Journal of Coastal Research	SI 64	1941 - 1945	ICS2011 (Proceedings)	Poland	ISSN 0749-0208

Stock assessement and management by restocking of *Melicertus kerathurus* (Forskäl, 1775) in the shallow coastal waters at Selinunte

L. Cannizzaro‡, S. Vitale†, M. Arculeo§, G. De Stefano‡, L. Lumare&, A. Milazzo† and G. Salvo‡

‡ National Research Council - Institute for Coastal Marine Environment, Capo Granitola Branch; via del Mare, 3, I-91021 Torretta Granitola - Campobello di Mazara (TP), Italy
e-mail: leonardo.cannizzaro@cnr.it
† National Research Council - Institute for Coastal Marine Environment, Mazara del Vallo, Branch; via L Vaccara, 61, I-91026 Mazara del Vallo (TP), Italy
§ Deparment of Animal Biology – University of Palermo; via Archirafi, 36, I-90100 Palermo, Italy
& National Consortium of Research for the Shrimp Aquaculture – Lecce Branch

ABSTRACT

L. Cannizzaro, S. Vitale, M. Arculeo, G. De Stefano, L. Lumare, A. Milazzo and G. Salvo. 2011. Stock assessement and management by restocking of *Melicertus kerathurus* (Forskäl, 1775) in the shallow coastal waters at Selinunte, SI 64 (Proceedings of the 11th International Coastal Symposium), 1941 – 1945. Szczecin, Poland, ISSN 0749-0208

From 1998 to 2010, monitoring was performed on the catch and fishing effort of *Melicerctus kerathurus* by the artisanal fleet based at the port at Marinella di Selinunte which operates in the wide gulf between Capo San Marco and Capo Granitola along the southwestern coast of Sicily. In 2004, a repopulation experiment with *Melicerctus kerathurus* post-larvae raised in an aquaculture plant from wild indigenous breeders was carried out in this area. The catch and cpue, in both number of specimens and in yield, were practically doubled in 2005. From 2006, catch and cpue returned to levels observed in the years prior to 2005. With the exception of 2004 and 2005, the stock of *Melicerctus kerathurus* in the study area is overfished. The increase in catch registered in 2005 seems due in part to the repopulation experiment and in part to the meteo-marine conditions of 2004 which were particularly favourable to reproduction and nursery of the king prawn.

Key-words: *Melicertus kerathurus*; Assessment; Management; Restocking; Artisanal Fishery.

INTRODUCTION

The king prawn (*Melicerctus kerathurus*, Forskäl, 1775), lives in coastal areas, burrowing into sandy or muddy seabeds. It is widely distributed and lives in the entire Mediterranean Sea, with the exception of the Black Sea; it is found in the northern Red Sea and along the Atlantic coast from Angola to the English archipelago (Holthuis, 1980).

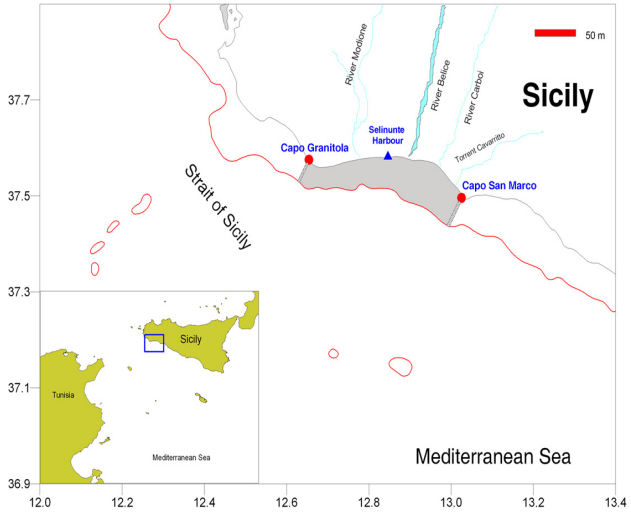
Statistics relative to the catch of king prawns in the Mediterranean are rather fragmentary in both space and time. In 1981, Italian fisheries caught approximately 257 t of king prawns. (Matta, 1981). According to the statistics of the Food and Agriculture Organization (FAO) in 1999 king prawn catches in the Mediterranean were: Tunisia 3,785 t; Greece 1,459 t; Spain 50 t; Albania 18 t (FAO, 2000). In 2006 they were: Greece 3,263 t; Tunisia 2.303 t; Italy 546 t; Spain 202 t; Albania 102 t; and France 1 t (FAO, 2008).

