Polychaetes of commercial and applied interest in Italy: an overview

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ABSTRACT

The commercial interest of polychaetes is mainly due to their use as bait in recreational fishing and as food in aquaculture. The species of worms collected in Italy for these commercial and applied purposes is reviewed. Eight species of worms are collected for bait in Italian waters. *Hediste diversicolor*, *Perinereis cultrifera*, *Perinereis rullieri* and *Marphysa sanguinea* are collected from the Venice Lagoon. *Lumbrineris impatiens* is harvested in the Gulf of Naples, while *Diopatra cuprea cuprea* is collected from a littoral lagoon in Southern Sardinia and *Sabella spallanzanii* from other coastal areas of Sardinia. Finally, *Eunice aphroditois* is collected along the coasts of Apulia. A review of the literature on the effects of worm exploitation on the population, the associated communities and the environment, pointed out different results and patterns, and suggested the need for further studies and for legislation to control indiscriminant bait collecting to ensure a balance between the environment and the polychaete resource. Moreover, for the species that are imported from Korea, Japan, U.S.A. and other European countries, there is a risk of their accidental introduction into local biotopes. In this study we show that small-sized, "r-strategist" polychaetes, such as *Spio decoratus* or *Polydora ciliata*, are suitable food for juveniles of fish and crustaceans in aquaculture.

RÉSUMÉ

Les Polychètes d'intérêt commercial et appliqué en Italie : une revue

Les Annélides Polychètes sont devenus un marché important car ils sont de plus en plus utilisés comme appât pour la pêche "au gros" et comme nourriture en vue de l'élevage dans des fermes aquatiques. Cette étude est l'actualisation de ce que nous savons en Italie sur l'utilisation des vers dans ces buts commerciaux. Huit espèces de polychètes sont utilisées comme appât dans les eaux italiennes. *Hediste diversicolor*, *Perinereis cultrifera*, *Perinereis rullieri* et *Marphysa sanguinea* sont pêchés dans la lagune de Venise. *Lumbrineris impatiens* est capturé par des plongeurs professionnels dans le golfe de Naples, alors que *Diopatra cuprea cuprea* et *Sabella spallanzanii* se pêchent dans les zones littorales de la

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Sardaigne. L'espèce *Eunice aphroditois* est pêchée par des marins professionnels et des pêcheurs "au gros" le long de la côte des Pouilles. Les études effectuées à ce jour sur les effets de la pêche des vers sur le niveau des populations, sur les communautés associées et le biotope ont conduit à des résultats qui suggèrent la nécessité d'autres recherches et d'une législation adéquate pour assurer un équilibre entre l'environnement et cette ressource en Polychètes. Comme beaucoup d'autres espèces étrangères sont importées des Etats-Unis, de la Corée, du Japon et d'autres pays européens, il reste aussi le risque de leur introduction accidentelle dans les biotopes locaux. Dans cette étude on montre également que des espèces de Polychètes de petites dimensions et à stratégie "r", comme *Spio decoratus* ou *Polydora ciliata*, peuvent servir de nourriture complémentaire à de jeunes poissons et de jeunes crustacés élevés dans un but commercial.

INTRODUCTION

Polychaetous annelids are gaining significant commercial importance because they are increasingly used as bait for amateur and professional fishing. The widespread and ancient activity of worm collecting for angling is relatively well documented but quantified only in a few cases, mainly along the North American coasts (D'ASARO & CHEN, 1976; CREASER *et al.*, 1983), in East Asia (CHOI, 1985) and in Northern Europe (BLAKE, 1979a, b; HEILIGENBERG, 1982; OLIVE, 1994 a). The commercial value of the most exploited species have been documented by various authors (KLAWE & DICKIE, 1957; CREASER *et al.*, 1983; SARDA, 1989; CHEN, 1990). Recently OLIVE (in press) summarized the different patterns of worm exploitation and the potential for their aquaculture-based production. In most countries, including Italy, species are harvested from field populations (KLAWE & DICKIE, 1957; BLAKE, 1979a, b; CHOI, 1985), and only a few cases of commercial rearing are known (RYTHER *et al.*, 1975; KURIHARA, 1983; OLIVE, 1994).

