MICHELE ROMANELLI, ENRICO TARULLI

ICRAM – Via di Casalotti, 300 – Rome (Italy)

MECHANIZATION OF FISHING OPERATIONS BY FIXED GEARS: REPORT ON TESTS PERFOMED BY TWO "AUTOMATION SYSTEMS" FOR BOTTOM LONGLINES IN THE SOUTHERN ADRIATIC AND NORTHEASTERN IONIAN SEAS.

Key – words: Mechanization, longline, epibathyal, catches, Mediterranean, Italy, Fishery.

Summary

During years 1991 – 1993 tests were intermittently carried out along the Apulian coast and in the NE Ionian Sea to assess the fishing performances of two "mechanization systems" for bottom longlines when operating at different depths. However, most data pertain to the period late June – late September 1993 during which a more continuos series of well–handled fishing trials were perfomed.

Our data showed that one of the mechanization systems being experimented effectively baited 70% - 90% ca of the available hooks when hard and soft–flesh fish were respectively used. Fishing yelds mainly ranged from 5 to 10 individuals and from 3 to 7 kilograms foe each hundred baited hooks. These yelds were low when compared with the output of two fishing operations carried out by means of one standard commercial longline. Nevertheless, experimental yields are supposed to be economically viable because of the high numbers of hooks that well–trained crews are expected to set daily using the automation systems.

In terms of number of individuals catches from experimental longlines were mainly composed of Scorpenids, Mediterranean hakes, conger eels and Selachians. Several clusters of fishes were outlined from our fishings data.

Riassunto

Una serie di prove di pesca con sistemi di automazione per palangari di fondo furono svolte a più riprese nel corso del triennio 1991 – 93 in limitati settori dell'Adriatico meridionale e dello Ionio NE al fine di valutare la funzionalità di questo tipo di attrezzatura ed i rendimenti ottenibili. Gran

parte dei risultati esposti nel presente lavoro si riferiscono però al periodo fine giugno – fine settembre 1993, poiché solo in questo lasso di tempo fu possibile effettuare prove di pesca in maniera sufficientemente continuativa. I dati ottenuti hanno evidenziato che sistemi d'automazione del tipo di quelli da noi sperimentati sono in grado di innescare in maniera efficace una frazione all'incirca pari al 70% - 90% degli ami offerti, in relazione alla minore o maggiore consistenza delle carni dei pesci utilizzati. Nella maggior parte delle cale le rese di pesca sono risultate comprese tra 5 e 10 individui e tra 3 e 7 kilogrammi di pesce per ogni centinaio di ami correttamente innescati.
Questi rendimenti sono risultati nettamente inferiori a quelli registrati in due prove di pesca svolte con un palangaro di tipo commerciale in una delle nostre aree di studio. I rendimenti rilevati nel corso delle nostre prove sperimentali sono stati tuttavia ritenuti economicamente validi, in considerazione dell'elevato numero di ami che equipaggi addestrati dovrebbero essere in grado di calare giornalmente con sistemi d'automazione del tipo di quelli in esame.
In termini numerici le catture ottenute con palangari sperimentali sono risultate composte prevalentemente da Scorpenidi, gronchi, naselli e Selaci. In base alla composizione delle catture sono stati individuati alcuni "clusters" di specie tra loro più frequentemente associate.

Introduction

The depleted state of most marine fish stocks (FAO, 1993) stresses the need for using more selective (i.e. minimising non – commercial catches) and less disruptive fishing methods.
In this view, great interest is given to the "automation systems" developed since the late Seventies to mechanise fishing operation by angling as well as bottom and surface longlines (CADE, 1981; ANONYMOUS, 1984; VON BRANDT, 1984). Nodaways such deck systems are largely employed throghout the world in fisheries aimed both at demersal and pelagic resources (e. g. BJORDAL, 1990a; CHOPIN, 1994).
In the Mediterranean Sea fishing operations by hooks are scarcely mechanized, in spite of the great relevance of such methods at local level or during several months of the year. The above mentioned "automation systems" could therefore help to mechanize operations at sea and make selective fishing methods such as angling and longlines more popular. An

increased level of mechanization could also force some of the smaller trawlers to turn to fixed gears, thus reducing the negative impact on onshore fishing grounds.
In view of such potential benefits, two automation systems were tested in a set of hauls intermittently performed in the Southern Adriatic and the north – eastern Ionian Seas during the years 1991 – 1993. The tests were mainly aimed at assessing operational performance of the "automation systems" on deep grounds (down to 400 m) exploited by local fishermen as well as at developing proper longlines for this kind of fishery.
A specialised fishery based on bottom and surface longlines has been long operating in the areas concerned with our study (MARANO *et al.*, 1988; PIETRUCCI and ANTOLINI, 1990a), but in our case most tests were perfomed by a common trawler to see how the crew coped with the sophisticated strategy required for fishing by fixed gears.
In more recent times the EC (now EU) passed new fishing regulations (Rule 1626/94) that reduce to 7,000 metres the maximum quantity of longlines to be stored aboard, so little room is left to automation systems like those tested during our trials. Nevertheless, we feel that our results deserve full reporting, since restrictions could be mitigated in the future and little is know about longlining in the Mediterranean Sea, Moreover, few independent reports exist on the performances of the automation systems for bottom longlines (e. g. DAHM, 1986a and b).

Material and methods

- Tests at sea

The experimental hauls concerning with this paper were mainly perfomed during June, July and September 1993 by a trawler (capacity: 36.00 GT; power: 280 HP; crew: 4 persons) for testing two automation systems for bottom longlines, respectively produced in USA and Germany (hereinafter called systems or models I and II). Shorter or less continuos sessions of trials were carried out during summer or autumn of years 1991 – 1992, so limited sets of data from these periods are also reported.
Both tested systems were composed of one baiter plus a single hauler by which the longlines were alternatively set and retrieved. Baiting and setting operations were simultaneous, since mainline and snoods were paid outboard passing trought special pipes where the hooks can snap the baits. When the longlines were retrieved, they were progressively wound on hauler heads

