Commercial fishery and fish species composition in the coastal waters of Libya

By Esmaile Shakman & Ragnar Kinzelbach

SHAKMAN E. & KINZELBACH R. (2007): Commercial fishery and fish species composition in coastal waters of Libya. Rostocker Meeresbiologische Beiträge 18: S. 63-78.

Abstract. This study was carried out along the Libyan coast from February 2005 to March 2006. A total of 1,511 fishing boats of four types were observed: 64.26% were “flouka”, 24.09% “mator”, 6.88% “lampara” and 4.77% “batah”. Most of them were concentrated in the western region (58.64%). The most common fishing gear used in the coastal area is the trammel net, which is used by flouka, mator and batah. Depending on the fishing season, the fish size and the target fish species, other fishing gear is also used occasionally. In this study forty two fish species of commercial value were found in the eastern region, twenty one in the Gulf of Sirt region and twenty eight in the western region. The percentage of native fish species was 61.90% of the total number of fish species in the eastern region, while in the Gulf of Sirt region and the western region the percentages were 54.55% and 71.43% respectively. The exotic herbivorous fish species Siganus rivulatus and Siganus luridus were found in greater abundance than the native herbivores *Sparisoma cretense* and *Sarpa salpa*. Their abundance varied in the different regions. S. rivulatus was abundant in the eastern part of Libya while S. luridus was more abundant in the Gulf of Sirt and the western region of Libya. The reason for this is probably that S. rivulatus is euyecous and adapts well to most habitats, since it was found in different herbivorous habitats (rock with algae, sand with algae and grass with algae), whilst the stenecous S. luridus was found in one specific habitat (rock with algae). Furthermore there might be competition between the Indo-Pacific herbivorous fish S. rivulatus and the native fish S. salpa; S. rivulatus and S. luridus may have benefited from low competition pressure, due to the low level of diversity and abundance of native herbivorous fish species.

Kurzfassung. Eine Untersuchung über die Fischerei an der Küste Libyens wurde von Februar 2005 bis März 2006 durchgeführt. Insgesamt wurden 1.511 Fischerboote in vier Typen angetroffen: 64.26% „flouka“, 24.09% „mator“, 6.88% „lampara“ und 4.77% „batah“. Sie werden kurz beschrieben. Die meisten, 58,64% waren im Westen des Landes konzentriert.
Das wichtigste Fanggeschirr der Küstenfischerei ist das Spiegel netz eingesetzt mit flouka, mator und batah. Abhängig von Jahreszeit, Größe und Art der erwarteten Fische wird nur gelegentlich auch anderes Gerät eingesetzt. In dieser Untersuchung wurden 42 Arten von wirtschaftlicher Bedeutung in der Ost-Region gefunden, 21 in der Region der Syrte und 28 in der West-Region. Der Anteil einheimischer Fische betrug 61.90% der Gesamtartenzahl in der Ost-Region, in der Syrte 54.55%, in der West-Region 71.43%. Die eingewanderten Pflanzen fressenden Arten Siganus rivulatus und Siganus luridus wurden häufiger gefischt als die einheimischen Herbivoren Sparisoma cretense und Sarpa salpa. Ihre Abundanz schwankte regional. S. rivulatus überwog in der Ost-Region, während S. luridus häufiger in der Syrte und im Westen war. Die Ursache ist wahrscheinlich die Euryökie von S. rivulatus: Er wurde in verschiedenen

Pflanzen produzierenden Habitaten angetroffen (Fels oder Sand mit Algen, Seegras mit Algen). Der stenöke S. luridus kam nur in einem spezifischen Habitat, Fels mit Algen, vor. Hinzu kommt möglicherweise eine Konkurrenz zwischen dem indopazifischen Herbivoren *S. rivulatus* und der autochthonen Art S. salpa. Beide Einwanderer, S. rivulatus und S. luridus, haben wahrscheinlich von einer geringen Konkurrenz durch die nur in geringer Diversität und Abundanz vorhandenen einheimischen Pflanzenfressern profitiert.

Key words: Coastal area, exotic fish, fishing vessels, herbivorous fish, Libya, species composition, trammel net.

Introduction

The Mediterranean Sea is an almost closed marine basin between Europe, Asia and Africa. It is connected with the Atlantic Ocean by the Straits of Gibraltar, which are fifteen kilometers wide and have an average depth of 290 m to a maximum 950 m. In addition to this natural connection, it has been connected to the Red Sea by the Suez Canal since 1869. The Suez Canal is one hundred and twenty meters wide and twelve meters deep. The number of fish species recorded for the Northeast Atlantic and the Mediterranean Sea totals about 1,255 (UNESCO 1984, 1985, 1986), a total of 540 fish species was listed for the Mediterranean Sea, including 362 shore dwellers, 62 of them endemic (Tortonese, 1963). It is unreasonable to assume that the whole Mediterranean Sea has the same species composition, due to the evident regional speciation in this sea (WHITEHEAD *ET AL*. 1984-1986).

A number of studies have been conducted in Libyan waters. The first was by VINCIGUERRA in 1881 who recorded seventeen species when reporting on the ichthyofauna of Libya. The number of species known increased rapidly in the early 20th century (NINNI 1914, VINCIGUERRA 1922, TORTONESE 1939). More detailed studies were conducted in the second half of the 20th century, ALDEBERT & PICHOT (1973), for instance, concentrated on some flat fishes, DUCLERC (1973) on Scorpaenidae. Some other surveys resulted in check lists: in the western part in 1972, for example, sixty two species were listed (GORGY 1972). A total of 131 fish species were registered by SOGREAH (1977). Also in 1977, 39 cartilaginous fish species and 185 osteichthyes species were listed (CONTRANSIMEX 1977). ZUPANOVIC & EL-BUNI (1982), using demersal fishing gear, reported that Libyan waters are potentially moderately productive in fish. They also stated that the Libyan fish fauna was mainly was related to the fauna of the eastern part of the Mediterranean Sea, the Levant Basin. In the eastern part of Libya (Benghazi region) a list of bony fishes came up with a total of 201 species belonging to seventy one families and fifteen orders (HASSAN & SILINI 1999). In 1993 a survey of the fishing fleet was carried out along the Libyan coast (LAMBOUEF & REYNOLDS 1994). Recently an investigation of artisanal fisheries was conducted along the Libyan coast (LAMBOUEF 2000).

