

WORKING PAPERS IN ECONOMICS

No 253

**Tenure Rights and Stewardship of Marine Resources:
A co-managed Swedish shrimp fishery in a marine reserve**

by

Håkan Eggert and Mats Ulmestrand

May 2007

ISSN 1403-2473 (print)

ISSN 1403-2465 (online)

SCHOOL OF BUSINESS, ECONOMICS AND LAW, GÖTEBORG UNIVERSITY

Department of Economics

Visiting address Vasagatan 1 Postal address P.O. Box 640, SE 405 30 Göteborg, Sweden

Phone + 46 (0) 31 786 0000

Tenure Rights and Stewardship of Marine Resources: A co-managed Swedish shrimp fishery in a marine reserve

Abstract Economic theory predicts that open access leads to myopic behaviour of fishermen, while improving property rights leads to more long-term decisions of fishermen. In this study, we report the experiences from a co-managed fishery within the Gullmar fjord, which is a marine reserve by the Swedish West coast. A group of fishermen initiated an informal co-management of the fishery in 2002, which was later formalized. Six fishermen were granted exclusive collective user right to 100 fishing days annually during 2004-06, which they distributed evenly within the group. First, we note a dramatic increase in real revenues, where the price differential in comparison with Swedish off-shore shrimp grew from 15% to 75% during 2000-07. Second, the fishermen within the reserve voluntarily increased the mesh size from the legal minimum requirement of 35 mm to 45 mm in order to leave specimen to grow as long as it is optimal. Finally, a small informal market where fishers bought and sold fishing days within the group emerged, which indicates the potential scope for using individual transferable quotas as a means to reduce overcapacity that exist also in Swedish fisheries.

Keywords: Co-management, Fisheries, Marine reserves, Property rights

JEL classification: Q22

Håkan Eggert, Department of Economics, Göteborg University, P.O. Box 640, SE 405 30 Göteborg, Sweden Tel.: +46-31-773 4175; Fax: +46-31-773 1326

Hakan.Eggert@economics.gu.se

Mats Ulmestrand, Institute of Marine Research, Swedish Board of Fisheries, P.O. Box 4, SE 453 21 Lysekil, Sweden. Tel.:+46-523-18727; Fax:+46-532-13977

mats.ulmestrand@fiskeriverket.se

1. INTRODUCTION

The problems related to open access marine fisheries lead fishermen to lack in responsibilities for future benefit flows. In fact, theoretically, open-access fishery implies that fishermen only care about their own catch today, but completely disregard their potential catch tomorrow and in the more distant future (Clark, 1973). It is sometimes held that wealth or the prospect of wealth leads to over exploitation of resources and that myopic behaviour of fishermen is a result of the human nature (Ludwig, Hilborn and Walters 1993). However, from an economics perspective, the problem is rather that poorly defined property rights lead to perverse economic incentives, which causes excessive effort and short-sightedness (Björndal and Munro, 1998).

Hence, fishermen can be made to behave in a more long term responsible manner with respect to stocks and landings and the prospect of wealth will foster stewardship and prevent overfishing, given that property rights are improved and fishermen are provided with more sound incentives. Simply put, fishermen are willing to invest in fish stocks given that they know that there is a fair chance that abstaining from catching a fish today is rewarded in the future. In this study, we report the experiences from a co-managed fishery within the Gullmar fjord, which is a marine reserve by the Swedish West coast.

2. THE GULLMAR FJORD SHRIMP FISHERY

A fjord is an inlet of the sea, which results from marine inundation of a glaciated valley, often with a limited depth at a narrow inlet and greater depths in the upper and middle reaches than on the seaward side, which limits the exchange of deep water within the fjord and the outside sea and provides a unique environment for marine flora and fauna. Hence, from a Swedish perspective the Gullmar fjord is unique being the only fjord in Sweden.

(Figure 1, map of Scandinavia and the Gullmar area).

Northern shrimp (*Pandalus borealis*) trawling in the Gullmar fjord started in 1902 and until 1960, three to four boats frequently trawled the fjord. In 1983, the fjord was made a marine reserve to preserve it as a valuable reference area for marine research. However, limited fishing activities were allowed but by 1990 a ban on trawling was introduced in order to study the effects of trawling on the benthic community and on fish species. During 1996-97 a large scale research experiment of trawling effects was carried out. The results from that project (Lindgarth et. al., 2000, Hansson et.al. 2000) indicated a limited impact on the benthic community and based on these results the management authority, the County of Västra Götaland, decided to re-open the trawl fishery but with new and more strict regulation.

Boats in this fishery is typically small scale trawlers, with a length in the range 8-15 meters, which combine the shrimp trawling with coastal trawling for Norway lobster (*Nephrops norvegicus*). The small vessels benefit particularly from fishing in the fjord during windy conditions when the open sea is not accessible without considerable risk. Thanks to

favourable prices, the landings are valuable to the vessels of concern. In table 1 we report aggregated price, landings and fishing effort data of the fishery.

