ISSN: 0001-5113
AADRAY

ACTA ADRIAT.,
44 (1): 51-59, 2003

UDC: 639.32(262-11)(569.4)
Preliminary paper

Fish assemblages associated with net pen mariculture and an adjacent rocky habitat in the Port of Ashdod, Israel (eastern Mediterranean) - preliminary results

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The present study compares the fish assemblage in the vicinity of fish net pen in the Port of Ashdod, Israel, with those fishes inhabiting the nearby rocky substrate, in order to determine the impact of the mariculture on the surrounding environment. Seven visual censuses were conducted during January 1995 - June 2000; in each census, the species' abundance in both habitats was recorded. A total of 41 species, belonging to 17 families, were recorded. Both fish assemblages revealed a high level of stability during the study. Species richness and similarity indices were relatively high in all censuses. The most abundant species associated with the net pen were: Siganus rivulatus, Liza ramada, Chelon labrosus *and occasionally* Boops boops. *In the adjacent rocky habitat, the most abundant species were:* Siganus rivulatus, Diplodus sargus, D. vulgaris and Thalassoma pavo. *The net pens attracted schooling species, which fed on algae growing nets and on food waste and other organic material discharged. No apparent harm to wild local fish assemblage was observed, probably due to the efficient exchange of water around the cages, resulting from the movement of ships in the harbor and the entry of currents under the breakwater.*

Key words: fish assemblages, fish net pen, Israel, eastern Mediterranean

INTRODUCTION

The rapid growth of mariculture has led to a parallel growth in the concern of its impact on the environment. This impact is multifaceted and includes the consequences of discharging waste materials, such as excess food, feces, and antibiotics into the surrounding waters. Escapees of farmed marine organisms are often exotic to local fauna and constitute a danger as invasive species; these escapees may also spawn with their closely related species and alter the gene structure of the native population (WINDSOR & HUTCHINSON, 1990; YOUNGSON *et al.*, 2001). The introduction of new diseases is another potential danger of mariculture (McVICAR, 1997; DIAMANT, 2000).

Many studies have been conducted throughout the world to assess the impact of mariculture on the environment (GOWEN & BRADBURY, 1987; WU, 1995; SILVERT & SOWLES, 1996; DEMPSTER *et al.*, 2002). In these studies, presumably affected sites located directly beneath the farm or in its immediate proximity were compared to natural habitat sites beyond the influence of the farm. In the Mediterranean, most studies on the impact of fish farming have concentrated on the biochemistry of the water column surrounding the farm (LA ROSA *et al.*,

2002) or of the sediment beneath (KARAKASSIS *et al.*, 1999). The effect of the fish farms on the adjacent biota was studied mainly regarding microbial and meiofauna (MITRO *et al.*, 2000).

Mariculture in Israel began in the 1970's and until quite recently was almost exclusively conducted in the Red Sea. The Mediterranean coast of Israel is smooth and lacks bays or sheltered areas required for net pen mariculture activity. However, a single fish net pen farm was established in June 1994 at the entrance to the Port of Ashdod as an experimental project, with only two pens, 250 m^3 each. It developed quickly, reaching 40 pens within two years. The main species cultured in the farm were the two Mediterranean indigenous species, the Gilt-head sea bream (*Sparus aurata* Linnaeus, 1758) and the European seabass (*Dicentrarchus labrax* Linnaeus, 1758), the Red drum *(Sciaenops ocellatus* (Linneaus, 1766)) imported from central America and a golden strain of cichlid, *Oreochromis auratus* (Steindachner, 1864), that was acclimated to a marine environment.

The objective of the present study was to assess the possible effects of the fish farm on the surrounding marine environment by researching the composition and abundance of the fishes inhabiting the substrate beneath the fish farm and in proximity to the farm, and comparing them to an adjacent natural fish assemblage.

MATERIAL AND METHODS

Study site

The net pen farm was situated at the entrance to the Port of Ashdod, approximately 10-20 m from the breakwater (Fig. 1).