Many exotic species have migrated into the Mediterranean through the Suez Canal and the Straits of Gibraltar from the Indo-Pacific and Atlantic Oceans (POR 1978, 1990). This represents a continued and unique phenomenon that allows direct observation of introductions and colonization in a marine environment. The estimated number of exotic species in the Mediterranean Sea is about 1,000, including at least 93 exotic fish species as of 2002 (GOLANI *ET AL*. 2002). Up to now 64 of them have penetrated the Mediterranean Sea through the Suez Canal

(Lessepsian migration) (GOLANI *ET AL*. 2004, GOLANI & SONIN 2006, BILECENOGLU & KAYA 2006). Some of them have become major components of the composition of the eastern and central Mediterranean ichthyofauna communities and have also gained economic importance in the fisheries of these regions (BILECENOGLU & TASKAVAK 2002, BARICHE *ET AL*. 2004, SHAKMAN & KINZELBACH 2007).The fact that many species successfully establish themselves in the new environment indicates that the dietary requirements of many migrant species reflect the non-selective nature of their feeding habits. This adaptation is of great importance for any migrant in its new environment; the ecological process occasioned by spatial and temporal overlap in the use of resources is considered an important force in organizing fish communities; competition can lead to adaptations which may include habitat selection and/or resource allocation or extinction (MADL 2001). The herbivores *S. salpa* (Linnaeus 1758) (Sparidae) and *S. cretense* (Linnaeus 1758) (Scaridae) are the only native herbivorous fish species in the Mediterranean Sea (BAUCHOT & HUREAU 1986, QUIGNARD & PRAS 1986). *S. cretense* feeds on seaweeds and small benthic invertebrates, while *S. salpa* is almost exclusively herbivorous. Two exotic herbivorous fish species *S. luridus* Rüppell, 1828 and *S. rivulatus* Forsskål, 1775 (Siganidae) were added to the ichthyofauna of the Mediterranean Sea after the opening of the Suez Canal in 1869 (STEINITZ 1927, BEN-TUVIA 1964), and they were recorded on the Libyan coast in 1970 (STIRN 1970).

Most published surveys were performed by trawling. The present study was an attempt to concentrate on the coastal area with the aims of: (a) identifying the most important fishing gear and fishing craft in this area (b) investigating the ichthyofauna collected by this fishing gear (trammel net) along the Libyan coast, (c) comparing the abundance of exotic and native fish species, especially herbivorous fish species, and finally (d) contributing to the general knowledge about species composition in this area.

Materials and methods

This study was conducted from February 2005 to March 2006; the survey was performed along the Libyan coast in an area extending from Farwah in the western part of Libya up to the Al Bardiyah Gulf on the Libyan border with Egypt (Fig. 1). The aim of this survey was to find out the number of boats, the type of boat and type of fishing gear used in the coastal area. Seventy six active landing sites were visited; the latitude and longitude of the region, the number of boats, and the types of fishing gear were recorded for each region. Important information about fishing vessels and fishing gear was collected from local fishermen and fishermen's unions.
For fish species composition, the study was carried out from March 2005 to March 2006. The study area was divided into three main regions according to topography and environment (eastern region, Gulf of Sirt, western region), two sites were selected in the eastern region (Tubruk, Benghazi), one site in the Gulf of Sirt (Musrata) and two sites were selected in the western region (Tripoli, Zwara); these were considered to be the most active catching sites and were investigated monthly, Al-Bardiyah in the eastern region and Farwah in the western region were also selected in the border areas and were investigated seasonally (Fig. 1). A total of 130 samples were collected from the Libyan coast, 53 samples from the eastern region, 52 samples from western region and 25 samples from the Gulf of Sirt region using the trammel nets (inner mesh 26 mm, outer mesh 120 mm) used by fishing vessels

of the type “flouka” (Fig.2). In order to standardize sampling bases and fishing effort, two fishing boats of the same size and two sets of fishing gear were considered from each sampling site. Each sample collected was washed in fresh water and sorted, then identified and classified according to WHITEHEAD *ET AL.* (1984-1986) for the native fish species and GOLANI et al. (2002) for the exotic fish species. The individual numbers of each fish species were counted and the estimated weights for each species were recorded. Information was collected about the length of fishing gear, the depth, the type of habitats, the catch, the first observation for newcomers, the season and the Libyan names of fish.

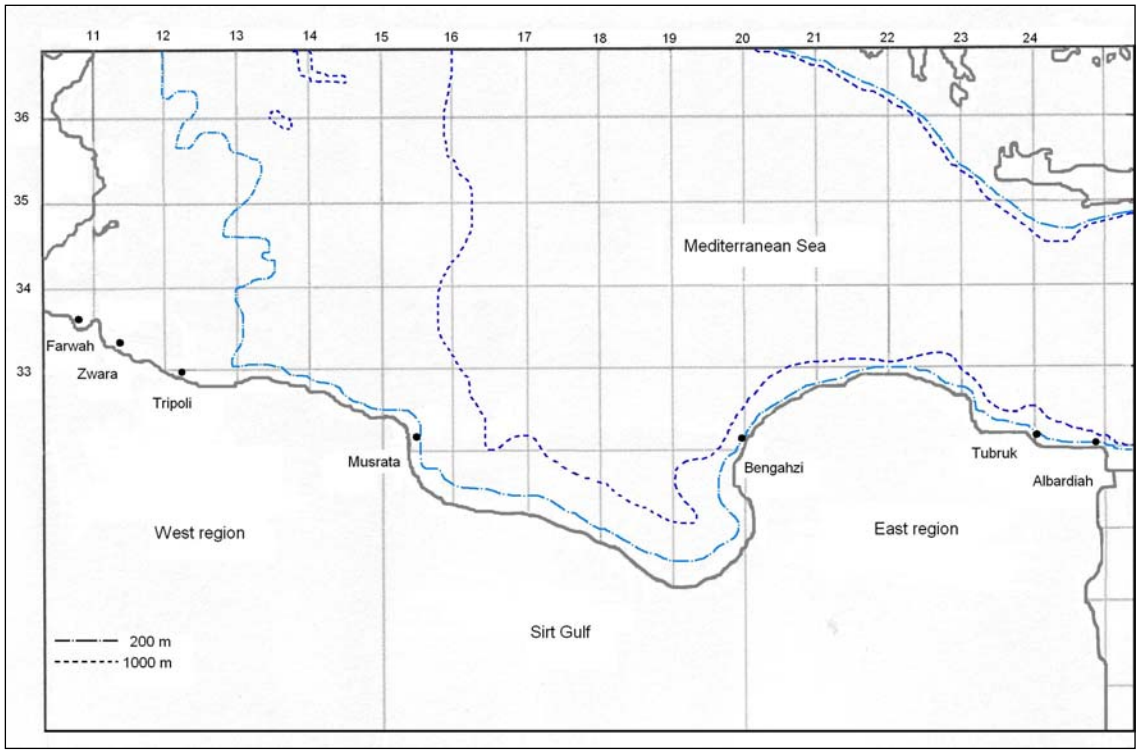

Fig. 1. Map of the Libyan coast, showing the study area

Fig. 2. The fishing vessels used along the Libyan coast: 1 Mator, 2 Batah, 3 Lampara, 4 Flouka.

Results

Fishing vessels

The number of boats counted by this study was 1,511; of them 64.26% were “flouka”, 24.09% were “mator”, 6.88% were “lampara” and 4.77% were “batah” (Fig.3). Most of them were concentrated in the western part of the Libyan coast (Tab.1). In the coastal area the fishing vessel used most was the flouka. Lampara, used to catch small pelagic fish, were concentrated in the western part, with a few in the Gulf of Sirt, especially in Musrata. Batah, on the other hand, were concentrated in the shallow waters of the western region (Farwah site), with only a small number of them found in the eastern region (Attimimi and Ainghazala sites) (Fig. 4).

