SCI. MAR., 62 (Supl. 1): 101-106 SCIENTIA MARINA 1998

NEPHROPS NORVEGICUS: COMPARATIVE BIOLOGY AND FISHERY IN THE MEDITERRANEAN SEA. *F. SARDÀ (ed.)*

Comparative technical aspects of the *Nephrops norvegicus* (L.) fishery in the northern Mediterranean Sea

FRANCESC SARDÀ

Institut de Ciències del Mar (CSIC), P. Joan de Borbó s/n, 08039 Barcelona, Spain

SUMMARY: A comparative study of the technical characteristics of the Norway lobster fishery in the Mediterranean Sea is presented. The different trawl vessels, trawl gears, trawling manoeuvres, and status of the statistics compiled by the administrations are described. The main conclusions are that catchability has increased with technological advances, official landings statistics are flawed in most of the Mediterranean, and fishing methods differed from country to country.

Key words: Norway lobster, *Nephrops norvegicus*, Mediterranean Sea, fishery, trawl, landings, fishing technology.

RESUMEN: COMPARACIÓN DE ASPECTOS TÉCNICOS EN LA PESQUERÍA DE *NEPHROPS NORVEGICUS* EN LA ZONA DEL NORTE DEL MEDITERRÁNEO. – En este trabajo se presenta un estudio comparado de las características técnicas de la pesquería de cigala en el Mediterráneo. Se describen los tipos de embarcaciones, artes, maniobras y estado de las estadísticas procedentes de la administración. Las principales conclusiones destacan un aumento de la capturabilidad en relación al avance tecnológico, unas estadísticas oficiales deficientes en la mayor parte del Mediterráneo, y unas técnicas pesqueras bien diferenciadas entre paises.

Palabras clave: Cigala, *Nephrops norvegicus,* Mediterráneo, pesquería, pesca de arrastre, desembarcos, tecnología pesquera.

INTRODUCTION

Fishing methods employed in the fishery mainly directed at *Nephrops* in the Mediterranean differ substantially. Such differences influence the quality and type of information available, which may in turn limit the reliability of scientific comparisons and interpretations.

We believe that the reliability of the quantitative information provided by government agencies and fishermen's associations is uncertain. On the other hand, compilation of field data by scientists directly from fishermen can offer valuable insight into the bias resulting from data collection procedures.

Literature describing fishing methods and gears (Lleonart and Sardà, 1986; Brabant and Nédédec, 1988; Prado and Drenière, 1990) and studies on the state and evolution of the fishery (Lleonart, 1993; Charbonnier, 1990; Martín, 1991) exists for the Spanish Mediterranean. However, there are no similar general papers for the *Nephrops* fisheries in other Mediterranean countries that can be used comparatively. Furthermore, the official landings statistics that have been published by FAO (Anon., 1993) offer low reliability.

*Received 15 January 1997. Accepted 10 October 1997.

Therefore, this paper can only present a description, qualitative study, and comparison of the fishing methods (vessels, gears, and marketing opportunities) involved in the harvesting of Norway lobster in the different regions considered. All these aspects should help shed light on the major problems encountered when attempting to set up a global management strategy for Norway lobster in the Mediterranean.

METHODOLOGY

A qualitative methodology has been used to define specific techniques as the only way to achieve precise, up-to-date information on the *Nephrops* fishery and thus pinpoint where information is inaccurate and as such a major contributor to inconsistencies in the quantitative data. Official statistics were excluded from this study, and the information used was collected on visits to the fishing harbours and was compiled directly from fishermen, using questionnaires designed specifically for that purpose on the basis of the experience of the participating scientists. This information is not amenable to statistical treatment but can readily be analysed and compared and thus has been collated according to the following procedure:

*Manoeuvres, fishing technology, and vessel characteristics (Table 1).

*Fishing gear structure (Table 2).

*Landings, sales and data recordal (Table 3).

Data and information processing:

1. Collection of precise, specific information on the *Nephrops norvegicus* fishery by questionnaire.

2. Standardization and comparison of the information collected, eliminating non-relevant or inexact information that might be misleading.

3. Arrangement of the data using a standardized table layout for integration and comparison.

RESULTS AND DISCUSSION

Results based on the filtered information are presented in Tables 1, 2, and 3. An analysis of those Tables has elucidated the following aspects:

TABLE 1. – Vessel size, equipment and technical characteristics of differents areas studied. +, yes. -, no.