[Table 1]

3. DEVELOPMENT OF THE CO-MANAGEMENT SHRIMP TRAWL FISHERY

In 1999 a new regulation on the requirements for fishing was decided and the trawl fishery was re-opened. The fishery was open to any fishermen with a size limited single trawl, minimum mesh size of 35 mm and equipped with species selective grid (Isaksen et.al., 1992; Ulmestrand and Larsson, 2000). In order to minimize the effect on bottom fauna, a maximum size and weight for the trawl door, i.e., the size used in the large scale experiment, was decided upon. The total annual fishing effort was limited to 100 vessel days (as was used in the large scale experiment) that could be distributed over the year during Mondays to Thursdays each week. Each vessel has to report to the Swedish coast guard when they want to enter the fjord. Furthermore, the allowed trawl area in the fjord was limited to roughly 30% of the total fjord area (see fig 1) to limit the effects in general and to avoid trawl activity close to hard bottoms with known rare and/or sensitive marine fauna in particular.

By the end of 1999, the first vessels did trawl the area and during 2000 and 2001, the allocation mechanism for vessel days was “race to catch”. As the catch per unit effort (CPUE) by that time was significantly higher in the off-shore shrimp fishery and no price difference between shrimp caught in the two areas existed, the major factor attracting fishermen to the fjord was bad weather. In 2000, the 100 days were used by September 6 and during 2001 all days were consumed by June 20, and consequently the fishery shut down for that year. In

figure 2 we show the distribution of vessel days for each year during 1999-2006. The “race to catch” in 2001 resulted in both lower price per kilo (figure 3) and lower CPUE (figure 4). Individual fishermen who were disappointed with the early shut down contacted the Institute of Marine Research (IMR), which is the local representative of the fishing authority Swedish Board of Fisheries. On several such occasions the biologist author of this article suggested that they should contact other fishermen in order to reach an agreement, but the initial reaction to this suggestion was most often that the other fishermen were not sensible enough to reach such an agreement. However, later on, the four most frequent trawlers commonly contacted the Institute of Marine Research to get help to reach a voluntary agreement on vessel day distribution, which led to a meeting. This first meeting was held by the end of 2001 and it was agreed that the fishery should open by April in 2002, and that the days should be distributed as 40, 40, and 20 for the second, third, and fourth quartile of the year, respectively. In addition, it was agreed that each vessel should not trawl the area more than twice a week.

[Figure 2]

In 2002, the five most frequent trawlers asked for a new meeting with the IMR staff, and reached a new voluntary agreement, which stated that the fishery should postpone the opening until April 14, 2003 and use 50 days until June 30, followed by a closure during July-August, and then use the remaining 50 days during September to December. The participating fishermen agreed that each fisherman could only trawl the area one day per week. During 2002 eight different vessels had acquired the necessary equipment and tried trawling in the fjord. Furthermore, a price difference between off-shore shrimp and the Gullmar shrimp due to superior quality was established, and was on average +34% in favor to the Gullmar shrimp

during 2002. In 2003 the average price difference was up to +50%, which is likely due to the larger shrimp sizes and more vivid specimen following from the reduction of by-catch thanks to the species selective grid.¹ There were still eight trawlers that tried trawling within the area and these two factors led to concern among the most frequent trawlers and the authority. The economist author of this article suggested to the authority that the days could be allocated on an auction basis with a maximum restriction on number of days that each fisherman could buy. This suggestion was ruled out by leading desk officers at the Swedish Board of Fisheries, as it would bear resemblance to Individual Transferable Quotas (ITQs), which at that time was regarded as an unacceptable regulatory instrument both among desk officers at the Board of Fisheries, and among individual fishermen (Eggert and Ellegård 2003; Eggert and Martinsson 2004).

Instead of any market based approach, a co-management initiative was encouraged. Until 2002, exclusion of any fisherman was not in accordance with the prevailing legislation, but at that time a Governmental proposition on amendments to the Act of Fisheries (Anon., 2002) was ratified, and it was now possible to grant sovereign access right to the fjord for a limited number of fishermen. Via an application procedure, where historical catches from the area was a requisite, six vessels were granted permits to fish the area from 2004-2006. Experiences from that period would be evaluated by the end of 2006, followed by a renewed three year period, which in turn implied high chances of a permanent system with this sovereign access and withdrawal right for the permit holders.

¹ A simple indicator of shrimp quality is the frequency of straight instead of curly specimen in a batch of cooked shrimp. A straight specimen indicate that it was dead by the time it was thrown into boiling water, while a fresh cooked specimen will get the characteristic u-shape of a high quality shrimp.

Property rights are in economics often described as a bundle of entitlements defining the owner's rights, privileges, and limitations for use of the resource (Tietenberg, 1996). Schlager and Ostrom (1992) refer to five different types of rights relating to property rights, which we list below, and hold that for common-pool resources the two most relevant are access and withdrawal rights.

