# The Italian Ministry for Agricultural, Food, Tourism and Forestry Policies

DEPARTMENT OF COMPETITIVE POLICIES, FOOD, EQUINE AND FISH QUALITY

DIRECTORATE GENERAL FOR MARITIME FISHING AND AQUACULTURE

# The National Management Plan for fishing with hydraulic dredges and boat-operated shell-rakes as identified in the classification of fishing equipment use by mechanical dredges including mechanised dredges (*HMD*) and boat dredges (*DRB*)

## ANNEX 1

***State of knowledge of fishing with hydraulic dredger***

(drafted in compliance with Article 19 of EC regulation no. 1967/2006 as well as Articles 7, 9 and 10 of EU Regulations No. 1380/2013 concerning Common Fisheries Policy).

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# 1. Hydraulic dredge fishing

## 1.1. General characteristics

A dredge is an apparatus with a fixed opening that is trawled along the seabed, manually or by a vessel, and used for catching bivalve molluscs. All dredges operate in shallow waters (generally less than 15 m) because bivalve molluscs that live in the sediment can be harvested at this depth.

Fishing with hydraulic dredges is practiced in Italy in 9 Regions along approximately 1400 km of the coastline out of a total length of approximately 8000 km. The fleet is concentrated mainly along the Adriatic coast, with important production centres in the Marche (31% of hydraulic dredges operating in Italy) and Veneto regions (23%) and their target species is above all clams (*Chamelea gallina*) and smooth clams (*Challista chione*). The dredges operating in the Tyrrhenian Sea (roughly 40) mainly fish razor clams (*Ensis minor*). These target species are present exclusively in areas characterised by sandy seafloors and never further than 1.5 - 2 nautical miles from the coast.

The current number of vessels operating with hydraulic dredges consists of 706 units. The number of human resources working on fishing vessels is estimated at approximately 1500, which means an average crew of 2 units per vessel. The average number of fishing days is approximately 85.

The management of bivalve molluscs is currently handled locally by the Consorzi di Gestione dei Molluschi: there are currently 17 consortia active in the sector, distributed throughout Italy. The management measures included in this Management Plan define the reference framework within which the activities of the Consorzi di Gestione dei Molluschi will be carried out. The measures are proportional to the aims, the objectives and the planned schedules and take into account the following factors:

a) maintaining a high productivity of the single species or species;

b) the biological characteristics of the single species o species;

c) the characteristics of management and harvesting activities;

d) the economic impact of the measures.

Rights-based management – RBM, in accordance with all that has been reported in the Commission's Communication, can improve the efficiency of fishing management, while facilitating achievement of the basic objectives pursued by the Community and the member States within the framework of the common fisheries policy (CFP), such as conservation of fish stock, preservation of the "relative stability" of fishing activities in member States and a competitive fishing industry. In the case of bivalve molluscs, management is effectively based on territorial fishing rights similar to those that exist in other Member States (in English TURF, Territorial Use Rights for Fishing). The introduction of territorial rights, that envisage the full transfer of responsibility to the holders of such rights, is appropriate in cases where the resources are sedentary; it is in this case only, in fact, that there is no competition between the parties who hold territorial rights and those who practice fishing outside the borders. The management of hydraulic dredges is very similar to this system, in which each fishing district operates and has fishing rights exclusively within its own territory (maritime district). However, there are in Italy innovative and highly successful situations, as is the case of OP Bivalvia Veneto and OP I Fasolari, that are an example of joint management and supra-district cooperation that is unique on the entire Italian fishing scene and a source of pride, achieving social and economic sustainability that is constant over time and a reduction in product fluctuations in terms of both space and time, supporting profitable and long-lasting fishing activities.

## 1.2. Overview of fishing with hydraulic dredges

In Italy, fishing with hydraulic dredges is carried out in the following Regions and for the species indicated in Table 1.

Table 1: Fishing of the various species of bivalve molluscs in the various Italian regions.

| Region | Clam | Razor shell | Smooth clam |
|---|---|---|---|
| Friuli Venezia Giulia | ● | ● | ● |
| Veneto | ● | ● | ● |
| Emilia Romagna | ● | | |
| Marche | ● | | |
| Abruzzo | ● | | |
| Molise | ● | ● | |
| Puglia | ● | ● | |
| Lazio | ● | ● | |
| Campania | ● | ● | |

Fishing with hydraulic dredges is carried out along a coastline of about 1400 km out of a total length of about 8000 km of Italian coastline. Clams and razor shells are found exclusively in areas with sandy seabeds.

Hydraulic dredgers are currently homogeneous vessels both from a technical point of view and in terms of size. The current number of vessels operating with hydraulic dredgers is 706. The number of people on board is estimated at about 1500, which is equivalent to an average crew of 2.12 units per vessel (Table 2). The Italian hydraulic dredging sector involves a number of employees (on-board personnel) who over the years, from 2012 to 2017, have fluctuated from 1453 in 2012 to 1541 in 2014 (Table 3). Such fluctuations follow in some way the production trend, employing fewer personnel when a production crisis imposes technical stoppages decided by the Consortia. The cost of labor has not shown any clear trend over the years. It is worth around 15 million Euros, except in 2017 when a sharp drop was observed and labor costs settled at 12 million Euros. Conversely, fuel costs have shown a steady decline over the years, also leading to net savings for shipowners. The average number of fishing days per year is about 85.

In economic terms, the contribution of the hydraulic dredgers segment to the gross saleable value of production of the entire Italian sector is approximately 5.7%. Total production in 2017 and 2018 was 21,796 tons, respectively, and accounts for 10.36% of the total production of the fishing fleet.

Table 2: Number of boardings by Region in the period 2012-2017.

| | N° boardings | | | | | |
|---|---|---|---|---|---|---|
| **Region** | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
| Abruzzo | 234 | 307 | 302 | 282 | 246 | 293 |
| Campania | 31 | 29 | 46 | 35 | 28 | 28 |
| E. Romagna | 108 | 116 | 108 | 108 | 108 | 104 |
| F.Venezia Giulia | 84 | 89 | 84 | 84 | 84 | 86 |
| Lazio | 41 | 53 | 48 | 48 | 48 | 49 |
| Marche | 448 | 457 | 458 | 442 | 464 | 459 |
| Molise | 29 | 21 | 18 | 20 | 18 | 20 |
| Puglia nord | 152 | 49 | 152 | 152 | 152 | 148 |
| Veneto | 326 | 398 | 326 | 322 | 322 | 332 |
| Grand total | 1453 | 1519 | 1541 | 1493 | 1470 | 1520 |
| No vessels | 706 | 706 | 706 | 706 | 706 | 706 |
| **Average number of boardings** | **2.06** | **2.15** | **2.18** | **2.12** | **2.08** | **2.15** |

Table 3: Number of employees in the hydraulic dredging sector in Italy, labor and fuel costs over the years.

| Year | No. employees | Cost of labor (Euro x 1000) | Cost of fuel (Euro x 1000) | Gross profit (Euro) | Revenues (Euro) | Added value (Euro) |
|---|---|---|---|---|---|---|
| 2012 | 1453 | 16201.7 | 10067.0 | 19416255.99 | 52566689.73 | 35617991.09 |
| 2013 | 1519 | 14369.6 | 6417.0 | 15698338.51 | 43672440.8 | 30067936.26 |
| 2014 | 1541 | 15309.0 | 4819.7 | 13821291.99 | 39974701.99 | 29130264.99 |
| 2015 | 1493 | 15135.6 | 4828.5 | 13687759.13 | 40542251.13 | 28823385.13 |
| 2016 | 1470 | 17890.0 | 4625.0 | 17299691.55 | 47554395.55 | 35189719.55 |
| 2017 | 1520 | 12413.8 | 2962.9 | 12401028.78 | 32977131.7 | 24814854.45 |

The fleet is concentrated on the Adriatic coast, with important production centers in the Marche region (31% of hydraulic dredgers operating in Italy) and in the Veneto region (23%). The dredgers operating in the Tyrrhenian Sea (about 40) mainly fish for razor shells (Ensis minor). At national level, in the period 2000-2017, the sector of hydraulic dredgers has kept the number of vessels constant over time (about 700), while the overall fishing fleet shows a decreasing trend (-33%), from over 18,000 units in 2000 to slightly more than 12,000 units in 2017.

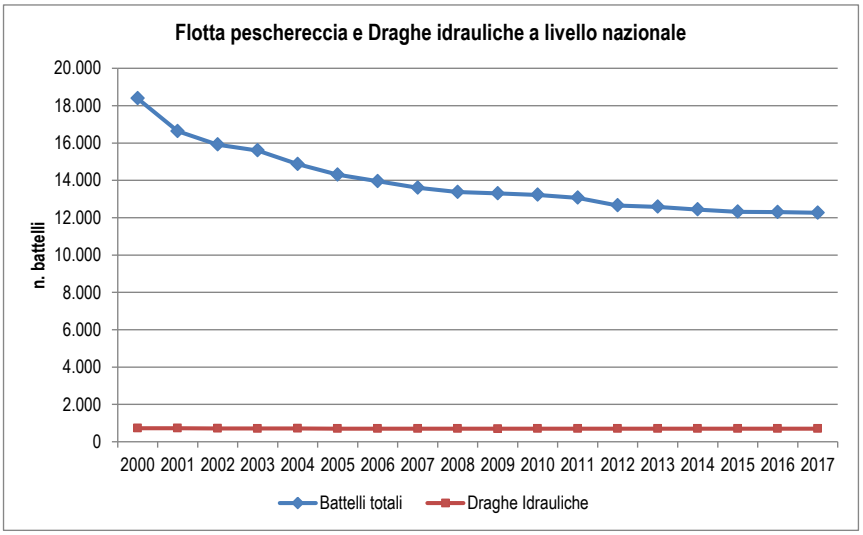



Figure 1: Trends in landings of *C. gallina* nationwide.

## 1.3. Clams (*Chamelea gallina*)

The national hydraulic dredging fisheries sector, as far as clams are concerned, suffered a progressive decrease in total catch from 2011 to 2017 (Table 4).

Table 4: Total annual catches (tons) of clams along the Italian coast.

| Year | January | February | March | April | May | June | July | August | September | October | November | December | TOT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2011 | 1405.7 | 1526.6 | 1629.2 | 1549.6 | 1440.5 | 1454.8 | 1605.2 | 1928.8 | 1520.5 | 1637.9 | 1580.7 | 2388.1 | 19667.5 |
| 2012 | 1677.0 | 1127.6 | 1977.8 | 1341.9 | 1725.3 | 1777.0 | 2073.1 | 1652.3 | 1657.6 | 1439.2 | 1352.1 | 2227.5 | 20028.3 |
| 2013 | 1380.4 | 1088.2 | 1237.2 | 1171.9 | 1425.3 | 1226.2 | 1529.5 | 1044.5 | 1205.8 | 980.3 | 682.6 | 1561.1 | 14532.9 |
| 2014 | 1076.0 | 595.3 | 916.2 | 602.6 | 1118.9 | 1571.8 | 1431.1 | 1715.7 | 1455.5 | 1188.5 | 1026.0 | 1419.9 | 14117.5 |
| 2015 | 1110.0 | 753.6 | 1051.0 | 856.1 | 1514.9 | 1799.3 | 1295.5 | 1314.0 | 791.3 | 1134.1 | 953.1 | 2087.1 | 14659.8 |
| 2016 | 1156.3 | 885.2 | 1280.4 | 988.8 | 1547.4 | 1720.6 | 1445.5 | 1405.9 | 1210.8 | 1118.0 | 1363.7 | 2160.3 | 16282.8 |
| 2017 | 836.8 | 908.2 | 1241.2 | 733.5 | 1258.5 | 1077.5 | 1183.2 | 1260.9 | 1001.4 | 553.5 | 513.4 | 1227.8 | 11795.8 |

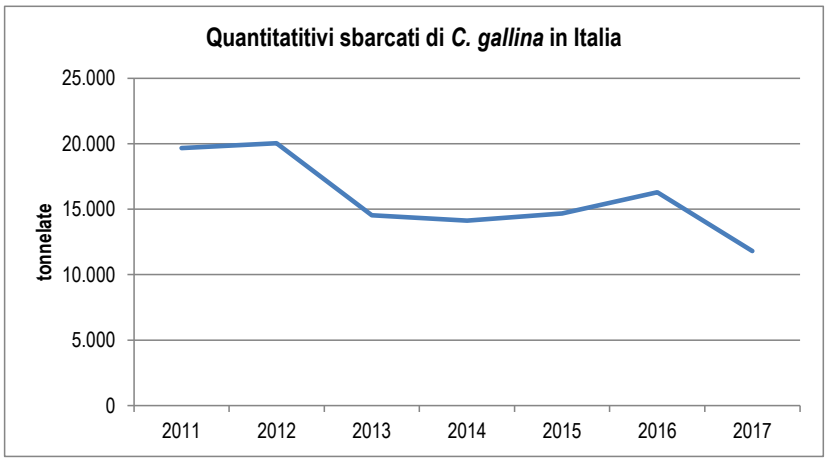



Figure 2: Trends in landings of *C. gallina* nationwide.

Similarly, sales fell sharply from 2011 to 2017, as shown in Table 5.

Table 5: Turnover (Euro x 1000) concerning the sale of clams at national level.

| Year | January | February | March | April | May | June | July | August | September | October | November | December | TOT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2011 | 4159.8 | 4636.8 | 4889.2 | 5271.0 | 4915.9 | 4182.9 | 4253.0 | 4741.9 | 3911.1 | 3635.9 | 3237.7 | 4879.3 | 52714.5 |
| 2012 | 3283.7 | 2157.5 | 3833.8 | 3032.8 | 4328.4 | 3667.2 | 4490.2 | 3622.3 | 3672.0 | 2896.8 | 2745.4 | 4615.5 | 42345.4 |
| 2013 | 3094.0 | 2456.7 | 2963.9 | 3110.8 | 3513.6 | 2734.3 | 3420.4 | 2670.5 | 2787.4 | 1999.7 | 1387.6 | 3129.0 | 33267.8 |
| 2014 | 2469.1 | 1347.1 | 2092.1 | 1499.5 | 2777.3 | 4026.3 | 3188.6 | 4058.5 | 3403.5 | 2364.9 | 2074.5 | 2873.4 | 32174.7 |
| 2015 | 2135.1 | 1423.3 | 2034.1 | 2007.8 | 3277.4 | 3920.9 | 3095.7 | 2965.4 | 1736.5 | 2396.0 | 1943.2 | 4540.2 | 31475.4 |
| 2016 | 2755.5 | 2121.6 | 2932.6 | 2289.5 | 3840.6 | 4486.6 | 3319.7 | 2857.9 | 2423.9 | 2635.2 | 3439.2 | 5170.9 | 38273.4 |
| 2017 | 2008.4 | 2125.1 | 3016.6 | 1699.9 | 2802.7 | 2483.2 | 2820.2 | 2728.0 | 2368.4 | 1353.1 | 1124.7 | 2673.2 | 27203.6 |

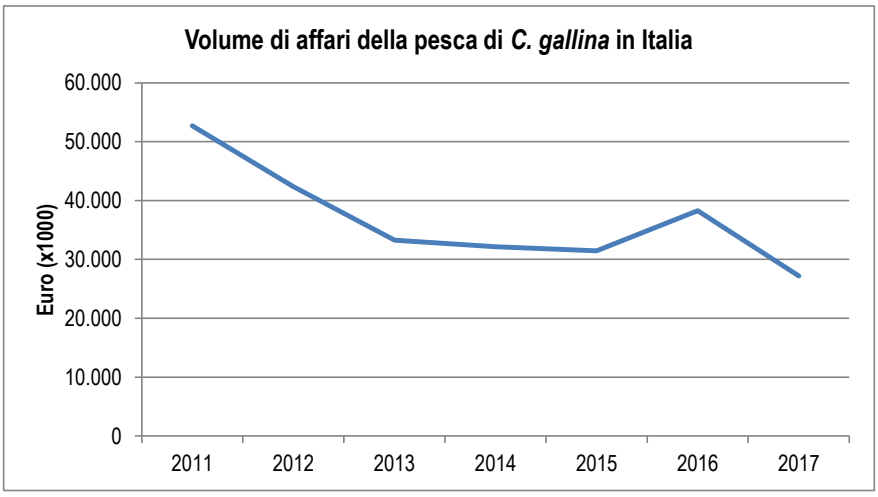



Figure 3: Trend in the turnover of *C. gallina* fishery across the country.

### 1.4. Clam biology (*Chamelea gallina*): Summary of results obtained

In consideration of the modified Minimum Conservation Reference Size - MCRS set a 22 mm, compared to the 2 mm envisaged by Reg. EC 1967/2006, it has been considered useful to examine in depth some aspects of the biology of this species. Information has been collected through an accurate review (already presented at the time of the first opinion on the Discard Plan) as well as new biological investigations.

The results obtained concerning sexual maturity and growth confirm what had already been observed by other authors in the past. Using the samples obtained through surveys both in 2017 and 2018 **it has been possible to determine the sex of individual specimens starting already from a size of 8-10 mm and to observe mature gametes in both sexes already from 11-12 mm**. The results of the analyses have indicated a high number of specimens for which it is possible to establish their gender from March to June, with a smaller percentage of indeterminate specimens in the months of May and June. These two months represent the reproductive peak with the highest number of mature specimens found. The reproductive peak is followed by a period of gonadal inactivity (resting stage) until November, when the gametogenic cycle resumes for both sexes.

The data concerning development have instead shown that clams grow by about 1 mm/month. This means that a clam takes just under 2 years to reach the size of 22 mm and that after they have been returned to the sea 22 mm clams, and slightly smaller ones , reach 25 mm in approximately 3 months.

## 2. Fishing effort

The implementation of the "National Discard Management Plan, for the clam resource (Chamelea gallina)" (DM 27/12/2016, OJ No 8 11/1/2017) has actually introduced a significant reduction in fishing effort, implemented through two measures:

- the actual reduction of weekly fishing days: as a partial amendment to Article 5(2) of Ministerial Decree 22/12/2000, the units authorized to fish clams must observe the stoppage of fishing activities on Saturdays, Sundays and holidays plus another day established by the Consortia, so as not to exceed 4 days of fishing per week. This has in fact meant a reduction of about 20% of fishing days, since DM 22/12/2000 art. 5 set the maximum limit of 5 fishing days per week;

- the reduction of the quantities that can be fished daily: art. 7 of Ministerial Decree 22/12/2000 set the daily fishing limit at 600 kg / boat. DM 27/12/2016 reduced the daily catch limit per boat by about 33% at 400 kg.

The measures contained in the Discard Plan have therefore had the effect of significantly reducing the fishing effort exerted by hydraulic dredgers. On the one hand, the total number of fishing days has decreased; on the other hand, the daily fishing effort has significantly declined for two reasons. In fact, the reduction of the maximum daily quota (from 600 to 400 kg) and the possibility of marketing even clams smaller than 25 mm ( even in the current situation, clams smaller than 23 mm are rarely marketed) have allowed to reach the daily quota in a shorter time, implying a reduction of the dredged areas.

In addition, all vessels authorized to fish for clams with hydraulic dredges are currently equipped with a position detection system. This system allows, on one hand, to check the fishing effort also from a spatial point of view and, on the other, to adopt appropriate management measures based on the degree of exploitation of the areas (e.g. rotation of fishing areas).

State-of-the-art systems for monitoring and recording the position at sea on board hydraulic dredgers are listed below.

Table 6: Type of position detection system adopted by the different Management Consortia.

| **Marine Position Monitoring and Recording System (VMS-AIS-GPS)** | | | |
|---|---|---|---|
| *Management Consortium* | *n. fishing boat* | *VMS-AIS-GPS* | *Remarks* |
| Co.Ge.Mo. Monfalcone | 42 | yes | All units are equipped with GPS system |
| Co.Ge.Vo. Venezia | 86 | yes | All units are equipped with AIS system |
| Co.Ge.Vo. Chioggia | 77 | yes | All units are equipped with AIS system |
| Co.Ge.Mo. Ravenna | 18 | yes | All 18 boats of the Consortium are equipped with GPS geolocation system |
| Co.Ge.Mo. Rimini | 36 | yes | GPS system provided by Visirun |
| Co.Ge.Mo. Pesaro | 65 | yes | All 65 boats are equipped with GPS recording system |
| Co.Ge.Vo. Ancona | 74 | yes | 73 boats are equipped with GPS, 1 with AIS sytem |
| Co.Ge.Vo. Civitanova Marche | 25 | yes | 23 boats are equipped with GPS, boats with AIS system |
| Co.Vo.Pi. San Benedetto del Tronto | 57 | yes | 46 units are equipped with GPS, 11 with AIS |
| Co.Ge.Vo. Abruzzo Pescara | 82 | yes | All 82 boats are equipped with AIS or GPS. |
| Co.Ge.Vo. Frentano Ortona | 21 | yes | 3 boats are equipped with AIS, 18 boats with GPS |
| Co.Ge.Vo. Termoli | 9 | yes | All 9 boats are equipped with GPS MOPEsystem |
| Consorzio Molluschi Nord Gargano | 51 | yes | 48 boats are equipped with GPS |
| Co.Ge.Mo. Il Colosso di Barletta | 25 | yes | All 25 boats are equipped with GPS |
| Co.Ge.Mo. Napoli | 14 | no | They will be equipped in the future |
| Co.Ge.Mo. Gaeta | 4 | no | |
| Co.Ge.Mo. Roma | 20 | no | |

The number of fishing days is a good indicator of the state of the hydraulic dredger fishery. In fact, the higher the number of fishing days, the better the resource situation. For example, Figure 4 below shows the average situation in different consortia. It can be observed that with the entry into force of the discard plan there has been no significant change, with a slight increase in the number of fishing days, indicating a positive trend for the fisheries sector. However, CPUE based on daily catches are not very meaningful for this quota-based fishery.

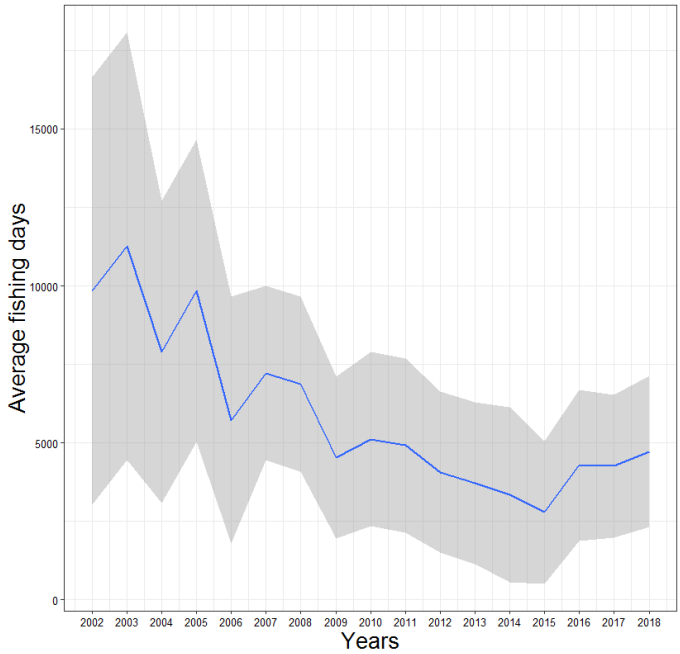



Figure 4: Fishing effort (average number of fishing days in a year) recorded over the years in Italian Clusters.

However, when considering the fishing effort in terms of actual daily fishing hours, a clear reduction can be observed with a daily average daily of less than 2 hours of fishing (Figure 5). This trend indicates a good state of the resource.