	Atlantic	Alboran	Catalan	Ligurian	Tyrrhenian	Adriatic	Euboikos
Port	Faro	Malaga	Barcelona	St. Margarita	St. Stefano	Ancona	Chalkis
Vessels (nº)	31	20	20	5-12	6	120	13
Working time (h)	24	16	12	12-16	12-18	96	14
Fishing time (h)	18	12	8	8-10	8-10	12 to 24	10
Mean depth (m)	450	400	450	400	400	80-110	150-200
Mean GRT (t) (min-max)	50	43 (47-53)	52 (45-125)	33 (10-54)	56 (33-120)	41 (12-109)	56 (56-116)
Hp Mean (min-max)	280	250 (190-400)	500 (400-1200)	290 (220-420)	470 (220-800)	300 (200-1000)	400 (275-500)
Warp (Ø mm)	16	16	16	11	14	12	11-26
Warp whinch	+	+	+	+	+	+	+
Gear whinch	+	+	+	-	-	+	+
GPS	+	+	+	+	+	+	+
Echo sounder	+	+	+	+	+	+	+
Plotter	+	+	+	-	+	+	-
Remote gear control	-	±	±	-	-	-	-
Door size (m)	1.8x1.1	2.5x1.25	2.3x1.4	1.6x1.09	1.8x1.15	0.9x1.0	2.2x1.3
Door weigth (k)	340	450	450	100	350	200	180
Mouth spread (m)	22-25	20-22	22-24	12	18-20	17	14
Bridle length (m)	250	250	250	250	260	250	230
Strech mesh size (mm)	45	55	38-40	40	40	38-40	32
Codend close	sewed	sewed	sewed	sewed	knoted	sewed	knoted
Chains	+	+	±	+	+	+	+
Trawling speed (kn)	3	2.8-3.5	3.5-4	2.5	3-3.5	3.5	2.7-3
Hauls/day	3	2-3	2	2-3	2-3	6.8	2-7
Stern	+	+	+	+	+	+	+
Total landings at ports in the area	5	5	3	7	3	2	1

General aspects

Norway lobster (*Nephrops norvegicus*) fisheries in the Mediterranean follow the general patterns of trawl fisheries (Sardà, 1998), due to their multispecies character. Although trawling on Norway lobster grounds is an activity directed primarily at the Norway lobster itself, hake (*Merluccius merluccius*), monkfish (*Lophius* sp.), conger eel (*Conger conger*), blue whiting (*Micromesistius poutassou*), and megrim (*Lepidorhombus boscii*) are also important target species.

The behaviour of Norway lobster is strictly benthic, mostly restricted to burrows, without any migratory activity (Farmer, 1975); and accordingly fishing techniques are fairly similar for this species throughout the Mediterranean, where the use of pots and trammel nets is uncommon.

The Norway lobster catch is highly variable over time (Thomas and Figueiredo, 1965; Bailey, 1986; Tully and Hillis, 1995), and that is also true in the Mediterranean Sea seasonally, weekly, and daily (Froglia, 1972; Artegiani *et al*., 1979; Sardà, 1995). That variability precludes the possibility of carrying out a directed fishery targeting only that species, hence the fishing gears are not totally modified or adapted to the capture of Norway lobster alone, because the species is considered one component of a multispecies fishery. In order to be able to catch other valuable species, the height of the quarter and top wings is increased, the trawl is hauled at a higher speed, and the bellies are fitted with larger mesh sizes. However, on Norway lobster grounds the wingtips are usually fitted with chains extending across the trawl opening at times of peak abundance. During trawling, these tickler chains are positioned about 1 m in front of the ground wire, thus facilitating "lifting" of Norway lobsters for pick-up by the trawl gear (Main and Sangster, 1985; Newland and Chapman, 1989).

Yields for the different localities vary from 15 to 20 kg/km^2 annually, suggesting fairly constant densities in all areas. Density studies carried out in N. Atlantic countries (Briggs, 1987; Chapman and Bailey, 1987) indicate a density-dependence between the number of individuals and individual size throughout the species' distribution range, including a preference for bottom type. Stocks in two specific localities differ significantly from the rest: shallow-water populations off the Ebro River delta (Maynou, 1998) and the Alborán Sea (Sardà, 1998). These populations exhibit considerably larger individual sizes and lower densities than in the remaining Mediterranean stocks.

Technical aspects

Vessel size and equipment

Average gross registered tonnage (GRT) is similar in all the study areas, (except the Ligurian Sea), (Table, 1) suggesting a tendency towards optimization of vessel size in relation to the trawl gear used and operating expenses. Smaller vessels would not allow deployment of two winches (one for the warp and the other for the net), proper engine aeration, to have fridge or the catch on deck. Larger boats would have higher fuel expenses. However, this is not an impediment to larger engines, which have real power ratings much higher than described in Tables 1 and 2 (as much as 25-40% higher than registered). In summary, the vessels employed in the Mediterranean are small to medium in terms of GRT, but with high engine power ratings that on occasion exceed 1 000 HP (registered up to 700-800 HP).