while the hooks were positioned on rails and driven to storage boxes.
Systems I and II mainly differ in their baiters, since in the first case the baiter is a large pipe filled with chopped fish where the hooks get baited in their fast run to the sea, whilst in model II the longline is paid outboard more slowly (expulsion rate: 0.5 – 1.0 vs. 1.0 – 3.0 ms^{-1}, all calculations were done without considering the speed of the boat) through a narrow pipe where each hook encounters single baits falling by gravity from a side reservoir.
In our tests, longlines of different structure were used (Table 1), the snoods were composed of monofilament and their lengths ranged from 0.90 to 1.80 m (shorter snoods had resulted unproductive during trials carried out in summer 1992), whilst hooks were either Mustad Sea Kirby 2330 n˚ 6 or Olympus 9403 n˚ 7/0 (whose length, depth and gape were ca 40-20-15 and 65-25-20 mm respectively; see SOUSA *et al,* 1999, for terminology).
However, most trials were performed by one longline (LLF1 in Table 1) whose mainline was composed of polypropylene (density: 0.91 g/cm^3) so the gear was at some distance from the sea floor, allowing to operate on uneven or silty grounds (VON BRANDT, 1984). Very similar to LLF1 was also the gear used for two commercial hauls (i.e. performed by a boat routinely fishing by longlines) which we monitored in summer and autumn 1995 (see hereinafter), the main difference between the gears being the smaller hooks of the commercial longline (LLCM in table 1) and that it had lead weights connected to the mainline by 1.0 - 1.5 m snoods. Morevoer, it should be stressed that only one third of all experimental hauls (i. e. those during which setting and/or retrieval operations were carried out by one of two automation suystems) the hooks were actually baited by the systems themselves because we preferred to do it by hand to increase the number of hooks effectively baited and gather more information on the fishing performance of the gears.
As far as fishing tactics are concerned, untrawlable areas were searched as they often host distinct assemblages of commercial fishes because of the existence of multiple microhabitats as well as the lower level of exploitation. Moreover, in areas with sharp slopes the coexistence of different water bodies sometimes increases plankton production and sedimentation rates for the organic matter, allowing commercial resources to be locally more abundant (CSANADY *et al.,* 1988; CARTES *et al.,* 1994).
On the whole 48 hauls were regularly carried out during summer 1993 for a total of 23,780 hooks (actually 20,625 , considering that the systems I and II did not bait all the hooks offered) and 32 fishing days. In details, 41 hauls

were performed by system I (average number of hooks: 468±151; baited hooks: 437±143) and 7 by model II (average number of hooks: 654±153 baited hooks: 387±95); the fishing days were 26 and 6 respectively for the former system and the latter one. These experimental hauls were performed in an area 25-40 km to the N/NE of the harbour of Mola di Bari (Apulia, SE Italy), in proximity to the local submarine canyon (FABBRI and GALLIGNANI, 1972; GALLIGNANI, 1973) (fishing A area in fig. 1; hauls = 41), then on grounds 10-14 km to the east of Otranto (fishing B area; hauls = 3) and just to the SE of the Greek island of Fano (fishing C area; hauls = 4). All experimental hauls by system II were performed in the fishing A area which was also selected for both commercial hauls, each numbering about 2,000 hooks, we observed in August and November 1995.

All experimental hauls of summer 1993 lasted from dawn to late morning, the minimum time of permanence at sea of baited hooks (i. e. the time calculated without considering the duration of the setting and retrieving operations) ranged from 1.5 to 2.5 hours. As a rule, baits were 6 - 8 g chops of fresh or thawed sardines, *Sardina pilchardus* (Walbaum); on one occasion 10 - 12 g pieces of fresh mackerel, *Scomber scombrus* L., were used. In commercial hauls the hooks were baited by intact sardines.

Depth and position of longlines were registered by echosounder and Loran. Hauls were carried out in the 110-405 m depth range.

As a rule fishes caught during experimental hauls were identified, measured and weighed. Total lengths were measured, in individuals of different species, approximating them to the lower limit of 0.5 or 1.0 cm; weights were obtained by two steelyard balances so they are intrisecally imprecise although single animals were formally weighed to the 0.01 or 0.1 kg (see Table 4). When many low-priced fishes were obtained in a single haul, they were simply counted and weighed together. In order to calculate the yields of the experimental fishing operations single weights (i. e. the weight of each fish) were summed up, neglecting small discrepancies due to a different precision of measures.

In both of the commercial hauls the total numbers of fishes caught and their average weights were estimated by counting the boxes filled for each species and making reasonable guesses on the average size of the fishes stored.

- Data analysis

In analysing experimental data, the hauls were first gathered into three depth groups (110 - 150, 150 - 300 and 300 - 405 m), without considering the sediment composition and the benthic communities involved since such information was lacking in most cases. Bathymetric limits were therefore identified to separate the hauls performed in proximity to the 1l0m contour line (where the average gradient of the Apulian shelf moves from 0˚ 39' to 0˚ 16'; GALLIGNANI , 1973), as well as to the outer edge of the shelf and on the upper sector of the continental slope. It is also worth noting that the 1l0m contour line separates more coastal silty areas from outer sectors covered with "relict sand" (FABBRI and GALLIGNANI, 1972; GALLIGNANI, 1973).

The consistency of the three assemblages of hauls was then tested by Canonical Discriminant Analysis (CDA, MASSART and KAUFMAN, 1989), based on the species composition of the catch observed for each haul. Because of the low number of hauls performed by system II (N = 7), partly with bad weather and untested longlines, most data concerning models I and II were put together.

Since the longlines presumably floated at some distance from the sea bottom, we calculated the average "hanging ratio" (i.e. the ratio obtained by dividing the total length of the mainline by the minimum distance existing between the two outermost buoys) for each haul to check whether the gear had been correctly positioned. In turn, the hanging ratios obtained and simple geometrical calculations based on the distribution of lead weights along the mainline allowed to estimate the average height of volutes formed (Table 1).

In comparing data from hauls with different numbers of hooks, we assumed that catches were proportional, for a given area and species, to the quantity of hooks baited each time, neglecting the influence due to somewhat different snood spacing (MURPHY, 1960; RICKER, 1975; SKUD and HAMLEY, 1978; LOKKEBORG and BJORDAL, 1992).

Normality of the values under study (yields, baiting frequencies and so on) was scrutinised by Kolmogorov-Smirnov test, all results showing that the distributions did not significantly move away from Gaussian curves. As numbers of hooks got baited or set at sea did not largely differ among hauls, the baiting frequencies registered in distinct groups of hauls were compared assuming they fitted to binomial distributions for "unpaired data groups", while the weighed means of the numbers and quantities of fishes caught during distinct sets of fishing trials were compared by Student test for similarly unpaired data groups, standard deviations being calculated after the following formulas:

$$WSDN = ((\sum(x_i-X)^2 n_i)/m(Y-1))^{0.5}$$

$$WSDW = ((\sum(c_i-C)^2 n_i)/m(Y-1))^{0.5}$$

where x_i is the frequency of fishes caught in the i^{th} haul, ci is the quantity of fish (as kilograms) caught in the same haul for each hundred baited hooks, when the comparison was in terms of weights), X and C are the weighed means of the same parameters, m is the average number of hooks in the set of Y hauls (ARMITAGE, 1977).

Comparison between commercial and experimental hauls was however based on logical concepts, because the great discrepancy in the numbers of hooks used for the two groups of hauls made formal tests unfeasible.

Results

a - *Baiting tests and longline retrieval*

In nine hauls by system I and seven ones by system II the hooks were baited mechanically, registering for each haul the numbers of hooks baited in the time unit and the fraction of them retaining the bait itself when they struck the sea surface.

In eight out of the nine hauls by system I the baits were pilchard chops (average number of hooks: 544±137). and a total frequency of 71.2% “correctly baited” hooks (i.e. that retained the fish chop when dipping in the water) was registered. In the ninth haul with mechanical baiting by system I mackerel chops were used, registering a total frequency of 90.0% hooks correctly baited (300 hooks offered to the baiter). In similar tests carried out during summer 1992 with two similar longlines (LLF4 and LLFS in Table 1), baiting frequencies approximately ranged from 50% to 60% of the hooks offered when the baits were pilchards (hauls = 3; average number of hooks = 906±100), whilst the total frequency of baited hooks rose to 84.1% for 5 hauls where chopped mackerels were used (average number of hooks = 676±27).

