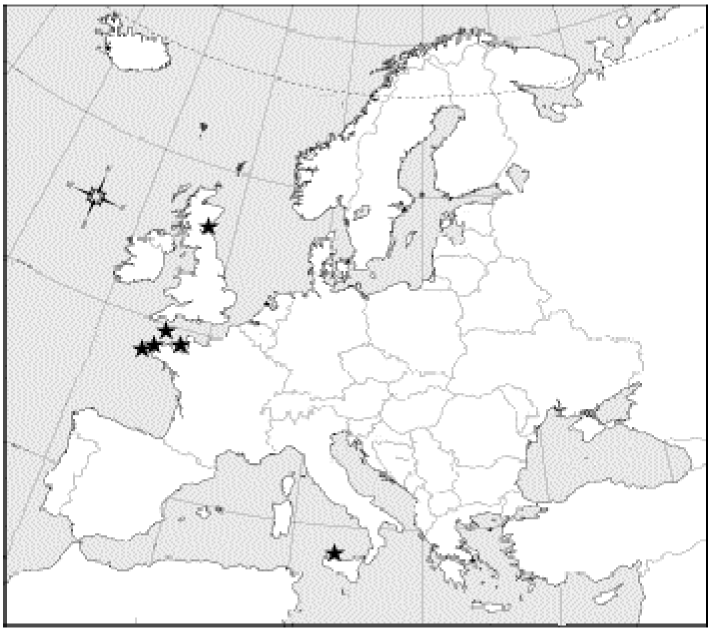
Value of Exclusion Zones as a Fisheries Management Tool in Europe

A strategic evaluation and the development of an analytical framework (QLK5-CT1999-01271)

Final Report



University of Portsmouth

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Disclaimer

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Contributors and Acknowledgements

The VALFEZ project was originally devised as a 2 year project, but has since been extended over the 3 year period (2000-2002). In total, 21 researchers have directly contributed to the project in 4 institutions in 3 countries, with several other persons providing key input throughout the project (see table below). This report is one output of that activity and is a product of the project team. The end result is a comprehensive study of fishing exclusion zones in EU fisheries. Six detailed case studies have been developed to analyse the potential value that such management tools and the analysis thereof can offer to the management process in the development of effective policy.

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Key staff in the project:

Institution	*Staff*
Centre for the Economics and Management of Aquatic Resources (CEMARE) University of Portsmouth Locksway Road Portsmouth. Hants. PO4 8JF United Kingdom.	Helen Pickering David Whitmarsh Sean Pascoe Simon Mardle Carl James Joanna Hampton Amber Himes Nicola Waterman[a]
Centre de Droit et Economie de la Mer (CEDEM) Universite de Bretagne Occidentale BP 816 12 Rue de Kergoat Brest 29285 France.	Jean Boncoeur Frederique Alban Olivier Curtil Stéphane Courtois Stéphane Pennanguer Matthieu Le Tixerant
School of Ocean and Earth Science University of Southampton Southampton Oceanography Centre European Way Southampton SP14 3ZH United Kingdom	Antony Jensen Philip Smith
Istituto di Ricerche sulle Risorse Marine e l'Ambiente Consiglio Nazionale delle Ricerche (CNR) Via G. da Verrazzano 17 Castellammare del Golfo (TP) 91014 Sicily Italy	Carlo Pipitone Fabio Badalamenti Giovanni D'Anna Michele Gristina Marco Kienzle Gianfranco Scotti

[a] Project administrator

Contents

Case Study 1: The Gulf of Castellammare, Sicily, Italy[1]

Fabio Badalamenti[‡], Giovanni D'Anna[‡], Carl James[†]*, Marco Kienzle[‡], Simon Mardle[†], Helen Pickering[†], Carlo Pipitone[‡], David Whitmarsh[†]

[†] *Centre for the Economic and Management of Aquatic Resources (CEMARE), University of Portsmouth, UK.*
*[*Present address: Seafish Industry Authority, Hull. UK.]*

[‡] *CNR-IRMA, Laboritorio di Biologia Marina, Sicily.*

Contents

[1] Please note there is no lead authorship assigned to this case study, hence the authors are listed alphabetically.

Acknowledgments

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1. Introduction

The use of exclusion zones as management tools in fisheries, for habitat protection and for species conservation has a long history, particularly in Europe. For example, Beverton and Holt considered such ideas for North Sea plaice in 1957 (see Guénette et al., 1998). For fisheries management, their use is widespread and their popularity growing in the form of marine protected areas, fishing boxes and gear exclusion zones. In a recent study, over 80 MEZs were identified in Europe, not including fishing boxes established in EC legislature such as the Plaice Box, Shetland Box, Norway Pout Box etc. The majority of these MEZs were identified in the Mediterranean Sea (approx. 72%) and consisted primarily of trawling bans, artificial reefs and marine parks. It is clear that in many of these areas the results reported for these zones have had significant effect specifically on potential benefits with respect to species conservation, especially where low-migratory species are concerned, and to environmental aspects.

However, even with such a history of MEZs in the Europe, other than with some fishing boxes such as the Plaice Box, the details of their effects are seldomly seen in the scientific literature. The Gulf of Castellammare is one area where a fishing exclusion zone (FEZ) has been in effect for some time and where data has been collected before and after the implementation of the trawl ban. This study has enabled the continuing research of this area to take place. The acknowledgement that the Gulf of Castellammare is probably (one of) the best studied FEZ in the Mediterranean Sea, make it a unique case to analyse.

The aims of this report are to consider the effects of this trawl ban on the stocks, the artisanal fleet using trammel nets and the now “outside” fleet of trawlers. Biological data from the trawl surveys, data obtained through interviews with fishers and results from cost and earnings surveys enable biological, bioeconomic and socio-economic analyses to be completed. The aim is to model the potential effects of future policy in the area of renewed trawling in the Gulf of Castellammare. Particularly, the consequences of lifting the trawl ban (partially and wholly) and evaluating how far this would jeopardise the sustainability of the artisanal fishery are explored via an analysis of artisanal trammel net vessels under alternative scenarios.

This introductory section outlines the background of the FEZ in the Gulf of Castellammare. Section 2 details the regulations that apply to this area. Section 3 presents the most recent results of the trawl surveys in the Gulf. Section 4 develops a bioeconomic model of the FEZ in the Gulf, detailing both the biological and economic components within the model. Section 5 presents an economic and social analysis of the artisanal fleet in the Gulf, with specific focus on the economic sustainability of the fleet, and investigates fishermen’s attitudes towards the trawl ban and their predisposition either to remain in the fishery or to quit in the event of the ban being removed. Section 6 compares the trawl ban area of the Gulf with similar areas in Greece and the changes in CPUE that have been seen in each area.

1.1. The Gulf of Castellammare

In 1990, the Sicilian Government recognised that the Gulf of Castellammare (figure 1.1), along with two other Sicilian Gulfs, should be designated a trawl-ban area. The aim of this was to rebuild the demersal resources by protecting them against excessive fishing. As a result, IRMA carried out research on the effect of the trawl ban on the abundance of groundfish stocks in 1993-94 (Study MED92/011: D'Anna et al., 1995) and in 1998-99 (Study 97/063: Pipitone et al., 2000b). The main and most straightforward effect of the ban was a dramatic increase in the abundance of the overall fish population (Pipitone et al., 2000a).

The importance and uniqueness of the Gulf of Castellammare is worth highlight. It is one of the few case studies, amongst those reported in the literature, where a comparison with the pre-ban state of the resources was possible thanks to the existence of data collected previously (Pipitone et al., 2000a). No such work was carried out in the other two Sicilian Gulfs (except that made by Potoschi et al., 1995 on the red mullet, Mullus barbatus in the Gulf of Patti). The only similar experience in the Mediterranean was studied in Greece (Vassilopoulou & Papaconstantinou, 1999). One of the most interesting features of the Gulf of Castellammare FEZ, if compared with most other fishery reserves or marine protected areas sensu lato, is that artisanal fishermen are allowed to fish within the trawl-ban area, with no special limitation with respect to the previous management regime. Pipitone et al. (2000b), Mardle and James (2001) and Whitmarsh et al. (2002) have addressed the social and economic aspects related to the artisanal fisheries located in the Gulf. The latter two are discussed further in sections 4 and 5 of this report.

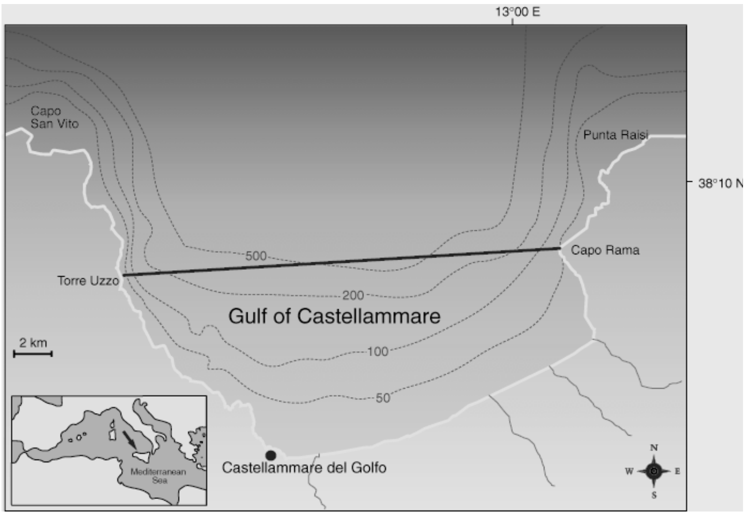

Figure 1.1: The Gulf of Castellammare (straight line = outer limit of the trawl ban area)

For the reasons above this study has enabled the collection of new data on the trawl ban in the Gulf of Castellammare and to update the knowledge on the ban's effect on the abundance of groundfish stocks, as well as the bioeconomic links in the fishery.

1.1.1. The Structure of the Fishery

The Gulf of Castellammare is located in north-west Sicily (see figure 1.1). Four main ports provide the bases for the fishing vessels in the Gulf: Balestrate, Trappeto, Castellammare and Terrasini. Since the trawl-ban, the fishery is characterised by 'low tech' artisanal vessels using mainly fixed gears: trammel net (80%), gill net (10%), purse seine, line & other (10%). The Gulf fishery is very diverse with approximately 96 species being of some commercial value. Higher valued species include red mullet and annular seabream, through medium valued species such as pandora and picarel, to low-valued species often termed 'soup-fish'.

The trawling ban in the Gulf was implemented following increasing pressure to do so. Before this time, the Gulf fishery was characterised by high incidences of gear conflict between the trawl and artisanal vessels, and by falling CPUEs. The trawler population in the Gulf is small with only approximately 10 vessels that now mainly operate at the margins of the ban area. There is well-documented evidence that since the trawling ban was implemented in 1990 that total biomass has increased more than 7 times. Biomass is now thought to be stable within the Gulf. It is also noticeable that many of the predicted effects of the trawl ban have not been realised, even though the overall biomass has increased. For example sharks and the biomass of some key species have not seen the benefits.

The total professional artisanal fishing vessel numbers have remained fairly constant since the implementation of the trawl ban 1990. Current numbers are presented in table 1.1 for the main ports. Typically there is a skipper plus possibly one crew for most trips. During a year, an artisanal boat can expect to average approximately 200 days at sea. Boats from the Western side of the Gulf, i.e. Castellammare and Balestrate showed a significantly higher number of days fished than those boats from the Eastern ports.

Table 1.1: Number of artisanal vessels operating in the Gulf.

Port	*No. artisanal vessels*	*Average days fished*
Balestrate	15	225
Trappeto	22	190
Castellammare	34	240
Terrasini	25	200

An overview of the artisanal fleet's economic characteristics is presented in table 1.2. It is particularly noticeable that revenues in Balastrate are far greater than in the other ports. This is due above all to the existence of an auction market for first sale. Fuel costs in Castellammare are significantly lower than in the other ports, primarily as a result of the lesser distance travelled to fishing grounds. This is also signified in the average number of days fished per year, where due to the location of grounds nearer to port, fishing is less restricted by weather and less hard on the running of the vessel. Crew share is also significantly lower in Castellammare and Terrasini. This is due simply to the use of less crew throughout the year. The proximity of fishing activity to port in these regions makes the use of crew less important in these cases.

Table 1.2: Overview of economic characteristics of artisanal vessels operating in the Gulf, by port (values are in € per day per vessel).

	Balestrate	Trappeto	Castellammare	Terrasini
Revenue	71.66	42.98	43.76	44.82
Variable costs:				
fuel	5.47	4.79	2.22	4.50
wharfage	0.00	0.00	0.00	1.23
commission	0.00	0.00	0.00	3.14
bait	0.00	0.00	0.00	0.23
other fishing expenses	0.28	0.03	0.05	0.06
Crew Costs:				
crew share (revenue)	21.1%	21.6%	5.2%	1.2%
Fixed Costs:				
garage	0.26	0.03	1.56	0.00
repairs	2.02	4.49	1.17	2.84
replacement	10.11	17.92	6.66	8.07
management	2.43	1.86	1.65	1.44
taxes	2.22	4.91	3.88	4.66

Plate 1.1 shows a typical artisanal vessel that operates in the Gulf.

Plate 1.1: Trammel net vessels typical of those employed in the Gulf of Castellammare artisanal fishery

2. Laws and Regulations of the Fisheries in the Gulf of Castellammare

The Gulf of Castellammare is currently the subject of a fisheries exclusion zone. As such the following legal review covers the regulations applying within the exclusion zone and to the creation of that zone.

Italy is divided into twenty regions and five of these have special autonomy, of which Sicily is one. As such Sicily has long had the capacity to manage its own fishery resources. Although potentially far reaching, the region must maintain compliance with European Community legislation and also maintain consistency with the other regions of Italy. In accordance with this, regional legislation largely pertains to the extrapolation of national and international provisions to fit the local conditions. The principal piece of regional legislation governing the fishery is RL 32/2000, articles 142 to 184, which lays down in generalities, inter alia:

- The general principals and objectives of fisheries management (art.142)
- The institutional relationship between the state and the region (art.143)
- The requirement for, objectives of, and institutional responsibilities for, a regional fisheries management programme (art.144, 145)
- Powers for the creation of biological rest and repopulation areas and periods (art.146)
- The composition and responsibilities of a Regional Council for Fisheries (art.147, 148)
- Provisions for the creation of special rules for fishing for certain specified species (art.150)
- Provisions for the regulation of sport and tourist fishing (art.151, 152)
- Provisions for the production, transformation and commercialisation of fisheries products, the up-grading of the fishing fleet, and various financial incentives and compensation measures (art. 157 to 180)

Locally, administration of the seas (including fishing) is the responsibility of the Harbour Masters' Offices. The shoreline of the Italian Republic is divided into 10 marine zones, which are further sub-divided into 48 naval districts[2], the centre of each being the Harbour Master's Office (L 381/1988). The administrative functions of the Harbour Masters' Offices pertain to navigation, marine traffic, the registration of fishing enterprises, the surveillance of fishing activities, the trade in fish products and the determination of violations of the laws and regulations entrusted to them[3].

Within Italy, all fishing enterprises, vessels and fishermen[4] are required to be registered with the Harbour Master's Office and are classified in terms of the type of fishing they can undertake, which is associated with the type of vessels they operate.

[2] Determined by the Ministry for the Merchant marine in conjunction with the Minister for the Environment.

[3] Certain aspects of the law pertaining to fisheries districts, along with registration and other aspects of national fisheries management, have recently been the subject of re-emphasis within DL 226/2001.

[4] The registration of fishermen is required prior to them fishing professionally (art. 9 L963/1965). However, while there is no fee involved there are certain costs associated with the number of registered fishermen per vessel. As a consequence, many of the artisanal vessels operating in the Gulf choose to operate with unregistered crew.

The artisanal vessels of the Gulf of Castellammare fall into the category of vessels and equipment suitable for fishing up to 6 miles from the coast[5]. Within the case study area, registration is either with the Harbour Master's Office in Palermo (covering Terrasini, Trappeto and Balestrate) or Trapani (covering Castellammare and San Vito).

In addition to the system of registration, vessels are also required to have a licence. Italy operates a system of restrictive licensing, which, in line with EU MAGP goals and objectives, means that no new licences are issued without the prior removal of equal capacity. However, as the artisanal vessels in the Gulf are typically below the 2.5 tons threshold this constraint does not effectively come into effect for the artisanal fleet[6]. The licences applying to the artisanal fleet operate for a period of 8 years, subject to the owner registering the vessel as active with the Harbour Master on a yearly basis[7]. The licence in particular determines what gear may be carried and used by the artisanal fleet in relation to the fishing enterprise. Though there are several licensing regimes in place, specifying up to five gear types, the majority of artisanal fishermen in the Gulf are licensed to use no more than three types of gear. For vessels of 10 tsl or less, such as those used by the artisanal fleet in the Gulf of Castellammare, the gears permitted are restricted to one or more of those in Table 1.

Which of these gears a vessel can use depends largely on the age of the vessel (ie. if it was licensed prior to 1995 or received its first licence after this date) and what gears it was previously authorised to use. Where a vessel was already authorised to use four or five of these gear categories, the licence under DM 26/07/1995 continued to permit their use. For vessels that were only authorised to use lines or harpoons, the new legislation permitted the addition of a further category from the first three categories. For vessels previously authorised to undertake one of the first three categories, they could add a further system from the first three categories with the exception of driftnets, plus one of the last two categories. For these latter vessels, applications could also be made to the Ministry to substitute between the first three categories, excluding driftnets (art.19(3-6) DM 26/07/1995). In relation to any changes made, a new licence is required from the Ministry (art.20, DM 26/07/1995). It should also be noted that for vessels of 10 tsl or 150Kw or less the vessel's area of operation is also restricted, with the licences issued restricting the vessels' operational scope to local coastal fishing and to the district within which the vessel is registered and the districts immediately adjacent to it (arts.10 and 23(1) DM 26/07/1995).

With regards to gear design and construction, there are minimum mesh sizes in place for all types of fixed and towed gear. However, this is only 20mm for fixed gears as measured across the diagonals, and for sardine and anchovy fishing there are no minimum mesh sizes. Minimum mesh sizes are only in force for species with an adult life stage of total length greater than 7cm (art. 86 and 87, DPR 1639/1968). There are

[5] The artisanal vessels are actually only allowed to fish no more than 3 miles from the shore (as stipulated within their licence conditions).

[6] However, the transfer of existing licences and the issue of new licences are restricted, and the Ministry for Agricultural Policy reserves the right to suspend new licence issues if this conflicts with the objectives of the National Fisheries Plan.

[7] Rather than being a license requirement, this action is needed to ensure payment of certain subsidies which have been available, which are based on the activity of the vessel and the fishermen in the previous year

also no legal restrictions on the length of gear that can be used, being effectively determined by the size of vessel. For the artisanal vessels in the Gulf, nets are typically between 1000m and 2000m in length.

Table 2.1: Gears available to vessels of 10 tsl or 150Kw or less

Gear Category		*Gears*	
Set gear	Attrezzi da posta	Gillnet Trammelnet Pot Trap (similar to pots) Fyke net Encircling net Stationary net Encircling gillnet	Imbrocco tramaglio nasse cestelli cogolli bertorelli rete circuitante rete da posta fissa rete da posta a circuizione
Driftnet	Ferrettara	Species specific driftnets of specified mesh size. For targeting small- and medium-sized pelagic species: Sardine, round sardinella, mackerel, bogue, saddled seabream, bullet tuna, little tunny, skipjack tuna & bonito	piccola derivante menaide sangusara bisantonara alacciara bisara bogara sgomberara occhiatara palamitara
Longline	Palangari	Bottom longline Drifting longline	palangari fissi palangari derivant
Line	Lenze	Hand line Pole and line Trolling line	lenze a mano lenze a canna lenze trainate
Harpoon	Arpione	Harpoon Multiple tipped harpoon Urchin pole Urchin dredge	arpione fiocina asta e specchio per ricci rastrello per ricci

(art.19(2), DM 26/07/1995)

In terms of minimum landing sizes, 7cm is set as a general minimum landing size for marine species. Where the adult life stage of a species is smaller than this, no minimum landing size is set (art.93 DPR 1639/1968). Table 2 lists the minimum landing sizes of species of interest to this case study that do not fall within this general provision, along with the source legislation.

There are no quotas in operation in the Gulf and the fishermen are free to land whatever they catch. However, of each catch, not more than 10% of the specimens or 10% of the weight (and where possible of the volume) of the catch should be less than the prescribed minimum landing size, with any fish smaller than the minimum landing size (where such is set) being thrown overboard (arts.87 and 91 DPR 1639/1968 as amended by art.1 DM 21/04/1983). Likewise, any berried female lobsters must be returned to the sea (art. 91 DPR 1639/1968). Minimum landing sizes are, however, not rigorously enforced for the artisanal fleet.

In addition to minimum landing sizes, several species are covered by closed periods. The species of interest to this case study so affected are given in table 3.

Table 2.2: Minimum sizes for species caught in the Gulf of Castellammare

Species	*Minimum size (cm)*	*Notes*
Finfish:		
spigola (Dicentrarchus labrax)	20	
sgombro (Scomber spp.)	15	
palamita (Sarda sarda)	25	
tonno (Thunnus thynnus)	70	
alalonga (Thunnus alalunga)	40	
tonnetto (Euthynnus alletteratus)	30	
pesca spada (Xiphias gladius)	140	
triglia (Mullus sp.)	9	Inserted by DM 3/08/1982, art.1
sogliola (Solea vulgaris)	15	
merluzzo o nasello (Merluccius merluccius)	11	
cefalo (Mugil sp)	20	Inserted by DM 5/06/1987, art.1
cernia (Epinephelus spp. and Polyprian americanum)	45	
orata (Sparus auratus)	20	
go (Gobius ophiocephalus)	12	
passera pianuzza (Platichthys flesus)	15	
Crustaceans:		
aragosta (Palinurus elephas)	30	
astice (Homarus gammarus)	30	
scampo (Nephrops norvegicus)	7	

(arts.87 and 88 DPR 1639/1968)

Of particular importance to the fishermen of the Gulf are the regulations pertaining to the exploitation of fish fry. The fry fishery provides valuable income to the fishermen at times when otherwise fishing would be poor. Being of very high value (at approximately 35,000 Lit per kilo it is one of the most valuable products to be caught), the fry fishery contributes significantly to many fishermen's annual income. Articles 126 and 127 of DPR 1639/1968 indicate that fishing for the fry of certain species may be carried out for a maximum of 60 days each year between 1st December and 30th April. There are no restrictions on the quantities that can be caught during this period, and accordingly the fishermen's activity increases substantially at these times; indeed it is not unusual for an artisanal vessels to be at sea for between 15 and 18 hours per day during the fry catching period. Failure to comply with these regulations can lead to the revocation of the fishing license.

In terms of the legal provisions for a fisheries exclusion zone, there are several measures in place, at both the national and regional level. Primarily for the protection of juveniles, these measures come in the form of area closures and repopulation initiatives. The trawling ban and artificial reef complexes are the manifestation of this in the Gulf of Castellammare.

Table 2.3: Temporal prohibitions on harvesting

Species	*Temporal Prohibitions*	*Legislation*
Lobster (Palinurus vulgaris, Homarus gammarus)	1 April to 30 April	Art.132, DPR 1639/1968
Swordfish	September to December	Art.134, DPR 1639/1968

National, generic provisions for area closures for fishing pertain to measures for the protection of juveniles and the interests of fish and mollusc culture. Article 92 of DPR 1639/1968 (as amended), for example, enables the Minister of Agricultural Policy to ban or limit fishing activities within 200m of the mouths of rivers and other man-made and natural watercourses and in lagoons, estuaries or basins used for aquaculture or mariculture. Article 98 of DPR 1639/1968 also permits the Minister for Agricultural Policy[8] to prohibit or limit, permanently or temporarily, fishing in the spawning[9] or nursery areas of marine species that are either commercially important or depleted due to over-exploitation.

At the local level, the Gulf of Castellammare, along with the Gulf of Catania and Gulf of Patti, are targeted areas for fish stock re-population. Under articles 144 to 146, LR32/2000, and previously art.8(1) of LR26/1987, the Regional Councillor for Co-operation, Commerce, Handicraft and Fishing has had and continues to have the power, in consultation with the Regional Council for Fishing, to create by decree a regional plan for fish stock re-population with the aim of conserving, enhancing and managing rationally the biological resources of Sicilian coastal waters. The means available to them for use in this plan include, *inter alia*, the introduction by decree of areas of biological rest and re-stocking. The decree prescribes the extent of exclusion and prohibition, the permanent or temporary nature of the prohibition, and the management objectives, criteria and mechanisms. Under earlier legislation, the regional administration also had the power to put into effect artificial reef programmes for the same purpose[10] (arts.1, 2, 3 and 6 LR31/1974) and create zones of biological protection (art.25 LR1/1980 adopting article 98 of the Regulations approved by DPR1639/1968).

Of those measures that are specific to the Gulf of Castellammare, the principle mechanism for stock re-population has been the use of zones of biological protection – the ban on trawlers and other vessels using similar gears fishing within that area of the Gulf lying landward of a line drawn between the Capo Rama and Torre Uzzo (art.9 LR25/1990).

This is supplemented by five artificial reef complexes installed between 1986 and 1997[11] in the Gulf by the Consortium for Fish Re-population for the Gulf under the

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[8] With the support of the Local Advisory Commission for Marine Fishing.

[9] On the basis of scientific and technical studies.

[10] Under LR31/1974 and art. 8 of LR25/1990 the regional administration is empowered to both put into effect and finance artificial reef initiatives in zones of active re-population to exclude trawling and maintain the productivity of fish stocks (art.1(1) LR31/1974).

[11] For further information refer to: Badalamenti F. & D'Anna G., 1995. Esperienze di barriere artificiali nel Golfo di Castellammare (Sicilia nord-occidentale). Biol. Mar. Medit., 2 (1): 165-173; Badalamenti F., D'Anna G. & Riggio S., 2000. Artificial reefs in the Gulf of Castellammare (north-west Sicily): a case study. In: Jensen A.C., Collins K.J. & Lockwood A.P.M. (eds.), Artificial reefs in European seas. Kluwer Academic Publishers: 75-96; Riggio S., Badalamenti F. & D'Anna G., 2000.

provisions of LR31/1974 and art. 8 of LR25/1990. The Consortium for Fish Re-population was established in the Gulf of Castellammare in 1980 under DPR 182/1980 and LR31/1974 (as amended by art.7 LR25/1990 and extended up to 1998 by art.3(1) LR33/1998)[12]. Its membership includes the towns of San Vito, Castellammare, Balestrate, Trappeto, Terrasini, plus the Chamber of Commerce of Trapani and its geographical area of competence stretches between Punta Molinazzo (Terrasini), San Vito and Capo del Saraceno di Monte Cofano (art.3(4) LR33/98).The artificial structures[13] are aimed at performing two jobs, modifying the natural environment so as to increase the quantitative and qualitative level of fish production and preventing fishing using bottom scrapping gears (art 1(1)).

2.1. National Legislation

L 963/1965 Legge 963, 14 July 1965 "Disciplina della pesca marittima", Gazzetta Ufficiale no.203, 14 August 1965.

L 41/1982 Legge 41, 17 February 1982 "Piano per la razionalizzazione e lo sviluppo della pesca marittima", Gazzetta Ufficiale no.73, 27 March 1992.

L 381/1988 Legge 381, 25 August 1988 "Modificazioni alla legge 14 luglio 1965, n.963, concernente disciplina della pesca marittima" Gazzetta Ufficiale no.205, 1 September 1988.

L 165/1992 Legge 165, 10 February 1992 "Modifiche ed integrazioni alla legge 17 febbraio 1982, n.41, recante il piano per la razionalizzazione e lo sviluppo della pesca marittima", Gazzetta Ufficiale no.48, 27 February 1992.

L 164/1998 Legge 164, 21 May 1998 "Misure in materia di pesca e di acquacoltura", Gazzetta Ufficiale no.124, 30 May 1998.

DPR 1639/1968 Decreto del Presidente della Repubblica 1639, 2 October 1968 "Regolamento per l'esecuzione della Legge 14 July 1965, n.963, concernente la disciplina della pesca marittima".

DL 143/1997 Decreto legislativo 226, 18 May 2001 "Orientamento e modernizzazione del settore della pesca e dell'acquacoltura, a norma dell'articolo 7 della legge 5 marzo 2001".

DM 3/08/1982 Decreto Ministeriale 3 August 1982 "Integrazione all'art.87 del decreto del Presidente della Repubblica 2 ottobre 1968, n.1639. Lunghezza minima della sogliola (solea vulgaris), del nasello o merluzzo (Merluccius merluccius) e della triglia (Mullus sp.)", Gazzetta Ufficiale no.230, 21 August 1982.

Artificial reefs in Sicily: an overview. *In*: Jensen A.C., Collins K.J. & Lockwood A.P.M. (eds.), Artificial reefs in European seas. Kluwer Academic Publishers: 65-73.

[12] LR70/1978 and LR33/1995 govern the constitution of consortia.

[13] The rules for state property concessions for the deployment of artificial reefs are prescribed by art.75 LR15/1993 in conformance with national law L41/1982 (as amended by art.21 L165/1992 and art.1 (2h) L164/1998), DM 19/07/1989 and L160/1989.

DM 21/04/1983 Decreto Ministeriale 21 April 1983 “Modificazione al regolamento per l’esecuzione della legge 14 luglio 1965, n.963, sulla disciplina della pesca marittima”, Gazzetta Ufficiale no.116, 29 April 1983.

DM 5/06/1987 Decreto Ministeriale no.250 5 June 1987 “Integrazione dell’art. 87 del decreto del Presidente della Repubblica 2 ottobre 1968, n.1639, che ha approvato il regolamento di esecuzione della legge 14 luglio 1965, n.963, sulla disciplina della pesca marittima”, Gazzetta Ufficiale no.149, 29 June 1987.

DM 26/07/1995 Decreto Ministeriale 26 July 1995 “Disciplina del rilascio delle licenze di pesca”, Gazzetta Ufficiale no.203, 31 August 1995.

2.2. Regional Legislation

LR 31/1974 Legge Regionale 31, 1 August 1974 “Iniziative per il riequilibrio del patrimonio ittico mediante opere di rippopolamento”, Gazzetta Ufficiale Regione Siciliana no.38, 10 August 1974.

LR 70/1978 Legge Regionale 70, 27 December 1978 “Modifiche ed integrazioni alla legge regionale 1 agosto 1974, n.31, contenente iniziative per il riequilibrio del patrimonio ittico mediante opere di ripopolamento”, Gazzetta Ufficiale Regione Siciliana no.57, 30 December 1978.

LR 1/1980 Legge Regionale 1, 4 January 1980 “Provvedimenti per la razionalizzazione della pesca in Sicilia”, Gazzetta Ufficiale Regione Siciliana no.2, 12 January 1980.

LR 26/1987 Legge Regionale 26, 27 May 1987 “Interventi nel settore della pesca”, Gazzetta Ufficiale Regione Siciliana no.22, 30 may 1987.

LR 25/1990 Legge Regionale 25, 7 August 1990 “Modificazioni e integrazioni della legislazione regionale in materia di pesca”, Gazzetta Ufficiale Regione Siciliana no.38, 11 August 1990.

LR 15/1993 Legge Regionale 15, 11 May 1993 “Interventi nei comparti produttivi, altre disposizioni di carattere finanziario e norme per il contenimento, la razionalizzazione e l'acceleramento della spesa”, Gazzetta Ufficiale Regione Siciliana no.24, 13 May 1993.

LR 33/1995 Legge Regionale 33, 6 April 1995 “Integrazioni alle leggi regionali 1 agosto 1974, n.31, e 27 dicembre 1978, n.70, e interpretazione autentica dell’articolo 9 della legge regionale del 7 agosto 1990, n.25, concernenti la materia della pesca”, Gazzetta Ufficiale Regione Siciliana no.19, 12 April 1995.

LR 33/1998 Legge Regionale 33, 9 December 1998, “Interventi urgenti per il settore della pesca”, Gazzetta Ufficiale Regione Siciliana no.62, 12 December 1998.

LR 32/2000 Legge Regionale 32, 23 December 2000, “Disposizioni per l'attuazione del POR 2000-2006 e di riordino dei regimi di aiuto alle imprese”, Gazzetta Ufficiale Regione Siciliana no.61, 23 December 2000.

3. Trawl Surveys in the Gulf of Castellammare 2000/2001

In the period 200-2001, four seasonal trawl surveys were undertaken in the Gulf of Castellammare, in order to update the knowledge on this special FEZ and to add better and more reliable information to the project itself. It was felt that, as the Gulf of Castellammare is probably the best studied FEZ in the Mediterranean Sea, up-to-date information on the current status of demersal stocks and on the effect of the trawl ban ten years after its start would add much to the overall findings and conclusions.

This section focuses on the methods adopted for the trawl surveys, and on the results obtained. Tables and figures summarise the data collected and the associated analysis. The results are briefly discussed, highlighting the effect of a ten-year trawl ban on the abundance of demersal stocks living on the continental shelf.

3.1. Materials and Methods

In order to assess the abundance of demersal stocks in the Gulf, the trawlable area of the continental shelf was surveyed over one year, from summer 2000 to spring 2001. Working methods were those employed in Studies MED92/011 (D'Anna et al., 1995) and 97/063 (Pipitone et al., 2000b), which can be used as a reference for further details.

3.1.1. Sampling design

Four trawl surveys were planned in order to account for seasonal fluctuations in the abundance and distribution of demersal stocks. A stratified random sampling design based on depth strata was chosen, according to standard procedures used in trawl surveys (e.g., Holden & Raitt, 1974). Like in other similar surveys carried out in Italian waters (Relini & Piccinetti, 1996). Three bathymetric strata were selected: 10-50m (stratum A), 51-100m (stratum B) and 101-200m (stratum C). The study area was divided in 52 ESUs (Elementary Sampling Units) (Figure 3.1). The sampling sites were randomly selected within each stratum using proportional allocation.

Table 3.1: No. of hauls made in the 2000-01 trawl surveys

	SUMMER	*AUTUMN*	*WINTER*	*SPRING*
str. A	6	6	6	7
str. B	10	12	12	11
str. C	10	10	12	12
Total	26	28	30	30

According to the previous studies, 26 hauls of 30 minutes were initially planned for each survey. Later a higher number of hauls was made in each survey, to gather enough samples to allow a balanced ANOVA (see Data analysis later in this chapter). The number of valid hauls made in each survey is shown in the table 3.1 (details on each haul are given in table 3.2).

