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Commercial catches, reproduction and feeding habits of *Raja asterias* (Chondrichthyes: Rajidae) in a coastal area of the Tyrrhenian Sea (Italy, northern Mediterranean)

Michele ROMANELLI *, Alessandro COLASANTE, Umberto SCACCO, Ivan CONSALVO, Maria Grazia FINOIA and Marino VACCHI

Istituto Centrale per la Ricerca Scientifica e Tecnologica Applicata al Mare (ICRAM), Via di Casalotti, 300 – 00166 Rome, Italy

****Corresponding author, e-mail: m.romanelli@icram.org***

A total of 52 "rapido" (towed toothed beam gears) trawls were monitored in late winter-summer of the 1999-2000 period to assess the R. asterias *size structure at this time of higher yields as well as 36 fishing operations performed by "volantina" (trawl nets with fairly high vertical opening) during distinct seasons on the continental shelf off the fishing harbour of Fiumicino (central western Italy) to gain data also for that gear. Daily yields recorded for the only boat locally authorised to use "rapido" nets gave median values of 32.0 individuals and 24.35 kg vs. 2.5 rays and 2.80 kg for trawlers fishing at the same time.*

Comparison of the body sizes at which 50% of the skates had been found mature in our samples (265 gonads examined) showed that most specimens caught by the "rapido" nets were in their juvenile stage. Examination of stomach contents from 129 skates confirmed previous reports that they mainly feed on crustaceans and bony fish and the role of the latter in the diet progressively increases as R. asterias *specimens grow older and larger.*

Key words: Rajidae, *Raja asterias*, fishery, reproduction, diet, Tyrrhenian Sea, Mediterranean

INTRODUCTION

As the Italian coastline is known to host 16 distinct ray species (TORTONESE, 1956), some of them endemic in sub-areas of the Western Mediterranean Sea, monitoring of commercial catches is important to know which species could need closer protection.

Although *Raja asterias* Delaroche is a fairly common species, endemic in the Mediterranean Sea and the neighbouring areas of the western Atlantic (FISCHER *et al*., 1987), little is known about its abundance, exploitation pattern, maturity size and fecundity (RELINI *et al*., 1999; FROESE & PAULY, 2004).

Along the NW Italian coast the species is strongly targeted by a small fishery operating "rapido" beam trawls (gears described in PRANOVI *et al*., 2001), thus yields and size/sex structure of catches were intermittently recorded (MINERVINI *et al*., 1985; FABI & SARTOR, 2002; ABELLA & SERENA, 2005). Moreover, information was gained on the presumptive time trends of stock biomass (MANCUSI *et al*., 2006), growth and diet of individuals of various sizes (MINERVINI & RAMBALDI, 1985; ABELLA *et al*., 1997; BONO *et al*., 2005; CUOCO *et al*., 2005) as well as short-term displacements of a few tagged juveniles (CATALANO *et al*., 2003). In the recent past similar studies were also carried out along the northern coast of Tunisia (CAPAPÉ, 1977; CAPAPÉ & QUIGNARD, 1977; CAPAPÉ, 1980).

As information on the *R. asterias* yields and catches of local trawlers are scarce (RELINI *et al*., 1999; ABELLA & SERENA, 2005; MANCUSI *et al*., 2006), in this paper we report data recorded during a short series of daily trips aboard two trawlers as well as one fishing vessel operating "rapido" nets off Fiumicino (central Tyrrhenian Sea); moreover, the mean sizes at which 50% of the males and females resulted in being sexually mature are estimated, and an appropriate comparison with the size structure of commercial catches was carried out. Finally, prey found in the stomachs of rays of different sizes are listed and compared with previous reports.

MATERIAL AND METHODS

In the Fiumicino area (Fig. 1) a scientific observer intermittently embarked to monitor fishing operations carried out on a daily basis by two trawlers (44.0 and 69.0 GT, with 295 and 440 kW engines respectively) operating "volantina" nets and by the only vessel locally authorised to use "rapido" towed gears (GT: 38.0; engine: 316 kW), in order to assess all elasmobranch catches.

A total of 52 trawls by "rapido" nets (no. gears: 2; width of the framed mouth: 3.3 m) were monitored during 10 distinct daily trips and the same was done during 12 distinct fishing days for 36 trawls performed by "volantina" nets (mouth size at sea: approx. 11 x 2 m, estimate based on net plans in FERRETTI *et al*., 2002, and authors' personal communications to us) on shelf grounds. Starting time, position, duration, direction and depth of each haul were recorded.

Fig. 1. Position of the fishing harbour of Fiumicino on the Italian coastline

During all daily trips the fishing tactics were selected by the vessel captains and all elasmobranchs caught during the fishing operations were identified, measured, sex-determined and either classified as dead or still alive, the latter individuals being further subdivided into a visual three-degree vitality scale (herewith un-detailed).

On nearly all *R. asterias* specimens the distance between the outer tips of the pectoral fins (afterwards named WPF) was recorded to the nearest 0.1 cm. On some occasions measures were either taken only on the skates caught during a subset of "rapido" trawls or on all specimens of the same sex obtained from a given trawl. Moreover, small skates caught during the "volantina" trawls were often gathered and weighed together.

