** (5): 1515–1525.

Kinnear, J.A.M., Barkel, P.J., Mojsiewicz, W.R., Chapman, C.J., Holbrow, A.J., Barnes, C. & Greathead, C.F.F. (1996) Effects of Nephrops creels on the environment. Fisheries Research Services Report 2/96, Agriculture, Environment and Fisheries Department, Scottish Office, Aberdeen, UK.

Knudson, E. & MacDonald, D. (2000) Sustainable fisheries: Are we up to the challenge? *Fisheries* **25** (12): 4 and 43.

Kula, E. (1992) *Economics of Natural Resources and the Environment*. London, UK: Chapman and Hall: 287 pp.

Langton, R.W. & Haedrich, R.L. (1997) Ecosystem-based management. In: *Northwest Atlantic Groundfish: Perspectives on a Fishery Collapse*, ed. J. Boreman, B.S. Nakashima, J.A. Wilson & R.L. Kendall, pp. 151–156. Maryland, USA: American Fisheries Society.

Lauck, T., Clark, C.W., Mangel, M. & Munro, G.R. (1998) Implementing the precautionary principle in fisheries management through marine reserves. *Ecological Applications* **8** (1, Supplement): 72–78.

McGlade, J., Price, A., Klaus, R. & Metuzals, K. (1997) Recovery plans for the North Sea ecosystem, with special reference to cod, haddock and plaice. Department of Biological Sciences, University of Warwick, Warwick, UK: 41 pp.

Minchin, D. (1992) Biological observations on young scallops, *Pecten maximus*. *Journal of the Marine Biological Association of the United Kingdom* **72**: 807–819.

Moran, M.J. & Stephenson, P.C. (2000) Effects of otter trawling on macrobenthos and management of demersal scalefish fisheries on the continental shelf of north-western Australia. *ICES Journal of Marine Science* **57**: 510–516.

Murawski, S.A. (2000) Definitions of overfishing from an ecosystem perspective. *ICES Journal of Marine Science* **57**: 649–658.

Murawski, S.A., Brown, R., Lai, H.-L., Rago, P.J. & Hendrickson, L. (2000) Large-scale closed areas as a fishery-management tool in temperate marine systems: the Georges Bank experience. *Bulletin of Marine Science* **66** (3): 775–798.

Murray, S.N., Ambrose, R.F., Bohnsack, J.A., Botsford, L.W., Carr, M.H., Davis, G.E., Dayton, P.K., Gotshall, D., Gunderson, D.R., Hixon, M.A., Lubchenko, J., Mangel, M., MacCall, A., McArdle, D.A., Ogden, J.C., Roughgarden, J., Starr, R.M., Tegner, M.J. & Yoklavich, M.M. (1999) No-take reserve networks: sustaining fishery populations and marine ecosystems. *Fisheries* **24** (11): 11–25.

Naidu, K.S. & Scaplen, R. (1979) Settlement and survival of giant scallop *Placopecten magellanicus* larvae, on enclosed polyethylene film collectors. In: *Advances in Aquaculture*, ed. T.V.R.Pillay & W.A. Pill, pp. 379–381. London, UK: Fishing News Books.

Neis, B., Schneider, D.C., Felt, L., Haedrich, R.L., Fischer, J. & Hutchings, J.A. (1999) Fisheries assessment: what can be learned from interviewing resource users? *Canadian Journal of Fisheries and Aquatic Science* **56**: 1949–1963.

Norse, E.A. & Watling, L. (1999) Impacts of mobile fishing gear: the biodiversity perspective. *American Fisheries Society Symposium* **22**: 31–40.

Palma, A.T., Wahle, R.A. & Steneck, R.S. (1998) Different early post-settlement strategies between American lobsters *Homarus americanus* and rock crabs *Cancer irroratus* in the Gulf of Maine. *Marine Ecology Progress Series* **162**: 215–225.

Pile, A.J., Lipicius, R.N., van Montfrans, J. & Orth, R.J. (1996) Density-dependent settler-recruit-juvenile relationships in blue crabs. *Ecological Monographs* **66** (3): 277–300.