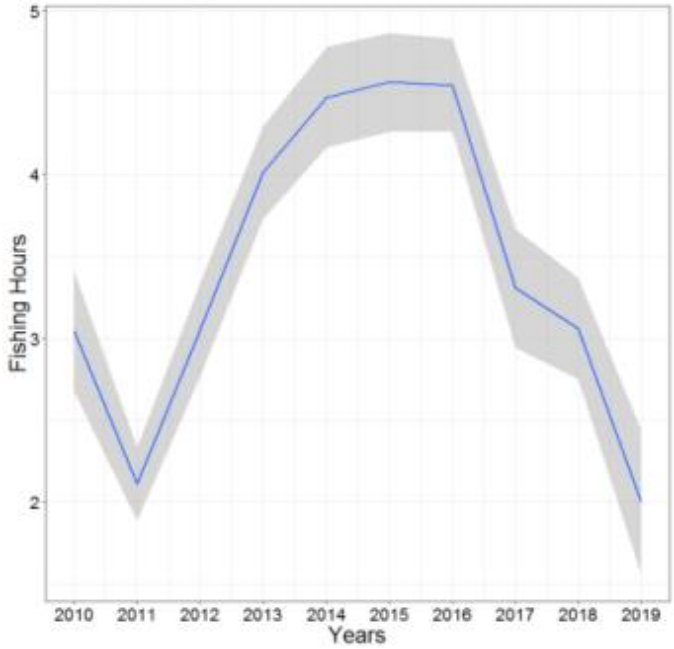



Figure 5: Daily fishing hours and confidence interval in the central Adriatic.

In addition, all vessels authorized to fish for clams with hydraulic dredges are currently equipped with a position monitoring system which verifies the fishing effort from a local point of view; also, it allows the adoption of appropriate management measures based on the degree of exploitation of the areas (e.g. rotation of fishing zones).

In the near future, the use of data from the vessel's position monitoring system will enable to calculate the CPUE using the real fishing effort in terms of actual fishing hours.

# 3. The impact of hydraulic dredges

Hydraulic dredges operate along the seabed and this inevitably causes a physical disturbance to sea bottom communities. In particular, the action of the dredges determines sediment resuspension with an effect on water turbidity. On the one hand this makes the superficial sediments mix favouring oxygenation of the deeper strata and the release of organic matter and nutrients while, on the other, it could produce negative effects such as destabilization and modification of the conditions of the sediment resulting in a reduced complexity of the habitat, with consequences on the benthic communities.

Fishing with hydraulic dredges gradually replaced previous techniques between 1960 and 1975.

The biological communities living in the fishing zones have undergone prolonged selection activities and the composition of the species that are currently present is the result of selective harvesting with dredges.

However, it is important to point out that the communities that live in areas exploited using hydraulic dredges are the ones that are typical of shallow and high energy environments and hence already naturally exposed to continued environmental stress due to exceptional events (unusually large waves, strong currents), and precisely for this reason they recover fairly quickly (resilience) depending also on the duration of the event. Because they adapt to these environmental stresses, these communities appear to be less susceptible to the disturbance caused by fishing that, in a way, might bring the effect of environmental stressors to an extreme. The short-term effects of dredges on the benthic communities in sandy sea beds have been described in a number of studies (e.g., Hall and Harding, 1997; Tuck et al., 2000). Morello et al. (2005) have proved that in the short term the impact appears to be considerable mainly on mollusc and crustacean communities. The environmental impact, studied in the past by the Bari Marine Biology and Fishing Laboratory, has indicated that in sandy sea beds over 90% of the species constituting the communities re-colonised dredged areas in the space of a month. The sea beds on which fishing is practiced are limited to the districts where motorised fishing boats are registered and given that there is a fixed quota of motorised fishing boats per district, it is not possible for fishing with hydraulic dredges to be practiced in new areas. Morello et al. (2006) have instead observed that, in the medium term, communities are able to recuperate, on condition that the fishing effort is reduced over time. In particular, the authors indicate in a threshold period of 6 months the time needed for the communities to recuperate.

The areas where dredges are used for fishing have been, for several years, the subject of studies on the benthic species caught by dredges at the level of macrozoobenthos in clam fishing.

The effects on the marine environment, and in particular the physical impact on the sea bed, are not negligible but available information regarding the accessory species intercepted by dredges make it possible to observe that the more extensively represented groups are molluscs followed by crustaceans and others. Accessory fauna intercepted by dredges is typical of strictly coastal environments. No species with specific emergencies or stock conservation issues have been found. The catching of fish has been so sporadic and limited that the use of dredges does not appear to raise any problems. It is obvious that the consequences on the eco-system of the impact of dredges are not easy to define, nor are there any exhaustive studies in this regard. In any event, trawling speed ensures that vagile species that can swim are easily able to escape capture.

During the standardised surveys to monitor the state of the resource, small mesh bags were installed in the dredges to collect the organisms intercepted by the dredges. For a detailed consultation of the results see Annex VII.

Table 7 shows the taxa present in over 5% of the samples collected using clam dredges, with next to them an indication of whether the species appears to be unaffected by fishing with dredges (N) or is only lightly affected (L) or seriously affected (S). Table 8 instead presents the list of species intercepted by razor shell dredges.

Table 7: List of species caught by clam dredge and indication of impact on species (N. null; L: Light; S: Serious).

| N. | Gruppo | Taxon | n. occorrenze | N | L | S |
|---|---|---|---|---|---|---|
| 1 | Gasteropodi | *Nassarius* spp. | 379 | X | | |
| 2 | Bivalvi | *Chamelea gallina* | 353 | X | | |
| 3 | Crostacei | Diogenidae | 328 | X | | |
| 4 | Crostacei | *Liocarcinus* spp. | 302 | | X | |
| 5 | Bivalvi | *Donax* spp. | 248 | X | | |
| 6 | Bivalvi | *Spisula subtruncata* | 231 | X | | |
| 7 | Bivalvi | *Tellina* spp. | 194 | X | | |
| 8 | Bivalvi | *Mactra* spp. | 170 | | X | |
| 9 | Bivalvi | *Acanthocardia* spp. | 165 | X | | |
| 10 | Bivalvi | *Dosinia lupinus* | 161 | X | | |
| 11 | Bivalvi | *Polititapes aureus* | 153 | X | | |
| 12 | Bivalvi | *Anadara spp.* | 130 | X | | |
| 13 | Gasteropodi | *Cyclope neritea* | 129 | X | | |
| 14 | Policheti | *Owenia fusiformis* | 102 | | X | |
| 15 | Bivalvi | *Corbula gibba* | 102 | X | | |
| 16 | Gasteropodi | *Acteon tornatilis* | 102 | X | | |
| 17 | Gasteropodi | *Bolinus brandaris* | 94 | X | | |
| 18 | Bivalvi | *Astropecten spp.* | 83 | | X | |
| 19 | Gasteropodi | *Neverita josephinia* | 78 | X | | |
| 20 | Bivalvi | *Abra* spp. | 73 | X | | |
| 21 | Echinodermi | *Ova canaliferus* | 63 | | | X |
| 22 | Bivalvi | *Glycymeris* spp. | 49 | X | | |
| 23 | Bivalvi | *Nucula necleus* | 42 | X | | |
| 24 | Echinodermi | *Echinocardium cordatum* | 30 | | | X |
| 25 | Bivalvi | *Pharus legumen* | 29 | X | | |
| 26 | Scafopodi | *Fustiaria ribescens* | 23 | X | | |
| 27 | Policheti | *Eunice aphroditois* | 21 | | | X |
| 28 | Gasteropodi | *Hexaplex trunculus* | 21 | x | | |

Table 8: List of species caught by the razor shell dredge and indication of impact on the species (N. null; L: Light; S: Serious).

| N. | Gruppo | Taxon | n. occorrenze | N | L | S |
|---|---|---|---|---|---|---|
| 1 | Molluschi | *Ensis* spp. | 121 | X | | |
| 2 | Crostacei | *Diogenes pugilator* | 107 | X | | |
| 3 | Policheti | *Sigalion mathildae* | 105 | | | X |
| 4 | Policheti | *Onuphis eremita* | 98 | | | x |
| 5 | Molluschi | *Tellina* spp. | 98 | X | | |
| 6 | Molluschi | *Donax* spp. | 90 | x | | |
| 7 | Molluschi | *Mactra stultorum* | 89 | | X | |
| 8 | Echinodermi | *Amphiura* spp. | 85 | | X | |
| 9 | Molluschi | *Pharus legumen* | 80 | X | | |
| 10 | Molluschi | *Dosinia lupinus* | 79 | X | | |
| 11 | Policheti | *Owenia fusiformis* | 78 | | X | |
| 12 | Policheti | *Glycera* spp. | 77 | | X | |
| 13 | Molluschi | *Chamelea gallina* | 69 | X | | |
| 14 | Policheti | *Nephtys hombergi* | 59 | | X | |
| 15 | Policheti | *Scoletoma impatiens* | 59 | | X | |
| 16 | Sipunculidi | *Sinpunculus nudus* | 53 | X | | |
| 17 | Crostacei | *Liocarcinus* spp. | 51 | X | | |
| 18 | Crostacei | *Platysquilla eusebia* | 49 | X | | |
| 19 | Echinodermi | *Echinocardium cordatum* | 47 | | | X |

An in-depth analysis of the biocenoses that characterise the fishing grounds exploited by dredges has been carried out in the Northern Adriatic Sea (present in percentages of generally above 90% and normally above 80% (Figure 6). Therefore the impact on other non-target species is in actual fact negligible.

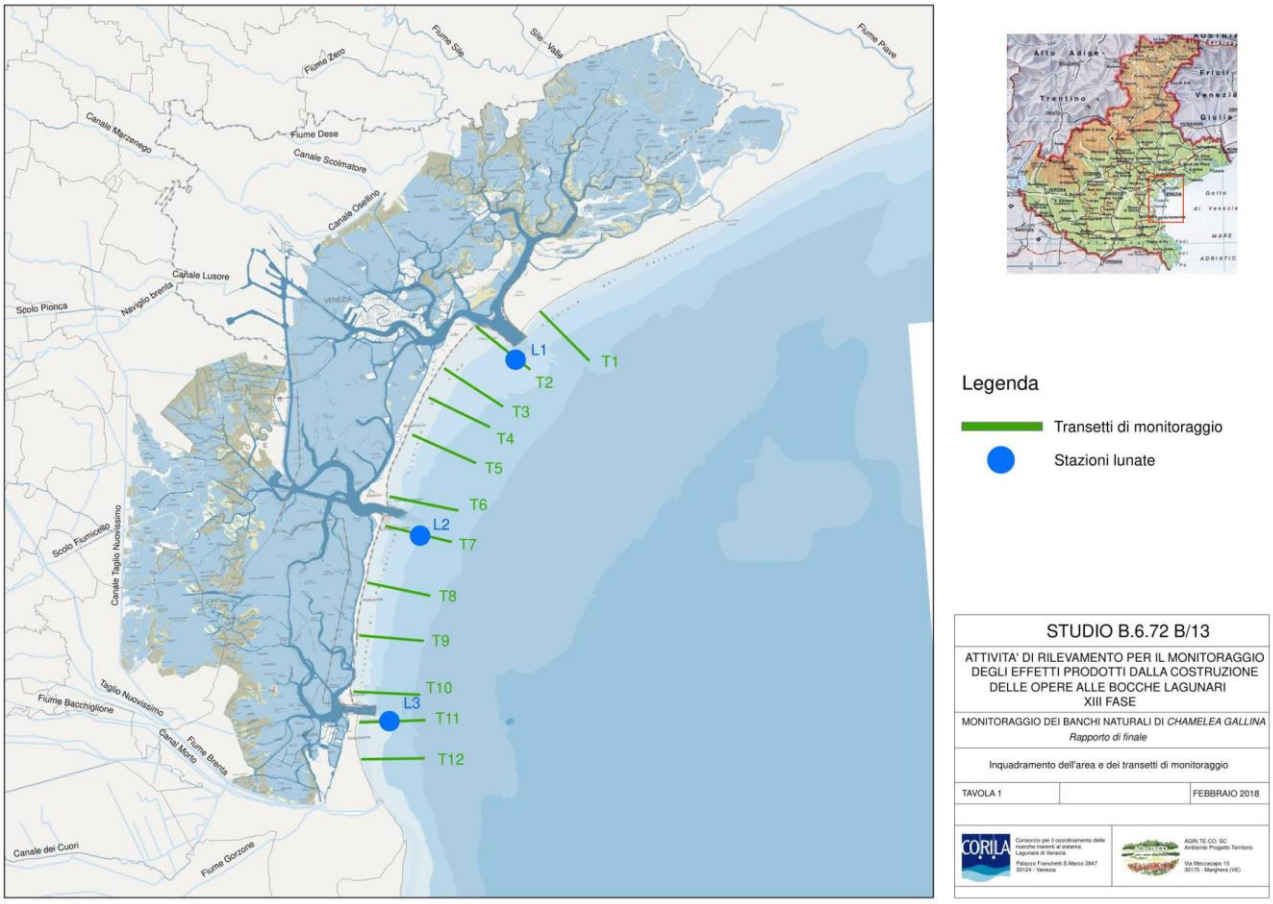



Figure 6: Position of the sampling transepts.

Table 9: List of species associated with the fishing zones found during the north Adriatic Sea survey

| Phylum | Class | Species |
|---|---|---|
| **MOLLUSCA** | Bivalvia | *Abra alba* |
| | | *Acanthocardia tuberculata Chamelea gallina Donax semistriatus* |
| | | *Dosinia lupinus* |
| | | *Glycimeris violacescens* |
| | | *Mactra stultorum* |
| | | *Paphia aurea* |
| | | *Scapharca demiri* |
| | | *Spisula subtruncata* |
| | | *Tellina spp* |
| | Gastropoda | *Acteon tornatilis* |
| | | *Bolinus brandaris Calyptrea chinensis Cyclope neritea Euspira guillemini* |
| | | *Nassarius mutabilis* |
| | | *Nassarius nitidus* |
| | | *Natica aebrea* |
| | | *Natica millepunctata* |
| | | *Phyllonotus trunculus* |
| **ARTHROPODA** | Crustacea | *Carcinus mediterraneus* |
| | | *Corystes cassivelaunus* |
| | | *Ilia nucleus* |
| | | *Maja squinado* |
| | | *Pagurus spp* |
| | | *Parthenope angulifrons* |
| | | *Portunus depurator* |
| **ECHINODERMATA** | Astroidea | *Astropecten aranciacus* |
| | Ophiuridea | *Ophioderma longicaudum* |
| | | *Ophiomyxa pentagona* |
| | Echinoidea | *Schizaster canaliferus* |
| **ANELLIDA** | Polichaeta | *Owenia fusiformis* |
| | | Policheti erranti |

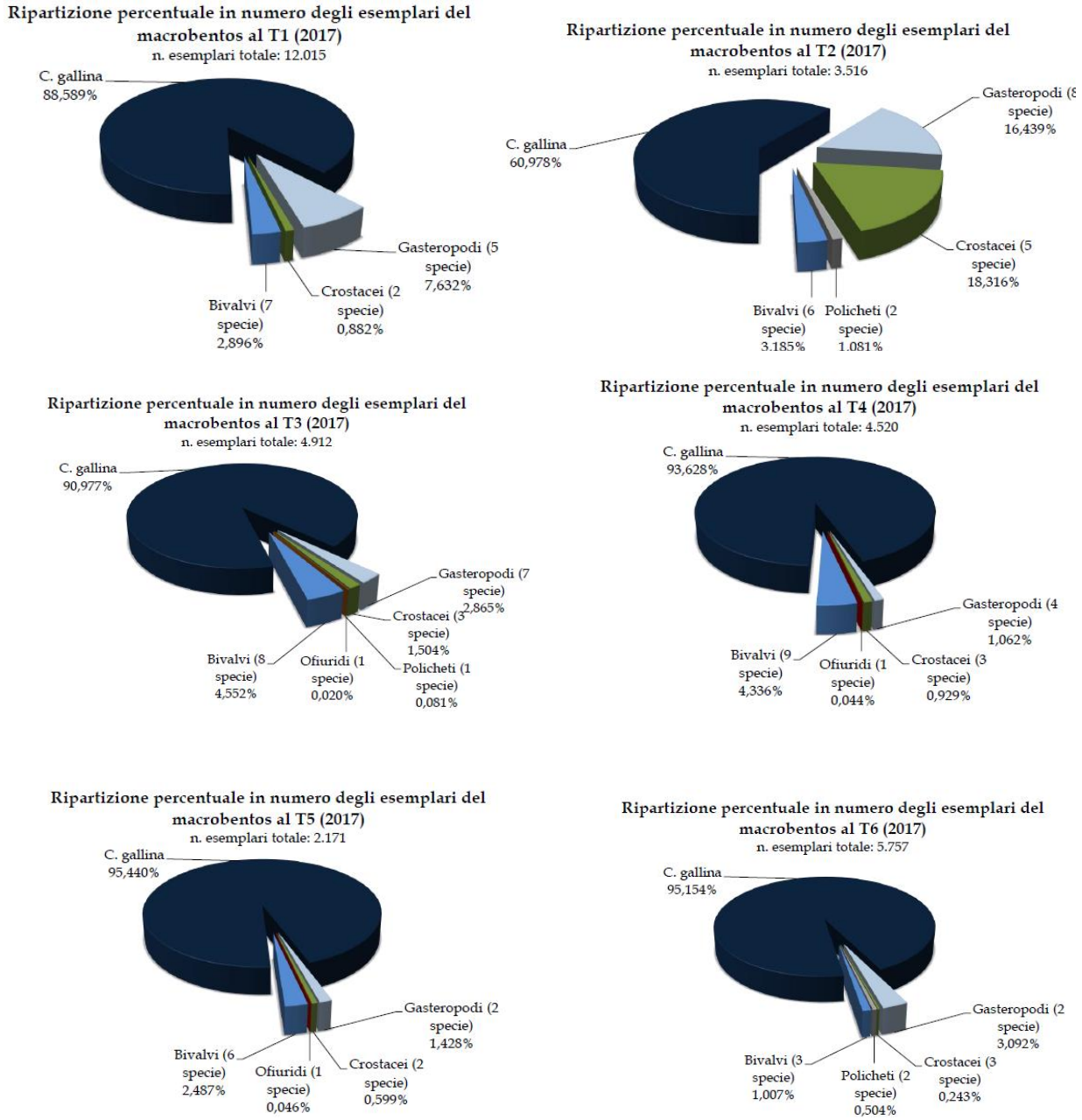



Figure 7: Breakdown of the species present in some transepts.

# 4. Selectivity of hydraulic dredges

## 4.1. General characteristics

Knowledge of the selective capabilities of fishing equipment, of the different species and different sizes is crucial in guaranteeing the rational management of marine resources. For the past five decades, the selectivity of equipment has been one of the fundamental technological aspects considered as essential, by modern population dynamics, for achieving a correct exploitation of marine resources (Sala, 2011).

Controlling and improving selectivity, in synergy with responsible management of fishing policies, are the necessary albeit not sufficient condition for achieving the objective of correct resource management.

The main objective of technical measures for the preservation of fish stocks is that of increasing the selectivity of fishing equipment and reducing catches of clams that are very young and at other stages of development (Sala, 2011; Sala and Lucchetti, 2010; 2011). The word **selectivity** defines the measurement of fishing equipment's selection process, hence the process that results in a catch the composition of which differs from that ensemble of organisms actually present in the area in which fishing takes place (Sala, 2011; Sala et al., 2006; 2007; 2008). In other words, selectivity represents the probability that different sizes and species of fish have of being caught by the fishing equipment.

In practice, this word can be used to depict both the equipment's ability to mainly catch only certain sizes of a given species and the selection of the diverse species present in the sea. In the first case, in order to try and obtain equipment that allows the juvenile specimens of a given species to escape, one generally uses nets that have a suitable shape and with the correct size of openings. In the second case, instead, equipment's selectivity cannot only be improved by the use of suitable nets, since it depends mainly on the equipment and possible devices placed on it that modify its behaviour (Sala et al., 2007; 2011).

Selectivity is therefore a function of both the technical features of a given fishing device and the ethological properties of the species to be caught. Since they are bivalve, clams do not have the means to escape and cannot actively avoid being caught by the dredge, so the selection process can take place either on the bottom of the sea by the dredge itself or on board using the sieves that separate the catch. As happens when trawling, where the selection process is the main function of the size of the nets, in the case of a selective dredge, selectivity will depend on the distance between the rods (Figure 8) or the diameter of the holes in the case of the perforated sheet of the sieve (**Errore. L'origine riferimento non è stata trovata.**). **Since the material collected by the dredge then undergoes selection using sieves, that latter may be considered as the main process in the selection of clams**.

Figure 8: There are national regulations that define some aspects of equipment's capability to select the size of the clams that are caught. The Ministerial Decree dated 22/12/2000 establishes that the distance between the metal rods on the lower part of the dredge cannot be smaller than 12 mm.

Some studies have emphasised that even tiny variations in the diameter of holes in the sieves result in significant changes as far as selectivity is concerned (Froglia and Gramitto, 1981). According to the Ministerial Decree dated 22/12/2000, they must comply with certain characteristics so as to allow the escape of clams smaller than the minimum size for a first catch and commercialisation, which for clams (*C. gallina*) is 22 mm.

According to regulations, the sieves can consist of metal rods with characteristics similar to those of the cages, or made of a perforated sheet (Figure *9*). It should be noted that in the case of rods in the dredge or the sieves, selection is carried out on the basis of the width of the clams, while the perforated sheet the selection is performed mainly on the basis of a smaller diameter. It is for this reason that the rods and holes are regulated by different rules: a minimum distance of 12 mm between the rods and a minimum diameter of 21 mm for the holes (Ministerial Decree dated 22/12/2000). This last solution (perforated sheet with holes having a minimum diameter of 21 mm) is the solution adopted almost everywhere.

The material collected by the dredge is brought on board and emptied into a steel tank on the bow (Figure 10), and then using a conveyer belt lowered onto slightly tilted vibrating sifter. The vibrations cause the clams to slowly fall from one sieve to another (Figure 11). These selections may differ between individual fishing vessels since they sometimes built by local craftsmen. Generally speaking, however, all vibrating sifters screeners have a series of sieves, the holes of which decrease in size (Figure 11). The top filter on which water is sprayed receives all the material and has large holes, usually larger than 32 mm, allowing all clams and organisms of this size to fall through (Figure 12). From the second sieve downwards the fisherman can freely use sieves with different sized holes. However, according to the Ministerial Decree dated 22/12/2000 their diameter most not be less than 21 mm. In order to guarantee uniformity between the catch from various vessels in the same district, Management Consortia establish the size of the minimum diameter of the holes used and at times seal the sifters so that the sieves cannot be replaced.

Figure 9: Details of vibrating sifters with perforated sheet, holes must not be smaller than 21 mm.

Figure 10: Detail of a dredge consisting of an entirely metal cage (left). All clam fishing vessels have a dredge placed on the bows; when trawling is completed the dredge is lifted on board using a rope and the entire catch directed into a large tank (right) and then into the sifter for the selection of commercial sizes.

Figure 11: Details of a vibrating sifter used to select commercial sized clams (≥22 mm).

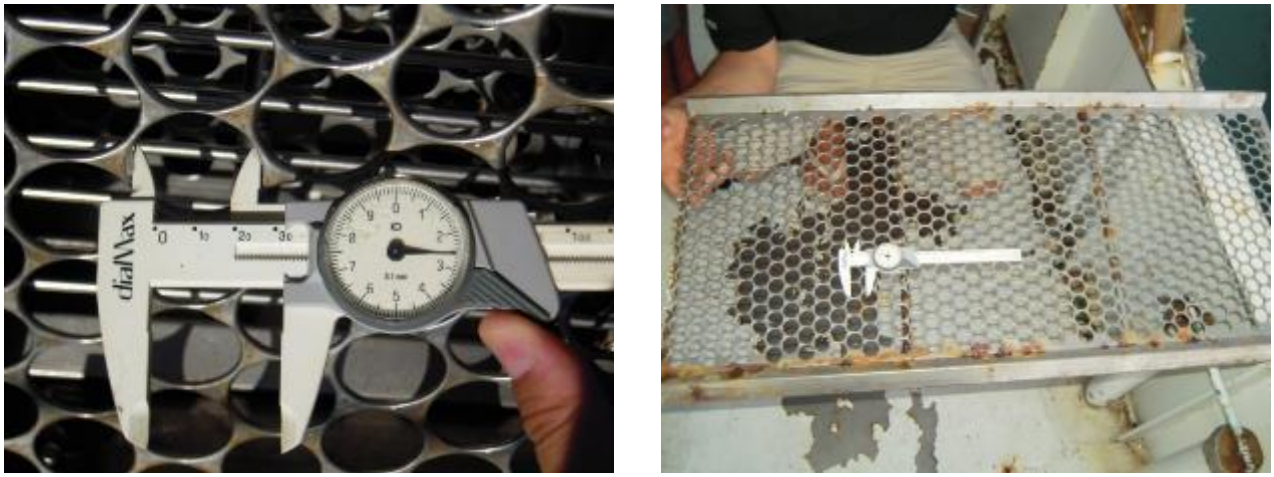



Figure 12: Measuring selection filters and sieves on the vibrating sifter used for sampling.