As vessel captains allowed the sampling of only a few skates from their catches (as daily catches are locally sold as a whole at auction), nearly all *R. asterias* specimens sectioned in the laboratory came from the market. Samples of unmarketable skates (weight < 0.50 kg) were obtained by the crews of several trawlers. All specimens were then frozen at –25 °C for several weeks or months.

In the laboratory the animals were thawed and measures such as WPF, TL and others were made to the nearest 0.1 cm, and all weights (entire and eviscerated animals, stomach contents, gonads and related glands) to the nearest decigram. Gonads and related glands were examined by the naked eye and staged after a modified version of the Stehmann's maturity scale (STEHMAN, 1987) and fairly similar to the description by GALLAGHER *et al.* (2005), also derived by the Stehlmann's stone-corner paper of the ripening processes of both sexes. Stomach samples obtained from the thawed skates were then stored in 70% v/v ethanol-aqueous solution for later examination.

In the analysis of experimental data, length-weight regression curves were estimated for skates of both sexes as well as, by means of logistic curves (ZOCCALI, 1998), the mean lengths at which 50% of the males and females were sexually mature in our samples (lengths afterwards named MTL_{50}). Weight estimates derived from the regression curves were then used to calculate the *R. asterias* biomass taken during each haul monitored at sea.

As nearly all prey were bony fishes and crustaceans, they were identified to the lowest possible level on the basis of their external features and the numbers of vertebrae/myomeres (TORTONESE, 1970, 1975; FISCHER *et al.*, 1987; FALCIAI & MINERVINI, 1992; ABOSSOUAN, 1994). All prey were counted and some linear size recorded for them to the closest millimetre; moreover, weight was recorded to the nearest decigram for those poorly digested. When otoliths were the only remains of preyed fishes they were coupled and recorded as unidentified teleosts; only in a few cases were otoliths recognised at the family level (HÄRKÖNEN, 1986).

Composition of prey by species and higher zoological *taxa* was compared in food samples from skates of different sizes by means of "Focused Principal Component Analysis" (FALISARSARD, 1999) as this test more carefully depicts than PCA correlations between independent variables (i.e. zoological *taxa*) and either *R. asterias* sizes or weights. The relevance of each *taxon* in the diet was assessed by the following index:

$Q = W_i (\%) \times N_i (\%)$ (HUREAU, 1970);
where:

W_i (%) = percentage of prey of the i-th cluster on the total weight of prey;

N_i (%) = percentage of prey of the i-th cluster on the total number of prey.

When reckoning the dietary index the weight of each food sample was estimated either by summing up those directly recorded for prey, or calculated from other specimens of the same species (or even belonging to similar species, with similar body proportions) assuming that animals grow isometrically; moreover, length-weight relationships reported in the literature (DO CHI, 1975; SINOVČIĆ, 1983; FERNANDÉZ *et al.*, 1991; RELINI *et al.*, 1999) were also used on some occasions.

In some instances body sizes were estimated by those of their parts, on the basis of photographs and drawings taken from several sources (TORTONESE, 1970, 1975; DO CHI, 1975; FISCHER *et al.*, 1987; FALCIAI & MINERVINI, 1992). When body sizes could not be estimated at all (e.g. when otoliths were the only fish remains) prey were all given the average weight calculated for animals of the same zoological cluster found in skates of approximately the same size.

Comparison with the zoological compositions reported by other authors was performed only at the level of *phyla* and classes because the fairly large numbers of species included presumably minimized the distorting effects of possible correlations in the abundance of some animals. Numbers of prey from each *phylum* and zoological class were therefore compared by Chi-square tests, assuming that outputs were nearly independent of each other.

RESULTS

All data on the numbers and weights of *R. asterias* specimens caught both by "volantina" and "rapido" nets during our daily trips to sea are summarised on Table 1.

Table 1. Numbers of trawls with R. asterias *catches, depth ranges and numbers of individuals recorded during our day trips on "rapido" and "volantina" trawlers*

Days	Total days at sea	Total number trawls	No. trawls with rays	Depth range trawls with rays (m)	*R. asterias* daily catches (Kg)	*R. asterias* daily catches (No.)	Maximum No. rays caught per haul
				"RAPIDO" NETS			
WINTER	1	6	4	62-78	9.8	10	3
SPRING	4	21	20	25-76	12.8-25.9	22-32	12
SUMMER	5	25	24	25-74	6.5-201.5	8-264	47
				"VOLANTINA" NETS			
WINTER	3	8*	5	25-98	2.6-6.0	2-7	3
SPRING	1	1*	1	68-100	0.8	1	1
SUMMER	2	5*	3	25-70	0.8-0.8	1-1	1
AUTUMN	5	17*	10	25-115	0.3-2.5	1-8	7

*only hauls at depths < 115 m

A total of 36 "volantina" trawls (average duration: 160 ± 28 min; towing speed: 1.7-2.0 ms^{-1}) carried out at shelf areas down to 115 m (maximum depth reached during hauls seizing *R. asterias* specimens) gave 46 skates (14 females, 15 males and 17 animals whose sex remained undetermined) weighing 26.8 kg. Through 52 monitored "rapido" trawls (average duration: 128 ± 13 min.; towing speed = 2.8-3.3 ms^{-1}) 530 skates were caught (262 females, 268 males) for a whole weight of 416.0 kg. The concerned trawls were all carried out in coastal areas within 60 km from Fiumicino (Fig. 1) and no specimens from other Rajidae were caught.

