SUSTAINABLE EXPLOITATION WITH MINIMAL CONFLICT: IS IT POSSIBLE?

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Abstract

To manage a fishery sustainably it is necessary for fishers to regard the future as valuable and avoid intense competition for access to the resource. We describe the Inshore Potting Agreement off the south coast of Devon, UK as a case study of a self-generated management measure that has functioned on a voluntary basis for 24 years and has acted to conserve parts of the ecosystem and reduce conflict between fishers. We then ask how we can understand the way in which this system has worked successfully concluding that the best approach is to regard fishers as driven by inbuilt social strategies, derived from our evolutionary past, which are then moderated by cultural norms. The Devon system acts as a

metaphor for how management of inshore fisheries should be developed in the future.

Introduction.

> " … how can it be possible to arrive at cogent aggregative judgements about the society (for example about 'social welfare,' or 'the public interest,' or 'aggregate poverty'), given the diversity of preferences, concerns and predicaments of the different individuals *within* the society?" (Sen, 2002)

An understanding of fishers' behaviour is crucial if we are to determine whether sustainable development is possible with minimal conflict between exploiters using different gears with conflicting needs. We also must recognize that there are two problems inherent in attempts to sustain exploitation but minimize conflict; how do we '… prolong the shadow of the future', using Axelrod's (1981) metaphor and how do we get fishers using different types of gear to partition the fishing grounds equitably? Prolonging the shadow of the future, requires fishers to reduce activity today so as to extend the chance of fishing in the future; the essence of sustainability (Anand and Sen, 1996).

This paper will address the issue of sustainability without conflict by first describing the south Devon UK inshore fishery. We will then outline the Inshore Potting Agreement (IPA) that was devised in the 1970s to reduce conflict between fishers that use static and mobile gear. We then outline the value of studying this fishery and why it is necessary to try to understand, from a scientific perspective, how the IPA works. This will lead to a discussion of the conceptual background required for a complete understanding of the IPA and the conclusion put forward is that a Darwinian approach to understanding human behaviour provides the bedrock on which potential explanations should be built.

The study area is bounded on the east by Brixham and on the west by Plymouth on the southwest coast of the United Kingdom. We are concerned only with the inshore waters, which extend in a belt of about 6 nautical miles from the shore extended from the two ports via Start Point (see Figure 1).

The South Devon inshore fishery.

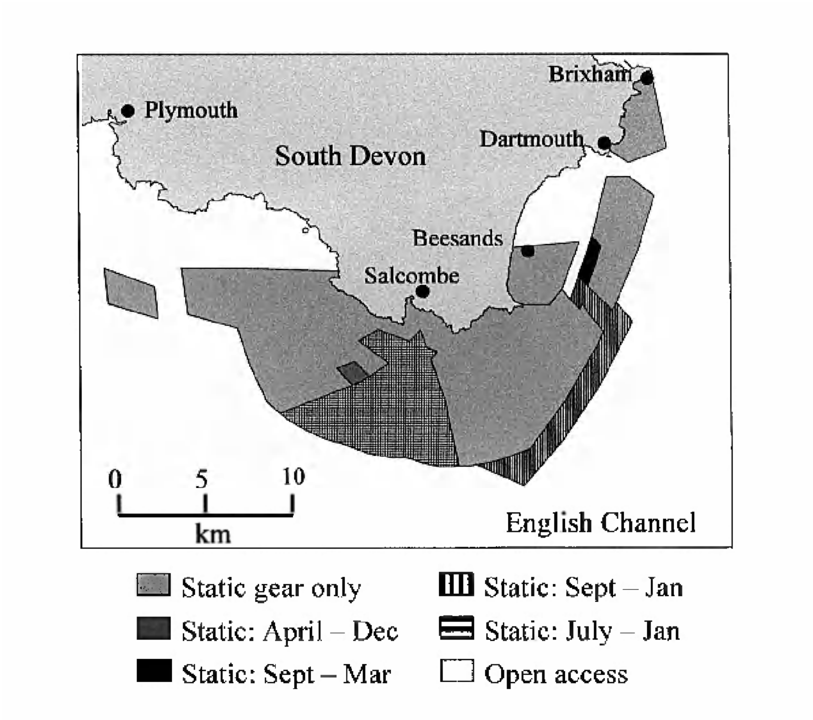

Figure 1. The area covered by the Inshore Potting Agreement off the south coast of Devon between Plymouth in the west and Brixham in the east. The boundaries shown are those agreed at the 2003 revision of the area. The key shows the times at which areas are open to potters.