- i) Access: The right to enter a defined physical property
- ii) Withdrawal: The right to obtain the "products" of a resource (e.g. catch fish, appropriated water etc.)
- iii) Management: The right to regulate internal use patterns and transform the resource by making improvements
- iv) Exclusion: the right to determine who will have an access right and how that right may be transferred
- v) Alienation: The right to sell or lease either or both of the above collective-choice rights

We note that for the standard setting of an ITQ fishery, where the governmental management sets an annual TAC, fishermen buy and sell shares of that TAC, all but iii) are to a large extent fulfilled. In the co-management setting for this particular fishery both exclusion and alienation rights are quite limited. On the other hand, management rights exist in the sense that our group of fishermen can regulate internal use and transform the resource by making improvements.

4. EXPERIENCES FROM THE CO-MANAGED SHRIMP FISHERY

Granting the sovereign rights to fish the fjord for six trawlers, all of them single operated most of the time, immediately led to activity among the beneficiary fishermen. Besides distribution of days over the year, they were concerned about the large fraction of small and undersized shrimp in their catches. The Swedish regulation and the market for shrimp basically divide shrimp into three size classes. The largest ones, which we refer to as big shrimp, are big enough to be caught in a 10 mm sieve, earn a price in the range USD 10-20 per kg depending on supply and demand variations over the year. The medium size is in a 8 mm sieve, which is sold to preservation factories at a stable price of USD 2 per kg. The smallest, undersized shrimp are less than about 15 mm carapax length, and go through the 8 mm sieve, and are discarded back to sea. All of the fishermen used a 38 mm mesh size from the start, which is larger than the mandatory 35 mm, and agreed that the four remaining days after each of them getting sixteen days would be used for testing whether a 45 mm mesh size could be motivated. A trawl has a retainment profile which follows an ogive curve. Hence, the larger shrimp the larger probability that it will be caught within the trawl. The net selection of shrimp is far from knife-edge and a substantial fraction of medium sized and even undersized shrimp are caught, while some big shrimp slips out of the mesh. Fishermen are often critical to regulatory suggestions, motivated by concern of immature specimen, to increase minimum mesh size with the argument that they will lose too many mature specimen. Here they eagerly gave up some of the big specimen with the aim of increasing the landings of high paid big shrimp 6-12 months later instead of catching them as small low paid specimen. Changing from 38 mm to 45 mm implies a short time reduction of about 5% for the most valuable big shrimp. By 2006 all of the trawlers had voluntary converted to 45 mm minimum mesh size in trawl codend and extension piece, while most other Swedish fishermen still use 35 mm mesh size in the off-shore shrimp fishery. The effect of the increase in mesh size cannot be

determined on the basis of a few years of observation. The average proportion of shrimp sizes in the catch from the Gullmar fjord, 2000-2006, is 67%, 25%, and 8% for big, medium, and undersized, respectively, which is substantially below corresponding figures for the off-shore shrimp fishery. A similar co-management initiative for a shrimp fishery 100 km north of this fishery includes 20-25 vessels where no one is excluded from the fishery. Whether it is due to the higher number of fishermen or that access is not limited, or a combination of both is unclear, but in this other shrimp fishery the fishermen still use the minimum mesh size 35 mm.

In Sweden, monitoring and enforcement of daily fishing activities are carried out by the Swedish Coast guard. Each skipper that wants to enter the reserve in the Gullmar fjord calls the Coast guard and enters the fjord. Random inspections at sea and at landing sites have so far, not reported any violation of the prevailing regulation. Marine researchers from Göteborg University using an underwater robot camera once detected traces from trawl activities outside the prescribed area, but that was before the sovereign rights were granted, and since 2004 no such trespassing has been revealed.

The Swedish off-shore shrimp fishery has a long regulatory history. Already in the 1930s, the industry agreed upon voluntary weekly rations for each vessel in the fleet. The rationale behind this was to prevent price drops due to oversupply, and linked to this agreement a price insurance scheme was developed which guarantees a minimum price for big shrimp. These measures also had the long run result that Swedish shrimp trawlers were small compared with Danish and Norwegian ones. Further, Swedish landings were kept at a low level, which led to a small fraction of the quota when a TAC was introduced in 1992. Denmark, Norway, and

Sweden share the Skagerrak stock, and while the area belonging to Sweden is 30%, Swedish fishermen got 19% of the shrimp TAC based on historical landings. This has led to a fishery where national quota never has been binding for Norwegian or Danish fishermen, while Swedish fishermen have fully used their quota each year during 1992-2005. The current regulation prescribes 35 mm mesh size, and the fishermen also use a voluntary landing composition of 50% big and 50% medium shrimp. Given the price difference between big and medium, a factor 5-10 to one, and the depletion of the annual quota, there is a strong incentive to high grade catches for Swedish fishermen, while the Danish and the Norwegians lack such incentive. Preliminary studies of length compositions for catches in the three countries 2003-04 indicate that Swedish off-shore shrimp fishermen discard roughly 50% of their medium shrimp catches in order to increase their landings of big, more valuable shrimp.

An immediate effect of the agreement on distributing annual effort was that the Gullmar fishermen could aim at landing shrimp when prices are high. A positive effect of the larger mesh size combined with a species selective grid is less weight from by-catch and more vivid specimen when landing. These factors, combined with some marketing efforts to establish the Gullmar shrimp, led to an increasing price difference compared to the off-shore shrimp. In figure 3 we show real price difference for Gullmar shrimp and off-shore shrimp 2000-2006, which confirm the finding by Homans and Wilen (2005) that revenue increases are the first improvement from introduction of rights-based fisheries.