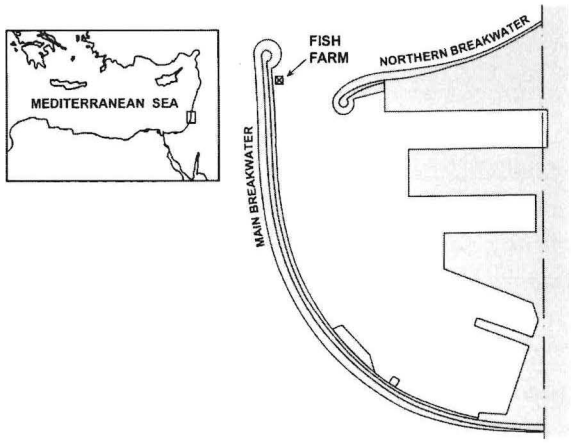

Fig. 1. Map of the study site

The net pens were located at a depth of 5-15 m, so that the bottoms of some pens were only 50 cm from the substrate (Fig. 2).

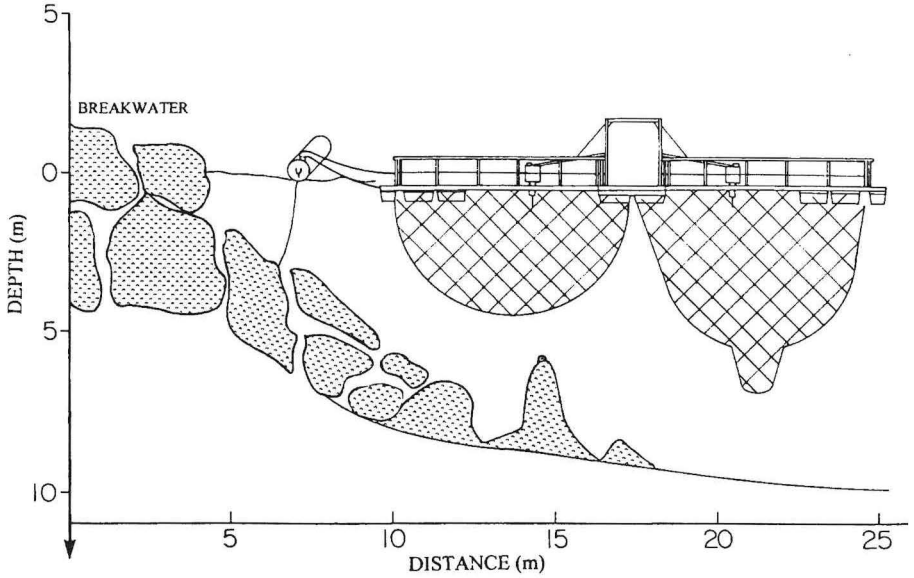

Fig. 2. Schematic illustration of the net pen at the Port Ashdod, Israel

The area under the net pens was primarily sandy with rocky patches of different sizes. The rocky site was part of the breakwater. It was composed of large rocks and cement tetrapods with a relatively smooth surface, creating large hollow spaces with narrow crevices between the rocks and the tetrapods.

Censuses

The first census was conducted in January 1995, six months after the establishment of the farm. Another six censuses were conducted until June 2000. The author conducted these censuses using SCUBA equipment. The duration of each census was 40 minutes, ca. 20 minutes under the pens and the remainder of the time at the adjacent rocky habitat. The abundance of each species in each habitat was recorded with a pencil on a PVC slate in quasi-quantitative manner: 1—rare (1-2 individuals); 2 - prevalent (3-6 individuals) and 3 - common (more than 6 individuals). This analytic method of assigning a numerical value to a category of relative abundance is frequently used to analyze communities and assemblages of fish and other organisms, when it is impossible to conduct a precise count of individuals (KARR, 1981; FORE *et al.*, 1994).

Analysis

The degree of similarities between the fish assemblages in both habitats in all censuses and between the two habitats on each census date were calculated by two indices. Qualitative analysis was calculated by the Jaccard coefficient (JACCARD, 1908):

$$J = \frac{c}{a+b+c}$$

where a and b are the number of species unique to the compared communities a and b, respectively, and c is the number of species shared by both communities. The values of the JACCARD index range between 0 (i.e. no similarity) and 1 (i.e. complete similarity).