From 1997 to 1999 a catch-effort survey was carried out on the entire Sicilian artisanal fishing fleet through statistically programmed landing interviews on a sampling basis in space and time. The king prawn catch, with trammel net and\or gil net, resulted about 1 t in 1997-98 and 1.2 t in 1998-99 (Cannizzaro et. al., 2000). Because no catches are made using other gear, these quantities encompass the total of the king prawn catch in Sicily. About a quarter of these catches is made by the artisanal fleet based at Marinella di Selinunte. This small port, located in the middle of the wide gulf reaching from Capo San Marco to the east to Capo Granitola to the west, is home to an artisanal fleet that works, with only rare seasonal exceptions, exclusively with trammel nets and gil nets along the coastline and at a depth not greater than 30 m. The fleet is composed of about 40 fishing boats in the winter, whereas in summer there may be more than 60. All the fishing vessels, which are registered with the Harbor Master's Office at Mazara del Vallo, are grouped together in small, poorly-equipped ports that are often made impracticable by stormy seas. Almost all the fishermen are organized into a single co-operative. Selinunte is famous for being the largest archaeological site in Europe and is a year-round tourist attraction. Ever since the Sixties, however, tourists have also come to Selinunte to buy fish directly at the auction, which is held punctually every morning at eight o'clock. On average, about 100-120 kilos of fresh fish are sold every day. The returns generally range between 1,000 and 3,000 Euro but depend on the season, day of the week, weather, tidal conditions expected for the next day and on the abundance of the catch of one or other species. Taking into account the fact that, on average, fewer than 20 fishing boats put out to sea every day, it is clear that this activity is highly profitable in relation to the few resources it involves. Moreover, it is important to bear in mind the fact that practically the entire catch is recorded and invoiced by the local co-operative. The fishing areas are heterogeneous and include various types of seabeds: sandy (40%), muddy (20%), rocky (20%) and a large area of sea-grass (20%). For this reason,

and because of its proximity to the CNR of Mazara del Vallo and the CNR of Capo Granitola, from the early 1990s, Marinella di Selinunte and its coastline were chosen as an experimental field and bio-ecologic laboratory dedicated to the assessment and management of fishing resources of the shallow coastal waters and to the study of Fishery Science from a bio-economic standpoint.

MATERIALS AND METHODS

In the scope of a series of projects begun in September of 1997 and still in course today, catch-effort surveys, by landing interviews, are performed to monitor the catch and fishing effort of the artisanal fleet that is based at Marinella di Selinunte and which operates in the wide gulf between Capo San Marco and Capo Granitola (southwestern coast of Sicily; see Figure 1).



Initially, a census (frame surveys) was made of all fishing vessels in port, of the fishing equipment used and of the fishing areas habitually frequented. The frame survey is updated at the beginning of each season. The statistical design of the monitoring in space and time was refined and optimized during the course of the study so that from Spring 2002, one day of interviews was conducted for every eight days, including holidays. The minimum number of interviews conducted on each sampling day is 25 % of the fishing boats active on that day. Moreover, from 2002, the total catch of *Melicerctus kerathurus* is recorded each fishing day in both number of specimens and in weight.

Total catch of the principal target species by artisanal fishing per season and per year was estimated, from sample data, by classic statistical methods according to the following formulas:

$$c_m = \sum_{i=1}^{I} c_i / I \; ; \quad i = 1, 2, \ldots, I$$

Variance will be:

$$\mathrm{Var}(c_m) = \sum_{i=1}^{I} (c_i - c_m)^2 / (I - 1); \quad i = 1, 2, \ldots, I$$

where c_m is the average catch per boat per day; c_i is the catch of the i-th fishing vessel interviewed; I are the total number of interviews in the period considered (month, season, year).