The principle catch in the area is of the edible crab (*Cancer pagurus*) though spider crabs (*Maja squinado*) and lobsters (*Homarus gammarus*) are also caught. Modern vessels that target crabs are 10-15 m long and can operate up to 1600 pots, although most use 600-700 (Blyth *et al* 2002). Most of these vessels are based in either Dartmouth or Salcombe whereas in the days before diesel engines, crabbers used rowing boats launched off the beach from within the home community (Firestone, 1972, 1976; Hart 1998).

In addition to the potters, who form the majority of the fishing fleet in the area, there are a small number of 10-15 m vessels that use trawls to catch a variety of demersal species including cod (*Gadus morhua*), plaice (*Pleuronectes platessa*), rays (Rajiidae) and lemon sole (*Microstomus kitt*). Some of the potters trawl for demersal fish between Christmas and Easter when returns from the crab fishery are at their lowest.

The area is also visited by a small number of 10-15 m vessels, mostly based in Brixham, that dredge for scallops (*Pecten maximus*). Occasionally large beam trawlers and scallop dredgers of around 15 m length and greater, fish illegally in the inshore area. The fishing activities of these vessels are responsible for most of the damage to static gear and to the biodiversity of the fishing grounds (Kaiser et al 2000).

The Inshore Potting Agreement.

We start by introducing a case study, which we use to make a number of points about voluntary fishery agreements. For a wider discussion of fisheries self-governance see Townsend (1995) and Wilson et al (2003). A well-documented case study similar to ours in its perspective is Acheson's Figure 1. The area covered by the Inshore Potting Agreement off the south coast of Devon between Plymouth in the west and Brixham in the east. The boundaries shown are those agreed at the 2003 revision of the area. The key shows the times at which areas are open to potters.

(1988) work on the Maine, USA lobster (*Homarus americanus*) fishery. Before 1970 in the Devon inshore fishery, there was no serious conflict between fishers using fixed gear and those using towed fishing gear (see Blyth *et al* 2002 for more detail). In response to improvements in fishing gear technology, in the mid 1970s, those using towed fishing gear began to expand their area of operation and in the process clashes developed between them and fishers using static gear. Potters lost equipment and incurred significant expense as a result of damage and this led to a reconciliation meeting under the auspices of the UK Ministry of

Agriculture Fisheries and Food who helped broker an agreement between them.

The agreement partitioned the inshore region most heavily exploited by potters into areas reserved exclusively for potting and other areas where mobile gear could be worked either all of the time or seasonally (Figure 1).