Trawls by the two "rapido" nets mainly caught *R. asterias* skates on 30-70 m grounds, whilst trawlers resulted in fishing these animals down to 115 m. Although the missing measurements for a large fraction of the skates caught by "volantina" nets make comparisons difficult, data on Table 1 show that skates fished down to depths of 50 m weighed on average 0.26 kg (N = 17) whilst for those obtained in deeper waters a mean weight of 0.86 kg (N = 25) was calculated apart from four small individuals (total weight = 0.9 kg) caught in a trawl that was carried out between depths of 25-98 m.

A similar increase of mean weight for rays fished in the deepest waters was not observed for the skates caught by "rapido" nets as a 280 mm WPF value was recorded for the smallest specimen. On the two graphs of Fig. 2 the WPF structures of 222 males and 169 females caught by these nets are displayed.

Data in Table 1 show that the daily median values of skates caught by each trawl ranged from 2.5-40.0 specimens and 1.85-29.50 kg. It is worth noting that about 50% of all rays taken during our study come from 7 hauls carried out during a single fishing trip in late August 2000 in an area 15 km southeast of Fiumicino. Both females and males fished that day were nearly the same size as those caught during the previous trips on the same vessel (data not detailed).

Putting aside such "anomalous" trawls, a total of 41 fishing operations by "rapido" nets carried out in two coastal areas, 70 km northwest and 30 km southeast of the home harbour, gave 29 and 12 rays, respectively. In the northwest area 13 trawls performed in summer and 16 trawls carried out during late winter and spring respectively gave mean values of 9.2 and 3.1 *R. asterias* skates, with similar fractions of daylight and night trawls in both clusters, with such difference being statistically significant by the Mann-Whitney test ($U = 160$; $p<0.02$).

In the laboratory a total of 138 females and 130 males were measured, weighed and examined for their maturity status. On the basis

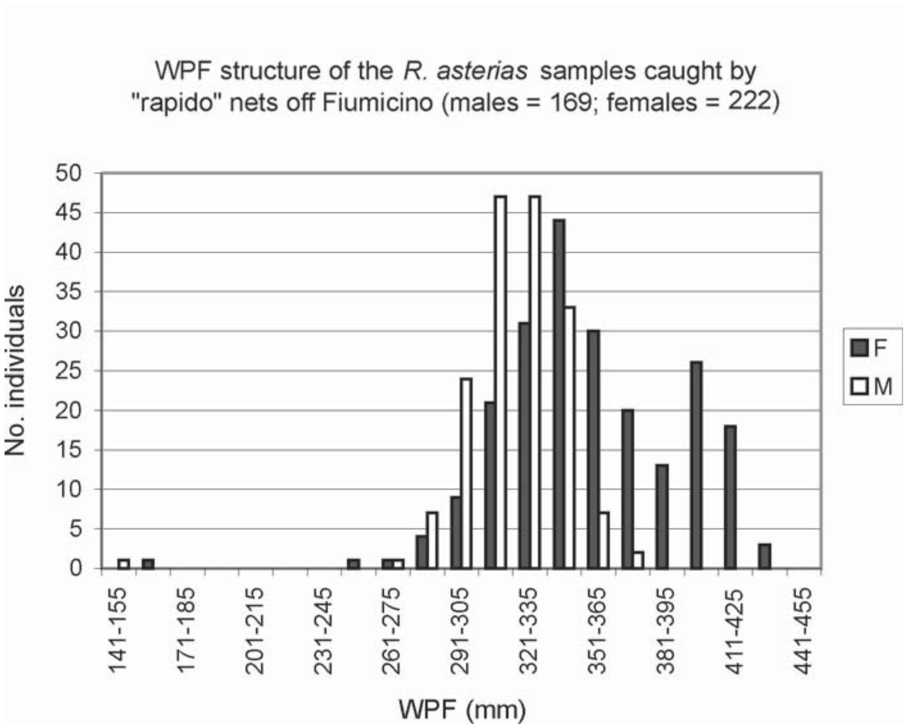

Fig. 2. Size composition of the samples of R. asterias *males and females caught either by "rapido" or "volantina" nets during our survey at sea*

of the weight and linear data the following regression curves were estimated:

$WPF = 0.6814{*}TL$ ($r^2 = 0.987$)
$WT = 0.01071{*}WPF^{3.1699}$ ($r^2 = 0.988$)
[135 females; TL range: 22.0 - 63.0 cm]
$WT = 0.00215{*}TL^{3.2727}$ ($r^2 = 0.975$)

$WPF = 0.6594{*}TL$ ($r^2 = 0.978$)
$WT = 0.01640{*}WPF^{3.0513}$ ($r^2 = 0.985$)
[125 males; TL range: 21.0 - 58.0 cm]
$WT = 0.006192{*}TL^{2.973}$ ($r^2 = 0.972$)

from which the WPF/TL ratios resulted in being different for males and females (Student test, $t = 2.913$; $P<0.005$; f. d.= 256), thus BINI (1967) statement that males have larger pectoral fins than females of the same lengths is erroneous.