Table 1. The number and percentage of fishing vessels along the Libyan coast

Region	East region	Middle region	West region	Total
Number	308	317	886	1511
Percentage	20.38%	20.98%	58.64%	100

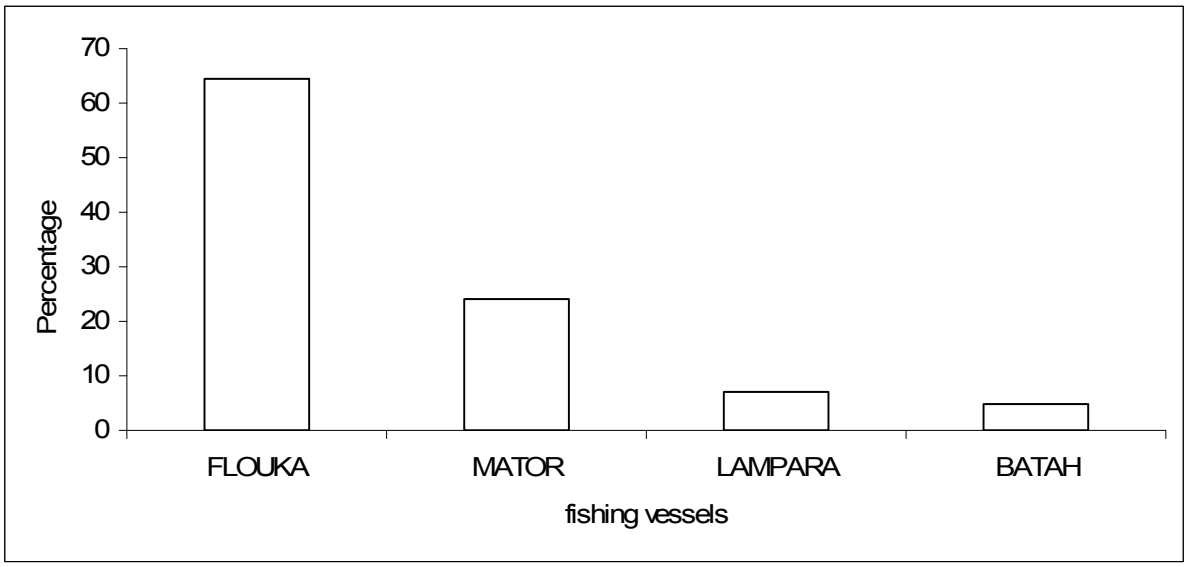

Fig. 3. The percentage of fishing vessels.

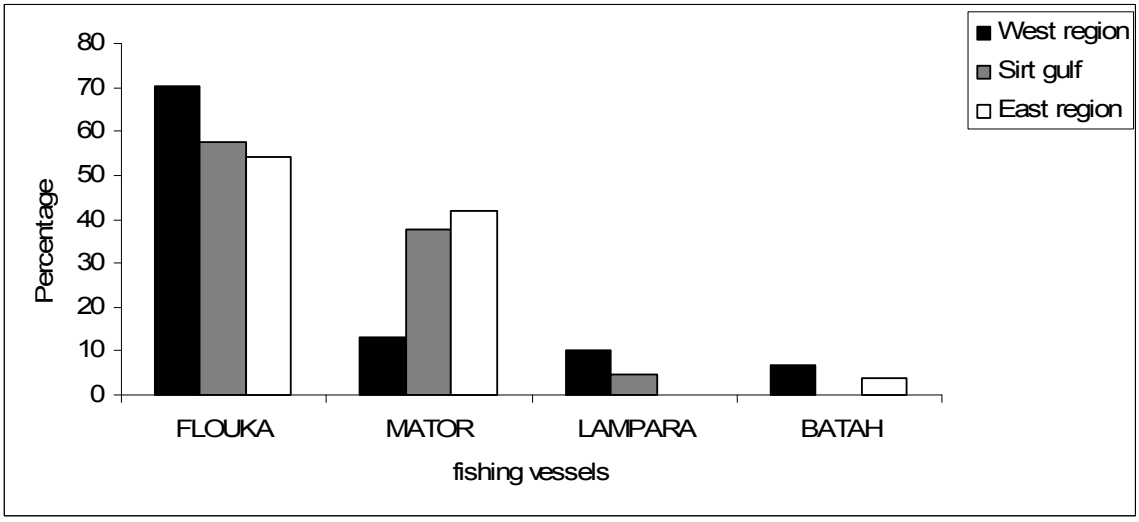

Fig. 4. The percentage of fishing vessels in the coastal area and their distribution along the coast of Libya.

The most commonly used fishing gear in the coastal area were trammel nets. These nets are used by flouka at depths of one to fifty meters, and are used by mator at more than thirty meters. They are also used by batah at depths of up to 5 meters (Fig. 5). Flouka also use other fishing gear such as long line, gill nets etc., depending on the season and size of the target fish species caught along the Libyan coast (Fig. 6).

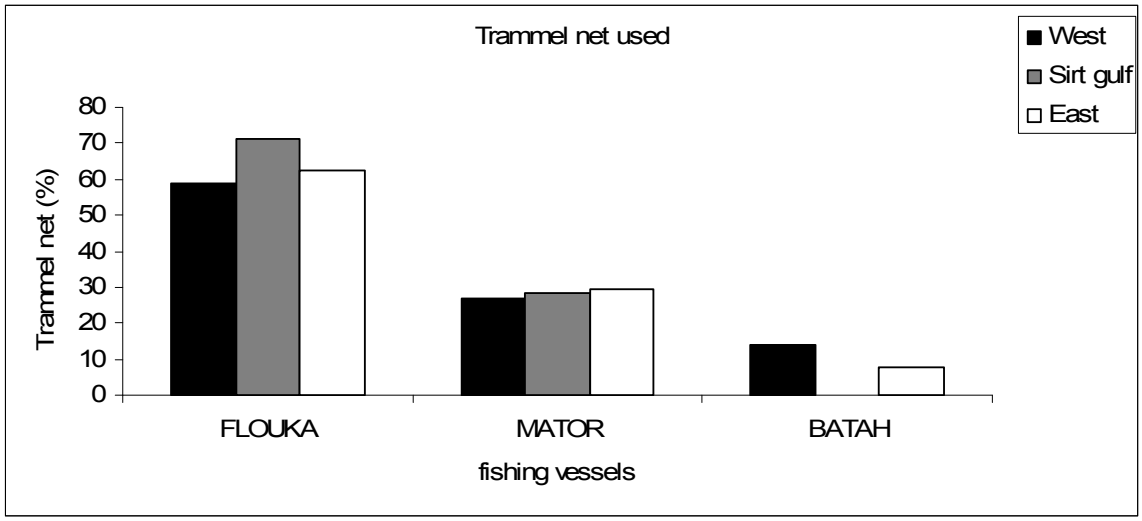

Fig. 5. The percentage of fishing vessels that used the trammel net.