Given the low catches obtaining in the Mediterranean and the high prices fetched by accompanying species, the increase in engine power is reflected in manoeuvring speeds and higher trawling time as a result of shorter transit times from the ports to the fishing grounds, shorter hauling times, and larger gears with larger otter doors and wider mouth openings.

In addition, new technological improvements in vessel construction are continuously being implemented: reinforced sterns, stronger bridge masts, larger otter doors, new engines, and hydraulically powered operation of warps during hauls.

New technologies are also being brought to bear on fishing procedures: global satellite positioning (GPS) aids in the accurate positioning of trawls through the use of electronic plotters as well as in locating and avoiding reefs, rocks, and wrecks; depth sounders; and remote acoustic gear control devices. All these measures represent increases in fishing effort that are difficult to quantify. In summary, in the last five years fishing effort on Norway lobster stocks has increased considerably, without any proper recording or assessment of those changes having been made.

Thus, the main problem in Norway lobster management is the unrecorded increase in fishing effort, with a concomitant increase in effective trawling time, as a result of:

-Increased engine power (although the total power per port does not vary), directed towards vessels working deeper Norway lobster and shrimp fishing grounds.

-Increased catchability due to the improved abil-

ity of gears to hug the sea bed, thanks to remote telemetry and control of trawl operations (a reminder concerning the limited locomotive capabilities of Norway lobster is relevant here).

-Pursuant to the two preceding factors, a general increase in the fishing effort deployed on *Nephrops* stocks, resulting from increased manoeuvrability and speed and more accurate vessel positioning.

Working time and fishing time

Fishing time is established on a daily basis, with local modifications which may amount to differences of 2-4 hours depending on the distance from the port to the fishing grounds (Table 1). The difference in actual working times comes to 2 hours on average. Working times may be considered homogeneous in each area, except for the Adriatic, where the continental shelf is wide and boats work 2-3 day shifts. In the Euboikos Gulf there is a six-month closed season, and during the open season fishing boats work 10-14 hours or more a day. This and the proximity of the fishing grounds to the ports result in an increase in the effective fishing time. The Adriatic and Euboikos Gulf stocks are shallow-water stocks, with marked population differences with respect to the remaining Mediterranean stocks (with the exception of the Ebro River delta stock).

Gear structure

Three different trawl gear structures have been observed: Atlantic and western Mediterranean trawls (Portugal and Spain), central Mediterranean trawls (Italy), and eastern Mediterranean trawls (Greece). The main characteristics of each type are summarized in Table 2. Very low Norway lobster catches are reported in Mediterranean in France.

Possible reasons accounting for the differences observed may include:

1.Spanish and Portuguese trawls have wider mouth openings and are longer. The low yields in these areas and the narrow continental shelves require maximization of efficiencies by using high-powered engines and larger trawls. As a result, the mesh size in the wings is relatively larger than the mesh size in the codend, and drag on the trawl netting is concentrated on the wings. Towing speed and are higher, and accordingly the trawl is fitted with longer codends.

2.Italian trawls are comparatively smaller, with smaller mouth openings and relatively lower wing to codend mesh size ratios.

3.Greek trawls are longer than the others because of their smaller codend mesh size.

In summary, Italian trawl gears seem to be better adapted and more specific to Norway lobster fishing. They are also better suited to vessel power ratings and

TABLE 2. – Technical characteristics of differents gears used in Mediterranean *Nephrops* fisheries.

	Atlantic	Alboran	Catalan	Ligur	Tyrrhenian	Adriatic	Euboikos
Mouth							
Headline (m)	59	53	47	32	42	34	30
Footrope (m)	69	66.5	64	40	55	43	37.5
Wings							
Length (m)	28	25	25	15	20	16	25
Width (nºof meshes)	275	180	210	200	380	188	240
Strech mesh (mm)	110	110	150	80	72	120	72
Opening among wings (m)	25	22	24	12	18	17	14
Body funnel							
Length (m)	18	18	47	21.6	22	24	20
Initial width (nº meshes)	550	600	468	450	400	406	500
Final width (nº meshes)	120	200	170	350	300	170	350
Streched mesh (mm, mean)	56	60	65	40	44	48	36
Codend							
Length (m)	11	11	13	5	5	5	6.5
Width (nº of meshes)	80	200	170	350	300	140	350
Streched mesh (mm)	56	40	38	40	40	40	32
Total length (m)	59	54	82	41.6	47	44.7	62

TABLE 3. – Catch recording of different localities studied. SNLV, Servicio Nacional de Lotas e Vendages do Portugal. IEO, Instituto Español de Oceanografía, Ministerio de Agricultura, Pesca y Alimentación. AG, Autonomous local administrations. ISTAT, Inst. Office for Statistics, Data collection from Gross Markets, Italy. NSS, National Statistic Service, Ministry of Agriculture of Greece. ETANAL, Company of Fisheries Development in Greece. FP, Fishing port. LM, IM, Local and International Markets. C, Directly to consumers.