Pitcher, T. J. & Pauly, D. (1998) Rebuilding ecosystems, not sustainability, as the proper goal of fishery management. In: *Reinventing Fisheries Management*, ed. T.J. Pitcher, P.J.B. Hart & D. Pauly, pp. 311–329. London, UK: Kluwer Academic Publishers.

Piskaln, C.H., Churchill, J.H. & Mayer, L.M. (1998) Resuspension of sediment by bottom trawling in the Gulf of Maine and potential geochemical consequences. *Conservation Biology* **12** (6): 1223–1229.

Roberts, C.M., Bohnsack, J.A., Gell, F., Hawkins, J. & Goodridge, R. (2001) Effects of marine reserves on adjacent fisheries. *Science* **294**: 1920–1923.

Roberts, C.M. & Hawkins, J.P. (1997) How small can a marine reserve be and still be effective? *Coral Reefs* **16**: 150.

Robinson, M. & Tully, O. (2000) Spatial variability in decapod community structure and recruitment in sub-tidal habitats. *Marine Ecology Progress Series* **194**: 133–141.

Sainsbury, K.J., Campbell, R.A., Lindholm, R. & Whitelaw, A.W. (1998) Experimental management of an Australian multispecies fishery: examining the possibility of trawl-induced habitat modification. In: *Global Trends: Fisheries Management*, ed. E. K. Pikitch, D.D. Huppert & M.P. Sissenwine, pp. 107–112. Bethesda, Maryland, USA: American Fisheries Society.

Sherman, K. (1991) The large marine ecosystem concept: research and management strategy for living marine resources. *Ecological Applications* **1** (4): 349–360.

Sinclair, M., Mohn, R.K., Robert, G. & Roddick, D.L. (1985) Considerations for the effective management of Atlantic scallops. Canadian Technical Report on Fisheries and Aquatic Science 1382, Department of Fisheries and Oceans, Halifax, Nova Scotia, Canada: 113 pp.

Stevens, B.G. & Kittaka, J. (1998) Postlarval settling behaviour, substrate preference, and time to metamorphosis for red king crab *Paralithodes camtschaticus*. *Marine Ecology Progress Series* **167**: 197–206.

Stevens, P.M. (1987) Response to excised gill tissue from the New Zealand scallop *Pecten novaezelandiae* to suspended silt. *New Zealand Journal of Marine and Freshwater Research* **21**: 605–614.

Stokesbury, K.D.E. & Himmelman, J.H. (1995) Biological and physical variables associated with aggregations of the giant scallop *Placopecten magellanicus*. *Canadian Journal of Fisheries and Aquatic Sciences* **52**: 743–753.

Thouzeau, G. (1991) Experimental collection of postlarvae of *Pecten maximus* (L.) and other benthic macrofaunal species in the Bay of Saint-Brieuc, France.I. Settlement patterns and biotic interactions among the species collected. *Journal of Experimental Marine Biology and Ecology*. **148**: 159–179.

Turner, W.H., Tammi, K.A. & Rice, M.A. (1996) 'Bags to drags,' the story of the bay scallop restoration project. *Journal of Shellfish Research* **16** (1): 276.

Veale, L.O., Hill, A.S., Hawkins, S.J. & Brand, A.R. (2000) Effects of long-term physical disturbances by commercial scallop fishing on subtidal epifaunal assemblages and habitats. *Marine Biology* **137**: 325–337.

Walters, C. (1998) Designing fisheries management systems that do not depend upon accurate stock assessment. In: *Reinventing Fisheries Management*, eds. T.J. Pitcher, P.J.B. Hart & D. Pauly, pp. 279–288. London, UK: Kluwer Academic Publishers.

Woodhatch, L. & Crean, K. (1999) The gentleman's agreement: a fisheries management case from the Southwest of England. *Marine Policy* **23** (1): 25–35.

Young, P.C., McLoughlin, R.J. & Martin, R.B. (1992) Scallop (*Pecten fumatus*) settlement in Bass Strait, Australia. *Journal of Shellfish Research* **11** (2): 315–323.