When the baiting tests of summers 1992-93 are summed up, we see that trials performed with mackerels gave a total frequency and standard deviation of correctly baited hooks equal to 84.5% (hauls = 6; hooks = 613±284); this value is statistically different from that observed for the above mentioned sequence of tests carried out with pilchards during June-September 1993 ($p<0.001$).

On the whole the baiting performances of system II (unreported data) were worse than those summarised for model I; however it must be stressed that our tests were part of the development process of such second baiter. The "utilisation rate" of fish pieces (i.e. the percentage of fish chops that actually baited the hooks) was estimated around 55.0% for the baiter of system I fed with pilchard baits. About 0.9 Kg of chopped sardines, approximately corresponding to 130 fish pieces, was indeed poured into the baiter for each hundred hooks of the longline, so the "utilisation rate" were easily calculated from the observed mean of correctly baited hooks. About 50 % of unutilised fish chops could in turn be given once again to the baiter as they were still stiff enough.

As a rule all longlines were retrieved by both systems at a steady rate of 5-6 hooks per minute, independently from the operational depth and ground of each haul. Retrieving operations were also poorly influenced by bad weather, since in 7 hauls performed with comparatively stronger sea (3 after the Douglas visual scale of waves) on 130 - 350 m grounds we recorded the retrieving speed of 6.1 ± 1.7 hooks/min. similar to the mean value 5.6 ± 1.4 hooks/min. observed for all other experimental hauls ($p > 0.30$, Student test for unpaired groups of data, 46 d. f.).

The hanging ratios estimated for the 41 hauls carried out by the LLF1 longline showed that the gear formed volutes rising on average 1.0-3.5 ms from the sea floor. All hauls by system II and longlines LLF2 - LLF3 gave hanging ratios inferior to 1.00, which probably means that the gears were dragged on the fishing grounds. Lastly, hanging ratios estimated for the two commercial hauls seem imply that the fishing gear mainly formed 5 - 6 m vertical volutes.

The checking and repairing of longlines (i.e. the operations by which fishermen check the gear before starting another haul) went on for bot automation systems at an approximate rate of 450 hooks/hour for each fisherman, although large variations were found among hauls. When the longlines fished on uneven grounds monofilament snoods were often excessively stretched, so extra time had to be spent to replace them. It is worth noting that in two hauls performed, in summer 1992, on soft bottoms by a special longline furnished by the manufacturer of system I (LLF6 in Table 1), automated storing of gear in the boxes was so perfect that no further control was needed.

b - *Composition of catches and yields*

During the tests of July-September 1993, 1,434 fishes of 26 species were caught for the total weight of 1,511.5 Kg. Four species - *Squalus acanthias* (L.), *Conger conger* (L.), *Merluccius merluccius* (L.) and *Helicolenus dactylopterus dactylopterus* (Delaroche) - made up 73.6% in terms of number and 76.3% in terms of weight of the total catches. Nine species were found only in the catch of one or two hauls or even as single individuals during the entire series of tests (Table 2).

In both commercial hauls a total of 565 ca fishes for an estimated total weight of 800 Kg were captured; among them the frequencies of specimens both of *M. merluccius* and *Lepidopus caudatus* (Euphrasen) were rather high, whilst catches of *C. conger* were low compared to the experimental trials (Table 3).

In Table 4 statistical descriptors of the length. and weight distributions of fishes caught at different depths during the series of experimental hauls are listed: as a rule the bathymetric range of the single species and size groups agree with data reported in the literature for the Southern Adriatic and other Mediterranean areas (BINI, 1968; BELLO and RIZZI, 1988; JARDAS, 1988; UNGARO *et al.*, 1993). One exception is the capture of 43 large conger eels (average weight = 2.2±1.5 Kg) on comparatively shallow grounds (depth sector 100 - 150 m) of the fishing A area.

With concern to our experimental hauls, *M. merluccius* and *C. conger* made the bulk of the catches, with 372.3 and 380.5 Kg respectively. However, most individuals of both species were obtained in a small number of "lucky hauls", so that half of the conger eel and hake catches came, considering only the fishing operations performed beyond 150 m, from two distinct groups of 5 hauls.

Similarly the catches of Selachians *S. acanthias* and *Galeus melastomus* Rafinesque were highly concentrated as 59 out 71 individuals of the former species fished in summer 1993 came from four hauls performed on 100 - l50 m grounds of the fishing A area (average number of baited hooks = 412±75), whilst 70 out of 105 individuals of the latter one were caught in a group of six hauls (average number of hooks baited = 367±66) carried out in the deepest sectors of the same area.

A further step in the analysis of data was performing a Discriminant Analysis test on 36 experimental hauls carried out in the fishing A and B areas (eight hauls were excluded for the low numbers of fishes caught) to assess the potential of the species composition of catches in discriminating groups of hauls similar to those defined on the basis of operational depths. Results in figure 3 show that hauls from the three depth sectors (100 - 150, 150 - 300, 300 - 400 m) are set apart, although groups are dispersed and scarcely homogeneous.

In figure 3 we see a similarity dendrogram obtained by cluster analysis (MOSSART and KAUFMAN, 1989) on data from 43 experimental hauls performed off the Apulian coast of the Southern Adriatic Sea (also this time 5 hauls were excluded for their poor yields); in the figure *C. conger, M. merluccius, S. elongata* and *H. d. dactylopterus* are linked together, whilst the catches of *S. acanthias* are connected with those of *Trigla lucerna* L. Other groups of fishes are *Phycis phycis* (L.), *Scorpaena scrofa* L. and *Trigla lyra* L.; then *Phycis blennoides* (Brunnich), *Polyprion americanus* (Bloch & Schneider) and *Pagellus bogaraveo* (Brunnich).

In order to find out several factors influencing the longlines'yields, all hauls performed in the fishing A area during summer 1993 were first depicted on nautical maps and then inscribed within the smallest possible circles defining distinct sub-areas. This procedure showed that "more profitable" and "less profitable" hauls (classified by comparison with the weighed average yield calculated on the entire set of 48 experimental hauls) were located in distinct subareas (named H_1-H_3 and L_1-L_4 respectively in Fig. 1).

If we put together data from all experimental hauls performed in L_1-L_4 and in H_1-H_3, yields concerning *C. conger, M. merluccius* and the group "all fishes" are statistically different, both in the 150-300 and 300-400 depth sectors. As an example, weighed means and standard deviations of the whole catches result 8.2 ± 1.8 vs. 3.6 ± 2.9 Kg for different clusters of hauls carried out at depths lower than 300 m ($p<0.0l$ Student's test for unpaired groups of data with 14 d. f; see Table 5 for further details).

These different yields are neither due to the longlines used in the H_1-H_3 and L_1-L_4 subareas nor to the average numbers of hooks baited for each haul, since these parameters are relatively similar both for the more and less productive sets of hauls (Table 5). Actually the more productive hauls performed beyond 300 m differ from the less productive ones for the greater depth range embraced each time (on average 115 ± 3 vs. 47 ± 3 metres; $p< 0.001$, Student's test for unpaired groups of data with 17 d. f), but no differences are observed for the same parameter among the hauls from the intermediate depth sector (Table 5). In the same way, no clear differences were observed on the faunistic composition of catches from sub-areas H_1-H_3 and L_1-L_4 , although we did not perform formal tests about this.