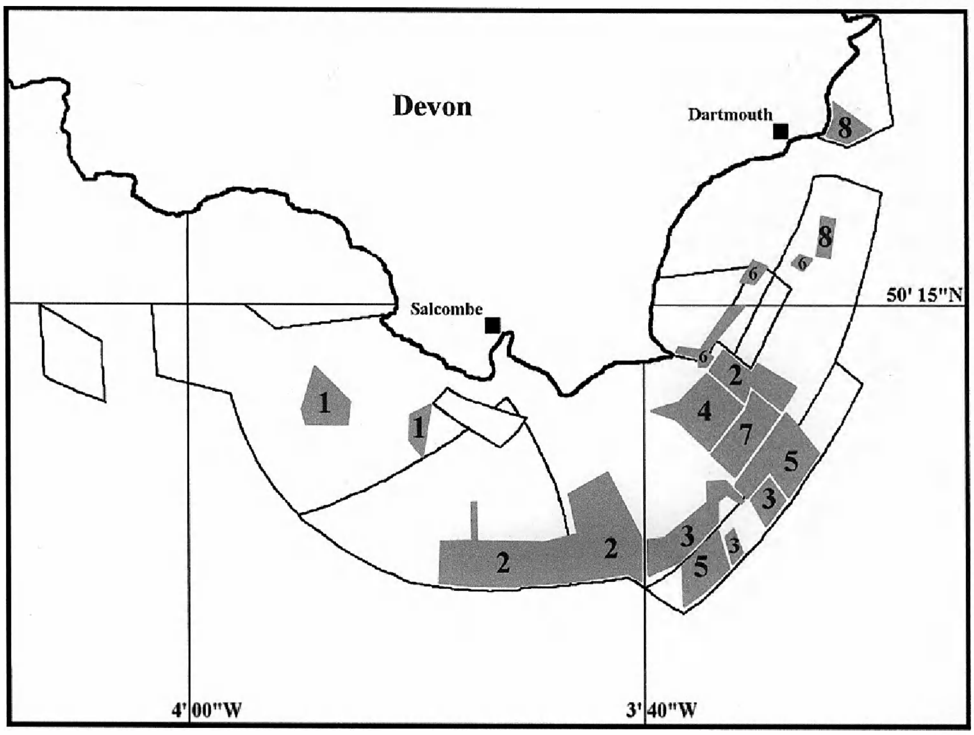

Figure 2. The IPA area with the territories occupied by eight potters. Gear is left in the areas at all times within the potting only areas but is only down in the remaining areas when trawling is not allowed

The area covered by the agreement at the beginning in 1978 was 527.3 km^2 of which 291 km^2 was reserved for static gear only. Various revisions of the areas have lead to the present situation where the total area covered by the agreement is 504 km^2 of which 341 km^2 is for potters only, all year round.

From its inception until March 2002, the IPA was a voluntary agreement. This had the disadvantage that there was no legal means of punishing fishers who broke the agreement. The IPA is of more than local interest, because for 24 years it worked without legal enforcement. In March 2002, national legislation was passed to protect the IPA with formal legislation with the consequence that transgressors can now be fined up to £50,000 (€75,000). This change was brought about by the need to deter increasing intrusion of the larger scallopers and beam trawlers who could inflict heavy damage yet could not be deterred through local personal interactions. This was largely because the fishers running the large boats are not part of the local fisher community as will be discussed later.

Within the areas closed to all but potters, each individual fisher has established his own patch or territory (Figure 2). Pots are left on the seabed for the whole year so marking their territory and preventing intrusions from neighbouring territory holders. As Figure 2 shows, those who have territories bordering zones that are open to mobile gear for some of the year, extend into these areas when mobile gear is excluded. In other words, territories expand and contract seasonally.

Before the crabbing area was so heavily exploited, potters would move their gear seasonally to take account of the movements of the crabs. In the spring, male crabs are found closer inshore, so pots were set close to shore to catch them. Later in the season pots would be moved further offshore to exploit the female crabs congregating in deeper water. As the density of pots is now so high, these seasonal movements are no longer possible and each fisher retains his static area. In effect, each potter has an established right to this ground, although proper ownership is not recognised either informally or formally. We discuss later the issue of ownership and its significance.

The IPA has minimized gear loss by the potters and has allowed them to maximize the exploitation of the area. The seabed of the potting only areas is ecologically distinct from the seabed that is trawled regularly (Kaiser *et al* 2000, Blyth et al., in press)). In this sense the potting only areas are equivalent to a Marine Protected Area (MPA) providing protection from trawling to demersal fish and epibenthic invertebrate fauna. In this sense the gear separation agreement has lead to conservation of parts of the ecosystem and perhaps acts as a reservoir for mobile species that may obtain some protection from trawling (eg Blyth et al., submitted). Fishing pressure on the crab stocks is high but cannot be increased much more within the closed areas as there is little or no room for more pots.

Fisher's perceptions of the IPA are a function of the type of gear used (Blyth *et al* 2002). In general, potters consider that the agreement is a good thing that benefits them whilst the fishers using towed gear are less favourably disposed towards the system. Potters see the system as providing conservation of the resources of their area so sustaining their livelihood.

Why did the IPA work as a voluntary agreement?