[Figure 3]

As noted earlier, ITQs are still seen with great suspicion by Swedish fishermen, Swedish fisheries managers, and also by managers at the European Union (EU) level. This negative view is probably the result of two major factors. First, the Common Fisheries Policy aims at maintaining communities with little alternative employment, and the same applied for the previous Swedish national fisheries policy. In Sweden, many fishermen fear that ITQ holders in remote areas will be tempted to sell their ITQs to fishermen in urban areas. Second, there is a general fear of introducing transferability. A recent document on rights-based management (RBM) from the European Commission (EC) states:

The most controversial aspect of RBM systems is the transferability of rights. The reasoning behind the tradability of rights is primarily economic: the efficiency of fishing enterprises improves following the exit of economically weaker vessels from the fleet while the transfer of quotas from less profitable to more profitable vessels introduces a price for using the resource. The introduction of a resource price may lead to large-scale buying of rights, resulting in concentration of ownership of quotas, geographical distribution of fishing activity and fleet composition. (page 5, EC 2007)

This view is pretty much shared by the fishermen exploiting the reserve. In 2004 some of the allocated days were not used, and in 2005 and 2006 this trend was even stronger. One important explanation to this was that one of the fishermen got alternative job opportunities, and only used a few or even none of the allocated sixteen days. When the others realized this, an informal trading started where those who wanted to fish paid approximately USD 150 per day that the non-fishing fisherman was willing to sell. Albeit the low sum this shows that transferability was ok with these fishermen, and that some resource rent had already been re-established in the fishery. At the same time fishermen within the group thought it is unfair that he, who doesn't fish, can enjoy additional income just by leasing out his days, and this was an important factor why not all days have been traded.

The issue of skipper skill is sometimes discussed in the literature (e.g. Pascoe and Coglan, 2002). The experience from the Gullmar fjord shrimp trawling provides overwhelming evidence in favour of skipper skill, where the best performing fisherman clearly stand out as a highliner with an average daily income of USD 2000 during 2002-2006, while the average daily income for the other fishermen is about USD 1000 for the same period. Hence, in case the days were transferable we would expect this highliner to lease/buy a substantial amount of the fishing days from the other fishermen.

5. DISCUSSION

The experiences from the co-management of the Gullmar fjord shrimp trawl fishery indicate that a small number of fishermen that gain sovereign right to a fishing area in terms of access and withdrawal, immediately shifted to a more long term perspective. These fishermen proved willing to give up short term catches in order to increase long term catches.

The rights granted to these fishermen also included a substantial amount of influence over management. The informal meetings between the fishermen lead to negotiations where agreements on how to allocate days between individuals were reached quite rapidly. Days with expected high demand for shrimp were targeted and the fishermen divided days between them in order to avoid congestion and get maximum returns. This led to dramatic improvements in price paid per kilogram of shrimp and increased revenues, just as predicted for the introduction of a rights-based fishery (Homans and Wilen, 2005). The meetings between the fishermen did not only end the race to fishing days, and distributed the days

evenly over the year, but also meant that some fishermen did not use all of their days. The daily comparison between the shrimp fishery and the coastal Norway lobster fishery was in favour of the lobster fishery to a large extent and so the total impact on the marine reserve for these years was below the safety limit resulting from 100 days of fishing. Hence, the fishermen could compensate themselves with equally rewarding fishery outside the reserve, which implies that eliminating the race to fishing days also entailed welfare improvements in terms of sustainability.

In terms of exclusion and alienation, the rights granted to the fishermen have been quite limited. The fishermen cannot formally transfer their fishing right, nor can they expect any payment for abstaining their right, and in practice they have limited possibilities to influence who can fish and who cannot fish. However, an informal practice of leasing days between fishermen has partly evolved, where some of the non-used days of one fisherman have been bought from one or two of the other fishermen.

While the project indicate success in terms of conservation and sustainability, it is less clear how potentially necessary future reduction in harvest can be handled by the co-managing fishermen. During 2006, one fisherman left. All the remaining co-managing fishermen argued in favour of keeping the exploitation rate at 100 days, or even increasing it. Given the short time series of the biological data and the great randomness concerning shrimp, little can be said in favour of increasing, or decreasing, the exploitation rate. The fisherman who left did it because of attractive alternative employment opportunities, i.e., high opportunity cost of fishing. Increasing opportunity cost is probably the most important factor in the structural adjustment process of Swedish fisheries over the last 40 years. In terms of numbers, Swedish

commercial fishermen have been reduced by almost 90% since 1960, from 16,000 to less than 2,000, while the real GDP per capita income for Swedes has increased from USD 11,000 to almost USD 30,000 in 2000 (Eggert and Tveterås, 2007).