Once smaller individuals were excluded (i.e. females <45.0 cm TL and males <43.0 cm TL; thresholds based on another BINI (1967) statement, that males start maturing at 45 cm and the common notion that females reach higher TLs), we report the number of rays in distinct maturity stages of the Stehmann's scale found in our samples at different times in Table 2.

In spring-summer 28 of 55 females had maturing follicles (stages 3-4) in the ovaries,

Table 2. Numbers of R. asterias *adults and sub-adults of both sexes seasonally recorded at different macroscopic maturity stages*

*No. *R. asterias* individuals staged seasonally

female maturity stages

	3	4	5	6	Total
Winter	0	0	0	3	3
Spring	13	3	7	7	30
Summer	3	9	6	7	25
Autumn	0	2	6	4	12
Total	16	14	19	21	70

male maturity stages

	2	3	4	Total
Winter	0	2	6	8
Spring	9	3	4	16
Summer	13	16	7	36
Autumn	3	0	3	6
Total	25	21	20	66

* only females with TL > 45.0 cm and males with TL > 43.0 cm;

whilst in autumn-winter they were found in only 2 of 15 examined individuals of the same sex and such difference was statistically highly significant (Chi-square test with Haber's correction for continuity, χ^2= 7.019; P<0.01; ZAR, 1999). In contrast, females either with egg capsules in the oviducts or recovering by egg laying nearly comprised a constant fraction of those examined during each season. Similarly, a significantly higher number of maturing individuals were noted among the adult and sub-adult males caught in spring-summer (41 of 52 males in 2-3 stages) than during other months (5 of 14 males in stages 2-3; Chi-square test with Haber's correction for continuity, χ^2= 5.543; p<0.025). Sexually active males (stage 4) also comprised almost constant fractions of the individuals of the same sex examined during each season.

As our data had shown that the breeding season was long for both sexes, MTL_{50} values were estimated by gathering all individuals obtained during our study, and they resulted in being 56.5 cm and 50.5 cm for females and males respectively. In our samples the smallest adult male (stage 4 on Table 3) was 51.0 cm TL and the smallest female with egg capsules in the oviduct was 53.0 cm TL (Table 3).

Gathering all ovaries of stages 5-6 (as these stages alternate in mature females as they undergo multiple spawning events, laying each time 1-2 egg capsules and then shortly recovering; LO BIANCO, 1909; CAPAPÉ, 1977) found in our samples (N = 36 females), we noted that in most cases 20-40 ovarian follicles were recorded, with small inter-seasonal variations. A maximum of 60 follicles were recorded for a 56.5 cm TL and 1,605.0 g female caught in early summer.

Out of the 264 stomachs examined only 32 were empty (vacuity index = 12.1%); unluckily about 45% of the food samples could not be later retrieved, thus prey were examined only from 129 residual rays, caught in nearly equal proportions during each season.

In the analysed food samples a total of 470 crustaceans, 75 teleosts, 3 cephalopods and 2 prey from other zoological *taxa* were found together with fish otoliths (60% of which were identified as Gobiidae *spp*. from their

Table 3. Size composition of R. asterias *samples made up of adults and sub-adults of both sexes at different macroscopic maturity stages*

Synopsis of the *R. asterias* samples				
Maturity stages	No. females	Median TL (cm)	Mean TL + S.D. (cm)	TL range (cm)
St. 1	45	32.00	31.18+3.88	22.0-37.0
St. 2	12	41.00	40.74+1.73	38.0-43.0
St. 3	19	48.50	47.73+2,26	43.0-51.0
St. 4	13	52.00	52.44+1.57	49.5-65.0
St. 5	24	59.40*	58.99*+3.58*	53.0-62.5
St. 6	20	-	-	63.5-63.0
Maturity stages	No. males	Median TL (cm)	Mean TL + S.D. (cm)	TL range (cm)
St. 1	48	31.50	30,81+4,03	21.0-36.0
St. 2	31	44.25	43,80+2,99	38.0-48.5
St. 3	18	49.40	49,87+1,93	46.5-53.0
St. 4	23	54.50	54,70+2,68	51.0-62.5

* females of stages 5 and 6 gathered

morphology) and crustacean remains (mainly limbs) belonging to about 15 other animals.

Data on Table 4 show that prey clearly differed among rays of various sizes because in food samples from individuals weighing less than 600 g small animals such as *Liocarcinus maculatus* (Risso) for the decapod crustaceans and gobies for of the bony fish were abundant whilst they are negligible in the stomach samples of larger *R. asterias*. Among prey from the cluster of largest skates it was also noticed many more individuals of the species *Goneplax rhomboides* (L.) which is known to live at greater depths than nearly all other crustaceans listed in the table (FISCHER *et al.*, 1987; FALCIAI & MINERVINI, 1992).

Data in the same table seem to indicate that numbers of otoliths were positively correlated with those of gobies whilst numbers of crustacean limbs would be nearly independent of the abundance of those animals; thus otoliths were included in the total count of Teleosts (therefore fish increase to 91 individuals in all our examined stomach samples) and crustacean limbs conversely ignored in all calculations on the numbers and biomass of prey (Table 4).