The first question to ask is why it is worth trying to understand how the voluntary version of the IPA worked. Our hypothesis is that the system worked because it provided an environment within which cooperative behaviour was encouraged. It might be better to say that the agreement was applied to a fisher community that had a social structure necessary for cooperation to develop. A corollary to this hypothesis is that if we can understand the structure of the community and the environment in which the IPA worked, then the lesson learned can be applied to similar situations.

The next problem is to decide whether any one intellectual tradition can be used to develop an answer to the question of why the agreement worked or whether we need to develop an interdisciplinary approach. Fishery science includes biological, economic and sociological approaches but the are rarely integrated to provide an understanding of aspects of fish conservation and management (Hart and Reynolds 2002).

In the pioneering days of fishery management, when analytical tools were under development, the emphasis was on trying to understand the factors determining the biological productivity of stocks (Townsend and Wilson, 1987; Smith 2002). The assumption was that if the stock was well managed then it would also be conserved and profitable. Models of exploited stocks were developed and used to predict the level of fishing effort that would produce the optimal catch, with Maximum Sustainable Yield being the most famous target set for management (see Shepherd and Pope 2002a & b and Schnute and Richards 2002 for recent reviews). Biological models are still in the majority with the emphasis now shifting to ecosystem models or multispecies models that recognize the interdependence of exploited species (Pauly and Christensen 2002). Mostly these models are used to set quotas which form the basis of fishery regulation in many areas.

The weakness with quotas is that they often require fishers to behave against their best interests. For example, a fisher catching a mixed net of demersal fish may have already caught his quota of one species but not for the remaining part of the catch. As a result he is required to throw back the over-quota part of the catch even though the fish are most likely dead. There is great temptation for fishers in these circumstances to keep the over-quota fish and to sell them illicitly on the black market. This dilemma arises from the present state of fish stock assessment and fisheries management, with its emphasis on biological productivity. Current approaches do not address the principle problem of how to control fisher's behaviour.

Not long after the early biological models of exploited fish stocks had been developed economists joined in and produced an analysis of exploited stocks expressed in economic terms. One of the earliest studies showed that common property resources were bound to equilibrate at the point where costs equal income and that maximum economic return was achieved at a lower stock level than maximum biomass catch (Smith 1969, Hannesson 2002). Until recently (Hammerstein 2001), economics was based on the assumption that humans always behaved rationally, although there was little experimental evidence to support this assumption. The 2002 Nobel Prize for Economics was awarded to Daniel Khaneman and Vernon Smith for their work in creating experimental economics where an understanding of real human behaviour is used to explain economic choice. This is a fast developing area of research with behavioural economics becoming an established sub discipline (Glimcher 2003; Camerer 2003; Sanfey et al 2003).

Clearly sociology is a strong candidate to be the natural discipline for understanding why the IPA worked as a voluntary agreement. Although sociologists have made extensive empirical studies of human societies, much of their conceptual framework, in the past came from an introspective analysis of human behaviour. Humans were regarded as rational agents with free will, who can evaluate the benefits and costs of a situation and take a decision to maximize their benefit. As Dennett (2003) argues we suppose ourselves to be " … Kantian rational agents, responsible for our own destiny." An important assumption in sociological analysis is that culture largely determines social structure meaning that one could always hope to achieve a given social outcome by manipulating the pattern of interactions between people (Reynolds 1980, Segerstråle 2000). As with classical economics the great weakness with this perspective is the lack of attention paid to what people really do and the failure to see humans as part of the evolved animal kingdom. The assumption is made that humans make their society and its institutions through a conscious deliberation of alternatives. A further problem with much sociology is that it tends to focus on groups of people, such as 'the working class', rather than on individual behaviour.

None of these three disciplines can provide a satisfactory conceptual framework for an explanation of why the IPA worked for 24 years as a voluntary agreement. It is our hypothesis that we can only hope to understand how the IPA worked by acknowledging that human behaviour is determined by inner as well as outer factors. For humans to cooperate they have to have a certain type of relationship with their collaborator. Without that relationship, cooperation is impossible. We will outline why in the next section.

The beginnings of an answer.