Concerning efficiency, the project implies major improvements since 2001. Still, efficiency is not an explicit objective of the CFP. The rights of exclusion and alienation are severely limited in the current regime. A fisherman who exits the fishery does not receive any reward for being part of improving the stock or vice versa. This may provide a distorted incentive during the last period before exiting. The absence of an institutionalized right to sell or lease the right to fish clearly hampers efficiency development. The two best performing fishermen can, according to their record, increase the aggregate landing value substantially and that could be done using less than the allocated 100 days, which would guarantee less impact on the benthic community. Render possible such a reform would be strictly welfare improving, given that the other fishermen can find alternative employment. Swedish unemployment rate is below 6% and the same applies for the region where the fishermen live, but those of concern still want to continue as fishermen. This issue rather reflects the current perception of the new CFP among desk officers and commercial fishermen. The new CFP should aim at supporting small-scale coastal fisheries, but the number of small-scale fishermen is rapidly decreasing in Sweden and in other European countries. There is a concern that there exists a critical threshold level of fishermen in remote areas, when the number of fishermen gets too low the supportive land based activities for fishery cannot survive, and if they shut down all commercial fisheries in the area ends. The current management regime, where five fishermen are supported to stay in business is in this sense preferable to only two fishermen that achieve full efficiency. A general finding in economics is that a beneficial aspect of improved property rights is that, e.g. a farmer can use his land as collateral, which facilitates more

investment and more efficient exploitation of the resource thanks to the possibility of taking a mortgage (Besley, 1995). A fully implemented ITQ system would imply that the ITQ holders could borrow money from the bank with the ITQs as security, and improve the technical level of their vessels, but that would come at the expense of less employment opportunities among fishermen. Swedish fisheries management has so far, been reluctant to the use of ITQs. The general concern is that ITQs would lead to concentration and large scale vessels with the loss of the cultural heritage of small-scale coastal fishing. In addition, the idea that an individual can buy or sell the right to fish, and even earn money on value increases for such fishing rights, is often seen as unfair. During 2007 the Swedish pelagic fishery will introduce an ITQ system with several constraints aiming at controlling potential negative side effects of the system. Demersal fishing in Sweden remains within the realm of regulated open-access (Homans and Wilen, 1997). Meanwhile, the co-management experiment with the Gullmar fjord shrimp fishery provides a neat example of how fishermen can be induced to change their perspective to a more long term one when property rights are improved in a fishery.

ACKNOWLEDGEMENT

This work was sponsored by the Swedish Board of Fisheries. Financial support from the Swedish International Development Agency to the Environmental Economics Unit at Göteborg University is acknowledged. The views expressed in this article are those of the authors alone and do not necessarily reflect those of the Swedish Board of Fisheries.

6. LITERATURE CITED

Anon. 2002/03:41

Besley, T. 1995. Property Rights and Investment Incentives: Theory and Evidence from Ghana. *Journal of Political Economy*, 103(5): 903-37.

Björndal, T. and G.R. Munro, (1999) 'The Economics of Fisheries Management: A survey' *The international yearbook of environmental and resource economics: 1998/1999*. Eds H. Folmer and T. Tietenberg. pp.153-188. Elgar, Cheltenham, U.K.

Clark, C. W. 1973. The economics of overexploitation. *Science* 181: 630-34. Eggert, H. and A. Ellegård. 2003 Fishery control and regulation compliance. A case for co-management in Swedish commercial fisheries, *Marine Policy* 27(6): 525-533.

Eggert, H. and P. Martinsson. 2004. Are Commercial Fishers Risk Lovers? *Land Economics* 80(4): 550-60.

Eggert, H. and R. Tveterås. 2007. Productivity Development in Icelandic, Norwegian and Swedish Fisheries. Paper presented at the The XVIIIth Annual EAFE Conference July 9-11, 2007, Reykjavik, Iceland.

European Commission:

- 2007. Communication from the Commission on rights-based management tools in fisheries {SEC(2007) 247}
- 2007. 2002 Reform of the CFP. http://ec.europa.eu/fisheries/cfp/2002_reform_en.htm
- 2005. Green Paper on the future of the Common Fisheries Policy
http://ec.europa.eu/fisheries/publications/reform/green_paper_en.htm

- Hansson, M., M. Lindegarth, D. Valentinsson and M. Ulmestrand, 2000. Effects of shrimp-trawling on abundance of benthic macro-fauna in Gullmarsfjorden, Sweden. *Marine Ecology Progress Series*.198: 191-201
- Homans, F. R., and J. E. Wilen. 2005. Markets and Rent Dissipation in Regulated Open Access Fisheries. *Journal of Environmental Economics and Management* 49(2): 381-404.
- Homans, F. R., and J. E. Wilen. 1997. A Model of Regulated Open Access Resource Use. *Journal of Environmental Economics and Management* 32, 1-21.
- Isaksen, B., J.W. Waldemarsen, R.B. Larsen, and L. Karlsen. 1992. Reduction of fish by-catch in shrimp trawl using a rigid separator grid in the aft belly. *Fisheries Research* 13: 335-352.
- Ludwig, D. R. Hilborn, C. Waters. 1993. Uncertainty, Resource Exploitation, and Conservation: Lessons from History. *Science* 260(2 April): 17;36.
- Lindegarth, M., D. Valentinsson, M. Hansson, and M. Ulmestrand, 2000. Effects of trawl disturbances on temporal and spatial structure of benthic soft-sediment assemblages in Gullmarsfjorden, Sweden. *ICES Journal of Marine Science*, 57: 1369-1376.
- Pascoe, S., and L. Cogan. 2002. The Contribution of Unmeasurable Inputs to Fisheries Production: An Analysis of Technical Efficiency of Fishing Vessels in the English Channel *American Journal of Agricultural Economics*, 84(3): 585-97.
- Schlager, E. and E. Ostrom. 1992. Property-Rights Regimes and Natural Resources: A Conceptual Analysis. *Land Economics* 68(3): 249-62.
- Tietenberg, T. H. *Environmental and Natural Resource Economics*. 4th ed.: HarperCollins College Publishers, New York, NY.