Table 4. Zoological composition of the food samples obtained from R asterias *individuals of different sizes (note: all* taxa *and other statistical clusters of data are labelled CL1, CL2 and so on, and these labels are used to identify them in Fig. 3)*

	Prey from *R. asterias* stomach samples			
	No. of examined rays	48	43	38
	Sex ratio (M/F)	1:53	1:53	37.00
	TL range of rays (cm)	21.0-46.5	46.0-56.0	55.0-62.5
	Weight range of rays (g)	46.6-594.8	607.4-1000.0	1014.0-1605.0
	Species/taxon	*No.	*No.	*No.
CL1	Nei Polychaeta	1	0	0
-	Total Polychaeta	1	0	0
CL2	Nei Amphipoda	0	0	1
CL3	Nei Isopoda	1	0	0
CL4	Nannosquilloides occultus (Giesbricht, 1910)	1	0	0
CL5	*Squilla mantis* (Linnaeus, 1758)	11	5	11
CL6	*Brachycarpus biunguiculatus* (Lucas, 1846)	0	1	0
CL7	*Periclimenes scriptus* (Risso, 1822)	0	0	1
CL8	Nei Palaemonidae spp.	1	4	0
CL9	*Pontocaris lacazei* (Gourret, 1887)	0	3	0
CL10	*Penaeus kerathurus* (Forskal,1775)	0	0	1
CL11	*Solenocera membranacea* (Risso, 1816)	0	0	1
CL12	Nei Decapod Natantia Crustacea	7	8	9
CL13	*Alpheus glaber* (Olivi, 1792)	22	34	3+[3]
CL14	*Brachynotus gemellarii* (Rizza, 1839)	1	2	3
-	*Cancer pagurus* (Linnaeus, 1758)	0	0+[1]	0
CL15	*Goneplax rhomboides* (Linnaeus, 1758)	1	3	14
CL16	*Ilia nucleus* (Linnaeus, 1758)	1	1	0
CL17	*Liocarcinus arcuatus* (Leach, 1814)	0	0	5
CL18	*Liocarcinus depurator* (Linnaeus, 1758)	13	20	20+[1]
CL19	*Liocarcinus maculatus* (Risso, 1827)	176	15	3

Table 4. Cont'd

CL20	*Liocarcinus vernalis* (Risso, 1827)	2	1	0
CL21	Nei Liocarcinus individuals	11	4	5
CL22	*Medorippe lanata* (Linnaeus, 1767)	2	1+[1]	1
CL23	*Pilumnus hirtellus* (Linnaeus, 1761)	0	1	1
CL24	*Upogebia pusilla* (Petagna, 1792)	0	1	2
CL25	Nei Upogebia	1	0	0
CL26	Nei Decapod Reptantia Crustacea	7+[1]	9+[3]	3+[2]
-	Small remains of unidentified Decapod Crustacea	4	6	5
-	**No. appendices from unidentified Decapod Crustacea	0**	3**	3**
-	Total Crustacea	262+[1]	119+[5]	89+[6]
CL27	Cerithium sp.	0	1	0
CL28	Nei Sepiolidae	0	1	0
CL29	*Loligo vulgaris* (Lamarck, 1798)	0	0	1
-	Cepahlopod remains [No. individuals]	0	[1]	0
-	Total Mollusca	1	1+[1]	1
CL30	*Engraulis encrasicholus* (Linnaeus, 1758)	1	1	5
CL31	*Sardina pilchardus* (Walbaum, 1792)	0	4	2
CL32	Sparidae spp.	0	0	3
CL33	Nei Clupeidae	1	0	0
CL34	*Lesueurigobius suerii* (Risso, 1810)	3	0	0
CL35	Nei Trachinidae	0	1	3
CL36	***Nei Gobiidae	13***	5***	2***
CL37	*Lepidotrigla cavillone* (Lacepède, 1801)	0	1	1
CL38	*Solea solea* (Linnaeus, 1758)	0	1	0
CL39	Nei Teleosts	6	13	9
CL40	Teleostean otoliths [no. pairs or related fishes]	[7] §	[7] §	[2]
-	Total Teleosts	24+[7]	26+[7]	25+[2]
-	Total preys	287+[8]	147+ [12]	114+[8]
	Estimated initial weight of preys (g)§§	157.8	152.3	310.3
	Median initial weight of meals (g)§§	1.5	2.9	5.9
	Median (100 x meal weight/body weight) (g)§§	0.97	0.41	0:42

* In brackets minimum numbers of animals estimated on the basis of their parts and/or appendices;

**Appendices were only remains of crustaceans from taxa other than those found in the same samples;

*** Individuals recognised from otoliths have been not counted;

§ On the whole, 6-8 pairs of otoliths presumably belonging to Gobiidae spp;

§§ Estimated weights are for preys kept in 70% ethanol-aqueous solution for a long time.

The "Focused Principal Component Analysis" in Fig. 3 confirms that few species were found with statistically different frequencies in rays of various weights (P≤0.05) and for many other animals either weak or non-significant correlations exist between their abundance in stomach samples and the ray weights. Moreover, the graph shows that several species were "tied" as they were often found together in food samples.

Because of the fairly high number of species and higher *taxa* found in the stomachs, single species are scarcely relevant in the *R. asterias* diet; indeed *L. maculatus* gives Q = 542 for the smallest rays and Q = 90 for other crustaceans of the same genus; among rays weighing between 600 and 1000 g *L. depurator* gives Q = 230, *G. rhomboides* Q = 215 and *S. mantis* Q = 91. If all teleosts are gathered (assigning to all unidentified otolith pairs an average weight equal to that calculated from all other fish found in the same ray clusters) we have Q = 185, Q = 640 and Q = 1,550 for the three *R. asterias* clusters in Table 4.