Area	Atlantic	Alboran	Catalan	Ligurian	Tyrrhenian	Adriatic	Euboikos
Official landings recording administration	SNLV	IEO-AG	IEO-AG	ISTAT	ISTAT	ISTAT	NSS-ETANAL
Reliable records for landings	NO	NO	NO	NO	NO	NO	NO
Reliable records for effort	NO	NO	NO	NO	NO	NO	NO
Marketing opportunities	FP-LM-C	FP-IM-LM	FP-IM-LM	FP-LM	FP-LM	FP-IM-LM	FP-LM-C
Fishermen's associations	YES	YES	YES	YES	YES	YES	NO
Change of ports for landings	YES	NO	NO	NO	YES	YES	YES
Landings/year, estimate (Kg)	40.000	20.000	15.000	8.000	20.000	150.000	30.000
and error (%)	(30)	(20)	(10)	(20)	(20)	(50)	(50-70)
Stock shared among ports	YES	YES	YES	YES	YES	YES	YES
Multispecies fishery	YES	YES	YES	YES	YES	YES	YES

smaller otter doors.

As shown in Table 2, trawl gear size is not closely related to engine power, as most vessels have fairly similar engine power ratings. Rather, there is a close relationship between trawl size and otter door size (larger trawls and otter doors in Portugal, Spain, and Greece, smaller doors in Italy). Warp diameter displays the same relationship. From this, we conclude that engine power is not a reliable effort measure, but expert assessment of warp diameter and otter door size can provide an accurate picture of the trawl gear used. Obviously, this consideration is valid only for the particular case of the *Nephrops* fishery, not generally.

Catch recordal

Table 3 is a compilation of the administrative structure surrounding the trawl catches and related issues.

In all countries there exist official agencies and administrative bodies that compile and analyse landings data by species, but in many cases it is not compulsory for fish sales always to be made at the same port. Vessels working a specific fishing ground may sell their catch at different ports (including other countries' ports), and the converse is also true, i.e., vessels from different ports may fish the same grounds. The various possible marketing opportunities for the catches make estimation a very approximate process, because:

1.There may be more than one point of sale at each port (for instance, both a fish wharf and a central market).

2.Catches may be sold directly to trucks for delivery to cities or international markets.

3.Catches may be sold directly to fishmongers, restaurants, etc.

4.Sales records may be quite exact in certain cases, e.g., through computerized sales at auction with official invoices delivered to sellers (as in some ports in Spain and Portugal) but not reliable in other places.

5.Sales of mixed boxes (crates) is not itemized. Mixed boxes often comprise small individuals which, if recorded, would constitute an important source of information on recruitment.

Thus, monitoring of landings and fishing vessels in the different markets can be quite difficult. In a small fishery like the Mediterranean Norway lobster fishery, unrecorded catches may amount to 30 % of officially recorded catches, especially in Greece and at certain ports in Italy and Portugal.

There are further complications involving species nomenclature and size classifications: many species that are commercially and ecologically important are marketed mixed and are either not recorded or recorded under generic terms encompassing various species. This is particularly important for juvenile Norway lobster (marketed mixed with other species under the category "fry"), but it is also important for other species, since in the Mediterranean fishing is deployed on rather small species.

Studies of population dynamics based on these very approximate data must be regarded with caution and used only on a comparative basis. This conclusion invalidates the use of fisheries models for quantitative management of the Norway lobster fishery. The seasonal variability in the behaviour of Norway lobster stocks that has been demonstrated

must also be taken into account for those purposes.

CONCLUSIONS

The following points summarize the main conclusions that can be drawn from the preceding qualitative analysis.

-Catchability on Norway lobster fishing grounds has increased substantially in recent years due to increased engine power and improvements in mechanical and electronic technologies (positioning, detection, and trawl controls).

-Official records are insufficient and inaccurate in some countries and disperse in others, precluding good quantitative fisheries management.