Figure 1.

Map of the Gullmar fjord.

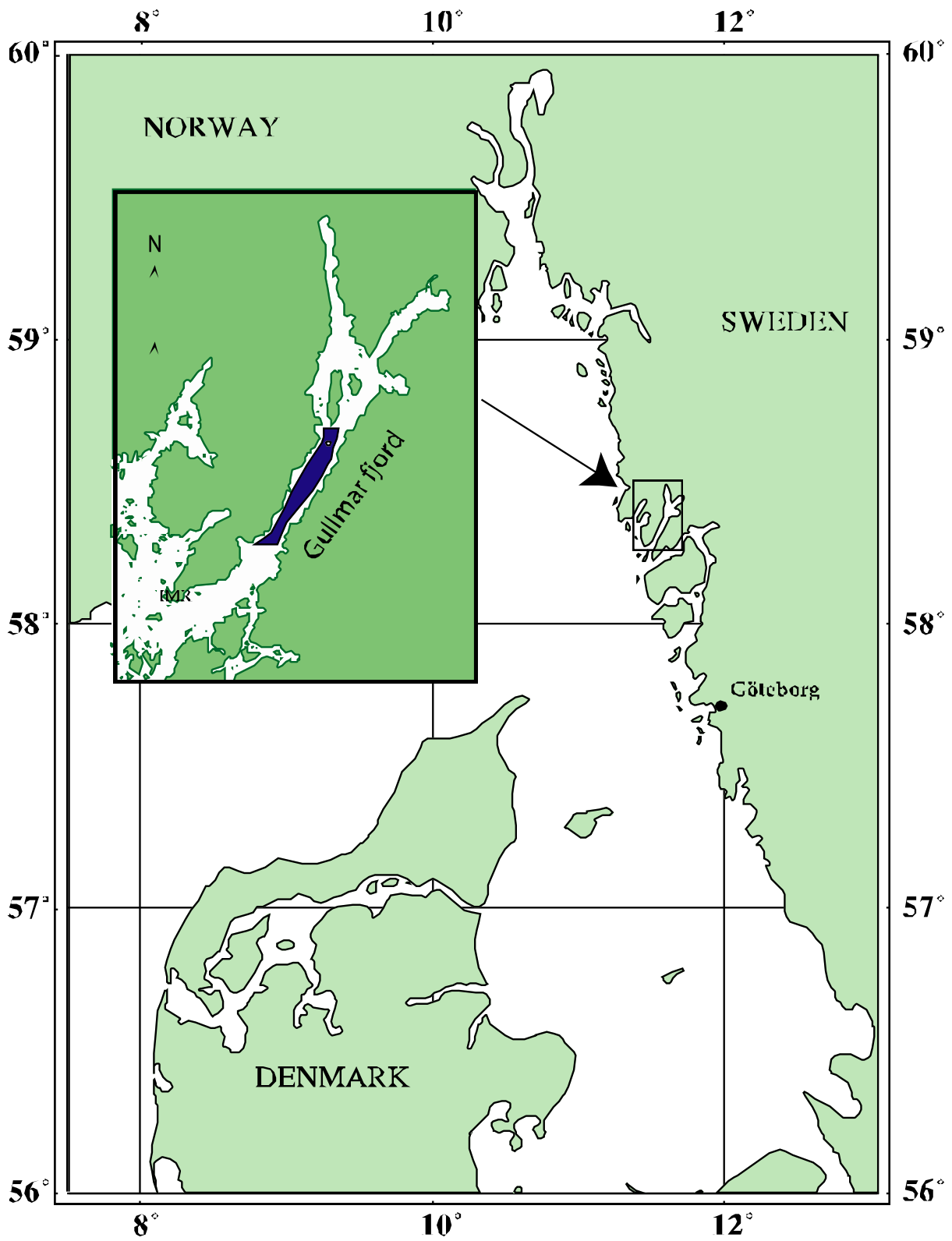


Figure 2.
Annual distribution of the 100 vessel days 1999-2006.