Polychaetes are also used for other applied purposes, such as food in mariculture, decomposers of domestic and aquaculture organic wastes (TENORE & GOPALAN, 1974; TENORE *et al.*, 1974; RYTHER *et al.*, 1975) and test animals for toxicological studies (REISH, 1980). The aim of this study is to review the species of polychaetes that are harvested as bait, or have a potential applied interest in Italy, and describe their known biology and their methods of harvesting.

RESULTS

Eight species of polychaetes are commercially collected from natural populations in Italy. The sites of more intensive harvesting for each of these species are shown in figure 1. Species are generally dug from tidal flats or from lagoons and shallow littoral biotopes by professional and amateur fishermen who use special raking hoes or shovels. A few species are harvested by SCUBA divers by hand or with small shovels in shallow waters from soft or hard substrates (GAMBI *et al.*, 1992; BELLO, 1993). Data on number of diggers and on quantity of specimens collected, their seasonality and commercial value are largely unavailable from the commercial companies involved in this market which is only just developing in Italy.

Hediste diversicolor (O.F. Müller, 1778).

This euryhaline species is common in various Italian brackish zones (GIANGRANDE *et al.*, 1983-84), and it is commercially harvested mainly from the Venice Lagoon (Fig. 1). Here *H. diversicolor* colonizes areas of low salinity, and reproduces from March to April (ANSALONI *et al.*, 1986). However, the spawning period of this species varies between different geographic areas (SCAPS, 1992). The specimens may reach 20 cm in length in Italy, but their commercial size is from 10-12 cm. *H. diversicolor* is sold as "Tremolina", however, it is often confused with other species of the genus *Perinereis*. The cost in 1992 was about US $ 1 for a box of 8-10 worms. It is also imported from France.

Perinereis cultrifera (Grube, 1840).

This species is common along the Italian coasts both in soft sediments and in shallow, algal covered hard bottoms. Commercial harvesting is mainly from the Venice Lagoon (ANSALONI *et al.*, 1986) (Fig. 1) where it thrives in shallow muddy bottoms forming burrows in the upper 10 cm. It is collected by shoveling and sieving the mud through large-mesh screens. Amateur anglers collect *P. cultrifera* from several other coastal areas, including the coasts of Sicily, where a $CuSO_4$ solution is used to force the worms out of their burrows. In the Venice Lagoon, *P. cultrifera* reproduces in March following epitokal modification (ANSALONI *et al.*, 1986).

However, other authors in the Mediterranean observed reproduction in different seasons and without epitoky (PÉRÈS & RANCUREL, 1948; DURCHON, 1957; MARCEL, 1962). In the Mediterranean *P. cultrifera* reaches a maximum length of 15 cm, while in the Atlantic it reaches 25 cm. The species is known commercially as "Saltarello veneziano", and it is often confused with *Perinereis rullieri* and sometimes with *H. diversicolor*. The commercial price is similar to that of *H. diversicolor* and a large number of *P. cultrifera* are also imported from France.