Table 3.2: Main characteristics of hauls (summer, autumn, winter, spring 2000-01)

summer 2000

DATE	No. HAUL	No. ESU	STARTING POINT LAT. N	STARTING POINT LONG. E	STARTING POINT DEPTH (m)	ENDING POINT LAT. N	ENDING POINT LONG. E	ENDING POINT DEPTH (m)
12/09/00	1	3012	38°05'26	12°52'63	124	38°05'53	12°50'94	124
12/09/00	2	3011	38°05'79	12°49'97	127	38°06'44	12°48'33	126
12/09/00	3	3014	38°06'70	12°48'85	201	38°05'99	12°50'22	134
12/09/00	4	3013	38°06'00	12°51'34	168	38°05'80	12°52'98	179
12/09/00	5	3034	38°05'09	12°54'39	121	38°05'30	12°56'13	120
13/09/00	6	3032	38°05'42	12°57'83	105	38°06'04	12°59'36	109
13/09/00	7	3041	38°07'15	13°00'70	105	38°08'37	13°01'47	114
13/09/00	8	3044	38°08'12	13°00'82	170	38°09'35	13°01'37	159
13/09/00	9	3043	38°10'02	13°01'59	193	38°11'12	13°02'02	142
13/09/00	10	2044	38°10'44	13°02'52	100	38°09'16	13°02'11	95
13/09/00	11	2043	38°09'98	13°02'76	81	38°08'70	13°02'50	72
13/09/00	12	2042	38°08'40	13°02'50	68	38°07'19	13°02'14	65
14/09/00	13	2034	38°03'80	12°55'25	77	38°04'00	12°56'98	72
14/09/00	14	2021	38°04'48	12°57'38	83	38°05'10	12°58'74	83
14/09/00	15	3022	38°06'50	12°58'87	117	38°07'28	13°00'22	120
14/09/00	16	2023	38°06'42	13°00'38	93	38°07'43	13°01'47	92
14/09/00	17	1033	38°07'56	13°02'83	50	38°06'26	13°02'61	45
14/09/00	18	2024	38°05'25	12°58'37	84	38°04'72	12°56'96	95
15/09/00	19	2012	38°03'52	12°52'96	69	38°03'52	12°54'61	67
15/09/00	20	2031	38°03'49	12°55'81	62	38°03'75	12°57'42	57
15/09/00	21	1013	38°03'52	12°58'08	42	38°03'17	12°56'97	43
15/09/00	22	1012	38°02'90	12°57'61	23	38°03'60	12°59'17	24
15/09/00	23	2013	38°03'98	12°54'32	86	38°03'85	12°52'72	80
16/09/00	24	1014	38°03'01	12°52'99	41	38°03'02	12°54'70	45
16/09/00	25	1011	38°02'66	12°54'30	29	38°02'73	12°52'64	22
16/09/00	26	1021	38°01'93	12°53'36	8	38°01'93	12°54'85	9

autumn 2000

DATE	No. HAUL	No. ESU	STARTING POINT LAT. N	STARTING POINT LONG. E	STARTING POINT DEPTH (m)	ENDING POINT LAT. N	ENDING POINT LONG. E	ENDING POINT DEPTH (m)
04/12/00	1	2013	38°03'88	12°54'58	80	38°03'86	12°52'87	84
04/12/00	2	3011	38°05'77	12°49'72	123	38°06'48	12°48'11	119
04/12/00	3	3014	38°06'55	12°48'86	179	38°05'87	12°50'40	135
04/12/00	4	3013	38°05'78	12°51'20	134	38°05'66	12°52'75	141
04/12/00	5	3021	38°05'65	12°54'33	134	38°05'64	12°56'14	128
05/12/00	6	2012	38°03'48	12°53'85	67	38°03'65	12°52'19	62
05/12/00	7	3031	38°04'53	12°54'50	104	38°04'88	12°56'10	107
05/12/00	8	3032	38°05'30	12°57'69	104	38°06'06	12°59'20	101
05/12/00	9	3023	38°07'02	12°58'80	152	38°06'44	12°57'51	161
05/12/00	10	2024	38°05'05	12°57'32	100	38°04'37	12°55'80	92
06/12/00	11	3041	38°06'85	13°00'32	105	38°07'92	13°01'51	101
06/12/00	12	3043	38°10'28	13°01'56	166	38°11'48	13°01'98	161
06/12/00	13	3042	38°11'45	13°02'41	123	38°10'19	13°02'00	124
06/12/00	14	2044	38°10'32	13°02'59	94	38°09'13	13°02'08	95
06/12/00	15	2042	38°08'28	13°02'60	63	38°09'60	13°03'09	64
06/12/00	16	2041	38°07'82	13°02'59	51	38°06'85	13°02'31	56
07/12/00	17	2034	38°03'88	12°55'79	76	38°04'05	12°57'58	65
07/12/00	18	2032	38°04'71	12°59'26	61	38°05'44	13°00'74	59
07/12/00	19	2033	38°05'84	13°00'95	66	38°05'20	12°59'48	72
07/12/00	20	2022	38°05'88	13°00'26	79	38°06'98	13°01'45	82
07/12/00	21	2023	38°07'16	13°00'86	101	38°06'01	13°00'02	88
07/12/00	22	1013	38°03'85	12°58'79	42	38°03'39	12°57'14	48
11/12/00	23	1023	38°02'36	12°57'04	10	38°02'92	12°58'61	11
11/12/00	24	1012	38°03'55	12°58'99	27	38°02'95	12°57'56	27
11/12/00	25	1011	38°02'65	12°54'35	28	38°02'69	12°52'75	23
11/12/00	26	2011	38°04'04	12°51'30	64	38°05'00	12°50'30	77
11/12/00	27	1055			N.V.			
11/12/00	27	1014	38°03'03	12°52'91	41	38°02'99	12°54'51	42
11/12/00	28	1021	38°01'84	12°54'06	8	38°02'00	12°54'90	9

winter 2000								
DATE	No. HAUL	No. ESU	STARTING POINT			ENDING POINT		
			LAT. N	LONG. E	DEPTH (m)	LAT. N	LONG. E	DEPTH (m)
01.03.01	1	3031	38°04'60	12°54'54	104	38°04'85	12°56'33	104
01.03.01	2	2013	38°03'93	12°54'24	84	38°04'00	12°52'70	70
01.03.01	3	2012	38°03'62	12°52'87	72	38°03'66	12°54'62	72
01.03.01	4	2011	38°03'82	12°51'50	62	38°04'80	12°50'65	80
04.03.01	5	3021	38°05'57	12°54'42	131	38°05'63	12°56'08	128
04.03.01	6	3024	38°06'02	12°55'66	147	38°06'00	12°54'09	188
04.03.01	7	3013	38°06'04	12°52'78	227	38°05'99	12°51'08	179
04.03.01	8	3014	38°06'12	12°49'72	135	38°06'80	12°48'75	230
04.03.01	9	3012	38°05'42	12°51'38	126	38°05'22	12°53'08	123
04.03.01	10	1055	38°03'80	12°51'24	50	38°03'25	12°52'25	44
04.03.01	11	1011	38°02'70	12°54'23	28	38°02'75	12°52'64	24
05.06.01	12	2034	38°03'72	12°55'63	71	38°04'01	12°57'32	67
05.06.01	13	2024	38°04'76	12°56'96	96	38°05'37	12°58'53	94
05.06.01	14	3032	38°05'35	12°57'79	103	38°06'06	12°59'16	103
05.03.01	15	3033	38°06'23	12°59'09	108	38°05'69	12°57'67	112
05.06.01	16	3022	38°06'21	12°58'26	121	38°06'94	12°59'63	118
05.03.01	17	2033	38°05'80	13°00'81	68	38°05'16	12°59'40	73
05.03.01	18	2031	38°04'20	12°58'46	58	38°03'52	12°57'10	53
05.03.01	19	1023	38°02'90	12°58'57	11	38°02'47	12°57'01	14
06.03.01	20	3044	38°07'96	13°00'96	134	38°09'17	13°01'36	135
06.03.01	21	3043	38°09'91	13°01'49	268	38°10'97	13°01'95	154
06.03.01	22	3042	38°10'67	13°02'45	107	38°09'45	13°02'02	104
06.03.01	23	1033	38°07'54	13°03'01	46	38°06'31	13°02'56	47
06.03.01	24	2032	38°05'97	13°01'71	56	38°05'21	13°00'38	58
06.03.01	25	1012	38°03'58	12°59'00	27	38°02'97	12°57'49	29
07.06.01	26	2023	38°06'37	13°00'46	90	38°07'39	13°01'34	94
07.03.01	27	2044	38°08'92	13°02'23	85	38°10'21	13°02'57	93
07.03.01	28	2043	38°10'14	13°03'01	76	38°08'89	13°02'53	73
07.03.01	29	2042	38°08'39	13°02'69	64	38°09'55	13°03'05	64
07.03.01	30	1013	38°04'09	12°58'94	47	38°03'30	12°57'57	42

spring 2001								
DATE	No. HAUL	No. ESU	STARTING POINT			ENDING POINT		
			LAT. N	LONG. E	DEPTH (m)	LAT. N	LONG. E	DEPTH (m)
01.06.01	1	2012	38°03'45	12°53'20	66	38°03'99	12°51'72	68
01.06.01	2	3012	38°05'29	12°51'79	125	38°05'05	12°53'38	121
01.06.01	3	3021	38°05'47	12°54'46	128	38°05'64	12°56'04	129
01.06.01	4	3024	38°05'97	12°55'46	139	38°06'00	12°53'80	183
01.06.01	5	3013	38°05'79	12°52'58	16+1	38°05'90	12°51'01	144
01.06.01	6	2011	38°04'52	12°50'97	67	38°03'64	12°51'69	53
02.06.01	7	3014	38°06'47	12°49'14	178	38°05'84	12°50'50	130
02.06.01	8	1055	38°03'75	12°51'11	44	38°03'30	12°52'23	45
02.06.01	9	1014	38°02'94	12°54'45	41	38°02'76	12°52'93	30
02.06.01	10	3031	38°04'52	12°54'36	103	38°04'86	12°55'89	107
02.06.01	11	3032	38°05'38	12°57'79	104	38°06'02	12°59'03	104
02.06.01	12	2024	38°05'28	12°58'26	95	38°04'71	12°56'94	94
05.06.01	13	2021	38°04'04	12°55'67	82	38°04'59	12°57'15	88
05.06.01	14	3022	38°05'99	12°57'79	127	38°06'63	12°59'15	116
05.06.01	15	3023				N.V.		
05.06.01	16	3044				N.V.		
05.06.01	17	3044	38°08'33	13°01'20	128	38°09'41	13°01'41	146
05.06.01	18	3043	38°10'34	13°01'53	180	38°11'28	13°01'75	179
05.06.01	19	3041	38°09'29	13°01'60	125	38°08'04	13°01'40	110
06.06.01	20	3023	38°06'37	12°57'75	137	38°07'01	12°59'00	134
06.06.01	21	2044	38°09'23	13°02'23	89	38°10'45	13°02'63	95
06.06.01	22	2043	38°09'95	13°02'72	82	38°08'80	13°02'43	75
06.06.01	21	2042	38°08'20	13°02'65	61	38°09'44	13°02'98	64
06.06.01	24	1033	38°07'40	13°02'90	48	38°06'16	13°02'46	46
06.06.01	25	2041	38°06'76	13°02'27	58	38°07'98	13°02'57	60
06.06.01	26	2033	38°06'14	13°01'41	64	38°05'32	12°59'98	67
06.06.01	27	2032	38°05'18	13°00'35	58	38°05'88	13°01'68	54
07.06.01	28	1021	38°01'93	12°54'23	10	38°02'07	12°52'95	9
07.06.01	29	1011	38°02'71	12°53'16	29	38°02'53	12°54'66	24
07.06.01	30	1012	38°02'87	12°57'54	23	38°03'50	12°58'85	27
07.06.01	31	1013	38°04'00	12°58'69	48	38°03'29	12°57'42	42
07.06.01	32	2034	38°03'72	12°55'73	71	38°04'05	12°57'23	69

N.V. – Non-valid.

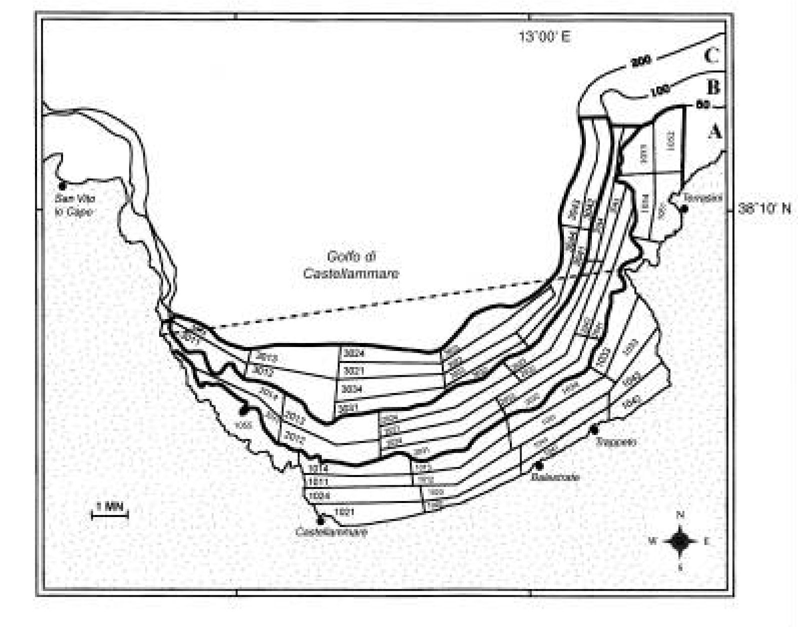


Figure 3.1: The study area with strata and ESUs.

3.1.2. Fishing vessel and fishing gear

In order to allow a reliable comparison with the data collected during the previous studies, the same vessel and gear were employed.

The vessel chosen was the F/V GIAGUARO, a commercial wooden trawler built in 1993; the net used to suit our requirements was different in many aspects from the one commonly used in commercial hauls. The trawler had a gross tonnage of 40.10 t, measured 18.36 m of overall length, and was powered with a 160 HP diesel engine. It was equipped with two loran sets (one of which with a plotter), radar, an echosounder with a colour display, and a radio set. The winch had two drums holding 1900 m of steel trawl warp each. Fishes were stored in a fish-hold (15 m^3) at about 0°C.

The fishing gear was a bottom trawl equipped with wooden otter boards. The stretched mesh side, the mesh number and the length of the components and accessories of the gear are reported in Tab. 3.3 and in the plan of the trawl net (Fig. 3.2).

Table 3.3: Characteristics of the trawl net

NETTING	ITALIAN NAME	LENGTH (m)	MESH no.	MESH SIDE (mm)
Codend	Pozzale (sacco)	5.55	290	18
Baiting	Cieletto posteriore	15.38	430^	20
"	Cieletto anteriore	5.80	680	29
Wing	Chiarazzo	13.6	420	29
Belly	III Sottano	4	130	18
"	II Sottano	10.6	130	22
"	I Sottano	8.6	130	26
Top gusset	Scaglietto di summo	4.1	90* - 41^	29
Lower gusset	Scaglietto di piombo	4.2	81* - 18^	37

Key: * = beginning; ^ = end

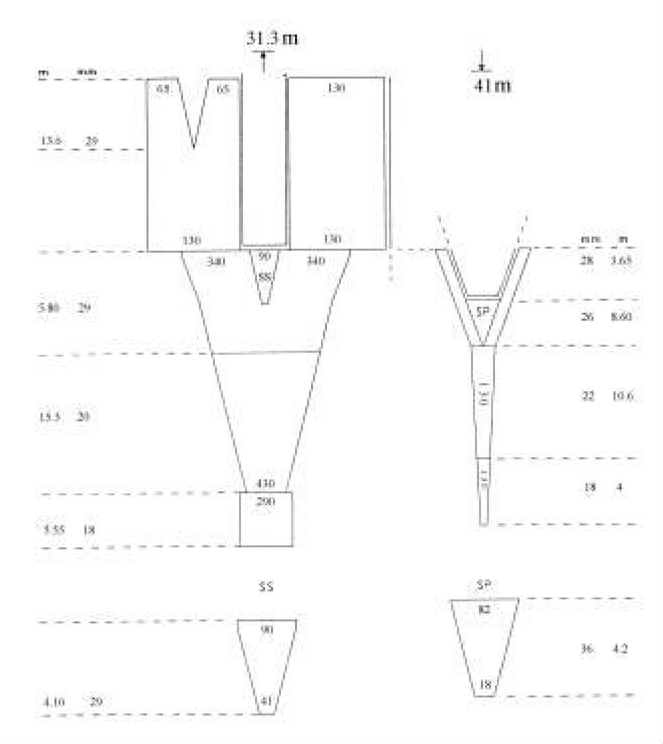


Figure 3.2: Plan of the trawl net.

3.1.3. Fishing operations

Four seasonal experimental trawl surveys were carried out in the Gulf of Castellammare: survey IX (summer) from 12 to 16 September 2000; survey X (autumn) from 4 to 11 December 2000; survey XI (winter) from 1 to 7 March 2001; survey XII (spring) from 1 to 7 June 2001. Four crew members and three research members took part to the operations. 114 valid hauls were made overall (Tab. 3.1). Each haul lasted 30 minutes; when towing lasted less than 20 min, or when the net was damaged by rocks or wrecks or did not work properly, the haul was considered non-valid and repeated. The hauls were made from about one hour after sunrise to about one hour before sunset. Fishes were refrigerated on board and landed after each trip to be frozen in the lab.

3.1.4. Laboratory operations

The samples were processed in the lab. Total abundance and weight were recorded for each species. Individual weight and length were recorded for a few target species of commercial importance.

The species collected (Appendix 3.I) were identified mainly with the aid of the FAO Identification Sheets (Fischer *et al*., 1987a, 1987b), which also provided the English common names. For the nomenclature and systematic order the following publications were used: Whitehead *et al*. (1984/86) for fishes, D'Udekem D'Acoz (1999) for decapod crustaceans and Bello (1986) for cephalopods.

3.1.5. Data analysis

<u>*Catch per unit effort*</u>

The catch per unit effort (CPUE) was calculated as weight per haul (gr/30min). For tows lasting more than 31 minutes or less than 29 minutes, the weight was standardized by means of a correction factor: standardized weight=catch weight/(tow duration/30).

The CPUEs obtained in 1993-94, 1998-99 and 2000-01 were compared to obtain a picture of the ban effect on a temporal scale. Furthermore, along the line tracked in the previous studies, we compared the spring pre-ban surveys with the spring post-ban surveys (spring surveys being the only with enough data before the ban).

An indicator of monetary value was used for each species, in order to look for any change in the value of experimental catches (hence of the available fish stock) since 1993-94. Highly commercial species (h.c.) had a wholesale price >10000 ITL, moderately commercial (m.c.) were those <10000 ITL, and non-commercial (n.c.) all those that are not sold at all. Prices were assigned according to information collected during the 1998 landings survey in the four ports (Pipitone et al., 2000b).

The Mann-Whitney U-test was performed to test the differences between the mean values in all the above cases.

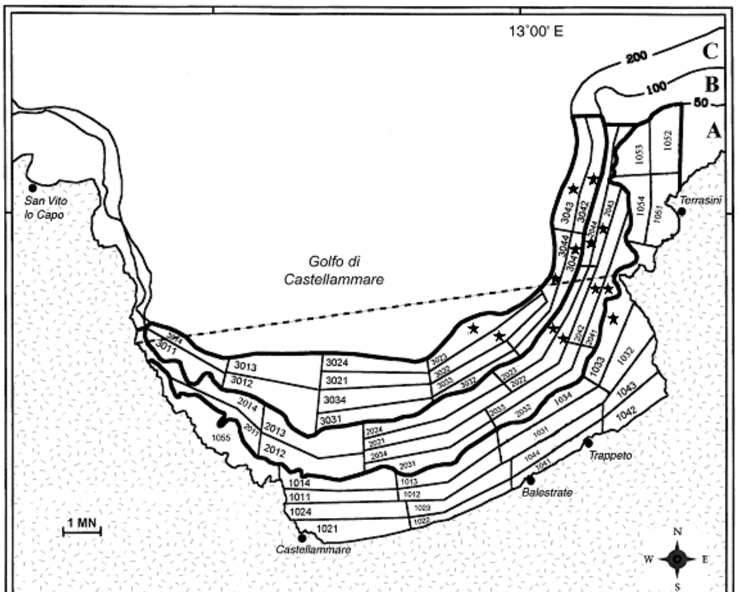


Figure 3.4: - The ESUs marked with a star are the “Out” ESUs

In order to assess the spatial effect of the trawl ban across the last ten years, a two-way ANOVA was performed on 20 randomly taken CPUE values from each of an In and an Out zone for each year (1993-94, 1998-99 and 2000-01). The Out zone includes ESUs that are beyond or across the FEZ boundary as well as a few ESUs close to the boundary where trawlers reportedly fish illegally (1033, 2022, 2023, 2041, 2042, 2043, 2044, 3022, 3023, 3041, 3042, 3043, 3044) (star-symbols in Fig. 3.4). The In zone includes the remaining ESUs, and can be defined as a fully protected area. This analysis allowed us to compare experimental catches obtained in the three periods as well as inside and outside the FEZ across the years, and gave us a picture of the temporal evolution of the ban's effect.

Biomass estimates

The biomass of the target species in the study area was expressed in terms of density (kg/km2) and of biomass (tons) in the total area, to allow a comparison with the previous studies. For further details on this analysis see Pipitone et al. (2000b).

3.2. Results

One hundred and twenty-one species plus six unidentified higher taxa were collected in the four trawl surveys. The complete list of species is reported in Appendix 3.I. Crustaceans included four families with five species, cephalopods included five families with fifteen species, fishes included forty-seven families with one hundred and one species.

3.2.1. Fishing yields

CPUEs for single species and for the total catch in each stratum and in the overall area, by season and over the year round are reported in Appendix 3.II.

Cumulated yearly data (Annex II.e): considering the overall area, the CPUE for the total catch was 34897 gr. The most abundant species was red mullet, *Mullus barbatus* (8334 gr) followed by hake, *Merluccius merluccius* (3612 gr). Considering the single strata, the highest CPUE for the total catch (49758 gr) was given by str. A, followed by str. B (36286 gr) and str. C (25031 gr). Red mullet was the most abundant species in str. A (22655 gr) and B (6668 gr), followed respectively by pandora, *Pagellus erythrinus* (5757 gr) and large-scaled gurnard, *Lepidotrigla cavillone* (4170 gr). In str. C hake was the most abundant species (5032 gr), followed by red mullet (1902 gr) and large-scaled gurnard (1872 gr).

Survey IX (summer) (Annex II.a): in the overall area the CPUE for the total catch was 35081 gr. The most abundant species was red mullet (8465 gr), followed by hake (3889 gr). Considering the single strata, the highest CPUE for the total catch (44254 gr) was given by str. A, followed by str. B (39698 gr) and str. C (24960 gr). Red mullet was the most abundant species in str. A (23684 gr) and B (5777 gr), followed respectively by pandora (5581 gr) and large-scaled gurnard (4242 gr). In str. C hake was the most abundant species (6255 gr), followed by black-bellied anglerfish, *Lophius budegassa* (2829 gr).

Survey X (autumn) (Annex II.b): in the overall area the CPUE for the total catch was 36320 gr. The most abundant species was red mullet (7748 gr), followed by hake (4758 gr). Considering the single strata, the highest CPUE for the total catch (40678 gr) was given by str. B, followed by str. A (34444 gr) and str. C (32215 gr). Red mullet was the most abundant species in str. A (14701 gr) and B (8752 gr), followed respectively by pandora (3023 gr) and large-scaled gurnard (5252 gr). In str. C hake was the most abundant species (8552 gr), followed by blackspot seabream, Pagellus bogaraveo (3615 gr).

Survey XI (winter) (Annex II.c): in the overall area the CPUE for the total catch was 38959 gr. The most abundant species was red mullet (7773 gr), followed by hake (4036 gr). Considering the single strata, the highest CPUE for the total catch (61274 gr) was given by str. A, followed by str. B (37754 gr) and str. C (29007 gr). Red mullet was the most abundant species in str. A (22080 gr) and B (6399 gr), followed respectively by axillary seabream, Pagellus acarne (9245 gr) and hake (4576 gr). In str. C silver scabbardfish, Lepidopus caudatus was the most abundant species (7409 gr), followed by hake (3821 gr)

Survey XII (spring) (Annex II.d): in the overall area the CPUE for the total catch was 29359 gr. The most abundant species was red mullet (9329 gr), followed by pandora (2557 gr). Considering the single strata, the highest CPUE for the total catch (57732 gr) was given by str. A, followed by str. B (26807 gr) and str. C (15147 gr). Red mullet was the most abundant species in str. A (29083 gr) and B (5497 gr), followed by annular seabream, Diplodus annularis (7284 gr) and pandora (7240 gr) in str. A and by large-scaled gurnard (2941 gr) in str. B. In str. C black-bellied anglerfish (2320 gr) and hake (2291 gr) were the most abundant species, followed by horned octopus, Eledone cirrhosa (1448 gr).

3.2.2. Commercial categories

Table 3.4 reports the CPUEs of commercial categories.

Considering the yearly average in the whole area, the scale of abundance was h.c.>m.c.>n.c. ($p<0.001$, U-test) on. The table below gives the results of the U-test performed on the CPUEs of commercial categories in each season (averaged over the whole area):

	summer		autumn		winter		spring	
	h.c.	m.c.	h.c.	m.c.	h.c.	m.c.	h.c.	m.c.
m.c.	*n.s.*		*<.01*		*n.s.*		*<.05*	
n.c.	*<.001*	*<.05*	*<.001*	*n.s.*	*<.001*	*<.05*	*<.001*	*n.s.*

The same h.c.>m.c.>n.c. rank was recorded in each stratum, except str. B in summer and str. C in winter (m.c.>h.c.>n.c.). In summary the highest CPUE of highly commercial species was found in str. A in spring, while the lowest was found in str. C in spring.

Table 3.4: CPUEs of commercial categories: highly, moderately, and non

	h.c.		m.c.		n.c.	
SUMMER						
	mean	*sd*	**mean**	*sd*	**mean**	*sd*
A	**34 608**	*28 709*	**7 450**	*6 231*	**2 196**	*1 309*
B	**14 656**	*13 025*	**17 538**	*14 931*	**7 504**	*5 390*
C	**11 226**	*4 180*	**8 224**	*4 222*	**5 509**	*4 816*
Total area	**17 941**	*17 923*	**11 628**	*10 827*	**5 512**	*4 835*
AUTUMN						
	mean	*sd*	**mean**	*sd*	**mean**	*sd*
A	**24 457**	*21 570*	**6 770**	*7 659*	**3 216**	*2 093*
B	**19 684**	*8 684*	**13 045**	*11 626*	**7 949**	*5 626*
C	**16 170**	*11 644*	**10 379**	*10 156*	**5 666**	*3 456*
Total area	**19 452**	*13 102*	**10 748**	*10 306*	**6 120**	*4 596*
WINTER						
	mean	*sd*	**mean**	*sd*	**mean**	*sd*
A	**37 275**	*26 348*	**20 358**	*14 495*	**3 642**	*3 016*
B	**17 165**	*14 476*	**13 953**	*13 693*	**6 636**	*5 877*
C	**9 877**	*6 358*	**15 097**	*27 687*	**4 032**	*2 786*
Total area	**18 272**	*17 857*	**15 692**	*20 100*	**4 996**	*4 415*
SPRING						
	mean	*sd*	**mean**	*sd*	**mean**	*sd*
A	**40 730**	*47 173*	**12 638**	*17 254*	**4 364**	*3 055*
B	**11 831**	*7 835*	**9 566**	*8 502*	**5 398**	*3 825*
C	**7 384**	*3 950*	**4 629**	*4 114*	**3 127**	*1 993*
Total area	**16 795**	*25 918*	**8 308**	*10 182*	**4 248**	*3 084*
ALL YEAR						
	mean	*sd*	**mean**	*sd*	**mean**	*sd*
A	**34 526**	*31 750*	**11 837**	*12 964*	**3 395**	*2 481*
B	**15 975**	*11 346*	**13 435**	*12 263*	**6 876**	*5 175*
C	**10 934**	*7 523*	**9 608**	*15 545*	**4 492**	*3 391*
Total area	**18 098**	*19 164*	**11 608**	*13 752*	**5 193**	*4 260*

3.2.3. Biomass estimates

The biomass of target species in the total study area was expressed in terms of density (Tab. 3.5) as well as of absolute biomass (Tab. 3.6). The values were estimated in each season and also as a mean value over the whole year of study. As already indicated by the analysis of fishing yields, the most abundant among the target species were red mullet (density: 311.2 kg/km^2, biomass: 49.8 t) and hake (density: 96.8 kg/km^2, biomass: 15.5 t).

Table 3.5: Density (kg/km^2) for the target species estimated over the trawlable area on the surveyed grounds (2000-01), by season (a) and over the year round (b). s.d.: standard deviation of the mean

(a)

	summer	autumn	winter	spring
hake	35.721	148.656	137.616	65.081
red mullet	306.905	264.969	307.316	365.759
striped mullet	1.136	1.660	3.047	1.069
pandora	24.404	50.240	106.204	98.762
striped seabream	3.304	19.332	19.826	3.933
pink shrimp	4.573	24.239	13.100	7.640
cuttlefish	0.831	16.500	22.859	0.964
European squid	1.668	7.974	4.700	1.100
broadtail squid	0.508	4.614	1.927	0.072
horned octopus	0.589	6.931	9.831	22.357
musky octopus	0.569	3.576	4.530	11.872
common octopus	6.279	39.844	12.381	17.340

(b)

	year round	*s.d.*
hake	**96.769**	*55.051*
red mullet	**311.237**	*41.423*
striped mullet	**1.728**	*0.918*
pandora	**69.902**	*39.189*
striped seabream	**11.599**	*9.220*
pink shrimp	**12.388**	*8.652*
cuttlefish	**10.289**	*11.151*
European squid	**3.860**	*3.165*
broadtail squid	**1.780**	*2.048*
horned octopus	**9.927**	*9.141*
musky octopus	**5.137**	*4.797*
common octopus	**18.961**	*14.639*

Table 3.6: Biomass (in tonnes) for the target species estimated over the trawlable area on the surveyed grounds (2000-01), by season (a) and over the year round (b). s.e. = standard error of the estimate; s.d. = standard deviation of the mean.

(a)

summer	t	s.e.
hake	**5.713**	*1.799*
red mullet	**49.081**	*14.232*
striped mullet	**0.182**	*0.477*
pandora	**3.903**	*3.897*
striped seabream	**0.528**	*0.908*
pink shrimp	**0.731**	*0.526*
cuttlefish	**0.133**	*0.137*
European squid	**0.267**	*0.365*
broadtail squid	**0.081**	*0.068*
horned octopus	**0.094**	*0.126*
musky octopus	**0.091**	*0.096*
common octopus	**1.004**	*0.834*
autumn	**t**	*s.e.*
hake	**23.773**	*5.631*
red mullet	**42.374**	*9.385*
striped mullet	**0.266**	*0.090*
pandora	**8.034**	*1.999*
striped seabream	**3.092**	*1.521*
pink shrimp	**3.876**	*0.621*
cuttlefish	**2.639**	*0.524*
European squid	**1.275**	*0.439*
broadtail squid	**0.738**	*0.215*
horned octopus	**1.108**	*0.382*
musky octopus	**0.572**	*0.136*
common octopus	**6.372**	*1.617*
winter	**t**	*s.e.*
hake	**22.008**	*3.877*
red mullet	**49.146**	*11.474*
striped mullet	**0.487**	*0.165*
pandora	**16.984**	*4.148*
striped seabream	**3.171**	*1.570*
pink shrimp	**2.095**	*0.667*
cuttlefish	**3.656**	*0.541*
European squid	**0.752**	*0.174*
broadtail squid	**0.308**	*0.113*
horned octopus	**1.572**	*0.472*
musky octopus	**0.724**	*0.202*
common octopus	**1.980**	*0.551*
spring	**t**	*s.e.*
hake	**10.408**	*1.407*
red mullet	**58.493**	*20.128*
striped mullet	**0.171**	*0.054*
pandora	**15.794**	*6.046*
striped seabream	**0.629**	*0.408*
pink shrimp	**1.222**	*0.259*
cuttlefish	**0.154**	*0.104*
European squid	**0.176**	*0.082*
broadtail squid	**0.012**	*0.006*
horned octopus	**3.575**	*0.888*
musky octopus	**1.899**	*0.497*
common octopus	**2.773**	*0.782*

(b)

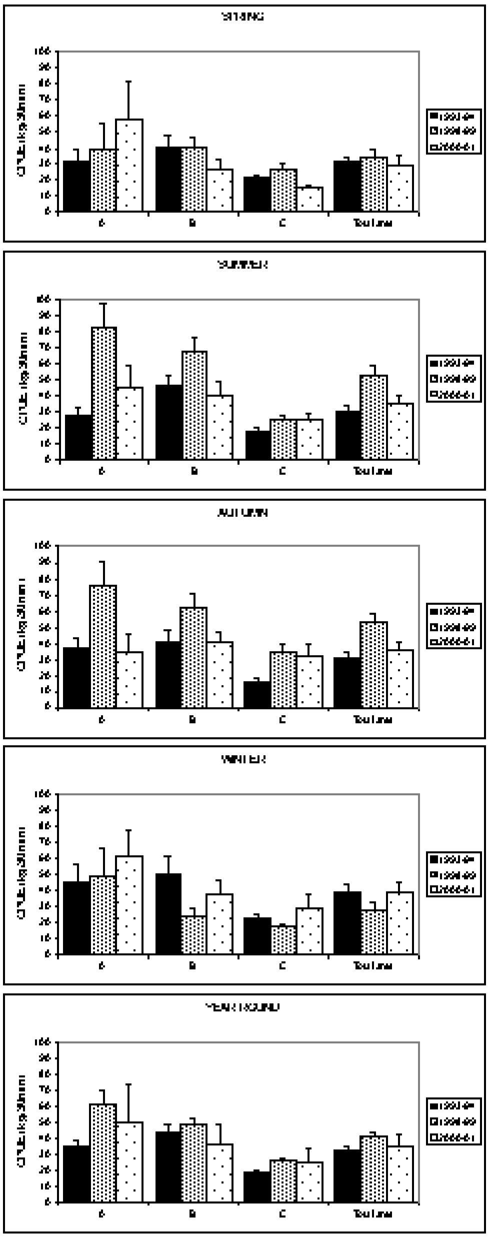
year round	t	s.d.
hake	**15.475**	*8.804*
red mullet	**49.774**	*6.624*
striped mullet	**0.276**	*0.147*
pandora	**11.179**	*6.267*
striped seabream	**1.855**	*1.475*
pink shrimp	**1.981**	*1.384*
cuttlefish	**1.645**	*1.783*
European squid	**0.617**	*0.506*
broadtail squid	**0.285**	*0.328*
horned octopus	**1.588**	*1.462*
musky octopus	**0.821**	*0.767*
common octopus	**3.032**	*2.341*

3.2.4. Assessment of the effect of the trawl ban

<u>Fishing yields (temporal effect)</u>

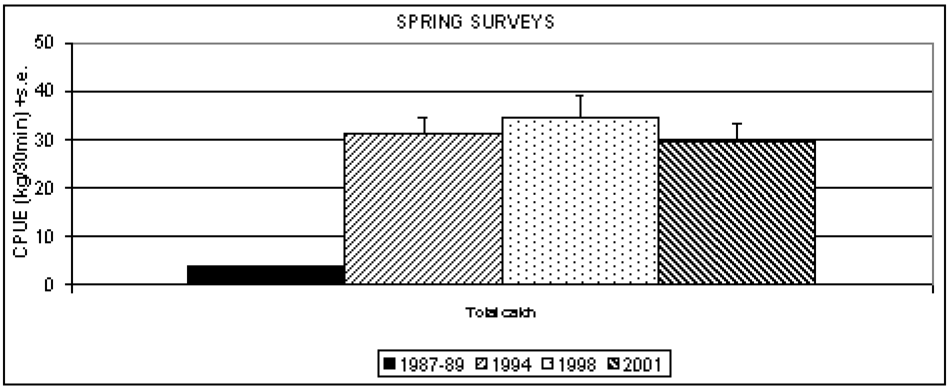
Fig. 3.5 depicts the CPUEs of the total catch in 1993-94, 1998-99 and 2000-01. Considering the yearly average, the total catch was always larger in 1998-99, both in the total area and in each stratum. Considering the single seasons, in 2000-01 the CPUEs were generally smaller than in 1998-99, except in winter and spring (only in stratum A). Due to the high variability between catches in each ESU, these differences were generally not significant.