The quasi-quantitative analysis were calculated using the overlap index (PINKAS *et al.*, 1971):

$$T = 1 - 0.5 \sum \left| P_{xi} - P_{yi} \right|$$

where Pxi and Pyi are the proportions of the i^{th} species of the community x and y.

The values of the overlap index range between 0 (i.e. no overlap) and 1 (i.e. complete overlap).

For the overlap calculation, rare species received the value: 1, prevalent: 2 and common: 3 (see: KARR, 1981; FORE *et al.*, 1994).

RESULTS

A total of 41 species, belonging to 17 families, were observed in the present study (Table 1).

Eight species (19.5%) were of Red Sea origin and invaded the Mediterranean via the Suez Canal (Lessepsian migrants). One species, the Golden Tilapia (*Oreochromis aureus*), is an escapee from the net pen farm. The relative abundances in the vicinity of the net pen and in the adjacent rocky substrate are given in Table 1.

The most common species associated with the net pens were the marbled rabbitfish (*Siganus rivulatus*), the thin-lipped grey mullet (*Liza ramada*), the thick-lipped grey mullet (*Chelon labrosus*) and bogues (*Boops boops*), who occasionally appeared in large schools.

The most common species in the rocky substrate were the White Sea Bream (*Diplodus sargus*), the Common Two-Banded Sea Bream (*Diplodus vulgaris*), the Ornate Wrasse (*Thalassoma pavo*) and the Marbled Rabbitfish (*S. rivulatus*). It is worth noting that the structure of the fish community on the rocky patches directly under the net pens was similar to that of the rocky substrate on the breakwater.

Species richness under the net pens ranged from 5 to 16 species while over the rocky substrate there were 10 to 20 species (Fig. 3). Both

*Table 1. List of fish species observed next to the net pen and on the adjacent rocky substrate in the Port of Ashdod. + = rare, ++ = prevalent, +++ = common; * = Lessepsian migrant*

Family	*Species*	Net pen	Adj. rocks
SCORPAENIDAE	*Scorpaena maderensis*	+	+
HOLOCENTRIDAE	*Sargocentron rubrum**	++	++
ATHERINIDAE	*Atherina boyeri*	++	+
	*Atherinomorus lacunosus**	++	+
SERRANIDAE	*Epinephelus marginatus*	+	+
	Mycteroperca rubra	++	++
	Serranus scriba		+
CARANGIDAE	*Alepes djedaba**	+	+
	Seriola dumerili		+
SPARIDAE	*Boops boops*	+++	++
	Diplodus annularis	+	
	D. cervinus	+	+
	D. puntazzo		+
	D. sargus	+++	+++
	D. vulgaris	+++	+++
	Lithognathus mormyrus		+
	Oblada melanura	++	+++
MULLIDAE	*Mullus surmuletus*	+	+
PEMPHERIDAE	*Pempheris vanicolensis**		+
CICHLIDAE	*Oreochromis aureus*	+	
POMACENTRIDAE	*Chromis chromis*		+
LABRIDAE	*Coris julis*		+
	Thalassoma pavo	++	+++
	Labrid sp.		
MUGILIDAE	*Chelon labrosus*	+++	++
	Liza aurata	+++	++
	*L. carinata**		+
	L. ramada	++	++
	L. saliens	+	+
	Mugilid sp.	+	+
GOBIIDAE	*Gobius bucchichi*	++	++
	G. cobitis		+
	G. paganellus		+
	Gobiid sp.		+
BLENNIDAE	*Parablennius incognitus*		+
	P. zvonimiri		+
TRIPTERYGIIDAE	*Tripterygion delaisi*		+
	T. tripteronotus		+
SIGANIDAE	*Siganus luridus**		+
	*S. rivulatus**	+++	+++
MONACANTHIDAE	*Stephanolepis diaspros**	++	++

assemblages showed a high degree of stability throughout the study period (Tables 2,3).The similarity indices values among all censuses in each habitat are given in Tables 2 and 3. The similarity indices values in each census between the two habitats are given in Fig. 3.