The H_3 sub-area was also selected by the fishermen of the mentioned longliner to perform both commercial hauls of summer and autumn 1995, registering high yields. Both hauls were carried out, exactly in the same site, on a 275 - 320 m deep ground, obtaining 14.1±6.4 fishes and 20.0±11.5 Kg for hundred baited hooks (Table 3).

d - *Additional observations*

In analysing the data from all experimental hauls of summer 1993, the number of conger eels caught during each haul resulted to increase with their average size. When all longlines were put together, an average rate of 2.27±1.54 conger-eels was observed in a group of nine hauls where these fishes weighed more than 1.8 Kg vs. the rate of 1.4±0.9 individuals registered in another group of 25 hauls where the average weight of the fishes ranged 0.4 and 1.6 Kg ($p<0.05$; Student's test for unpaired groups of data, 32 d. f.).

Both LLF2 and LLF3 longlines fished better on *P. bogaraveo* than the LLF1 gear equipped with larger hooks. All hauls carried out in the fishing A area by the first two longlines gave, in the 150 - 300 m depth, an average catch of 2.0±0.9 individuals every hundred baited hooks, whereas the same rate resulted 0.5±0.1 for the fishing operations by LLF1 ($p<0.01$; Student's test for unpaired groups of data, 9 d. f.).

On this matter we observe that the average body lengths of the blackspot breams caught during the above mentioned groups of experimental hauls were almost equal: 32.0±4.5 cm for the operations by LLF1 (N 18; hauls 7) vs. 32.0±4.0 cm for the specimens caught by LLF2-LLF3 (N = 28; hauls = 4). Moreover the conger-eels and seabreams caught during our trials were usually found with the hook positioned on the anterior edge of the mouth, instead of being swallowed as seen in both hauls by LLCM longline.

Lastly, it is interesting to see that high catches of the Selachian *Squalus blainvillei* (Risso) obtained in a set of 13 experimental hauls carried out during summer 1992 near the Greek island of Cephalonia (NE Ionian Sea, area not shown in Fig. 1). These hauls were performed at depths from 135 to 440 meters baiting on average 393±110 hooks and obtaining 332 *S. blainvillei* sharks on the whole.

Discussion

Longlining is supposed to be a selective fishing method, since larger fishes from few piscivorous species are usually taken (BJORDAL, 1990a and b; KENCHINGTON, 1996). Catches are therefore largely composed of mature individuals that spawned at least once before being fished, thus fish stocks should be exploitable more confidently and for longer time.

However longlining is a demanding fishing method, requiring large crews to ensure continuity to the work at sea (PEDERSEN, 1989; PIETRUCCI and ANTOLINI, 1990a); moreover, revenues largely depend on the numbers of hooks set every day as well as the prevalence of large specimens in the catch (BJORDAL, 1990a; LOKKEBORG and BJORDAL, 1992; KENCHINGTON, 1996).

These problems could be alleviated by installing mechanisation systems to increase the numbers of hooks "worked" per unit of time. The fact that longlines of strong design have been used for long time along the Apulian coast of the Southern Adriatic Sea (PIETRUCCI and ANTOLINI, 1990a and b) would presumably ease, in absence of the EC fishing rule 1626/94, the spreading of such mechanisation systems in the area.

Analysis of our results is therefore of great relevance to evaluate fishing efficiency of the tested systems as well as their performance in making operations at sea faster.

I - *Baiting and longline retrieval*

All tests carried out during summers 1992 and 1993 point out that the baiting rates registered with *S. pilchardus* chops never exceeded 75.0% of the hooks fed to the baiter; when mackerel pieces were used instead, the rates of hooks correctly baited progressively increased with time to 90.0% ca. All these data agree with the manufacturers'directions (ANONYMOUS, 1984) and reports from independent observers (e. g. DAHM, 1986a and b) that hard baits, as Cephalopods or harengs, are needed to operate with the mentioned automation systems.

The "utilisation rates" of baits registered for system I (manufactured in USA) pointed out that one can presumably bait almost all available hooks (when hard-flesh fish are used) simply by filling the bait revervoir with 30% extra chops beyond the number of hooks offered each time to the baiter. Approximately 50% of the extra baits can be used for the following haul, so little fish would be actually wasted.

Automation systems performance during the retrieval of longlines could be hardly assessed, because fishermen needed to check the gears carefully before launching them again. Nevertheless checking operations seem to be partially accelerated in comparison with traditional procedures, since our unexperienced crew stored the longlines at an average rate of 450 snoods/hour/man similar to that registered by other authors on a specialised longliner (PIETRUCCI and ANTOLINI, 1990a).

II - *longline positioning*

In the Mediterranean longlines aiming at demersal fishes are usually positioned at some distance from the sea bed to minimise predation by epifaunal invertebrates as well as fortuitous entanglements (RUSSO, 1928; PIETRUCCI and ANTOLINI, 1990b). In additon these longlines are usually equipped with long monofilament snoods (up to 1.8 m each) that are supposed to catch more fish (SCACCINI *et al.*, 1970; PIETRUCCI and ANTOLINI, 1990b).

Such design is a great obstacle to the mechanisation of fishing operations: this explains why automation systems like those we have tested are widespread in geographic areas where the existence of large rocky or sandy grounds on the continental shelf (e. g. off NE European coast, see Boillot *et al.*, 1971) makes it possible to use “simple” longlines to be directly set on the sea floor (SKUD and HAMLEY, 1978; FLAGEUL, 1994). In fact the only longline supplied to us by the U.S. manufacturer of system I (LLF6 in Table 1) was composed of a mainline with an inner lead rope to make it steadily lay on the sea floor.

Theoretical hanging ratios calculated on hauls performed by LLF1 and the automation system I (n = 41) showed that the longline formed vertical volutes on sea floor but they were presumably smaller than those originated during the couple of commercial hauls scrutinised in summer-autumn 1995. As the height of volutes depends on the ratio between the boat speed and the rate at which the longline is expelled from the baiter during the setting operations, it is clear that the complex design of the gear (which had long vertical ropes and snoods) made proper modulation of these parameters difficult. Analogously, system II resulted to bait the hooks too slowly to prevent longlines from being dragged on the sea floor even when the boat engine was kept at minimum.

III - *Composition of catches*

Our results confirm that longlines are highly selective, since specimens from five species - *G. melastomus, S. acanthias, C. conger, M. merluccius* and *H. d. dactylopterus* — numerically made up 81% of total fishes caught. Moreover, in both commercial hauls of summer-autumn 1995 almost all fishes were *M. merluccius, L. caudatus, S. elongata* and *H. d. dactylopterus*. The species and size composition of catches clearly differed from that reported for trawling surveys carried out in the Southern Adriatic Sea at depths from 200 to 400 m (BELLO *et al.,* 1988; UNGARO *et al.,* 1993). In details, Scorpaenidae and the sparid *P. bogaraveo* made up about 15.0% , in terms of weight, of the marketable product obtained during our trials compared with 2.0 - 3.0% fractions registered in trawl catches.