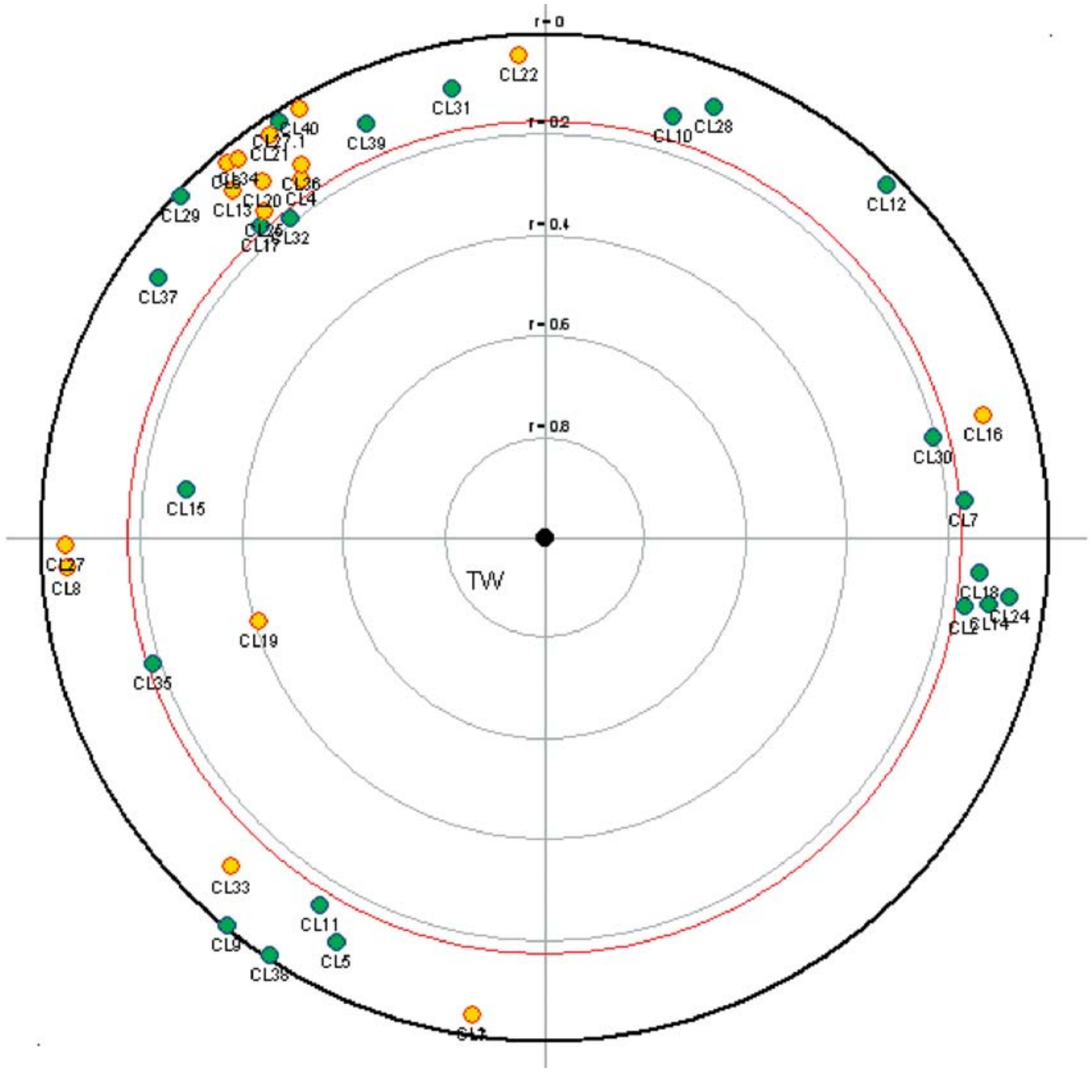

Fig. 3. Graph depicting the Focused Principal Component Analysis based on the prey composition (see caption of Table 6 for details on the labelled zoological taxa*) found in stomach samples from rays with different body weights (note: brighter dots and darker dots respectively show variables, i.e. preyed* taxa*, positively and negatively correlated with* R. asterias *weights. Dots within the largest inner and sketched circle, such as those labelled CL19 and CL30, are variables correlated at P <0.05. Clustered dots are prey frequently found together in our food samples, whilst uncorrelated clusters make right angles at the circle origin)*

DISCUSSION

Although a limited set of fishing data was obtained during our study, it shows that some spatial and seasonal differences exist for *R. asterias* yields in the Fiumicino area. Indeed, significantly higher yields were recorded for "rapido" trawls carried out in summer and on grounds southeast of the home harbour. All of this agrees, to some extent, with a previous report (FABI & SARTOR, 2002) that higher yields were seen in summer-autumn during a series of daily fishing trips carried out in the same area, between December 2000 and March 2002 (14 days and 84 trawls monitored on the whole), within a study on "rapido" fisheries of distinct sectors of the Italian coastline.