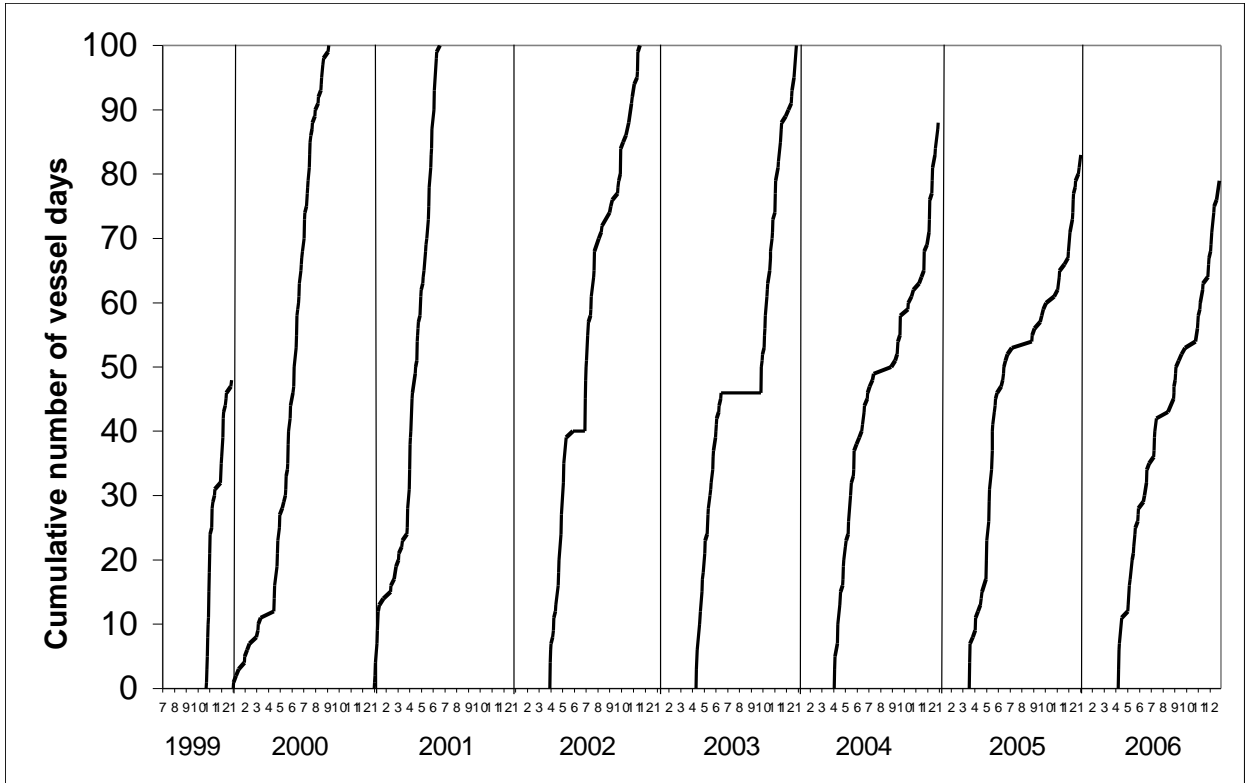


Figure 3.

Annual percentage real price difference between off-shore shrimp and Gullmar shrimp