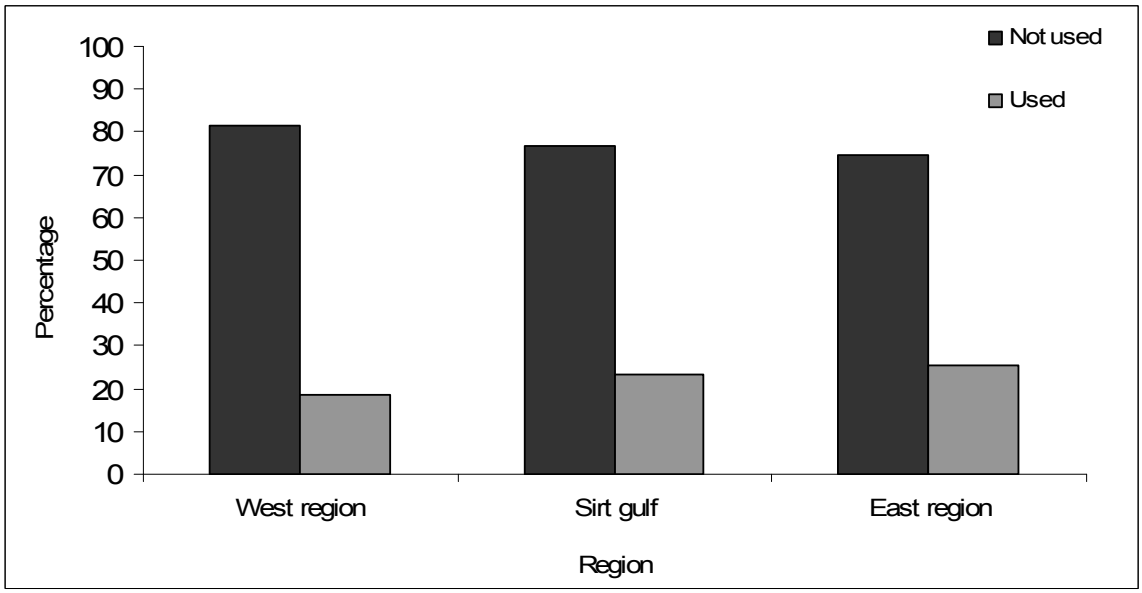

Fig. 6. The percentage of flouka that used and did not use the trammel net along the coast of Libya.

Species composition

In this study, the highest fish species diversity in the coastal area was in the eastern region (45.65%), while in the Gulf of Sirt and western regions the figure was 23.91% and 30.43% respectively (Fig. 7). The percentage of native fish species was higher than exotic fish species in the eastern region (61.90%), in the Gulf of Sirt region the percentage of native fish species was 54.55%, while 71.43% of fish were native fish species in the western region (Fig. 8).

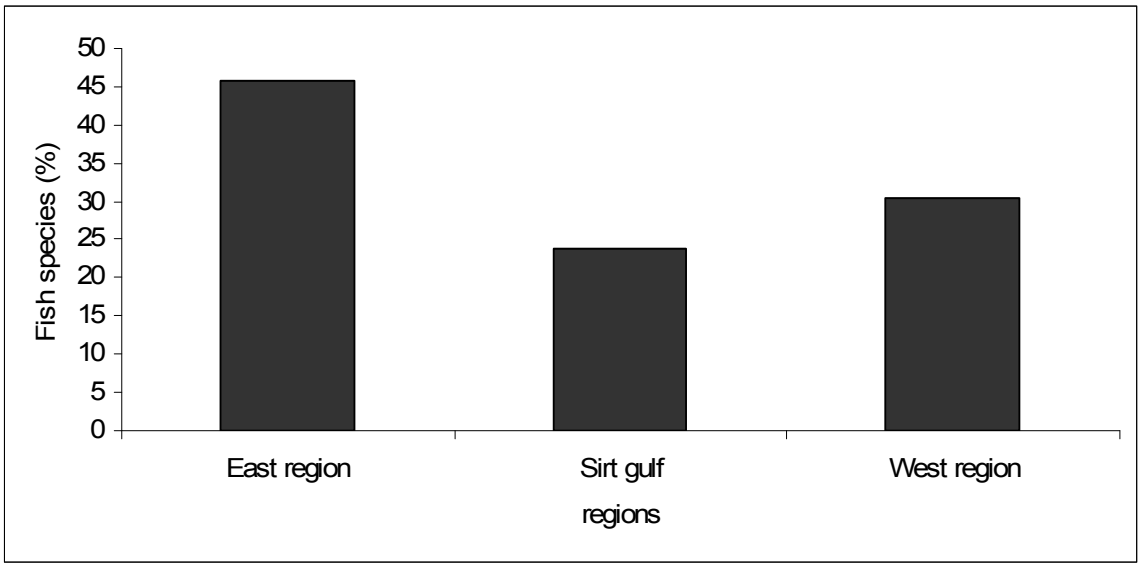

Fig. 7. The number percentage of fish species.

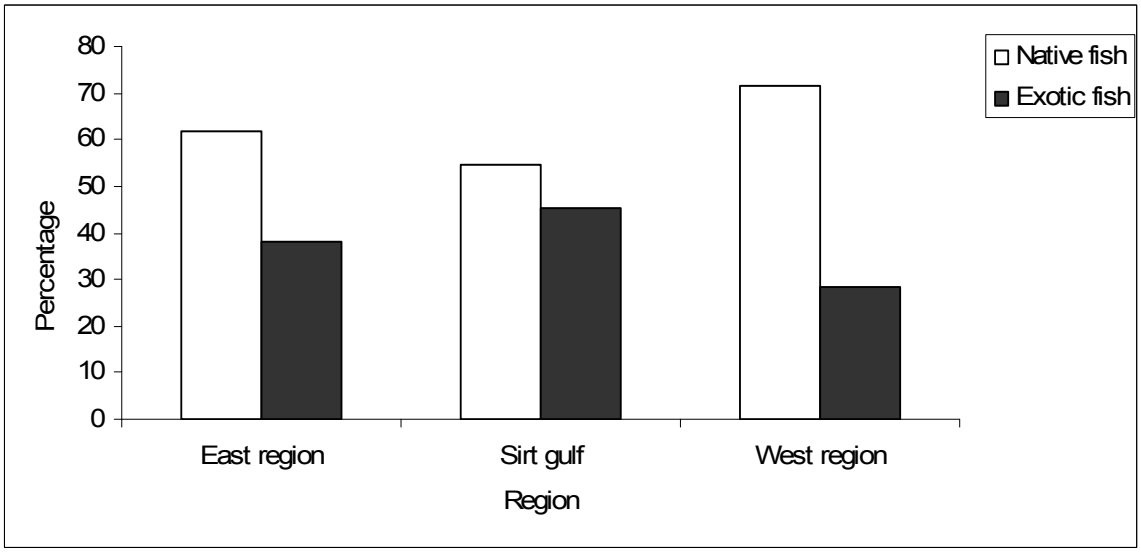

Fig. 8. The relation between the number of exotic fish species and the number of native fish species.

In the eastern region of the Libyan coast, forty two fish species were found (Tab. 2). The highest percentage for native species was Annular Seabream *D. annularis* (Sparidae) at 7.74% of the catch and the lowest percentage was Shi Drum *Ubbrina cirrosa* (Sciaenidae) at 0.10% of the total catch; the highest percentage for exotic fish species was Marbled Spine-foot *S. rivulatus* (Siganidae) at 41.20% and the lowest percentage was Blue-spotted Cornetfish *F. commersonii* (Fistularidae) at 0.02% and Spotback Herring *Herklotsichthys punctatus* (Clupeidae) at 0.02% of the total catch.

Table 2. The species composition and number percentage collected from the coastal waters of the eastern part of Libya (* Cephalopod).