Total catch in the reference period will be:

$$C_t = (N_{ba}/I)(G_p/g_I) \sum_{i=1}^{I} c_i \; ; i = 1, 2, \ldots, I$$

The variance will be given by:

$$\mathrm{VAR}(C_t) = (N_{ba}/I)^2 (G_p/g_I)^2 \, \mathrm{Var}(c_m);$$

where C_t is the total catch in the reference period; N_{ba} is the number of active fishing vessels in the reference period; G_p and g_I are, respectively, the total number of available fishing days and the number of interview days in the reference period. Fishing effort was defined as: length in kilometers of the nets (trammel net and gil net) put into the sea by all boats active in each season or year and mathematically treated with the same formulation used for the catch as reported above:

$$e_m = \sum_{i=1}^{I} e_i / I \; ; \quad i = 1, 2, \ldots, I$$

The variance will be:

$$\mathrm{Var}(e_m) = \sum_{i=1}^{I} (e_i - e_m)^2 / (I - 1); \quad i = 1, 2, \ldots, I$$

where e_m is the average effort per fishing vessel per day; e_i is the effort of the i-th fishing vessel interviewed.

Total effort in the reference period will be:

$$E_t = (N_{ba}/I)(G_p/g_I) \sum_{i=1}^{I} e_i \; ; i = 1, 2, \ldots, I$$

Variance will be given as:

$$\mathrm{VAR}(E_t) = (N_{ba}/I)^2 (G_p/g_I)^2 \, \mathrm{Var}(e_m);$$

where E_t is the total effort in the reference period.

The catch per unit of effort (cpue) was calculated as the relationship between the total catch in the reference period and the fishing effort in the same period.

A restocking experiment, as management tool, with the aim of incrementing the numbers of king prawn and attempting to minimize its natural mortality, was made during the summer of 2004. A few female *Melicerctus kerathurus*, at the maximum stage of ovarian development and with spermatophore inserted in the thelycum, were caught in the area routinely fished by the fleet of Selinunte. These females were brought to an aquaculture facility where a hatching area had been readied. The hatching area consisted of a vat for the deposition of eggs, a vat for the hatching of the eggs, four vats for raising larvae and a device for the production of feed. When the larvae reached a total length of at least 2.2 cm, that is after 36 days from birth, they were introduced into the sea in an enclosed area of about 100 m^2 with a minimum depth of 50 cm and a maximum depth of 80 cm. After 36 hours of acclimatization in the above described enclosure, the post-larvae were liberated by removal of the enclosure. A sample of post-larvae was studied genetically for useful and advantageous comparisons with samples of adults from successive generations.

RESULTS

Table 1 shows boats from the artisanal fleet based at Marinella di Selinunte that use trammel nets and gill nets.

Year	Number of Boats	Trammel net	Multiple Gear: Trammel net and Gil net
		FAO 750	FAO 9000
1998	41	56 %	44 %
1999	41	56 %	44 %
2000	-	-	-
2001	-	-	-
2002	37	49 %	51 %
2003	41	44 %	56 %
2004	41	44 %	56 %
2005	37	38 %	62 %
2006	39	31 %	64 %
2007	39	31 %	64 %
2008	35	23 %	77 %
2009	36	22 %	78 %
2010	34	18 %	82 %

Table 1 – Number of boats based at Marinella di Selinunte and fishing gear employed.

The fleet at Selinunte is comprised of small vessels suited to fishing exclusively along the coast with a mean length of 6.5 m and motors whose average power is about 16 Kw. Even if most of the boats are able to fish up to 6 miles from the coast, they are unlikely to operate beyond 3 miles. It is a moderately old fleet with an average age of 39 years; the newest boat is 17 years old, the oldest over 70. It is a typically artisanal fleet, the crew is generally comprised of a single and, except in rare cases, elderly fisherman. The entire catch is packed in 1 kilogram crates and sold at a typical auction which is open to the public. The auction, which begins every morning at 8:00, is run by the local cooperative to which all the fishermen belong. Even though the auction maximizes the value of the catch, often the most prized species are sold directly to local restaurants.