Figure 3.5: CPUEs of total catch from 1993-94 and 2000-01 trawl surveys, per stratum and in the total area, in each season and the year round.



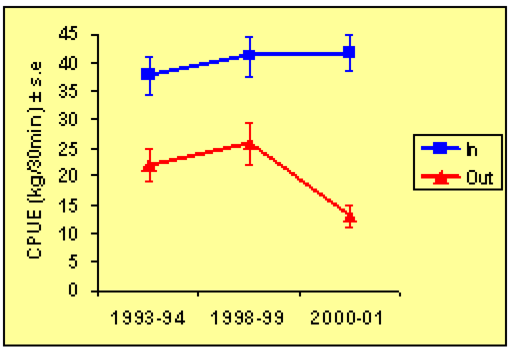
We have also analysed the time trend of total catches comparing the CPUEs before and during the trawl ban (Fig. 3.6). For this purpose, we have taken data from the spring surveys made in 1987-89 (Pipitone et al., 2000a) and compared them with the spring data collected in 1994, 1998 and 2001. The choice of spring data was dictated by the low amount of data available in the other seasons before the ban (1987 and 1989 spring data were cumulated anyway). The dramatic increase between 1987-89 and 1994 is immediately clear. In the following years the level of catches remained approximately constant.

Figure 3.6: CPUEs before (1987-89) and during (1994, 1998 and 2001) the trawl ban. Data comes from the SPRING surveys only, averaged over the whole study area. The chart refers to the total catch.



Fishing yields (spatial effect)

Pipitone et al. (2000b) have shown that some species had declined from 1993-94 to 1998-99, as suggested by the experimental trawl surveys data, and that the increase of some of them as well as of the total catch has been much lower than the increase recorded between 1987-89 and 1993-94. Fig. 3.5 and Fig. 3.6 have shown that the CPUEs of the total catch in 2000-01 were generally lower than in 1998-99. To analyse space and time trends in experimental catches, we have compared the CPUEs from the eastern sector of the study area (Out) with the CPUEs from the rest of the banned area (In) with an ANOVA:



ANOVA

SOURCE OF VARIATION	df	MS	F
Time (T)	2	0.4465	0.92
Protection (Pr)	1	21.2929	43.85***
T x Pr	2	2.6052	5.37 **
Residual	114	0.4855	
Transformation		Ln (x)	
Cochran test		C = 0.2358 (P > 0.05)	

SNK Test

Time	*Protection*	*Time*
T1 (1994)	In > Out	
T2 (1998)	In > Out	
T3 (2000)	In > Out	
Protection		
In		T1 = T2 = T3
Out		T1 = T2 > T3

From the ANOVA it stems that, within each study period, experimental catches were higher in In than in Out, and the differential was more pronounced in 2000-01 than in the previous years. This means that the trawl ban caused a strong increase of the protected portion of the stocks, and suggests that the non-protected portion is probably suffering a higher exploitation by trawlers than before. As can be drawn from interviews and sparse information gathered in the harbours (Pipitone et al., 2001), trawlers encroach more often than in the past within the banned zone, in correspondence of a reduced coastguard patrolling action.

The conclusion is that: (a) fish populations were effectively protected inside the banned area, as suggested by the higher CPUEs in the In zone; (b) there was no significant increase of fish biomass in the banned area from 1993 to 2001; (c) fish populations in the Out zone were affected by the trawling activities going on along the eastern border, that led to a decrease in 1998-2001.

Commercial categories

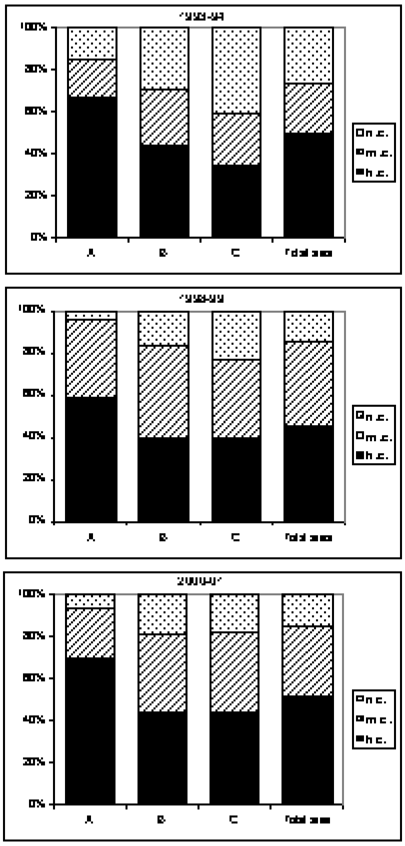
Fig. 3.7 shows the proportion of commercial categories in the 1993-94, 1998-99 and 2000-01 trawl surveys (yearly average). The results of the U-test performed on the mean values are reported in the table below:

	93-94 vs. 98-99			
	str. A	str. B	str. C	Tot. Area
h.c.	n.s.	n.s.	n.s.	n.s.
m.c.	<.001	n.s.	<.01	<.01
n.c.	<.05	n.s.	n.s.	n.s.

	98-99 vs. 2000-01			
	str. A	str. B	str. C	Tot. Area
h.c.	n.s.	n.s.	n.s.	n.s.
m.c.	<.05	<.05	n.s.	<.01
n.c.	n.s.	n.s.	<.05	n.s.

Only slight differences were found between the years, due to the high variability of catches.

Figure 3.7: Proportion of highly commercial (h.c.), moderately commercial (m.c.) and non-commercial (n.c.) species in the trawl surveys in 1993-94, 1998-99 and 2000-01, in each stratum and in the total area. Proportions calculated from CPUE data.



Appendix 3.I: List of species collected during the 2000-01 trawl surveys

Family	Taxon	Common name
	CRUSTACEA	
SQUILLIDAE	*Squilla mantis*(Linneo 1758)	Spot-tail mantis shrimp
PENAEIDAE	*Parapenaeus longirostris*(Lucas 1846)	Pink shrimp
	Penaeus kerathurus(Forsskal 1775)	Caramote prawn
PANDALIDAE	*Plesionika heterocarpus*(Costa 1871)	Arrow shrimp
SOLENOCERIDAE	*Solenocera membranacea*(Risso, 1816)	Atlantic mud shrimp
	CEPHALOPODA	
SEPIIDAE	*Sepia elegans*(Blainville 1827)	Elegant cuttlefish
	Sepia officinalis(Linneo 1758)	Common cuttlefish
	Sepia orbignyana(Ferussac 1826)	Pink cuttlefish
SEPIOLIDAE	*Rossia macrosoma*(Delle Chiaje 1829)	Stout bobtail
	Sepiolinae unident.	---
LOLIGINIDAE	*Alloteuthis media*(Linneo 1758)	Midsize squid
	Loligo vulgaris(Lamarck 1798)	European squid
OMMASTREPHIDAE	*Illex coindeti*(Verany 1839)	Broadtail squid
	Todarodes sagittatus(Lamarck 1798)	European flying squid
	Todaropsis eblanae(Ball 1841)	Lesser flying squid
OCTOPODIDAE	*Eledone cirrhosa*(Lamarck 1798)	Horned octopus
	Eledone moschata(Lamarck 1799)	Musky octopus
	Octopus macropus(Risso 1826)	White-spotted octopus
	Octopus vulgaris(Cuvier 1797)	Common octopus
	Pteroctopus tetracirrhus(Delle Chiaje 1830)	Fourhorn octopus
	Scaeurgus unicirrhus(Orbigny 1840)	Unihorned octopus
	Octopodidae unident.	---
	PISCES	
SCYLIORHINIDAE	*Galeus melastomus* Rafinesque, 1810	Blackmouth catshark
SQUALIDAE	*Etmopterus spinax*(Linnaeus, 1758)	Velvet belly
TORPEDINIDAE	*Torpedo marmorata*(Risso 1810)	Marbled electric ray
	Torpedo torpedo(Linneo 1758)	Common torpedo
RAJIDAE	*Raja radula*(Delaroche 1809)	Bullray
MYLIOBATIDAE	*Pteromylaeus bovinus*(E. Geoffroy Saint-Hilaire, 1817)	Bullray
CLUPEIDAE	*Sardina pilchardus*(Walbaum, 1792)	European pilchard
	Sardinella aurita Valenciennes 1847	Round sardinella
ENGRAULIDAE	*Engraulis encrasicholus*(Linneo 1758)	European anchovy
ARGENTINIDAE	*Argentina sphyraena* Linneo 1758	Argentine
SYNODONTIDAE	*Synodus saurus*(Linneo 1758)	Atlantic lizardfish
CHLOROPHTHALMIDAE	*Chlorophthalmus agassizi* Bonaparte 1840	Shortnose greeneye
MURAENIDAE	*Muraena helena* Linneo 1758	Mediterranean moray
	Muraenidae unident.	---
CONGRIDAE	*Conger conger*(Linneo 1758)	European conger
	Gnathophis mystax(Delaroche 1809)	Thinlip conger
	Echelus myrus(Linneo 1758)	Painted eel
MACRORAMPHOSIDAE	*Macroramphosus scolopax*(Linneo 1758)	Longspine spinefish
MACROURIDAE	*Coelorhynchus coelorhynchus*(Risso 1810)	Blackspot grenadier
MERLUCCIIDAE	*Merluccius merluccius*(Linneo 1758)	Hake
GADIDAE	*Gadiculus argenteus* Guichenot,1850	Silvery pout
	Phycis blennoides(Brunnich 1768)	Greater forkbeard
	Phycis phycis(Linneo 1766)	Forkbeard
	Trisopterus minutus(Linneo, 1758)	Poor cod
ZEIDAE	*Zeus faber* Linneo 1758	John Dory
CAPROIDAE	*Capros aper*(Linneo 1758)	Boarfish
SERRANIDAE	*Anthias anthias*(Linneo 1758)	Swallowtail seaperch
	Callanthias ruber Rafinesque 1810	Parrot seaperch
	Epinephelus aeneus(G.Saint-Hilaire E.1817)	White grouper
	Serranus cabrilla(Linneo 1758)	Comber
	Serranus hepatus(Linneo 1758)	Brown comber
MORONIDAE	*Dicentrarchus labrax*(Linneo 1758)	European seabass
APOGONIDAE	*Apogon imberbis*(Linneo 1758)	Cardinal fish
CEPOLIDAE	*Cepola rubescens* Linneo, 1756	Red bandfish
CARANGIDAE	*Caranx crysos*(Mitchill 1815)	Blue runner
	Trachurus trachurus(Linneo 1758)	Atlantic horse marckerel
MULLIDAE	*Mullus barbatus* Linneo 1758	Red mullet

	Mullus surmuletus Linneo 1758	Striped mullet
SPARIDAE	*Boops boops* (Linneo 1758)	Bogue
	Dentex dentex (Linneo 1758)	Common dentex
	Diplodus annularis (Linneo 1758)	Annular seabream
	Diplodus sargus (Linneo 1758)	White seabream
	Diplodus vulgaris (G. Saint-Hilaire 1817)	Common two-banded seabream
	Lithognathus mormyrus (Linneo 1758)	Striped seabream
	Pagellus acarne (Risso 1826)	Axillary seabream
	Pagellus bogaraveo (Brunnich 1768)	Blackspot seabream
	Pagellus erythrinus (Linneo 1758)	Pandora
	Pagrus auriga (Valenciennes, 1834)	Red-banded sea bream
	Pagrus pagrus (Linneo 1758)	Common seabream
	Sparus aurata Linnaeus, 1758	Gilt-head sea bream
	Spondyliosoma cantharus (Linneo 1758)	Black seabream
CENTRACANTHIDAE	*Centracanthus cirrus* Rafinesque 1810	Curled picarel
	Spicara flexuosa Rafinesque 1810	Picarel
	Spicara maena (Linneo 1758)	Blotched picarel
	Spicara smaris (Linneo 1758)	Picarel
LABRIDAE	*Symphodus cinereus* (Bonnaterre, 1788)	Grey wrasse
	Symphodus roissali (Risso 1810)	Five-spotted wrasse
	Xyrichthys novacula Linneo 1758	Pearly razorfish
TRACHINIDAE	*Trachinus draco* Linneo 1758	Greater weever
URANOSCOPIDAE	*Uranoscopus scaber* Linneo 1758	Stargazer
TRICHIURIDAE	*Lepidopus caudatus* (Euphrasen 1788)	Silver scabbardfish
GOBIIDAE	*Deltentosteus quadrimaculatus* (Valenciennes 1837)	Fourspot goby
	Gobiidae unident.	---
CALLIONYMIDAE	*Callionymus maculatus* Rafinesque 1810	Spotted dragonet
	Synchiropus phaeton (Gunther 1861)	---
BLENNIIDAE	*Blennius ocellaris* Linneo 1758	Butterfly blenny
OPHIDIIDAE	*Ophidion barbatum* Linneo 1758	Snake blenny
CARAPIDAE	*Carapus acus* (Brunnich 1768)	Pearlfish
SPHYRAENIDAE	*Sphyraena sphyraena* (Linneo 1758)	European barracuda
SCORPAENIDAE	*Helicolenus dactylopterus* (Delaroche 1809)	Rockfish
	Scorpaena elongata Cadenat 1943	Slender rockfish
	Scorpaena notata Rafinesque 1810	Small red scorpionfish
	Scorpaena porcus Linneo 1758	Black scorpionfish
	Scorpaena scrofa Linneo 1758	Red scorpionfish
TRIGLIDAE	*Aspitrigla cuculus* (Linneo 1758)	Red gurnard
	Aspitrigla obscura (Linneo 1764)	Longfin gurnard
	Lepidotrigla cavillone (Lacepede 1801)	Large-scaled gurnard
	Lepidotrigla dieuzeidei Audouin in Blanc & Hureau 1973	Spiny gurnard
	Trigla lucerna Linneo 1758	Tub gurnard
	Trigla lyra Linneo 1758	Piper gurnard
	Trigloporus lastoviza (Bonnaterre 1788)	Streaked gurnard
PERISTEDIIDAE	*Peristedion cataphractum* (Linneo 1758)	African armoured searobin
DACTYLOPTERIDAE	*Dactylopterus volitans* (Linneo 1758)	Flying gurnard
CITHARIDAE	*Citharus linguatula* (Linneo 1758)	Spotted flounder
SCOPHTHALMIDAE	*Lepidorhombus boscii* (Risso 1810)	Fourspotted megrim
	Lepidorhombus whiffiagonis (Walbaum 1792)	Megrim
	Psetta maxima (Linnaeus, 1758)	Turbot
	Scophthalmus rhombus (Linneo 1758)	Brill
BOTHIDAE	*Arnoglossus imperialis* (Rafinesque 1810)	Imperial scaldfish
	Arnoglossus kessleri Schmidt 1915	Scaldback
	Arnoglossus laterna (Walbaum 1792)	Scaldfish
	Arnoglossus rueppelli (Cocco 1844)	Rueppell's scaldback
	Arnoglossus thori Kyle 1913	Thor's scaldfish
	Arnoglossus sp.	---
	Bothus podas (Delaroche 1809)	Wide-eyed flounder
SOLEIDAE	*Buglossidium luteum* (Risso 1810)	Solenette
	Microchirus ocellatus (Linneo 1758)	Foureyed sole
	Microchirus variegatus (Donovan 1808)	Thickback sole
	Solea lascaris (Risso 1810)	Sand sole
	Solea vulgaris Quensel, 1806	Common sole
	Solea sp.	---
CYNOGLOSSIDAE	*Symphurus nigrescens* Rafinesque 1810	Tongue sole
BALISTIDAE	*Balistes carolinensis* Gmelin 1789	Grey triggerfish
LOPHIIDAE	*Lophius budegassa* Spinola 1807	Black-bellied anglerfish
	Lophius piscatorius Linneo 1758	Anglerfish

Appendix 3.II(a): Trawl hauls (survey IX, summer) catch (g) and CPUE (g/30min) [Key: Std.dev. (sd) high, mod. & non commercial species; A, B, C sampling strata.]

		A			B			C			Total area		
		catch	cpue	sd	catch	cpue	sd	catch	cpue	sd	catch	cpue	sd
h.c.	Alloteuthis media	438.7	73.1	88.5	871.0	87.1	44.0	857.0	85.7	60.1	2 166.7	83.3	60.0
n.c.	Argentina sphyraena				7.0	0.7	2.2	13 980.8	1 398.1	2 487.5	13 987.8	538.0	1 645.7
n.c.	Arnoglossus laterna	2 378.5	396.4	418.8	4 403.0	440.3	197.4	923.0	92.3	109.4	7 704.5	296.3	284.2
n.c.	Arnoglossus rueppelli	11.0	1.8	4.5				323.3	32.3	48.9	334.3	12.9	33.4
n.c.	Arnoglossus sp.							1.0	0.1	0.3	1.0	0.0	0.2
m.c.	Aspitrigla cuculus				497.5	49.8	68.3	6 095.0	609.5	979.9	6 592.5	253.6	655.8
m.c.	Aspitrigla obscura	210.0	35.0	39.1	88.5	8.9	28.0				298.5	11.5	27.9
n.c.	Blennius ocellaris	17.0	2.8	6.9	233.5	23.4	27.6	127.5	12.8	15.9	378.0	14.5	21.0
m.c.	Boops boops	783.5	130.6	91.1	7 190.8	719.1	1 458.5				7 974.3	306.7	938.4
n.c.	Bothus podas	2 431.0	405.2	761.7							2 431.0	93.5	382.6
n.c.	Callionymus maculatus	3.0	0.5	1.2	96.3	9.6	12.2	192.0	19.2	30.1	291.3	11.2	20.8
n.c.	Capros aper							1 430.6	143.1	190.5	1 430.6	55.0	134.6
n.c.	Carapus acus				4.0	0.4	1.3	14.0	1.4	2.4	18.0	0.7	1.7
n.c.	Cepola rubescens	56.0	9.3	15.1	662.5	66.2	47.2	1 932.7	193.3	292.1	2 651.2	102.0	193.6
m.c.	Chlorophthalmus agassizi							113.0	11.3	29.7	113.0	4.3	18.7
m.c.	Citharus linguatula	41.2	6.9	11.9	6 752.3	675.2	916.2	62.0	6.2	13.1	6 855.6	263.7	642.2
m.c.	Conger conger	1 822.0	303.7	480.0	2 710.2	271.0	363.3	738.9	73.9	107.2	5 271.1	202.7	329.7
n.c.	Dactylopterus volitans	238.0	39.7	97.2							238.0	9.2	46.7
n.c.	Deltentosteus quadrimaculatus	7.0	1.2	2.0	7.2	0.7	2.3	64.0	6.4	11.1	78.2	3.0	7.4
h.c.	Dentex dentex	179.0	29.8	73.1							179.0	6.9	35.1
h.c.	Dicentrarchus labrax	3 170.0	528.3	1 294.1							3 170.0	121.9	621.7
m.c.	Diplodus annularis	14 875.8	2 479.3	2 429.7	17 910.8	1 791.1	2 594.1				32 786.6	1 261.0	2 169.8
h.c.	Diplodus vulgaris	49.0	8.2	14.0							49.0	1.9	7.2
n.c.	Echelus myrus				2 196.0	219.6	438.1	2 436.0	243.6	324.7	4 632.0	178.2	342.2
h.c.	Eledone cirrhosa				1 232.0	123.2	196.3	419.6	42.0	49.5	1 651.6	63.5	131.7
h.c.	Eledone moschata	108.8	18.1	44.4	1 263.0	126.3	140.7	154.0	15.4	48.7	1 525.8	58.7	106.5
h.c.	Epinephelus aeneus				7 825.0	782.5	2 474.5				7 825.0	301.0	1 534.6
n.c.	Gadiculus argenteus							101.0	10.1	28.0	101.0	3.9	17.5
n.c.	Gobiidae	1 114.4	185.7	218.1	1 243.3	124.3	164.7	14.9	1.5	1.6	2 372.7	91.3	158.4
h.c.	Helicolenus dactylopterus				6.0	0.6	1.9	722.2	72.2	124.6	728.2	28.0	82.8
h.c.	Illex coindetii				365.0	36.5	63.2	1 117.8	111.8	96.9	1 482.8	57.0	83.4
m.c.	Lepidopus caudatus				35.0	3.5	11.1	13 649.0	1 364.9	3 115.2	13 684.0	526.3	1 987.7
m.c.	Lepidorhombus bosci				332.0	33.2	105.0	1 186.0	118.6	166.1	1 518.0	58.4	128.2
m.c.	Lepidorhombus whiffiagonis							52.0	5.2	16.4	52.0	2.0	10.2
n.c.	Lepidotrigla cavillone	2 317.2	386.2	508.7	42 417.2	4 241.7	3 889.1	15 689.0	1 568.9	2 057.3	60 423.4	2 324.0	3 101.7
n.c.	Lepidotrigla dieuzeidei							6 219.0	621.9	1 322.7	6 219.0	239.2	851.5
h.c.	Lithognathus mormyrus	7 927.9	1 321.3	1 640.0							7 927.9	304.9	927.5
h.c.	Loligo vulgaris	1 963.0	327.2	457.9	2 496.0	249.6	448.2				4 459.0	171.5	366.4
m.c.	Lophius budegassa	43.0	7.2	17.6	11 257.2	1 125.7	1 139.1	28 289.4	2 828.9	2 980.9	39 589.6	1 522.7	2 227.8
m.c.	Lophius piscatorius				1 189.3	118.9	352.9	2 089.0	208.9	385.3	3 278.3	126.1	323.8
n.c.	Macroramphosus scolopax				30.0	3.0	9.5	3 766.4	376.6	567.0	3 796.4	146.0	387.8
h.c.	Merluccius merluccius	7 492.3	1 248.7	1 561.9	31 083.0	3 108.3	1 754.7	62 553.4	6 255.3	2 034.1	101 128.7	3 889.6	2 890.0
h.c.	Mullus barbatus	142 104.2	23 684.0	22 115.5	57 768.5	5 776.9	7 529.2	20 228.0	2 022.8	1 995.8	220 100.7	8 465.4	13 954.9
h.c.	Mullus surmuletus	305.2	50.9	55.5	295.0	29.5	47.6	2 559.0	255.9	774.7	3 159.2	121.5	478.9
h.c.	Octopus vulgaris	5 584.9	930.8	1 320.2	6 745.0	674.5	512.3	4 734.0	473.4	607.9	17 063.9	656.3	779.6
m.c.	Pagellus acarne	8 628.4	1 438.1	1 613.9	14 073.7	1 407.4	2 978.6				22 702.1	873.2	2 051.9
m.c.	Pagellus bogaraveo	302.2	50.4	97.4	26 287.1	2 628.7	3 777.3	748.0	74.8	121.4	27 337.3	1 051.4	2 600.2
h.c.	Pagellus erythrinus	33 484.6	5 580.8	5 216.5	26 420.0	2 642.0	3 086.0	255.0	25.5	56.3	60 159.6	2 313.8	3 683.9
h.c.	Pagrus pagrus	152.0	25.3	39.3							152.0	5.8	20.7
h.c.	Parapenaeus longirostris				2 780.2	278.0	524.2	10 351.6	1 035.2	688.4	13 131.8	505.1	681.0
n.c.	Peristedion cataphractum				53.0	5.3	16.8	549.7	55.0	91.9	602.7	23.2	61.7
h.c.	Phycis blennoides				335.7	33.6	58.0	1 827.1	182.7	128.5	2 162.8	83.2	117.3
m.c.	Psetta maxima				2 910.0	291.0	920.2				2 910.0	111.9	570.7
m.c.	Rossia macrosoma							606.2	60.6	111.5	606.2	23.3	73.3
m.c.	Rossiinae							67.0	6.7	21.2	67.0	2.6	13.1
h.c.	Scaeurgus unicirrhus				719.0	71.9	201.1	1 510.0	151.0	193.0	2 229.0	85.7	177.5
h.c.	Scophthalmus rhombus	89.0	14.8	36.3							89.0	3.4	17.5
h.c.	Scorpaena elongata				13.0	1.3	2.8	3.0	0.3	0.9	16.0	0.6	1.8
m.c.	Scorpaena notata	996.6	166.1	261.0	419.9	42.0	73.8				1 416.5	54.5	140.8
h.c.	Scorpaena porcus	50.7	8.5	14.9							50.7	2.0	7.6
h.c.	Scorpaena scrofa	29.0	4.8	11.8	835.1	83.5	220.2				864.1	33.2	138.3
h.c.	Sepia elegans	11.5	1.9	3.8	2 188.0	218.8	126.6	2 212.7	221.3	170.7	4 412.2	169.7	158.2
h.c.	Sepia officinalis	2 020.9	336.8	270.3							2 020.9	77.7	188.6
h.c.	Sepia orbignyana				227.0	22.7	39.2	1 575.0	157.5	186.7	1 802.0	69.3	135.1
h.c.	Sepiolinae	5.0	0.8	2.0	55.0	5.5	9.6	107.6	10.8	9.6	167.6	6.4	9.1
m.c.	Serranus cabrilla	1 844.3	307.4	371.3	9 297.8	929.8	926.0	93.0	9.3	29.4	11 235.1	432.1	714.8
n.c.	Serranus hepatus	4 541.0	756.8	783.1	23 688.5	2 368.9	1 978.5	6 939.2	693.9	718.7	35 168.7	1 352.6	1 545.8
m.c.	Solea lascaris	78.0	13.0	31.8							78.0	3.0	15.3
h.c.	Solea vulgaris	656.0	109.3	169.5	710.0	71.0	224.5				1 366.0	52.5	161.0
m.c.	Solenocera membranacea				1.0	0.1	0.3	2.7	0.3	0.9	3.7	0.1	0.6
m.c.	Spicara flexuosa	11 404.6	1 900.8	2 063.2	34 439.2	3 443.9	5 549.0	8 568.0	856.8	1 101.3	54 411.8	2 092.8	3 704.4
h.c.	Spondyliosoma cantharus	128.0	21.3	52.3							128.0	4.9	25.1
m.c.	Squilla mantis				1 086.3	108.6	297.5	53.1	5.3	11.2	1 139.4	43.8	186.1
n.c.	Symphurus nigrescens				4.0	0.4	0.8	1.0	0.1	0.3	5.0	0.2	0.6
n.c.	Synchiropus phaeton							385.7	38.6	113.5	385.7	14.8	70.7
n.c.	Synodus saurus	60.0	10.0	24.5							60.0	2.3	11.8
m.c.	Todaropsis eblanae							1 527.0	152.7	275.3	1 527.0	58.7	181.7
h.c.	Trachinus draco				893.5	89.4	106.6	76.0	7.6	24.0	969.5	37.3	77.9
m.c.	Trachurus trachurus	2 472.9	412.1	463.1	8 647.4	864.7	1 086.2	2 755.0	275.5	397.0	13 875.3	533.7	773.6
h.c.	Trigla lucerna	1 697.1	282.9	343.0	1 430.2	143.0	261.2	999.0	99.9	310.7	4 126.3	158.7	296.7
m.c.	Trigla lyra							596.7	59.7	89.9	596.7	23.0	61.5
m.c.	Trisopterus minutus				11 107.4	1 110.7	1 032.2	2 245.0	224.5	314.5	13 352.4	513.6	811.5
m.c.	Uranoscopus scaber	763.0	127.2	311.5	4 433.6	443.4	394.4	1 322.0	132.2	167.2	6 518.6	250.7	331.1
m.c.	Xyrichthys novacula	53.0	8.8	21.6							53.0	2.0	10.4
m.c.	Zeus faber	383.5	63.9	124.3	14 710.7	1 471.1	1 658.9	11 385.3	1 138.5	1 141.0	26 479.6	1 018.4	1 330.0
	TOTAL SPECIES	265 523.0	44 253.8	34 949.4	396 979.2	39 697.9	28 093.3	249 596.1	24 959.6	9 151.7	912 098.4	35 080.7	25 061.2
	TOTAL h.c.	207 646.8	34 607.8	28 709.0	146 556.1	14 655.6	13 025.3	112 262.0	11 226.2	4 180.3	466 464.9	17 941.0	17 922.9
	TOTAL m.c.	44 702.1	7 450.3	6 231.4	175 377.7	17 537.8	14 931.4	82 243.3	8 224.3	4 221.9	302 323.0	11 627.8	10 827.6
	TOTAL n.c.	13 174.1	2 195.7	1 308.7	75 045.5	7 504.5	5 389.6	55 090.8	5 509.1	4 816.5	143 310.4	5 511.9	4 835.2

Appendix 3.II(b): Trawl hauls (survey X, autumn) catch (g) and CPUE (g/30min)
[Key: Std.dev. (sd) high, mod. & non commercial species; A, B, C sampling strata.]