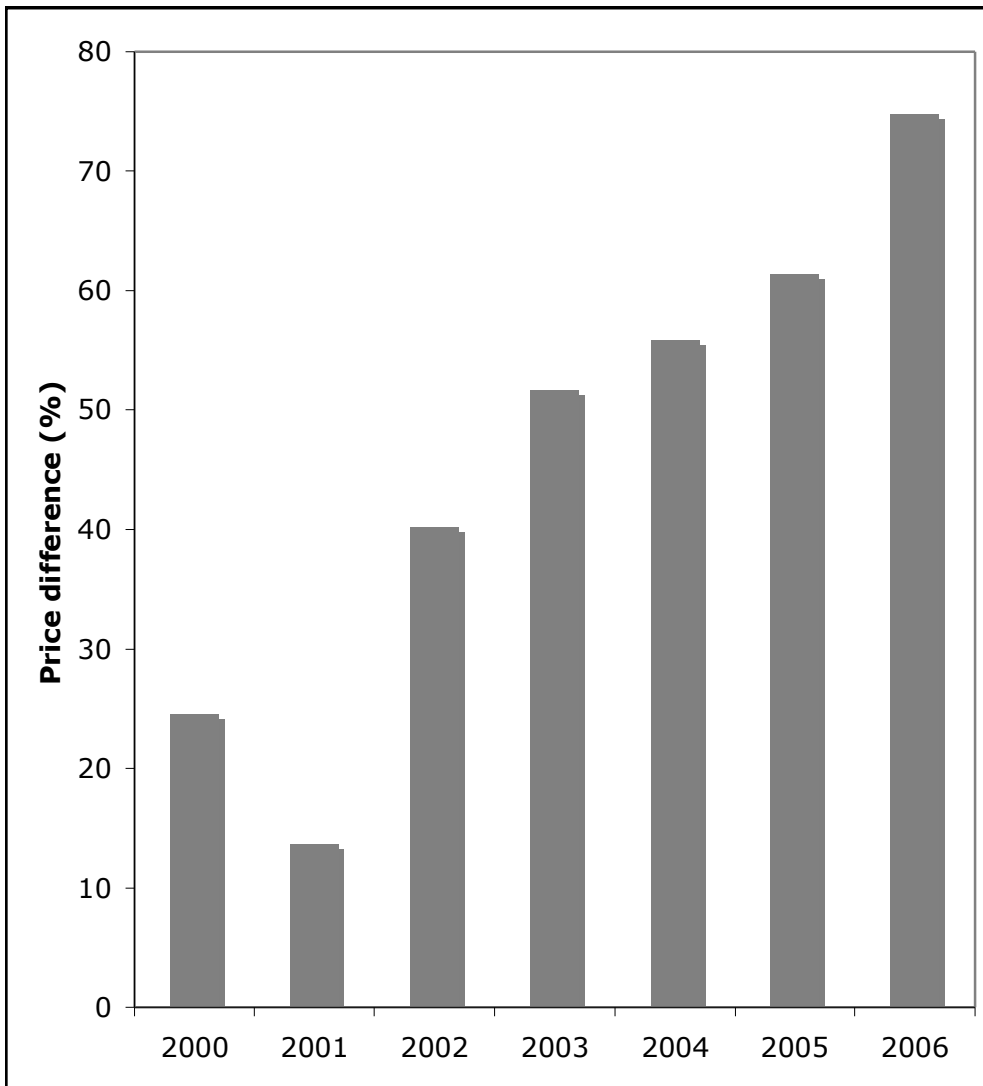


Figure 4.

Annual average shrimp landing per trawling hour. Error bars represent 95% confidence limits.

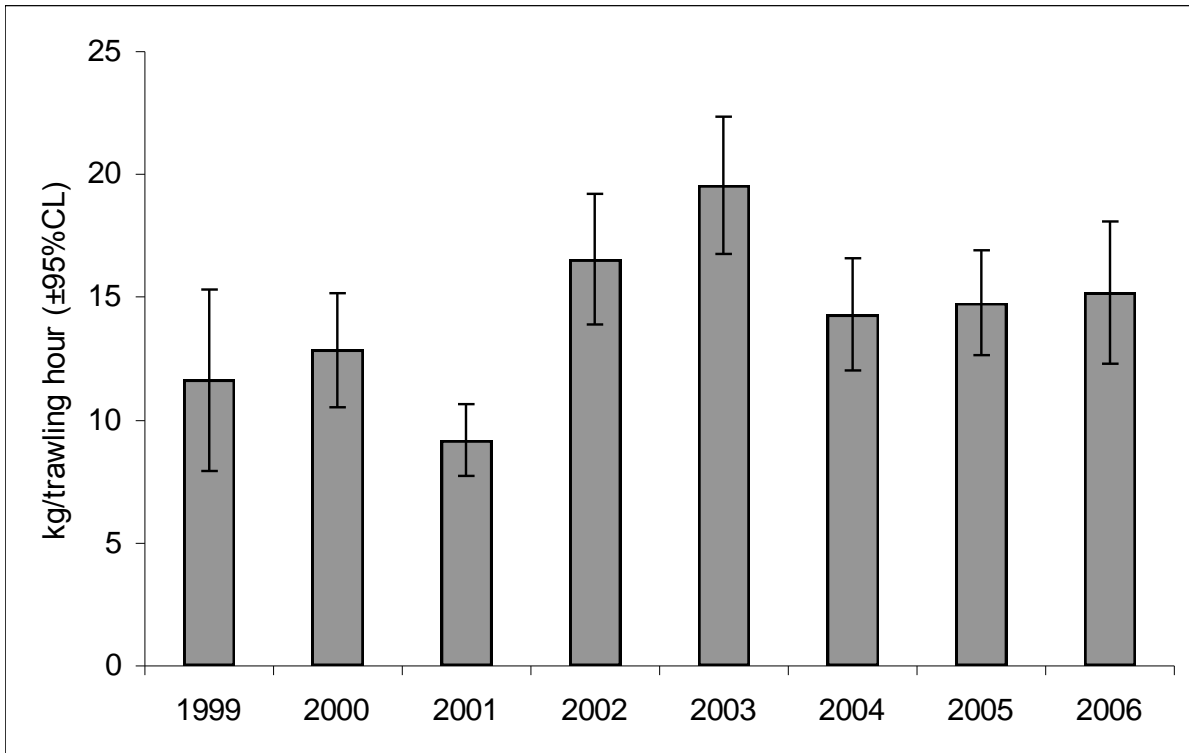


Table 1

Gullmar fjord Shrimp landings, real value, and fishing effort 2000-2006.

Year	Landings (kg)			Discards (kg)		Real price/kg		Fishing effort	
	Large	Medium	Small	Large	Medium	Hours	Days		
2000	3,358	738	55	100,08	15,03	807	100		
2001	5,201	1,252	297	93,27	15,59	998	100		
2002	10,518	2,744	2,430	112,82	13,51	789	100		
2003	11,953	5,756	473	103,09	13,24	945	100		
2004	10,391	2,209	369	100,75	11,76	820	88		
2005	5,807	5,355	2925	130,83	11,61	845	76		
2006	5,377	3,115	831	137,86	12,09	628	71		