Before outlining the detail of a potential answer, we need to be reminded of the central place that the fisher has in the fishery (Figure 3). This figure shows the major elements in the system that exists in developed countries for the execution of a fishery and for its management. The basis of the system is the existence of a viable fish stock. There also needs to be a demand for the fish that can be caught by the fisher. Because of the emphasis fishery managers have placed on stock assessment and determination of sustainable yield, a massive apparatus has developed over the past 100 years to assess the biological status of exploited stocks. This is shown in Figure 3 by the rectangles representing fishery laboratories, and international management agencies. The entire focus of their efforts is on the exploited stock and the catch that comes from it. Little effort has been made up to now to understand how the fisher behaves in relation to the stock and the management measures that are imposed to control his/her inputs or outputs. We propose that for a full understanding of a fishery, the lack of work on fisher's behaviour must be made good. We need to understand the fisher putting him/her back into the ecosystem as a top predator. It is our contention that human behaviour is best understood in terms of its evolutionary history, i.e. humans manifest a set of behavioural universals, which have been shaped by selective forces that have acted during human evolution.

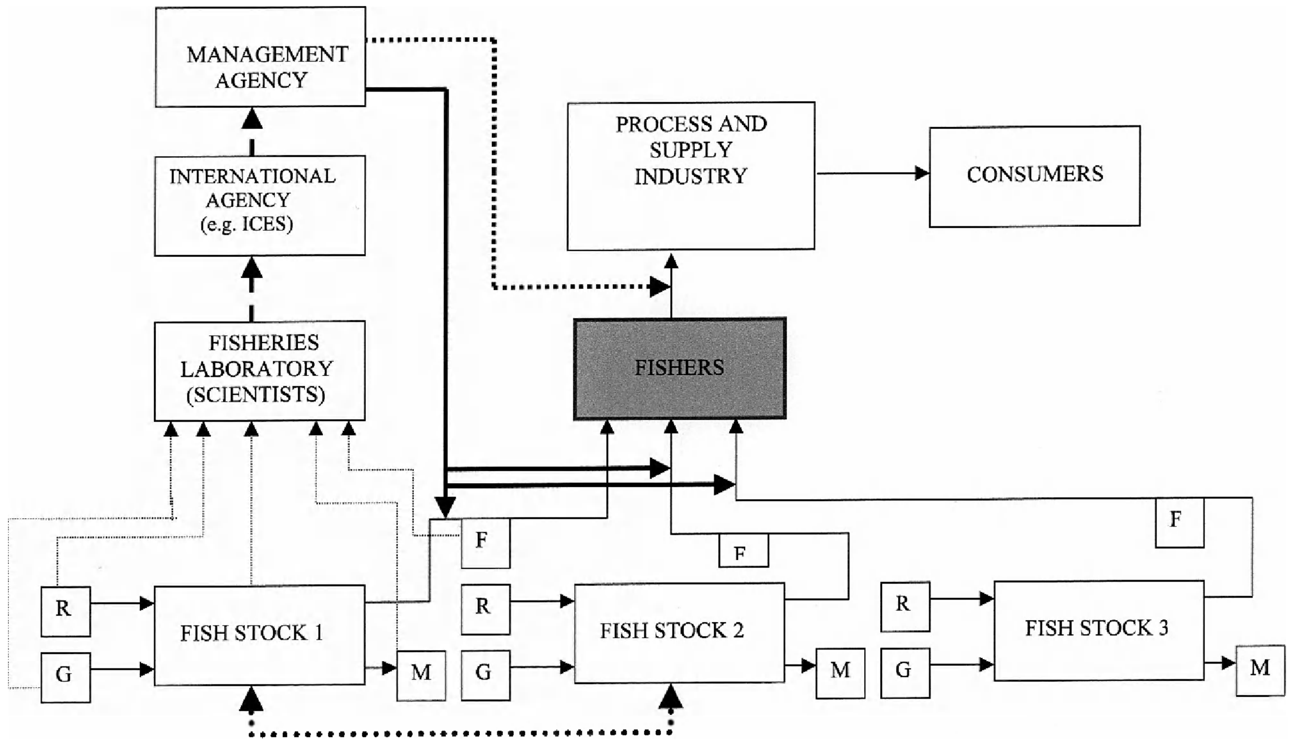

Figure 3. A characterization of the fishery system to show the pivotal place occupied by fishers. The diagram also shows how most of the management effort goes into assessing the state of the fish stocks and regulating inputs to and outputs from the fishers. As explained in the text, we need to have more information on how the fishers respond both to stocks and to the management measures imposed on them.