		A			B			C			Total area		
		catch	**cpue**	*sd*	catch	**cpue**	*sd*	catch	**cpue**	*sd*	catch	**cpue**	*sd*
h.c.	Alloteuthis media	101.3	**16.9**	*32.9*	1 564.9	**130.4**	*79.2*	1 475.0	**147.5**	*87.7*	3 141.2	**112.2**	*89.2*
n.c.	Anthias anthias							19.0	**1.9**	*6.0*	19.0	**0.7**	*3.6*
n.c.	Argentina sphyraena							7 932.0	**793.2**	*1 148.1*	7 932.0	**283.3**	*767.6*
n.c.	Arnoglossus kessleri							5.0	**0.5**	*1.6*	5.0	**0.2**	*0.9*
n.c.	Arnoglossus laterna	889.2	**148.2**	*193.4*	6 384.7	**448.7**	*204.2*	1 158.2	**115.8**	*138.2*	7 432.0	**265.4**	*237.8*
n.c.	Arnoglossus rueppelli	17.0	**2.8**	*6.9*	6.0	**0.5**	*1.2*	111.0	**11.1**	*24.8*	134.0	**4.8**	*15.4*
n.c.	Arnoglossus thori				30.0	**2.5**	*8.7*				30.0	**1.1**	*5.7*
m.c.	Aspitrigla cuculus	107.0	**17.8**	*43.7*	534.2	**44.5**	*123.7*	7 884.8	**788.5**	*1 027.8*	8 526.0	**304.5**	*702.7*
h.c.	Balistes carolinensis	1 207.0	**201.2**	*492.8*							1 207.0	**43.1**	*228.1*
n.c.	Blennius ocellaris	43.0	**7.2**	*17.6*	163.6	**13.6**	*14.9*	53.0	**5.3**	*10.2*	259.6	**9.3**	*14.0*
m.c.	Boops boops	3 166.1	**527.7**	*958.0*	4 625.9	**385.5**	*688.2*	1 137.5	**113.7**	*207.4*	8 929.4	**318.9**	*636.0*
n.c.	Bothus podas	8 244.9	**1 374.1**	*1 761.6*							8 244.9	**294.5**	*951.0*
m.c.	Buglossidium luteum	15.0	**2.5**	*4.2*							15.0	**0.5**	*2.1*
n.c.	Callionymus maculatus				63.1	**5.3**	*5.0*	179.2	**17.9**	*24.6*	242.3	**8.7**	*18.3*
n.c.	Capros aper							981.6	**98.2**	*184.4*	981.6	**35.1**	*116.7*
m.c.	Caranx crysos	171.0	**28.5**	*69.8*							171.0	**6.1**	*32.3*
n.c.	Carapus acus							3.6	**0.4**	*1.1*	3.6	**0.1**	*0.7*
n.c.	Cepola rubescens	20.0	**3.3**	*8.2*	279.8	**23.3**	*44.4*	592.0	**59.2**	*119.2*	891.8	**31.9**	*77.7*
m.c.	Chlorophthalmus agassizi							1 388.0	**138.8**	*429.9*	1 388.0	**49.6**	*257.3*
m.c.	Citharus linguatula	10.0	**1.7**	*4.1*	6 353.0	**529.4**	*606.6*	814.6	**81.5**	*151.4*	7 177.6	**256.3**	*466.2*
n.c.	Coelorhynchus coelorhynchus							190.0	**19.0**	*60.1*	190.0	**6.8**	*35.9*
m.c.	Conger conger	479.0	**79.8**	*125.1*	2 953.9	**246.2**	*344.6*	2 497.0	**249.7**	*594.5*	5 929.9	**211.8**	*417.1*
n.c.	Dactylopterus volitans	118.8	**19.8**	*28.0*							118.8	**4.2**	*14.6*
n.c.	Deltentosteus quadrimaculatus				36.3	**3.0**	*4.1*	80.8	**8.1**	*12.3*	117.1	**4.2**	*8.2*
h.c.	Dentex dentex	508.0	**84.7**	*108.8*	124.0	**10.3**	*35.8*				632.0	**22.6**	*61.9*
m.c.	Diplodus annularis	14 970.2	**2 495.0**	*2 614.6*	9 443.6	**787.0**	*1 316.9*				24 413.8	**871.9**	*1 686.0*
h.c.	Diplodus vulgaris	22.0	**3.7**	*9.0*	905.0	**75.4**	*234.6*				927.0	**33.1**	*154.4*
n.c.	Echelus myrus				553.0	**46.1**	*169.6*	457.0	**45.7**	*101.3*	1 010.0	**36.1**	*119.0*
h.c.	Eledone cirrhosa				2 941.0	**245.1**	*470.3*	3 306.0	**330.6**	*456.6*	6 247.0	**223.1**	*418.5*
h.c.	Eledone moschata	294.0	**49.0**	*79.1*	2 236.0	**186.3**	*179.6*	630.0	**63.0**	*115.7*	3 160.0	**112.9**	*151.6*
m.c.	Engraulis encrasicholus				31.4	**2.6**	*5.2*				31.4	**1.1**	*3.5*
h.c.	Epinephelus aeneus	7 362.0	**1 227.0**	*3 006.5*	7 705.0	**642.1**	*2 224.2*				15 067.0	**538.1**	*1 976.3*
n.c.	Etmopterus spinax							63.0	**6.3**	*19.9*	63.0	**2.3**	*11.9*
n.c.	Gadiculus argenteus							1 676.0	**167.6**	*481.0*	1 676.0	**59.9**	*289.5*
n.c.	Galeus melastomus				5.0	**0.4**	*1.4*				5.0	**0.2**	*0.9*
n.c.	Gnathophis mystax				192.0	**16.0**	*55.4*	656.0	**65.6**	*144.6*	848.0	**30.3**	*94.7*
n.c.	Gobiidae	527.5	**87.9**	*121.2*	1 378.8	**114.9**	*115.6*	32.0	**3.2**	*8.5*	1 938.3	**69.2**	*103.9*
h.c.	Helicolenus dactylopterus							1 299.0	**129.9**	*317.5*	1 299.0	**46.4**	*193.9*
h.c.	Illex coindetii				388.0	**32.3**	*74.6*	3 543.0	**354.3**	*362.9*	3 931.0	**140.4**	*269.6*
m.c.	Lepidopus caudatus				61.0	**5.1**	*17.6*	625.0	**62.5**	*127.3*	686.0	**24.5**	*79.8*
m.c.	Lepidorhombus boscii							563.0	**56.3**	*122.2*	563.0	**20.1**	*75.7*
m.c.	Lepidorhombus whiffiagonis							424.0	**42.4**	*91.6*	424.0	**15.1**	*56.8*
n.c.	Lepidotrigla cavillone	3 848.0	**641.3**	*1 243.8*	63 028.1	**5 252.3**	*4 169.9*	30 538.5	**3 053.0**	*2 423.0*	97 414.6	**3 479.1**	*3 547.0*
h.c.	Lithognathus mormyrus	12 877.1	**2 146.2**	*2 801.4*							12 877.1	**459.9**	*1 502.5*
h.c.	Loligo vulgaris	2 183.0	**363.8**	*663.8*	4 769.2	**397.4**	*466.0*				6 952.2	**248.3**	*463.6*
m.c.	Lophius budegassa				15 303.4	**1 275.3**	*1 787.9*	25 517.9	**2 551.8**	*2 318.0*	40 821.3	**1 457.9**	*2 006.9*
n.c.	Macroramphosus scolopax				92.0	**7.7**	*14.2*	3 637.9	**363.8**	*368.6*	3 729.9	**133.2**	*276.7*
h.c.	Merluccius merluccius	858.0	**143.0**	*338.7*	46 849.4	**3 904.1**	*2 584.8*	85 517.8	**8 551.8**	*9 382.0*	133 225.2	**4 758.0**	*6 517.0*
n.c.	Microchirus ocellatus				30.0	**2.5**	*8.7*				30.0	**1.1**	*5.7*
n.c.	Microchirus variegatus				10.0	**0.8**	*2.9*				10.0	**0.4**	*1.9*
h.c.	Mullus barbatus	88 207.4	**14 701.2**	*15 908.1*	105 020.4	**8 751.7**	*6 211.3*	23 706.0	**2 370.6**	*1 687.7*	216 933.8	**7 747.6**	*9 243.0*
h.c.	Mullus surmuletus	513.8	**85.6**	*172.0*	317.0	**26.4**	*61.2*	422.0	**42.2**	*77.1*	1 252.8	**44.7**	*79.7*
h.c.	Octopodidae	8.6	**1.4**	*2.4*	2.0	**0.2**	*0.6*				10.6	**0.4**	*1.2*
h.c.	Octopus vulgaris	5 138.0	**856.3**	*2 097.6*	18 582.1	**1 548.5**	*1 437.3*	10 792.0	**1 079.2**	*1 203.0*	34 512.1	**1 232.6**	*1 491.1*
m.c.	Pagellus acarne	3 256.0	**542.7**	*1 329.3*	13 117.8	**1 093.1**	*1 762.7*	1 393.3	**139.3**	*251.1*	17 767.0	**634.5**	*1 341.7*
m.c.	Pagellus bogaraveo				15 629.4	**1 302.5**	*2 610.2*	36 155.7	**3 615.6**	*8 871.5*	51 785.1	**1 849.5**	*5 673.0*
h.c.	Pagellus erythrinus	18 136.1	**3 022.7**	*3 283.0*	21 477.2	**1 789.8**	*1 597.6*	1 808.0	**180.8**	*369.4*	41 421.3	**1 479.3**	*2 068.3*
h.c.	Pagrus pagrus	1 522.6	**253.8**	*537.8*							1 522.6	**54.4**	*254.6*
h.c.	Parapenaeus longirostris	4.1	**0.7**	*1.7*	4 518.3	**376.5**	*563.5*	16 543.8	**1 654.4**	*926.9*	21 066.2	**752.4**	*949.1*
n.c.	Peristedion cataphractum							167.0	**16.7**	*43.0*	167.0	**6.0**	*26.1*
h.c.	Phycis blennoides				246.0	**20.5**	*48.8*	2 719.3	**271.9**	*277.8*	2 965.3	**105.9**	*206.5*
h.c.	Phycis phycis				100.0	**0.3**	*28.9*	184.0	**18.4**	*42.5*	284.0	**10.1**	*31.5*
m.c.	Plesionika heterocarpus							237.0	**23.7**	*60.7*	237.0	**8.5**	*36.9*
m.c.	Raja radula	507.5	**84.6**	*207.2*							507.5	**18.1**	*95.9*
m.c.	Rossia macrosoma							122.0	**12.2**	*28.5*	122.0	**4.4**	*17.5*
m.c.	Sardina pilchardus				49.0	**4.1**	*9.7*	110.0	**11.0**	*27.9*	159.0	**5.7**	*17.8*
m.c.	Sardinella aurita				45.0	**3.8**	*13.0*				45.0	**1.6**	*8.5*
h.c.	Scaeurgus unicirrhus				110.0	**9.2**	*31.8*	1 211.0	**121.1**	*115.0*	1 321.0	**47.2**	*89.3*
m.c.	Scorpaena notata	768.0	**128.0**	*214.2*	1 301.3	**108.4**	*211.1*	5.0	**0.5**	*1.6*	2 074.3	**74.1**	*172.7*
h.c.	Scorpaena scrofa				622.0	**51.8**	*121.1*	3 596.2	**359.6**	*854.2*	4 218.2	**150.7**	*524.2*
m.c.	Scorpaenidae	11.0	**1.8**	*4.5*	42.0	**3.5**	*8.2*				63.0	**1.9**	*5.8*
h.c.	Sepia elegans				1 051.4	**87.6**	*56.6*	1 235.0	**123.5**	*117.7*	2 286.4	**81.7**	*89.8*
h.c.	Sepia officinalis	2 464.0	**410.7**	*416.3*	11 594.5	**966.2**	*749.6*	334.0	**33.4**	*105.6*	14 392.5	**514.0**	*666.0*
h.c.	Sepia orbignyana				216.0	**18.0**	*43.2*	1 694.0	**169.4**	*207.8*	1 910.0	**68.2**	*146.2*
h.c.	Sepiolinae				30.0	**2.5**	*3.2*	105.0	**10.5**	*14.4*	135.0	**4.8**	*9.6*
m.c.	Serranus cabrilla	3 378.6	**563.1**	*886.4*	12 795.5	**1 066.3**	*1 048.6*	1 032.7	**103.3**	*170.9*	17 206.8	**614.5**	*889.4*
n.c.	Serranus hepatus	4 016.7	**669.5**	*925.1*	23 678.8	**1 973.2**	*1 531.2*	7 845.5	**784.5**	*771.6*	35 541.0	**1 269.3**	*1 303.6*
	Solea sp				2.0	**0.2**	*0.6*				2.0	**0.1**	*0.4*
h.c.	Solea vulgaris	1 996.5	**332.7**	*383.9*	948.0	**79.0**	*273.7*				2 944.5	**105.2**	*271.5*
m.c.	Solenocera membranacea				1.0	**0.1**	*0.3*	9.0	**0.9**	*2.0*	10.0	**0.4**	*1.3*
h.c.	Sparus aurata				3 273.0	**272.8**	*944.8*				3 273.0	**116.9**	*618.5*
m.c.	Sphyraena sphyraena	721.0	**120.2**	*294.3*	1 527.0	**127.3**	*341.7*				2 248.0	**80.3**	*269.5*
m.c.	Spicara flexuosa	10 232.0	**1 705.3**	*2 269.2*	15 034.2	**1 252.8**	*1 175.6*	2 819.4	**281.9**	*312.8*	28 085.5	**1 003.1**	*1 367.7*
m.c.	Spicara smaris				25.0	**2.1**	*7.2*				25.0	**0.9**	*4.7*
h.c.	Spondyliosoma cantharus	105.0	**17.5**	*30.6*							105.0	**3.8**	*15.1*
m.c.	Squilla mantis	24.0	**4.0**	*9.8*	1 557.0	**129.8**	*441.0*	345.7	**34.6**	*83.3*	1 926.7	**68.8**	*290.8*
n.c.	Symphodus cinereus	23.8	**4.0**	*9.7*							23.8	**0.8**	*4.5*
n.c.	Symphurus nigrescens				2.0	**0.2**	*0.6*				2.0	**0.1**	*0.4*
n.c.	Synchiropus phaeton							205.0	**20.5**	*54.5*	205.0	**7.3**	*33.0*
n.c.	Synodus saurus	1 550.8	**258.5**	*473.6*							1 550.8	**55.4**	*230.7*
m.c.	Todaropsis eblanae							406.0	**40.6**	*103.0*	406.0	**14.5**	*62.7*
n.c.	Torpedo marmorata				455.4	**38.0**	*131.5*	78.0	**7.8**	*24.7*	533.4	**19.1**	*86.8*
h.c.	Trachinus draco				515.0	**42.9**	*74.8*	681.7	**68.2**	*101.1*	1 196.7	**42.7**	*79.6*
m.c.	Trachurus trachurus	847.0	**141.2**	*311.8*	22 081.7	**1 840.1**	*4 205.9*	2 529.8	**253.0**	*400.1*	25 458.5	**909.2**	*2 820.3*
h.c.	Trigla lucerna	3 236.2	**539.4**	*544.9*	100.0	**8.3**	*28.9*	901.6	**90.2**	*208.7*	4 237.8	**151.4**	*337.3*
m.c.	Trigla lyra							477.0	**47.7**	*84.1*	477.0	**17.0**	*53.9*
m.c.	Trigloporus lastoviza	550.6	**91.8**	*150.7*	272.0	**22.7**	*78.5*				822.6	**29.4**	*89.0*
m.c.	Trisopterus minutus	58.0	**9.7**	*23.7*	15 922.9	**1 326.9**	*1 667.2*	5 593.1	**559.3**	*890.1*	21 574.1	**770.5**	*1 295.9*
m.c.	Uranoscopus scaber	334.0	**55.7**	*136.4*	8 042.4	**670.2**	*632.6*	1 545.7	**154.6**	*265.5*	9 922.0	**354.4**	*518.6*
m.c.	Xyrichthys novacula	166.0	**27.0**	*47.1*							166.8	**6.0**	*23.4*
m.c.	Zeus faber	848.0	**141.3**	*178.3*	9 791.8	**816.0**	*1 229.6*	10 156.1	**1 015.6**	*1 150.8*	20 795.9	**742.7**	*1 083.3*
	TOTAL SPECIES	**206 665.0**	**34 444.2**	*28 166.3*	**488 137.4**	**40 678.1**	*21 434.9*	**322 154.7**	**32 215.5**	*21 623.8*	**1 016 957.1**	**36 319.9**	*22 481.4*
	TOTAL h.c.	146 744.7	**24 457.4**	*21 670.6*	236 205.4	**19 683.8**	*8 684.1*	161 704.4	**16 170.4**	*11 643.8*	544 654.5	**19 451.9**	*13 102.0*
	TOTAL m.c.	40 620.8	**6 770.1**	*7 659.1*	156 541.4	**13 045.1**	*11 626.0*	103 789.1	**10 378.9**	*10 156.1*	300 951.3	**10 748.3**	*10 306.5*
	TOTAL n.c.	19 299.5	**3 216.6**	*2 093.2*	95 388.6	**7 949.1**	*5 606.1*	56 661.2	**5 666.1**	*3 456.7*	171 349.4	**6 119.6**	*4 596.1*

Appendix 3.II(c): Trawl hauls (survey XI, winter) catch (g) and CPUE (g/30min) [Key: Std.dev. (sd) high, mod. & non commercial species; A, B, C sampling strata.]

		A			B			C			Total area		
		catch	cpue	sd	catch	cpue	sd	catch	cpue	sd	catch	cpue	sd
h.c.	Alloteuthis media	277.8	46.3	43.1	1 101.0	91.8	91.7	550.5	45.9	56.2	1 929.2	64.3	72.3
n.c.	Argentina sphyraena							4 515.0	376.2	591.8	4 515.0	150.5	409.9
n.c.	Arnoglossus imperialis				5.0	0.4	1.4				5.0	0.2	0.9
n.c.	Arnoglossus laterna	1 977.3	329.5	315.3	4 015.8	334.6	273.9	1 142.6	95.2	150.6	7 135.6	237.9	261.2
n.c.	Arnoglossus rueppelli							63.0	5.3	9.0	63.0	2.1	6.1
n.c.	Arnoglossus thori				3.0	0.3	0.9				3.0	0.1	0.5
m.c.	Aspitrigla cuculus				64.0	5.3	18.5	7 308.2	609.0	962.4	7 372.2	245.7	665.2
n.c.	Blennius ocellaris	131.6	22.0	38.3	257.0	21.4	36.2	68.0	5.7	13.6	456.6	15.2	29.7
m.c.	Boops boops	14 456.5	2 409.4	2 827.2	7 173.3	597.8	727.6	249.0	20.8	48.7	21 878.8	729.3	1 642.3
n.c.	Bothus podas	2 239.0	373.2	718.8							2 239.0	74.6	334.9
m.c.	Buglossidium luteum	30.0	5.0	8.0							30.0	1.0	3.9
n.c.	Callanthias ruber							16.0	1.3	4.6	16.0	0.5	2.9
n.c.	Callionymus maculatus				33.0	2.8	6.8	120.8	10.1	12.9	153.8	5.1	9.7
n.c.	Capros aper	1.0	0.2	0.4				656.7	71.4	120.4	657.7	28.6	82.2
n.c.	Carapus acus	1.3	0.2	0.5				26.8	2.2	3.6	28.1	0.9	2.4
n.c.	Cepola rubescens	40.3	6.7	16.4	355.8	29.6	53.5	350.1	29.2	38.3	746.1	24.9	42.1
m.c.	Chlorophthalmus agassizi							3 674.2	306.2	1 009.7	3 674.2	122.5	640.3
m.c.	Citharus linguatula	285.0	47.5	116.4	6 603.0	550.3	667.6	1 330.0	110.8	263.7	8 218.0	273.9	501.0
n.c.	Coelorhynchus coelorhynchus							282.0	23.5	56.5	282.0	9.4	36.7
m.c.	Conger conger	409.0	68.2	107.0	792.0	66.0	136.5	1 248.1	104.0	145.3	2 449.1	81.6	131.5
n.c.	Dactylopterus volitans	658.0	109.7	268.6							658.0	21.9	120.1
n.c.	Deltentosteus quadrimaculatus	3.0	0.5	1.2				16.0	1.3	4.6	19.0	0.6	3.0
h.c.	Dentex dentex	118.0	19.7	48.2							118.0	3.9	21.5
h.c.	Dicentrarchus labrax	2 722.0	453.7	709.2							2 722.0	90.7	347.5
m.c.	Diplodus annularis	14 327.0	2 387.8	2 016.2	2 602.8	216.9	361.8				16 929.8	564.3	1 272.6
h.c.	Diplodus vulgaris	426.5	71.1	90.7							426.5	14.2	47.5
n.c.	Echelus myrus				109.0	9.1	31.5	1 096.0	91.3	188.6	1 205.0	40.2	125.2
h.c.	Eledone cirrhosa				1 873.0	156.1	217.3	7 893.1	657.8	823.6	9 766.1	325.5	595.6
h.c.	Eledone moschata	287.0	47.8	117.2	2 578.0	214.8	276.2	1 382.0	115.2	182.4	4 247.0	141.6	219.2
h.c.	Epinephelus aeneus				10 950.0	912.5	3 161.0				10 950.0	365.0	1 999.2
n.c.	Gadiculus argenteus							2 206.3	183.9	568.4	2 206.3	73.5	367.9
n.c.	Gobiidae	411.5	68.6	92.1	649.8	54.1	79.7	7.2	0.6	2.1	1 068.5	35.6	68.9
h.c.	Helicolenus dactylopterus							1 301.0	108.4	288.9	1 301.0	43.4	186.0
h.c.	Illex coindetii	26.3	4.4	10.7	166.0	13.8	25.7	1 698.2	141.5	209.6	1 890.5	63.0	145.6
m.c.	Lepidopus caudatus				22.0	1.8	4.3	88 911.7	7 409.3	24 161.9	88 933.7	2 964.5	15 325.9
m.c.	Lepidorhombus bosci							2 850.1	237.5	417.2	2 850.1	95.0	282.9
m.c.	Lepidorhombus whiffiagonis							1 660.0	138.3	479.2	1 660.0	55.3	303.1
n.c.	Lepidotrigla cavillone	9 122.3	1 520.4	1 776.3	49 866.8	4 155.6	4 075.2	24 255.9	2 021.3	1 873.3	83 244.9	2 774.8	3 086.1
n.c.	Lepidotrigla dieuzeidei							273.9	22.8	62.4	273.9	9.1	40.1
h.c.	Lithognathus mormyrus	13 916.0	2 319.3	2 840.0							13 916.0	463.9	1 510.3
h.c.	Loligo vulgaris	1 606.0	267.7	200.2	1 934.0	161.2	208.5	344.0	28.7	99.3	3 884.0	129.5	189.0
m.c.	Lophius budegassa	2 492.5	415.4	432.7	5 179.0	431.6	597.0	11 584.8	965.4	1 284.0	19 256.3	641.9	930.1
m.c.	Lophius piscatorius	1 007.0	167.8	411.1	587.0	48.9	169.5				1 594.0	53.1	209.6
n.c.	Macroramphosus scolopax				65.0	5.4	13.3	2 533.8	211.2	232.1	2 598.8	86.6	176.6
h.c.	Merluccius merluccius	20 318.8	3 386.5	3 776.8	54 918.0	4 576.5	3 678.5	45 850.0	3 820.8	3 225.0	121 086.7	4 036.2	3 429.9
h.c.	Mullus barbatus	132 480.5	22 080.1	18 115.4	76 790.0	6 399.2	6 472.7	23 931.6	1 994.3	1 664.3	233 202.1	7 773.4	11 421.9
h.c.	Mullus surmuletus	902.3	150.4	242.2	586.0	48.8	66.3	918.6	76.6	114.4	2 406.9	80.2	134.6
h.c.	Octopodidae	2.0	0.3	0.8							2.0	0.1	0.4
m.c.	Octopus macropus	503.0	83.8	205.3	646.0	53.8	125.7				1 149.0	38.3	120.0
h.c.	Octopus vulgaris	398.8	66.5	162.8	3 124.0	260.3	488.4	8 257.1	688.1	803.2	11 779.8	392.7	636.5
m.c.	Pagellus acarne	55 469.3	9 244.9	7 807.9	21 667.5	1 804.8	3 183.4	2 330.0	194.2	324.9	79 456.8	2 640.6	5 138.2
m.c.	Pagellus bogaraveo	948.0	158.0	219.6	40 815.5	3 401.3	4 463.7	33 825.1	2 818.8	7 837.4	75 588.6	2 519.6	5 690.1
h.c.	Pagellus erythrinus	41 633.8	6 939.0	6 005.1	39 850.0	3 320.8	4 064.3	2 478.0	206.5	476.5	83 961.8	2 790.7	4 379.0
h.c.	Pagrus pagrus	1 035.5	172.6	228.4	130.0	10.8	37.5				1 165.5	38.9	119.1
h.c.	Parapenaeus longirostris				318.7	26.6	51.5	12 003.9	1 000.3	1 086.5	12 322.6	410.8	829.8
h.c.	Penaeus kerathurus	48.0	8.0	19.6							48.0	1.6	8.8
n.c.	Peristedion cataphractum							497.6	41.5	90.7	497.6	16.6	59.5
h.c.	Phycis blennoides				208.0	17.3	41.6	2 278.2	189.9	135.1	2 486.2	82.9	124.5
m.c.	Plesionika heterocarpus							132.8	11.1	27.3	132.8	4.4	17.7
n.c.	Pteroctopus tetracirrhus							1 135.4	94.6	151.4	1 135.4	37.8	104.5
n.c.	Pteromylaeus bovinus	2 063.0	343.8	842.2							2 063.0	68.8	376.7
m.c.	Rossia macrosoma							468.3	39.0	51.5	468.3	15.6	37.2
h.c.	Scaeurgus unicirrhus							543.4	45.3	60.7	543.4	18.1	43.7
	Scorpaena sp	155.8	26.0	63.6	8.0	0.7	2.3				163.8	5.5	28.4
m.c.	Scorpaena notata	335.5	55.9	86.1	913.8	76.1	140.5				1 249.3	41.6	100.1
h.c.	Scorpaena scrofa				252.0	21.0	72.7	20.3	1.7	5.9	272.3	9.1	46.0
h.c.	Sepia elegans				267.0	22.3	29.4	538.2	44.8	33.5	805.2	26.8	32.3
h.c.	Sepia officinalis	4 593.3	765.5	524.9	8 845.0	737.1	358.2	6 345.0	528.8	673.4	19 783.3	659.4	529.2
h.c.	Sepia orbignyana				33.0	2.8	9.5	1 645.7	137.1	194.6	1 678.7	56.0	137.6
h.c.	Sepiolinae	2.0	0.3	0.8	86.0	7.2	20.6	42.0	3.5	10.6	130.0	4.3	14.5
m.c.	Serranus cabrilla	2 219.3	369.9	623.0	13 630.8	1 135.9	1 209.9	444.0	37.0	51.5	16 294.0	543.1	908.5
n.c.	Serranus hepatus	4 623.3	770.5	827.9	23 496.3	1 958.0	1 744.8	8 670.4	722.5	809.5	36 789.9	1 226.3	1 375.1
h.c.	Solea vulgaris	752.5	125.4	307.2	400.0	33.3	115.5				1 152.5	38.4	153.4
m.c.	Solenocera membranacea							4.0	0.3	1.2	4.0	0.1	0.7
h.c.	Sparus aurata				692.0	57.7	199.8				692.0	23.1	126.3
m.c.	Sphyraena sphyraena	861.0	143.5	351.5	92.8	7.7	26.8				953.8	31.8	157.5
m.c.	Spicara flexuosa	21 129.5	3 521.6	2 929.5	21 545.3	1 795.4	2 010.8	4 589.7	382.5	835.4	47 264.5	1 575.5	2 161.1
m.c.	Spicara maena	453.0	75.5	184.9							453.0	15.1	82.7
m.c.	Spicara smaris	72.0	12.0	29.4	184.0	15.3	32.4				256.0	8.5	24.5
h.c.	Spondyliosoma cantharus	50.0	8.3	20.4							50.0	1.7	9.1
m.c.	Squilla mantis				117.0	9.8	22.9	123.1	10.3	28.3	240.1	8.0	22.8
n.c.	Symphodus roissali	11.0	1.8	4.5							11.0	0.4	2.0
n.c.	Synchiropus phaeton							200.4	16.7	40.7	200.4	6.7	26.4
n.c.	Synodus saurus	106.0	17.7	43.3							106.0	3.5	19.4
h.c.	Todarodes sagittatus							87.0	7.3	25.1	87.0	2.9	15.9
m.c.	Todaropsis eblanae							587.0	48.9	116.1	587.0	19.6	74.9
n.c.	Torpedo marmorata							54.0	4.5	15.6	54.0	1.8	9.9
n.c.	Torpedo torpedo	463.0	77.2	189.0	775.3	64.6	223.8				1 238.3	41.3	162.3
h.c.	Trachinus draco	243.5	40.6	85.6	195.0	16.3	56.3	273.0	22.8	58.2	711.5	23.7	61.9
m.c.	Trachurus trachurus	1 189.8	198.3	300.0	16 749.8	1 395.8	2 010.1	4 598.3	383.2	816.6	22 537.8	751.3	1 446.3
h.c.	Trigla lucerna	1 653.8	275.6	219.3	673.8	56.1	194.5	146.4	12.2	42.3	2 473.9	82.5	182.7
m.c.	Trigla lyra							673.4	56.1	145.9	673.4	22.4	94.1
m.c.	Trigloporus lastoviza	697.3	116.2	238.5	554.0	46.2	119.2				1 251.3	41.7	130.7
m.c.	Trisopterus minutus	661.8	110.3	239.7	16 994.0	1 416.2	1 447.0	3 265.5	272.1	612.7	20 921.3	697.4	1 143.0
m.c.	Uranoscopus scaber	1 124.3	187.4	236.1	2 661.3	221.8	341.4	1 365.8	113.8	277.7	5 151.3	171.7	292.3
m.c.	Zeus faber	3 475.5	579.3	762.1	7 855.0	654.6	976.8	9 942.5	828.5	987.4	21 273.0	709.1	917.9
	TOTAL SPECIES	367 647.3	61 274.5	39 613.7	453 049.5	37 754.1	32 653.1	348 080.7	29 006.7	33 328.3	1 168 777.4	38 959.2	35 226.9
	TOTAL h.c.	223 649.8	37 275.0	26 347.8	205 978.5	17 164.9	14 475.9	118 527.1	9 877.3	6 358.1	548 155.3	18 271.8	17 857.6
	TOTAL m.c.	122 146.0	20 357.7	14 494.7	167 439.5	13 953.3	13 692.9	181 165.5	15 097.1	27 687.2	470 751.0	15 691.7	20 100.1
	TOTAL n.c.	21 851.5	3 641.9	3 016.0	79 631.5	6 636.0	5 876.7	48 388.0	4 032.3	2 786.1	149 871.0	4 995.7	4 414.6

Appendix 3.II(d): Trawl hauls (survey XII, spring) catch (g) and CPUE (g/30min) [Key: Std.dev. (sd) high, mod. & non commercial species; A, B, C sampling strata.]

		A			B			C			Total area		
		catch	**cpue**	sd	catch	**cpue**	sd	catch	**cpue**	sd	catch	**cpue**	sd
h.c.	Alloteuthis media	787.1	**112.4**	77.6	1 634.0	**148.5**	90.1	494.0	**41.2**	35.7	2 915.1	**97.2**	84.1
n.c.	Argentina sphyraena	42.5	**6.1**	16.1				5 345.0	**445.4**	1 216.7	5 387.5	**179.6**	780.7
n.c.	Arnoglossus imperialis				14.0	**1.3**	4.2				14.0	**0.5**	2.6
n.c.	Arnoglossus laterna	4 245.3	**606.5**	605.6	3 599.0	**327.2**	299.9	636.0	**53.0**	79.6	8 480.3	**282.7**	386.6
n.c.	Arnoglossus rueppelli							70.0	**5.8**	17.8	70.0	**2.3**	11.3
n.c.	Arnoglossus thori	5.8	**0.8**	2.2	30.0	**2.7**	9.0				35.8	**1.2**	5.5
m.c.	Aspitrigla cuculus	65.0	**9.3**	22.4	485.0	**44.1**	122.3	4 063.0	**338.6**	561.6	4 613.0	**153.8**	385.5
m.c.	Aspitrigla obscura	913.5	**130.5**	233.0	381.0	**34.6**	66.6				1 294.5	**43.1**	124.1
n.c.	Blennius ocellaris	47.5	**6.8**	8.6	42.0	**3.8**	8.8	29.0	**2.4**	6.3	118.5	**4.0**	7.7
m.c.	Boops boops	615.7	**88.0**	107.6	5 075.0	**461.4**	610.8				5 690.7	**189.7**	420.1
n.c.	Bothus podas	5 259.8	**751.4**	1 664.0							5 259.8	**175.3**	777.3
n.c.	Callionymus maculatus	2.3	**0.3**	0.9	21.0	**1.9**	3.2	165.0	**13.8**	17.4	188.3	**6.3**	12.6
n.c.	Capros aper							1 000.0	**83.3**	200.7	1 000.0	**33.3**	130.4
n.c.	Carapus acus							106.0	**8.8**	16.2	106.0	**3.5**	10.9
m.c.	Centracanthus cirrus				41.0	**3.7**	12.4				41.0	**1.4**	7.5
n.c.	Cepola rubescens	299.9	**42.8**	67.0	721.0	**65.5**	84.2	1 292.0	**107.7**	114.7	2 312.9	**77.1**	95.3
m.c.	Chlorophthalmus agassizi							726.0	**60.5**	208.0	726.0	**24.2**	131.6
m.c.	Citharus linguatula	106.3	**15.2**	40.2	4 540.0	**412.7**	511.3	2 076.0	**173.0**	392.2	6 722.3	**224.1**	417.1
n.c.	Coelorhynchus coelorhynchus							1.0	**0.1**	0.3	1.0	**0.0**	0.2
m.c.	Conger conger	337.0	**48.1**	82.2	3 848.0	**349.8**	626.1	1 961.0	**163.4**	183.0	6 146.0	**204.9**	404.8
n.c.	Dactylopterus volitans	36.9	**5.3**	14.0							36.9	**1.2**	6.7
n.c.	Deltentosteus quadrimaculatus				13.0	**1.2**	2.0	25.0	**2.1**	4.6	38.0	**1.3**	3.2
m.c.	Diplodus annularis	50 989.4	**7 284.2**	11 448.0	12 489.0	**1 135.4**	1 610.3	233.0	**19.4**	40.4	63 711.4	**2 123.7**	6 053.2
h.c.	Diplodus sargus	242.5	**34.6**	91.7							242.5	**8.1**	44.3
h.c.	Diplodus vulgaris	201.9	**28.8**	76.3							201.9	**6.7**	36.9
n.c.	Echelus myrus				375.0	**34.1**	77.1				375.0	**12.5**	48.3
h.c.	Eledone cirrhosa				3 048.0	**277.1**	627.1	17 378.0	**1 448.2**	1 345.0	20 426.0	**680.9**	1 113.2
h.c.	Eledone moschata	1 077.5	**153.9**	407.3	3 839.0	**349.0**	357.8	5 046.0	**420.5**	670.7	9 962.5	**332.1**	461.5
h.c.	Epinephelus aeneus	12 125.0	**1 732.1**	4 582.8							12 125.0	**404.2**	2 213.7
n.c.	Gadiculus argenteus							251.0	**20.9**	40.3	251.0	**8.4**	25.9
n.c.	Gobiidae	1 162.3	**166.0**	167.6	598.0	**54.4**	50.8	93.0	**7.8**	11.6	1 853.3	**61.8**	103.0
h.c.	Helicolenus dactylopterus							3 928.0	**327.3**	620.7	3 928.0	**130.9**	415.6
h.c.	Illex coindetii							69.0	**5.8**	10.7	69.0	**2.3**	7.2
m.c.	Lepidopus caudatus				6.0	**0.5**	1.8	3 381.0	**281.8**	936.3	3 387.0	**112.9**	692.9
m.c.	Lepidorhombus boscii							2 614.0	**217.8**	163.3	2 614.0	**87.1**	148.0
m.c.	Lepidorhombus whiffiagonis							368.0	**30.7**	56.7	368.0	**12.3**	38.1
n.c.	Lepidotrigla cavillone	11 974.7	**1 710.7**	2 056.6	32 348.0	**2 940.7**	2 639.0	11 891.0	**990.9**	1 022.3	56 213.7	**1 873.8**	2 105.7
n.c.	Lepidotrigla dieuzeidei				193.0	**17.5**	58.2	856.0	**71.3**	145.7	1 049.0	**35.0**	100.9
h.c.	Lithognathus mormyrus	2 706.1	**386.6**	634.0							2 706.1	**90.2**	332.9
h.c.	Loligo vulgaris	633.8	**90.5**	121.3	123.0	**11.2**	24.9				756.8	**25.2**	68.0
m.c.	Lophius budegassa	111.3	**15.9**	25.4	14 279.0	**1 298.1**	1 323.0	27 837.0	**2 319.8**	3 389.3	42 227.3	**1 407.6**	2 403.6
m.c.	Lophius piscatorius	63.0	**9.1**	24.1				1 297.0	**108.1**	374.4	1 360.0	**45.4**	236.7
n.c.	Macroramphosus scolopax	96.5	**13.8**	35.4	1 016.0	**92.4**	303.7	1 868.0	**155.7**	187.9	2 980.5	**99.4**	220.3
h.c.	Merluccius merluccius	5 315.0	**759.3**	582.2	23 493.0	**2 135.7**	1 117.1	27 499.0	**2 291.6**	2 036.6	56 307.0	**1 876.9**	1 572.2
n.c.	Microchirus ocellatus				130.0	**11.8**	39.2				130.0	**4.3**	23.7
n.c.	Microchirus variegatus	25.0	**3.6**	9.4	95.0	**8.6**	28.6	149.0	**12.4**	26.4	269.0	**9.0**	24.1
h.c.	Mullus barbatus	203 579.7	**29 082.8**	36 068.4	60 468.0	**5 497.1**	4 856.7	15 839.0	**1 319.9**	1 247.6	279 886.7	**9 329.6**	20 104.3
h.c.	Mullus surmuletus	342.1	**48.9**	72.6	313.0	**28.5**	39.9	196.0	**16.3**	43.1	851.1	**28.4**	50.0
m.c.	Muraena helena							348.0	**29.0**	100.5	348.0	**11.6**	63.6
h.c.	Octopus vulgaris	1 941.7	**277.4**	437.7	7 879.0	**716.3**	987.6	4 307.0	**358.9**	509.2	14 127.7	**470.9**	715.1
n.c.	Ophidion barbatum							34.0	**2.8**	9.8	34.0	**1.1**	6.2
m.c.	Pagellus acarne	20 869.7	**2 981.4**	5 601.8	3 770.0	**342.7**	492.2	148.0	**12.3**	29.3	24 787.7	**826.3**	2 839.0
m.c.	Pagellus bogaraveo				3 411.0	**310.1**	806.1	139.0	**11.6**	28.4	3 550.0	**118.3**	496.4
h.c.	Pagellus erythrinus	50 679.4	**7 239.9**	10 647.0	25 021.0	**2 274.6**	2 474.2	1 011.0	**84.3**	239.8	76 711.4	**2 557.0**	5 782.7
h.c.	Pagrus auriga	23.1	**3.3**	8.7							23.1	**0.8**	4.2
h.c.	Pagrus pagrus	1 223.5	**174.8**	460.2	197.0	**17.9**	59.4				1 420.5	**47.3**	224.1
h.c.	Parapenaeus longirostris				680.9	**61.9**	131.3	5 975.0	**497.9**	343.3	6 655.9	**221.9**	322.1
n.c.	Peristedion cataphractum							1 256.0	**104.7**	189.5	1 256.0	**41.9**	127.8
h.c.	Phycis blennoides				29.0	**2.6**	5.5	1 980.0	**165.0**	132.4	2 009.0	**67.0**	115.3
m.c.	Plesionika heterocarpus							186.0	**15.5**	53.7	186.0	**6.2**	34.0
n.c.	Pteroctopus tetracirrhus							2 125.0	**177.1**	323.9	2 125.0	**70.8**	218.1
m.c.	Raja radula	73.8	**10.5**	27.9	361.0	**32.8**	108.8				434.8	**14.5**	66.8
m.c.	Rossia macrosoma							204.0	**17.0**	25.8	204.0	**6.8**	19.0
h.c.	Scaeurgus unicirrhus	17.0	**2.4**	6.4				278.0	**23.2**	38.0	295.0	**9.8**	26.1
	Scorpaena sp				23.0	**2.1**	6.9	77.0	**6.4**	22.2	100.0	**3.3**	14.5
m.c.	Scorpaena notata	1 299.8	**185.7**	269.9	831.0	**75.5**	92.4				2 130.8	**71.0**	152.6
h.c.	Scorpaena porcus				392.0	**35.6**	118.2				392.0	**13.1**	71.6
h.c.	Scorpaena scrofa							636.0	**53.0**	183.6	636.0	**21.2**	116.1
h.c.	Sepia elegans	7.0	**1.0**	2.6	579.0	**52.6**	64.5	695.0	**57.9**	44.4	1 281.0	**42.7**	52.3
h.c.	Sepia officinalis	647.5	**92.5**	161.6							647.5	**21.6**	83.6
h.c.	Sepia orbignyana							2 235.0	**186.3**	276.7	2 235.0	**74.5**	194.0
h.c.	Sepiolinae				76.0	**6.9**	9.6	311.0	**25.9**	26.3	387.0	**12.9**	19.9
m.c.	Serranus cabrilla	4 506.6	**643.8**	703.9	9 266.0	**842.4**	1 003.2	646.0	**53.8**	108.0	14 418.6	**480.6**	765.1
n.c.	Serranus hepatus	6 601.0	**943.0**	895.3	20 180.0	**1 834.5**	1 600.6	9 332.0	**777.7**	914.2	36 113.0	**1 203.8**	1 268.4
m.c.	Solenocera membranacea							6.0	**0.5**	1.7	6.0	**0.2**	1.1
h.c.	Sparus aurata	486.7	**69.5**	118.8							486.7	**16.2**	61.8
m.c.	Spicara flexuosa	4 908.8	**701.3**	795.2	20 589.0	**1 871.7**	2 785.9	727.0	**60.6**	97.3	26 224.8	**874.2**	1 862.6
m.c.	Spicara smaris	94.0	**13.4**	35.5	3 348.0	**304.4**	493.8	34.0	**2.8**	9.8	3 476.0	**115.9**	325.1
m.c.	Squilla mantis	37.0	**5.3**	9.0	310.0	**28.2**	45.3	186.0	**15.5**	34.5	533.0	**17.8**	35.9
	Symphodus sp	9.2	**1.3**	3.5							9.2	**0.3**	1.7
n.c.	Synchiropus phaeton							740.0	**61.7**	143.2	740.0	**24.7**	93.4
n.c.	Synodus saurus	740.9	**105.8**	133.1							740.9	**24.7**	75.8
m.c.	Todaropsis eblanae	91.3	**13.0**	34.5				422.0	**35.2**	74.6	513.3	**17.1**	51.1
n.c.	Torpedo marmorata							106.0	**8.8**	30.6	106.0	**3.5**	19.4
n.c.	Torpedo torpedo							85.0	**7.1**	24.5	85.0	**2.8**	15.6
h.c.	Trachinus draco	112.0	**16.0**	27.7	1 160.0	**105.5**	182.6	408.0	**34.0**	56.3	1 680.0	**56.0**	119.9
m.c.	Trachurus trachurus	756.3	**108.0**	189.0	2 104.0	**191.3**	315.8	25.0	**2.1**	3.9	2 885.3	**96.2**	216.2
h.c.	Trigla lucerna	2 960.8	**423.0**	240.9	1 191.0	**108.3**	139.6	245.0	**20.4**	70.7	4 396.8	**146.6**	215.0
m.c.	Trigla lyra							236.0	**19.7**	40.5	236.0	**7.9**	25.8
m.c.	Trigloporus lastoviza	1 068.3	**152.6**	387.7	610.0	**55.5**	138.2				1 678.3	**55.9**	203.1
m.c.	Trisopterus minutus				6 453.0	**586.6**	928.8	807.0	**67.3**	189.6	7 260.0	**242.0**	618.8
m.c.	Uranoscopus scaber	294.0	**42.0**	74.8	9 949.0	**904.5**	926.0	2 408.0	**200.7**	330.0	12 651.0	**421.7**	693.9
m.c.	Xyrichthys novacula	155.8	**22.3**	58.9							155.8	**5.2**	28.4
m.c.	Zeus faber	1 109.3	**158.5**	179.3	3 077.0	**279.7**	458.5	4 477.0	**373.1**	461.0	8 663.3	**288.8**	408.5
	TOTAL SPECIES	404 125.2	**57 732.2**	62 660.3	294 879.9	**26 807.3**	19 232.0	181 762.0	**15 146.8**	7 750.6	880 767.1	**29 358.9**	35 256.7
	TOTAL h.c.	285 109.4	**40 729.9**	47 173.0	130 145.9	**11 831.4**	7 836.5	88 607.0	**7 383.9**	3 949.9	503 862.3	**16 795.4**	26 918.5
	TOTAL m.c.	88 466.1	**12 638.0**	17 254.4	105 223.0	**9 565.7**	8 502.3	55 555.0	**4 629.6**	4 113.7	249 244.1	**8 308.1**	10 181.7
	TOTAL n.c.	30 549.7	**4 364.2**	3 055.5	59 375.0	**5 397.7**	3 825.5	37 521.0	**3 126.8**	1 993.5	127 445.7	**4 248.2**	3 083.9