On the basis of our estimated MTL_{50} (50.5 and 56.5 cm TL for males and females, respectively) and TL-WPF curves, 70-75% of the rays of both sexes caught by "rapido" nets resulted in being smaller and therefore immature (Fig. 2). It is worth noting that our size data agree with those reported by FABI & SARTOR (2002) as they state that about 93% of the 522 measured *R. asterias* individuals (males and females gathered) fell in the 42-60 cm TL range and 92% of the rays in Fig. 2 actually lie within those values.

In agreement with information available on the depth distribution of the species under study (RELINI *et al*., 1999), our data recorded aboard two "volantina" trawlers show that small juveniles are caught down to 50 m and much larger specimens beyond this limit. Comparison of the upper and lower parts of Table 1 indicates that the vessel operating daily catches by "rapido" nets showed in late winter – midsummer (the period in which more data were gathered), median values of 32.0 rays and 24.35 kg compared to 2.5 *R. asterias* individuals and 2.80 kg for those trawlers towing the "volantina" and such differences were highly significant (No. fishing days = 6 + 6; P = 1.082 x 10^{-3} for both daily median numbers and weights, Fisher exact test for 2 x 2 contingency tables; ZAR, 1999). On the basis of the calculated median daily catches we estimate that the "rapido" vessel on average caught 25% of all *R. asterias* individuals fished in the Fiumicino area during spring and early summer of the years 1999-2000.

Adult rays synchronised fairly well their annual maturation cycle but the numbers of ovarian follicles were seasonally nearly constant. Thus, we suppose mature females produce at least two egg clusters each year, with one or more fairly long recovery time(s) (Table 2). On the whole our data seem to agree with those by CAPAPÉ (1977) according to which mature females would spawn about 40-60 egg capsules twice a year.

Analysis of our stomach samples made clear that the average size of prey increases with those of rays – thus, bony fish progressively become more relevant in the diet and crustaceans almost negligible. Less or more clear discrepancies with previous reports on the same topic were also noted.

MINERVINI & RAMBALDI (1985) found prey in 124 *R. asterias* stomachs caught near Fiumicino by "rapido" on grounds inside the coastal closed area with a few dozen *Brachynotus gemellarii* (Rizza), *Upogebia pusilla* (Petagna), *Liocarcinus vernalis* (Risso) and *Dorippe lanata* (L.) individuals reported whilst the same crustaceans were extremely scarce in our samples. Although statistical comparison is impossible, as often happens for dietary studies (CORTES, 1997), such differences seem to be real and due to the fact that rays examined by MINERVINI & RAMBALDI (1985) came from grounds covered with sand in shallow water whilst our samples were obtained from somewhat deeper areas where sediments invariably contain silt. Indeed, in the mentioned paper the authors pointed out that *B. gemellarii* and *U. pusilla* had been found in rays from shallow waters and *A. glaber* and *G. rhomboides* from presumptive silty areas. Moreover, *L. maculatus* is a species known to live on the clean sand of shallow waters (VACCARELLA *et al*., 1998).

Our data agree with those reported by CUOCO *et al*. (2005) on the species composition of prey found in the stomachs of 563 *R. asterias* rays (TL range: 12-64 cm) mainly fished by "rapido" nets along the coast of the southern Ligurian Sea (NW Italy). If amphipods are excluded, as they were an important food resource only for rays up to 22 cm TL, we indeed saw that 78 % of the 2,360 residual prey were decapod and stomatopod crustaceans, 19.7 % were teleosts and a few animals came from other *taxa*. Moreover, almost all crustaceans listed in that paper (where the relevance of the single species/*taxon* as a food resource is reported only by dietary indexes, HYSLOP, 1980) are also given in Table 4 herein and some discrepancies exist only for the species and other zoological clusters for which only few individuals were recorded in our samples. Of teleosts about half of the fish resulted in being gobies, in agreement with the relevant dietary role we found for these prey. The mentioned paper also shows that rays start feeding mainly on bony fish from 38-40 cm TL onwards.

In *R. asterias* samples from the northern coast of Tunisia a quite different prey composition was assessed (CAPAPÉ & QUIGNARD, 1977). If comparison is restricted to the medium and advanced juvenile rays (as we could examine very few adults, and amphipods were fairly scarce in the samples from northern Tunisia) we noted that from 400 non-empty stomachs from the Tunisian samples a total of 238 crustaceans, 160 teleosts, 44 cephalopods and 14 prey from other *taxa* were counted; in 91 juvenile stomachs examined during our study 381 crustaceans, 74 teleosts, 2 cephalopods and 2 other prey were found instead. Even when all *L. maculatus* individuals are "eliminated" from our data (as these animals make up about 50% of the crustaceans found in our samples so that they seem to be strongly aggregated), discrepancies of the numbers of prey from the mentioned zoological clusters result in being statistically significant (Chi-square = 44.088; $P<0.001$; 3 f. d.).

To further detail, the stomach samples examined by CAPAPÉ & QUIGNARD (1977) contained fewer crustaceans but more cephalopods. Moreover, at least 15 distinct fish species were recorded, some of them mainly living on shallow grounds (*Citharus linguatula* L.; *Solea solea* L.; *Mullus barbatus* L.) and other ones in somewhat deeper areas (*Merluccius merluccius* L.; *Argentina sphyraena* L.).