It should be noted that when the Discard Plan came into force the characteristics of vibrating sifters were not changed.

## 4.2. Study on the selectivity of vibrating sifters

A recent study carried out in the Adriatic (Sala et al., 2017) has made it possible to verify the selectivity of the vibrating sifters currently used.

The sifting process was carried out on a stationary vessel and the catch contained in each basket was sifted using all the sieves that were part of the vibrating sifters on board. As illustrated in Figure 13, after the sifting process the contents of a single basket (*P0*) were divided into 6 portions (*debris, r1-r5* and *P5*), which were then weighed and, in the event of large quantities as usually occurred for the *P5* portion, a sub-sample was taken (about 3 kg) for the next analysis of size distribution: 1) *debris*: portion retained by the initial filter (32.5 mm holes) containing coarse material and a few large clams; 2) *r1*: portion retained by the 1st sieve (21.5 mm holes) containing commercial sized clams; 3) *r2*: portion retained by the 2nd sieve (21.1 mm holes) containing sub-commercial sized clams; 4) *r3*: portion retained by 3rd sieve (20.3 mm holes, not used in the commercial phase but useful for research); 5) *r4*: portion retained by the final filter with metal rods set 10.5 mm apart; 6) *P5*: portion not retained by any sieve.

All the 54 sifting processes analysed (*e.g.* 3 hauls x 2 baskets x 3 speeds x 3 sieves, see Table 10) were valid and used in estimating the average selectivity of each sieve. **Errore. L'origine riferimento non è stata trovata.** to 4 indicate the selectivity parameters of each sifting process repeated for each of the three sieves obtained using the *Covered Codend* method. A careful analysis of the validity of each individual logistic model (*p*-value and deviance vs. DOF) indicates that there were no problems in the adoption of logistic curves to describe the retaining data for each individual sifting process following the adoption of procedures dictated by the Covered Codend method.

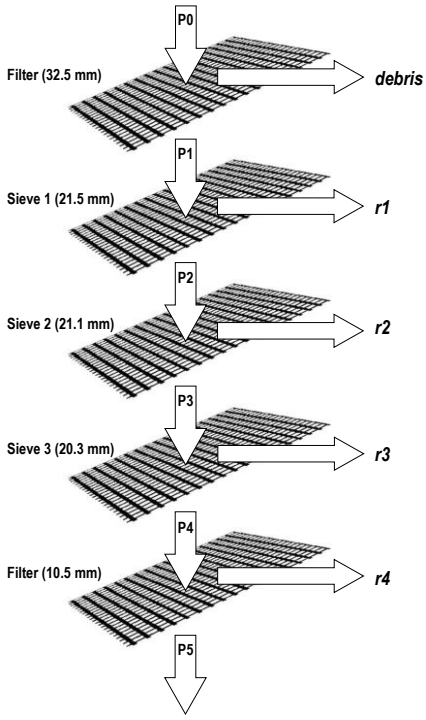



Figure 13: Clam sifting process using 3 sieves and filters that constitute the on board vibrating sifters. Samples obtained following the screening process of a single basket were: portion retained by initial filter (32.5 mm holes) containing coarse material and a few large clams; r1: portion retained by the 1st sieve (21.5 mm holes) containing commercial sized clams; r2: portion retained by the 2nd sieve (21.1 mm holes) containing sub-commercial sized clams; r3: portion retained by 3rd sieve (20.3 mm holes, not used in the commercial phase but useful for research); r4: portion retained by the final filter with metallic rods set 10.5 mm apart; P5: portion not retained by any sieve.

The study also included the spiral's rotation speed, a parameter that could affect selective properties. Estimated selectivity parameters were significant for all sifting processes carried out at the three speeds of 1180, 1210 and 1230 RPM.

For a description of the statistical methodology applied in this selectivity study see Sala et al. (2017).

Table 10: Number of repetitions obtained for each sieve analysed (e.g. hauls x 2 baskets) at the three different sifting speeds of 1180, 1210 and 1230 RPM.

| No. sieve *(diameter of holes)* | Speed (RPM) | | | Total and siftings |
|---|---|---|---|---|
| | **1180** | **1210** | **1230** | |
| ***Sieve* 1 (21.5 mm)** | 3 x 2 | 3 x 2 | 3 x 2 | **18** |
| ***Sieve* 2 (21.1 mm)** | 3 x 2 | 3 x 2 | 3 x 2 | **18** |
| ***Sieve* 3 (20.3 mm)** | 3 x 2 | 3 x 2 | 3 x 2 | **18** |
| Total siftings | **18** | **18** | **18** | **54** |

Average selectivity parameters, calculated for each sieve according to the methodology proposed by Fryer (1991), which in our case takes into account between-haul variation, are reported in Table 11 and Figure 31. In this case, average values for each sieve have been calculated both on average at every speed of the screening process as well as with all aggregated screenings without taking into account the speed parameter. The highest average figure of the *L50* was the one for the 2nd sieve (*L50*=25.30 mm), which did not, however, differ significantly from that of the 1st sieve (24.91 mm). On the contrary, the best *SR* (lowest figure) was that of the 1st sieve with 1.12 mm compared to the 1.76 mm of the 2nd sieve. The average figure of *L50* for the 3rd sieve (*L50*=22.87 mm) was instead significantly inferior to the other two ($p<0.001$; Table 12).

A comparative analysis of selectivity parameters between the three sieves, illustrated in the chart *L50*-versus-*SR* of Figure 31**,** allows for a better appreciation of the fact that although there was a rise in the length of the *L50,* that the selection rate moving from the first to the second sieve, these increases are not significant since the projections of the two ellipses depicting confidence intervals of *L50* and *SR*, overlap in both *x* and *y*. Observing the ellipsis concerning the third sieve, one observes on the contrary that there is a significant fall in the length of retained clams which falls to 22.87 mm from the 24.91 and 25.30 mm of the first and second sieves (Table 13)

The results of this study, and in particular average selectivity curves, indicate that when using a regulatory sieve (Grid 2 in this study) retaining of specimens smaller than 22 mm is irrelevant (Figure 14).

Table 11: Estimated selectivity parameters for the 1st sieve, D1(215), holes with a diameter of 21.5 mm. Individual values were calculated at the three speeds used for the screening process (Speed), 1180, 1210 and 1230 RPM. Data was analysed according to the methodology proposed by Fryer (1991). Retention length at 50%, 25% and 75% (L50, L25 and L75), selection rate (SR), Akaike's Information Criterion (AIC) verification test, degrees of freedom (DOF), p-value, confidence limit of L50 and SR (±DelL50, ±DelSR), deviation standard of L50 and SR (SdL50, SdSR), between-haul variation {D}, minimum and maximum lengths retained (MinL, MaxL), total number of clams screened, retained and released (Nr Tot, Nr Tes, Nr Cov).

| **Code** | **Speed** | **Diam** | **L50** | **SR** | **L25** | **L75** | **AIC** | ***p-value*** | **Deviance** | **DOF** | **R2** | **DelL50** | **SdL50** | **DelSR** | **SdSR** | **D11** | **D12** | **D13** | **MinL** | **MaxL** | **NrTot** | **NrTes** | **NrCov** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Sieve-Spe-Haul* | [RPM] | [mm] | [mm] | [mm] | [mm] | [mm] | | | | | | [mm] | [mm] | [mm] | [mm] | | | | [mm] | [mm] | | | |
| D1(215)-1230-1 | 1230 | 21.5 | 25.05 | 0.94 | 24.58 | 25.51 | 1139.83 | 0.969 | 11.40 | 22 | 0.999 | 0.07 | 0.03 | 0.09 | 0.04 | 0.0010 | 0.0001 | 0.0020 | 20.5 | 32.0 | 1886 | 909 | 977 |
| D1(215)-1230-1 | 1230 | 21.5 | 25.25 | 1.07 | 24.72 | 25.78 | 1654.04 | 0.191 | 26.42 | 21 | 0.997 | 0.07 | 0.03 | 0.09 | 0.05 | 0.0010 | 0.0004 | 0.0020 | 20.5 | 32.0 | 2412 | 885 | 1527 |
| D1(215)-1210-1 | 1210 | 21.5 | 24.95 | 1.01 | 24.45 | 25.46 | 991.26 | 1.000 | 3.22 | 19 | 1.000 | 0.08 | 0.04 | 0.11 | 0.05 | 0.0014 | 0.0002 | 0.0030 | 21.0 | 31.0 | 1424 | 694 | 730 |
| D1(215)-1210-1 | 1210 | 21.5 | 24.92 | 1.12 | 24.36 | 25.48 | 1366.53 | 0.972 | 9.75 | 20 | 0.999 | 0.07 | 0.03 | 0.11 | 0.05 | 0.0012 | 0.0001 | 0.0028 | 21.0 | 33.0 | 1834 | 927 | 907 |
| D1(215)-1180-1 | 1180 | 21.5 | 24.96 | 1.24 | 24.34 | 25.58 | 1590.92 | 0.880 | 13.75 | 21 | 0.998 | 0.07 | 0.04 | 0.12 | 0.06 | 0.0012 | 0.0002 | 0.0035 | 20.5 | 32.5 | 1878 | 904 | 974 |
| D1(215)-1180-1 | 1180 | 21.5 | 25.05 | 1.03 | 24.53 | 25.56 | 1267.46 | 0.993 | 8.51 | 21 | 1.000 | 0.07 | 0.03 | 0.11 | 0.05 | 0.0011 | 0.0002 | 0.0026 | 20.5 | 31.5 | 1715 | 843 | 872 |
| D1(215)-1230-2 | 1230 | 21.5 | 25.01 | 1.11 | 24.45 | 25.56 | 975.57 | 0.965 | 8.76 | 18 | 0.998 | 0.09 | 0.04 | 0.13 | 0.06 | 0.0017 | 0.0006 | 0.0040 | 20.5 | 30.0 | 1288 | 515 | 773 |
| D1(215)-1230-2 | 1230 | 21.5 | 24.88 | 1.10 | 24.33 | 25.43 | 667.38 | 0.077 | 28.34 | 19 | 0.936 | 0.10 | 0.05 | 0.16 | 0.07 | 0.0023 | 0.0001 | 0.0055 | 20.5 | 31.0 | 914 | 454 | 460 |
| D1(215)-1210-2 | 1210 | 21.5 | 24.93 | 1.27 | 24.30 | 25.56 | 1291.63 | 0.317 | 20.29 | 18 | 0.998 | 0.09 | 0.04 | 0.14 | 0.07 | 0.0016 | 0.0005 | 0.0043 | 20.5 | 30.0 | 1582 | 677 | 905 |
| D1(215)-1210-2 | 1210 | 21.5 | 24.78 | 1.39 | 24.09 | 25.48 | 1085.38 | 0.213 | 23.58 | 19 | 0.964 | 0.10 | 0.05 | 0.17 | 0.08 | 0.0023 | 0.0005 | 0.0065 | 20.5 | 31.0 | 1243 | 581 | 662 |
| D1(215)-1180-2 | 1180 | 21.5 | 24.80 | 1.12 | 24.24 | 25.36 | 1026.51 | 0.985 | 7.48 | 18 | 0.999 | 0.09 | 0.04 | 0.13 | 0.06 | 0.0016 | 0.0005 | 0.0038 | 20.5 | 30.0 | 1372 | 566 | 806 |
| D1(215)-1180-2 | 1180 | 21.5 | 24.78 | 1.70 | 23.93 | 25.63 | 1100.20 | 0.395 | 18.95 | 18 | 0.991 | 0.12 | 0.06 | 0.24 | 0.11 | 0.0034 | 0.0013 | 0.0130 | 21.0 | 31.5 | 1089 | 485 | 604 |
| D1(215)-1230-3 | 1230 | 21.5 | 24.75 | 1.03 | 24.24 | 25.27 | 1230.51 | 0.981 | 9.83 | 21 | 0.999 | 0.07 | 0.03 | 0.10 | 0.05 | 0.0011 | 0.0001 | 0.0024 | 20.5 | 32.0 | 1770 | 869 | 901 |
| D1(215)-1230-3 | 1230 | 21.5 | 24.70 | 1.13 | 24.14 | 25.27 | 1777.07 | 0.572 | 18.24 | 20 | 0.997 | 0.06 | 0.03 | 0.10 | 0.05 | 0.0009 | 0.0001 | 0.0022 | 20.5 | 31.0 | 2327 | 1175 | 1152 |
| D1(215)-1210-3 | 1210 | 21.5 | 24.88 | 1.14 | 24.31 | 25.45 | 1612.63 | 0.759 | 15.31 | 20 | 0.999 | 0.07 | 0.03 | 0.11 | 0.05 | 0.0011 | 0.0002 | 0.0026 | 20.5 | 31.0 | 2033 | 963 | 1070 |
| D1(215)-1210-3 | 1210 | 21.5 | 24.90 | 0.83 | 24.48 | 25.31 | 1041.28 | 0.142 | 26.77 | 20 | 0.999 | 0.06 | 0.03 | 0.09 | 0.04 | 0.0009 | 0.0001 | 0.0017 | 20.5 | 33.0 | 1722 | 857 | 865 |
| D1(215)-1180-3 | 1180 | 21.5 | 24.81 | 0.97 | 24.32 | 25.29 | 1150.92 | 0.867 | 13.23 | 20 | 0.999 | 0.07 | 0.03 | 0.10 | 0.05 | 0.0011 | 0.0002 | 0.0022 | 20.5 | 32.0 | 1788 | 828 | 960 |
| D1(215)-1180-3 | 1180 | 21.5 | 24.96 | 1.18 | 24.37 | 25.55 | 1470.60 | 0.165 | 24.86 | 19 | 0.997 | 0.07 | 0.04 | 0.12 | 0.06 | 0.0013 | 0.0003 | 0.0031 | 20.5 | 30.5 | 1851 | 807 | 1044 |

Table 12: Estimated selectivity parameters for the 2nd sieve, D2(211), holes with a diameter of 21.1 mm.

| Code | Speed | Diam | L50 | SR | L25 | L75 | AIC | *p-value* | Deviance | DOF | R2 | DelL50 | SdL50 | DelSR | SdSR | D11 | D12 | D13 | MinL | MaxL | NrTot | NrTes | NrCov |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Sieve-Spe-Haul* | [RPM] | [mm] | [mm] | [mm] | [mm] | [mm] | | | | | | [mm] | [mm] | [mm] | [mm] | | | | [mm] | [mm] | | | |
| D2(211)-1230-1 | 1230 | 21.1 | 25.78 | 2.72 | 24.43 | 27.14 | 928.66 | 0.373 | 10.81 | 10 | 0.951 | 0.47 | 0.21 | 0.76 | 0.34 | 0.0445 | 0.0629 | 0.1158 | 20.5 | 26.0 | 975 | 204 | 771 |
| D2(211)-1230-1 | 1230 | 21.1 | 25.79 | 1.55 | 25.02 | 26.57 | 949.83 | 0.334 | 11.31 | 10 | 0.984 | 0.25 | 0.11 | 0.30 | 0.13 | 0.0126 | 0.0127 | 0.0177 | 20.5 | 26.0 | 1518 | 186 | 1332 |
| D2(211)-1210-1 | 1210 | 21.1 | 25.26 | 1.43 | 24.54 | 25.98 | 573.76 | 0.973 | 2.75 | 9 | 0.998 | 0.23 | 0.10 | 0.34 | 0.15 | 0.0107 | 0.0115 | 0.0225 | 21.0 | 26.0 | 727 | 136 | 591 |
| D2(211)-1210-1 | 1210 | 21.1 | 25.13 | 1.24 | 24.52 | 25.75 | 688.22 | 0.352 | 9.98 | 9 | 0.988 | 0.16 | 0.07 | 0.24 | 0.11 | 0.0052 | 0.0050 | 0.0111 | 21.0 | 26.0 | 903 | 179 | 724 |
| D2(211)-1180-1 | 1180 | 21.1 | 25.46 | 1.58 | 24.67 | 26.25 | 781.74 | 0.921 | 4.52 | 10 | 0.995 | 0.23 | 0.10 | 0.34 | 0.15 | 0.0109 | 0.0126 | 0.0236 | 20.5 | 26.0 | 967 | 179 | 788 |
| D2(211)-1180-1 | 1180 | 21.1 | 25.43 | 1.37 | 24.74 | 26.11 | 666.37 | 0.369 | 10.85 | 10 | 0.978 | 0.21 | 0.09 | 0.30 | 0.13 | 0.0089 | 0.0095 | 0.0176 | 20.5 | 26.0 | 869 | 155 | 714 |
| D2(211)-1230-2 | 1230 | 21.1 | 25.13 | 1.77 | 24.25 | 26.01 | 715.70 | 0.273 | 12.19 | 10 | 0.973 | 0.24 | 0.11 | 0.41 | 0.19 | 0.0119 | 0.0148 | 0.0343 | 20.5 | 26.0 | 771 | 180 | 591 |
| D2(211)-1230-2 | 1230 | 21.1 | 24.80 | 2.18 | 23.72 | 25.89 | 496.14 | 0.862 | 5.41 | 10 | 0.868 | 0.30 | 0.14 | 0.64 | 0.29 | 0.0183 | 0.0232 | 0.0829 | 20.5 | 26.0 | 459 | 144 | 315 |
| D2(211)-1210-2 | 1210 | 21.1 | 25.55 | 2.28 | 24.41 | 26.69 | 814.56 | 0.742 | 6.83 | 10 | 0.910 | 0.37 | 0.16 | 0.57 | 0.26 | 0.0269 | 0.0350 | 0.0658 | 20.5 | 26.0 | 904 | 183 | 721 |
| D2(211)-1210-2 | 1210 | 21.1 | 24.93 | 1.27 | 24.30 | 25.57 | 522.82 | 0.109 | 15.70 | 10 | 0.953 | 0.18 | 0.08 | 0.27 | 0.12 | 0.0064 | 0.0058 | 0.0144 | 20.5 | 26.0 | 661 | 146 | 515 |
| D2(211)-1180-2 | 1180 | 21.1 | 24.99 | 1.29 | 24.35 | 25.63 | 569.71 | 0.892 | 4.98 | 10 | 0.995 | 0.19 | 0.09 | 0.27 | 0.12 | 0.0073 | 0.0070 | 0.0142 | 20.5 | 26.0 | 803 | 143 | 660 |
| D2(211)-1180-2 | 1180 | 21.1 | 25.24 | 1.73 | 24.38 | 26.10 | 522.89 | 0.064 | 16.12 | 9 | 0.932 | 0.29 | 0.13 | 0.46 | 0.20 | 0.0167 | 0.0195 | 0.0409 | 21.0 | 26.0 | 602 | 127 | 475 |
| D2(211)-1230-3 | 1230 | 21.1 | 25.28 | 2.39 | 24.09 | 26.48 | 880.38 | 0.149 | 14.56 | 10 | 0.631 | 0.35 | 0.16 | 0.60 | 0.27 | 0.0253 | 0.0353 | 0.0734 | 20.5 | 26.0 | 900 | 207 | 693 |
| D2(211)-1230-3 | 1230 | 21.1 | 25.09 | 1.75 | 24.21 | 25.96 | 1026.55 | 0.088 | 16.44 | 10 | 0.952 | 0.21 | 0.09 | 0.33 | 0.15 | 0.0089 | 0.0106 | 0.0223 | 20.5 | 26.0 | 1150 | 250 | 900 |
| D2(211)-1210-3 | 1210 | 21.1 | 25.33 | 2.09 | 24.28 | 26.37 | 1030.50 | 0.820 | 5.95 | 10 | 0.985 | 0.27 | 0.12 | 0.46 | 0.21 | 0.0147 | 0.0199 | 0.0428 | 20.5 | 26.0 | 1068 | 247 | 821 |
| D2(211)-1210-3 | 1210 | 21.1 | 26.05 | 1.87 | 25.12 | 26.99 | 522.26 | 0.778 | 6.43 | 10 | 0.935 | 0.54 | 0.24 | 0.59 | 0.26 | 0.0586 | 0.0582 | 0.0693 | 20.5 | 26.0 | 865 | 91 | 774 |
| D2(211)-1180-3 | 1180 | 21.1 | 25.27 | 2.00 | 24.27 | 26.27 | 835.62 | 0.638 | 7.91 | 10 | 0.932 | 0.30 | 0.14 | 0.46 | 0.21 | 0.0184 | 0.0227 | 0.0423 | 20.5 | 26.0 | 960 | 189 | 771 |
| D2(211)-1180-3 | 1180 | 21.1 | 25.86 | 2.82 | 24.45 | 27.27 | 985.65 | 0.070 | 17.23 | 10 | 0.513 | 0.49 | 0.22 | 0.79 | 0.35 | 0.0490 | 0.0694 | 0.1250 | 20.5 | 26.0 | 1040 | 214 | 826 |