Disciplines that take this approach are behavioural ecology and evolutionary psychology. Both take a very similar approach although there are subtle differences (Winterhalder and Smith, 2000; Laland and Brown, 2002; Barrett *et al.*, 2002). The principle utility of the evolutionary approach is that there is a body of theory already established for understanding cooperation and conflict in competing animals including humans. This theory allows one to make predictions about how people will behave in particular circumstances, which can then be tested by experiment or by observation. We are not the first to propose this approach, for example social scientists such as Richerson *et al* (2002) have already mapped this area out in detail with respect to the exploitation of common pool resources and their output should be read for a much fuller exposition than we have space for here. In addition other social scientists, without using an evolutionary approach to reach an understanding of human behaviour, for example Ostrom (1990), have made efforts to understand how humans cooperate in situations where individual self interest might be expected to dominate. The sad fact is that the results and ideas of social scientists have not yet been incorporated into the practices of fishery managers.

To understand why fishers off Devon do or do not follow the regulations, we suggest that we need to do three things. We need to determine what fishers actually do, what their population structure is and we need to understand the short-term costs and benefits that direct their decisions. It will then be possible to develop a model or adapt existing models with which we can predict when a fisher will comply with the regulations. Models would be based on the extensive work already done to understand how cooperative behaviour has evolved in non-human animals (see Hammerstein, 2003 for a review).

The first explanation of how cooperative behaviour could evolve, given that Darwinian natural selection is operating, was Hamilton's (1964) theory of kin selection. Individuals will help another if they share genes and in particular when $rb - c > 0$, where r is the coefficient of relatedness between the interactors, b is the benefit to the receiver of an altruistic act and c is the cost to the giver. For all possible pairs, $0 \leq r \leq 1$. These costs and benefits are measured in fitness units or contributions to lifetime reproductive output.

A frequently used model for the evolution of cooperative behaviour between unrelated individuals has been the Prisoner's Dilemma game (PD) (Trivers 1971; Axelrod and Hamilton 1981; Axelrod 1984). The PD is part of a mathematical discipline known as game theory first developed in the 1940's by von Neumann and Morgenstern (1944). Classical game theory deals with interactions between two or more individuals (players) where the pay-off to each is dependent on what everyone else does (Hammerstein 2001, 2003). In the PD game two players have two strategies each; they can either choose to cooperate with their partner or not cooperate, or to defect, as it is usually called in the literature. What defines behaviour as cooperation or defection will vary with the context. In the case of the Devon fishers, cooperation would be abiding by the regulations, whilst defection would be breaking the rules.

Axelrod (1984) showed that the best strategy to play in a repeated PD played for an unknown length of time was Tit for Tat (TFT). This requires individuals playing it to cooperate on the first move and thereafter copy what their opponent did on the previous move. According to Axelrod (1984) this strategy is robust against other strategies because it is 'nice, provocable, forgiving, and clear'. The strategy's ‘niceness’ means it is never the first to defect so it does not get itself into trouble unnecessarily. Because it retaliates quickly against an opponent who has defected, TFT stops other strategies from persisting with defection. The mirror of this is that TFT forgets defection in its opponent after just one cooperative move; so one defection does not lead to a vicious circle of continued defection. Finally the simplicity of the TFT strategy means that the opponent knows where it stands.