Appendix 3.II(e): Trawl surveys IX-XII (year) catch (g) and CPUE (g/30min)
[Key: Std.dev. (sd) high, mod. & non commercial species; A, B, C sampling strata.]

		A			B			C			Total Area		
		catch	cpue	sd	catch	cpue	sd	catch	cpue	sd	catch	cpue	sd
h.c.	Alloteuthis media	1 604.9	64.2	134.5	5 170.9	114.9	202.4	3 376.5	76.7	154.9	10 152.2	89.1	180.2
n.c.	Anthias anthias							19.0	0.4	4.8	19.0	0.2	3.0
n.c.	Argentina sphyraena	42.5	1.7	15.0	7.0	0.2	1.8	31 772.8	722.1	3 936.4	31 822.3	279.1	2 663.4
n.c.	Arnoglossus imperialis				19.0	0.4	4.9				19.0	0.2	3.0
n.c.	Arnoglossus kessleri							5.0	0.1	1.3	5.0	0.0	0.8
n.c.	Arnoglossus laterna	9 490.2	379.6	1 125.4	17 402.4	386.7	627.1	3 859.8	87.7	369.6	30 752.4	269.8	803.8
n.c.	Arnoglossus rueppelli	28.0	1.1	6.7	6.0	0.1	1.1	567.3	12.9	68.3	601.3	5.3	46.3
n.c.	Arnoglossus sp.							1.0	0.0	0.3	1.0	0.0	0.2
n.c.	Arnoglossus thori	5.8	0.2	2.0	63.0	1.4	16.3				68.8	0.6	10.1
m.c.	Aspitrigla cuculus	172.0	6.9	40.3	1 580.7	35.1	234.1	25 351.0	576.2	2 675.4	27 103.7	237.8	1 847.1
m.c.	Aspitrigla obscura	1 123.5	44.9	246.4	469.5	10.4	60.1				1 593.0	14.0	123.9
h.c.	Balistes carolinensis	1 207.0	48.3	426.7							1 207.0	10.6	193.3
n.c.	Blennius ocellaris	239.3	9.6	40.7	696.1	15.5	44.7	277.5	6.3	17.1	1 212.9	10.6	36.5
m.c.	Boops boops	19 021.7	760.9	2 725.4	24 064.9	534.8	1 639.4	1 386.5	31.5	176.2	44 473.1	390.1	1 801.5
n.c.	Bothus podas	18 174.7	727.0	3 657.1							18 174.7	159.4	1 824.1
m.c.	Buglossidium luteum	45.0	1.8	7.0							45.0	0.4	3.8
n.c.	Callanthias ruber							16.0	0.4	4.0	16.0	0.1	2.6
n.c.	Callionymus maculatus	5.3	0.2	1.2	213.5	4.7	15.7	657.0	14.9	60.6	875.8	7.7	42.6
n.c.	Capros aper	1.0	0.0	0.4				4 268.9	97.0	440.6	4 269.9	37.5	307.1
m.c.	Caranx crysos	171.0	6.8	60.5							171.0	1.5	27.4
n.c.	Carapus acus	1.3	0.1	0.4	4.0	0.1	1.0	150.4	3.4	14.1	155.7	1.4	10.0
m.c.	Centracanthus cirrus				41.0	0.9	10.6				41.0	0.4	6.6
n.c.	Cepola rubescens	416.2	16.6	66.7	2 019.0	44.9	160.5	4 166.8	94.7	297.3	6 602.0	57.9	228.2
m.c.	Chlorophthalmus agassizi							5 901.2	134.1	1 011.3	5 901.2	51.8	661.4
m.c.	Citharus linguatula	442.5	17.7	136.2	24 248.3	538.9	2 124.9	4 282.6	97.3	639.8	28 973.4	254.2	1 524.6
n.c.	Coelorhynchus coelorhynchus							473.0	10.8	93.1	473.0	4.1	60.3
m.c.	Conger conger	3 047.0	121.9	558.7	10 304.1	229.0	719.0	6 445.0	146.5	533.1	19 796.0	173.6	617.1
n.c.	Dactylopterus volitans	1 051.7	42.1	248.3							1 051.7	9.2	119.4
n.c.	Deltentosteus quadrimaculatus	10.0	0.4	2.8	56.5	1.3	5.0	185.8	4.2	16.2	252.3	2.2	11.6
h.c.	Dentex dentex	805.0	32.2	138.9	124.0	2.8	32.0				929.0	8.1	74.2
h.c.	Dicentrarchus labrax	5 892.0	235.7	1 162.5							5 892.0	51.7	582.8
m.c.	Diplodus annularis	95 162.4	3 806.5	13 040.9	42 446.1	943.2	3 747.2	233.0	5.3	35.7	137 841.5	1 209.1	7 525.3
h.c.	Diplodus sargus	242.5	9.7	85.7							242.5	2.1	38.8
h.c.	Diplodus vulgaris	699.4	28.0	102.0	905.0	20.1	210.3				1 604.4	14.1	139.7
n.c.	Echelus myrus				3 233.0	71.8	507.5	3 989.0	90.7	313.5	7 222.0	63.4	378.2
h.c.	Eledone cirrhosa				9 094.0	202.1	849.2	28 996.7	659.0	2 015.1	38 090.7	334.1	1 554.8
h.c.	Eledone moschata	1 767.3	70.7	365.4	9 916.0	220.4	530.1	7 212.0	163.9	602.5	18 895.3	165.7	546.7
m.c.	Engraulis encrasicholus				31.4	0.7	4.7				31.4	0.3	3.0
h.c.	Epinephelus aeneus	19 487.0	779.5	4 686.6	26 480.0	588.4	5 106.9				45 967.0	403.2	3 835.1
n.c.	Etmopterus spinax							63.0	1.4	15.8	63.0	0.6	10.1
n.c.	Gadiculus argenteus							4 234.3	96.2	640.2	4 234.3	37.1	423.3
n.c.	Galeus melastomus				5.0	0.1	1.3				5.0	0.0	0.8
n.c.	Gnathophis mystax				192.0	4.3	49.6	656.0	14.9	116.6	848.0	7.4	81.0
n.c.	Gobiidae	3 215.8	128.6	491.7	3 869.9	86.0	261.5	147.1	3.3	17.7	7 232.8	63.4	308.0
h.c.	Helicolenus dactylopterus				6.0	0.1	1.5	7 250.2	164.8	1 061.9	7 256.2	63.7	704.3
h.c.	Illex coindetii	26.3	1.1	9.3	919.0	20.4	95.3	6 428.0	146.1	452.4	7 373.3	64.7	342.0
m.c.	Lepidopus caudatus				124.0	2.8	19.0	106 566.7	2 422.0	20 897.6	106 690.7	935.9	13 541.9
m.c.	Lepidorhombus bosci				332.0	7.4	86.7	7 213.1	163.9	559.6	7 545.1	66.2	416.8
m.c.	Lepidorhombus whiffiagonis							2 504.0	56.9	420.4	2 504.0	22.0	276.4
n.c.	Lepidotrigla cavillone	27 262.2	1 090.5	4 505.7	187 660.0	4 170.2	11 907.8	82 374.3	1 872.1	5 301.8	297 296.5	2 607.9	9 100.8
n.c.	Lepidotrigla dieuzeidei				193.0	4.3	49.8	7 348.9	167.0	1 127.1	7 541.9	66.2	743.5
h.c.	Lithognathus mormyrus	37 427.1	1 497.1	4 825.9							37 427.1	328.3	2 820.1
h.c.	Loligo vulgaris	6 385.8	255.4	791.3	9 322.2	207.2	730.1	344.0	7.8	86.0	16 052.0	140.8	653.9
m.c.	Lophius budegassa	2 646.8	105.9	407.3	46 018.6	1 022.6	1 627.7	93 229.1	2 118.8	5 541.8	141 894.5	1 244.7	4 192.6
m.c.	Lophius piscatorius	1 070.8	42.8	353.5	1 776.3	39.5	315.8	3 386.0	77.0	427.3	6 233.1	54.7	365.8
n.c.	Macroramphosus scolopax	96.5	3.9	33.1	1 203.0	26.7	257.5	11 806.1	268.3	1 090.1	13 105.6	115.0	780.8
h.c.	Merluccius merluccius	33 984.0	1 359.4	4 171.9	156 343.4	3 474.3	5 828.2	221 420.1	5 032.3	10 496.4	411 747.6	3 611.8	8 492.6
n.c.	Microchirus ocellatus				160.0	3.6	41.3				160.0	1.4	25.6
n.c.	Microchirus variegatus	25.0	1.0	8.8	105.0	2.3	27.1	149.0	3.4	23.3	279.0	2.4	22.5
h.c.	Mullus barbatus	566 371.8	22 654.9	69 474.4	300 046.9	6 667.7	18 408.0	83 704.6	1 902.4	4 873.6	950 123.3	8 334.4	40 482.9
h.c.	Mullus surmuletus	2 063.4	82.5	285.0	1 511.0	33.6	132.3	4 095.6	93.1	709.3	7 670.1	67.3	475.3
m.c.	Muraena helena							348.0	7.9	87.0	348.0	3.1	55.7
h.c.	Octopodidae	10.6	0.4	2.1	2.0	0.0	0.5				12.6	0.1	1.1
m.c.	Octopus macropus	503.0	20.1	177.8	646.0	14.4	113.7				1 149.0	10.1	106.1
h.c.	Octopus vulgaris	13 063.4	522.5	2 096.9	36 330.1	807.3	1 800.4	28 090.1	638.4	1 904.6	77 483.5	679.7	1 886.7
n.c.	Ophidion barbatum							34.0	0.8	8.5	34.0	0.3	5.4
m.c.	Pagellus acarne	88 223.3	3 528.9	10 456.2	52 618.9	1 169.3	5 594.9	3 871.3	88.0	428.0	144 713.5	1 269.4	6 935.1
m.c.	Pagellus bogaraveo	1 250.2	50.0	271.7	86 143.1	1 914.3	6 700.3	70 867.8	1 610.6	10 470.0	158 261.0	1 388.3	8 013.0
h.c.	Pagellus erythrinus	143 933.8	5 757.4	17 295.0	112 768.2	2 506.0	8 380.7	5 552.0	126.2	888.1	262 254.0	2 300.5	11 197.7
h.c.	Pagrus auriga	23.1	0.9	8.2							23.1	0.2	3.7
h.c.	Pagrus pagrus	3 933.6	157.3	734.2	327.0	7.3	58.9				4 260.6	37.4	373.4
h.c.	Parapenaeus longirostris	4.1	0.2	1.4	8 298.1	184.4	1 025.9	44 874.3	1 019.9	2 301.2	53 176.5	466.5	2 000.7
h.c.	Penaeus kerathurus	48.0	1.9	17.0							48.0	0.4	7.7
n.c.	Peristedion cataphractum				53.0	1.2	13.7	2 470.3	56.1	294.1	2 523.3	22.1	199.9
h.c.	Phycis blennoides				818.7	18.2	127.7	8 804.6	200.1	369.5	9 623.3	84.4	355.1
h.c.	Phycis phycis				100.0	2.2	26.8	184.0	4.2	34.2	284.0	2.5	26.9
m.c.	Plesionika heterocarpus							555.8	12.6	104.6	555.8	4.9	68.0
m.c.	Psetta maxima				2 910.0	64.7	751.4				2 910.0	25.5	466.0
n.c.	Pteroctopus tetracirrhus							3 260.4	74.1	388.5	3 260.4	28.6	264.4
n.c.	Pteromylaeus bovinus	2 063.0	82.5	729.4							2 063.0	18.1	330.3
m.c.	Raja radula	581.3	23.3	177.6	361.0	8.0	93.2				942.3	8.3	98.7
m.c.	Rossia macrosoma							1 400.5	31.8	146.4	1 400.5	12.3	101.8
m.c.	Rossinae							67.0	1.5	16.8	67.0	0.6	10.7
m.c.	Sardina pilchardus				49.0	1.1	8.7	110.0	2.5	22.3	159.0	1.4	15.2
m.c.	Sardinella aurita				45.0	1.0	11.6				45.0	0.4	7.2
h.c.	Scaeurgus unicirrhus	17.0	0.7	6.0	829.0	18.4	193.3	3 542.4	80.5	323.7	4 388.4	38.5	253.0
h.c.	Scophthalmus rhombus	89.0	3.6	31.5							89.0	0.8	14.3
	Scorpaena sp.	155.8	6.2	55.1	8.0	0.2	2.1				163.8	1.4	24.9
h.c.	Scorpaena elongata				13.0	0.3	2.3	3.0	0.1	0.8	16.0	0.1	1.5
m.c.	Scorpaena notata	3 399.9	136.0	731.8	3 465.9	77.0	367.9	5.0	0.1	1.3	6 870.8	60.3	419.2
h.c.	Scorpaena porcus	50.7	2.0	13.2	392.0	8.7	101.2				442.7	3.9	62.9
h.c.	Scorpaena scrofa	29.0	1.2	10.3	1 709.1	38.0	201.5	4 252.5	96.6	695.7	5 990.6	52.5	466.5
m.c.	Scorpaenidae	11.0	0.4	3.9	42.0	0.9	7.4				53.0	0.5	5.0

h.c.	Sepia elegans	18.5	**0.7**	3.8	4 085.4	**90.8**	241.7	4 680.9	**106.4**	266.1	8 784.8	**77.1**	250.4
h.c.	Sepia officinalis	9 725.6	**389.0**	672.0	20 439.5	**454.2**	913.6	6 679.0	**151.8**	614.6	36 844.1	**323.2**	860.9
h.c.	Sepia orbignyana				476.0	**10.6**	62.8	7 149.7	**162.5**	518.4	7 625.7	**66.9**	390.8
h.c.	Sepiolinae	7.0	**0.3**	1.8	247.0	**5.5**	23.2	565.6	**12.9**	29.6	819.6	**7.2**	26.9
m.c.	Serranus cabrilla	11 948.8	**478.0**	2 217.7	44 990.1	**999.8**	3 065.2	2 215.7	**50.4**	193.0	59 154.5	**518.9**	2 459.6
n.c.	Serranus hepatus	19 781.9	**791.3**	2 737.0	91 043.6	**2 023.2**	5 417.4	32 787.1	**745.2**	2 337.3	143 612.6	**1 259.8**	4 246.1
	Solea sp.				2.0	**0.0**	0.5				2.0	**0.0**	0.3
m.c.	Solea lascaris	78.0	**3.1**	27.6							78.0	**0.7**	12.5
h.c.	Solea vulgaris	3 405.0	**136.2**	391.1	2 058.0	**45.7**	381.6				5 463.0	**47.9**	327.5
m.c.	Solenocera membranacea				2.0	**0.0**	0.4	21.7	**0.5**	2.9	23.7	**0.2**	1.9
h.c.	Sparus aurata	486.7	**19.5**	112.7	3 965.0	**88.1**	1 023.8				4 451.7	**39.0**	636.2
m.c.	Sphyraena sphyraena	1 582.0	**63.3**	559.3	1 619.8	**36.0**	306.2				3 201.8	**28.1**	313.2
m.c.	Spicara flexuosa	47 674.9	**1 907.0**	5 617.2	91 607.6	**2 035.7**	7 913.9	16 704.1	**379.6**	1 345.8	155 986.6	**1 368.3**	5 986.8
m.c.	Spicara maena	453.0	**18.1**	160.2							453.0	**4.0**	72.5
m.c.	Spicara smaris	166.0	**6.6**	38.9	3 557.0	**79.0**	439.7	34.0	**0.8**	8.5	3 757.0	**33.0**	290.3
h.c.	Spondyliosoma cantharus	283.0	**11.3**	66.1							283.0	**2.5**	31.8
m.c.	Squilla mantis	61.0	**2.4**	10.7	3 070.3	**68.2**	679.1	707.9	**16.1**	96.6	3 839.2	**33.7**	425.5
n.c.	Symphodus cinereus	23.8	**1.0**	8.4							23.8	**0.2**	3.8
	Symphodus sp	9.2	**0.4**	3.3							9.2	**0.1**	1.5
n.c.	Symphodus roissali	11.0	**0.4**	3.9							11.0	**0.1**	1.8
n.c.	Symphurus nigrescens				6.0	**0.1**	0.8	1.0	**0.0**	0.3	7.0	**0.1**	0.6
n.c.	Synchiropus phaeton							1 531.1	**34.8**	187.0	1 531.1	**13.4**	126.8
n.c.	Synodus saurus	2 457.6	**98.3**	453.4							2 457.6	**21.6**	231.7
h.c.	Todarodes sagittatus							87.0	**2.0**	21.8	87.0	**0.8**	13.9
m.c.	Todaropsis eblanae	91.3	**3.7**	32.3				2 942.0	**66.9**	421.5	3 033.3	**26.6**	280.0
n.c.	Torpedo marmorata				455.4	**10.1**	117.6	238.0	**5.4**	33.4	693.4	**6.1**	75.3
n.c.	Torpedo torpedo	463.0	**18.5**	163.7	775.3	**17.2**	200.2	85.0	**1.9**	21.3	1 323.3	**11.6**	143.1
h.c.	Trachinus draco	355.5	**14.2**	72.8	2 763.5	**61.4**	270.6	1 438.7	**32.7**	111.2	4 557.7	**40.0**	189.8
m.c.	Trachurus trachurus	5 266.0	**210.6**	888.3	49 582.9	**1 101.8**	3 946.7	9 908.1	**225.2**	927.6	64 756.9	**568.0**	2 821.3
h.c.	Trigla lucerna	9 547.9	**381.9**	1 027.9	3 394.9	**75.4**	392.9	2 292.0	**52.1**	345.8	15 234.8	**133.6**	686.2
m.c.	Trigla lyra							1 983.1	**45.1**	218.6	1 983.1	**17.4**	150.6
m.c.	Trigloporus lastoviza	2 316.1	**92.6**	420.2	1 436.0	**31.9**	256.8				3 752.1	**32.9**	261.9
m.c.	Trisopterus minutus	719.8	**28.8**	229.3	50 477.3	**1 121.7**	3 623.2	11 910.6	**270.7**	1 422.3	63 107.7	**553.6**	2 768.1
m.c.	Uranoscopus scaber	2 515.3	**100.6**	510.9	25 086.2	**557.5**	1 471.1	6 641.4	**150.9**	564.0	34 242.9	**300.4**	1 173.5
m.c.	Xyrichthys novacula	375.5	**15.0**	112.9							375.5	**3.3**	52.1
m.c.	Zeus faber	5 816.3	**232.7**	717.6	35 434.5	**787.4**	1 966.7	35 960.9	**817.3**	2 461.8	77 211.7	**677.3**	2 081.0
	TOTAL SPECIES	1 243 960.4	**49 758.4**	42 966.8	1 632 887.0	**36 286.4**	25 646.7	1 101 371.4	**25 031.2**	21 414.9	3 978 218.9	**34 896.7**	30 170.0
	TOTAL h.c.	863 150.6	**34 526.0**	31 749.9	718 885.9	**15 975.2**	11 345.6	481 100.5	**10 934.1**	7 522.8	2 063 137.0	**18 097.7**	19 163.6
	TOTAL m.c.	296 934.9	**11 837.4**	12 964.4	604 581.5	**13 435.1**	12 262.9	422 752.9	**9 608.0**	15 545.4	1 323 269.4	**11 607.6**	13 751.7
	TOTAL n.c.	84 874.9	**3 395.0**	2 491.0	309 440.6	**6 876.5**	5 175.0	197 661.0	**4 492.3**	3 390.8	591 976.5	**5 192.0**	4 259.7

4. A Bioeconomic Model of the Gulf of Castellammare

One of the key components of modelling MPAs is spatiality. Generally, the spatial nature of the models reported in the literature has been restricted in most cases to inside and outside the MPA, primarily modelling a 'no-take' zone inside. Holland (2000) is one of the only examples where multiple areas are considered as well as the dynamics of the fleet, to evaluate potential MPA for 3 principal species on Georges Bank. One of the aims of this bioeconomic model is also to include a detailed spatial component.

This study develops a bioeconomic model for the Gulf of Castellammare to investigate its overall effects. Potential changes in policy to the ban are also considered, where for example a region(s) of the Gulf is relaxed to vessels using trawling gear for part of the year. The next sections develop the bioeconomic model that is used for the analysis and then presents the results and offers a brief discussion.

4.1. The Overall Structure of the Bioeconomic Model

Although biomass has increased significantly, the abundance of high value and many medium value species has fallen from pre-ban times. It is reported that catches are now dominated by medium and low value species. There is increasing pressure from the trawl vessel owners to re-allow access to the Gulf. Illegal trawling in the eastern most parts of the Gulf is impacting negatively upon the artisanal vessels operating from those ports.

Biological data has been collected on a regular basis since the implementation of the trawl ban via seasonal Trawl surveys, and monthly trammel net surveys. Biological data is readily available for 5 main commercially valuable species (see presentation by Pipitone et al. 2002).

One of the biggest single problems faced when examining the potential effects of MPAs is that of determining the migration rate of fish into or out of the reserve area. Due to the geographical characteristics of the Gulf we are able to assume that migration out of the reserve is likely to be minimal as the Gulf is bounded on both sides by very deep water. Migration within the Gulf does, however, have huge implications for the four fishing ports. Here, seasonal density of fish in any particular area of the Gulf has been used as a proxy for migration of the fish throughout the year.

In the model, the fleets incorporated are defined into two groups: the artisanal vessels principally using trammel nets and the external trawlers. The artisanal fleet is indexed by regions fished within the trawl ban area. Five of the key commercial target species are included: annular seabream, axillary seabream, red mullet, pandora and picarel. Effort is applied to an area rather than individual species. The remaining commercial species are included in the model as a category "other". Catches of each species are estimated based on the level of fishing activity in a given area in a given season and the relative density of each stock in that area in a specific season. An overview of the characteristics of the model are given in table 4.1. The stocks modelled are considered to be bounded by the trawl ban area, except on the Eastern edge where some 'spill over' exists. This is a reasonable assumption due to the topography of the Gulf (see figure 4.1).

Figure 4.1: Sectors in the trawl ban area by strata and region.

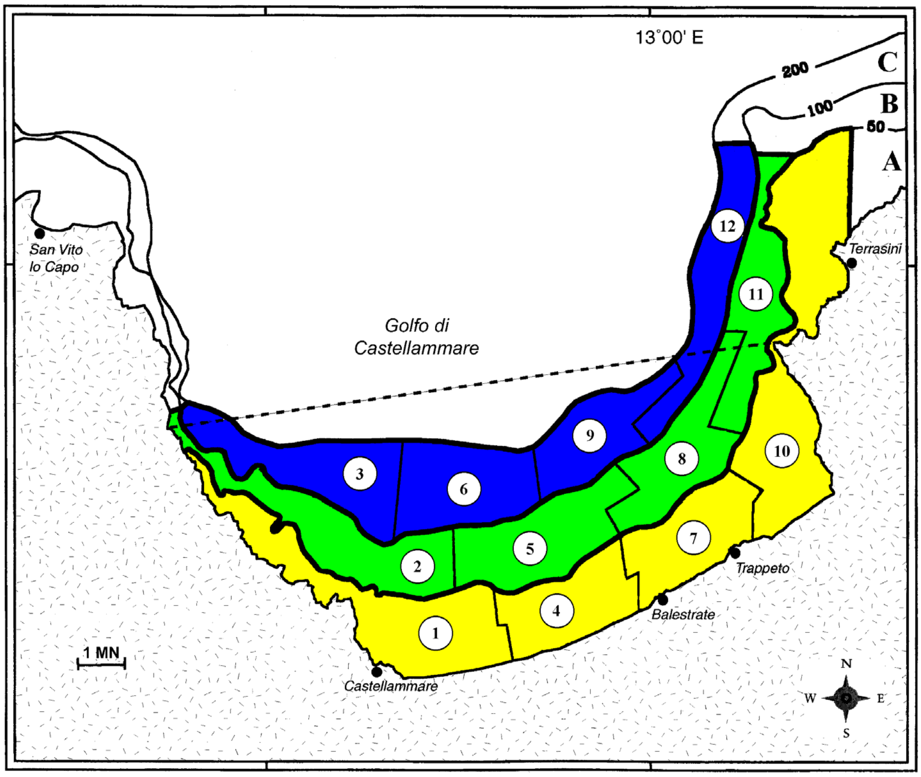


Table 4.1: Bioeconomic model characteristics.

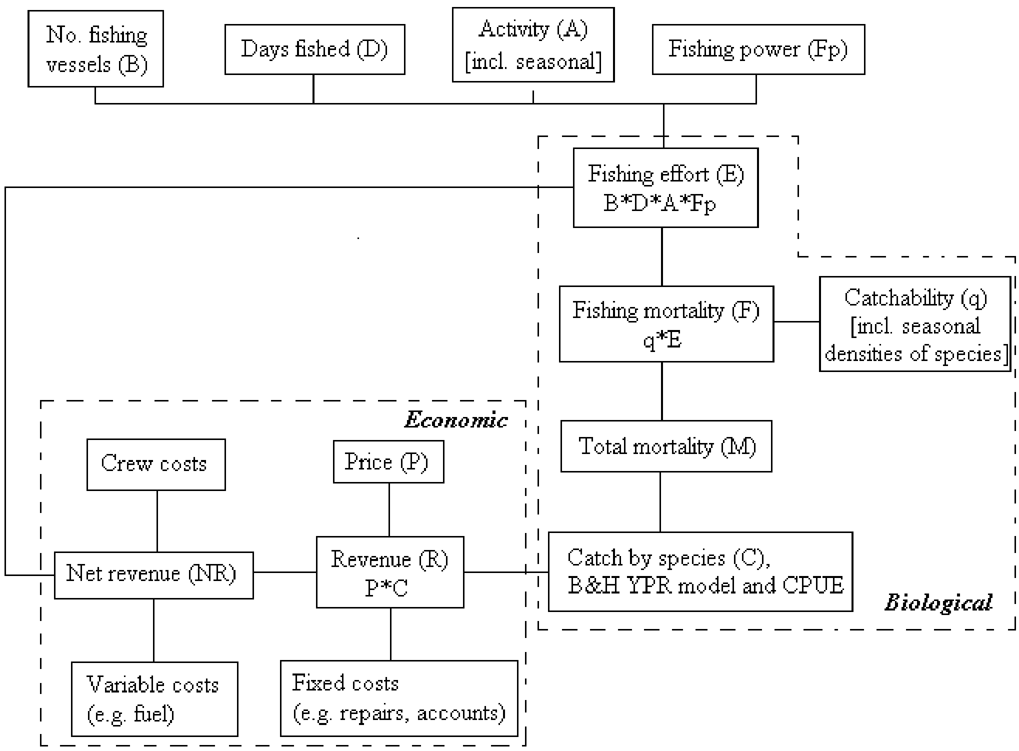
Biological Characteristics	**Economic Characteristics**
Multispecies, concentrating on 5 key commercially valuable species, red mullet (*M. barbatus*), pandora (*P. erythrinus*), axillary seabream (*P. acarne*), picarel (*S. flexuosa*) and annular seabream(*D. annularis*). Age structured representation of the 5 main species, simple aggregated production data for the remaining catch S/ R relationships developed for 5 main species Density data (analogous to seasonal Migration) available for whole fishery for Spring, Summer, Autumn and Winter Gulf spatially divided into 12 areas corresponding to substratum, Depth, & port locality.	Detailed Cost and Earnings Data available for artisanal vessels in the Gulf following a previous study (EU 97/063) Effort data according to fishing method, area (effort represented in terms of days active per year) Price information from the 1 wholesale market in the Gulf and also from independent wholesale fish buyers

The effects of the trawl fleet operating in the Gulf are estimated along with the artisanal fleet, however the accuracy of this is not known as data has not been collected from this fleet to validate these results. Therefore, where the trawl fleet is discussed, it will be in relation only to its potential effects on the artisanal fleet through the increased fishing mortality that would result if trawling were allowed in the Gulf.

Age-structured biological models were developed for the 5 key stocks in the model. The models were incorporated as equilibrium yield-per-recruit models, with the equilibrium stock structure estimated for the given levels of effort. For the "other" stocks a simple fixed rate of exploitation was used.