Libyan name	Common name	Scientific name	family	N%	W%
Kahlla	Saddledbream	*Oblada melanura*	Sparidae	0.67	1.15
Treellya	Striped red mullet	*Mullus surmuletus*	Mullidae	3.01	4.31
Garagous mausham	Banded seabream	*Diplodus vulgaris*	Sparidae	1.48	1.37
Garagous	white sea bream	*Diplodus sargus*	Sparidae	4.16	4.79
Brakash	Painted comber	*Serranus scriba*	Serranidae	0.30	0.22
Sbarus	Annular seabream	*Diplodus annularis*	Sparidae	7.74	4.29
Shkorfo	Scorpionfish	*Scorpaena* spp	Scorpaenidae	2.12	1.90
Buri	Box lip mullet	*Oedalechilus labeo*	Mugilidae	3.18	5.10
Mankos	Striped sea bream	*Lithoganthus mormyrus*	Sparidae	2.71	2.59
Zemrina	Mediterranean moray	*Muraena helena*	Muraenidae	0.27	0.38
Ghazla	Parrotfish	*Sparisoma cretense*	Scaridae	6.31	11.1
Abokather	Ballan wrasse	*Labrus bergylata*	Labridae	1.31	1.93
Dout	Dusky grouper	*Epinephelus guaza*	Serranidae	0.81	1.62
Morjan	Common sea bream	*Pagrus pagrus*	Sparidae	0.89	0.84
Baghllah	Shi drum	*Ubbrina cirrosa*	Sciaenidae	0.10	0.41
Grab	Brown meagre	*Sciaena umbra*	Sciaenidae	0.76	1.21
Pullem	Stargazer	*Uranoscopus scaber*	Uranoscopidae	0.27	0.39
Halof	Grey trigger fish	*Balistes carolinensis*	Balistidae	0.30	0.40
Homrayah	Common dentex	*Dentex dentex*	Sparidae	0.22	0.11
Dendashie	Common dentex	*Dentex dentex*	Sparidae	0.30	0.33
Shelpa	Salema	*Sarpa salpa*	Sparidae	1.11	0.97
Tannut	Black seabream	*Spondyliosoma cantharus*	Sparidae	0.22	0.39
Mdas	Common Sole	*Solea spp*	Soleidae	0.15	0.09
Mugalzl	Barracuda	*Sphyraena spp*	Sphyraenidae	0.12	0.23
Strelia	Leerfish	*Lichia amia*	Carangidae	0.02	0.29
Sardine	Madeiran Sardinella	*Sardinella maderensis*	Clupeidae	5.05	6.18
Moshta	obtuse barracuda	*Sphyraena obtusata*	Sphyraenidae	1.33	2.61
Moshta	red barracuda	*Sphyraena pinguis*	Sphyraenidae	4.29	5.60
Sridna	Spotback herring	*Herklotsichthys punctatus*	Clupeidae	0.02	0.01
Makarona	Brushtooth lizardfish	*Saurida undosquamis*	Synodontidae	0.54	0.66
Abo- meshfa	Halfbeak	*Hemiramphus far*	Hemiramphidae	1.77	0.75
Gaeta	Cornetfish	*Fistularia commersonii*	Fistularidae	0.02	0.09
Namousa	Silverside fish	*Atherinomorus lacunosus*	Atherinidae	0.42	0.06
Saurou Asfar	Shrimp scad	*Alepes djedaba*	Carangidae	0.89	0.56
Treellya Khadra	Goatfish	*Upeneus pori*	Mullidae	0.05	0.04
Sparus Masrry	Porgie	*Crenidens crenidens*	Sparidae	0.05	0.03
Gasaetlla	Sweeper fish	*Pempheris vanicolensis*	Pempheridae	0.05	0.02
Buri	Roving grey mullet	*Liza carinata*	Mugilidae	0.05	0.05
Balameta Yamania	Spanish Mackerel	*Scomberomorus commerson*	Scombridae	0.30	4.41
Halofboresha,	Filefish	*Stephanolepis diaspros*	Monacanthidae	0.25	0.13
Batata Khahlla	Dusky spine-foot	*Siganus luridus*	Siganidae	3.57	3.36
Batata beda	Marbled spine-foot	*Siganus rivulatus*	Siganidae	41.2 0	25.8
* Garneat	Common octopus	*Octopus* spp	Octopodidae	0.17	0.70
* Sepei	Cuttlefish	*Sepia offlcinalis*	Sepiidae	1.45	2.51

Twenty one fish species were found in the Gulf of Sirt region of the Libyan coast (Tab. 3). The highest percentage for native fish species was Annular Seabream *D. annularis* (Sparidae) at 17.11 % of the total catch and the lowest percentage was Saddled Bream *Oblada melanura* (Sparidae) at 4.56% of total catch; the highest percentage for exotic fish species was Dusky Spine-foot *S. luridus* (Siganidae) at 36.82% and the lowest percentage was Blue-spotted Cornetfish *F. commersonii* (Fistularidae) at 0.07% of the total catch.

Table 3. The species composition and number percentage collected from the coastal waters? of the middle part of Libya (* Cephalopod).

Libyan name	Common name	Scientific name	family	N%	W%
Treellya	Striped red mullet	*Mullus surmuletus*	Mullidae	2.88	3.24
shkorfo	scorpionfish	*Scorpaena* sp	Scorpaenidae	9.26	5.47
Kahlla	Saddledbream	*Oblada melanura*	Sparidae	4.56	4.32
Sbarus	Annular seabream	*Diplodus annularis*	Sparidae	17.1	10.1
Grab	Brown meagre	*Sciaena umbra*	Sciaenidae	1.26	3.31
Garagous	white sea bream	*Diplodus sargus*	Sparidae	3.86	3.02
Shelpa	Salema	*Sarpa salpa*	Sparidae	2.31	2.00
Dout	Dusky grouper	*Epinephelus guaza*	Serranidae	0.98	2.06
Ghazla	Parrotfish	*Sparisoma cretense*	Scaridae	2.88	4.63
Abokathear	Ballan wrasse	*Labrus bergylate*	Labridae	4.42	8.05
Mankos	Striped sea bream	*Lithoganthus mormyrus*	Sparidae	3.65	2.06
Moshta	obtuse barracuda	*Sphyraena obtusata*	Sphyraenidae	0.35	0.50
Moshta	red barracuda	*Sphyraena pinguis*	Sphyraenidae	1.54	1.54
Makarona	Brushtooth lizardfish	*Saurida undosquamis*	Synodontidae	0.14	0.15
Gaeta	Cornetfish	*Fistularia commersonii*	Fistularidae	0.07	0.11
Namousa	Silverside fish	*Atherinomorus lacunosus*	Atherinidae	0.21	0.09
Saurou Asfar	Shrimp scad	*Alepes djedaba*	Carangidae	0.28	0.36
Balameta	Spanish Mackerel	*Scomberomorus commerson*	Scombridae	0.49	5.44
Yamania					
Halof boresha	Filefish	*Stephanolepis diaspros*	Monacanthidae	0.21	0.20
Batata Khahlla	Dusky spine-foot	*Siganus luridus*	Siganidae	36.8	37.2
Batata beda	Marbled spine-foot	*Siganus rivulatus*	Siganidae	5.19	5.31
* Sepia	Cuttlefish	*Sepia offlcinalis*	Sepiidae	1.54	0.91

Twenty eight fish species were found in the western region of Libya (Tab. 4). The highest percentage for native fish species was Annular Seabream *Diplodus annularis* (Sparidae) at 10.74% of the catch, and the lowest was Red Sea Bream *Pagellus bogaraveo* (Sparidae) at 0.16% of the total catch; the highest percentage for exotic fish species was Dusky Spine-foot *S. luridus* (Siganidae) at 40.06% of the catch, and the lowest was Blue-spotted Cornetfish *Fistularia commersonii* (Fistulariidae) at 0.03% of total catch.