The repeated PD game or Iterated Prisoner’s Dilemma (IPD), has been used to interpret many aspects of human cooperative behaviour (Axelrod 1984) but it was realized early on that its simplicity does not capture many aspects of human interaction. For example it is common in western societies for people to cooperate with strangers who are never going to be seen again. This has been called strong reciprocity by Fehr et al., (2002). Within the IPD a once off interaction should lead to defection as this is mathematically the optimal response. Evolutionary psychologists might argue that strong reciprocity is brought about by people employing behaviours that are appropriate when living in small groups but which have become non-optimal in the fluid societies in which western people live today. In simpler terms, our Stone Age human nature is ill suited to present day conditions. This was a point made by Niko Tinbergen (1981), one of the founding fathers of ethology, the naturalistic study of animal behaviour.

Human cooperative practices are also influenced by culture. This too can be studied from an evolutionary perspective and aspects of cultural transmission have been analyzed in terms of memes, the cultural equivalent of genes and regarded as the units of cultural transmission (Dawkins 1976, Blackmore 1999). For a full discussion of the contribution of culture to the development of cooperative behaviour in the exploitation of common pool resources, see Richerson *et al* (2002) and Hammerstein (2003).

These finer points of theory will continue to be debated but doubts about the exact form of the theoretical base do not detract from our main hypothesis; that fishers' behaviour is best understood as a result of our evolutionary history and in terms of evolutionary theory. This comes with the corollary that we can borrow theory from evolutionary psychology and behavioural ecology to develop theories of how fishers should behave. This theory can then be used to make testable predictions.

It should also be recognized that although theory is a powerful way to interpret and predict the behaviour of fishers, the relevance of observation should not be forgotten. One of the key contributions that the early ethologists made to the study of animal behaviour was their emphasis on observing what animals do in their natural environment (Lehner, 1996; Kruuk, 2003). Early work on animal behaviour had often been driven by preconceptions of what motivated animals, very often derived from introspective analysis of human motivation. The same thoughts apply to the study of how fishers behave. We must look at what they do, not what we think they do, or what they say they do.

From existing work with non-humans and humans we know that a number of characteristics typify cooperating and non-cooperating groups. Examples are that the interactants are genetically related, that they are familiar with each other and interact repeatedly and that they have a long-term interest in the relationships they have

(Barrett *et al* 2002). Bearing these features in mind, we can look at the fishers that exploit the Devon fishing grounds. Preliminary results from our Devon study show that inshore fishers are often related. This is particularly true of the crab fishers where it is not uncommon for sons to work with fathers and other close relations will work together (Firestone 1972, 1976). If crews are not relatives then they will usually come from the same small community. For example the village of Beesands with just a few hundred inhabitants contains many fishers who operate crab boats. Many of the people now fishing the inshore area come from families that have been fishing for generations, so giving a long term interest in the occupation and the resource. For example the 1891 UK census listed 11 families in the Parish of Stokenham with the surname Steer and for each family the occupations of the adult males were recorded as 'fisher'. Today members of this family are still active in the crab fishery.

Within the area regulated by the IPA, potters have close relations with potters using neighbouring territories (Figure 2). The fishers using neighbouring areas will interact year in year out building strong relations which will usually be cooperative although frictions do arise.

Within the inshore trawling and scallop dredging community, which is not large, similar conditions can be found. We have recorded instances of private agreements between potters and scallop dredgers, which make it possible for the latter to use their gear between the strings of pots sitting on the sea bed. Such private agreements go against the principles of the IPA, in that the dredgers are deploying their gear within the 'potting only' areas, but such intrusions are tolerated so long as the two fishers involved can come to a mutual agreement. This is possible when they interact frequently over a long period of time and without a time limit on their relationship. The fishers who are most likely to disregard the IPA and to cause significant damage to static gear are the large beam trawlers and scallop dredgers based in Brixham. These vessels and their crews illustrate a number of features that predispose them to defect. Hired crew who work for a wage and a share of the revenues often operate the vessels. Most of the large vessels will be used all around the UK, so the south Devon area is just a tiny portion of the territory they normally exploit. This means that the large vessels do not need to fish within the IPA area but when they do, a great deal of damage may be caused. This damage is not of much consequence to the crew of the beamers and scallopers as they have no interest in the long term well being of the inshore fishery. For them, there are other areas that can be exploited, so the inshore area may be only occasionally targeted either on the way home, or if the weather prevents trips further a field.