Moreover *S. elongata,* fish presumed to be uncommon in the Southern Adriatic Sea (SCACCINI *et al.,* 1970; BELLO and RIZZI, 1988), on the contrary appeared a somewhat relevant resource for longliners operating in the area.

Comparing our data with those reported on commercial longlining carried out some decades ago in different sub-areas of the Mediterranean Sea (PASQUINI, 1926; RUSSO, 1928; ARCIDIACONO, 1936; KIRINCIC and LEPETIC, 1955; SCACCINI, 1963; SCACCINI *et al.,* 1970; BOLOGNARI *et al.,* 1971; DE ZIO *et al.,* in press), no clear differences can be seen about the species or size composition of the catches, due to the descriptive nature of most papers as well as to planopy of environmental and operative factors influencing yields and catch composition (SKUD and HAMLEY, 1978; LOKKEBORG *et al.* 1989; LOKKEBORG and BJORDAL, 1992; 1995; ENGAS and LOKKEBORG, 1994).

It is worth noting that several old papers (PASQUINI, 1926; RUSSO, 1928; ARCIDIACONO, 1936) report that in distinct areas of Italian seas hakes weighing from 3 to 6 Kg were often captured by commercial longliners operating on the continental shelf, while so large specimens of *M. merluccius* made less than 3% of total fishes of this species caught during our experimental trials, although deep grounds had mainly been explored. This discrepancy may be due, to some extent, to the preferential distribution of mature individuals in restricted areas as during a year-round study performed in 1992 on the landings of commercial longliners operating in the Southern Adriatic Sea (DE ZIO *et al.,* in press) one quarter ca of hakes weighed more than 3.0 Kg.

In Table 6 the size compositions of our catches are compared with data reported in the literature about the growth and length at maturity of different fishes (although often data are ascribed to populations from extra-mediterranenan areas) in order to make some guesses on the age structure of our samples and the fractions of mature individuals. In our samples the fractions of mature individuals presumably ranged from 9.1% for *P. bogarvaeo* to ca 100.0% for *M. merluccius* and *T. lucerna.* Age composition of our samples presumably ranged from 3 years or more for *T. lyra* individuals to a minimum age of 10 - 15 years for *S. acanthias.*
During our tests good fishing yields were also registered for *S. acanthias*, and *G. melastomus*, in summer 1993 and for *S. blainvillei* respectively one year earlier, so our longlines seemed to efficiently capture large and medium-sized Selachians. These results agree with the report by ERZINI *et al.* (1998) that *G. melastomus, Scyliorhinus canicula L.* and *Etmopterus pusillus* (Lowe) numerically amounted to ca 35% of the catches obtained by monofilament longlines at 200 - 700 m depths off the Algarve coast (southern Portugal).

IV - *Fishing yields and species clusters*
Our experimental data showed the relevance of the haul sites to determine fishing yields, since in the fishing A area distinct sub-areas of limited extension with higher and lower yields were recognised. Moreover the good catches registered in one of the sub-areas during both experimental hauls of summer 1993 and the commercial ones performed two years later imply that more productive sectors preserve, to some extent, such productivity over time.
These observations agree with many reports in the literature about positive effects on the fishing yields of persistent factors such as sharp slopes (LEHODEY *et al.*, 1994), local currents (LOKKEBORG *et al.*, 1989; ENGAS and LOKKEBORG, 1994) and untrawlable grounds (SCACCINI, 1963; RUSSELL *et al.*, 1988).
On average the yields observed during our trials were higher o close to those reported for similar studies as well as commercial vessels operating by bottom longlines in several sectors of the Italian coast (KIRINCIC and LEPETIC, 1955; SCACCINI *et al.*, 1970; BOLOGNARI *et al.*, 1971); nevertheless our experimental longlines fished much less than the analogous gears used in the couple of commercials hauls of summer-autumn 1995

(Tables 3 and 5).

Our data clearly showed that the rather large hooks used for the LLFl, LLF2 and LLF3 longlines reduced the catches of small-mouth fishes such as *C. conger* and *P. bogaraveo.* In this view the overlapping body sizes registered for blackspot breams caught by different experimental longlines are explained assuming that all hooks were so large that only the biggest individuals could be captured. These results agree with the report by SOUSA *et al*. (1999) saying that in comparative tests performed in the Azores on the fishing efficiency of distinct hooks best yields for *P. bogaraveo* were registered using hooks measuring 23-8-7 mm ca.

Bigger baits were probably another important factor determining the higher yields seen in the couple of commercial hauls; the great care paid by the fishermen to select large pilchards (otherwise two fishes were put together on the hook, our personal observation) clearly showed the relevance attached to the “bait factor”. This agrees with the general notion that the greater preys increase the average size of the predator fishes caught at sea (PITCHER and HART, 1985; LOKKEBORG and BJORDAL, 1992 and 1995). Nevertheless a reduction of bait costs is an important goal for commercial longliners (LOKKEBORG and BJORDAL, 1995), so small chops were used during our trials.

Higher volutes of LLCM (as inferred on the basis of the longline’s theoretical hanging ratios) may be the third factor determining the higher yields of *L. caudatus* and *M. merluccius* registered for this gear since partly lifted bottom longlines are often used to catch Gadoids or frost-fishes (POLICE, 1919; FAO, 1987; DEMESTRE et al., 1993; KENCHINGTON, 1996).

Some clues on the nature of the fishing grounds were our experimental hauls were paerfomed can be drawn from the species clusters depicted in Fig. 3: combined catches of *Phycis phycis* (L.), *Scorpaena scrofa* and *Trigla lyra* (L.), all fishes often located in medium-depth rocky areas (BINI, 1968), may imply that longlines operated on these areas or neighbouring sectors; the cluster *P. blennoides*, *P. americanus* and *P. bogaraveo*, presumably reflects catches from medium-depth soft or mixed areas as the above mentioned species are preferentially located on these grounds (BINI, 1970; ORSI-RELINI and FIDA, 1992). In our opinion, the strong correlation between *S. acanthias* and *T. lucerna* was due instead to the fact that both species are mainly distributed on the shelf zone (TORTONESE, 1956; JARDAS, 1988;

KIRNOSOVA, 1989). Analogously, the positive correlation found between the catches of *C. conger*, *M. merluccius*, *S. elongata* and *H. d. dactylopterus* presumably derives from wide depth distributions observed for these species (Table 4).

Conclusion

Both tested automation systems turned out to be of sturdy structure and sound mechanics since we could operate down to 400 m without registering failures.

Baiting tests by random system I registered fair “success rate”, even when soft-flesh baits as pilchards were used. Moreover, little extra consumption of baits was requested in comparison with the traditional hand-made baiting method.

The fishing yields registered with the LLF1 longline fell far behind those registered for a couple of commercial hauls performed off Mola di Bari in summer-autumn 1995. Such lower yields were presumably due to the simpler rigging adopted for the experimental longlines which made them compatible with the automation system but less efficient in catching fishes. Nevertheless, the yields observed for these longlines turned to be economically viable (Dr. M. FERRETTI, pers. comm.*) when they were linearly extended to the average number of number of baited hooks — 1,500 hooks per man a a day - that experienced crews are expected to set daily on the basis of all data available from distinct geographic areas (CADE, 1981; ANONYMOUS, 1984).