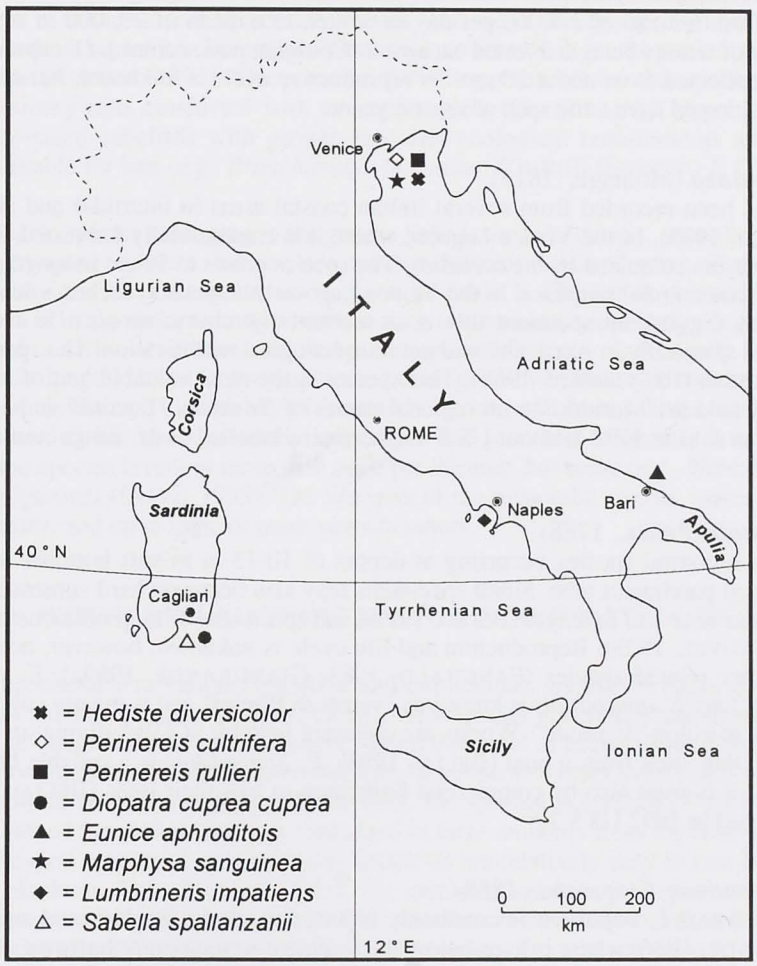

FIG. 1. — Map of Italy with the location of the main harvesting sites for each of the eigth species of polychaetes exploited as bait. Only the areas of intensive commercial collecting are indicated.

Perinereis rullieri Pilato, 1974.

P. rullieri has been recorded only along the Italian coasts, and it is probably endemic to the Mediterranean Sea (PREVEDELLI *et al.*, 1990). The commercial digging occurs mainly in the Venice Lagoon where *P. rullieri* reaches 18-20 cm in length. It is harvested commercially from 8-10 cm. Worms are collected from the intertidal zone from a substrate of gravel, muddy sand and small stones (PREVEDELLI *et al.*, 1990). Spawning is generally in April, but not via epitoky, and fertilisation takes place on the bottom. Fertilized eggs are embedded in gelatinous envelopes which are attached to the stones where they form large, green coloured clumps. The hatched larvae are nectochaetae with three setigerous segments (PREVEDELLI *et al.*, 1990; PREVEDELLI & ZUNARELLI VANDINI, 1992). The species is often confused with the co-generic *P. cultrifera*, and is labelled and sold at the same prices of the other nereidids.

Diopatra cuprea cuprea (Bosc, 1802).

Along the Italian coasts *D. cuprea cuprea* is found generally in shallow depths in sandy sediments mixed with mud. This species is commercially collected mainly in the littoral lagoon of Santa Gilla, near to Cagliari and in a few other shallow and sheltered areas nearby (Fig. 1) (COTTIGLIA, pers. comm). This species is sold as "Tremuligione", and is collected both using a spade in shallow water, and by SCUBA diving at 2 m depth. Number of bait diggers varies from about 25 in autumn and winter, to about 40 in spring and summer. The demand was great for this species, however, its harvest has been reduced recently because of the use of other local and imported bait worms (Cottiglia, pers. comm.). The number of worm dug depends on market demand and season, and ranges from a mean of 3-4,000 per day in winter, to a mean of 20, 000 in summer, resulting in an estimated 3.5 million of worms being harvested each year (Cottiglia, pers. comm.). *D. cuprea cuprea* can reach 30 cm in length but is collected from about 20 cm. Its reproductive cycle is unknown, but as other large onuphids (FAUCHALD, 1983), it could have a life span of several years.

Marphysa sanguinea (Montagu, 1815).