Table 13: Estimated selectivity parameters for 3rd sieve, D3(203), diameter of holes 20.3 mm

| Code | Speed | Diam | L50 | SR | L25 | L75 | AIC | *p-value* | Deviance | DOF | R2 | DelL50 | SdL50 | DelSR | SdSR | D11 | D12 | D13 | MinL | MaxL | NrTot | NrTes | NrCov |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Sieve-Spe-Haul* | [RPM] | [mm] | [mm] | [mm] | [mm] | [mm] | | | | | | [mm] | [mm] | [mm] | [mm] | | | | [mm] | [mm] | | | |
| D3(203)-1230-1 | 1230 | 20.3 | 22.79 | 2.52 | 21.53 | 24.05 | 864.32 | 0.275 | 13.28 | 11 | 0.790 | 0.29 | 0.13 | 0.61 | 0.28 | 0.0174 | -0.0254 | 0.0776 | 20.5 | 26.5 | 773 | 532 | 241 |
| D3(203)-1230-1 | 1230 | 20.3 | 22.29 | 2.45 | 21.06 | 23.51 | 1247.98 | 0.057 | 20.57 | 12 | 0.719 | 0.31 | 0.14 | 0.48 | 0.22 | 0.0197 | -0.0254 | 0.0479 | 20.5 | 27.0 | 1335 | 1048 | 287 |
| D3(203)-1210-1 | 1210 | 20.3 | 22.92 | 3.44 | 21.20 | 24.64 | 743.62 | 0.144 | 14.68 | 10 | 0.679 | 0.43 | 0.19 | 1.27 | 0.57 | 0.0369 | -0.0764 | 0.3275 | 21.0 | 26.5 | 592 | 374 | 218 |
| D3(203)-1210-1 | 1210 | 20.3 | 22.57 | 4.51 | 20.32 | 24.83 | 921.41 | 0.055 | 16.63 | 9 | 0.726 | 0.61 | 0.27 | 1.93 | 0.86 | 0.0730 | -0.1849 | 0.7313 | 21.0 | 26.0 | 724 | 463 | 261 |
| D3(203)-1180-1 | 1180 | 20.3 | 22.78 | 2.99 | 21.29 | 24.28 | 916.66 | 0.001 | 33.79 | 13 | 0.434 | 0.57 | 0.27 | 1.30 | 0.60 | 0.0704 | -0.1191 | 0.3615 | 20.5 | 27.5 | 791 | 541 | 250 |
| D3(203)-1180-1 | 1180 | 20.3 | 22.75 | 4.13 | 20.69 | 24.81 | 893.66 | 0.002 | 30.15 | 11 | 0.575 | 0.94 | 0.43 | 2.71 | 1.23 | 0.1831 | -0.4274 | 1.5157 | 20.5 | 26.5 | 716 | 469 | 247 |
| D3(203)-1230-2 | 1230 | 20.3 | 22.97 | 2.40 | 21.78 | 24.17 | 683.95 | 0.050 | 18.29 | 10 | 0.944 | 0.28 | 0.12 | 0.63 | 0.28 | 0.0155 | -0.0206 | 0.0809 | 20.5 | 26.0 | 591 | 381 | 210 |
| D3(203)-1230-2 | 1230 | 20.3 | 24.00 | 2.81 | 22.60 | 25.40 | 389.97 | 0.141 | 16.01 | 11 | 0.671 | 0.36 | 0.16 | 1.05 | 0.48 | 0.0269 | 0.0241 | 0.2263 | 20.5 | 30.0 | 316 | 135 | 181 |
| D3(203)-1210-2 | 1210 | 20.3 | 23.25 | 1.96 | 22.27 | 24.23 | 810.81 | 0.473 | 9.63 | 10 | 0.979 | 0.18 | 0.08 | 0.40 | 0.18 | 0.0069 | -0.0058 | 0.0329 | 20.5 | 26.0 | 721 | 437 | 284 |
| D3(203)-1210-2 | 1210 | 20.3 | 20.11 | 4.84 | 17.69 | 22.53 | 472.13 | 0.007 | 25.88 | 11 | 0.199 | 3.26 | 1.48 | 4.63 | 2.10 | 2.1966 | -3.0050 | 4.4253 | 20.5 | 26.5 | 516 | 425 | 91 |
| D3(203)-1180-2 | 1180 | 20.3 | 22.54 | 3.22 | 20.93 | 24.15 | 804.15 | 0.221 | 13.04 | 10 | 0.922 | 0.37 | 0.16 | 0.97 | 0.43 | 0.0270 | -0.0464 | 0.1881 | 20.5 | 26.0 | 660 | 422 | 238 |
| D3(203)-1180-2 | 1180 | 20.3 | 23.58 | 3.70 | 21.73 | 25.43 | 628.27 | 0.520 | 9.13 | 10 | 0.894 | 0.36 | 0.16 | 1.46 | 0.65 | 0.0263 | -0.0164 | 0.4277 | 21.0 | 26.5 | 477 | 248 | 229 |
| D3(203)-1230-3 | 1230 | 20.3 | 22.79 | 3.21 | 21.18 | 24.39 | 862.67 | 0.219 | 14.25 | 11 | 0.893 | 0.35 | 0.16 | 1.00 | 0.45 | 0.0247 | -0.0462 | 0.2053 | 20.5 | 26.5 | 694 | 436 | 258 |
| D3(203)-1230-3 | 1230 | 20.3 | 21.72 | 6.03 | 18.70 | 24.73 | 1133.71 | 0.099 | 17.31 | 11 | 0.130 | 1.02 | 0.46 | 3.04 | 1.38 | 0.2157 | -0.5808 | 1.9020 | 20.5 | 26.5 | 901 | 599 | 302 |
| D3(203)-1210-3 | 1210 | 20.3 | 22.63 | 3.60 | 20.84 | 24.43 | 1001.22 | 0.055 | 17.97 | 10 | 0.448 | 0.44 | 0.20 | 1.15 | 0.52 | 0.0386 | -0.0785 | 0.2684 | 20.5 | 26.0 | 821 | 544 | 277 |
| D3(203)-1210-3 | 1210 | 20.3 | 22.57 | 3.19 | 20.98 | 24.17 | 898.84 | 0.077 | 16.89 | 10 | 0.862 | 0.42 | 0.19 | 0.94 | 0.42 | 0.0350 | -0.0614 | 0.1783 | 20.5 | 26.0 | 774 | 534 | 240 |
| D3(203)-1180-3 | 1180 | 20.3 | 22.71 | 2.88 | 21.26 | 24.15 | 929.37 | 0.157 | 14.37 | 10 | 0.910 | 0.30 | 0.14 | 0.78 | 0.35 | 0.0187 | -0.0313 | 0.1241 | 20.5 | 26.0 | 771 | 497 | 274 |
| D3(203)-1180-3 | 1180 | 20.3 | 22.74 | 2.58 | 21.45 | 24.03 | 920.44 | 0.150 | 15.76 | 11 | 0.925 | 0.29 | 0.13 | 0.61 | 0.28 | 0.0176 | -0.0255 | 0.0756 | 20.5 | 26.5 | 830 | 574 | 256 |

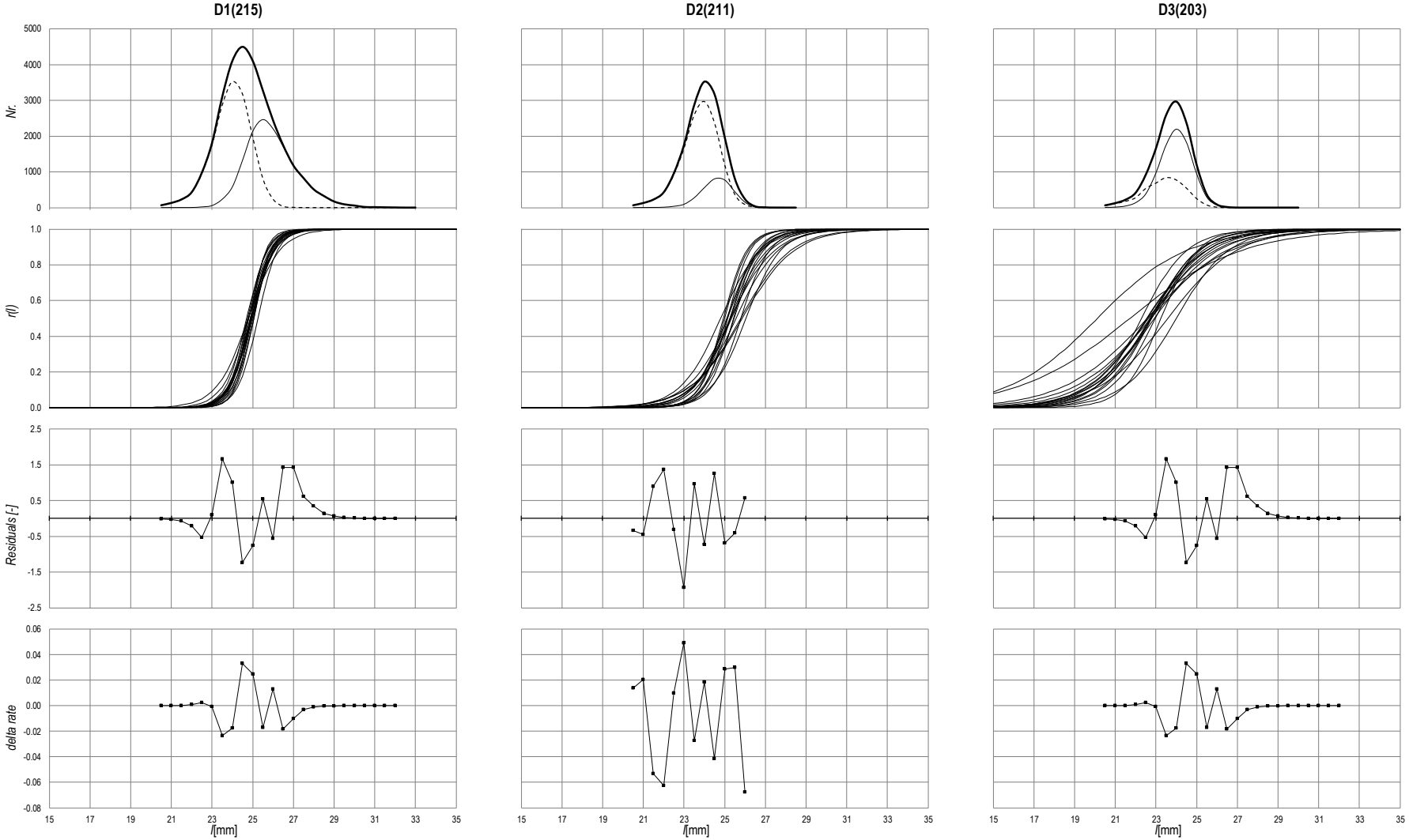



Figure 14: Distributions of clam sizes sifted in total (▬), retained (—) and released (---) by 1st sieve D1(215) with holes having a diameter of 21.5 mm, 2nd sieve D2(211) diameter of holes 21.1 mm and 3rd sieve D3(203) diameter of holes 20.5 mm; selectivity curves for individual sieves, chart of residuals and delta rate. These last two charts set out the quality of the approximation in the logistic model considering the ensemble of experimental observations obtained during screening tests.

Table 14: Estimated average selectivity parameters for the 1st sieve D1(215) with a hole diameter of 21.5 mm; 2nd sieve D2(211) with a hole diameter of 21.1 mm and 3rd sieve D3(203) with a hole diameter of 20.5 mm. The average values were calculated according to the methodology proposed by Fryer (1991) at each sieving speed (1180, 1210, 1230 RPM) and at all combined speeds, e.g. pooled data (All.P.), highlighted in grey. 50% retention length, selection range (SR), with average (estimate), standard error (S.E.), 95% confidence interval (C.I.95%) and p-value, selection factor (SF), estimators of the curve that best approximates data (v1, v2), within-haul variation {Ri} (WHV, within-haul variation), between-haul variation {D} (BHV, between-haul variation), Akaike's Information Criterion (AIC) verification test, Log-Likelihood delta (Delta).

| **Sieve** | **Speed** | **L50** | | | | **SR** | | | | SF | $\upsilon 1$ | $\upsilon 2$ | WHV | | | BHV | | | log-likel. | AIC | *Delta* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Estimate | S.E. | C.I.95% | *p* -value | Estimate | S.E. | C.I.95% | *p* -value | | | | $R_{11}$ | $R_{12}$ | $R_{22}$ | $D_{11}$ | $D_{12}$ | $D_{22}$ | | | |
| D1(215) | 1180 | **24.89** | 0.046 | *(24.78-25.00)* | 1.99E-17 | **1.20** | 0.099 | *(0.96-1.43)* | 6.08E-06 | 1.16 | -45.72 | 1.84 | 0.0021 | -0.0016 | 0.0098 | 0.0112 | -0.0097 | 0.0544 | 4.01 | 1.978 | 3.82E-15 |
| | 1210 | **24.89** | 0.021 | *(24.84-24.94)* | 7.93E-20 | **1.12** | 0.082 | *(0.93-1.31)* | 2.58E-06 | 1.16 | -48.81 | 1.96 | 0.0004 | -0.0008 | 0.0067 | 0.0013 | -0.0048 | 0.0367 | 8.98 | -7.951 | 9.72E-15 |
| | 1230 | **24.94** | 0.083 | *(24.74-25.13)* | 1.20E-15 | **1.06** | 0.031 | *(0.98-1.13)* | 4.98E-09 | 1.16 | -51.83 | 2.08 | 0.0069 | -0.0007 | 0.0010 | 0.0401 | -0.0045 | 0.0030 | 7.01 | -4.012 | 6.72E-15 |
| D2(211) | 1180 | **25.33** | 0.105 | *(25.08-25.58)* | 5.48E-15 | **1.69** | 0.163 | *(1.31-2.08)* | 1.65E-05 | 1.20 | -32.84 | 1.30 | 0.0110 | 0.0098 | 0.0265 | 0.0432 | 0.0323 | 0.1066 | -2.62 | 15.24 | 6.41E-15 |
| | 1210 | **25.33** | 0.136 | *(25.01-25.65)* | 3.48E-14 | **1.64** | 0.170 | *(1.23-2.04)* | 2.74E-05 | 1.20 | -34.01 | 1.34 | 0.0186 | 0.0131 | 0.0289 | 0.0930 | 0.0582 | 0.1370 | -3.75 | 17.51 | 6.17E-15 |
| | 1230 | **25.29** | 0.148 | *(24.94-25.64)* | 6.06E-14 | **2.02** | 0.173 | *(1.61-2.43)* | 7.61E-06 | 1.20 | -27.54 | 1.09 | 0.0218 | -0.0031 | 0.0298 | 0.1117 | -0.0423 | 0.1264 | -5.52 | 21.05 | 8.39E-15 |
| D3(203) | 1180 | **22.90** | 0.155 | *(22.53-23.27)* | 1.74E-13 | **2.98** | 0.206 | *(2.49-3.47)* | 1.79E-06 | 1.13 | -16.89 | 0.74 | 0.0241 | 0.0068 | 0.0424 | 0.1117 | 0.0821 | 0.0604 | -5.67 | 21.34 | 7.48E-09 |
| | 1210 | **22.87** | 0.146 | *(22.53-23.22)* | 1.13E-13 | **2.86** | 0.490 | *(1.70-4.02)* | 6.43E-04 | 1.13 | -17.58 | 0.77 | 0.0213 | -0.0551 | 0.2403 | 0.0772 | -0.2331 | 1.1045 | -10.65 | 31.31 | 9.96E-15 |
| | 1230 | **22.94** | 0.232 | *(22.39-23.49)* | 2.88E-12 | **2.58** | 0.138 | *(2.25-2.91)* | 3.15E-07 | 1.13 | -19.53 | 0.85 | 0.0540 | 0.0027 | 0.0191 | 0.3004 | 0.0428 | 0.0061 | -9.22 | 28.45 | 7.52E-09 |
| D1(215) | *All.P.* | **24.91** | 0.032 | *(24.84-24.97)* | 5.62E-74 | **1.12** | 0.040 | *(1.04-1.20)* | 4.81E-25 | 1.16 | -48.85 | 1.96 | 0.0010 | -0.0004 | 0.0016 | 0.0167 | -0.0066 | 0.0254 | 15.9 | -21.8 | 3.23E-15 |
| D2(211) | *All.P.* | **25.30** | 0.072 | *(25.16-25.45)* | 3.43E-62 | **1.76** | 0.101 | *(1.56-1.97)* | 1.69E-18 | 1.20 | -31.57 | 1.25 | 0.0051 | 0.0025 | 0.0102 | 0.0753 | 0.0244 | 0.1445 | -14.29 | 38.58 | 8.64E-15 |
| D3(203) | *All.P.* | **22.87** | 0.112 | *(22.64-23.09)* | 4.04E-54 | **2.76** | 0.144 | *(2.47-3.06)* | 8.87E-20 | 1.13 | -18.19 | 0.80 | 0.0125 | -0.0037 | 0.0208 | 0.1843 | -0.0104 | 0.1563 | -31.43 | 72.86 | 7.96E-15 |

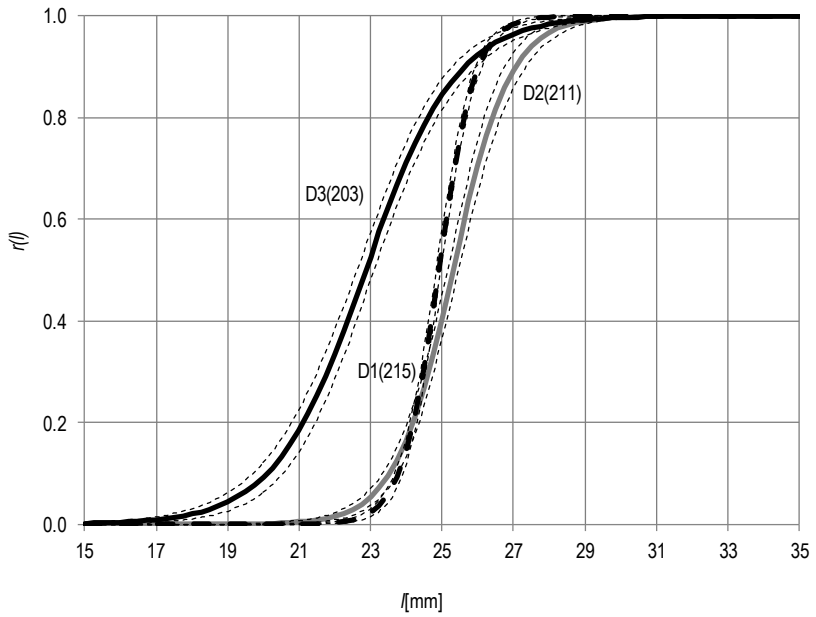



Figure 15: Average selectivity curves estimated for the 1st sieve D1(215) with a hole diameter of 21.5 mm; 2nd sieve D2(211) with a hole diameter of 21.1 mm and 3rd sieve D3(203) with a hole diameter of 20.5 mm. The average values have been calculated according to the methodology proposed by Fryer (1991) at all combined speeds. The dotted lines graphically represent the confidence intervals.

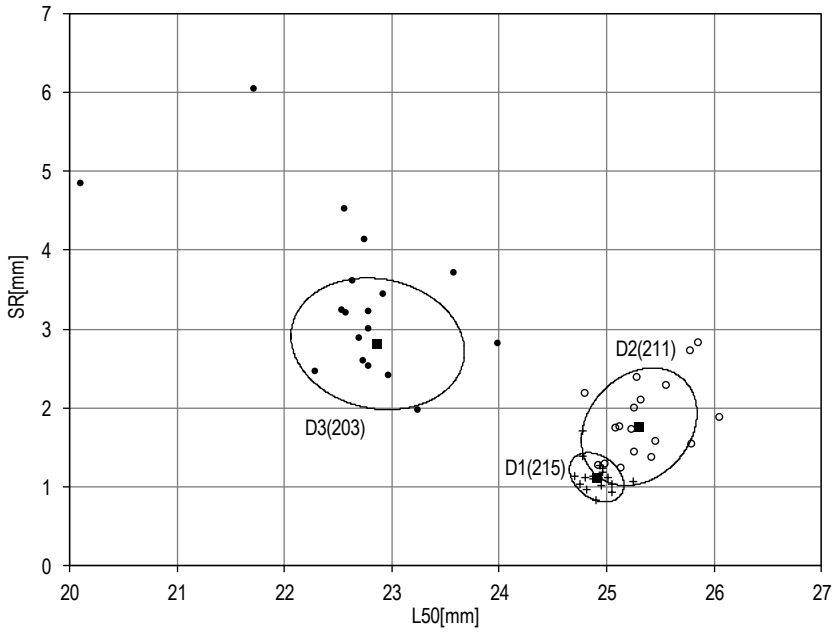



Figure 16: L50 versus SR, the ellipses have been calculated on the basis of the variance of the estimated parameters and graphically represent the confidence intervals of both L50 and SR of each sieve: 1st sieve D1(215) with a hole diameter of 21.5 mm; 2nd sieve D2(211) hole diameter 21.1 mm and 3rd sieve D3(203) with hole diameter of 20.5 mm.

## 4.3. Study of dredge selectivity

The first selection process in clam fishing occurs when clams enter the bottom towed dredger. The space between bars allows small clams to escape directly from the cage. Sea trials to assess the selectivity of a hydraulic dredge were performed with a standard dredge with 12 mm bar spacing. A sampling net consisting of a stainless steel frame and a 12 mm mesh nylon net was used to collect the entire clam population in the dredged area. This net has been fixed inside the dredger. Then, a classic covered-codend method was applied used to study the selectivity of the trawl bag.

For each dredge, the probability of retention r(l) in the dredge was modelled using the logistic selectivity curve:

$$r(l) = \frac{e^{\upsilon_1 + \upsilon_2 l}}{1 + e^{\upsilon_1 + \upsilon_2 l}},$$

r(l) (Wileman et al., 1996), and is the vector of selectivity parameters.

where r(l) is the probability that a fish of length l is retained once it has entered the dredge (Wileman et al., 1996), and $\hat{\upsilon} = (\upsilon_1, \upsilon_2)^T$ is the vector of selectivity parameters.

Fryer model (1991) was used to study the variation of selectivity criteria $\upsilon_1$ and $\upsilon_2$, to estimate an average curve..

The results of the selectivity study are shown in Figure 15 and Figure 16. Selectivity parameters were:

*L50* = 50% retention length

*SR* = Selection Range (L75 – L25)

Selectivity parameters estimated from the pooled data of the individual coves are:

*L50* = 22.29 ± 0.95

*SR* = 2.13 ± 1.04

The results obtained through the Fryer method were:

*L50* = 22.39 ± 0.17

*SR* = 1.79 ± 0.14

Therefore, the dredge on the bottom is responsible for the first and effective selection phase. L50 obtained from this process is the same as MCRS for this species. Therefore, most of the small clams are not carried on board for sieving but they return directly to the bottom.

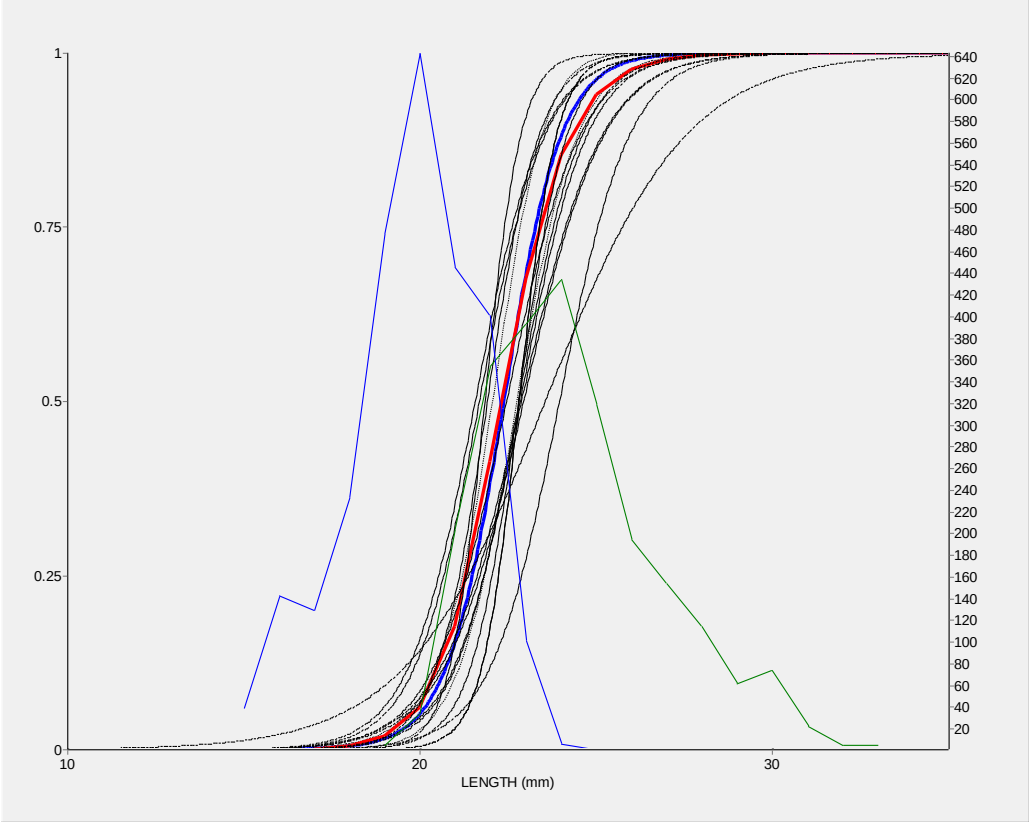



Figure 17: Selectivity curves for single fishing operations (thin lines) and average selectivity curves obtained with pooled data and Fryer model (1991, red and blue, respectively.) In green and blue, the population retained and escaped.