Year	Effort	ErSf
1998	6970	3 %
1999	6863	3 %
2000	-	-
2001	-	-
2002	3030	2 %
2003	3192	2 %
2004	5220	2 %
2005	4705	2 %
2006	6012	2 %
2007	5012	2 %
2008	5374	2 %
2009	6180	2 %
2010	3583	2 %

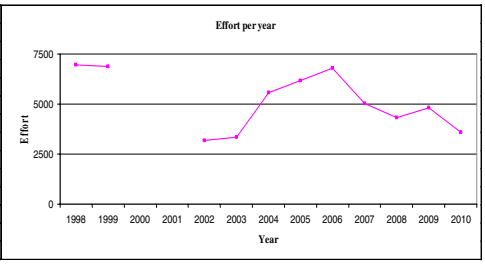


Figure 2 – Fishing effort, relative error and graphic of fishing effort per year.

Year	Total Catch specimens	Ern	cpue specimens	Total Yield Kg	Erp	cpue Kg
1998	10567	4 %	1,516	294	4 %	0,042
1999	8194	7 %	1,194	329	6 %	0,048
2000	-	-		-	-	-
2001	-	-		-	-	-
2002	7059	-	2,223	293	-	0,093
2003	6348	-	1,904	196	-	0,056
2004	10983	-	1,976	360	-	0,062
2005	18716	-	3,038	765	-	0,130
2006	9139	-	1,343	344	-	0,047
2007	5113	-	1,017	164	-	0,034
2008	4500	-	1,042	138	-	0,033
2009	4142	-	0,860	125	-	0,026
2010	4744	-	1,324	146	-	0,041

Table 3 – Total catch estimated or counted in number of specimens, cpue in number of specimens, catch in weight, cpue in weight and relative error of the estimate of *Melicertus keraturus*.

Table 3 shows the catches in number of specimens and weight and the relative cpue per year of the king prawn.

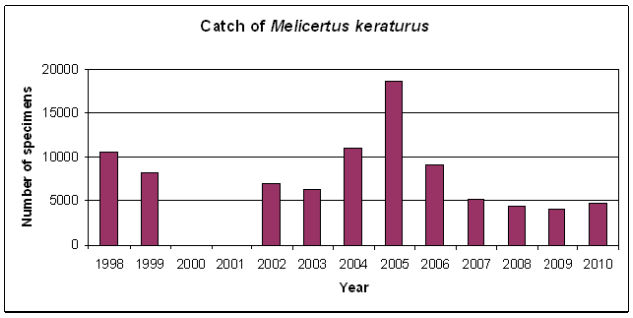


Figure 3 – Chart of catch in number of specimens per year.

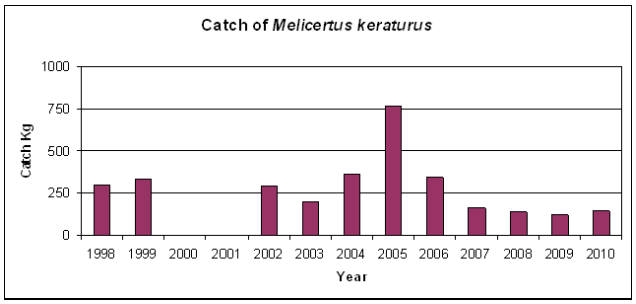


Figure 4 – Chart of catch in weight per year.

Figures 5 and 6 show the progression of the cpue in number of specimens and weight, respectively, from 1998 to 2010.

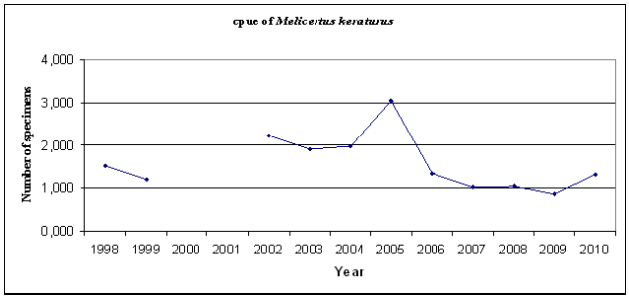


Figure 5 – cpue in number of specimens per year.