M. sanguinea has been recorded from several Italian coastal areas in intertidal and shallow littoral muddy bottoms (PREVEDELLI, 1989). In the Venice Lagoon, where it is commercially harvested, it burrows deep in the sediment, below the layers colonized by the nereidids. The species grows to 50 cm in length, and specimens 20-30 cm long are used for commercial purposes. In the Venice Lagoon this species reaches a density up to 60 ind. m^{-2}, and it is collected by digging up sediment that is sieved through coarse screens. In the Venice Lagoon *M. sanguinea* reproduces seasonally in April, and without morphological modification. The spawning is synchronized and occurs on the bottom (PREVEDELLI, 1989). This species is the most valuable bait of all species collected in Italy. It is commonly sold as "Muriddo", with regional names of "Murone, "Bacone" and "Verme sanguigno". A box of 6-8 worms was sold in 1992 at about US $ 4. Specimens labelled as *M. sanguinea* are imported from the U.S.A. and Korea.

Eunice aphroditois (Pallas, 1788).

E. aphroditois is a coastal species occurring at depths of 10-15 m in soft bottoms where it lives inside a characteristic U-shaped parchment tube. Small specimens may also occur on hard substrates (FAUVEL, 1923). In Italian waters it reaches over 1 m in length (BELLO, 1993), and specimens of larger dimensions have been reported from the Atlantic (FAUVEL, 1923). Reproduction and life cycle is unknown, however, because of the large size reached and like other related species (FAUCHALD, 1983; GIANGRANDE, 1989a), *E. aphroditois* may be a long-lived species. In Italy *E. aphroditois* is known as "verme di Rimini" and is mainly collected along the Apulia coasts (Fig. 1) where is called "Vermara". Worms are collected both by SCUBA diving up to 10 m depth, and by using a special long, thin stick from a boat (BELLO, 1993). *E. aphroditois* is a suitable bait to catch fish of the family Sparidae, and it is used also by commercial fishermen to bait their lines (BELLO, 1993). The price of a single specimen reached in 1992 US $ 1.5.

Lumbrineris impatiens Claparède, 1868.

Along the Italian coasts *L. impatiens* is commonly reported in sandy, muddy-sand and detritic soft bottoms (GAMBI & GIANGRANDE, 1986) where it lives below the sediment in temporary burrows. Specimens collected in shallow waters (1-5 m depth) are of greater dimensions measuring up to 40 cm in length, than those collected from deeper waters (10-20 m) which are only a few centimeters in length. This suggests age class distribution according to depth, or an ecotype determined by different trophic and ecological conditions. However, the existence of "sibling" species cannot be excluded. The biology of *L. impatiens* is poorly known. MCNULTY & LOPEZ (1969) observed mature eggs throughout the year in Florida, but with a decrease in frequency in winter. CAZAUX (1972) studied the larval development of a population of the north Atlantic French coast, and he found that the larva is planctotrophic with a pelagic phase of about 15 days. Biological data of the Mediterranean Sea population of this species are lacking. For commercial purposes *L. impatiens* is mainly harvested from shallow sandy areas in the Gulf of Naples. Within the Gulf it is particularly abundant at the mouth of the Sarno river which is enriched with organic matter deriving from agricultural industry wastes. Worms are collected by about 10 SCUBA-divers who are organized in a cooperative. There is a great demand for this species which is locally called "Esca rossa" or also "Tremolina". A single diver may collect over 200 worms a day. The commercial size of the worms is generally over 20 cm long and the cost in 1992 varies form US $ 0.5 to US 1 $ for a single specimen.

Sabella spallanzanii (Gmelin, 1791).