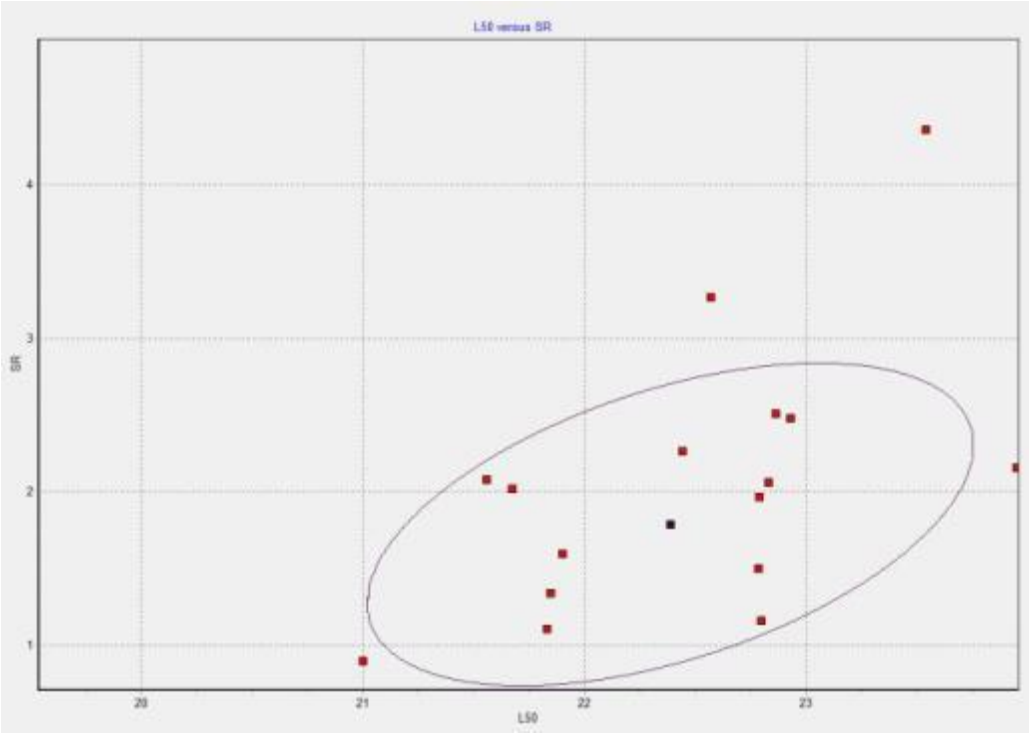



Figure 18: Ratio of L50 and SR obtained from experimental data.

# 5. Summary of Scientific Surveys for *Chamelea gallina*

## 5.1. Boats and gear used

The experimental verification of the state of the clam population in the different Districts has included a series of samplings, in the Spring-Summer period. On board were the crew, composed of at least 2 people, and two technicians from the Scientific Institutes of reference, in charge of collecting information on fishing data and coordinating activities. The sampling operations were carried out with the help of boats used for professional clam fishing with hydraulic dredger.

A professional hydraulic dredger with one front slide and two small side slides was used for sampling operations. The mouth had a width of about 3 m (slightly variable from one Consortium to another), while the dredge was characterized by a space between the rods of about 11 mm. For the purposes of this research, the commercial sieve with hydraulic handling on board has been modified (Figure 19a). The various grids used during commercial fishing were replaced by a single grid with 19 mm holes (Figure 19b).

Figure 19: a) A vibrating sieve was used on board the hydraulic dredgers to select the commercial sizes and b) A 19 mm grid was used during the surveys (b).

## 5.2. Sampling methodology

All information concerning the catch quantities, coordinates and depths of each haul has been reported on appropriate forms. The track of each individual haul was recorded with a GPS detector and then analyzed on the ground on a computer. The sampling was carried out by fishing on transects equidistant from each other and perpendicular to the coast, with stations at 0.25, 0.50, 0.75 and 1 nautical mile. Other stations were carried out when the distribution of the resource extended beyond the mile.

According to an operational protocol, the dredger was lowered with the fishing boat almost stationary and once the water pump was started, the position at the beginning of the haul was recorded as soon as the two side slings came into tension. The end of the haul, on the contrary, coincided with turning off the water pump, stopping the propeller and stopping the tension of the two side slings. In each cove we tried to explore exactly the same area (length of the stretch swept by the dredge equal to 100 m). To this end, considering that the speed of the boat was not a reliable parameter to precisely define the length of the cove (operating at a speed of 1-2 knots, it is easy to make mistakes even by a few tens of meters), we decided to use a GPS. GPS was able to accurately indicate that the trawl had reached 100 m in length. The GPS data allowed in any case to standardize the catch accurately, even if the haul lasted longer than what was established in the protocol. At each station at the end of the haul the dredger was opened over the vessel and the catch was rinsed to remove

mud. Once washed, the catch was screened using a single sieve with an opening of 19 mm. All clams retained by the sieve in each haul were weighed on board with a marine type compensation scale. In case of abundant catch, a sub-sample (about 2 kg) was taken in order to analyse the size distribution.

One purpose of the biological sampling was to study the fraction of juvenile clams that would reach a commercial size in the following months and their distribution. To sample the juveniles of 8-16 mm (1st year of age; commonly called seed) and 17-24 mm (2nd year of age), it was necessary to use a sampler screen, consisting of a stainless steel frame and a nylon mesh of 12 mm. The screen was properly fastened inside the dredger (Figure 20) with clamps. The catch (benthic organisms, accessory fauna and clams of all sizes) was weighed and, where it exceeded 10 kg, a sub-sampling was made..

Figure 20: Sampler screen consisting of a stainless steel frame (40 cm internal length, 20 cm internal width with a thickness of 1 cm) and a nylon mesh by 12 mm.

## 5.3. Processing of survey data

The samples coming from the dredger and the sampler screen were marked with labels placed inside watertight tubes, bearing the code with the numbers of the relevant District, the transept number and the station number. At the end of the fishing day, samples were moved to a freezing room (-18 °C) for biometric laboratory measurements. At the time of the measurements, after being thawed, each sample was weighed again and the clams were sorted and measured.

The biometric surveys were carried out by means of video analysis. A detail of the procedures is given in Seasons (2010). The clam samples were then divided into groups and placed each time on a special light table (Figure 21) with a digital camera. This latter had a 8.2 Megapixel resolution and a 28/80 mm lens ( at a constant height during all analyses ). Alternatively, clams could be measured manually with a gauge.

Figure 21: Camera on bright stand for photo sensing.

The photos taken were then processed with the ImageJ video analysis software (Rasband, 2010), able to detect the maximum width of each clam, which is described by the parameter Feret X (the longest distance between any two points along the selection boundary, also known as maximum caliper). Calibration was carried out from time to time on the central clam, measured manually with a laboratory gauge (Figure 22) to minimize any errors due to the distortion given by the lens. The biometric measurements were carried out with an accuracy of 0.5 mm and then, during data processing, were rounded to the nearest unit.

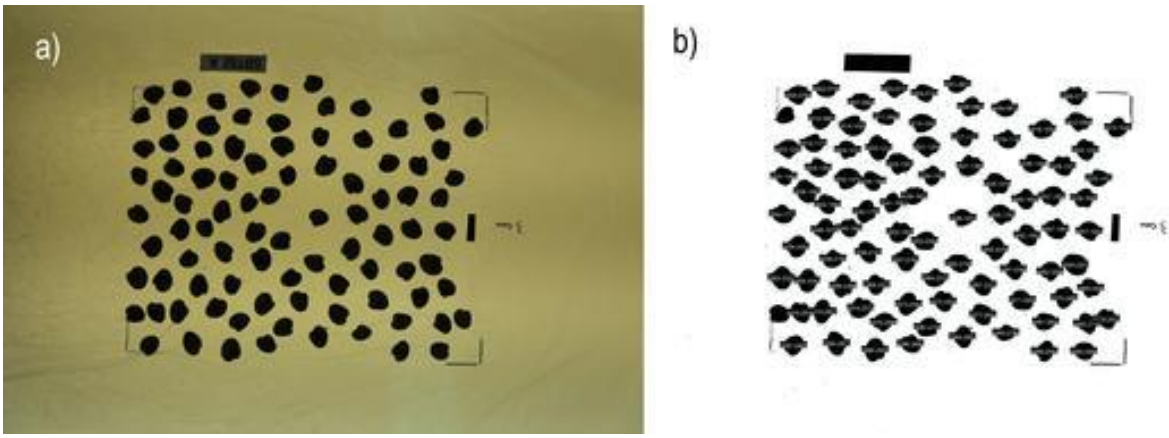



Figure 22: Detail of a photo of a sample of clams photographed on the light stand and with a metric reference (3 cm) on the right, with the central clam highlighted and used as a calibration to measure the others (a); (b) result of the image manipulation through filters and graphic overlays through the ImageJ software and its automatic numbering of each individual clam.

The general protocol provided for: (i) a comparative assessment of the efficiency of the 19 mm sieve and 12 mm mesh sampler screens; (ii) differences in catch between the dredger and the sampler screens at four different distances from the coast and, in general, differences between the areas themselves. Since the duration of the hauls was often different, the catches were standardized in the data analysis in order to obtain the yields expressed as number and weight of individuals per sampled area. The values of abundance and biomass per unit area were calculated in number and grams per m2, respectively (Nr/100 m2 and g/m2).

## 5.4. Veneto Region

### *5.4.1. State of the resource in the last 15 years*

In Veneto, management of bivalve mollusc resources *Chamelea gallina*, *Callista chione*, *Ensis minor* is carried out through a (unique in Italy) of supra-District system; hence, any choices on harvesting quantities, management of the rotation of fishing areas and voluntary stoppages are made by the decision-making bodies of the two joint Consortia. This type of approach has enabled the fishing fleet to remain unaltered over time and ensured an economic and production guarantee for all member undertakings.

The number of fishing undertakings affiliated to the management consortia of Venice and Chioggia, as shown in Table 15 below, has remained unchanged since 2002. The variations were only of an internal nature in the choice of trade (V= clam, F= fasolar, CL= razor clams).

Table 15: Trend in the number of vessels by fishery (2002-2018). V = Clam; F = Fasolar; CL = razor claw. Cannellarie are clam fishing vessels that for certain periods, fish for razor claws.

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **V** | 125 | 123 | 123 | 123 | 121 | 121 | 121 | 121 | 103 | 103 | 103 | 105 | 105 | 105 | 111 | 120 | 121 |
| **F** | 38 | 40 | 40 | 40 | 42 | 42 | 42 | 42 | 60 | 60 | 60 | 58 | 58 | 58 | 52 | 43 | 42 |
| **CL** | 15 | 25 | 25 | 17 | 19 | 20 | 26 | 33 | 33 | 27 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Total** | 163 | 163 | 163 | 163 | 163 | 163 | 163 | 163 | 163 | 163 | 163 | 163 | 163 | 163 | 163 | 163 | 163 |

The annual production between 2002 and 2017 (Figure 23) shows a fluctuating trend. In the period 2009-2011, production was suffering due to an important death phenomenon, but later, also thanks to numerous interventions by the Consortia themselves, the production status improved significantly and 2017 was one of the best years of production.

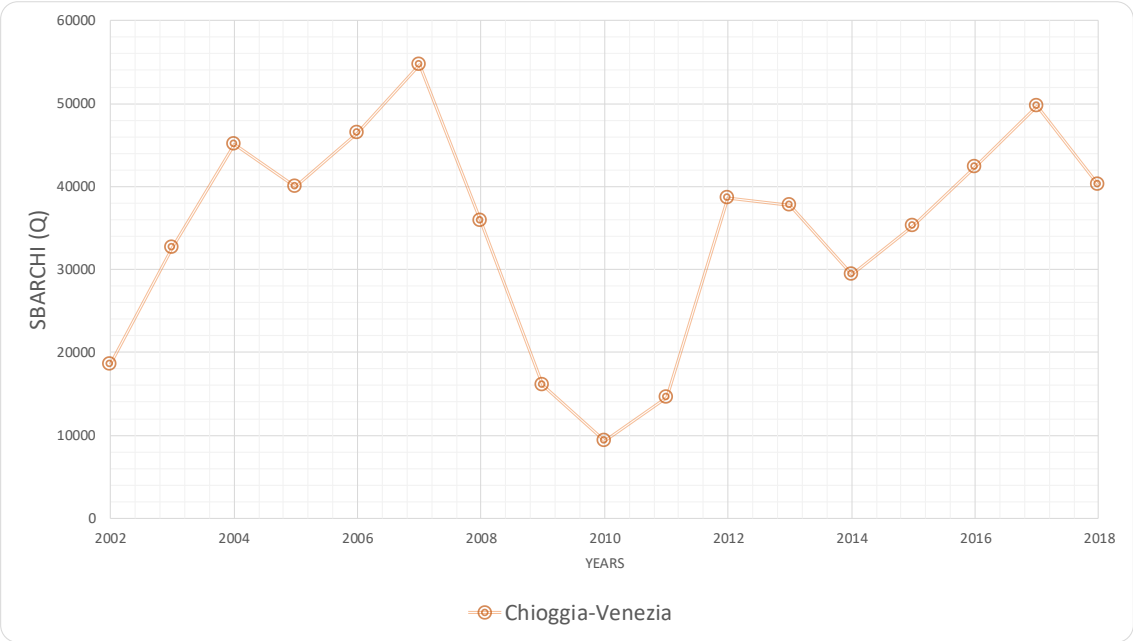



Figure 23: Annual production (q) of the Veneto Consortia between 2002 and 2018 (sources: Co. Ge. Vo.).

During 2018 (end of October) a major meteorological phenomenon caused production losses in the Po Delta areas and restricted the production recovery practices in Eastern Veneto (Brussa-Caorle area).

### *5.4.2. Summary of 2016-2018 surveys*

Surveys carried out in 2016 and 2018 show higher densities in 2016 for both the commercial and sub-commercial fractions (between 20 and 21 mm). It is important to note that in 2017 the average densities for the entire Veneto District ranged between 90 and 100 g/m2.

Table 16: Standardized average yields (g/m2) obtained for clam catches with the dredge and the sampler screen in the Venice (VE) and Chioggia (CI) Districts in the two-year period 2016-2018. The values of commercial (22 mm) and sub-commercial (20-21 mm) individuals are reported.

| | **2016 Catch [g/m²]** | | | | **2018 Catch [g/m²]** | | | |
|---|---|---|---|---|---|---|---|---|
| | **≥ 22mm** | | **20-21 mm** | | **≥ 22mm** | | **20-21 mm** | |
| | Mean | St Dev. | Mean | St Dev. | Mean | St Dev. | Mean | St Dev. |
| **VE** | 14.3 | 9.4 | 34.3 | 22.3 | 11.5 | 12.5 | 30.4 | 25.4 |
| **CI** | 38.9 | 10 | 72.5 | 42.4 | 15.5 | 5 | 48.9 | 17.5 |

The above data show that in the Venice Maritime Department the biomass of the natural banks of *C. gallina* remains at similar levels after two years, while in the Chioggia District there is a slight decrease in biomass due to some external variables, including a death phenomenon that characterized the area of Sottomarina and adverse weather and sea events at the end of October 2018 affecting the entire Venetian coastline.

During the surveys in the areas in front of the Venice lagoon, the structure of the population of *C. gallina* collected with a sampler bag was analyzed in a standardized manner. The main results are summarized in the graph below (Figure 24).

The year 2016 was marked by a high recruitment rate, while the year 2017 showed a growth with an abundance of individuals between 13 and 20 mm.

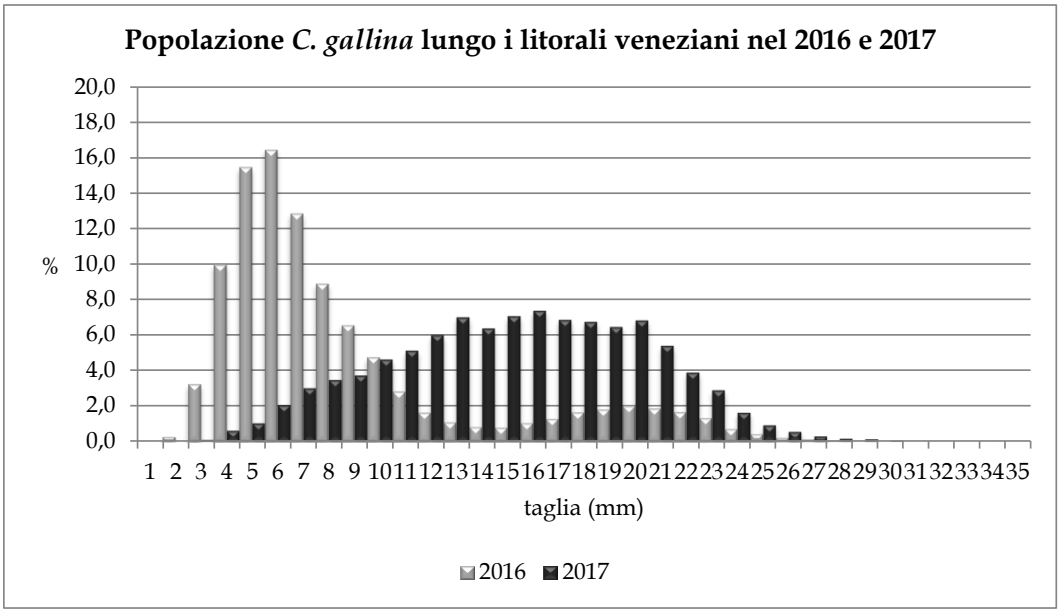



Figure 24: Frequency distributions (in percentage) of individuals caught with the sampler screen along the Venetian coasts in 2016 and 2107.

## 5.5. Emilia Romagna Region

### *5.5.1. State of the resource in recent years*

The number of fishing boats operating in the two Districts is 36 and 18 in Rimini and Ravenna, respectively.

The annual trend of total landings in the Emilia Romagna region (Figure 25) shows an increase from 2016 with a consequent settlement at around 25,000 quintals, mainly due to an increase in landings in the Rimini District. The Ravenna District has not shown significant increases in recent years.

The decrease observed in 2018 is mainly due to the strong death event that occurred in September 2018.

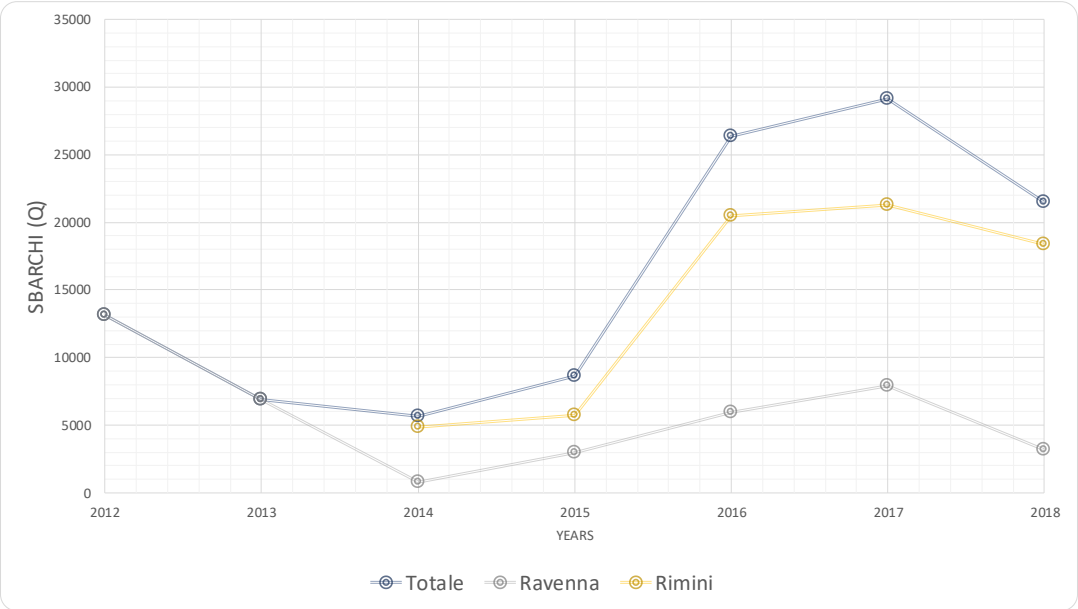



Figure 25: Annual production (q) of the Romagna Consortia between 2012 and 2018.

### 5.5.2. *Summary of survey results*

Rimini District

Data on size breakdown, obtained with the sampler screen, are shown in Figure 26.

It is clear that commercially sized clams represent a small fraction of the population and that for a monthly growth of 1-2 mm there is a large part of the population that will reach commercial size during the year.

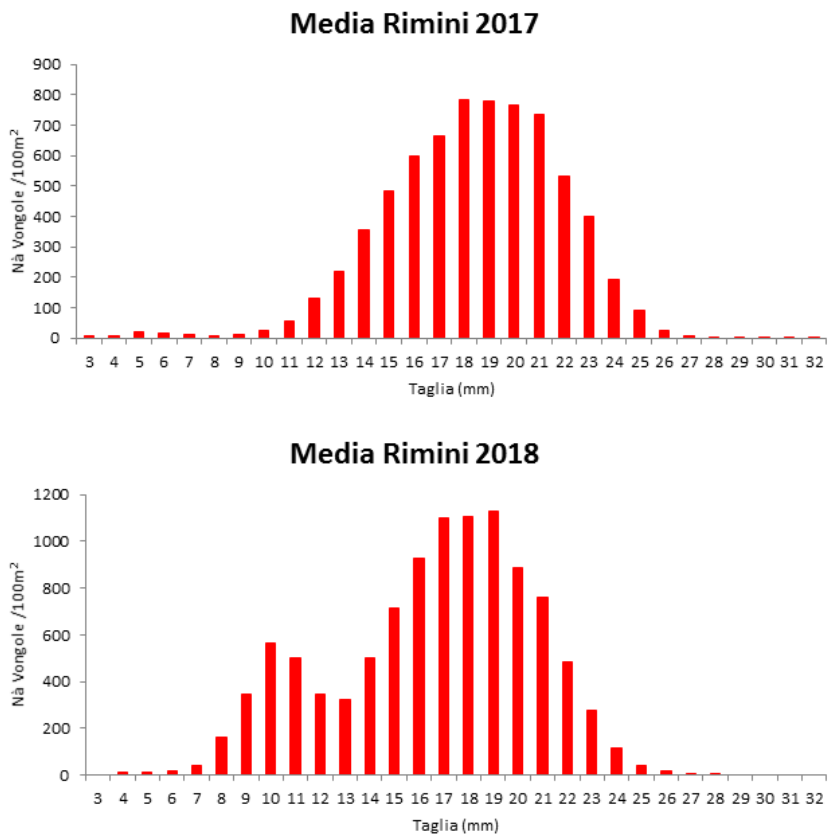



Figure 26: Standardized frequency distributions (N° individuals/100m2) of individuals caught with the sampler screen in the Ravenna District in 2017 and 2018.

Ravenna District

Data on the average size of the population at sea, obtained with the sampler screen, are shown in Figure 27.

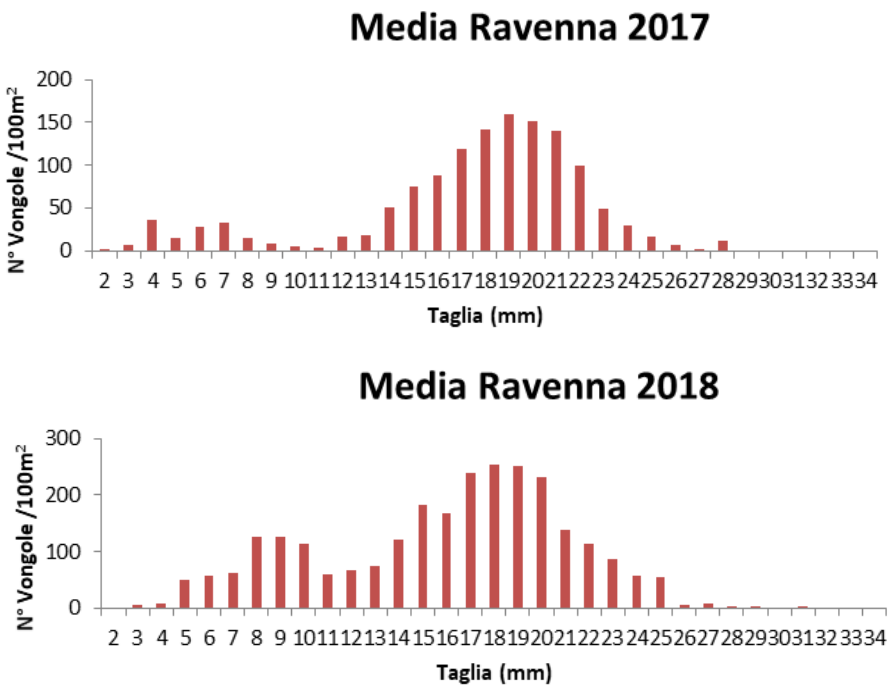



Figure 27: Standardized frequency distributions (N° individuals/100m2) of individuals caught with the sampler screen in the Rimini District in 2017 and 2018.

The size distributions between the two surveys do not show significant differences, except for densities that in 2018 were higher. In addition, it is clear that size classes above 25 mm are almost completely absent in both years.