Our data showed that bottom longlining could adversely affect the consistence of the Selachian stocks as these fishes get late to maturity and are voracious predators often eating the baits. Similarly the comparatively high yields registered for the couple of hauls performed by commercial longlines induce to suspect that the catches obtained by longliners operating in the Southern Adriatic Sea (ca 15 boats in 1998) could adversely influence the spawner stocks of Teleosts as *M. merluccius* and *T. lucerna* whose populations are heavily exploited by local trawlers.

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*Dr. M. Ferretti, CIRSPE, Via dei Gigli d’Oro, 21 - 00186 Rome (Italy).

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STRUCTURE AND RIGGING OF THE TESTED LONGLINES						
Codes	Hooks	Main line (material and diameter)	Snoods (material and diameter)	Snood length	Spacing of snoods	Rigging
LLF1	Olympus 9405 No 7/0 (ca 65-45-20 mm)	5.0mm PP multifilament braided rope	1.2mm PA monofilament	1.80 m	3.60 m	- snoods connected to the main line by swivels; - one 30g weight every 3 snoods, plus one 400 g float every 15 snoods and one 1,000g weight every 45 snoods.
LLF2	Mustad Sea Kirby 2330 No 3/0 (ca 40-20-15 mm)	2.0mm PA monofilament	0.9mm PA monofilament	4.00 m	2.50 m	- snoods connected to the main line by swivels; - one 400 g weight and one small float every 15 snoods and one 1,000g weight every 45 snoods;
LLF3	as LLF1	3.5mm PA stranded rope	0.5mm PA monofilament	0.90 m	2.30 m	as LLF2
LLF4 (summer 1992)	Mustad Sea Kirby 2330 No 6/0 (ca 48-13-13 mm)	5.0mm PP multifilament braided rope	1.2mm PA monofilament	4.90 m	3.60 m	as LLF1
LLF5 (summer 1993)	as LLF4	4.0mm PP multifilament braided rope	1.2mm PA monofilament	1.20 m	4.20 m	- snoods connected to the main line by swivels; - 70 g weights connected every five snoods to the main line by 0.9m snoods, all other weights as LLF1;
LLF6 (summer 1992)	as LLF1	lead rope with outer PP jacket (total diameter: 5.8 mm)	2.0mm PA multifilament braided rope	4.00 m	1.50 m	- snoods simply tied to the mainline;
LLCM (summer and autumn 1993)	much smaller than in LLF4 and LLF5 (ca 25-10-10 mm)	5.0mm PP multifilament braided rope	1.2mm PA monofilament	1.80 m	5.60 m	- as LLF5, but snoods connecting the 70g weights to the main line are longer (1.2 m);
PA= Polyamide PP=Polypropylene						

TABLE 1 - Structure and rigging of the experimental and commercial longlines used during the entire three-year series of intermittent fishing trials.

	SPECIES	TOTAL SPECIMENS	TOTAL WEIGHTS (kg)	AVERAGE NUMBERS OF SPECIMENS CAUGHT IN POSITIVE HAULS	NUMBERS OF SPECIMENS CAUGHT IN POSITIVE HAULS MIN. - MAX.
CHONDRICHTHYES	*Scyliorhinus canicula* (L.)	10	2.98	2.50	1-5
	Galeus melastomus Raf.	105	37.06	6.17	1-18
	Prionace glauca (L.)	1	0.8	1,00	*
	Squalus acanthias L.	71	297.0	10.14	1-21
	Squalus blainvillei (Risso)	15	15.1	3.75	1-10
	Somniosus rostratus (Risso)	2	12.6	1.00	1-1
	Raja asterias Delaroche	2	1.6	2.00	*
	Raja clavata L.	2	4.0	1.00	1-1
	Raja oxyrinchus L.	1	2.1	1.00	*
	Chimaera monstrosa L.	1	1.3	1.00	*
OSTEICHTHYES	*Conger conger* (L.)	243	380,5	5.40	1-22
	Muraena helena (L.)	1	2.7	1.00	*
	Merluccius merluccius (L.)	313	372.3	6.98	1-23
	Phycis phycis (L.)	17	20.0	1.21	1-2
	Phycis blennoides (Brunnich)	8	6.2	2.67	2-3
	Polyprion americanus (Bloch & Schneider)	10	25.3	2.00	1-3
	Pagellus bogaraveo (Brunnich)	44	23.71	3.67	1-10
	Trachurus trachurus (L.)	2	1.20	1.00	1-1
	Lepidopus caudatus (Euphrasen)	48	85.2	3.20	1-12
	Scomber japonicus Houttuyn	2	1.30	2.00	*
	Scorpaena elongata Cadenat	38	51.2	2.33	1-6
	Scorpaena scrofa L.	22	24.2	2.75	1-7
	Helicolenus d. dactylopterus (Delaroche)	429	103.50	10.97	1-37
	Trigla lyra L.	22	11,5	1.57	1-3
	Trigla lucerna L.	24	27.3	2.18	1-8
	Lophius budegassa Spinola	1	0.7	1.00	*

* : Species caught in single hauls only.

TABLE 2 - List of the fishes caught by means of experimental longlines in summer 1993

YIELDS OBSERVED FOR COMMERCIAL HAULS IN SUMMER-AUTUMN 1995														
			C. conger		*M. merluccius*		*L. caudatus*		*S. elongata*		*H. d. dactylopterus*		All fishes	
Haul	Day	No hooks set per haul	No/ 100 hooks	Kg/ 100 hooks	No/ 100 hooks	Kg/ 100 hooks	No/ 100 hooks	Kg/ 100 hooks	No/ 100 hooks	Kg/ 100 hooks	No/ 100 hooks	Kg/ 100 hooks	No/ 100 hooks	Kg/ 100 hooks
Haul no 1	Aug 8th 1995	2,000	1.1	2.4	7.4	7.1	4.0	10.0	2.3	4.2	3.3	1.2	18.7	28.1
Haul no. 2	Oct. 30th 1995	2,000	0.9	1.6	5.4	4.9	1.4	3.0	0.6	1.1	1.0	0.3	9.6	11.5
Mean	-	2,000	1.0	2.0	6.4	6.0	2.7	6.5	1.4	2.6	2.1	0.7	14.1	19.8
s. d.	-	0.00	0.1	0.6	1.5	1.6	1.9	4.9	1.2	2.2	1.6	0.6	6.5	11.5

TABLE 3 - Yelds recorded for two fishing trial performed in fishing A area by one commercial longline in summer-autumn 1995