S. spallanzanii, better known under its original generic name of *Spirographis,* is very common on hard substrate along the Italian coasts (GIANGRANDE, 1989, b). It is found in the open coastal areas from 1 to 30 m depth, and in shallow confined areas such as harbours, where it often reaches very high densities. *S. spallanzanii* reproduces in winter, and the egg dimensions suggest a lecithotrophic development (GIANGRANDE & PETRAROLI, in press). Specimens can reach up to 40 cm in length and preliminary observations suggest a growth rate of about 10 cm per year (GIANGRANDE & PETRAROLI,1994). Since this species is a suspension feeder, it can be fed in laboratory with various kinds of suspended food, including probably particulate organic matter, and it may be suitable in the treatment of domestic and aquaculture wastes. The use of this species as a bait by anglers is limited to some localities in Sardinia where it is known as "Tremuligione amaro". It seems particularly suitable as bait for catching large Sparidae (RIGHINI, 1991). The potential for a larger market for this species is supported by the results of some preliminary tests conducted with amateur anglers (GIANGRANDE, unpublished data). It is also likely that other large-sized sabellids with growth rate and ecological requirements similar to those of *S. spallanzanii* may be suitable for bait (*e.g.*, *Branchiomma luctuosum* (Grube)) (SORDINO & GAMBI, 1992).

A few other polychaete species belonging to the genera *Sabellaria* and *Ophelia,* are collected as bait in various coastal areas by local amateur anglers, but are not commercialized. A list of some of the polychaete species harvested as bait in Italy and in other countries is given in Table 1. The list is probably incomplete and the number of species taken is likely underestimated because such information is usually not reported. However, about 32 species are exploited in various countries, and share some general features : a) relatively large adult dimensions (between 15 to 30 cm in length); b) wide geographic and ecological distribution, indicating a broad tolerance to different environmental conditions; c) a variety of feeding behaviour and food sources, with most of them being detritivores or omnivores; d) life spans generally longer that one year, and frequently 3 to 5 years; e) many are polytelic (= iteroparous) species breeding more than once per lifetime, but some (*e.g.*, Nereididae and Glyceridae) are monotelic (= semelparous) (OLIVE, 1983). The life span of the monotelic species varies between 1-2 years in the case of *H. diversicolor*, and up to three or more years in others.

OTHER APPLICATIONS AND USES OF POLYCHAETES

Small-sized polychaetes, such as various Spionidae and Capitellidae, are used in aquaculture to supplement the diet of commercial fish and crustaceans (GUÉRIN, 1978). These species generally show many "r-strategy" traits in their life histories. In an integrated polyculture system for the treatment of acquaculture wastes, *Capitella capitata* was used as food for juvenile stages of the commercial fish *Pseudopleuronectes americanus* (RYTHER *et al.*, 1975). In a semi-intensive culture of *Penaeus japonicus* in Italy, the spionid polychaete *Polydora ciliata* played an important role in the diet of the shrimp and was consumed in large amounts from the bottom of the culture tanks (ZUPO *et al.*, 1989). Several species of spionids and capitellids are relatively easy to rear in the laboratory from larvae collected from plankton, (CHU & LEVIN, 1989). The culture of spionids throughout their life cycle has been documented for *Malacoceros fuliginosus* (GUÉRIN, 1987), for *Boccardia semibranchiata* (GUÉRIN, 1991) and for *Streblospio benedictii* (LEVIN, 1984). *Spio decoratus* has been reared from larvae collected in plankton to mature adults (GIANGRANDE *et al.*, 1992). This species is polytelic, a feature common to several Spionidae (GUDMANSSON, 1985). It has a short life span and reproduces continuously after reaching maturiry at six months ; egg laying then occurs about every other month. The above studies suggest that several species of spionids may be suitable to be reared in the tanks with cultured fish and crustacean to supplement their diet.

DISCUSSION

The bait polychaetes which are commercially the most valuable in Italy are likely to be the species with the longest life spans: *M. sanguinea, L. impatiens, D. cuprea cuprea* and *E. aphroditois.* Because of their long life cycle, the long term exploitation of these species needs a knowledge of their biological and ecological requirements for management that optimizes their harvest and minimises the impact of collecting on their populations and on their habitat. However, apart from *M. sanguinea* and *P. rullieri,* studies on the life cycle and population dynamics

TABLE 1. — Bait species harvested and/or cultured in Italy and in other countries. The data are from literature, market surveys and other sources.