Revenue is estimated based on the level of landings and the price. Running costs are determined as a function of revenue and the level of effort, while fixed and capital costs are determined by the fleet size and structure. Cost data were derived from socio-economic surveys of the fishery (Pipitone et al., 2000). A schematic representation of the model is shown in figure 4.2.

Figure 4.2: Schematic representation of the bioeconomic model



4.1.1. Mathematical framework of the model

The model of the Castellammare FEZ investigates the interaction between the fish stocks and the artisanal fleet activity. It relies on the description of both these components based on data collected in the framework of the EC-funded Studies 92/011 and 97/063 as well as this study.

Five finfish species (annular seabream <*Diplodus annularis*>, red mullet <*Mullus barbatus*>, axillary seabream <*Pagellus acarne*>, pandora <*Pagellus erythrinus*> and picarel <*Spicara flexuosa*>) were chosen as the target species for inclusion in the bio-economic model. Their choice was dictated by (a) their abundance in the study area, and (b) their commercial importance.

The fish population analysis focused on the description of the following processes of population dynamics:

- Growth
- Stock-recruitment relationship
- Natural and fishing mortality

The pattern of exploitation of the fish populations was described by:

- The spatial distribution of the populations in the FEZ
- The gear and its selectivity
- The yield-per-recruit model.

The study area of the Gulf of Castellammare has a surface area of 397 km^2 (=116 nm^2) from Capo San Vito to Punta Raisi (figure 1.1). The surface banned to trawlers is 200 km^2 (=58 nm^2). The surface within and immediately outside the banned area, included between the -10 m and -200 m isobaths, was split into depth strata and into ESUs (Elementary Sampling Units) to allow for stratified random sampling (D'Anna *et al*., 1995)

The model was developed as a non-linear mathematical programme. The basic formulation considered a profit maximisation philosophy where the maintenance of vessel numbers was constrained at current levels. The descriptive format of the model is detailed in the following subsections, with firstly the objective function defined,

$$\max\ z = \sum_r p_r \tag{1}$$

where p_r is the level of economic profit in each region r, and z is the aggregated maximum profits achieved. The model is based on sustainable yield curves, and thus the biological objectives (i.e. resource conservation) are modelled implicitly.

4.2. The Biological Component of the Model

The model is driven principally by the number of boats operating within the fishery. Therefore, although the number of days fished per year by area of activity may be an endogenous variable, in the base case they are considered as the current average. The model is calibrated using the operating levels and associated data of the fishery in 1998/99. Therefore, effort and fishing mortality may be defined as follows

Effort and fishing mortality
Effort in each métier is estimated by

$$E_{r,g,t,a} = ta_{tg} B_{r,g} d_{r,g} a_{g,r,a} fp_g \qquad \forall t, r, g, a \tag{2}$$

where $E_{r,g,t,a}$ is the level of effective (standardised) effort expended by boats from each port r in each area a in season t (spring, summer, autumn, winter), $B_{r,g}$ is the number of boats in each fleet g (e.g. trammel netters and trawlers) from region r, $d_{r,g}$ is the average number of days fished by a boat, $a_{g,r,a}$ is the proportion of time vessels from each port spend in each area, ta_{tg} is the activity of boats in a specific season and fp_g is the relative fishing power of a boat from fleet g[14] (see tables 4.2 and 4.3 for a and ta).

Table 4.2: Activity of fishermen by region and strata in % time.

	A	*B*	*C*
Balstrate	25	60	15
Trappeto	82	18	-
Castellammare	50	45	5
Terrasini	75	25	-

Table 4.3: Seasonal activity of artisanal fishermen in % days.

Spring	*Summer*	*Autumn*	*Winter*
15	35	30	20

Fishing mortality of each species in the Gulf is then estimated by

$$f_{s,a,r,t,g} = q_{g,r,a,t,s} E_{r,g,t,a} \qquad \forall t, s, a, r, g \tag{3}$$

where the fishing mortality, $f_{s,a,r,t,g}$ of species s, in area a, by boats from region r from fleet g in season t, and the catchability coefficients $q_{g,r,a,t,s}$ are defined for the 5 key species modelled.[15] Other stocks are considered to be a fixed element within the model, and are modelled through known catch per unit effort (CPUE) data.

Total mortality of each species s is estimated by

$$z_s = M_s + \sum_a \sum_r \sum_g \sum_t f_{s,a,r,t,g} \qquad \forall s \tag{4}$$

where z_s is the total mortality of each species s, and M_s is the natural mortality for the species.

The estimation of biological parameters was based, depending on the cases, on data collected during trawl surveys carried out in 1987-89, 1993-94 and 1998-99 (see D'Anna *et al*., 1995 and Pipitone *et al*., 2000b for details).

[14] Note that the index g is used to represent the artisanal fleet and the external trawl fleet. In the base model, it is only fleet fishing legally within the Gulf that is considered (i.e. the artisanal fleet). Fishing power of the trawl fleet is not known, but assumed to be greater than the artisanal fleet.

[15] The catchability coefficients include known density distributions of the stocks throughout the Gulf by region, area and season. In this way, migration of the species is simulated through the availability of a species in a given season.

Length-weight relationship
The length-weight relationship, used to estimate W_∞ in the yield per recruit (Y/R) model, was estimated through regression analysis, utilising the least squares method for fitting data to a straight line.

Growth
The growth of fishes was described by the seasonalised Von Bertalanffy growth function (VBGF) (Pauly et al., 1992) (equation 5) using the mean length at age (L_t) estimated with the Bhattacharya's method.

$$L_t = L_\infty \times \left(1 - \exp\left(-K \times \left(t_i - t_0\right) + S_{ts} + S_{to}\right)\right) \quad (5)$$

where $S_{ts} = (C \times \frac{K}{2\pi})\sin(2\pi(t - t_S))$ and $S_{to} = (C \times \frac{K}{2\pi})\sin(2\pi(t_o - t_S))$. Ages ($t_i$) were estimated according to the biological information on the spawning season of each species drawn from Relini et al. (1999) (table 4.4). All estimates were performed using the Marquardt's algorithm as implemented in the FISAT software package (Gayanilo et al., 1996).

Table 4.4: - Spawning season for the five target species (Source: Relini et al., 1999)

Species	*Spawning season*	*Birth date*
D. annularis	Between April and June	1st May
M. barbatus	Between May and July	1st June
P. acarne	Between June and September	15th July
P. erythrinus	Between April and May	1st May
S. flexuosa	Between March and May	1st April

The results of the analysis of the length frequency distributions using the Bhattacharya's method are presented in table 4.5. These results allowed the estimation of the VBGF parameters for the five target species shown in table 4.6.

Table 4.5: Summary of the Bhattacharya's analysis (S.I.: separation index).

Species	*Survey*	*Age group*	*Mean length (SL, cm)*	*S.D.*	*No. of individuals*	*S.I.*
D. annularis	June 1998	1	8.83	0.514	30.00	-
		2	11.12	0.491	144.92	4.56
		3	12.88	0.504	329.64	3.525
		4	14.17	0.704	174.60	2.148
	Aug-Sep 1998	1	7.09	0.337	31.00	-
		2	11.01	0.810	527.00	6.828
		3	13.22	0.866	953.80	2.634
		4	15.13	0.521	69.17	2.766
	Dec 1998	1	9.18	0.328	28.00	-
		2	11.6	0.548	250.00	5.512
		3	13.23	0.489	246.62	3.152
		4	15.25	0.67	29.83	3.476
	Feb-Mar 1999	1	9.79	0.450	45.00	-
		2	11.41	0.717	216.60	2.777
		3	13.25	0.864	363.98	2.324

		4	15.24	0.437	60.78	3.064
M. barbatus	June 1998	1	12.17	1.434	5343.00	-
		2	15.84	0.794	609.00	3.297
		3	19.00	0.682	169.2	4.277
		4	22.49	0.631	49.00	5.319
	Aug-Sep 1998	1	7.17	0.598	795.00	-
		2	12.45	1.154	8767.00	6.026
		3	15.76	1.355	1517.72	2.637
	Dec 1998	1	7.86	0.479	293.00	-
		2	12.30	0.814	5463.00	6.873
		3	15.41	0.510	848.93	4.696
	Feb-Mar 1999	1	8.41	0.514	1680.00	-
		2	12.64	1.049	3781.00	5.415
		3	15.00	0.541	488.68	2.970
		4	16.35	0.899	287.56	2.150
P. acarne	June 1998	1	6.99	0.484	258.00	-
		2	13.64	0.592	720.00	12.360
		3	16.40	0.878	438.20	3.755
		4	18.80	0.552	59.06	3.359
	Aug-Sep 1998	1	10.86	0.409	1276.00	-
		2	14.13	0.636	706.00	6.269
		3	18.43	0.533	107.00	7.350
	Dec 1998	1	11.37	0.457	957.00	-
		2	14.26	0.593	664.990	5.512
		3	16.50	0.512	268.440	4.057
		4	17.77	0.566	108.200	2.350
	Feb-Mar 1999	1	6.07	0.517	2365.00	-
		2	12.59	0.593	615.00	11.747
		3	15.05	0.607	228.61	4.106
P. erythrinus	June 1998	1	10.68	1.457	44.00	-
		2	17.61	1.617	99.93	4.510
		3	20.59	1.320	102.34	2.032
	Aug-Se. 1998	1	14.49	1.509	230.50	-
		2	19.23	1.887	396.58	2.795
		3	24.50	1.391	82.780	3.211
	Dec 1998	1	8.70	0.760	67.00	-
		2	14.66	1.318	227.00	5.733
		3	19.50	1.686	226.15	3.223
		4	24.86	1.330	62.710	3.553
	Feb-Mar 1999	1	9.87	0.848	46.50	-
		2	15.27	1.325	173.82	4.974
		3	19.78	1.721	102.86	2.958
		4	25.13	1.561	37.05	3.260
S. flexuosa	June 1998	1	12.28	1.147	865.00	-
		2	15.34	0.765	114.92	3.201
	Aug-Sep 1998	1	12.69	1.001	4121.00	-
		2	15.11	0.911	730.18	2.449
	Dec 1998	1	8.84	1.015	96.00	-
		2	12.59	0.938	1218.62	3.837
	Feb-Mar 1999	1	9.66	0.826	597.50	-
		2	13.05	1.000	794.68	3.705
		3	15.57	1.143	104.39	2.359

Table 5: Parameters of the Von Bertalanffy growth function (VBGF).

	L_∞ *(SL, cm)*		*K (years-1)*		t_0 *(years-1)*	
Species	Value	S.E.	Value	S.E.	Value	S.E.
D. annularis	19.902	4.495	0.262	0.152	-1.674	0.355
M. barbatus	28.275	10.087	0.253	0.184	-0.988	0.352
P. acarne	19.599	1.599	0.606	0.176	0.207	0.166
P. erythrinus	37.695	8.214	0.254	0.104	-0.524	0.375
S. flexuosa	21.388	5.901	0.359	0.254	-0.958	0.319

Stock-recruitment relationship
The S/R relationship was initially modelled after both the Ricker and the Beverton and Holt equations. Ricker (1975) described this relationship by the following equation:

$$R = \alpha \times P \times e^{-\beta \times P} \quad (6)$$

where R represents the number of recruits, P the size of the parental stock (measured in numbers, weight, egg production, etc.), and α and β two parameters describing their relationship. Table 4.7 shows the data used for the S/R relationships. P and R were estimated using the season of recruitment of each species to the fishery. P was obtained summing the weight of the individuals larger or equal to the estimated length of the smallest spawners in the sampling area. R was equal to the number of individuals having a length smaller than the smallest length at recruitment as drawn by the experimental trammel net surveys carried out by IRMA in the Castellammare FEZ. It is noted that the data points available for the model fitting were only three: one for a year before the trawling ban (between 1985 and 1989) and two after the trawl ban was established (1993-94 and 1998-99). The fitting was realized using the non-linear least square (nls) algorithm implemented in the S-Plus 2000 package.

Table 4.7: Biological information used for the estimation of the stock-recruitment relationship (size and age at first maturity from Relini et al., 1999)

Species	*Size (age) at first maturity (SL, cm)*	*Recruitment period*	*Recruitment length (SL, cm)*	*~Length of smallest spawners (SL, cm)*
D. annularis	9.5-10	Autumn (Dec)	10	10
M. barbatus	M 11-13; F 12-14	Summer (Aug-Sep)	10	11
P. acarne	13-18 (2 years)	Winter (Feb-Mar)	8	13
P. erythrinus	17-18 (3 years)	Autumn (Dec)	10	17
S. flexuosa	8	Autumn (Dec)	11	11

The Ricker model for the S/R relationship provided the best fit over other alternatives to the data, and thus the parameter estimates for the Ricker model are presented in table 4.8.[16]

[16] Since there were only 3 data points available for fitting the model, the estimate of parameters did not differ significantly from zero. In spite of this statistical non-significance, we have accepted them since there was no alternative to estimate the S/R relationship with the available data. The effects of this are further considered in the analysis section.

Table 4.8: Parameters of Ricker's model for stock-recruitment relationship.

	a			*b*		
Species	*Value*	*S.D.*	*t value*	*Value*	*S.D.*	*t value*
D. annularis	39.7	713	0.0557	0.3900	2.57	0.151
M. barbatus	136	29.5	4.61	0.0599	0.0121	4.95
P. acarne	274	602	0.455	0.0585	0.0661	0.885
P. erythrinus	0.0252	0.0191	1.32	0.0475	0.186	0.256
S. flexuosa	10.1	6.70	1.51	0.0333	0.0168	1.98

Mortality

It is assumed that the sum of natural (M) and fishing (f) mortalities determines the total mortality (z) in the exponential decay model (Ricker, 1975). z and M are among the parameters used to feed the yield-per recruit model. z was estimated using the linearized catch curve method based on length data (Sparre and Venema, 1998). M was estimated using the Chen and Watanabe's method (Chen and Watanabe, 1989), which allows the calculation of the average natural mortality over the reproductive span:

$$\overline{M}(t, t+\Delta) = \frac{1}{\Delta} \ln \frac{e^{k(t+\Delta)} - e^{k \times t_0}}{e^{k \times t} - e^{k \times t_0}} \qquad (7)$$

where t is the age of beginning of stable growth, Δ is the reproductive span, k is the growth rate in the VBGF, and t_0 is the adjustment parameter in the VBGF. t was calculated using the ages of massive reproduction (T50%) given by Relini et al. (1999) (see table 4.10). Moreover 100,000 randomly generated triplets (t, k, Δ) of values were created, with parameters k and t0 varying according to a Gaussian distribution with adequate mean and standard deviation. Δ was randomly chosen as an integer lying between 1 and 10. Mean values of the resulting vector and quantiles of levels 2.5 and 97.5% were used as descriptors of the mean value and variability M.

Estimates of M (natural mortality rate) and Z (total mortality rate) are presented in table 4.9.

Table 4.9: Natural mortality rate (*M*) and Total mortality rate (*Z*).

Species	*M (years-1)*	*95% limits of the C.I.*		*Z (years-1)*	*95% limits of the C.I.*	
		Lower	*Upper*		*Lower*	*Upper*
D. annularis	0.39	0.17	0.63	1.26	1.17	1.35
M. barbatus	0.43	0.17	0.73	1.21	1.08	1.34
P. acarne	0.70	0.41	1.0	1.22	1.04	1.41
P. erythrinus	0.38	0.22	0.57	1.33	0.97	1.68
S. flexuosa	0.51	0.17	0.93	1.75	1.41	2.09

Exploitation parameters

To describe the seasonal distribution of fish biomass, the Gulf's surface was divided into four main fishing regions (from west to east: CM, BA, TR, TE) roughly corresponding to the four harbours, each of which was assumed to be exploited only by fishermen from one harbour (figure 4.3)

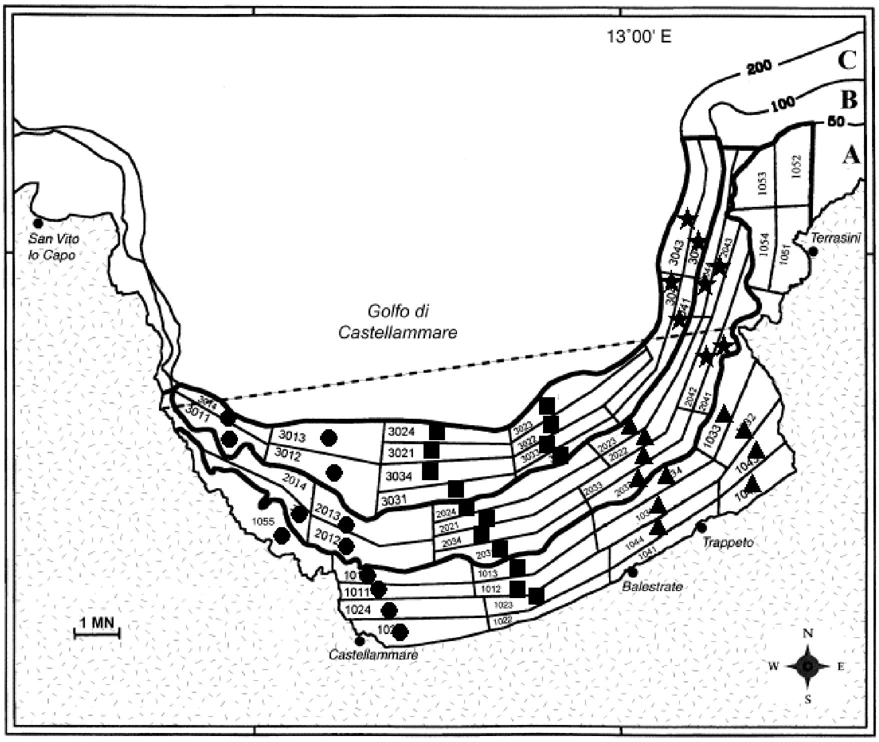


Figure 4.3: The four fishing regions. Circle: CM, square: BA, triangle: TR, star: TE

Table 4.10: Age of massive reproduction (from Relini et al., 1999)

Species	*T50% (year)*
D. annularis	1
M. barbatus	1
P. acarne	2
P. erythrinus	2
S. flexuosa	1

This assumption is acceptable because fishermen in the Gulf tend to act conservatively, exploiting generally the same areas across time (Pipitone et al., 2000b). Each sector maintained the division in three depth strata adopted in the trawl surveys: A (10-50 m), B (51-100 m) and C (101-200 m) (Pipitone et al., 2000a), thus yielding three areas in each region (except in TE). The biomass potentially available in each season and in each area to artisanal fishermen was expressed by the proportion of CPUE of fishes whose length was equal or above the length at recruitment Lr, (see table 4.2). The CPUEs employed were those obtained in the 1998-99 trawl surveys (i.e., the CPUEs were used as an index of biomass). The proportion of biomass of each species potentially available to the artisanal fishermen in the four fishing regions is summarized in table 4.11.

Table 4.11: Proportion of the biomass catchable by artisanal fishermen in the Gulf, based on CPUEs from the 1998-99 trawl surveys

Geographic localisation: Region	*Area*	*D. annularis - % of biomass (1998-1999)* spring	summer	autumn	winter	*M. barbatus - % of biomass (1998-1999)* spring	summer	autumn	winter
BA	A	6.3	25.3	27.1	52.5	2.5	10.5	7.7	17.5
BA	B	0.0	2.1	1.9	5.5	0.0	3.5	14.6	14.4
BA	C	4.7	10.3	0.0	0.0	10.1	6.6	5.8	6.4
CM	A	55.6	21.4	69.1	33.2	44.9	32.2	36.3	31.1
CM	B	20.2	17.0	0.0	6.7	20.5	21.7	11.8	13.7
CM	C	0.0	0.9	0.0	0.0	7.2	8.5	8.8	6.9
TE	B	1.9	0.9	0.0	0.0	3.8	2.9	4.0	1.6
TE	C	0.0	0.1	0.0	0.0	1.4	0.2	0.0	1.8
TR	A	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TR	B	10.8	22.0	2.0	2.1	7.8	14.1	8.6	5.3
TR	C	0.4	0.0	0.0	0.0	1.9	0.0	2.5	1.3

Geographic localisation: Region	*Area*	P. acarne - % of biomass *(1998-1999)* *spring*	*summer*	*autumn*	*winter*	P. erythrinus - % of biomass *(1998-1999)* *spring*	*summer*	*autumn*	*winter*
BA	A	0.2	5.3	6.9	42.2	0.6	6.5	12.9	23.8
BA	B	0.0	1.7	12.8	6.1	0.0	11.4	27.2	20.3
BA	C	11.4	1.0	0.4	0.0	13.8	7.9	0.6	1.1
CM	A	29.8	47.6	65.6	38.9	24.5	28.9	28.7	29.2
CM	B	55.6	34.6	7.7	2.4	30.0	15.6	5.6	8.2
CM	C	0.2	2.9	3.0	0.0	0.3	4.7	5.6	3.9
TE	B	0.2	0.0	0.0	0.0	5.5	3.1	4.1	0.3
TE	C	0.0	0.0	0.0	0.0	1.4	0.0	0.0	0.0
TR	A	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TR	B	1.4	6.9	3.6	10.4	22.3	21.8	12.4	12.8
TR	C	1.2	0.0	0.0	0.0	1.6	0.0	2.9	0.5

Geographic localisation: Region	*Area*	S. flexuosa - % of biomass *(1998-1999)* *spring*	*summer*	*autumn*	*winter*
BA	A	3.8	0.8	7.9	14.0
BA	B	0.0	2.6	15.8	7.1
BA	C	10.9	18.3	10.1	7.5
CM	A	4.8	6.1	33.1	43.5
CM	B	7.0	7.2	12.5	4.4
CM	C	7.8	3.7	2.6	10.6
TE	B	13.5	10.0	6.4	2.7
TE	C	2.9	2.6	0.0	3.7
TR	A	0.0	0.0	0.0	0.0
TR	B	34.7	48.5	8.1	5.8
TR	C	14.5	0.0	3.4	0.8

In the case of gear type and selectivity, Pipitone et al. (2000b) gave a detailed description of the artisanal fleet and of the gears used in the Gulf. The main gear used in the Castellammare FEZ is a mixed trammel-gillnet (i.e., a trammel with a gillnet fitted on top). For the needs of the yield-per-recruit model, the mean length at first capture (L_c) was calculated fitting the logistic function on the length data from the experimental trammel net surveys carried out in the Gulf by IRMA. Although a Gaussian model would better describe the selectivity of the trammel-gillnet, fitting the logistic model to data was dictated by the assumptions underlying the Y/R model. The gear selectivity, expressed in terms of length at first capture, is given in table 4.12.

Table 4.12: Length at first capture for the trammel-gillnet (SL, cm).

Species	L_c
D. annularis	14.0
M. barbatus	16.0
P. acarne	14.2
P. erythrinus	17.2
S. flexuosa	14.4

Yield-per-recruit model

The exploitation of each fish stock by the artisanal fleet was described by the length-based version of the Beverton and Holt's yield-per recruit (Y/R) model (equation 10) (Sparre and Venema, 1998).[17]

$$\left(Y/R\right)_{s,r,a,t,g} = f_{s,r,a,t,g} \times A \times W_\infty \times [\frac{1}{Z} - \frac{3U}{Z+K} + \frac{3U^2}{Z+2K} - \frac{U^3}{Z+3K}] \qquad (8)$$

where *Y/R* is the yield per recruit in grams, *f* is the fishing mortality rate defined previously, W_∞ is the asymptotic body weight (as estimated by the length-weight relationship), *Z* is the total mortality rate, *K* is the growth rate (from the VBGF) and for each of the 5 key species,

$$A = \left[\frac{L_\infty - L_c}{L_\infty - L_r}\right]^{M/K} \text{ and } U = 1 - L_c/L_\infty .$$

where L_∞ is the asymptotic body length (from the VBGF), L_c is the length at first capture, and L_r is the length at recruitment. The graphical representation of the Y/R model is shown in figure 4.4.

Catch

Therefore the catch of each species is estimated through the multiplication of the recruitment of the species and the Beverton and Holt Yield per Recruit function (*Y/R*),

$$C_{s,a,r,t,g} = R_s \left(Y/R\right)_{s,a,r,t,g} \qquad \forall a,r,t,g,s \in \text{"the 5 key species"} \qquad (9a)$$

$$C_{s,a,r,t,g} = (E_{r,g,t,a} / fp_{r,g}).CPUE_{s,a,r,t} \qquad \forall a,r,t,g,s \in \text{"other species"} \qquad (9b)$$

where R_s *is* the number of recruits into the fishery.

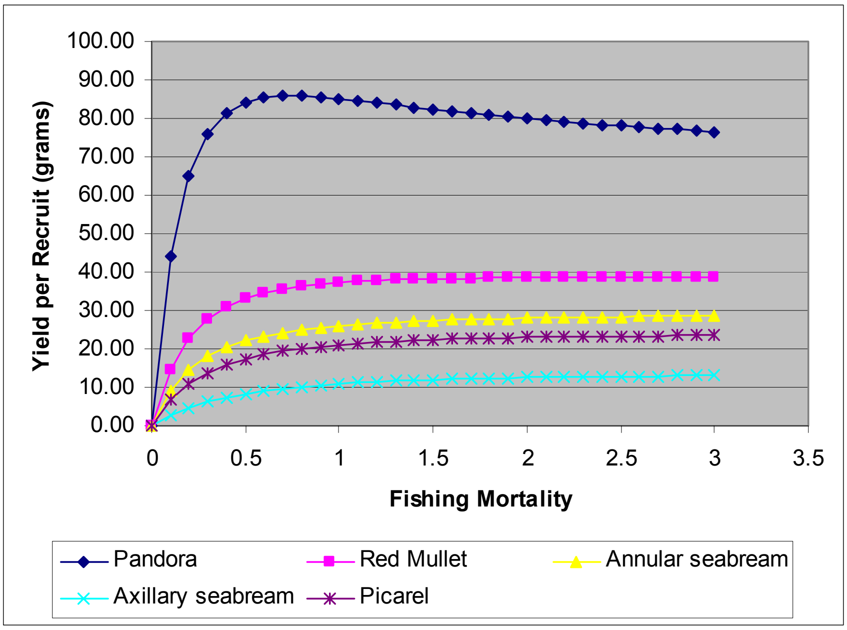
The catch of the external trawling fleet is estimated through an assumption on their fishing power. The operating characteristics of the trawl fleet are thus assumed to be the same as the artisanal fleet, but with greater yield from less effort.

For the length-structured species, the level of recruitment (i.e. the number of juvenile fish entering the fishery) was assumed ultimately in the model to be exogenously determined, due

[17] The species index is omitted from part of this equation for clarity but appears on each parameter.

to the unknowns inherent in the analysis. Analyses of many fisheries, however, suggest that, above a given critical stock size, changes in the number of recruits (the juvenile fish entering the fishery) is largely a function of environmental factors, and is effectively stochastic rather than deterministic (see, for example, Hilborn and Walters 1992). At the operating levels analysed in this fishery, this view was therefore presumed and the effects on the levels of recruitment analysed stochastically through random change. It is considered that as a result, this constant recruitment is not expected to prejudice the analyses performed with this model.

Figure 4.4: YPR graphical representation of the 5 key species.



4.3. The Economic Component of the Model

A summary of the economic data incorporated in the model is presented in sections 1 (see table 1.2).

Economic equations
Revenue is estimated by,

$$R_{r,a,g} = \sum_{s}\sum_{t} p_{s,r} C_{s,a,r,t,g} \qquad \forall r,a,g \tag{10}$$

where $p_{s,r}$ is the price of species s in region r.

Net revenue is estimated by

$$NR_{r,g} = \sum_{a}\left[R_{r,a,g} - B_{r,g} d_{r,g} a_{r,a,g} \left(\sum_{v} vc_{g,r,a,v} \right) \right] \qquad \forall r, g \in "artisanal" \tag{11}$$

where NR is the total net revenue in region r, area a and fleet g, and $vc_{g,r,a,v}$ is the variable cost per day (trip cost)[18] of the different boats by individual variable costs v.

Hence, the economic profit in each region ($P_{r,g}$) is estimated by

$$P_{r,g} = NR_{r,g} - \left[cs_{r,g} + \left(B_{r,g} * \sum_{f} f_{g,r,f} \right) \right] \qquad \forall r, g \in \text{"}artisanal\text{"} \qquad (12)$$

where $f_{g,r,f}$ is the fixed cost by category f associated with each boat, and $cs_{r,g}$ is the crew share of defined as,

$$cs_{r,g} = B_{r,g} d_{r,g} a_{a,r,g} c_{r,g} \qquad \forall r, g \in \text{"}artisanal\text{"} \qquad (13)$$

4.4. The Bioeconomic Analysis

The principal aim of the bioeconomic analysis was to investigate the changing effects of the Gulf of Castellammare trawl ban on the economy of the artisanal fleet.[19] That is, not only investigating the current status of the artisanal fishing fleet but also the potential effects on that fleet should trawling be made a legal activity once more in the currently protected Gulf. Therefore, as well as evaluating the "current" situation of the artisanal fleet and the effects of a reduced and increased artisanal fleet under the trawl ban, the following scenarios were also simulated to evaluate changing restrictions on trawling in the Gulf:

1) to allow trawlers to fish in the Terrasini region;
2) to allow trawlers to fish in area C (i.e. the 100-150m stratum);
3) to allow trawlers to fish in areas B and C (i.e. the 50-150m strata); and
4) to remove the trawling ban in the Gulf of Castellammare.

The reason for looking at the first of these scenarios was to consider the effects of illegal trawling activity in the Gulf, which is thought to be increasing. There are known to be approximately 10 trawlers based in the port of Terrasini (just outside the trawl ban area), and it is reported that any illegal activity largely occurs in this side of the Gulf (termed the Terrasini region in the model).[20] As a result of the success of the trawl ban in the Gulf, in the recovery of many of the species, there is pressure to allow trawlers to once again fish inside the current exclusion zone. The three latter scenarios are designed to evaluate the effect of this potential change in policy through reducing the size of the exclusion zone and finally through removing the exclusion zone. Further, the effects of scenario 3 (i.e. areas B and C) are evaluated by season (i.e. spring, summer, autumn and winter) in addition to the yearly case.

Unlike the artisanal fleet, little detail is known about the trawling fleet in terms of both economics (i.e. costs and earnings) and fishing capability (i.e. catchability and fishing power).

[18] A trip for all vessels is assumed to be equivalent to one day.
[19] The bioeconomic model developed was calibrated to known "current" levels of estimated catch in the Gulf under the premise that no trawling activity exists. The "current" situation of the model is calibrated to 1998.
[20] See section 6 for further reported details on such activity.

Therefore, increased benefits to the trawlers cannot be considered as part of this analysis, and as such the analysis is undertaken from the point of view of the impact of regulation changes on the artisanal fleet. In terms of the fishing capability of the trawling fleet, firstly it is assumed that the catchability of trawling vessels is the same as the artisanal fleet. This is a fair assumption as catchability of the artisanal fleet is calibrated through known species seasonal density. Secondly, for the case of fishing power two situations are considered: that is, where a trawler can expect 4 times the catch of an artisanal vessel for the same level of effort; and where a trawler can expect 10 times the catch of an artisanal vessel for the same level of effort.

The results of the analysis using the model form three sections: simulation, optimisation and sensitivity analysis. The bioeconomic model developed was fundamentally as a simulation tool, to evaluate effects on the artisanal fleet given the current structure of the fleet with "current" activity levels. As developed in the previous sections, the bioeconomic model is a long-term equilibrium based model where any solution suggests sustainability of the modelled stocks at the levels indicated. The model was also implemented in an optimisation framework where the levels of boats in each of the regions were optimised given permitted trawling activity. Finally, the sensitivity of the model was investigated through two of the key parameters: price and the level of species' recruitment.

4.5. Results

4.5.1. Simulations

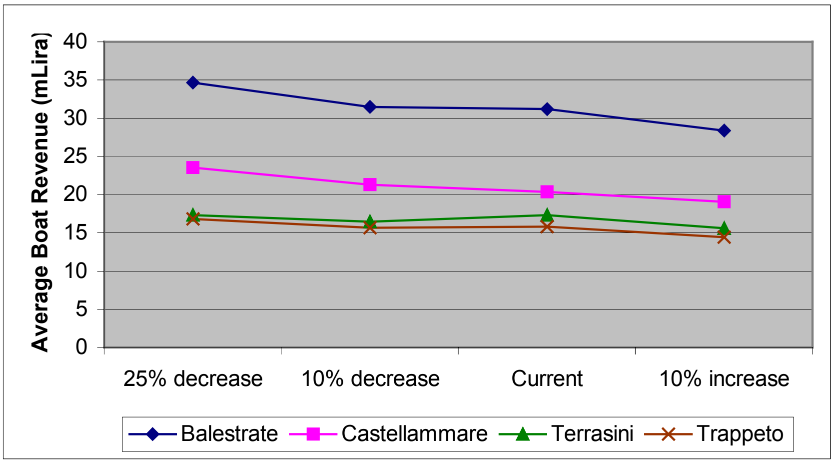
With the artisanal fleet at current levels, catches and subsequently revenues of the 5 main species are stable. This is highlighted by the model through the fact that both the simulation and optimisation of boats in the fishery results in the same solution. Table 4.13 shows the estimated current revenue of the species by region. The abundance of the 5 main species in the Balestrate and Castellammare regions, is particularly noticeable in the importance to the estimated catch composition. In Trappeto and Terrasini the "other" species are of more importance, which is reflected in the lower average revenues observed.

Table 4.13: Total estimated "current" revenue of the artisanal fleet (in €'000s).

	Balestrate	*Castellammare*	*Trappeto*	*Terrasini*
Annular Seabream	16.37	32.67	6.50	1.16
Axillary Seabream	11.93	37.03	4.63	0.06
Red Mullet	80.43	127.09	38.81	37.88
Pandora	22.56	32.90	14.99	8.52
Picarel	6.40	10.00	10.45	8.66
Other	104.15	117.39	104.30	167.81

As well as the investigation of distribution of revenue, the change in revenue to the number of artisanal vessels in the Gulf was also considered (see figure 4.5). It is again shown to be relatively stable, with little variation in average boat revenue to changes in the regions' fleets of 10%. Therefore, at current levels, the situation is seemingly sustainable. With a 25% decrease in each fleet, a slight increase in average boat revenue becomes apparent.

Figure 4.5: Average boat revenue with changes to the no. of artisanal vessels in the regions.