-Three clearly differentiated areas can be delimited in the Mediterranean on the basis of fishing and exploitation practices: a) the western and central Mediterranean, including the Atlantic Iberian stocks, the Mediterranean coast of Spain, and the western coast of Italy; b) the Adriatic Sea; and c) the region around Greece, extending to the entire Aegean Sea.

-Engine power rating data can be misleading. Spain, Portugal, and Greece have larger trawls and higher engine power as compared to Italy.

-A fisheries management system established to monitor and regulate Norway lobster fisheries in the Mediterranean would have to take into account the three types of trawl structures identified and the multispecies character of this fishery.

ACKNOWLEDGEMENTS

This work has been supported by the EC, DG. XIV (MED92/008). The author thanks Pedro Torres of the IEO in Málaga for his collaboration in data collection and G. Fuster and J.M. Anguita for their technical assistance.

REFERENCES

Anonymous. – 1993. *Fishery Statistics. Catches and Landings*. Yearbook. FAO. Roma. 688 pp.

Artegiani, A., P. Curzi, C. Froglia, R. Lenaz, and L. Tomadin.- 1979. Primi resultati delle indagini sui fattori bilogici, oceanografici e sedimentologici che condicionano la distribuzione degli scampi in Adriatico. *Conv. Scien. Naz. P.F. Oceanogr. e Fondi Mar.,* 229-241.

Bailey, N. – 1986. Why does the size of *Nephrops* vary*?. Scotish Fisheries Bulletin*, 49:31-36.

Brabant, J.Cl., and Cl. Nédélec. – 1988. *Les chaluts: conception, construction, mise en oeuvre*. IFREMER. Brest. 204 pp.

Briggs, R.P. – 1987. A review of the factors influencing landing size in the northern *Nephrops* fishery. *ICES. CM/K*:34, 24 pp.

Chapman, C.J., and N. Bailey. – 1987. *Biological research on fish and shellfish stocks. Recent progress in* Norway lobster *research*. Fishing New Books. London.

Charbonnier, D. – 1990. *Pêche and Aquaculture en Mediterranée. Etat actuel et perspectives*. Economica. 94 pp.

Froglia, C. – 1972. Osservazioni sulle variazioni di cattura dello scampo, *Nephrops norvegicus* (l.) in riferimento all'etologia de alla biologia della specie. *Quad. Lab. Technol. della Pesca.*, 1(4):83-99.

Lleonart, J. – 1993. La pesquería de Cataluña y Valencia. Descripción global y bases para su seguimiento. *Final Report CEE. DG XIV*.(1989/3):1634 pp.

Lleonart, J., and F. Sardà. – 1990. Tècniques d'explotació. In: J. Lleonart (coord.) *L'oceanografía: recursos pesquers de la mar catalana*. Diputació de Barcelona, 9: 43-65.

Main, J., and G.L. Sangster. – 1985. The behaviour of the Norway lobster, *Nephrops norvegicus* (L.) during trawling. *Scottish fisheries Research, Rep*. 34: 1-23.

Martín, P. – 1991. La pesca en Cataluña y Valencia (NO Mediterráneo): análisis de las séries históricas de captura y esfuerzo. *Informes Técnicos de Scientia Marina. Instituto de Ciencias del Mar de Barcelona* (CSIC): 43 pp.

Maynou, F. – 1998. The application of geostatistics in mapping and assessment of demersal resources. *Nephrops norvegicus* (L.) in the northwestern Mediterranean: a case study. *Sci. Mar,*. 62 (Supl. 1): 117-133

Newland, P.L., and C.J. Chapman. – 1989. The swimming and orientation behaviour of the Norway lobster, *Nephrops norvegicus* (L.), in relation to trawling. *Fisheries Research,* 8: 63-80.

Prado, J., and P.Y. Dremiére. – 1990. *Fisherman's Workbook*. Fishing News Books. Oxford. 180 pp.

Sardà, F.- 1995. A review (1967-1990) of some aspects of the life history of *Nephrops norvegicus. ICES. Sci. Symp*. 199: 78-88.

Sardà, F. – 1998. *Nephrops norvegicus* (L.): Comparative biology and fishery in the Mediterranean Sea. Introduction, conclusions and recommendations. *Sci. Mar.,* 62(Supl. 1): 5-15.

Thomas, H.J. ,and J.M. Figueiredo. – 1965. Seasonal variations in the catch composition of the Norway lobster,*Nephrops norvegicus* (L.) around Scotland. *J. Cons. perm. Explor. Mer.,* 30(1): 75-85.

Tully, O., and J.P. Hillis. – 1995. Causes and spatial scales of variability in population structure of *Nephrops norvegicus* (L.) in the Irish Sea. *Fish. Res.,* 21: 329-347.