Neanthes virens Sars is harvested in the U.S.A. (sandworm, CREASER *et al.*, 1983), in Spain (SARDÀ, 1989) and U.K. (BLAKE, 1979a) where it is also industrially cultured (OLIVE, 1994) and exported to Italy and other countries.
Neanthes arenaceodentata (Moore) is cultured and sold as test animal for aquatic and sediment toxicological testing (REISH, 1980).
Neanthes spp., two species (*N. succinea* (Leuckart) and *N. caudata* Delle Chiaje) are collected in France (BELLAN, pers. comm.) and Spain (SARDÀ, 1989).
N*eanthes japonica* (Izuka) is harvested and cultured in Japan (KURIHARA, 1983).
Perinereis nuntia vallata (Grube) is harvested and cultured in Japan (KURIHARA, 1983) and imported to Italy (named "cinese").
Perinereis vancaurica (Ehlers) is harvested in Korea and imported to Italy, where it is sold as "coreano".
Perinereis aibuhitensis Grube is collected in south-east Asia; it is imported to Italy and sold as "coreano" or "cinese".
Perinereis brevicirris (Grube) is cultured in Taiwan (CHEN, 1990; OLIVE, 1994).
Perinereis cultrifera (Grube) is harvested in Italy (Ansaloni *et al.*, 1986) and in France (BELLAN, 1964).
Perinereis rullieri Pilato is collected in Italy (Venice Lagoon) (present paper).
Hediste diversicolor (O.F. Müller) is harvestd in Italy (ANSALONI *et al.*, 1986) and in France (BELLAN, 1964).
Pseudonereis variegata Ehlers is collected from South Africa (VAN HERWERDEN, 1989).
Nephtys caecoides Hartman is collected in Northern California and Oregon where it is used in marine toxicological testing (REISH, pers. comm.).
Nephtys spp., two species *(N. hombergii* Audouin & Milne Edwards, and *N. cirrhosa* Ehlers) are collected in Spain (Sardà, 1989) and U.K. (OLIVE, pers. comm.).
Glycera dibranchiata Ehlers is harvested in the USA ("bloodworm", CREASER *et al.*, 1983) and it is exported to Italy where it is sold as "americano" or "canadese".
Halla partenopeia (Delle Chiaje) is collected and greatly valued in Spain (SARDÀ, 1989) .
Lumbrineris latreilli Audouin & Milne Edwards is collected in Spain (SARDÀ, 1989) .
Lumbrineris impatiens Claparède is collected in Italy (GAMBI *et al.*, 1992, present paper) and in Spain (Sardà, 1989).
Hyalinoecia tubicola (O.F. Müller) was collected in Spain (SARDÀ, 1989).
Diopatra cuprea cuprea (Bosc) is harvested in Italy (Sardinia, GAMBI *et al.*, 1992, present paper).
Onuphis teres Ehlers is collected in Australia (OLIVE, 1994).
Eunice aphroditois (Pallas) is collected in Italy (BELLO, 1993; present paper).
Marphysa sanguinea (Montagu) is collected in Italy (ANSALONI *et al.*,1986), in Spain (SARDÀ, 1989), in France (BELLAN, 1964), in U.S.A. and Korea (CHOI, 1985) and in Australia (OLIVE, 1994).
Arenicola marina L. is collected in The Netherlands (Heilingeberg, 1982), along the Atlantic coasts of Spain (SARDÀ, 1989), U.K. and Ireland (OLIVE, 1994), and U.S.A. (D'ASARO & CHEN, 1976).
Arenicola cristata Stimpson is collected along the northern Mediterranean coasts of Spain (Catalonia; SARDÀ, 1989) and in the U.S.A. (D'ASARO , 1973).
Arenicola brasiliensis Nonato. This species is reported among the various lugworms collected as bait (D'ASARO , 1973).
Capitellidae gen. spp. Various species (probably of the genus *Notomastus)* are collected in Spain (SARDÀ, 1989).
Ophelia spp. Various species are collected occasionally by amateur anglers both in Italy and in Corsica (BELLAN, pers. comm.).
Sabellaria spp. Various species are occasionally collected in a few localities along the Italian coasts (GAMBI *et al.*, 1992).
Sabella spallanzanii (Gmelin) is collected in a few localities in Sardinia (Italy) (present paper).

of the commercial species in the exploited sites in Italy are lacking. They are harvested with no regard to their life history and the potential destructive effects of collecting. Moreover, worms are generally harvested without appropriate legislation to regulate periods of collecting and number of individuals which can be removed.