Table 4. The species composition and number percentage collected from the coastal waters of the western part of Libya (* Cephalopod).

Libyan name	Common name	Scientific name	family	N%	W%
Treellya	Striped red mullet	*Mullus surmuletus*	Mullidae	3.25	2.57
Shkorfo	scorpionfish	*Scorpaena* spp	Scorpaenida	7.03	7.08
Dendashie	common dentex	*Dentex dentex*	Sparidae	0.20	0.67
Sbarus	Annular seabream	*Diplodus annularis*	Sparidae	10.7	6.23
Grab	Brown meagre	*Sciaena umbra*	Sciaenidae	3.97	4.11
Morgan abo ain	Large-eyed dentex	*Dentex macrophthalmus*	Sparidae	1.07	0.83
Kahlla	Saddledbream	*Oblada melanura*	Sparidae	1.37	1.56
Tanot	Black sea bream	*Spondyliosoma cantharus*	Sparidae	0.81	1.70
Garagous	white sea bream	*Diplodus sargus*	Sparidae	4.88	3.68
Garagose mausham	Banded seabream	*Diplodus vulgaris*	Sparidae	2.34	0.53
Abokathear	Ballan wrasse	*Labrus bergylate*	Labridae	5.43	5.25
Djaja	Tub gurnard	*Trigla lucerna*	Triglidae	0.98	1.47
Dout	Dusky grouper	*Epinephelus guaza*	Serranidae	1.11	2.16
Brakash	Painted comber	*Serranus scriba*	Serranidae	0.33	0.25
Ghazla	Parrotfish	*Sparisoma cretense*	Scaridae	2.73	3.98
Mankos	Striped sea bream	*Lithoganthus mormyrus*	Sparidae	1.69	1.64
Shelpa	Salema	*Sarpa salpa*	Sparidae	3.12	0.48
Morjan	Commonsea bream	*Pagrus pagrus*	Sparidae	2.60	0.28
Hamreia	Red sea bream	*Pagellus bogaraveo*	Sparidae	0.16	0.18
Strelia	Leerfish	*Lichia amia*	Carangidae	0.10	0.15
Moshta	obtuse barracuda	*Sphyraena obtusata*	Sphyraenidae	0.10	0.16
Moshta	red barracuda	*Sphyraena pinguis*	Sphyraenidae	0.16	0.18
Gaeta	Bluespotted	*Fistularia commersonii*	Fistularidae	0.03	0.06
SaurouAsfar	Shrimp scad	*Alepes djedaba*	Carangidae	0.16	0.37
Balameta	Spanish	*Scomberomorus*	Scombridae		
Yamania	Mackerel	*commerson*		0.49	3.91
Halofboresha	Filefish	*Stephanolepis diaspros*	Monacanthidae	0.13	0.15
Batata Khahlla	Dusky spine-foot	*Siganus luridus*	Siganidae	40.1	45.3
Batata beda	Marbled spine-foot	*Siganus rivulatus*	Siganidae	4.52	4.47
* Sepia	Cuttlefish	*Sepia offlcinalis*	Sepiidae	0.42	0.64

Herbivorous fish species

S. rivulatus was most abundant in the eastern region of the Libyan coast (more than *S. luridus* and the native fish species *S. salpa* and *S. cretense*). In the Gulf of Sirt region the exotic herbivore *S. luridus* was more abundant than *S. rivulatus* and the native fish species *S. salpa* and *S. cretense*; in the western region the highest percentage was for *S. luridus*, which was more abundant than *S. rivulatus* and the native *S. salpa* and *S. cretense* (Fig.9).

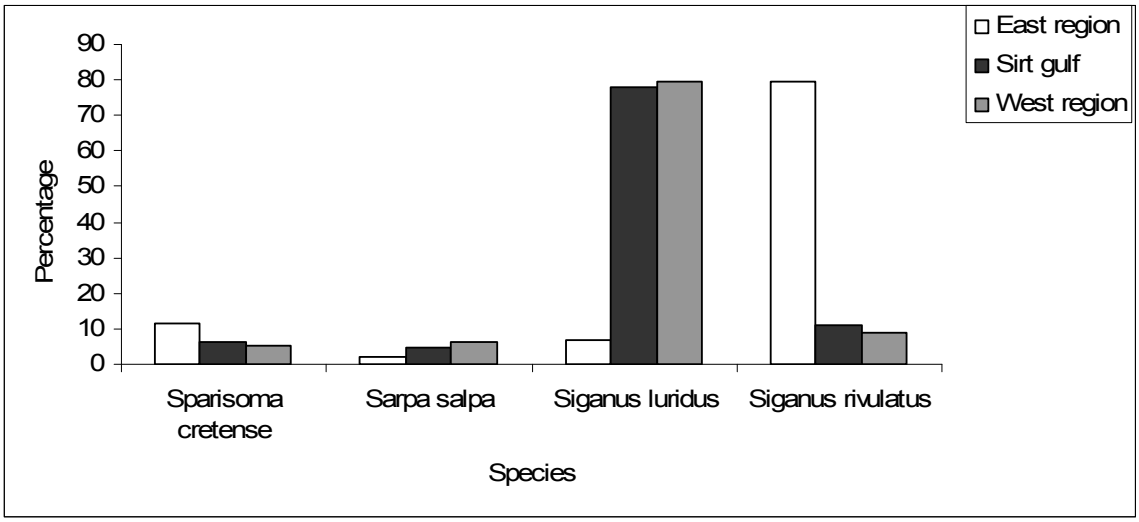

Fig. 9. The relation between herbivorous fish species and native fish species in the main regions.

Discussion

The ichthyocoenosis of the Mediterranean Sea consists primarily of Atlanto-Mediterranean species (62%) from the adjacent Atlantic biogeographic provinces beyond the Straits of Gibraltar (Lusitanian Sea). Many Mediterranean species are endemic (20%) while others are cosmopolitan or circumtropical (13%) or Indo-Pacific (5%). These proportions differ for different major taxonomic groups and also for different parts of the Mediterranean Sea, but the pattern remains essentially the same (Ketchum, 1983).

At the time of this study, a total of 1,511 boats were being used in the coastal area of Libya. The percentages of different fishing craft were: 64.26% flouka, 24.09% mator, 6.88% lampara and 4.77% batah (Fig.3). Most of them were concentrated in the western part of Libya (58.64%) (Tab. 1, the main fishing area in Libya). The lampara was found predominantly in the western part, with a few exceptions in the Gulf of Sirt. The lampara is used to catch small pelagic fish species (Sardine, Mackerel etc.). The flouka and the mator were found right along the Libyan coast, while the batah, which is used in shallow water (Fig. 5) was found in the Farwah Lagoon, with a few boats of this type in the Attimimi and Ainghazala regions. The flouka was used in regions where the water was between one and fifty meters deep, while the mator was used for depths of more than thirty meters; the batah was used in depths of up to 5 meters.