	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Fishing A+B areas, 110-150 m depths (5 longlines, No. baited hooks = 2,[illegible])									
No. individuals	39	43	17	1	0	0	3	0	1	2
No. data^	48	43	17	1	-	-	3	-	1	2
Average TL*	67	[illegible]	45.0	67.0	-	-	46.0	-	35.0	66
s. d.*	8	23	3.8	-	-	-	3.5	-	-	1
Average WT**	4.5	2.2	0.79	5.0	-	-	1.00	-	0.48	2.8
s. d.**	1.1	1.3	0.56	-	-	-	0.89	-	-	0.2
	Fishing A+B areas, 150-300 m depths (24 longlines, No. baited hooks = 7,320)									
No. individuals	9	93	141	1	20	11	14	208	7	19
No. data^	9***	87	128	1	20	11	14	33	7	19
Average TL*	82	77	48.5	51.5	31.8	38.0	52.3	23.3	39.0	46
s. d.*	14	17	9.0	3.5	4.8	6.0	7.0	3.0	8.0	3
Average WT**	2.8	1.1	1.00	2.6	0.52	0.84	1.06	0.11	0.48	0.9
s. d.**	1.3	0.9	0.47	0.5	0.24	0.34	0.72	0.09	0.15	0.3
	Fishing A+B areas, 300-405 m depths (19 longlines, No. baited hooks = 7,700)									
No. individuals	3	100	92	6	13	25	5	215	11	1
No. data^	2	91	92	6	13	25	5	107	11	1
Average TL*	98	85	54.0	48.5	33.5	43.0	56.0	24.5	38.0	44
s. d.*	0	28	10.3	6.0	4.1	7.8	8.0	4.0	4.5	5
Average WT**	5.2	1.5	1.43	2.1	0.77	1.30	0.79	0.26	0.47	0.9
s. d.**	0.3	1.6	0.55	0.8	0.27	0.76	0.17	0.12	0.19	0.3
	Fishing C area, 150-300 m depths (4 longlines, No. baited hooks = 2,100)									
No. individuals	0	6	40	0	1	2	0	7	1	1
No. data	-	6	40	-	1	2	-	7	1	1
Average TL*	-	127.5	53.6	-	33.0	46.2	-	26.6	48.0	40.0
s. d.*	-	8.3	12.0	-	-	0.5	-	3.4	-	-
Average WT**	-	4.4	1.42	-	0.60	1.78	-	0.36	0.77	1.1
s. d.**	-	1.1	1.16	-	-	0.14	-	0.13	-	-

^ : Number of measured and weighed individuals;
* : TL, cm;
** : WT, dressed weight in Kgs;
§ : One haul performed off Otranto at 230-300 m [illegible].

TABLE 4 - Synopsis of the average sizes and weights recorded for different fishes during our trials performed along the Apulian coast in summer 1993

FISHING A AREA, ALL LONGLINES								
Depth Sector	150-300 m				300-403 m			
Clusters of hauls	H		L		H		L	
	WAN±WSDN (No./100 baited hooks)	WAW±WSDW (Kg/100 baited hooks)	WAN±WSDN (No./100 baited hooks)	WAW±WSDW (Kg/100 baited hooks)	WAN±WSDN (No./100 baited hooks)	WAW±WSDW (Kg/100 baited hooks)	WAN±WSDN (No./100 baited hooks)	WAW±WSDW (Kg/100 baited hooks)
[illegible]	0.1±0.1	0.3±0.7	0.2±0.6	0.5±1.7	0	0	0.1±0.1	0.2±0.5
C. conger	[1]2.1±0.8	2.3±0.9	[1]0.6±0.8	0.9±1.3	2.2±1.7	3.5±3.1	0.7±0.6	1.8±1.3
M. merluccius	[2]2.4±1.1	[3]2.5±1.2	[2]0.9±0.7	[3]0.8±1.0	[4]1.8±1.0	[5]3.0±1.7	[4]0.8±0.5	[5]0.9±0.6
H. d. dactylopterus	3.4±2.2	0.69±0.48	1.6±3.2	0.66±0.56	4.2±2.8	0.94±0.64	2.5±1.7	0.58±0.42
Other exploited fishes	1.9±1.2	1.6±1.2	0.7±0.4	0.4±0.4	1.4±1.3	2.8±2.1	0.9±0.7	0.8±0.7
Other unexploited fishes	0.4±0.4	0.7±0.4	0.3±0.5	0.3±0.5	0.6±0.9	0.3±0.3	1.7±1.6	1.0±1.8
All fishes, *H. d. dactylopterus* individuals excluded	[6]5.9±1.1	-	[6]2.7±1.9	-	6.2±3.1	-	4.2±0.1	-
All fishes	10.2±2.5	[7]5.2±1.8	6.3±4.5	[7]3.6±2.9	10.3±3.3	[8]9.7±5.5	6.7±2.5	[8]4.3±2.4
No. of hauls	7		9		7		12	
No. LLPL hauls/All hauls	5/7		7/9		7/7		11/12	
Average numbers of hooks baited	465±167		358±83		401±89		396±93	
Average depth ranges of the hauls (m)	[9]115±34		[9]47±26		43±19		42±28	
Average slopes of the hauls	[10]7.8±4.4%		[10]2.4±1.4%		2.9±2.0%		1.9±1.4%	

H, L = see text;
WAN = Weighed average number of fishes caught in a single haul;
WSDN = Weighed standard deviation of number of fishes caught in a single haul;
WAW = Weighed average quantity of fish caught in a single haul;
WSDW = Weighed standard deviation of the quantity of fish caught in a single haul;
2, 4, 5, 6, 7, 9, 10 = Weighed averages differing each other at P<0.01 after a Student's test run on independent sets of data,
3, 8 = Weighed averages differing each other at P<0.02 after a Student's test run on the independent sets of data;

TABLE 5 - Average yelds obtained in the "high - production" (H) and "low-production" (L) sites of the fishing area A during summer 1993

Species	Average Total Length at Maturity (ALM) Minimum Total Length at Maturity (MLM) (cm)	Further observations	Presumptive age range of samples	References	Geographic areas of the studies	Fraction of measured individuals beyond limits in column 2
S. acanthias	ALM, females = 93.0; 74.0; 109.0	Males not longer than 80 cm	> 10-15 years	Ketchen (1972) Fahy (1989) Kirnosova (1989)	NE Pacific Irish Sea Black Sea	94.9% >74.0 cm 55.9% >93.0 cm 3.4% >109.0 cm
C. conger	-	Males rarely longer than 100 cm	≥ 4 years	Cau & Manconi (1983) Cau & Manconi (1984) Fannon *et al.* (1990)	Mediterranean Sea Irish Sea	
M. merluccius	ALM, females = 30.0 ALM, males = 25.0	In trawl catches females largely predominate in size classes beyond 40 cm	Mainly 4-8 years	Zupanovic (1968) Flamigni (1984) Ungaro *et al.* (1993)	Mediterranean Sea	99.6% > 30.0 cm
P. bogaraveo	ALM, females = 37.0* ALM, males = 34.0* MLM, females = 35.0* MLM, males = 34.0*	-	Mainly 3-6 years	Krug (1990) Orsi-Relini & Fida (1992)	Azorean Islands Mediterranean Sea	9.1% >37.0 cm 20.5% >35.0 cm
H. d. dactylopterus	MLM, females = 21.5	Males predominate in the largest size classes	Mainly 4-8 years	Peirano & Tunesi (1986) D'Onghia *et al.* (1992) Ragonese & Reale (1994) Romanelli *et al.* (1998)	Mediterranean Sea	67.9% >21.5 cm
T. lyra	-	-	≥ 3 years	Papacostantinou (1981) Papacostantinou *et al.* (1992)	Mediterranean Sea	-
T. lucerna	ALM, females = 40.0 ALM, males = 35.0	Males not longer than 50 cm	Mainly 3-7 years	Baron (1985a) Baron (1985b)	Western Brittany (NE Atlantic)	81.8% >40.0 cm 100.0% >35.0 cm