In our opinion such discrepancies mainly originate from the fact that all rays from Tunisian waters were caught by trawl nets, thus wide depth ranges and more distinct benthic communities were presumably explored. It is also worth noting that the large number of crustaceans found in our stomach samples agree with the general notion that they mainly live on sand and silt (FALCIAI & MINERVINI, 1992), and the shelf fishing grounds around Fiumicino are actually covered with thick sediments as the Tiber river flows into the sea nearby (LA MONICA & RAFFI, 1996). Similarly, the fairly high frequencies found in the Tunisian stomach samples of prey from motile species such as *Sepia officinalis* (L.), *Sepia elegans* Blainville, as well as *Loligo vulgaris* Lamarck, and *Trachurus trachurus* (L.), and the previously mentioned teleosts strongly suggest that the *R. asterias* juveniles from northern Tunisia swam more actively and therefore were more easily caught by trawl nets. In turn, this assumption implies that low yields recorded for the "volantina" trawlers based at Fiumicino are partly due to the fact that local rays remain buried in the sediment for a long time and can easily hide there if any danger approaches.

CONCLUSIONS

Our data confirm previous reports on the *R. asterias* depth distribution, the scarce catches obtained by trawl nets mainly used along the Italian coasts as well as other facets of its biology. The estimated MTL_{50} values were slightly lower than those reported for males and females of northern Tunisian waters (54 cm and 61 cm TL, respectively; CAPAPÉ, 1977; FISCHER *et al.*, 1987). Moreover, the extent of the breeding season and the presumptive numbers of egg capsules laid each year are also confirmed to some extent (LO BIANCO, 1909; CAPAPÉ, 1977).

Analysis of stomach samples confirms that the species feeds on many prey but bony fish and crustaceans are the main food sources. Moreover, comparison with previous reports shows that the diet differs in distinct biocenoses and this presumably influences the behaviour of the rays as well as their availability to trawlers.

Fishing data obtained for "rapido" nets show that ray yields are much higher than for trawling nets and fairly conspicuous catches are usually recorded in spring-summer, in agreement with similar observations from the same area as well as the southern Ligurian Sea (FABI & SARTOR, 2002; ABELLA & SERENA, 2005). However, most rays caught during each season are sexually immature. Moreover, visual examination of rays caught during commercial trawls both by "rapido" and "volantina" nets indicated that most of them had died before being unloaded on the deck (only 10-15% of the rays whose weight was ≥ 0.50 kg were still alive at the end of each trawl, but with low vitality levels; data not detailed). Thus, the supposition by other authors that large portions of the unmarketable rays survive when returned to the sea (ABELLA & SERENA, 2005) is not true when nets are towed for two hours or longer.

As "volantina" and most towed nets do not efficiently seize *R. asterias* rays and very few fishing vessels are nowadays allowed to use "rapido" nets along the western Italian coasts (not more than 5-6 boats, in the entire area), the local stock of this species seems to withstand the undefined current level of exploitation, and actually MANCUSI *et al.* (2006) state that yields from non-commercial trawl surveys show that biomass has been stationary (or nearly so) in recent years and the same pattern is expected in the next future. Nevertheless, we suggest that the fishing effort exerted on the population and related commercial catches monitored under EC Regulations should always be monitored as are currently other rays from Italian waters, under EU Regulation No. 1581/2004 (EUROPEAN COMMISSION, 2004).

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Gospodarski ulov, reprodukcija i prehrambene navike raže zvjezdopjege *Raja asterias* (Chondrichthyes: Rajidae) u priobalju Tirenskog mora (Italija, sjeverni Mediteran)

Michele ROMANELLI *, Alessandro COLASANTE, Umberto SCACCO,
Ivan CONSALVO, Maria Grazia FINOIA i Marino VACCHI

Centralni institut za znanstvena istraživanja i primjenjene tehnologije mora (ICRAM), Via di Casalotti 300, 00166 Rim, Italija

**Kontakt adresa, e-mail: m.romanelli@icram.org*

SAŽETAK

Istraživana su ukupno 52 potega dredžama (“rapido”) u kasnom zimskom-ljetnom periodu 1999.-2000. godine kako bi se ustanovila veličina raže zvjezdopjege, *R. asterias* u vrijeme većeg ulova. Obavljeno je 36 ribarstvenih uzorkovanja pomoću “volantina” (koće većeg okomitog raspona) tijekom različitih godišnjih doba na kontinentalnom šelfu pokraj luke Fiumicino (srednji zapadni dio Italije) kako bi se dobili podaci i o ovom ribarskom alatu. Dnevni ulov zabilježen na brodu registriranom za uporabu “rapido” mreža iznosio je 32.0 jedniki i 24.35 kg od toga 2.5 kg raža i 2.80 kg koćarskog ulova istovremeno.

Usporedbom veličine tijela uzoraka 50% raža je bilo zrelo (265 ispitanih gonada) što ukazuje na činjenicu da je većina ulovljenih primjeraka “rapido” mrežom bilo u juvenilnom stadiju. Ispitivanje želučanog sadržaja kod 129 raža potvrdilo je dosadašnja izvješća da se pretežito hrane rakovima i koštunjičavim ribama, koje su zastupljenije u prehrani starijih i većih primjeraka *R. asterias*.

Ključne riječi: raža zvjezdopjega, *Raja asterias*, ribarstvo, reprodukcija, prehrana, Tirensko more, Mediteran