Table 2. JACCARD index (bottom left) and Overlap index (upper right) values among fish assemblages associated with net pen in the Port of Ashdod

	Jan. 95	June 99	Aug. 99	Oct. 99	Nov. 99	Dec. 99	June 00
Jan. 95		0.335	0.292	0.432	0.350	0.300	0.300
June 99	0.222		0.454	0.547	0.420	0.495	0.619
Aug. 99	0.217	0.300		0.738	0.484	0.400	0.500
Oct. 99	0.285	0.388	0.476		0.441	0.588	0.323
Nov. 99	0.333	0.285	0.333	0.437		0.516	0.562
Dec. 99	0.235	0.400	0.285	0.600	0.416		0.400
June 00	0.214	0.500	0.235	0.250	0.300	0.272	

Table 3. JACCARD index (bottom left) and Overlap index (upper right) values among fish assemblages on a rocky substrate adjacent to the net pen in the Port of Ashdod

	Jan. 95	June 99	Aug. 99	Oct. 99	Nov. 99	Dec. 99	June 00
Jan. 95		0.474	0.473	0.451	0.411	0.342	0.332
June 99	0.300		0.576	0.550	0.421	0.378	0.492
Aug. 99	0.181	0.370		0.661	0.622	0.573	0.534
Oct. 99	0.275	0.407	0.458		0.645	0.653	0.619
Nov. 99	0.250	0.291	0.473	0.450		0.751	0.739
Dec. 99	0.208	0.250	0.500	0.550	0.615		0.629
June 00	0.192	0.230	0.380	0.304	0.437	0.375	

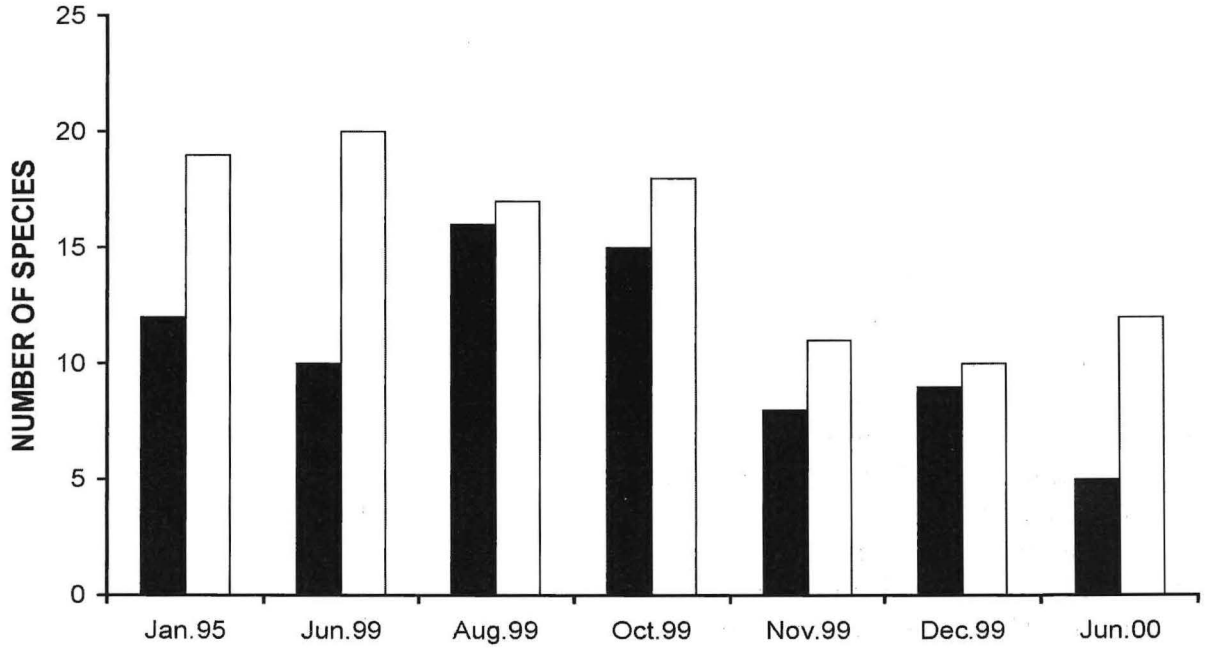

Fig. 3. Number of species observed next to the net pens (black bars) and in the adjacent rocky habitat (open bars) throughout the study