In 2000 the country's entire fishing fleet numbered 1,866 boats; of these 1,266 boats were operated along the Libyan coast. Around 55% of the total number of boats was found in the western region, while 23% and 22% were found in the Gulf of Sirt region and in the eastern part of Libya respectively. The results of this study are almost identical to the framework survey of 135 landing sites in 2000, in which 61% of the fleet were flouka, 28% were mator, 7% were lampara used to catch small pelagic fish, while the batah represented only a small fraction of the total number of boats (4%) (LAMBOEUF *ET AL.* 2000). However, two major differences distinguish this study from the one conducted in 2000, namely: a) in the present study only 76 active sites were considered because some of the landing sites investigated in the year 2000 were only temporary, b) in the year 2000 all the craft were counted (operational

(68%), non-operational (8%), under repair (22%) and unknown (2%)) whereas in this study only operational craft were counted.
As mentioned earlier, the percentage of exotic fish species relative to native fish species decreases from east to west along the Libyan coast. This means that there is a correlation between early arrival and greater abundance which can be explained (a) because the longer a species is in the Mediterranean, the greater the opportunity to build up its population, or (b) by the greater research effort, which was much less intense in the past (GOLANI 2002). This also means that there are many Lessepsian fish species included in the Libyan ichthyofauna which are of commercial value (SHAKMAN & KINZELBACH 2007). The exotic fish species are still spreading in the various parts of the Mediterranean Sea (GOLANI *ET AL.* 2002, GOLANI *ET AL.* 2004), and some of these species have become established, become commercially important, and become regular catch species in many different parts of the Mediterranean Sea (EL-SAYED 1994, TORCU & MATER 2000, PAPACONSTANTINOU 1990, BARICHE *ET AL.* 2004, SHAKMAN & KINZELBACH 2007). There is a difference in the distribution of native and exotic fish species along the Libyan coast, with the diversity of fish species in the eastern region being high in comparison with the middle and the western parts of Libya. The most abundant native fish species along the Libyan coast was Annular Seabream *Diplodus annularis* (Sparidae), which made up 7.74% of the total in the eastern part, 17.11% in the middle region and 10.74% in the western part; the least abundant were the two Indo-Pacific fish species Spotback Herring *Herklotsichthys punctatus* (Clupeidae) at 0.02% and Blue-spotted Cornetfish *Fistularia commersonii* (Fistulariidae) at 0.02% in the eastern part, and the Blue-spotted Cornetfish *F. commersonii* (Fistulariidae) at 0.07% in the middle region and 0.03% in the western part of Libya. In the present study, the results do not mean that these fish species are only established in this area, for the simple reason that different fish species are caught using different types of fishing gear, whereas this study only investigates the trammel nets used throughout the year along the Libyan coast. It is illogical to assume that the whole body of the Mediterranean Sea has the same species composition; regional speciation is evident in the Mediterranean Sea (WHITEHEAD *ET AL.* 1984-1986). Many surveys have been carried out along the Libyan coast in order to study species composition in different parts of Libya. In 1972 sixty two fish species were listed (GORGY *ET AL.* 1972). Some other surveys concentrated on trawler fishing and found 131 fish species (SOGREAH 1977), while 185 bony fish are listed by CONTRANSIMEX (1977). The highest diversity of fish species was found in a specific area of the Benghazi region (201 species). This figure was based on the catch captured by different types of commercial fishing gear (Hassan & Silini 1999).
The low diversity of herbivorous fish in the Mediterranean Sea includes only two herbivorous fish *S. salpa* (L., 1758) (Sparidae) and *S. cretense* (L., 1758) (Scaridae) (BAUCHOT & HUREAU 1986, QUIGNARD & PRAS 1986). In the present study the most abundant herbivorous fish were the Indo-Pacific fish species *S. rivulatus* and *S. luridus*, which are more numerous than the native fish species *S. cretense* and *S. salpa* along the Libyan coast. The concentration of these Indo-Pacific fish species varied along the coast, with *S. rivulatus* being concentrated in the eastern part of the Libyan coast, while *S. luridus* was concentrated in the middle region and western part of Libya (Fig.9). It might be that there is competition between Indo-Pacific herbivorous fish species and native herbivorous fish species. On the other hand *S. rivulatus* was more abundant (79.47%) than *S. luridus* (6.89%) and the herbivorous native fish species *S. salpa* (2.14%) and *S. cretense* (11.50%) in the eastern region, and when this result is compared with results from the eastern Mediterranean

(Lebanon coast), the abundance of these species is quite similar: *S. rivulatus* was the most abundant at 72 % and *S. luridus* numbered 8 %, with the native species *S. cretense* at 20 % and the least abundant *S. salpa* (<1 %) (BARICHE *ET AL.* 2004). Similar relative abundances were reported from the eastern Mediterranean (84% Siganids, 11% Scarids and 5% Sparids) (DIAMANT *ET AL.* 1986). In the Gulf of Aqaba (Red Sea), the dominant herbivores were the Acanthuridae (63%) and the Scaridae (35%) (BOUCHON-NAVARO & HARMELIN-VIVIEN 1981). *S. rivulatus* has an ability to adapt to most habitats, as it was found in different herbivorous habitats (rock with algae, sand with algae and grass with algae), whereas *S. luridus* was found in one specific habitat (rock with algae). It might be that *S. rivulatus* has benefited from a reduction of competition pressure due to the low diversity and abundance of native herbivorous fish species. GEORGE & ATHANASSIOU (1967) suggested that as *S. salpa* and *S. rivulatus* present similarities in body shape and habits, they might be in close competition for the same resources. Furthermore, this indicates that the population of the native fish species *S. salpa* has declined dramatically in the last seventy years (BARICHE *ET AL.* 2004). To conclude, the main fishing vessel used in the coastal area was the flouka, the most commonly used fishing gear in the coastal area were trammel nets, the fish species diversity in the coastal area was higher in the eastern part of Libya than in the middle and western parts, the abundance of exotic herbivorous fish species was higher than that of native herbivorous fish species with different concentrations on the coast, *S. rivulatus* is more abundant and has the ability to adapt to different habitats while *S. luridus* was found in one specific habitat.

Acknowledgments

We would like to express our thanks to the fishermen and fishermen's union for their collaboration, and we would also to thank the staff and administration of the Marine Biology Research Center (MBRC) - Libya and Environment General Authority (EGA) branch Benghazi - Libya for their cooperation, Our thanks to Mr. Khaled Tayeb for his help in the survey and also our thanks to Mr. Mike Smart, Gloucester GL2 OJH, United Kingdom, for the linguistic revision of the text, this article forms part of a PhD Thesis.

References

ALDEBERT Y. & PICHOT, P. 1973: Observations sur les Heterosomes de Mediterrannee oriental/ secteur Tuniso-Libyen/ CIESM Journees Ichthyol. 57-60, Rome.

AL-HASSAN L.A.J. & EL-SILINI O.A. 1999: Check-list of bony fishes collected from the Mediterranean coast of Benghazi, Libya. Revista de Biologia Marina y Oceanografia 34: 291-301.

BARICHE M., LETOURNEUR Y. & VIVIEN M.H. 2004: Temporal fluctuations and settlement patterns of native and Lessepsian herbivorous fishes on the Lebanese coast (eastern Mediterranean). Environmental Biology of fishes 70: 81-90.