Geographic variability in reproductive mode and time has been documented in different cospecific populations (*e.g., H. diversicolor* or *P. cultrifera*). In addition, population structure may vary and not all populations may be commercially viable (OLIVE, 1994). A few studies have examined how harvesting may affect population parameters such as fecundity, growth rate, mortality and genetic variability. The spawning stock and the population structure of *Glycera dibranchiata* (KLAWE & DICKIE, 1957) and of *Neanthes virens* and *Arenicola marina* (BLAKE, 1979 a, b) were not effected by digging. On the other hand, for a different population of *Glycera*

dibranchiata, intensive harvesting reduced heterozygosity, enhanced genetic drift and altered rapidly the genetic structure of the population (VADAS & BRISTOW, 1985).

The commercial harvesting of polychaetes also has general implications at community and environmental level, and raises problems of resource management that are common to other cases of marine resource exploitation. Digging for worm collection causes great physical disturbance to the substrate and this affects the benthic community. A study on the rocky coasts of South Africa (VAN HERWERDEN, 1989) demonstrated dramatic destruction of the environment and of biotic resources, particularly mussel beds, caused by the collection of *Pseudonereis variegata.* Digging for the bait *Arenicola marina* along the Norfolk coast (U.K.) caused massive death of the cockle, *Cerastoderma edule* (JACKSON & JAMES, 1979). On the other hand, investigations on the effects of digging for *Arenicola* on a tidal flat in The Netherlands (HEILIGENBERG, 1982) and on an estuary in the U.K. (McLUSKY *et al.*, 1983) revealed that, after an initial period of community collapse, the density of some benthic species was enhanced, and there was a rapid population recovery of the worms, mainly due to the above-surface migration of adults from surrounding areas. A similar recolonization pattern, observed for a different population of *Arenicola* (OLIVE, in press), suggests that periods of exploitation alternating with periods of recovery from reserve zones could be a suitable management method for this species, as well as for other exploited worms (*e.g., M. sanguinea*; CHOI, 1985).

These few reports and their different results demonstrate the need for systematic studies to evaluate the environmental impact of long term exploitation of worm populations. There is an increasing awareness of this problem also in the Venice Lagoon and in other Italian areas where habitat damage coupled with competition among professional and amateur fishermen is starting to limit these worm resources (BELLO, 1993).

Another important environmental risk is that the importation of allochtonous species which are generally sold alive (in Italy mainly the tropical *Perinereis* spp.), may increase the risk of accidental introduction of foreign taxa. To reduce and overcome these environmental problems, commercial rearing is an attractive solution both scientifically and economically. To date a few polychaete species are commercially reared (RYTHER *et al.*, 1975 ; REISH, 1980; KURIHARA, 1983; OLIVE, 1994), and various biological problems related to their large scale production, such as diseases, parasites, supply of larvae, still need to be resolved (SCAPS, 1992; OLIVE, in press, a). Some of the Italian species are potentially suitable for commercial culturing. Those species are the nereidids that have short life spans, and *M. sanguinea* or *L. impatiens* that can fed various organic detritus. *S. spallanzanii* which has a fast growth rate and can utilize organic compounds produced and released in the water column by other cultured organisms (*e.g.*, mussels) is another potential species.

The main aim and the scientific challenge of the research on the biology of the bait polychaete species should be to develop rearing techniques for intensive production that, increasing resource supply, would greatly reduce the harvest impact on natural populations, associated organisms and biotopes.

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