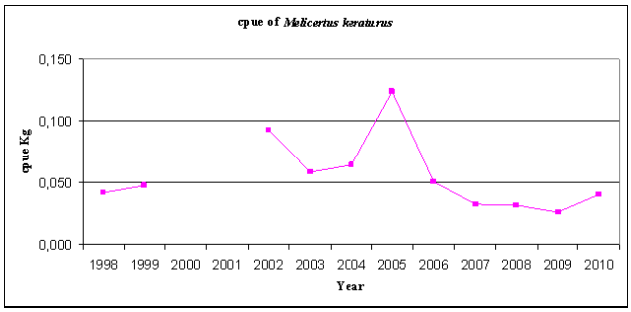


Figure 6 – cpue in weight per year.

Figures 7 and 8 show the cpue in number of specimens and weight, respectively versus Effort.

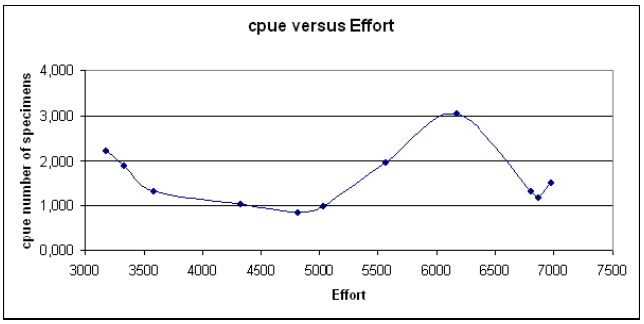


Figure 7 – cpue in number of specimens versus Effort

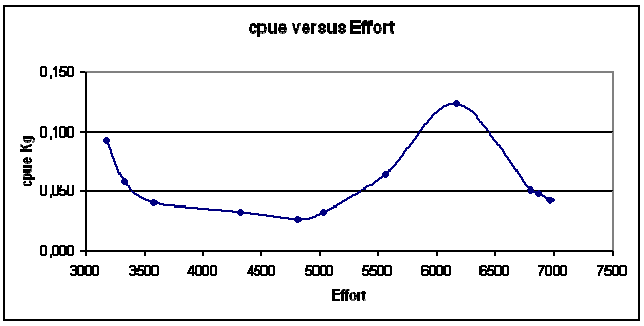


Figure 8 – cpue in weight versus Effort

ANALYSES

During the monitoring period, from 1998 to 2010, the number of fishing boats was in continual diminution passing from 41 to the present 34 as seen in Table 1. This reduction is in part due to the revocation of the subsidy for lost income paid by the European Union for the fishing ban and in part to fishermen going into retirement. In most cases, new fishermen do not take the place of those retiring and their fishing boats are either demolished or transformed into pleasure craft. For these reasons, between 1998 and 2002, the fishing effort declined sharply. From 2002, fishermen again obtained reimbursements from the Italian state and also from the Region of Sicily to effect 45 days of fishing ban allowing them to repair abandoned boats and upgrade fishing equipment in terms of increasing the length of trammel and gill nets. At the end of the last century, 56 % of fishing boats used only trammel nets; since 2002 the percentage of boats employing both the trammel net and the gil net grew continuously until reaching 82 % in 2010. Consequently fishing effort grew from 2002 to reach, in 2006, the levels of the late 1990s. Beginning in 2007 the subsidy for lost income due to the fishing ban was reduced and in particular the fishing ban was no longer compulsory. Therefore, from 2007 fishing effort began to decrease until, in 2010, it was again close to the 2002 level.

Catches in number of specimens and in yield (weight), shown in Table 2 and in Figures 3 and 4, reach the maximum in 2005, that is, the year following the repopulation. However, it should be noted that the increase in catches in 2005 cannot be due solely to the repopulation. In fact, although about 6,000 king prawn post-larvae were put to sea in August of 2004, the catch went from about 11,000 specimens in 2004 to over 18,500 in 2005. The 2004 yield of 360 Kg more than doubled in 2005, reaching 765 Kg. It is also important to note that the medium weight of the specimens caught varies from year to year and generally oscillates from about 30 g to about 40 g.

The progression of the cpue in number of specimens and in weight in time (see Figures 5 and 6) shows a maximum in 2005 due also, but not only, to the repopulation effected in 2004 and leads one to recall another maximum in 2001 or 2002 likely due exclusively to natural causes. The minimum cpue was registered in 2009.