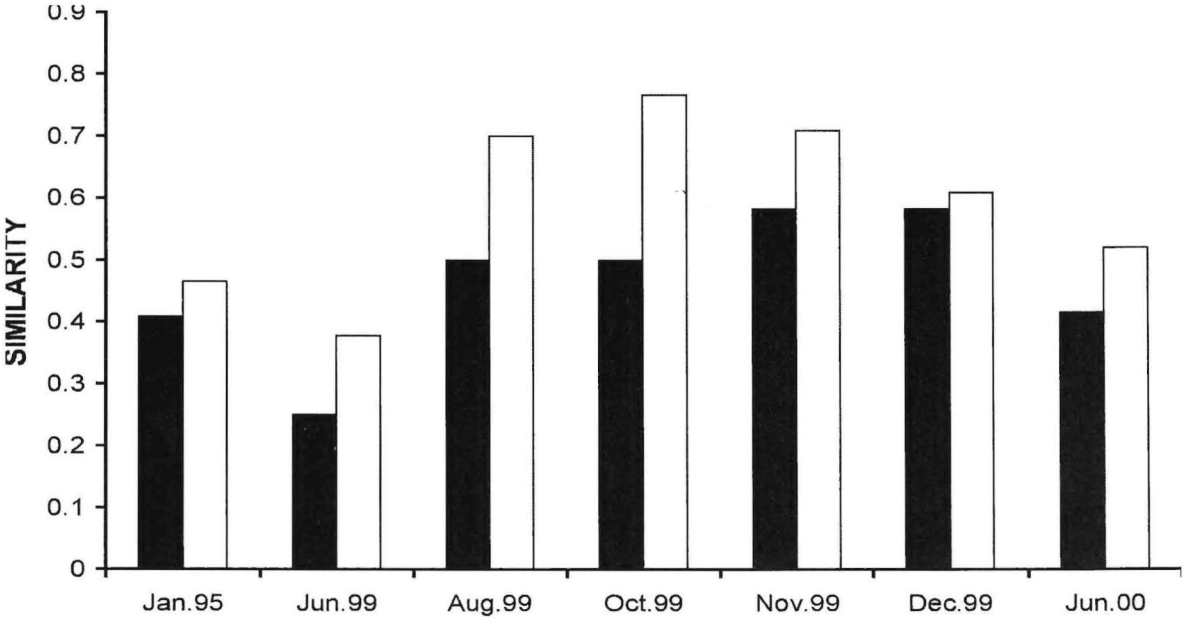

Fig. 4. Similarities between the fish assemblage next to net pens and the adjacent rocky habitat throughout the study (black bars - JACCARD index, open bars - Overlap index)

DISCUSSION

The results of this study revealed that the fish assemblages associated with the net pens and those of the adjacent rocky breakwater where highly stable throughout the study period (Tables 2, 3). The slightly low number of species in Nov - Dec 1999 censuses was due to poor visibility. Heightened activity around the cages during the June 2000 observation caused a similar effect. Most of the common species found to inhabit the rocky breakwater were also observed on the rocky patches directly beneath the net pen, although it is possible that some small and/or cryptic species (e.g. blennids, gobiids, etc.) were overlooked in the visual census. The structures of both fish assemblages were typical of natural shallow rocky habitats of the Mediterranean Coast of Israel (DIAMANT *et al.*, 1986; GOREN & GALIL, 2001). The percentage of Lessepsian migrant species observed in the study site (19.5%) is similar to the overall percentage (14.0%) of Lessepsian fish in the entire eastern Mediterranean ichthyofauna (GOLANI, 2002).

The main difference between the two compared fish assemblages was due to large schools of *Liza ramada, Chelon labrosus, Siganus rivulatus* and *Boops boops* that aggregated around the pens and fed on sessile algae growing on the net, on food waste and other organic material discharged from the net pens. DEMPSTER *et al.* (2002), who studied offshore cages in the Mediterranean shores of Spain, observed a similar effect of aggregation of species. Common to both studies were the aggregations of *Boops boops* and the mugilids, which were not identified to the specific level by DEMPSTER *et al.* (2002). The other common species in this study, namely, *Siganus rivulatus*, is a Lessepsian (Red Sea) migrant that has not reached the Mediterranean coast of Spain. CARSS (1990) found the same effect in freshwater and marine cages farms in Scotland and reached a similar conclusion. He also observed aggregations next to empty cages and suggested that the cages performed a role similar to that of artificial reefs by attracting a concentration of many fish species (SEAMAN & SPRAGUE, 1991).