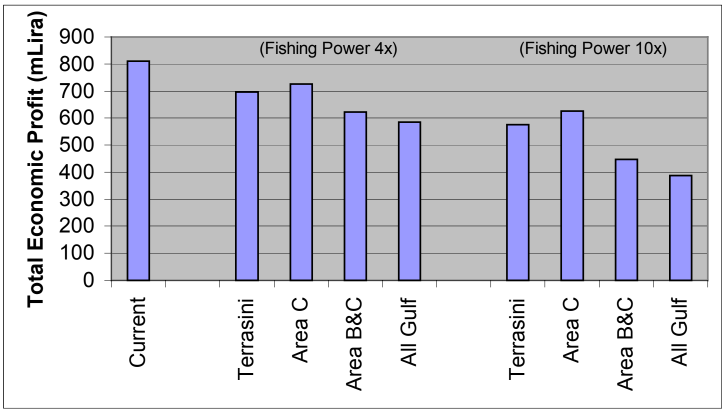
The effects on the economy of the artisanal fleets under the different scenarios of allowing trawling in the Gulf are summarised in table 4.14. The differences between profitability of regions is noticeable (Pipitone et al., 2000b). The levels of revenue achieved in Balstrate are deemed to be the result of a more formal market structure available in the region. The activity in Trappeto is thought to be unprofitable in the long-term at current levels. Due to the importance of areas A and B to the artisanal fishers, the results of allowing trawling in are distinctly ordered. However, the effects on the artisanal vessels is marked. If the trawling ban is removed totally and the fishing power assumed to be 10 times that of the artisanal vessels, then the long-term consequence on the artisanal fishers is dramatic with a halving in attained economic profit. For revenue, the effect is less apparent with a reduction of around 25%.

Table 4.14: Economic statistics summary of the artisanal fleet if trawling is allowed in stated areas compared to the "current" situation (in €'000s).

		Fishing Power x4				*Fishing Power x10*			
	Current	*Terrasini*	*Area C*	*Areas B,C*	*All Gulf*	*Terrasini*	*Area C*	*Areas B,C*	*All Gulf*
Total Gulf profit	418.60	359.31	374.91	321.42	301.88	297.08	322.76	230.77	200.41
Average Boat Revenue:									
Balestrate	16.12	15.07	15.33	14.36	14.00	13.95	14.39	12.72	12.16
Castellammare	10.50	9.78	9.94	9.23	8.92	9.00	9.27	8.01	7.53
Terrasini	8.96	8.62	8.73	8.49	8.43	8.28	8.46	8.05	7.98
Trappeto	8.17	7.69	7.85	7.47	7.36	7.22	7.47	6.83	6.67
Average Boat Profit:									
Balestrate	7.59	6.54	6.80	5.83	5.47	5.42	5.86	4.19	3.63
Castellammare	6.18	5.45	5.62	4.90	4.59	4.68	4.94	3.69	3.21
Terrasini	3.84	3.49	3.60	3.36	3.30	3.15	3.33	2.93	2.85
Trappeto	-0.05	-0.53	-0.37	-0.75	-0.86	-1.00	-0.75	-1.39	-1.55

For each of the scenarios allowing yearly trawling, the results of total economic profit to the artisanal fleet are shown in figure 4.6. It is clear that under the modelled conditions, allowing trawling in the Gulf for the whole year has an adverse effect on the profits of the artisanal fleet. It is reported that illegal trawling is occurring in the eastern side of the Gulf (i.e. the Terrasini region), and the effects of legally opening this region up to trawling can be seen against the other scenarios. The effect on the profitability of the artisanal fleet is greater in this case than in reducing the boundary of the trawl ban to the edge of area C. In percentage terms, the difference in profit increases as the assumed fishing power of the trawlers is increased. This is also shown in opening up the Gulf even more to trawling.

Figure 4.6: Total economic profit to the artisanal fleet if trawling is allowed in stated areas.



In terms of average boat revenue and economic profit, the effects of the alternative scenarios are shown in figures 4.7 and 4.8. In the case where trawling is allowed in area C, the difference in average boat revenue to the current situation is low, approximately 3-5% and 9-11% in each of the fishing power cases respectively. However, the consequent effect on profits is more pronounced with an average drop of ~12% and ~20% in each case.

Figure 4.7: Av. boat revenue by region of the artisanal fleet if trawling is allowed in stated areas.

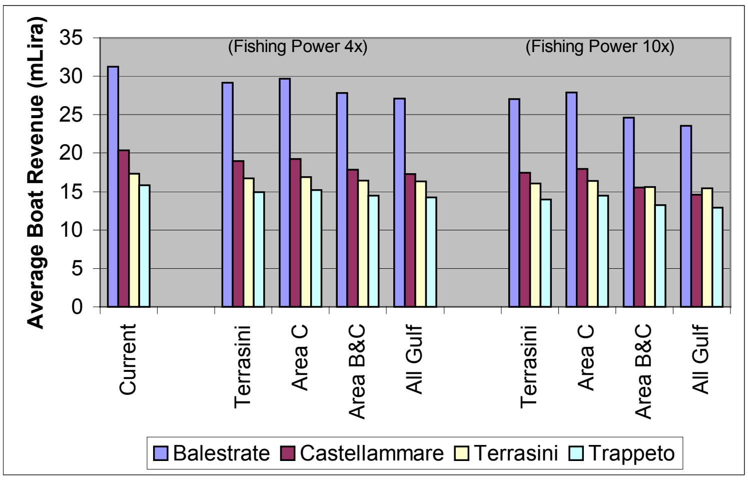
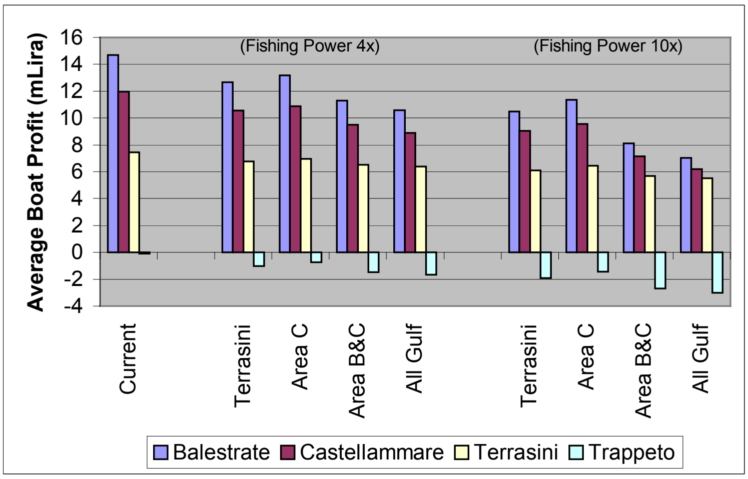
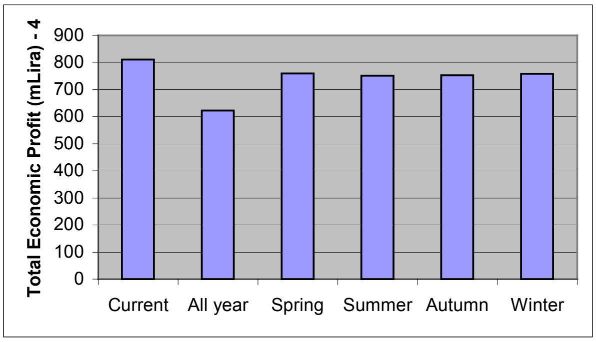


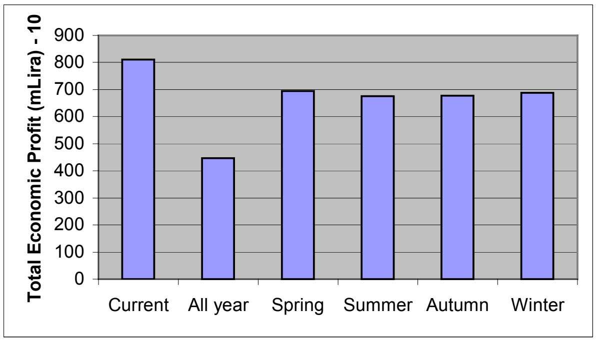
Figure 4.8: Av. boat economic profit by region of the artisanal fleet if trawling is allowed in stated areas.



In order to explore the situation of alleviating the trawling effects by lifting the trawl ban in the Gulf for one season a year, the "areas B and C" open for trawling case was used. The results of this analysis are shown in figure 4.9. It is clear that a seasonal relaxing of the trawl ban would have far less effect on the profitability of artisanal vessels than for the complete year. In fact the effect of opening up the fishery for any season has similar outcomes, although marginally allowing trawling in either summer or autumn would have the greater effect. The change in revenue of the artisanal vessels by seasonal opening is far less prominent, suggesting a more distinct change in species mix.

Figure 4.9: Total economic profit to the artisanal fleet if trawling is allowed in areas B and C for all and part of the year (fishing power x4 and x10 respectively).





The change in this species mix for this case is reported in table 4.15. The change in availability if each of the varies between 90%-99% for the fishing power x4 case, and between 77%-99% for the fishing power x10 case. It is shown that the long-term effects in this scenario have least effect on annular seabream and axillary seabream and most effect on pandora and picarel, with red mullet in the middle. It is also shown that seasonal effects amongst species differ, with for example autumn showing more effect for pandora and summer more effect for annular seabream. The "other" class of species are represented in the model through CPUE relationships are therefore appear unchanged under the scenario. The effect on the species is therefore greater in Balestrate and Castellammare than in Trappetto and Terrasini as there percentage catch of the 5 key species is significantly higher (see table 4.15).

As fishing power increases, the artisanal catches of pandora and picarel are particularly impinged upon.

Table 4.15: % change in availability of species to the artisanal fleet by season if trawling is allowed in areas B and C.

	Fishing Power x4				*Fishing Power x10*			
	Spring	*Summer*	**Autumn**	*Winter*	*Spring*	*Summer*	*Autumn*	*Winter*
Annular Seabream	97%	94%	99%	98%	92%	87%	99%	94%
Axillary Seabream	96%	97%	98%	98%	91%	93%	95%	95%
Red Mullet	96%	94%	94%	94%	90%	87%	85%	86%
Pandora	92%	92%	90%	92%	82%	81%	77%	82%
Picarel	90%	90%	94%	96%	78%	79%	85%	92%
Other	100%	100%	100%	100%	100%	100%	100%	100%

The effects of the various scenarios on the species mix for the yearly case are summarised in table 4.16. These effects are considerably different in each case, as would be expected from the known density distributions of the species. If area C is opened to trawling for the whole year, then, it is for the most part, the artisanal catches of red mullet and pandora that are of most concern as they are valued as highly commercial. As the fishing power of the trawling fleet increases, it can be seen in table 4.16 that the effect on the artisanal fleet is substantial.

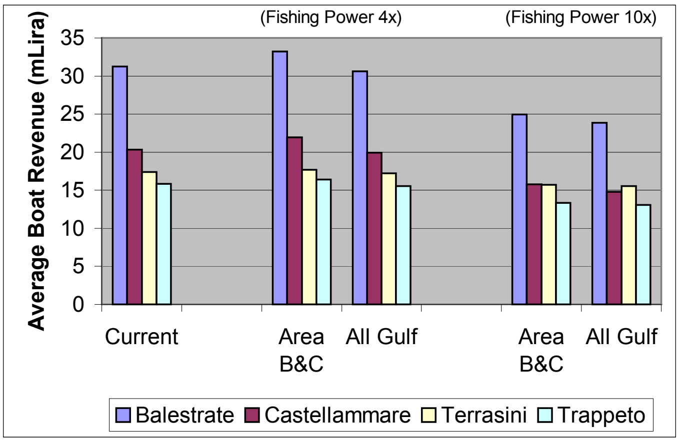
Table 4.16: % change in availability of species to the artisanal fleet if trawling is allowed in stated areas.

	Fishing Power x4			*Fishing Power x10*		
	Area C	*Areas B,C*	*Terrasini*	*Area C*	*Areas B,C*	*Terrasini*
Annular Seabream	97%	89%	97%	92%	76%	93%
Axillary Seabream	98%	90%	100%	95%	79%	100%
Red Mullet	90%	81%	88%	78%	62%	74%
Pandora	92%	72%	85%	81%	50%	68%
Picarel	86%	75%	70%	72%	55%	48%
Other	100%	100%	100%	100%	100%	100%

4.5.2. Optimisations

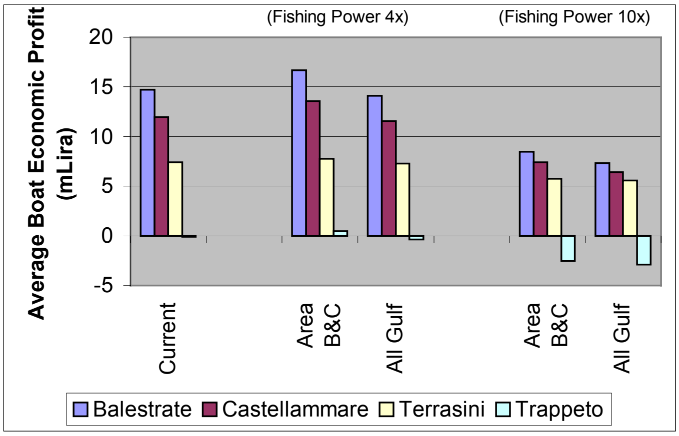
The model has been used in an optimisation framework to evaluate how the artisanal fleet may adjust to a level of highest profitability given the relaxing of the exclusion zone to trawlers. In these runs of the model, the numbers of vessels in each region are allowed to vary between current numbers and half that level, using the assumption that artisanal vessels would not increase under the scenarios. The average optimal boat revenue is shown in Figure 4.10. In the case where trawling is assumed to be 4 times more powerful that of the artisanal fleet, the average boat revenue actually increases slightly on current levels for “area B,C” and is almost identical in the case of opening up the whole Gulf to trawling. In both of these cases, the number of artisanal vessels active to produce this result is decreased to half current levels in both Castellammare and Trappeto. The regions of Balestrate and Terrasini did not show a change from current levels. This would suggest that the vessels in the two former regions are less efficient per day fished than the latter, if only by a small amount. However, it is indicative, along with the results from the simulations, that in order to maintain revenues to the artisanal fleet, should trawling be allowed in the Gulf, some rationalisation to the artisanal fleets would have to be made. In the case where trawling is assumed to be 10 times more powerful, it is interesting to note that Terrasini is less affected than the other regions. It could be surmised that this region is already affected implicitly to some degree in the current situation, and therefore on allowing trawling to fish legally in the Gulf would not have the same level of negative effects as the other regions.

Figure 4.10:Average optimal artisanal boat revenue if trawling is allowed in stated areas



The average optimal economic profit per artisanal vessel allowing trawling is given in figure 4.11. Similarly to the average revenues, the 4 times fishing power case sees a significant increase over the current situation. In the scenario “area B&C”, even the profit in Trappeto is indicated to increase to positive long-term levels. The 10 times fishing power case, however, is far less positive, with average boat profits seemingly halving in the long-term. This is a similar result to the simulation with current levels of artisanal vessels (see figure 4.11).

Figure 4.11: Average optimal artisanal boat profit if trawling is allowed in stated areas



4.5.3. Sensitivity Analysis

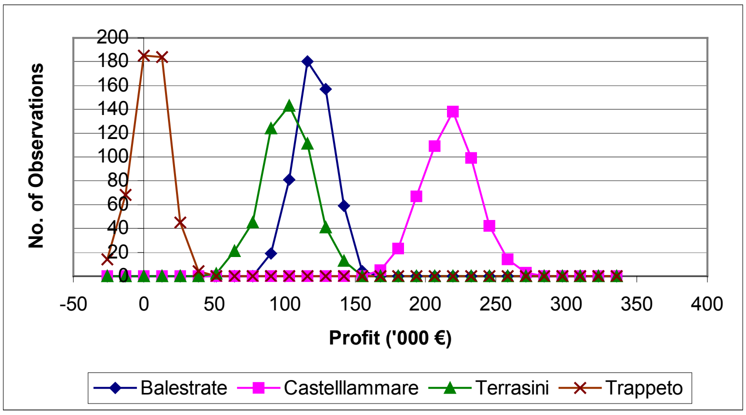
In order to ascertain the sensitivity of the model towards two key parameters, namely price and species recruitment, stochastic simulations were undertaken. In different runs, price and recruitment were chosen randomly using a normal distribution with a standard deviation of 10% and 25% respectively of current levels. In total, 500 simulations were performed for each of the runs to evaluate the sensitivity of the model. It would be expected for variation to be apparent, but the degree of variation to the current situation is of most interest in each case. The current economic profit and revenue for each region are reminded in table 4.17.

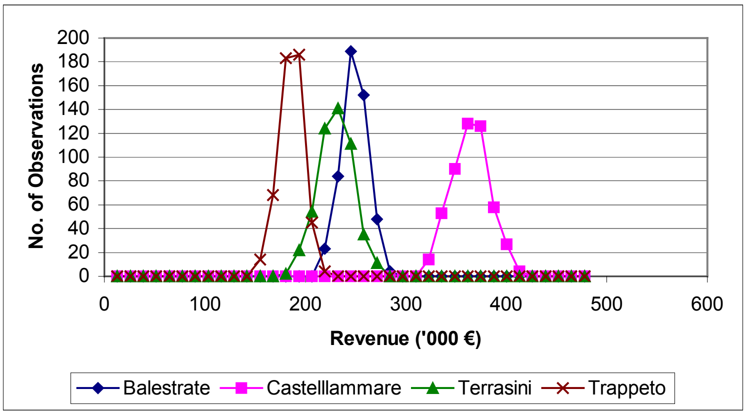
Table 4.17: Current economic profit and revenue by region (in €'000s).

	Economic Profit	*Revenue*
Balestrate	113.82	241.84
Castelllammare	210.06	357.08
Terrasini	95.90	224.09
Trappeto	-1.17	179.67

The stochastic simulations on price are shown in figure 4.12. As expected, the same trend is visible on both total revenue and profit, however the curves positions in relation to each other differ significantly. This is indicative of the costs experienced in each region, particularly Trappeto. On the revenue graph in this run, it is especially clear that Castellammare experiences higher levels of catches as a region. This is due to the larger number of vessels based here than in the other regions. Also, it is more sensitive to levels of price in both profit and revenue to either Balestrate or Trappeto, but similar to Terrasini. For example, ~40% of the simulations for Balestrate and Trappeto developed current levels of profit and revenue. Based on the results presented in the previous sections, the results of this run, with a standard deviation of 10% of current price, are of acceptable sensitivity.

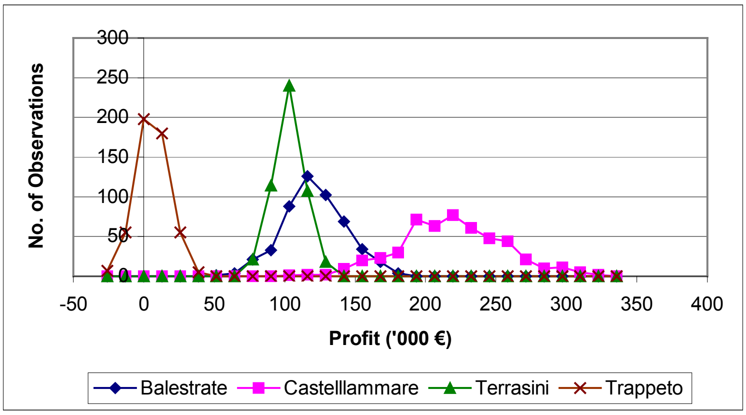
Figure 4.12: Results of 500 simulations on total economic profit and revenue of the artisanal fleet with a random normal variation, standard deviation 10%, on price of species

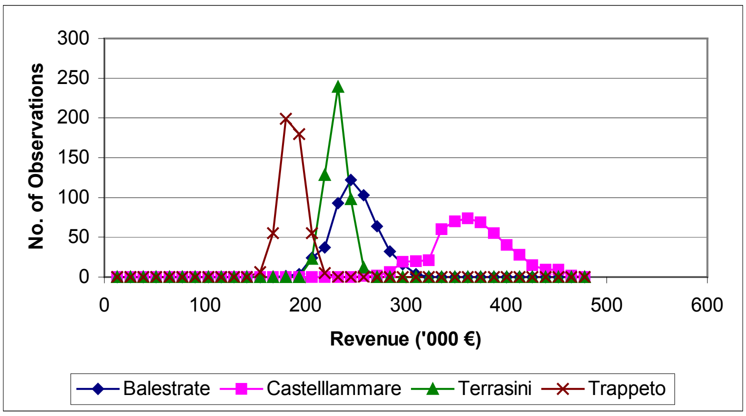




The stochastic simulations on species' recruitment are shown in figure 4.13. Similarly to the price runs and, as expected, the same trend is visible on both total revenue and profit. Again, Castellammare appears far more sensitive to the levels of species' recruitment than the other regions, especially in profit. The least sensitive region to recruitment, is Terrasini with ~50% of the runs' simulations approaching current levels. With a standard deviation 25% of current recruitment, this is highly insensitive. This is similar for Trappeto, but less so for Balestrate. Generally, the sensitivity of the model to variation in this parameter, as with price, is for the most part at an acceptable level.

Figure 13:Results of 500 simulations on total economic profit and revenue of the artisanal fleet with a random normal variation, standard deviation 25%, on species' recruitment





4.6. Discussion and Conclusions

Solutions obtained from the bioeconomic model developed indicate the long-term equilibrium position of the fishery given the levels of parameters and constraints imposed. The results obtained do not give a path to which a solution is met, and are therefore indicative of the effects of potential regulation or policy and not predictive. However, a solution is consistent with current knowledge. To ensure validity and confidence of the model, it was tested and calibrated to the "current situation" (i.e. 1998), which was the latest position where all key data required was available.

The model was run under the simulation of current regulation in the Gulf of Castellammare with the current structure of the fleet. Results suggest that this current position is stable in the long-term. The model indicates that the fishery is operating below MSY catch levels for the 5 key species modelled and that effort and catches are relatively stable. Thus, under current regulation of the trawl ban in the Gulf, simulations indicate that the artisanal fishery can operate under the current conditions well into the future, even though profitability of the average vessel in some regions, particularly Trappeto, could probably be increased through structural improvements. The effects of a more formal structure are evidenced in Balestrate.

The main group that has been affected in the implementation of the trawl ban is of course the trawlers. They are based in the port of Terrasini, just outside the trawl ban area and are reported to have decreased in numbers since the trawl ban was introduced and now stand at about 10 vessels. The recovery of species in the Gulf has far surpassed expectations. The trawler population is considered in some parts to have lost out on these biological benefits of the trawl ban and is now seeking re-admission to the Gulf. It is reported that illegal trawling is now a problem in the eastern-most parts of the Gulf (i.e. the region of Terrasini) which leads to increasing gear conflict and to a falling CPUE.

Through the analysis undertaken the long-term position of the current situation is sustainable. However, if trawlers are permitted to enter the trawl ban area in part (i.e. area C, or areas B&C) on a seasonal basis, the effect on the artisanal fleet may not be as great as expected. This does of course depend on the fishing power of the trawling sector. With only 10 trawlers, a seasonal opening may be manageable, however increased profit rekindles interest in such investment. Therefore, an optimal fishery in the Gulf may have elements of both the trawl and artisanal fishery, however it is clear that there will be negative effects on the artisanal fleet in the short term as it rationalised. Many of the artisanal vessels appear highly inefficient compared to others over the regions of the Gulf, shown in the averages of the economic variables reported, and so allowing trawling would make their existence difficult to maintain. A more accurate indication to the trawlers' effect on stocks would require better estimation of the fishing capability of the trawlers.

With respect to the stocks, evidence suggests that many high value species have decreased in abundance since the trawl ban, probably as a result of displacement. In support of trawling, it has been suggested that the increased catch from trawling might allow such species to recover to higher levels, due to increased food availability and decreased predation from other more dominant species. However, this is purely conjecture and would be highly difficult to prove.

Initial estimates of the potential success of the trawl ban from a biological perspective have been far surpassed, however, some of the economic opportunities seem to have been lost. This is evident in two key respects: the inefficiency within the artisanal fleets, and to the uncontrolled expansion of effort in the recreational sector. Due to lack of knowledge, this latter point could not be modelled. However, it appears from anecdotal evidence that recreational fishing appears to have filled the gap left by the trawlers and, it is suspected, has decreased the opportunities for expansion by the artisanal fleet. Nevertheless, the current effects of this are implicitly included in the analysis through known CPUEs and density of species in the Gulf.

In terms of policy, if changes to the trawl ban status were considered, then stricter management of the recreational fishery and any allowed trawling would be a necessity to maintain the benefits that have been realised under the trawl ban. Limiting conditions, such as improved licensing, may be one such management tool. Biological changes may once again occur under such a management system, but measures must be put into place to retain the improvements that have been achieved.

The Gulf of Castellammare exhibits many features and characteristics common to several other areas prosecuted for their fisheries in Europe. The methodology may be transferable, and the results of such analysis may be extremely useful in planning the use and management of future marine reserves or exclusion zones in similar areas.

5. Economic Sustainability of the Artisanal Fisheries[21]

Artisanal fisheries are widely acknowledged to be an important source of income and employment for many countries (World Bank, 1991), and are estimated to account for at least 40% of world fish production (FAO, 2001). These fisheries, characterised by being small-scale and involving fishing households rather than commercial organisations, play a major role in sustaining the livelihoods and ensuring the food security of large numbers of rural people throughout the developing world (Kurien, 1998; Allison and Ellis, 2001). In developed countries also, artisanal fisheries may be important at a local level in helping to maintain communities where alternative employment opportunities are limited. Indeed, it is the community-support role of artisanal fisheries – arguably an important dimension of their 'sustainability' - which is often explicitly recognised in the policy making process, most visibly through measures designed to protect such fisheries from the effects of larger and more powerful vessels. A common method of doing this is via the designation of fishing zones from which non-artisanal vessels are excluded, the rationale being to eliminate gear conflict and to allow artisanal fishermen to enjoy better fishing opportunities. An example of this approach is the trawl ban which was introduced in 1990 in the Gulf of Castellammare to deal with the serious overfishing in the area as well as improving the fortunes of the local small-scale fleet of trammel net vessels (Plate 1). The evidence is now clear that the prohibition on trawling was successful in its primary aim, and contributed significantly to the recovery of the demersal resources (Pipitone et al. 1996, 2000a and 2000b). The artisanal fishery also benefited from the ban, as a result both of the recovery of the stocks as well as the elimination of the conflict with the trawlers that had previously been severe. (Whitmarsh et al. 2002). Though the Gulf of Castellammare fishery reserve is not a pure 'no take' zone, the scientific results to date are consistent with those of other studies that have demonstrated the positive effects of marine protected areas (MPAs) in helping to rebuild fish stocks (Pauly et al., 2002; Roberts et al. 2002)

One of the results of the previously published work on the Gulf of Castellammare concerned the economic sustainability of the artisanal fishery. This suggested that, given the increase in the harvestable fish stocks which had taken place within the trawl ban area throughout the decade, the financial performance of the trammel net vessels was sufficient to make it worth retaining capital within the fishery. Equally, however, there were no obvious signs that profitability was causing the numbers of artisanal vessels to increase or for catching capacity to become excessive in relation to the stocks. Accordingly, the conclusion was that the fishery was sustainable so long as operating conditions – notably the absence of competition from trawling – remained unchanged.

The present paper re-examines this issue, but moves the discussion forward to consider the obvious follow-on question of what the consequences would be of removing this protection from the artisanal fishermen and allowing trawlers unrestricted access to all parts of the Gulf. As part of this exercise we explore the implications for the individual operators, and see what factors are likely to predispose fishermen to want to remain in the fishery or to leave it. The results of the analysis

[21] This section has been based on the results of a paper submitted to the journal *Marine Policy*.

will, we hope, add to the stock of knowledge about the economics of small-scale fisheries and their vulnerability in the face major perturbations or policy shocks.

5.1. Spatial management of fisheries: a bioeconomic framework

The methodology we use to answer this question is best understood by first presenting a stylised picture of a fishery, which mimics in all essentials the one considered here, so as to identify the bioeconomic tendencies that can be expected to emerge under alternative management regimes. Consider, therefore, an open-access fishery where two types of vessel, distinguished by their method of fishing, are in competition. Those of the first type are characterised by the use of low-productivity capture technology, those of the second by more sophisticated and powerful harvesting methods. If we now suppose that the fishery has been partitioned spatially into separate zones (A and B) and that the two vessel types operate exclusively within each (Type 1 vessels in A, Type 2 in B), it can be shown that differences in the harvesting efficiency of the two fleets will be mirrored in the long run by differences in the fish stock biomass of the two zones. This follows from the familiar proposition of bioeconomics that in an open-access fishery effort will enter in pursuit of resource rent, which will be fully dissipated once the exploitable fish stock biomass (X) has been reduced to the economic equilibrium level (Clark, 1985; Hartwick and Olewiler, 1986; Sanchirico and Wilen 1999 and 2001). Given a number of assumptions it can be demonstrated that this equilibrium will be such that:

$$X = [c + \Pi] / pq$$

where:

X = fish stock biomass
c = direct cost of fishing effort
Π = opportunity cost of effort
p = price of harvested fish
q = technical efficiency parameter (‘catchability coefficient’)

The common-sense interpretation of this relationship is that whatever makes a fishery more profitable (e.g. higher price of fish relative to the cost of capture, improved technical efficiency of harvesting) will encourage more effort and cause the exploitable biomass to be reduced. Entry will cease once vessels find that there is no more profit to be obtained, biomass having adjusted to a new (lower) equilibrium level.

For our purposes the crucial parameter is the catchability coefficient (q), because the equilibrium relationship implies that where a fishery is spatially partitioned and vessels of differing technical efficiencies are confined exclusively to separate zones, stock density will be *higher* in the zone reserved for the vessels with *lower* catchability. In our example this will be Zone A, reserved for Type 1 vessels. How many vessels will find it commercially worthwhile to operate in the fishery as a whole, and indeed whether spatial partitioning will create the conditions necessary to support a positive effort in both zones, depends on the biological characteristics of the system. An important factor is the rate of biomass dispersal, and it can be shown theoretically that in a density-dependent fishing system a dispersal rate which is high relative to the intrinsic growth rate of the stock will not be able to support a viable fishery in the zone reserved for the less productive operators (Sanchirico and Wilen, 2001, p.266). This is an important conclusion because it tells us that a policy of merely creating fisheries exclusion zones and restricting access to certain types of vessel (e.g. artisanal) will not guarantee that an economically sustainable fishery based on those vessels will necessarily occur as a result.

We may now explore the reverse scenario, namely the consequences of *removing* access restrictions from a zone previously established for the protection of lower-productivity vessels. To return to our example, let us now suppose that higher-productivity (Type 2) vessels are free to fish in Zone A. Entry will be expected to occur since the starting situation is one where stock density in Zone A is higher than in Zone B and the new entrants will be able to earn profits. Following the same reasoning as before, entry will continue until the stock density in Zone A has been fished down to the level at which the higher-productivity vessels will just break even. Crucially, however, this lower stock level will now be insufficient for the Type 1 vessels to make a profit and they will be forced to exit. The implication of removing zonal protection is therefore stark: the more efficient vessels will expropriate the less efficient in the competition to exploit the resource. Though the speed of this expropriation will depend on the dynamics of the fishery system, the end result is clear.

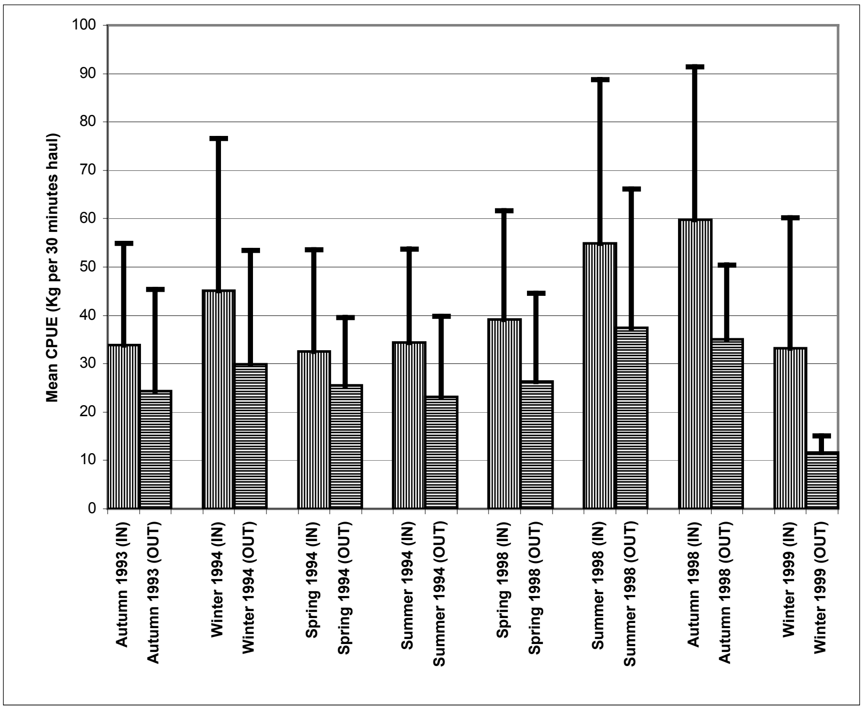
These ideas underpin the methodology that we use to investigate the likely consequences of removing the trawl ban in the Gulf of Castellammare, where the fisheries management regime broadly fits the stylised picture described above. The starting point is an empirical comparison of stock density inside and outside the trawl ban area, the latter being taken as an indication of the level to which stocks would fall if the current exclusion zone were to be opened up to trawling. Given a knowledge of the financial performance of artisanal fishermen within the exclusion zone it then becomes possible to predict how their performance will be impacted once the stock-depleting effects of intensified fishing have worked through. There are a number of important respects, however, in which the bioeconomic model outlined earlier over-simplifies the real situation in the Gulf. To start with, we are not only dealing with a multi-species fishery but one where the range of species harvested by certain of the trammel netters is not identical to that caught by trawlers. It is known, for example, that artisanal fishermen at two of the ports within the protected area of the Gulf generally fish on rocky bottom grounds where the species mix is somewhat different from that found on the soft bottom grounds which are more typical of those targeted by trawlers. This means that, even though intensified trawling can be expected to reduce the demersal resources of the area, the effects on the catches of some of the artisanal vessels may not be as severe as they would be otherwise. Secondly, we know that the trammel-net fishermen making up the artisanal fleet differ greatly in their operating performance, suggesting that in some cases intra-marginal rents are being earned. These may be sufficient to enable some of the better ('highliner') operators to survive even in the absence of protection from trawlers – in contrast to the bleak predictions of the model. To allow for this fact we have analysed the distribution of financial returns across the artisanal fleet as a whole, rather than simply looking at one supposedly 'representative' vessel.