TABLE 6 - Synopsis of biological data derived from the literature on some of the fishes caught during the fishing trials of summer 1993

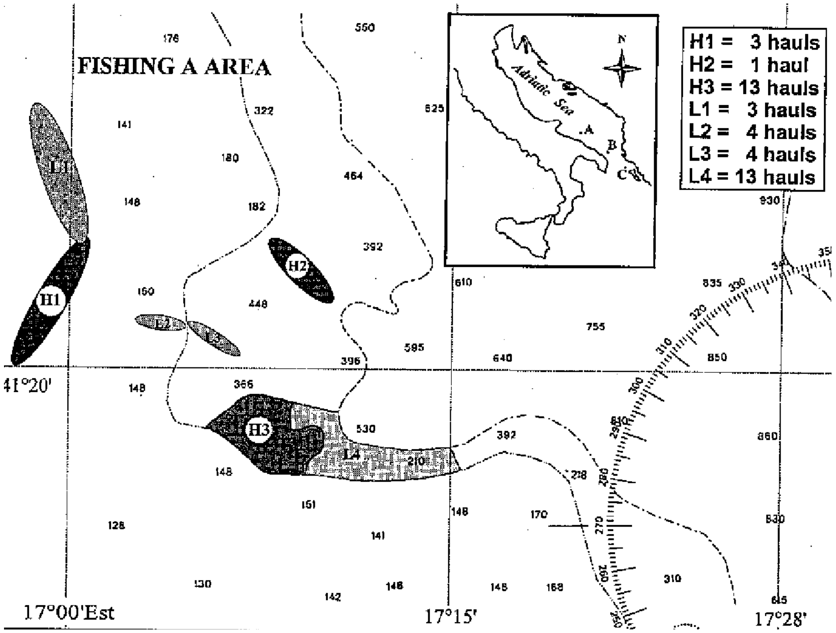

Fig. 1 - Map of the three fishing areas where experimental longlines were tested and locations of the “scarcely productive” (L) and “highly productive” (H) sites found in the fishing A area.

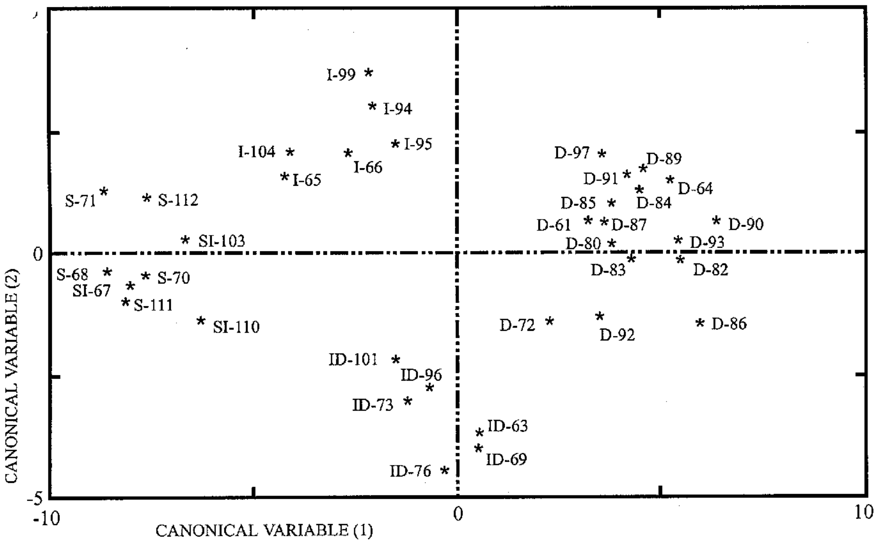

Fig. 2 - Discriminant analysis based on the species composisiton of the catches obtained in 36 hauls performed in fishing A and B areas during summer 1993.

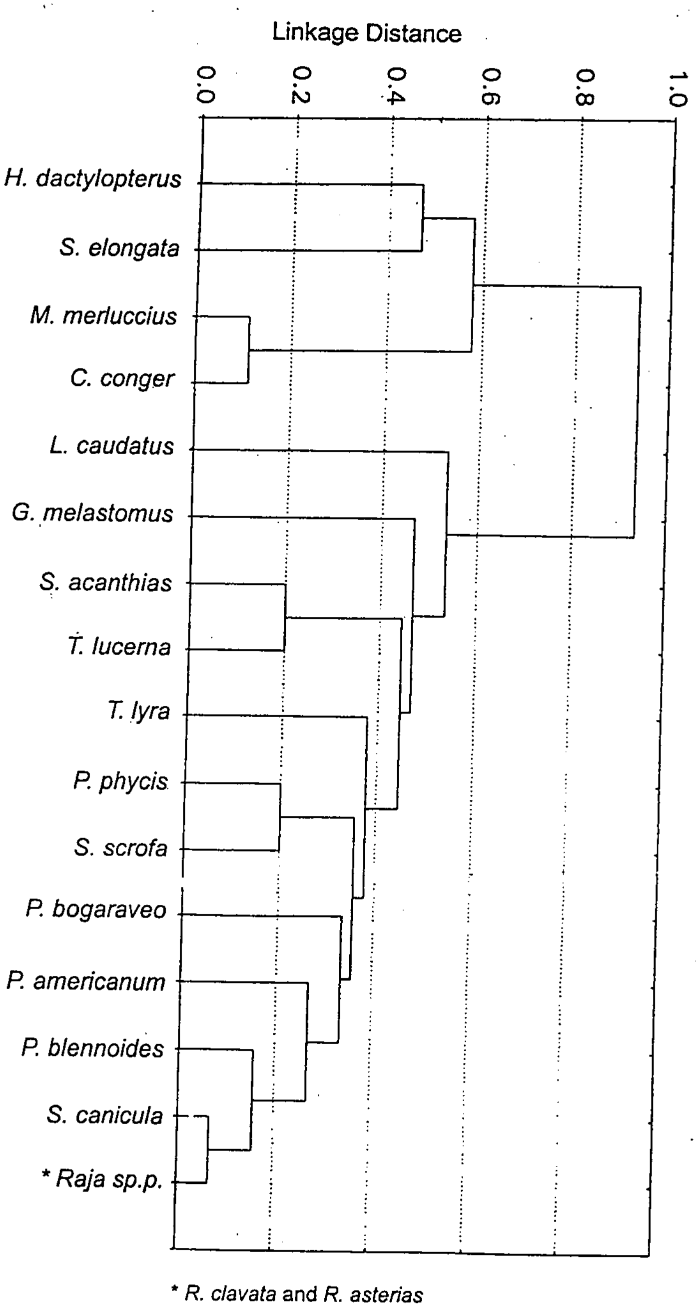

Fig. 3 - Dendrogram of the fish clusters obtained on the basis of the species composition of catches from the fishing A and B areas.