BAUCHOUT M.L. & HUREAU J.C. 1986: Sparidae. In fishes of the north-eastern Atlantic and the Mediterranean (ed. P. J. P. WHITEHEAD *ET AL.),* pp. 883-907. Paris: UNESCO.

BILECENOGLU M. & KAYA M. 2006: A new alien fish in the Mediterranean Sea - *Platax teira* (Forsskål, 1775) (Osteichthyes: Ephippidae). Aquatic invasion 1 (2): 80-83.

BILECENOGLU M., & TASKAVAK E. 2002: Characterization of Lessepsian migrant fish at Turkish sea. In: Bayram Öztürk and Nuri Basusta (eds). Workshop on Lessepsian migration, 20-21 July 2002 Gökceada- Turkey: 87-91.

BOUCHON-NAVARO Y. & HARMELIN-VIVIEN, M. 1981: Quantitative distribution of herbivorous reef fishes in the Gulf of Aqaba (Red Sea). Marine Biology 63: 79-86.
CONTRANSIMEX C. 1977: Final report concerning the results of the fisheries oceanographic survey, carried out by the Romanian researcher teams on board "Delta Dunarii" and "Gilort" in the eastern territorial waters of the Libyan Arab Republic between Ras Azzaz and Ras Karkura, II: 173-563.
DIAMANT A., BEN-TUVIA, A., BARANES, A. & GOLANI, D. 1986: An analysis of rocky coastal eastern mediterranean fish assemblages and a comparison with an adjacent small artificial reef. J. Exp.Mar. Biol. Ecol. 97: 269-285.
DUCLERC J. 1973: Les Scorpaenides de L'Est Tunisien et de Libye. Journées Ichthyol. : 73-74, Rome, C.I.E.S.M.
EL-SAYED R.S. 1994: Check-list of Egyptian Mediterranean fishes. National Institute of Oceanography and Fisheries, 77 + IX pp., Alexandria, Egypt.
GOLANI D., ORSI-RELINI L., MASSUTI E. & QUIGNARD J.P. 2002: CIESM Atlas of Exotic species in the Mediterranean. In: Briand F (ed). Fishes. Vol.1, CIESM publishers, Monaco. 256 pp.
GOLANI D., ORSI-RELINI L., MASSUTI E. & QUIGNARD J.P. 2004: Dynamics of fish invasions in the Mediterranean: update of the CIESM Fish Atlas. Rapports de la Commission Internationale pour l´ Exploration Scientifique de la Mer Méditerranée 37: 367.
GOLANI D. & SONIN, O. 2006: The Japanese threadfin bream *Nemipterus japonicus*, a new Indo-Pacific fish in the Mediterranean Sea. Journal of Fish Biology 68: 940-943.
GEORGE C.J. & ATHANASSIOU, V. 1967: A two year study of the fishes appearing in the seine fishery of St George Bay, Lebanon. Ann. Mus. Civ. Storia Nat. Genova 76: 237-294.
GORGY S.A, MUGAHID, A & ALI, R. 1972: Survey of the Libyan territorial waters and the adjacent international waters in the central Mediterranean. Communication presentée au 23e Congrès-Assemblée Pleniere CIESM., Athens 3-11 (4), 72 J.
KETCHUM B.H. 1983: Ecosystems of the world 26 Estuaries and Enclosed Seas. Amsterdam, Oxford, New York: Elsevier Scientific Publishing Company.
LAMBOEUF M. 2000: Artisanal fisheries in Libya, census of fishing vessels and inventory of artisanal fishery metiers. FAO-COPEMED-MBRC, 42 pp.
LAMBOEUF M., & REYNOLDS J.E. 1994: The fishing fleet of Libya: preliminary results of the 1993 frame survey. TBN No. 16.
MADL P. 2001: Essay about the phenomenon of Lessepsian Migration. Marine Biology I. http : www.sbg.ac.at/ipk/avstudio/pierofun/lm/lesseps.htm. Cited 12 Apr. 2006.
NINNI E. 1914: Min. Colonie Uff. Marina Roma (in Tortonese, 1939).
QUIGNARD J.P. & PRAS A. 1986: Scaridae In fishes of the northern-eastern Atlantic and the Mediterranean, (ed. P. J. P. Whitehead et al.) pp. 943-944. Paris: UNESCO.
PAPACONSTANTINOU C. 1990: The spreading of Lessepsian fish migrants into the Aegean Sea (Greece). Scientia Marina. 54 (4): 313-316.
POR F.D. 1978: Lessepsian migration. The influx of Red Sea Biota into the Mediterranean by way of the Suez Canal. Berlin: Springer Verlag. p. 228.
POR F.D. 1990: Lessepsian migration. An appraisal and new data. Bulletin of the institute of Oceanography Monaco 7: 1-10.
SHAKMAN E.A. & KINZELBACH R. 2007: Distribution and characterization of Lessepsian migrant fish along the coast of Libya. Acta Ichthyologica et Piscatoria 37 (1): 7-15.
SOGREAH E. 1977: Trawl fishing ground survey off the Tripolitanian coast. Final Report. Part V: 1-44, and final report: Introduction and General Conclusions: 1-30.
STEINITZ W. 1927: Beiträge zur Kenntnis der Küstenfauna Palästinas. I. Pubblicazioni della Stazione Zoologica di Napoli 8 (3-4): 311-353.
STIRN J. 1970: Some note on western trends of Lessepsian migration. Journées Ichthyologiques, Rome, 30 nov- 1dec 1970, CIESM, Monaco 187-190.
TORCU H. & MATER S. 2000: Lessepsian fishes spreading along the coasts of Mediterranean and the Southern Aegean Sea of Turkey. Turkish Journal of Zoology 24: 139-148.
TORTONESE E. 1939: Appunti di ittiologica Libica: Pescidi Tripoli. Annali Museo Libico Storia Naturale 1: 359-375.

TORTONESE E. 1963: Elenco riveduto dei Leptocardi, Ciclostomi, Pesci Cartalaginei e ossei del Mare Mediterraneo. Annali. Mus. Civ. Stor. Nat. Giacomo Doria, 74: 156-185.
UNITED NATION EDUCATIONAL, SCIENTIFIC, AND CULTURAL ORGANIZATION (UNESCO) 1984, 1985, 1986. Fishes of the North eastern Atlantic and the Mediterranean. 3 vols. Paris.
VINCIGUERRA D. 1881: Risoltati ittiologici delle crociere del" Violante" Annali Museo Civico Storia Naturale, Genova 18: 465-590.
VINCIGUERRA D. 1922: Ittiologici delle Libya. Bolletino Museo Zoologia Anatomia Comparata Torini 36 (745).
WHITEHEAD P.J.P., BAUCHOT M.L., HUREAU J.C., NIELSEN J. & TORTONESE E. (eds) 1984-1986: Fishes of the north-eastern Atlantic and the Mediterranean. Vols. I-III, 1473 pp., UNESCO, Paris.
ZUPANOVIC S. & EL-BUNI A.A. 1982: A contribution to demersal fish studies off the Libyan coast. Bulletin of the Marine Research Centre, Tripoli, Libya 3: 78-122.

Authors' addresses:

Esmaile Shakman
Prof. Dr. Ragnar Kinzelbach

Universität Rostock
Allgemeine & Spezielle Zoologie
Universitätsplatz 2
D-18055 Rostock
Germany

E-Mail: shugmanism@yahoo.com