## 5.6. Marche Region

### *5.6.1. State of the resource in the last 10 years*

The Marche region is home to about 30% of the entire national fleet of hydraulic dredgers, followed by Veneto (about 23%), Abruzzo (about 15%) and Puglia (about 10%). Ancona is the numerically most important District followed by Pesaro, San Benedetto del Tronto and Civitanova Marche (Table 17; source IREPA and Co. Ge. Vo.); the number of boats has remained almost constant over the years, with some variations affecting all Districts.

Table 17: Number of vessels per Management Consortium (source IREPA and Co. Ge. Vo.). AN = Ancona; CIV = Civitanova Marche; PES = Pesaro; SBT = San Benedetto del Tronto; Tot = Total.

| | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **PES** | 64 | 64 | 64 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 |
| **AN** | 55 | 55 | 55 | 75 | 75 | 74 | 74 | 74 | 74 | 74 | 74 | 74 |
| **CIV** | 44 | 44 | 44 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 |
| **SBT** | 56 | 56 | 57 | 57 | 57 | 57 | 57 | 57 | 57 | 57 | 57 | 57 |
| **TOT** | 219 | 219 | 220 | 222 | 221 | 221 | 221 | 221 | 221 | 221 | 221 | 221 |

A comprehensive overview of clam fishing with hydraulic dredges in the Marche Districts was established by collecting information on the quantities fished and the various management measures developed by the different consortia over the last 10 years (Figure 28).

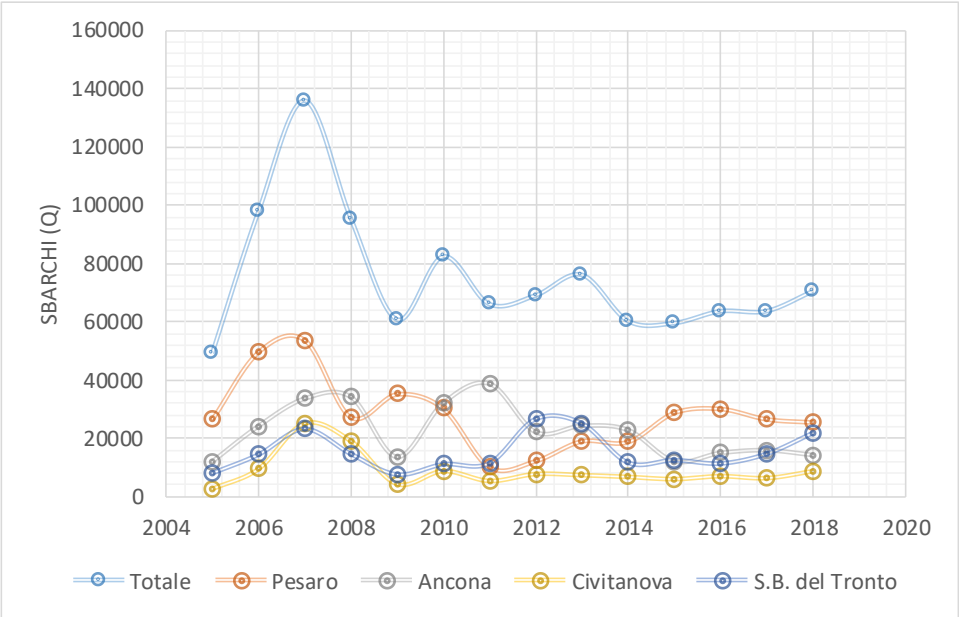



Figure 28: Annual production (q) of Consortia in the Marche region between 2005 and 2018 (sources: Co.Ge.Vo. and Co.Vo.Pi.)..

The trend shows periodic fluctuations that are typical for a resident resource often subject to exploitation or localized death phenomena. In the last decade, 2007 has been the most productive year, with a total regional landing of more than 135,000

quintals. From 2010 onwards, with slight fluctuations, the trend in landings has stabilized. Since 2017, landings have been showing a positive trend.

### *5.6.2. Summary of survey results*

Pesaro District

The size distributions obtained by the sampler screen during the 2017 and 2018 surveys in Pesaro show that the average size breakdown is different from year to year, with very long annual recruitment periods. Moreover, there is a high number of clams over 16 mm long, which have reached the first size of maturity. As for commercial sizes, those between 22 and 24 mm reach quantities over 5 times greater than those ≥ 25 mm.

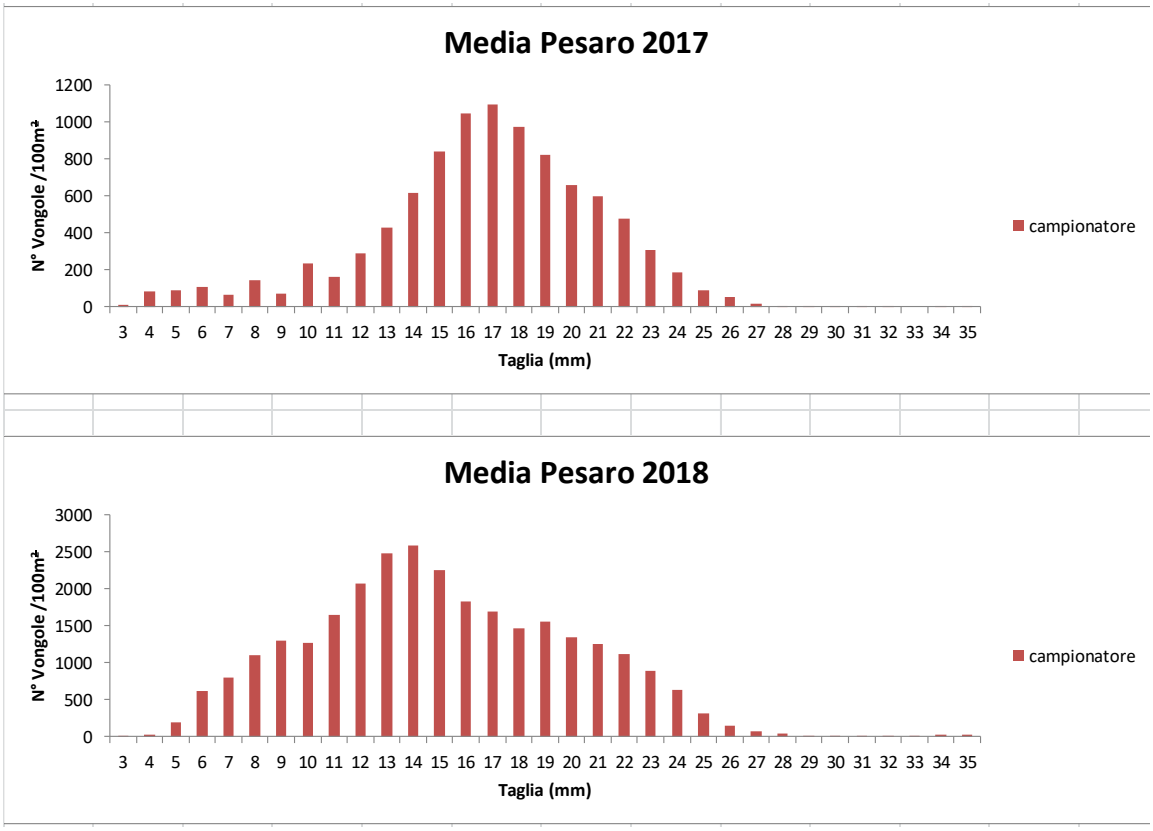



Figure 29: Standardized frequency distributions (N° individuals/100m2) of individuals caught with the sampler screen in the Pesaro District in 2017 and 2018.

Districts of Ancona (and Consortium of Civitanova Marche) and San Benedetto del Tronto

Table 18 shows the average yields per District. A sharp recovery of the resource can be observed in all areas from 2017 to 2018.

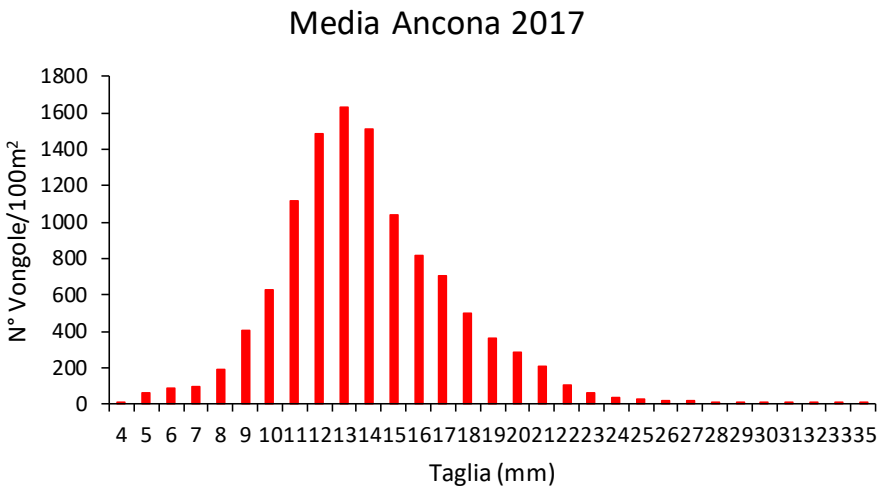
Table 18: Standardized average yields (g/m2) obtained for clam catches with the dredge and sampler screen for the Districts of Ancona (AN), Civitanova Marche (CIV) and San Benedetto del Tronto (SBT) in the two-year period 2017-2018.

| | **2017 Catch [g/m²]** | | | | **2018 Catch [g/m²]** | | | |
|---|---|---|---|---|---|---|---|---|
| | **Dredger** | | **Screen** | | **Dredger** | | **Screen** | |
| | Mean | St.dev | Mean | St.dev | Mean | St.dev | Mean | St.dev |
| **AN** | 10.7 | 12.0 | 175.1 | 253.1 | 77.1 | 62.9 | 551.1 | 363.7 |
| **CIV** | 8.5 | 6.3 | 219.5 | 284.0 | 130.6 | 80.9 | 319.7 | 239.1 |
| **SBT** | 28.9 | 42.7 | 75.5 | 89.7 | 183.3 | 131.0 | 454.4 | 399.8 |

According to data collected during the 2017 campaign, the San Benedetto del Tronto area was the most productive in terms of both biomass and abundance for commercial sizes regardless of the distance from the coast. An opposite trend was observed when considering sizes < 22 mm; in this case the Mayri densities were mainly found in the areas of Ancona (in front of Senigallia) and Civitanova Marche. The 2018 survey shows a marked recovery of the resource compared to the previous year in the Ancona district and an increase in San Benedetto del Tronto. The increase in weight density also results in an increase in individual densities in both Districts.

The analysis of frequency distributions obtained from the sampler screen shows that in the Ancona district (Figure 30), the high abundance of recruits recorded in 2017 has been reflected in the increased density of commercial-sized individuals in 2018. Certainly, not all 2017 recruits developed into oversized individuals and this may be due to density-dependent dying phenomena or other factors that led most of those recruits to die. The same may have happened in the San Benedetto district (Figure 32) between 2017 and 2018.

In general, a very good recruitment was also observed in 2018, which suggests that fishing will continue to perform well in 2019, as actually seems to be the case.



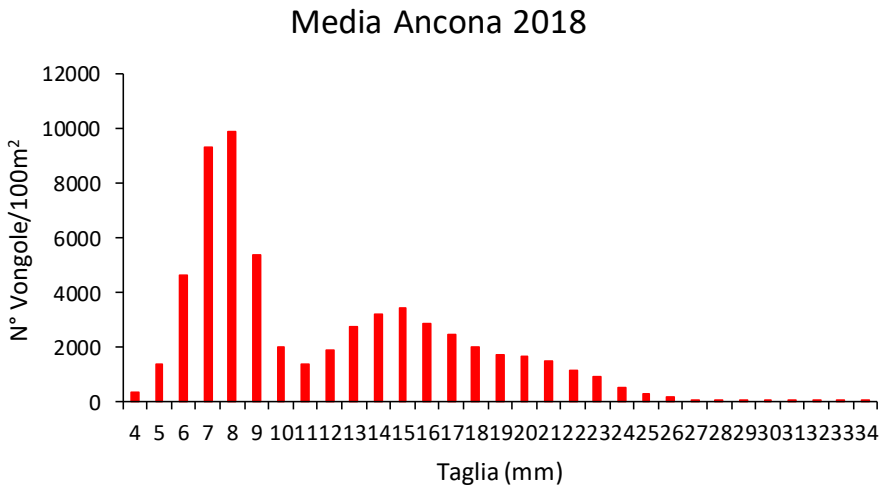




Figure 30: Standardized frequency distributions (N° individuals/100m2) of individuals caught with the sampler screen in the Ancona district in 2017 and 2018.

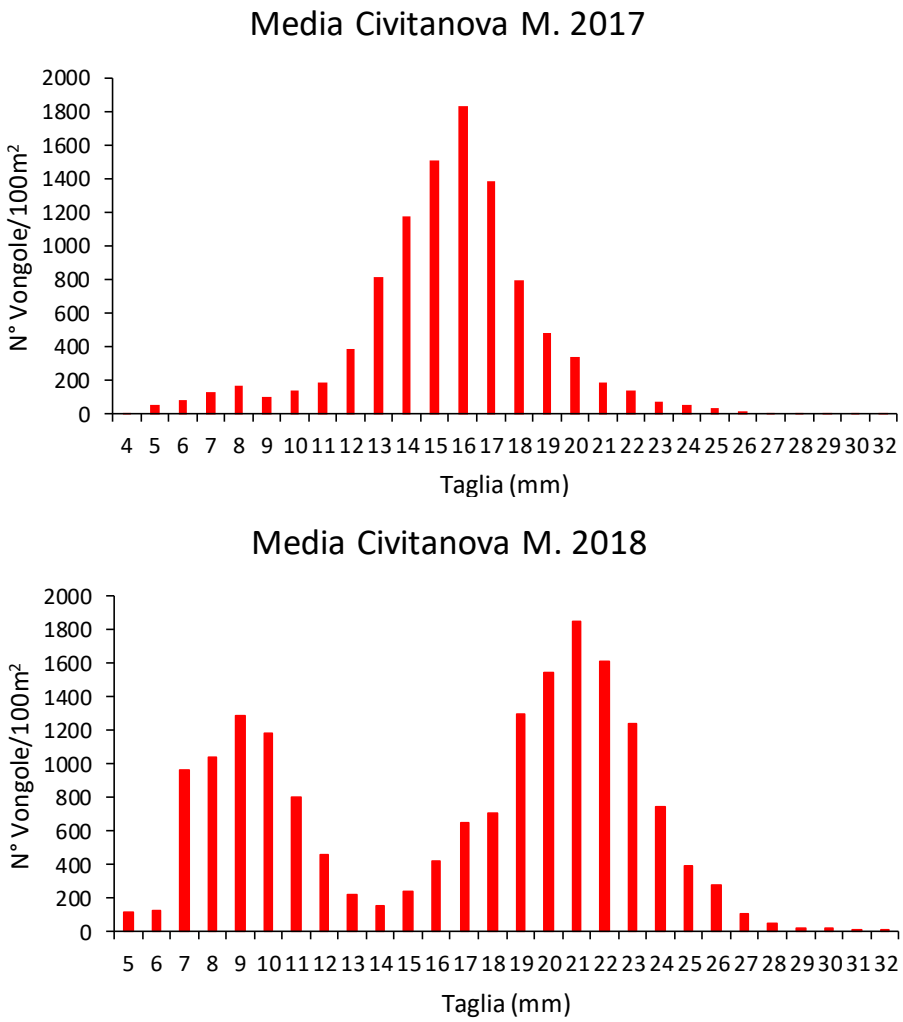
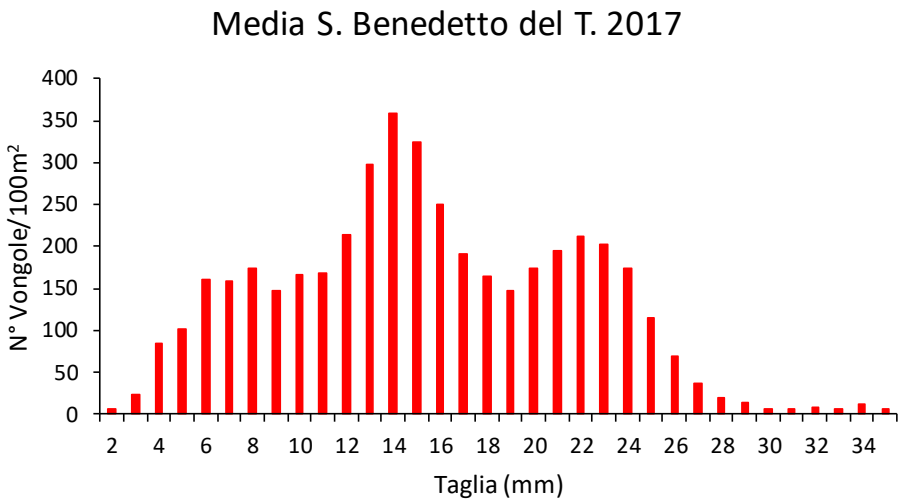



Figure 31: Standardized frequency distributions (N° individuals/100m2) of individuals caught with the sampler screen in the Ancona district (area covered by the Civitanova Marche Consortium) in 2017 and 2018.



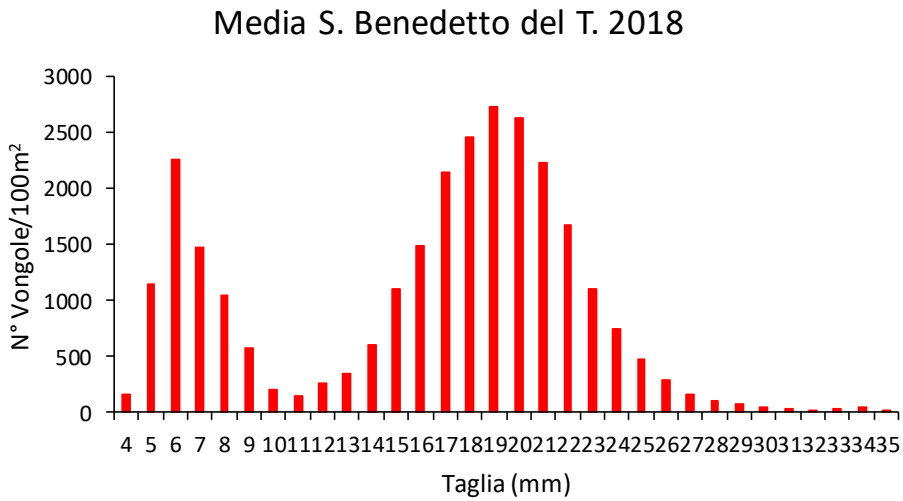




Figure 32: Standardized frequency distributions (N° individuals/100m2) of individuals caught with the sampler screen in the San Benedetto del Tronto district in 2017 and 2018.

## 5.7. Abruzzo and Molise Regions

### *5.7.1. State of the resource in recent years*

In the Abruzzi and Molise districts, 10, 21 and 73 boats are currently fishing in Termoli, Ortona and Pescara, respectively. The total trend of landings in the Regions of Abruzzo (excluding Pescara where no data are available) and Molise (Figure 33) is influenced by data from the Ortona district, with the longest historical series. These trends show significant fluctuations after 2013, when only around 900 quintals of clams were caught. In 2018, a total peak landing of more than 9,500 quintals was reached.

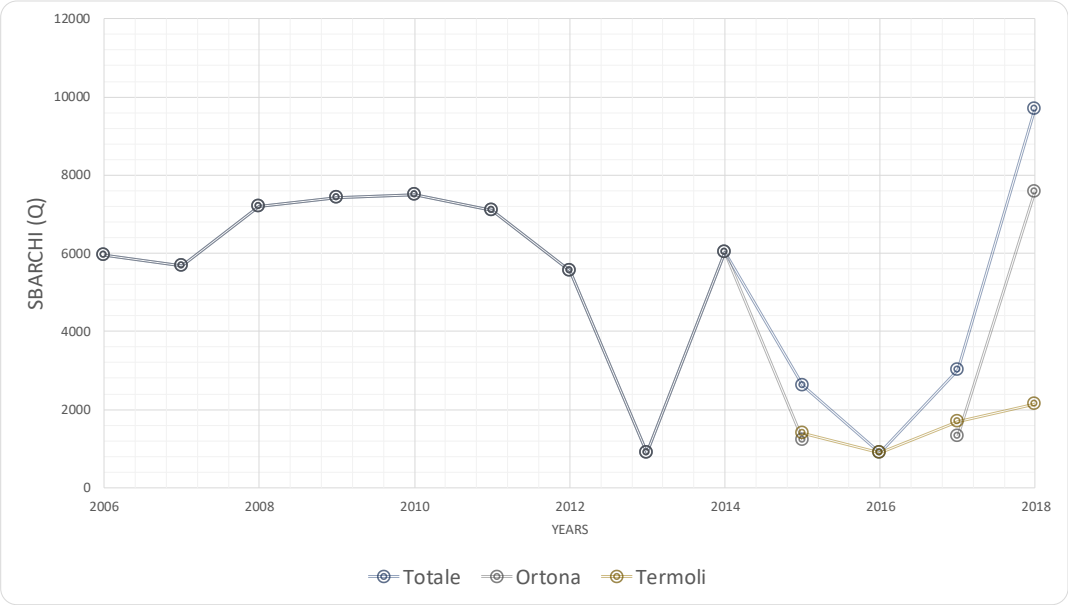



Figure 33: Annual production (q) of the Abruzzo and Molise Consortia between 2006 and 2018 (sources: Co. Ge. Vo. Frentano).

### *5.7.2. Summary of survey results*

Below is a summary (Table 19) of the average densities measured in the clam sampling campaigns carried out in 2017-2018 for Pescara and only in 2018 for Ortona and Termoli. The densities observed in Pescara increased between surveys and showed much higher quantities in 2018 compared to the other two districts. The Termoli District seems to be the most affected in terms of weight density.

Table 19: Standardized average yields (g/m2) obtained for clam catches with dredger and sampler screen in the Pescara (PE), Ortona (OR) and Termoli (TE) districts in 2017-2018.

| | **2017 Catch [g/m²]** | | | | **2018 Catch [g/m²]** | | | |
|---|---|---|---|---|---|---|---|---|
| | **Dredger** | | **Screen** | | **Dredger** | | **Screen** | |
| | Mean | St.dev | Mean | St.dev | Mean | St.dev | Mean | St.dev |
| **PE** | 35 | 34.4 | 145.2 | 169.5 | 44.7 | 46.4 | 181.5 | 191.4 |
| **OR** | - | - | - | - | 15 | 33.4 | 7.7 | 18.6 |
| **TE** | - | - | - | - | 2.7 | 4.2 | 2.1 | 5.4 |

## Pescara district

The size distribution of the clams collected by the sampler screen (Figure 34) is shown below.