5.2. Removing the Gulf of Castellammare trawl ban: Effects on artisanal fleet performance

5.2.1. Pressure on the stocks

Stock assessments undertaken by CNR-IRMA in 1993-94 and 1998-99, based on experimental trawl surveys, reveal that catch per unit of effort (CPUE) within the area of the Gulf protected by the exclusion zone was higher than in the unprotected area (Pipitone et al. 2000b). This result accords with the expectations of the theory outlined above, since the catchability of the artisanal vessels was substantially lower than that of trawlers and the harvesting pressure applied to the stocks within the exclusion zone correspondingly less. In the 1993-4 and 1998-99 survey periods, CPUE outside the trawl ban area was on average about 60% of that inside, though seasonal variation in both sectors was evident (Figure 5.1). Since the late 1990s, however, there has been strong anecdotal evidence that exploitation by trawlers illegally encroaching the easternmost part of the protected area has increased since the late 1990s, and indeed the non-protected part also seems to be suffering from higher exploitation by trawlers than previously. This is now confirmed by new scientific data suggesting that the differential has widened such that in 2000-01 CPUE outside the trawl ban area was down to approximately 30% of that inside. Given our basic argument that what is observed de facto in the current open-access area provides a portent of what to expect if access restrictions were lifted from the protected area, these estimates (60% and 30%) provide alternative benchmarks for assessing the likely impact of removing the trawl ban.

Figure 5.1: Relative abundance of demersal stocks in- and outside the trawl ban area of the Gulf of Castellammare in 1993-4 and 1998-9. (Error bars denote std. deviations)



5.2.2. Financial viability

The criterion used to assess the sustainability of the artisanal fleet is based on a measure of the financial viability of capital investment, net present value (NPV). This has been calculated for a sample of trammel net vessels operating in 1998-99 from the ports located within the trawl ban area under three scenarios regarding vessel catch rates: (i) maintained at their 1998-99 levels (ii) fall to 60% of their 1998-99 levels (iii) fall to 30% of their 1998-99 levels. The 1998-99 baseline catch rate data were derived from a landings survey undertaken in that year (Pipitone et al, 2000b), while the relevant data on vessel expenses and earnings was obtained in part from the landings survey and also from information supplied by manufacturers regarding the costs of capital items (boat, gear and equipment). Details of how these data were used to calculate NPV are given in Appendix 5.I, but two key points need to be highlighted. Firstly, it is assumed that the changes in artisanal vessel catch rates under scenarios (ii) and (iii) directly reflect the expected changes in stock abundance following the removal of the trawl ban, implying that the catchability coefficient remains constant. Secondly, the NPV calculation has been performed for each of the boats in the sample so as to account for the known variation in operating performance between fishermen. The assumption is that the ranking of performance will remain unchanged under each of the three scenarios, meaning that even though the absolute level of profit may fall under scenarios (ii) and (iii) the relative positions of the fishermen within the hierarchy will be unaffected.

The results are summarised in Figures 5.2 to 5.4. Figure 5.2 represents the baseline case in which the NPV of investment in trammel net fishing is calculated on the assumption that vessel catch rates are maintained at their 1998-99 levels. In over ¾ of the cases NPV was greater than zero, signifying that for the majority of fishermen, capital invested in this activity would be expected to earn a positive return. The implication, therefore, is that under the present regime of fisheries management most (but not all) artisanal vessels could be considered financially viable and accordingly would find it worthwhile staying in the fishery. Figure 5.3 shows the situation where catch rates for the same set of vessels are assumed to be down to 60% of their 1998-99 levels (scenario 2). Here we get a mixed result, such that in just under half the cases NPV is positive while for the rest it is negative. This scenario is interesting because it suggests that, if access restrictions were lifted and stock density was to fall to the level implied by the pressure of fishing observed outside the trawl ban area in the late 1990s, some artisanal fishermen - just under half -would still remain financially viable. This prediction is validated by the observation that in 1998-99 a number of trammel net boats did, in fact, operate outside the trawl ban area (from the port of Terrasini) despite the overt competition from trawlers and despite experiencing on average lower physical productivity than their counterparts located at ports inside the protected zone (Whitmarsh et al. 2002). Scenario 2 therefore suggests that the lifting of the trawl ban, though having a serious adverse impact on the viability of the artisanal fishery, would not necessarily result in its complete elimination. The result with scenario 3, by contrast, is inevitably more pessimistic (Figure 5.4). Here we are considering the situation where vessels in the artisanal fleet suffer a severe fall in catch rates which are assumed to be down to 30% of their 1998-99 levels. The consequence of this is that in none of the cases is NPV positive, meaning that even the more efficient operators would become financially unviable and in the long run could be expected to exit from the fishery. If we regard scenario 3 as the more realistic outcome, which is not unreasonable given that it is based on the most recent set of observations, the prospects for the artisanal fishery are less than auspicious.

Figure 5.2: Net present value (NPV) of investment in trammel net fishing assuming vessel catch rates maintained at 1998-99 levels

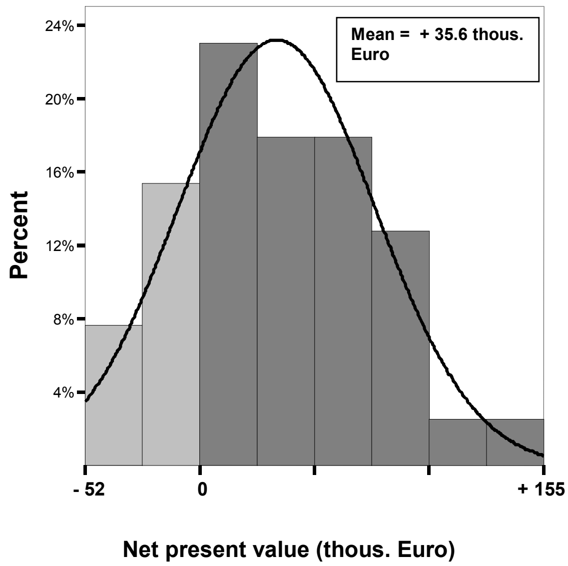


Figure 5.3: Net present value (NPV) of investment in trammel net fishing assuming vessel catch rates reduced to 60% of their 1998-99 levels

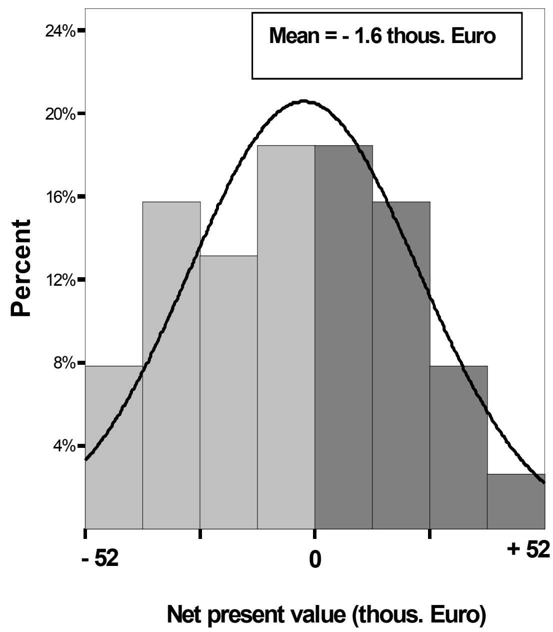
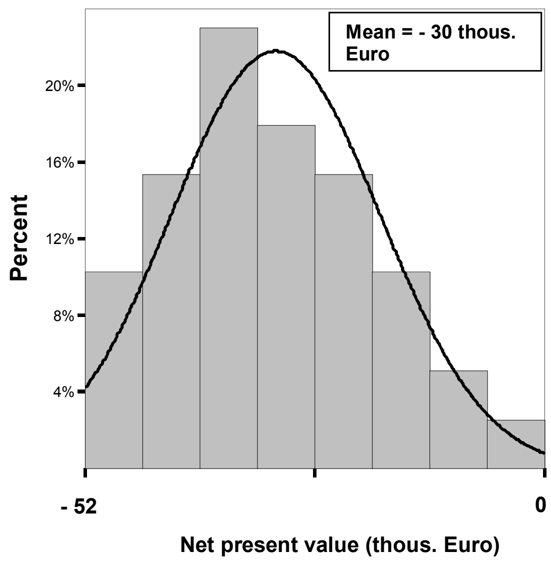


Figure 5.4: Net present value (NPV) of investment in trammel net fishing assuming vessel catch rates reduced to 30% of their 1998-99 levels



5.3. Fishermen's expressed intentions

A question which naturally arises from the previous analysis concerns fishermen's attitudes towards the trawl ban and the influences that would be likely to shape their intention to remain in the fishery or quit if the ban were lifted. A motivation survey undertaken in 1998-99 (Pipitone et al. 2000b) revealed that many artisanal fishermen would give up fishing if the trawl ban were removed, the major reasons given being intensified competition, worsening gear conflict and the increased costs of gear replacement. Those that signalled their intention to carry on typically stated that it was because there were no alternative sources of employment, implying that the opportunity cost of their labour was low or close to zero. Here we have re-worked the data from the original survey, which produced 36 usable answers from fishermen located within the protected area of the Gulf. This figure represented approximately half the total number of artisanal vessels registered at the three inner ports in 1998-99. Out of this sample, just over 44% declared explicitly that they would carry on if the trawl ban were lifted, while 50% confirmed that they would exit from the fishery. Fewer than 6% gave non-committal answers. This slight preponderance in favour of fishermen wishing to leave, as against those wishing to remain, is all the more interesting in the light of the analysis from the previous section. There it was predicted that under Scenario 2 (catch rates falling to the level of that obtaining outside the trawl ban area in 1998-99) a sizeable minority of artisanal vessels would find it financially worthwhile to remain in the fishery. The split of choices made by the fishermen themselves – those wanting to quit slightly outnumbering those wanting to carry on - thus supports our earlier result.

These contingent responses to the lifting of the trawl ban can be validated by comparing the financial performance of the 'stayers' and 'leavers' groups of fishermen. Table 5.1 shows the results of an independent samples t-test in which we have compared the two groups of fishermen against their performance in 1998-99 measured in terms of the profit-to-sales ratio (i.e. the share of profit in total revenue). Fishermen committed to carrying on in the face of a relaxation of the trawl ban generally out-performed those intending to give up, the former having a mean profit ratio of 0.547 as against 0.072 for the latter. As the results of the t-test show, the differences in the means was statistically significant. To pursue this line of enquiry further we have undertaken a logit analysis in order to establish whether profitability can be used as a predictor of the likelihood of a fisherman wishing to remain in the fishery or leave. In logit analysis the response variable is treated as dichotomous (i.e having a value of zero or one), with the regression coefficients on the independent variables being estimated by the method of maximum likelihood (Gujurati, 1999). The estimated logit model can be used to calculate the *odds ratio* (the probability of an event occurring divided by the probability of its not occurring), and from this the probability of the response variable falling into one or other of the binary categories. In this instance the response variable is the intention to either remain in the artisanal fishery or to leave, with fishermen asked to make a discrete choice contingent upon the trawl ban being removed.

Table 5.1: Independent samples t-test of the differences in group means of the financial performance of artisanal vessels

Groups Statistics

Variable	Group	N	Mean	Std. Deviation	Std. Error Mean
PROFITABILITY	Remain	16	0.5470	0.2342	0.0585
	Exit	18	0.0717	0.7053	0.1662

Independent samples t-test

			PROFITABILITY	
			Equal variances assumed	Equal variances not assumed
Levene's Test for Equality of Variances	F		6.804	
	Sig.		0.014	
t-test for Equality of Means	t		2.569	2.697
	Sig. (2-tailed)		0.015	0.013
	Mean Difference		0.4754	0.4754
	Std. Error Difference		0.185	0.1762
	95% Confidence Interval of the Difference	Lower	0.0985	0.109
		Upper	0.8522	0.8418

Note: Profitability is measured as the ratio of financial profit to total revenue.

The logit model was initially estimated with two independent variables, the first being profitability (as previously defined) and the second being a dummy variable measuring fishermen's attitudes towards future prospects in the fishery. The latter was derived from a series of questions asking fishermen whether they expected there to be an improvement or a deterioration in the fishery, the answers being used to classify fishermen as 'optimists' or 'pessimists'. The rationale for including this attitude variable in the logit model was to see whether fishermen's view of prospects under the present regime of fisheries management (i.e. with the trawl ban intact) had any bearing on their attitude towards prospects under a different regime (i.e. without the ban), and hence on their willingness to stay in the fishery. The results of the preliminary analysis showed, in fact, that the attitude variable was statistically insignificant, and the model was accordingly re-run with profitability as the only independent variable. The results are given in Table 5.2, and show that the estimated regression coefficient on the profitability variable (2.572) is statistically significant. What this means, therefore, is that fishermen's intentions to carry on in the event of the trawl ban being lifted are positively associated with current financial performance. Indeed, the estimated results enable us to calculate, on the basis of the known profit ratios, what the probability will be of any individual fisherman choosing to remain in the fishery rather than quit. For a fisherman with a profit ratio of 0.5 (i.e. profit comprising 50% of total revenue), the probability is 0.55 – in other words, slightly in favour of remaining. By contrast, a fisherman who is only just covering costs would have only a 0.25 chance of choosing to stay in the fishery in the event of the trawl ban being lifted.

Table 5.2: Logit analysis of fishermen's intentions to either remain in the fishery or to exit following removal of the trawl ban

Model summary

Total	Exit	Remain	-2 log likelihood	Cox & Snell R^2	Nagelkerke R^2
34	18	16	39.311	0.203	0.271

Variables in the equation

Variable	B	S.E.	Wald	Sig.	Exp(B)
PROFITABILITY	2.572	1.236	4.332	0.037	13.094
CONSTANT	-1.096	0.669	2.683	0.101	0.334

Note: The dependent variable takes a value of zero or one depending on whether a fisherman intended to either leave the fishery or remain following removal of the trawl ban

5.4. Conclusions

The artisanal fishery in the Gulf of Castellammare appears to be sustainable under the present regime of fisheries management. This claim rests on the *ex post* evidence that for several years the fishery has provided a flow of benefits to producers and consumers which has not entailed heavy pressure on the resource and has therefore not jeopardised future harvesting options. Since 1990 demersal stocks in the Gulf as a whole have recovered well, and within the trawl ban area have been maintained at a high and stable level. Reassuringly too, the profitability of the artisanal fishery has not so far led to any significant expansion in the number of commercial operators – a state of affairs which contrasts with other marine fisheries (e.g. Indonesia) where trawling bans have caused an expansion in fishing effort by the small-scale fleet (Bailey, 1997). The sustainability claim is also supported by the *ex ante* assessments made in this paper showing that artisanal fishing is capable of earning an adequate return on investment for most vessel owners and is therefore likely to remain retentive of capital in the long run. This finding underscores the difference between ecological and socio-economic definitions of sustainability (Charles, 1994, 1998 and 2001) and highlights the need to recognise that 'sustainable development' in the context of fisheries is as much concerned with human well-being as with the maintenance of the natural environment (Alder et al., 2002; Garcia et al. 2000). It is perfectly possible in theory for restrictions on powerful fishing methods such as trawling to be successful in ecological terms (by enabling stocks to be protected and rehabilitated) but to be unsuccessful in socio-economic terms if the recovery in the stocks is not sufficient to support a financially viable alternative fishery based on less environmentally destructive methods. A totally unexploited resource would most surely be 'sustainable' in the sense that it could persist in perpetuity, but apart from pure conservation benefits (i.e. unpriced passive use values) there would be no gain to society in terms of material output. In the case of the Gulf of Castellammare, however, the partial exclusion zone has evidently been successful along both dimensions of sustainability: the resource has been rehabilitated, and a viable fishery has been supported.

Removal of the trawl ban would undermine this sustainability. Stocks within the current protection zone can be expected to be reduced under the intensified pressure of fishing, imposing an external cost on artisanal vessels which would manifest itself in lower catch rates. The analysis presented in this paper traces through the implications of this stock externality by seeing how far it would impact on the financial viability of individual vessel operators and hence on their ability (and willingness) to remain in the fishery. The main area of uncertainty concerns the magnitude of the stock reduction that increased trawling would entail, since the observable trend outside the current trawl ban area suggests that the impact of trawling is likely to be more severe than previously thought. Under the more favourable scenario, opening up the whole of the Gulf to trawling would result in the elimination of just over half the artisanal fleet of trammel netters. Under the less favourable, but possibly more realistic, scenario the prognosis is far more bleak. None of the artisanal vessels is likely to remain financially viable, and it is difficult to see how in the long run any could remain in operation. This analysis has its counterpart in terms of fishermen's attitudes. Artisanal fishermen, faced with the prospect of the trawl ban being removed, have been shown to have a predisposition towards either staying in the fishery or quitting which is influenced by their current financial performance. Evidence from both the motivations survey and the landings survey undertaken in 1998-99 suggests that the propensity to remain in the fishery declines with profitability. By way of illustration, the results of the logit analysis showed that an artisanal operator who was just breaking even would be roughly three times more likely to quit the fishery than stay in the event of the trawl ban being removed. This result is quite important, because it supports the contention that the current financial performance of fishermen – specifically, whether it is weak or strong – is likely to influence their attitudes and responses to future events that are expected to impact on that performance. The obvious inference to draw is that the closer fishermen are to the margin of 'acceptable' performance, the less willing are they likely to be to continue in the fishery if circumstances take a turn for the worse – which is precisely what is anticipated to happen if the trawl ban were removed.

Appendix 5.I: Net present value calculations

Net present value (NPV) has been calculated for each vessel comprising the sample of trammel net fishermen based at the three inner ports of the Gulf of Castellammare in

1998-99. It represents the financial worth of investment in this activity under a given set of assumptions that define the stream of revenue and costs over a specified time horizon. The opportunity cost of capital is represented by the discount rate, which is incorporated into the calculation as follows:

$$NPV = \frac{[R_0 - C_0]}{[1 + r]^0} + \frac{[R_1 - C_1]}{[1 + r]^1} + \frac{[R_2 - C_2]}{[1 + r]^2} \ldots\ldots + \ldots\ldots \frac{[R_n - C_n]}{[1 + r]^n}$$

where:

$R_0 \ldots R_n$	=	Revenue earned in years 0 to n
$C_0 \ldots C_n$	=	Costs incurred in years 0 to n
r	=	Discount rate
n	=	Investment Time horizon in years

NPV has been calculated for each vessel based on revenue and cost data obtained from surveys undertaken in 1998-99 (Pipitone et al. 2000b). The discount rate is taken as 8% and the time horizon 20 years, at the end of which it is assumed that the salvage value of the vessel and gear is zero. Running costs incurred annually include: fuel, ice, bait, garage and loft expense, wharfage, wholesalers commission, other running expenses. Fixed costs incurred annually include: repairs, taxes and other items. Where vessels employ extra crew, labour costs are based on a share of net revenue (total revenue minus running costs). Capital items are assumed to be purchased or replaced with the following frequencies: vessel every 20 years, engine every 10 years, headline and footrope every 5 years, net every year.

In the baseline NPV calculations, the revenue stream is represented by the actual sales value of landings earned by each vessel. Differences are taken as indicative of variations in skill, efficiency and catch composition. Costs are also based on those actually incurred by individual operators, with the exception of the following items which are treated as being the same for all fishermen: capital items (boat, engine and gear), repairs, tax and other fixed costs. Capital costs are treated the same since vessels are similar in terms of size and technology.

Scenarios 2 and 3 maintain these assumptions but recalculate NPV assuming that catches for each vessel are reduced to (a) 60% and (b) 30% of their baseline level. This necessarily reduces the revenue stream for all vessels, but for vessels which employ extra crew it also partially reduces labour costs since crew payments are a function of net revenue.

6. The Gulf of Castellammare Compared to FEZs in Greece

The Greek seas, like elsewhere in the Mediterranean, feature multispecies and multigear fisheries that are hard to manage, due to the different and conflicting factors in play. According to G. Petrakis[22] (pers. comm.), several fishing exclusion zones (FEZs) were created in Greece in the last three or four decades, aimed at releasing the overexploited fish stocks from excessive fishing effort. Stergiou & Petrakis (1993) and Stergiou & Pollard (1994) suggested the use of experimental FEZs (in the form of marine harvest refugia) in the North Aegean continental shelf as a first tentative step to address the overexploitation problem common to the inshore demersal Greek fisheries.

The main FEZs implemented in the Greek seas are:

1. Patraikos and Korinthiakos (Ionian Sea): 6-month trawl ban;
2. North Euvoikos (Aegean Sea): 6-month trawl ban;
3. South Euvoikos and Pagasitikos (Aegean Sea): year-round trawl ban;
4. Three wide Aegean areas (Gulf of Thermaikos/Thracian, North Aegean and Cyclades/Dodecanessos) are subjected to fishing bans, but no further details are available to us.

Considering the similarities between the above areas and the Gulf of Castellammare in terms of management regime (in all areas artisanal fishing is permitted), IRMA activated a collaboration with the National Centre for Marine Research (NCMR, Athens) in the context of VALFEZ, in order to compare the results obtained in different Mediterranean FEZs as a consequence of a multi-year trawl ban. The task wasn't an easy one. Other than the similar type of data available (CPUEs from experimental trawl surveys), there was very few information deemed useful to directly compare the two areas.

In this section, we report the catch trends in some Greek FEZs and discuss briefly the results side-by-side to the Castellammare case.

6.1. Data Set

After a preliminary survey of the data stored in the files of the Dept. of Fisheries at NCMR, it was decided to select data that would allow for two kinds of comparison:

i. between areas with a different management regime at the same time *(=spatial analysis)*;
ii. between different periods in the same area *(=temporal analysis)*.

For case i) data collected in Pagasitikos in 1986-88 were compared to data collected in Petalii at the same time; the two areas have similar biotic and geomorphologic features. Pagasitikos (=year-round trawl ban) represented the impact site, while Petalii (=4-month trawl ban, from June to September) represented a control site.

For case ii) data collected in Pagasitikos in 1987 were compared to data collected in 1999 in the same area.

The data were CPUEs (catch per unit effort expressed in kg/h) of the total catch collected during experimental trawl surveys. The number of hauls was: 48 in Pagasitikos 1986-88, 48 in

[22] *George Petrakis is at the National Centre for Marine Research, Athens, Greece*

Petalii 1986-88, 40 in Pagasitikos 1999. Samples were collected according to a stratified random sampling design based on bathymetric strata, a frequently used design in Mediterranean trawl surveys (e.g.: Bertrand et al., 2000). Strata are as follows: A (10-50 m), B (51-100 m). The lack of catch data from single hauls made statistical testing impossible.
Fig. 6.1 shows the study areas:

Figure 6.1: Map of the study areas in Greece

6.2. Data Analysis

6.2.1. Spatial analysis

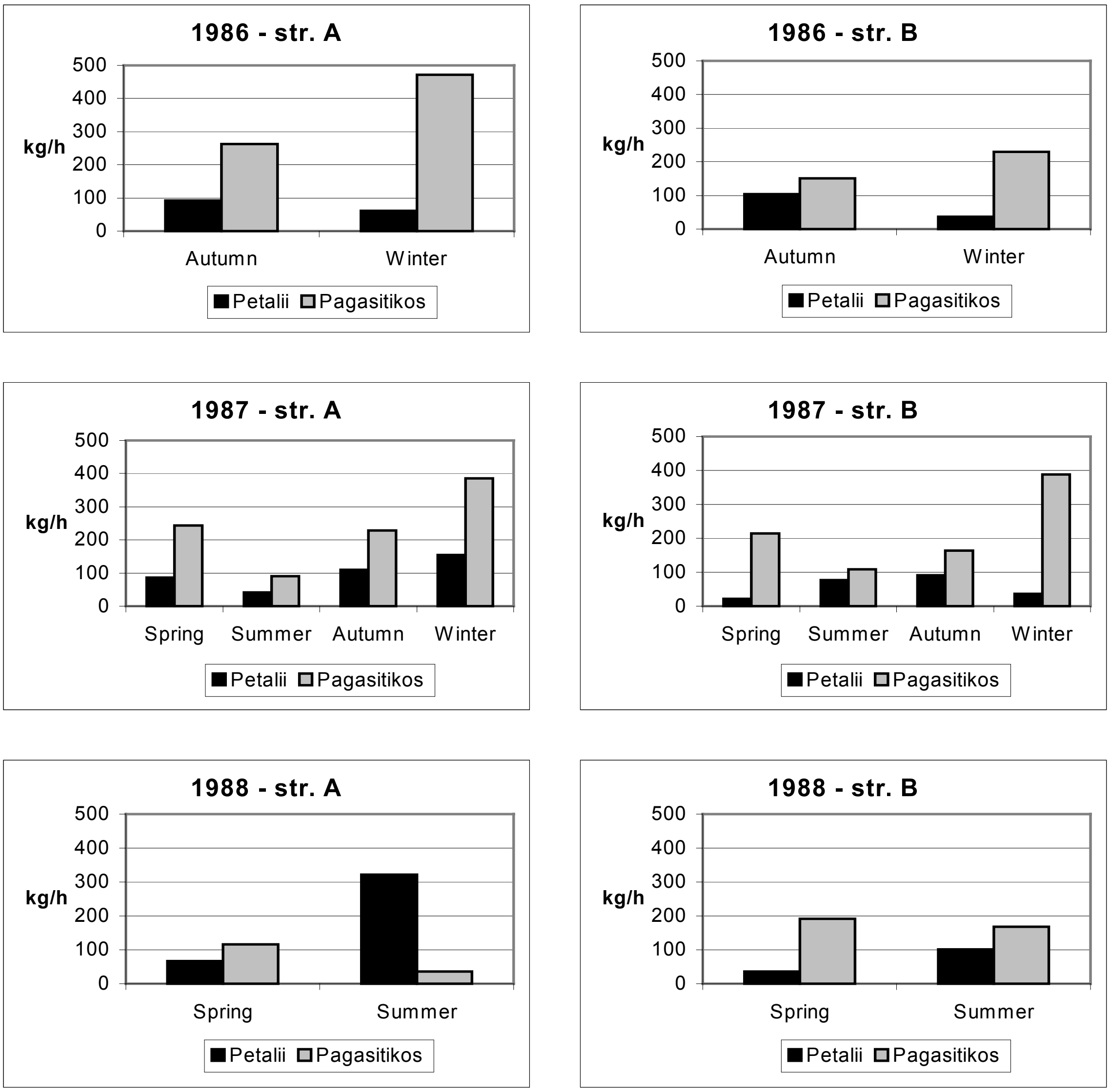
The CPUEs for each site are reported in Tab. 6.1:

AREA	YEAR	SEASON	STRATUM	CPUE (kg/h)
Pagasitikos	1986	Autumn	A	262.00
Pagasitikos	1986	Autumn	B	150.52
Pagasitikos	1986	Winter	A	471.53
Pagasitikos	1986	Winter	B	230.16
Pagasitikos	1987	Spring	A	243.75
Pagasitikos	1987	Spring	B	213.87
Pagasitikos	1987	Summer	A	91.00
Pagasitikos	1987	Summer	B	108.42
Pagasitikos	1987	Autumn	A	228.96
Pagasitikos	1987	Autumn	B	164.19
Pagasitikos	1987	Winter	A	385.60
Pagasitikos	1987	Winter	B	388.36
Pagasitikos	1988	Spring	A	115.40
Pagasitikos	1988	Spring	B	190.74
Pagasitikos	1988	Summer	A	36.60
Pagasitikos	1988	Summer	B	167.46
Petalii	1986	Autumn	A	91.80
Petalii	1986	Autumn	B	104.16
Petalii	1986	Winter	A	60.98
Petalii	1986	Winter	B	36.70
Petalii	1987	Spring	A	86.40
Petalii	1987	Spring	B	21.87
Petalii	1987	Summer	A	41.66
Petalii	1987	Summer	B	76.93
Petalii	1987	Autumn	A	110.10
Petalii	1987	Autumn	B	91.30
Petalii	1987	Winter	A	153.60
Petalii	1987	Winter	B	36.69
Petalii	1988	Spring	A	67.05
Petalii	1988	Spring	B	36.00
Petalii	1988	Summer	A	322.20
Petalii	1988	Summer	B	101.70

Table 6.1: CPUE data for the spatial analysis

Fig. 6.2 gives a graphic representation of the data in Tab. 6.1:

Figure 6.2: CPUE data for the spatial analysis



6.2.2. Temporal analysis

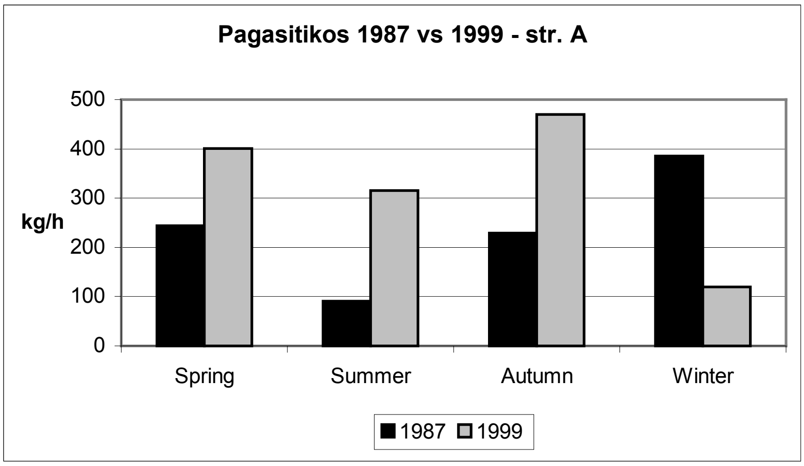
The CPUEs for Pagasitikos 1987 and 1999 are reported in Tab. 6.2:

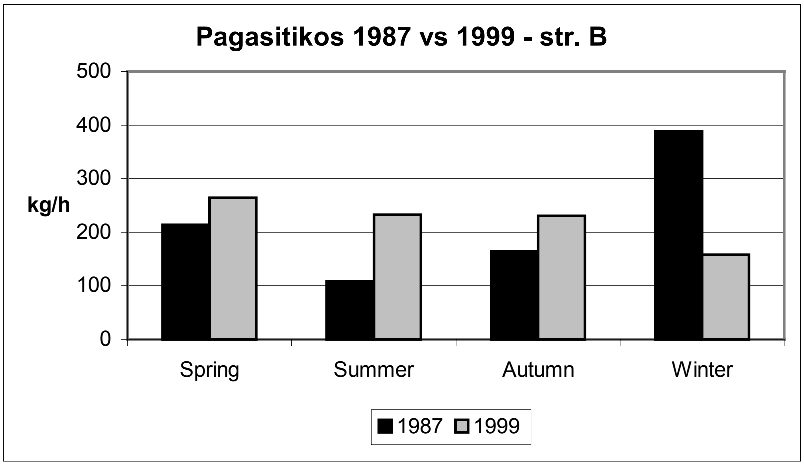
YEAR	SEASON	STRATUM	CPUE (kg/h)
1987	Spring	A	243.75
1999	Spring	A	400.51
1987	Summer	A	91.00
1999	Summer	A	314.83
1987	Autumn	A	228.96
1999	Autumn	A	470.12
1987	Winter	A	385.60
1999	Winter	A	119.68
1987	Spring	B	213.87
1999	Spring	B	264.63
1987	Summer	B	108.42
1999	Summer	B	232.85
1987	Autumn	B	164.19
1999	Autumn	B	230.89
1987	Winter	B	388.36
1999	Winter	B	158.27

Table 6.2: CPUE data for the temporal analysis

Fig. 6.3 gives a graphical representation of the data in Tab. 6.2:

Figure 6.3: CPUE data for the temporal analysis





6.3. Discussion

An analysis of the Greek FEZs is not easy, due to the scarcity of available data and the lack of regular monitoring over the demersal resources. Also the literature is particularly poor, being limited (to our best knowledge) to a technical report (Papaconstantinou et al., 1989) and to a short article containing few and poorly presented data (Vassilopoulou & Papaconstantinou, 1999). It is hard to assess even the year when each single management regime was put in force (G. Petrakis, pers. comm.). Apparently there has not been any effort to monitor the state of demersal resources in order to assess the effect of the trawl ban. This is a major problem in many Mediterranean areas, where management bodies and political institutions do not show much interest in a correct (and probably politically hard to enforce) resource management, and the financial resources allocated to such monitoring activities are very scarce.[23]

The spatial analysis (Tab. 6.1, Fig. 6.2) shows that the CPUEs were always higher in Pagasitikos (=year-round protected area) irrespective of year, season or depth. In summer and autumn the difference is less marked: this could be due to the effect of the trawl ban enforced in Petalii from June to September, which seems to allow for a recovery of fish stocks. The summer 1988 CPUE from stratum 1 is surprisingly high in Petalii. Since we do not have detailed catch data, at this stage we cannot investigate the reasons of this countertendency.

The temporal analysis (Tab. 6.2, Fig. 6.3) shows that, within the Pagasitikos year-round protected area, CPUEs in 1999 were higher than in 1987 in both depth strata. This could be due to a build-up effect of the ban through time: although the effect of the ban was already evident in 1987 (as demonstrated by the spatial analysis), such effect seems to have increased over the years. A striking countertendency arises from winter CPUEs, which are much higher in 1987. Again, the lack of detailed by-haul data prevented us from making any inference on the reason of such result.

A direct comparison between Pagasitikos and Castellammare (i.e., the two zones subjected to a year-round ban) is not easy. CPUEs in Pagasitikos were generally much higher than in Castellammare (see Fig. 6.5), even compensating for the double duration of experimental tows in the Greek seas, but we don't know the technical characteristics and the performance of the Greek vessel. Further, Pagasitikos has been closed to trawlers for many more years than Castellammare (its ban dates back to the Sixties), and this could have lead to a continuous (even though most likely at a progressively slower rate), increase of biomass. Also the seasonal pattern of CPUEs between the two areas is not similar (nor it is consistent within each area).

Notwithstanding the difficulties met in the analysis of the Greek data and in the attempted comparison between Castellammare and Pagasitikos, at least two aspects are common to both areas: the much larger abundance of fish within the banned area compared to an outside less (or not at all) protected area (for Castellammare, see the analysis of spatial effect in section 3), and the increase of fish biomass over time within the banned area. Differences between the two areas may be attributed to differences in the size and structure of the artisanal fleet, in the type of sea bottom, in the environmental parameters, in the fish assemblage or in the density and size structure of fish populations before the ban. Both case studies bring evidence of a high effectiveness of the year-round trawl ban, when the increase of stock size in the main

[23] This preamble is intended also as a justification for the inadequacy of our analysis, based on few data and lacking any statistical test. Nonetheless our analysis sheds some light on the effect of the year-round trawl ban in Pagasitikos.

purpose of fisheries management. Such evidence suggests that trawl bans can be successfully implemented in most areas where there is need for rebuilding depleted stocks. At the same time, an increase of catches and an enhancement of the economic performance for the artisanal fishermen operating inside the areas banned to trawlers are likely to occur (Bailey, 1997; Pipitone et al., 2000; Whitmarsh et al., in press). Small experimental FEZs could be implemented before extending the ban to larger areas, provided that the effect of the ban is monitored by *ad hoc* scientific surveys.

7. References

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