It is mostly the damage done by the larger boats, which has forced the local people to persuade the government to change the IPA from a voluntary to a statutory agreement. Whilst voluntary there was no legal way that the crews of large vessels that broke the IPA could be punished for the damage or loss of pots. It was possible for fishers to bring private cases for damages to court but this was expensive and therefore not an attractive route for small operators. The new statutory system means that policing can be carried-out by the Devon Sea Fisheries Committee (who were effectively powerless to prevent transgressions prior to the introduction of legislation), and transgressors can now be fined £50,000 for breaking the agreement. This could be a sufficient penalty to deter would be non-cooperators.

Conclusions.

Over the past 25 years the IPA has been successful in keeping apart fixed and mobile gear in the inshore fishery. The evidence we have indicates that the potting only areas additionally act as Marine Protected Areas with the greatest benefits accruing tothe static fauna. For those animals that move over large distances (for example, fish), the conservation benefits of the closed areas are not consisten although some species could have benefitied (Blyth et al, submitted). The contribution the closed areas make to sustainability of exploited stocks remains unknown. Crabs are exploited heavily within the IPA area, but the activities of the trawl and dredge fleet restrict the use of potting gear outside the system, and the limited availability of space within the IPA does mean that new entries to the fishery are prevented. In this sense, the closed areas have set a ceiling to the amount of fishing effort that can be deployed on the crab stocks, as there is a physical constraint on the amount of gear that can be deployed at any one time.

It has been argued in this paper that the IPA has worked because of the social structure of the fishing community. As yet our evidence for this is still preliminary. Gathering the data we require is problematic in that fishers are naturally suspicious of outsiders who want to know about their activities. They are less concerned about investigations of the resources they exploit but it takes a great deal of time to build up the trust required to obtain data on the fishers themselves. There is also the methodological problem of how data is collected on natural behaviour. An observer on board a fishing vessel with a declared intention of recording fisher behaviour is likely to influence what happens. If the behaviours are recorded without first informing the fisher, and under the pretext of collecting data on the resource, there is an ethical issue that would be hard to overcome. These issues have been addressed by social scientists and protocols have been worked out for collecting information through questionnaires and interviews. This approach would not fulfill our requirements of recording actions as well as expressed intentions.

It has been argued that an explanation of how the IPA works should be based on the notion that the fisher's behaviour is governed by rules developed over evolutionary time overlain by cultural norms. To uncover the rules used, requires patient observation of fishers' behaviour and their population's structure and life style.

The evidence we have so far indicates that the IPA works because it is a homegrown system, which grew out of the needs to resolve conflicts of interest. So many fishery management measurements are imposed from the top down and are based on either no knowledge of fishers' behaviour or faulty knowledge. As has been emphasized by others (eg Ostrom *et al*., 1994, 2001), resource management has to be tailored to the social structure of the exploiters, taking into account the costs and benefits that determine the decisions they make about their livelihood.

The touchstone for good management is sustainable exploitation without conflict between fishers. It is unlikely that conflict can be eliminated entirely, but the Devon IPA illustrates how it can be reduced to an acceptable level. The IPA can also be a model for sustainability if one key aspect of the agreement is taken not of. This is that the IPA gives ownership of the resource to the potters. This is not a politically correct thing to say as fishers using mobile gear do not like to think that their freedom to go where they like has been restricted. In the case of the IPA, trawlers are not confined to the 504 km^2 included in the agreement. They have plenty of room further out from the shore to trawl. This may be part of the reason why they are willing to cooperate and not trawl in the potting only area and to abide by the restrictions in the areas open to trawling for only part of the year.

The theme of the workshop was *Who owns the sea?* Many would argue that society owns the sea and fishers are exploiting it on behalf of the rest of us. Such an arrangement gives little incentive for individual fishers to pay attention to the 'shadow of the future'. Some form of ownership gives fishers an interest in conserving fish today for use tomorrow and the IPA has achieved this for the potters. The IPA has now become statutory but its great glory was that for 24 years it operated as a voluntary agreement. That it did, is because the agreement recognized the key features that are needed for a cooperative system to work and these have been outlined in this contribution.

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