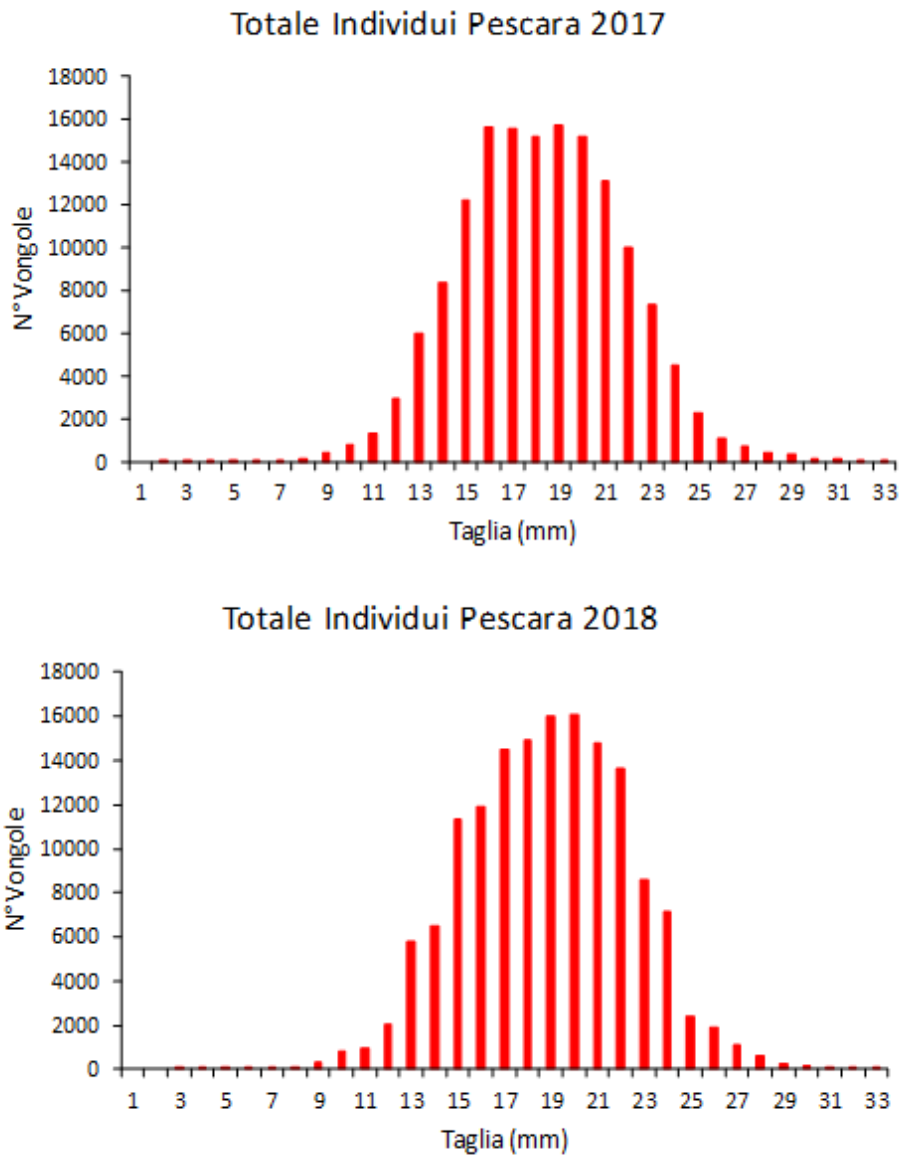



Figure 34: Total frequency distributions of individuals caught with the sampler screen in the Pescara District in 2017 and 2018.

Data emerging from the field survey show values that do not differ between the two years. The distributions are unimodal with a peak at around 19 mm.

The values found by the sampler show for both 2017 and 2018, a good presence in the recruitment of *Chamelea gallina*, demonstrating a proper balance between the harvesting and protection of the resource.

District of Ortona

An analysis of the size distribution of clams sampled with the screen in 2018 (Figure 35) shows the presence of two cohorts with peaks at 10 - 13 and 23 mm. The graph shows a generation of juveniles in recruitment and therefore a fraction of juveniles feeds the stock of commercial product.

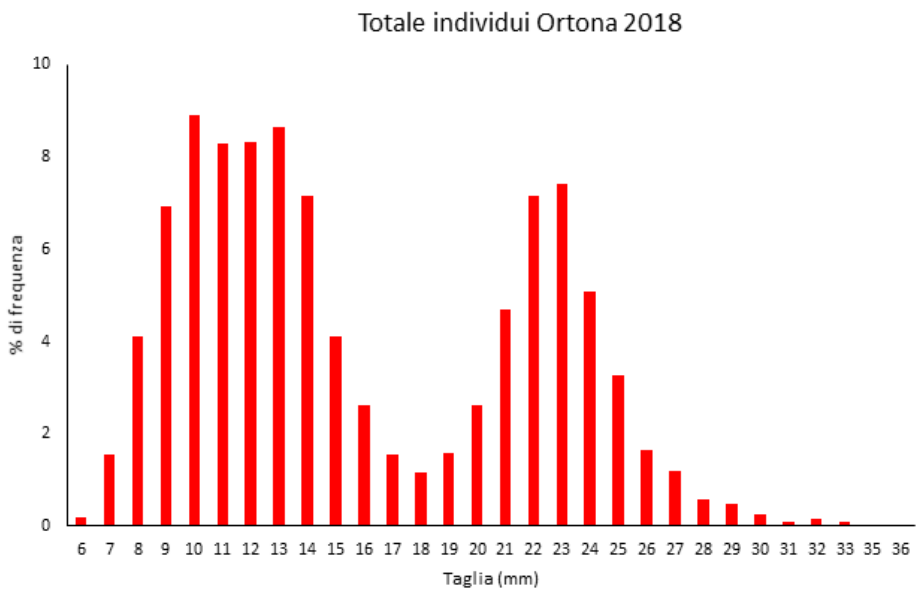



Figure 35: Total frequency distributions of individuals caught with the sampler screen in the Ortona district in 2018.

District of Termoli

The analysis of the size distribution of clams sampled with the screen in 2018 (Figure 36) shows the presence of two cohorts: a larger one with 11 mm mode and another one at 28 mm mode. However, the graph shows a generation of juveniles in recruitment.

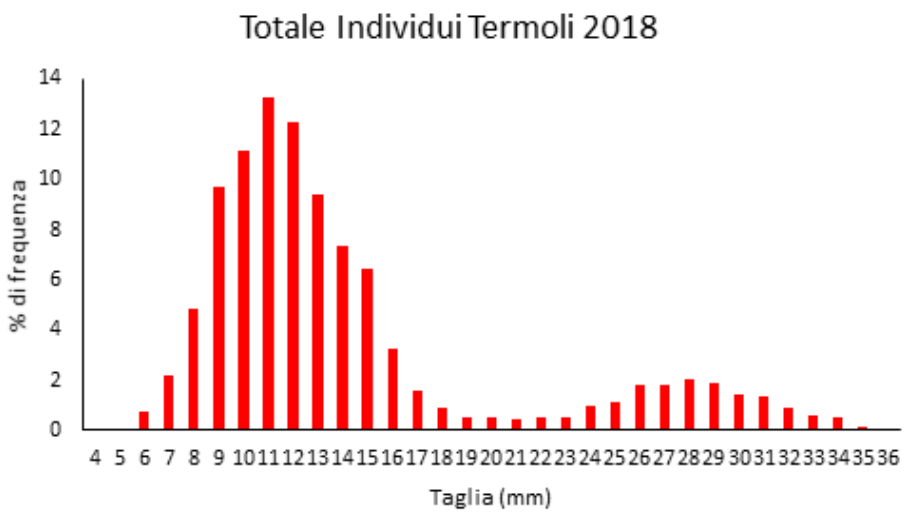



Figure 36: Total frequency distributions of individuals caught with the sampler screen in the Termoli District in 2018.

The highest density is recorded at 0.25 nautical miles from the coast, it then decreases offshore and the resource is already disappearing at 0.75 nautical miles.

The populations of adults and juveniles are similar, and there is a fraction of juveniles that feeds the stock of commercial product.

## 5.8. Puglia Region

### *5.8.1. Summary of survey results*

The standardized average yield values obtained in the sub-areas investigated through the transepts realized in Summer and Autumn 2018 in the Maritime Districts of Barletta and Manfredonia are shown in Table 20. In the Barletta Maritime Department, the abundance of commercial clam stock was less than 4 g/m2. In Autumn, a greater availability of clams was observed, although limited to some sampling stations where standardized yields were well above the reference points.

Table 20: Estimated standardized average yields (g/m2) per area for clam catches obtained with the dredger and sampler screen in the Barletta (BL) and Manfredonia (MF) districts.

| | **Summer 2018 Catch [g/m²]** | | | | **Autumn 2018 Catch [g/m²]** | | | |
|---|---|---|---|---|---|---|---|---|
| | **Dredger** | | **Screen** | | **Dredger** | | **Screen** | |
| | Mean | St.dev | Mean | St.dev | Mean | St.dev | Mean | St.dev |
| **BL** | 1.81 | 2.6 | 0.14 | 0.2 | 25.5 | 36.1 | 1.9 | 2.7 |
| **MF** | 0.5 | 0.9 | 0.6 | 0.8 | 1.6 | 2.2 | 0.7 | 0.8 |

Throughout the area, results confirm the presence of clams only in some well-defined zones, as historically observed.

In the Barletta districts, 99% of the individuals caught with the dredger in Summer and 95% in Autumn were over 22 mm in size.

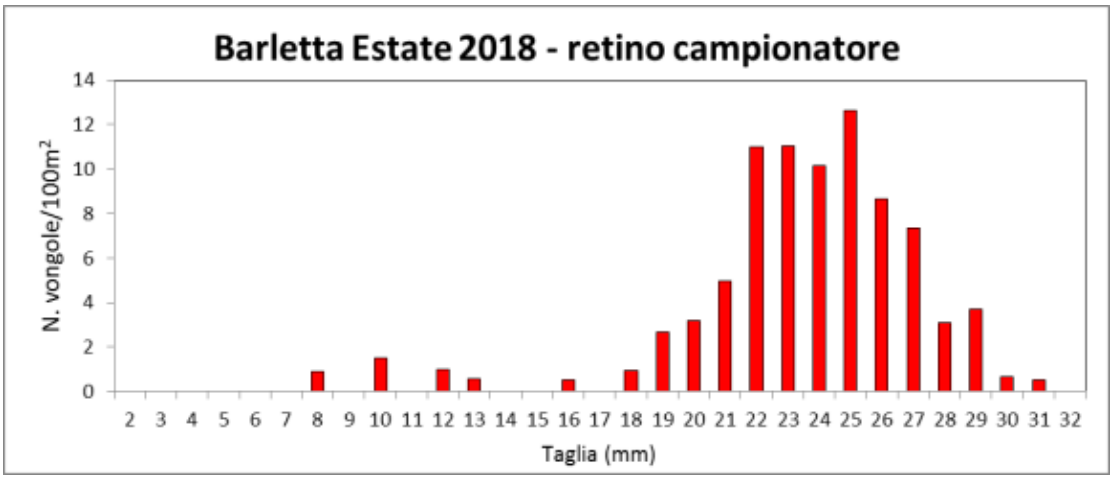



Figure 37: Standardized frequency distributions ( No clams/100m2 ) of individuals caught with the sampler screen in the Barletta district in 2018 in Summer.

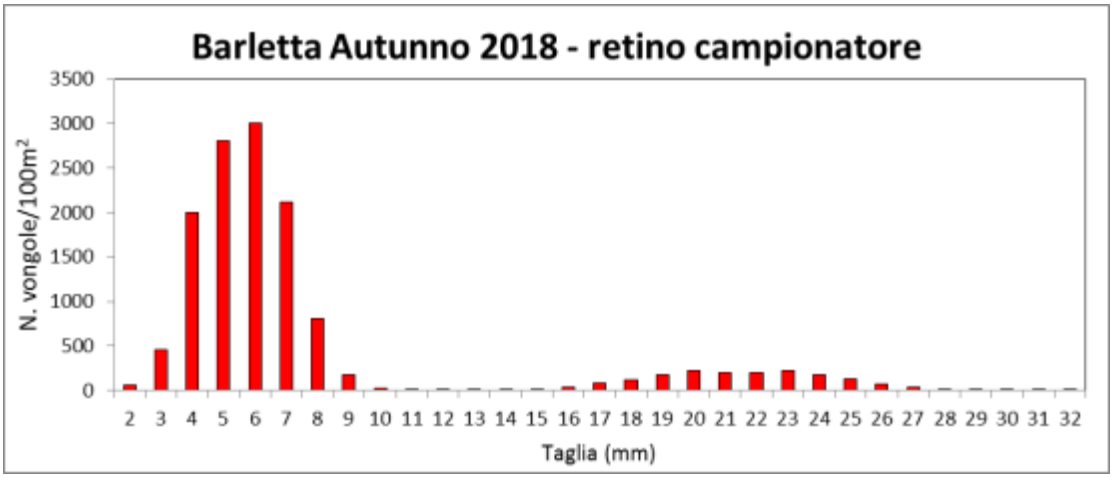



Figure 38: Standardized frequency distributions ( No clams/100m2 ) of individuals caught with the sampler screen in the District of Barletta in Autumn 2018.

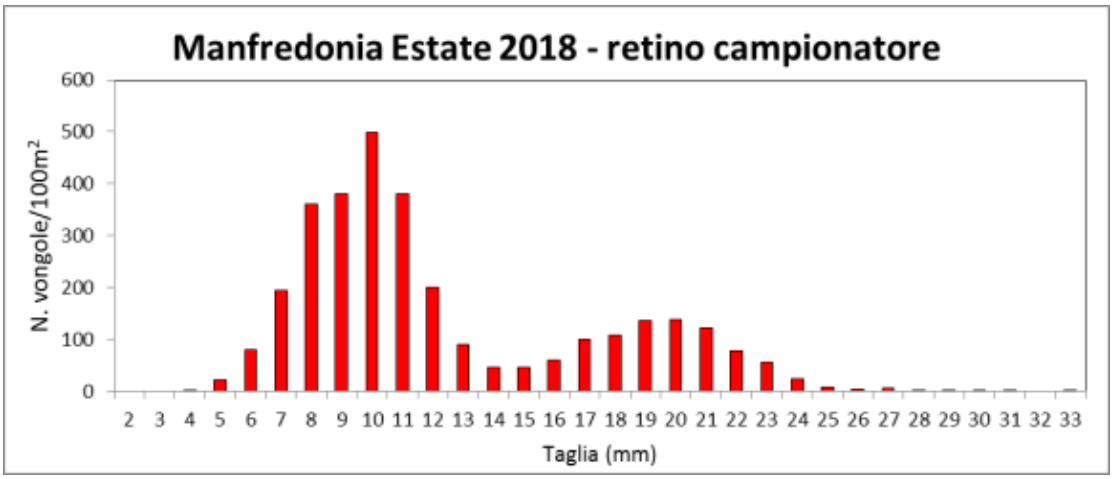



Figure 39: Standardized frequency distributions ( No clams/100m2 ) of individuals caught with the sampler screen in the Manfredonia District in 2018 in Summer.

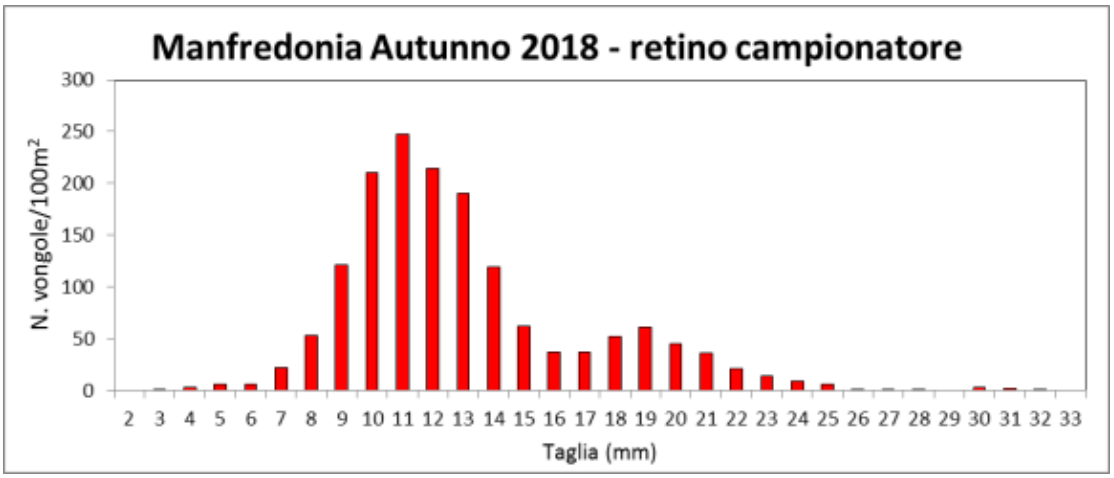



Figure 40: Standardized frequency distributions ( No clams/100m2 ) of individuals caught with the sampler screen in the Manfredonia District in 2018 in Autumn.

# 6. Monitoring of the National Plan

The National Plan envisages that the Directorate General for Maritime Fishing, in cooperation with regional administrations, should supervise the correct implementation of the National Plan for the Management of Hydraulic Dredges, acting as the go-between for the European Commission's relevant offices. In order to achieve this, the Directorate General for Maritime Fishing receives all necessary information through Harbour Master Offices, the Regions, Scientific Institutions and recognised individual Management Consortia.

Monitoring takes place at two levels; district and national.

Monitoring at the Maritime District level is entrusted to a scientific centre approved by the Ministry for Agriculture, Food, and Forest Policies, chosen by the Management Consortium, which cooperates with the same consortium for all required technical and scientific aspects.

Every consortium, with its associates and with support provided by the chosen scientific institution, is responsible for continuously monitoring the state of resources in the area for which it is responsible. In order to be implemented, the consortium's management decisions, such as closing and re-opening areas, establishing the maximum amounts that may be fished, the periods of time during which fishing is permitted, the creation of repopulation areas, seeding and moving activities, must be accompanied by the expert opinion of the appointed scientific institution.

The Consortia may divide up the territory they are responsible for into several areas for managerial reasons and establish their borders. On the basis of the results of their monitoring, the Consortium decides which areas can be closed or opened according to the reference points as set out in the Chapter entitled "*Reference points*". Management decisions proposed by each management consortium, such as maximum amounts of fishing permitted, period of time during which fishing is allowed, the creation of repopulation areas, etc. must be accompanied by the expert opinion of the reference scientific institution in order to be adopted.

By November 30th of every year, the Consortium for the Management and Protection of bivalve molluscs is obliged to send the programme for management and protection activities it plans to implement for the following year to the Directorate General for Maritime Fishing, and also for their information to its regional authorities. By February 28th, each Consortium prepares a detailed report on management activities carried out by the Consortium itself during the previous year.

National monitoring will be carried out once a year, in one of the two months during which is it compulsory to suspend all fishing, following a protocol and standard methodology for all areas in which hydraulic dredges operate.

A working group for fishing with hydraulic dredges is set up at the Directorate General, the members of which are chosen among mollusc fishing, biology and environmental experts. The working group sets out the sampling procedures for the annual national monitoring programme, analyses the results and cooperates with the Directorate General in the preparing of the yearly report on the state of bivalve mollusc resources in Italy, a report that will then be sent to the European Commission.

National monitoring will be carried out by one or more approved scientific institutions identified by the Directorate General for Maritime Fishing and operating on the territory in cooperation with the consortia.

Monitoring results concerning individual districts will be reported to the individual consortia by the Directorate General, indicating possible measures to be adopted on the basis of density figures found and compared to reference point figures as set out in the chapter entitled "*Reference points*".

Should individual consortia reveal inadequacies or malfunctions in managing activities, the Directorate General will adopt appropriate provisions aimed at avoiding such shortcomings to the extent of revoking the appointment.

Bivalve mollusc fishing will be regulated directly by the Ministry in maritime districts where Management Consortia have not yet been established or have not obtained results or whose ministerial approval has been withdrawn.

The Management Plan will be reviewed every three years, on the basis of annual management reports for individual districts and on the basis of the situation concerning the state of resources found in annual monitoring carried out using a uniform methodology as requested by the Italian Fishing Administration. Since within the Directorate General for Fishing there is a working group cooperating in the preparation of the yearly report on the state of bivalve mollusc resources, it will be the responsibility of this Directorate General for Fishing to send this paper as an intermediary report to the offices of the European Commission.

The Management Plan itself may be reviewed by the Directorate General for Maritime Fishing on the basis of results arising from monitoring or should elements arise to improve its efficiency.

# 7. Summary of Scientific Surveys for the razor shell (*Ensis minor*)

## 7.1. Razor shell Biology (*Ensis minor*; *Solen marginatus*)

Razor shells that are harvested populate the shallow waters of the north Adriatic, Latium and Campania. The harvested species are of two types, *Ensis* and *Solen*, but fishing is almost exclusively targeted to the *Ensis* type. The *Ensis minor* species is characterised by a limited area of distribution that goes from the coast to a depth of 4-5 metres, on coarse sandy almost mud-free sea beds. This strictly coastal area at times coincides with the strip of water where, for health reasons, the harvesting of molluscs is prohibited and, therefore, in many areas such as the coasts of Emilia Romagna, Marche, Abruzzi, razor shell fishing with hydraulic dredges has not been developed. In the Friuli Districts, where the sea bottom slope is more gentle and where there are inland water basins that act as filters for pollutants, razor shells are harvested by hydraulic dredges. In Veneto the razor shell resources subject to commercial fishing have in fact disappeared as a result of the extraordinary weather events of 2012, with bora winds that caused sudden and significant drops in the seabed temperature.

The most important harvesting activities are carried out in Latium and Campania. In other areas there are occasional case of manual harvesting by amateur fishermen.

The biological cycle of this species that lives embedded in the sediment where it moves vertically to escape predators, is similar to that of clams. There are separate genders, external fertilization, planktonic larvae and they settle on the seabed after a few weeks. Their development is faster than that of clams also because of the elongated shape of this species. They first reproduce after one year of age; at a length of 8 cm reproduction has taken place. Given that this species lives in the narrow strip of sea close to the shore, it is strongly affected by all human activities, in particular seaside tourism, and it presents significant fluctuations in its abundance year on year with a density that is generally low.

## 7.2. State of the razor shell resource in the Italian seas over the last 10 years

The historical catch data sent by all the Management Consortia (except the one in Rome) are shown in Figure 41. Some series are actually incomplete due to the fact that for some boats it was not possible to trace the quantities landed over the years. The historical series show the landings in kg (standardization is difficult due to the lack of some important data such as the actual fishing hours and days in some Districts). In the Naples district, indicating a trend over the years is difficult due to the limited data available, but there was a peak in catches in 2014 followed by a decline in subsequent years. The same peak of 2014 can be observed also in the Gaeta district, bordering the previous one. This may indicate a possible recovery of the resource in that year. The Gaeta series shows the typical ups and downs of this type of resource, with peaks in 2005, 2011 and 2014. As far as the Adriatic Districts are concerned, the quantities reported in Chioggia in 2004 and in Monfalcone between 2012 and 2013 stand out.

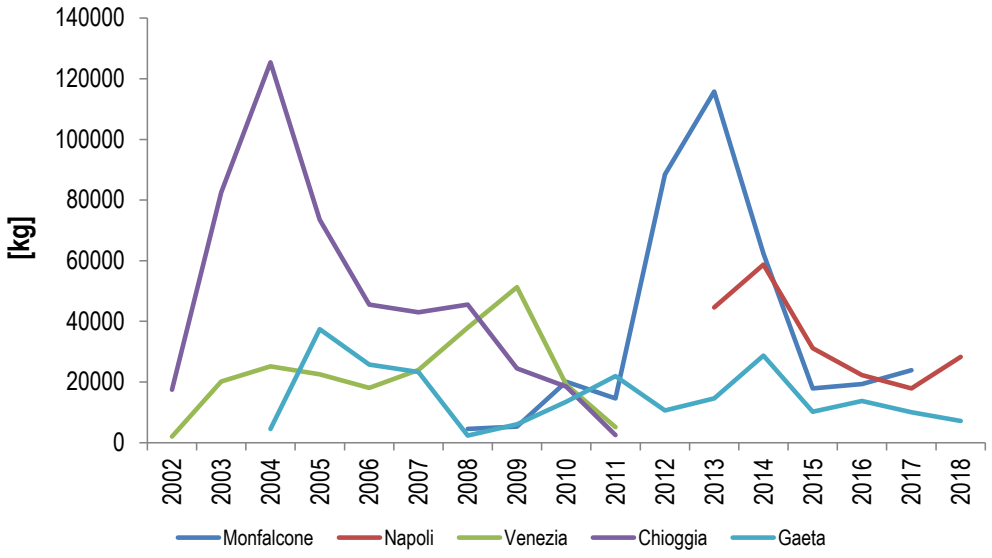



Figure 41: Annual production (kg) in the Tyrrhenian and Adriatic districts (Sources: Management Consortia). Data for the Rome district are not available.