No discernable seasonality in the fish assemblages was observed, with the exception of the mass mortality of *Siganus rivulatus* in the 6 August 1999 census. Mass mortalities of *S. rivulatus* were observed on several occasions in other various locations along the Mediterranean coast of Israel, where no mariculture cages were located (personal observation). It is hereby postulated that these may result from either certain pathogenic infestations (ZLOTKIN *et al.*, 1998; DIAMANT *et al.*, 1999) or from feeding exclusively on algae (LUNDBERG & GOLANI, 1995). It is reasonable to assume that seasonal blooming of some toxic algae may cause this mortality.

The lack of seasonality and absence of juveniles in the study site is somewhat surprising since it is a semi-enclosed area. It has been shown that this is a typical habitat, serving as a nursery ground for many fish species (GOLANI, 1993).

In general, this study showed that there was no visible effect on the benthic ichthyofauna in the vicinity of the fish farm with the possible exception of some schooling species attracted to the net pens. The lack of harm was probably due to the serendipitous location of the farm, in which a constant exchange of water flowed under the net pens. This water flow resulted from currents under the breakwater and from the continual entry and exit of vessels in the harbor causing strong currents that removed efficiently disuents fro charged efflm the farm, reducing sediment anoxia.

Despite the success of the net pen farm studied in this paper, it is obvious that large-scale mariculture should not be based in commercial harbors due to limited space and the disturbance to regular port activity. It is economically infeasible to build protected sites especially for mariculture farms. Therefore, to develop the mariculture industry on a large scale in the Mediterranean coast of Israel, better technologies must be developed for the establishment of inland farms or deepwater farms where the effect of stormy weather will be minimal.

ACKNOWLEDGMENTS

The author thanks to O. MEYDAN and E. GABAY for participating in same of the underwater censuses, to J. AVISHAY, owner of the farm, for his encouragement and for providing all the necessary logistics for the study, to D. DAROM and A. LERNER for the drawings and to B. APPELBAUM-GOLANI for editorial assistance.

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Received: 18 September 2002
Accepted: 26 March 2003

Asocijacije riba povezane s njihovim kaveznim uzgojem i ribama obližnjeg stjenovitog habitata u luci Ashdod, Izrael (istočni Mediteran) - preliminarno priopćenje

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SAŽETAK

Uspoređene su asocijacije riba u blizini njihova kaveznog uzgoja u luci Ashdod, Izrael, s onima koje nastanjuju obližnji stjenoviti supstrat, kako bi se odredio utjecaj marikulture na okoliš. Od siječnja 1955. do lipnja 2000. ribe su promatrane sedam puta. Svaki put je zabilježena abundancija vrsta u oba habitata. Ukupno je zabilježena 41 vrsta iz 17 obitelji. Obje riblje asocijacije bile su vrlo stabilne. Kod svih promatranja bogatstvo vrsta i indeksi sličnosti bili su relativno visoki. Najabundantnije vrste, povezane s onima iz kaveza, bile su: *Siganus rivulatus, Liza ramada, Chelon labrosus* i povremeno *Boops boops*. U obližnjem stjenovitom habitatu najbogatije su bile zastupljene vrste: *Siganus rivulatus*, *Diplodus sargus*, *D. vulgaris* i *Thalassoma pavo*. Kavezi privlače one ribe koje se hrane algama, koje rastu na njihovoj mreži i one koje se hrane ostatcima hrane i ostalim organskim otpadom. Nije uočeno oštećenje divljih ribljih vrsta, vjerojatno zbog dobre izmjene voda oko kaveza koju uzrokuje promet brodova u luci i ulazne struje ispod lukobrana.

Ključne riječi: asocijacije riba, kavezni uzgoj, Izrael, istočni Mediteran