The king prawn is available for catch by the gear employed only in spring and summer when it moves into shallow waters for reproduction. However, as for all species that frequent shallow coastal waters, it is strongly influenced by meteo-marine conditions which determine the success of reproduction and nursery.

The cpue in number of specimens and the cpue in weight have the same progression (see Figures 7 and 8) and show that the stock is overfished even when subjected to a relatively light fishing effort.

Nevertheless, in the few years in which the haul is particularly abundant due to natural causes, and in 2005 also due to repopulation, the catches increase following the increase of effort. But because fishing effort is too high, catches immediately return to levels generally found in absence of repopulation efforts or exceptionally favourable natural conditions.

CONCLUSIONS

The management strategies based on active restocking aim to reduce the natural mortality of *Melicerctus kerathurus* which is elevated in the first phases of life. It is not always useful to perform repopulation interventions because the increase in population can be damaging to other species or to the environment itself. A corner stone is that repopulation must be made with non-predator indigenous species. In the case of the repopulation affected in the waters of Selinunte with *Melicerctus kerathurus*, these conditions were easily verified and respected. Unfortunately, it was not possible to evaluate perfectly the effect of the repopulation on the catch because, by sheer and fortuitous coincidence, in 2005 the growth of the catch was, due to natural causes, much higher than predicted. Even so, it seems useful and opportune to practice consistent repopulation interventions with the objective of stabilizing the cpue with respect to effort. Because it does not seem possible to intervene on fishing mortality, it is necessary to strengthen the king prawn stock that frequents the fishing grounds of Selinunte in order to maintain the normally practiced level of fishing effort.

REFERENCES

Andreoli M.G., D. Levi, L. Cannizzaro, G. Garofalo, e G. Sinacori, 1995. Sampling statistics of Southern Sicily trawl fisheries (MINIPESTAT): methods. N.T.R.-I.T.P.P. Special Publication N° 4, vol. I

Bazigos G.P., 1974. The design of fisheries statistical surveys inland waters. FAO Fish. Tech. Pap., (133): 122 p.

Bazigos G.P., 1974. Applied fisheries statistics. FAO Fish. Tech. Pap., (135): 164 p.

Caddy J.F., and G. P. Bazigos, 1985. Practical guidelines for statistical monitoring of fisheries in manpower limited situation. FAO Fish. Tech. Pap., (257): 86 p.

Cannizzaro L., M. Arculeo, F. Lumare, A. M. Beltrano, A. Milazzo, S. Vitale, 2006. Sperimentazione di una strategia di ripopolamento con *Penaeus kerathurus* (Forskäl, 1775) nella

Fascia Costiera fra Capo San Marco e Capo Granitola. Final Report, Progetto n° C 117 (mimeo)

Cannizzaro L., and A. Kallianiotis, 2001. La mazzancolla (*Penaeus keraturus*, Forskal, 1775) nella fascia costiera siciliana: quale futuro? Atti del Workshop "Stato della pesca e dinamica di popolazione del gambero mediterraneo Penaeus keraturus in alcune aree della costa adriatica", 16 March, Lecce, Italy: 39-46 .

Cannizzaro L., G. Garofalo, M. Arculeo, A. Kallianiotis, A. Potoschi, 2000. Stocks assessment of some coastal species caught by artisanal fishery. Final Report, Contract U.E. 96/054 (mimeo)

FAO, 2008. FAO yearbook 2006. Fishery and Aquaculture Statistics. FAO, Rome: pp57 &CD.

FAO, 2000. FAO yearbook, Fishery statistics. Capture production. Vol. 86/1. Rome, FAO, 2000: 713 pp.

Lumare F., 1979. Reproduction of *Penaeus kerathurus* using eyestalk ablation. Aquaculture, 18, 203-14.

Sparre P., Venema S. C., 1998. Introduction to tropical fish stock assessment. Part 1. Manual. Fao Fisheries Technical Paper. N° 306.1, Rev. 2. Rome, FAO. 1998. 407p.

ACKNOWLEDGEMENT

Many thanks to Dr.ssa Elaine Trigiani for useful discussions, suggestions and for the patience demonstrated in the revision of the English version of this paper.