With the 2016 and 2018 Ministerial Decrees, an attempt was made to provide a solution to the problems concerning the collection of data on the landings of 'cannellaria'. Until the establishment of the Management Consortia, the resource was managed on an individual basis and there was not always a clear and accurate archive of the quantities landed (moreover, many small boats used to sell, and still sell, directly to the retail trade without filling in a proper logbook of the quantities fished). The MDs, on the other hand, oblige the fishermen involved in the experimentation to complete daily logbooks indicating the quantities fished, the coordinates of the hauls and the actual fishing hours. Unfortunately, these measures were not always observed and data were collected sporadically and inconsistently (the decrees require that statistics are sent monthly). Unfortunately, not all the boats involved in the experiment were able to provide the required statistics. Such information is therefore incomplete and does not represent the entire fleet.

Table 21 summarizes the data reported in the logbooks received from fishermen in the years 2017 and 2018.

Table 21: Data relating to the quantities fished in 2017 and 2018 by the boats that provided the fishing statistics through logbooks, as provided for by MD 15/01/2016 and subsequent amendments. The months of April and May are not reported because of the compulsory biological rest period; FT = technical rest period; FB = compulsory biological rest period.

| District | | January | February | March | June | July | August | September | October | November | December | TOT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Gaeta (2017) | kg | - | 2033 | 1310 | 2129 | 1674 | 1649 | 613 | 1298 | 214 | 90 | 11010 |
| | n. boats | - | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 2 | 1 | - |
| | Fishing days | FT | 23 | 25 | 36 | 34 | 45 | 18 | 30 | 7 | 2 | 220 |
| | Fishing hours | | 160.5 | 179 | 141 | 132.5 | 162 | 55 | 195 | 49 | 14 | 1088 |
| | No. hauls | | 416 | 455 | 579 | 541 | 726 | 284 | 623 | 155 | 40 | 3819 |
| Gaeta (2018) | kg | - | - | - | 2959 | 2008 | 960 | 589 | 527 | 80 | - | 7123 |
| | n. boats | - | - | - | 3 | 3 | 3 | 3 | 3 | 1 | - | - |
| | Fishing days | FT | FT | FT | 33 | 36 | 28 | 22 | 15 | 4 | FT | 138 |
| | Fishing hours | FT | FT | FT | 125.5 | 129 | 96 | 75 | 83 | 24 | FT | 532.5 |
| | No. hauls | FT | FT | FT | 572 | 544 | 404 | 302 | 235 | 68 | FT | 2125 |
| Naples (2017) | kg | 615 | 201 | 885 | 4382 | 2998 | 2060 | 372 | 232 | - | - | 11745 |
| | n. boats | 3 | 3 | 6 | 9 | 8 | 9 | 6 | 2 | - | - | - |
| | Fishing days | 12 | 4 | 20 | 66 | 41 | 49 | 12 | 6 | FT | FT | 210 |
| | Fishing hours | 99 | 31 | 125 | 315 | 223 | 194 | 56 | 30 | | | 1073 |
| | No. hauls | 383 | 121 | 409 | 1144 | 795 | 664 | 152 | 74 | | | 3742 |
| Naples (2018) | kg | 1211 | 786 | 739 | 3734 | 4977 | 4189 | 5019 | 2988 | 1466 | 3031 | 28140 |
| | n. boats | 7 | 7 | 7 | 10 | 10 | 10 | 10 | 9 | 6 | 10 | - |
| | Fishing days | 28 | 12 | 18 | 31 | 56 | 57 | 61 | 42 | 15 | 52 | 372 |
| | Fishing hours | 184 | 96 | 108 | 219 | 348 | 390 | 370 | 290 | 105 | 329 | 2439 |
| | No. hauls | 625 | 321 | 355 | 729 | 1164 | 1303 | 1263 | 976 | 374 | 1073 | 8183 |
| Rome (2017) | kg | - | - | 6819 | 3505 | 2758 | 3334 | 1273 | 2341 | 46 | - | 20076 |
| | n. boats | - | - | 5 | 5 | 5 | 5 | 5 | 5 | 1 | - | - |
| | Fishing days | FT | FT | 55 | 40 | 30 | 39 | 16 | 44 | 1 | FT | 225 |
| | Fishing hours | | | 381 | 298 | 233 | 312 | 129.5 | 337 | 9 | | 1699.5 |
| | No. hauls | | | 1508 | 1206 | 958 | 1445 | 522 | 1525 | 30 | | 7194 |
| Monfalcone (2017) | kg | - | - | 4448.9 | - | - | - | - | 3543.3 | - | 2909.5 | 10902 |
| | | - | - | 18 | - | - | - | - | 8 | - | 13 | - |
| | | FT | FT | 190 | FB | FB | FB | FB | 120 | FT | 93 | 403 |
| | | | | 680.87 | | | | | 603.67 | | 444.1 | 1728.64 |
| | | | | 3648 | | | | | 2716 | | 2183 | 8547 |

This table does not include the data relating to the Adriatic Districts of Chioggia and Venice, which have not been fishing for razor shells for over 7 years due to the scarcity of the resource, nearly disappeared from the Venetian coast. Monfalcone is also suffering from a scarcity of the resource, so much so that in 2018 the Management Consortium closed the razor shell fishery because the resource did not reach a density compatible with the commercial exploitation.

The above table, and even more so the following graphs, show the monthly trend of the resource in terms of CPUE (Catch Per Unit Effort; Figure 42 and Figure 43) calculated on the basis of total fishing hours.

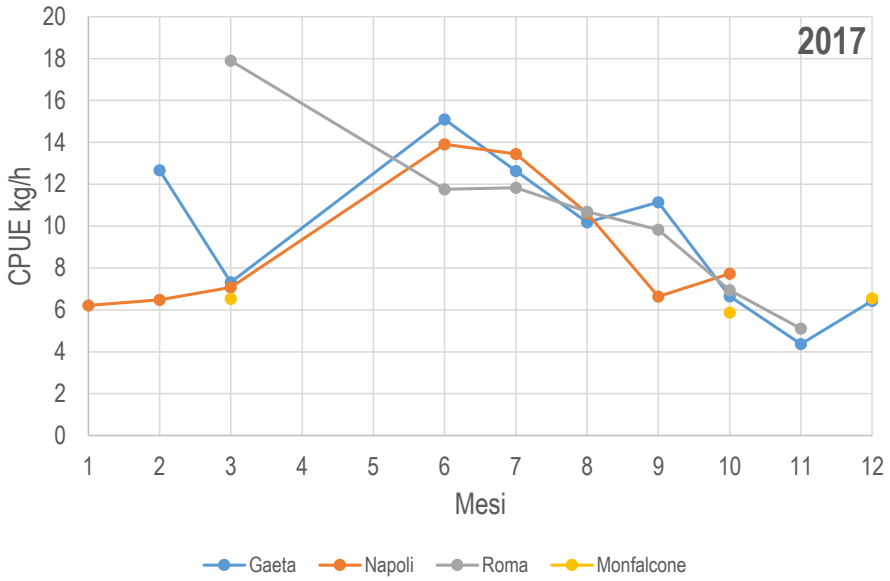



Figure 42: CPUE trend (kg/h) calculated on the basis of the logbooks sent by the Management Consortia in 2017

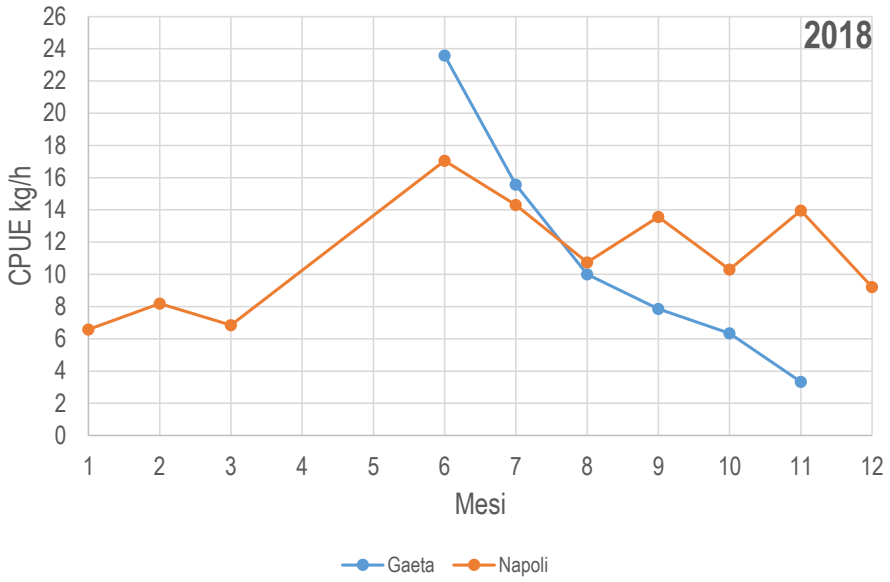



Figure 43: CPUE trend (kg/h) calculated on the basis of the logbooks sent by the Management Consortia in 2017.

In both years in June, immediately after the compulsory biological rest period, the most important catches were observed in the Tyrrhenian districts. They gradually decreased, with the only exception of Naples in 2018, where, after a first peak in June, the values were around 10 - 14 kg/h per boat. As far as the Monfalcone district is concerned, in just three months of fishing in 2017, there does not seem to be any deviation in pre- and post-fishing rest period catches.

## 7.3. Past information and monitoring

Table 22 shows the average values of the technical characteristics of the fleet of hydraulic dredgers and the average price of the catch for the 4 regions examined.

Table 22: Average technical characteristics of the fleet of hydraulic dredgers, average number of employees on board and average price of landings in 2011 (source Mipaaf/IREPA)

| Region | n. boats | Avg GT | Avg kW | Average no. of crew | €/kg |
|---|---|---|---|---|---|
| **Lazio** | 24 | 9.9 | 108.4 | 3.6 | 5.62 |
| **Campania** | 14 | 10.1 | 142.2 | 2.2 | 5.10 |
| **Veneto** | 163 | 11.3 | 109.9 | 2 | 3.28 |
| **Friuli V. G.** | 42 | 10.6 | 119.4 | 2 | 4.55 |

### *7.3.1. District of Naples*

The Co. Ge. Mo. of Naples has been in operation since 1997 and has experienced several difficulties related to resource fluctuations, with alternating periods of abundance and scarcity. The resource is sometimes present in the district of Salerno (where shellfish fishing is currently closed) and sometimes in the district of Naples. These fluctuations have been mainly linked to fishing activities and to death phenomena that drastically reduced the population of razor shells at the beginning of 2000. A total of 14 dredgers are members of the Consortium whose target species are razor shells and, occasionally, clams. Wedge shells, on the other hand, are fished through boat rakes. The last monitoring of the resource was conducted in 2013 by Unimar. According to their report, biomass values were below the reference points threshold, which would suggest that fishing activities in most of the district, with the exception of the northern part, north of the Volturno river, should be closed. A comparison with older data (Mariani et al., 1999) confirms the near absence of the resource beyond 6 m depth. Moreover, the population of razor shells is clearly declining compared to the past.

### *7.3.2. District of Gaeta*

The Consortium of Gaeta was established in 2008 and includes 4 dredgers, one of which is currently inactive. Another resource exploited is the wedge shell, with a fleet of 12 boat rakes. Two factors affect fishing with hydraulic dredges in the Gaeta Maritime District: the limited number of areas with razor shells and the small number of hydraulic dredges in use. Recently, the number of razor shells in this district has allowed to maintain a modest level of commercial exploitation of the species, although with an unstable space and time pattern. The scarcity of the resource has become evident since the early 2000s. It can be explained by a number of factors, probably linked to changes in environmental conditions, including the erosion of the coasts, beach re-sanding and, lastly, mucilage phenomena. The last monitoring to assess the state of the resource was conducted by Unimar in 2013 and showed that the areas of greatest profitability are extremely small. A

profitability level in line with the reference points was observed in the southern part of the district, in the areas of Gianola and the Garigliano river. In the rest of the district, biomass values are always below sustainable fishing limits. In 2013, Unimar findings were is in line with what Mariani et al. (1999) had already observed, i.e. the distribution of razor shells is uneven in the Gaeta district and is concentrated in the southern area.

### *7.3.3. District of Rome*

The Management Consortium of Rome was established in 1997. It runs 20 hydraulic dredges and 45 boat rakes for fishing wedge shells. Unimara conducted the last monitoring in 2012. The resource was homogeneous and continuous along the entire stretch of coast, although the highest density values were found in front of Torvajanica, and sporadically in some areas to the north. Historical research before the 1990s was rather poor, while data collected at the end of the 1990s reflected a disease that had severely affected the stock.

### *7.3.4. District of Monfalcone*

The Co.Ge.Mo. of Monfalcone, established following Ministerial Decree 44/1995, manages and coordinates 42 motor fishing boats, authorized to fish bivalves of the species Chamelea gallina (clam), Callista chione (smooth clam) and Ensis minor (razor shell) through the use of hydraulic dredges. The clam fishing activity involves 18 motor fishing boats. During the winter season, some fishing companies are used to catch razor shells, thus diversifying the fishing effort. The fleet that is authorized to fish for smooth clams includes 24 fishing boats that operate in synergy with the Venetian companies under the commercial supervision of the O.P. "I Fasolari".

The main effects of the high mortality of recent years resulted in a general impoverishment of resources along the entire coastline, both of specimens of commercial size, and smaller ones (sub-commercial and juveniles), causing a serious crisis for all fishing enterprises in Friuli.

In recent years, hydraulic dredges have also been used to fish for the sipunculide called "peanut worm" (Sipunculus nudus), a species that was considered as a by-catch of razor shell fishing until a couple of years ago. Over the years, peanut worm has gained increasing importance, driven by the market demand for bait used by sports fishermen. The low productivity of fishing for species such as clams and razor shells has resulted in a decreased fishing effort of these species in recent years, thus intensifying the fishing of the sipunculide.

Currently, the state of the natural stocks of bivalve molluscs managed by the Co.Ge.Mo. of Monfalcone is going through an extremely delicate phase; the Executive Board is trying to find solutions by means of a series of activities (restrictive measures, productive reactivation of the resource, detailed fishing programs, etc.) in collaboration with the Management Consortia of Veneto (Co.Ge.Vo. of Venice and Chioggia).

### *7.3.5. District of Chioggia*

The Co.Ge.Vo. of Chioggia, established following Ministerial Decree 44/1995, manages and coordinates 77 motorized fishing boats to fish bivalve shellfish through the use of hydraulic dredges. They fish for the species Chamelea gallina (clam), Callista chione (cockle), Ensis minor (wedge shell) and peanut worm (Sipunculus nudus). Saltwater clams (Acanthocardia spp.) and muricide gastropods (Bolinus brandaris and Hexaplex trunculus) are considered by-catches.

For several years now, the Chioggia district has been closely collaborating with the Co.Ge.Vo. of Venice, not only as regards cockle fishing (establishment of a single PO), but also clams and razor shells. Such collaboration involves a discussion and

preliminary development phase for each activity leading to an almost unified management of the entire Veneto fishing area. Currently, the hydraulic dredgers of Co.Ge.Vo. of Chioggia can also operate in the district of Venice and the units of Venice can operate also in the district of Chioggia, on the basis of common rules shared by the two Consortia. This collaborative efforts developed synergistically with the producers' organizations for the commercial part, OP I Fasolari and OP Bivalvia Veneto, sharing also the infrastructures to promote the sale of the product.

With regard to clam fishing, the Chioggia consortium manages 53 vessels, regulating the fishing effort on a monthly basis. Until 2011, the fishing effort of these boats was distributed between clams and razor shells: 20-30 motor boats (Veneto Region) were used to fish for razor shells, with a reduced fishing effort on the resource C. gallina for 6 month a year. Twenty-four vessels are dedicated to cockle fishing and their authorization is reviewed every three years.

#### *7.3.6. District of Venice*

The Co.Ge.Vo. of Venice, established following Ministerial Decree 44/1995, runs and coordinates 86 motorized fishing boats to fish bivalve shellfish through the use of hydraulic dredges for of the species *Chamelea gallina* (clam), *Callista chione* (cockle) and *Ensis minor* (wedge shell). Saltwater worms (*Acanthocardia* spp.) and muricide gastropods (Bolinus brandaris and Hexaplex trunculus) are considered by-catches. The intense collaboration with the consortium of Chioggia has resulted in a regional management of various activities, leading to the creation of the O.P. Bivalvia Veneto. This latter was established in 2005 and recognized by Mipaaf in 2006. In Italy, the Bivalve Molluscs fisheries management is still one of the best examples of cooperation and management on macro-areas. An even more representative example is the O.P. I Fasolari (recognized by Mipaaf in 2000). It coordinates businesses and fishing activities for this species in the three northern Adriatic districts (Chioggia, Venezia and Monfalcone) and two different regions.

With regard to clam fishing, the Venetian consortium manages 52 vessels, regulating the fishing effort on a monthly basis. Until 2011, the fishing effort of these vessels was distributed between clams and razor shells: 20-30 motorized fishing boats (Veneto Region) fished for razor shells allowing for a reduced fishing effort on the resource *C. gallina* six months a year. Thirty-four vessels are dedicated to cockle fishing. Their authorization is reviewed every three years, as also provided by the consortia of Chioggia and Friuli.

## 7.4. Summary of surveys

#### *7.4.1. Description of fishing areas*

The Maritime Districts involved in the surveys for the razor shell resource are 6, equally distributed across the Tyrrhenian Sea and the northern Adriatic Sea. All districts share the same geographical constraints, i.e. works at sea (breakwaters, coastal basins, soft dams, protected areas), which effectively reduce the fishing area within 0.3 nm. In the Tyrrhenian districts, this problem is even more evident due to the fact that depth abruptly increases just a few hundred meters from the coast and granulometry shifts from sandy to muddy: both factors are not compatible with the survival and proliferation of razor shells. In the Adriatic, however, due to the conformation of the seabed and the low bathymetry even at great distances from the coast, razor shells can be fished even beyond 0.3 miles.

Table 23 below shows the geographical limits of the individual districts.

Table 23: Geographical boundaries of the Maritime Districts where razor shell fishing is carried out and where surveys were conducted in 2017 and 2018.

| District | District boundaries | Coastline km | Nr. Dredgers |
|---|---|---|---|
| Naples | From the mouth of the Garigliano river to Pozzuoli | 52 | 14 |
| Gaeta | From Torre Astura up to the mouth of the Garigliano river | 150 | 4 |
| Rome | From Fosso Cupino up to the Astura river | 69 | 20 |
| Monfalcone | From Punta Tagliamento to San Giovanni di Duino | 53 | 42 |
| Chioggia | From the city of Chioggia up to the mouth of Po river in Goro | 62 | 77 |
| Venice | From Villaggio Caroman to Punta del Tagliamento | 82 | 86 |

### *7.4.2. 2017 Survey findings*

The results of the 2017 surveys showed worrying biomass density values in all Maritime Districts considered (Table 24 and Table 25). Most transects did not even exceed the fishing closure threshold according to the current reference points (< 8 g/m2 and < 10 g/m2, for GSA 9 - 10 and GSA 17, respectively).

Considering the average densities across the whole area, it appears that the highest values (always within the attention threshold of the reference points) for the Tyrrhenian Districts were in Naples and Gaeta, while Rome keeps an average density well below the fishing limit. In the Adriatic districts, on the other hand, the average values for all districts are always below the fishing limit.

In the Tyrrhenian Sea and in Monfalcone, the proportion between undersized and oversized individuals was almost always in favor of the former, indicating a good recruitment for the following year. As to the other two Adriatic Districts, the catches were so small that it was not possible to draw any information about the population.

Table 24: 2017 Monitoring - Weight densities for standardized commercial size classes (g/m2) of razor shells in the Tyrrhenian Sea Districts. In bold, density values exceeding the limits of good management of the resource; italics indicate values that fall within the limits of attention for commercial exploitation: A: 1.5 m depth; B: 2.5-3 m depth; C: 4 m depth.

| Naples | | | | |
|---|---|---|---|---|
| Individuals ≥ 80 mm | | | | |
| Transect | A | B | C | TOT |
| NA01 | **36** | **22** | 1.8 | **60** |
| NA02 | 2.7 | 4.3 | 3.4 | **10.4** |
| NA03 | 2.4 | 3.8 | 1.9 | *8.2* |
| NA04 | 1.7 | 3.2 | - | 4.9 |
| NA05 | *8* | 0.4 | 0.7 | *9.1* |
| NA06 | 1.5 | 2.8 | 0.9 | 5.2 |
| NA07 | 0.6 | 2 | 1.7 | 4.3 |
| NA09 | 1 | 4 | 1.6 | 6.6 |
| NA10 | - | 2.9 | 0.7 | 3.6 |
| NA11 | 6.3 | 2.7 | 0.2 | *9.2* |
| NA12 | 1.3 | 4.4 | 0.1 | 5.8 |
| NA13 | 0.5 | 3.3 | 1.5 | 5.3 |
| NA14 | 2.4 | 0.4 | 2.8 | 5.6 |
| Mean | 5.4 | 4.3 | 1.4 | 10.6 |
| St.dev. | 10 | 5.4 | 1 | 15 |

| Rome | | | |
|---|---|---|---|
| Individuals ≥ 80 mm | | | |
| Transect | A | B | TOT |
| RO01 | 0.6 | 3.5 | 4.2 |
| RO02 | 2.1 | 1 | 3.1 |
| RO03 | 1.1 | 5.7 | 6.7 |
| RO05 | 0.5 | 0.1 | 0.6 |
| RO06 | 0.8 | 3.2 | 4 |
| RO07 | 5.1 | 3.4 | *8.6* |
| RO08 | - | 0.1 | 0.1 |
| RO09 | 7 | 2.6 | *9.6* |
| RO10 | 0.7 | 3.6 | 4.3 |
| RO11 | 1.7 | 1.6 | 3.4 |
| RO12 | 2 | 1.4 | 3.4 |
| RO13 | 1.8 | 0.7 | 2.5 |
| RO14 | 0.3 | 0.8 | 1.1 |
| Mean | 2 | 2.1 | 4 |
| St.dev. | 2.1 | 1.7 | 2.9 |

| Gaeta | | | | |
|---|---|---|---|---|
| Individuals ≥ 80 mm | | | | |
| Transect | A | B | C | TOT |
| GA01 | 7.4 | **18.4** | 0.3 | **26** |
| GA02 | 4.1 | 1.5 | 1.1 | 6.7 |
| GA03 | - | 0.5 | 0 | 0.5 |
| GA04 | 0.2 | - | - | 0.2 |
| GA05 | 0.1 | 1 | 0 | 1.2 |
| GA08 | 0.7 | 3.7 | - | 4.4 |
| GA09 | *12.7* | *14.4* | 0.4 | **28** |
| GA10 | *14.8* | 0.2 | - | **15** |
| GA11 | 0.6 | 0.8 | 0.2 | 1.6 |
| Mean | 5.1 | 5.1 | 0.3 | 9.2 |
| St.dev. | 5.9 | 7.1 | 0.4 | 10 |

Table 25: 2017 Monitoring - Weight densities for standardized commercial size classes (g/m2) of razor shells in the Adriatic Sea Districts. In bold, density values exceeding the limits of good management of the resource; italics indicate values that fall within the limits of attention for commercial exploitation: A: 1.5 m depth; B: 2.5-3 m depth

| Venice | | | |
|---|---|---|---|
| Specimens ≥ 80 mm | | | |
| Transept | A | B | TOT |
| VE01 | 0.04 | 0.14 | 0.19 |
| VE02 | - | - | 0 |
| VE03 | - | 0.04 | 0.04 |
| VE04 | 0.24 | 0.04 | 0.29 |
| VE05 | 0.03 | 0.09 | 0.12 |
| VE06 | 0.14 | 0.03 | 0.17 |
| VE07 | 0.04 | - | 0.04 |
| VE08 | - | 0.03 | 0.03 |
| VE09 | 0.03 | 0.11 | 0.14 |
| VE10 | - | - | 0 |
| VE11 | - | - | 0 |

| Chioggia | | | |
|---|---|---|---|
| Specimens ≥ 80 mm | | | |
| Transept | A | B | TOT |
| CH01 | 0.39 | - | 0.39 |
| CH02 | 0.21 | - | 0.21 |
| CH03 | 0.63 | 0.35 | 0.97 |
| CH04 | 0.03 | 0.08 | 0.11 |
| CH05 | 0.34 | 0.77 | 1.1 |
| CH06 | - | 0.03 | 0.03 |
| CH07 | 0.19 | 0.11 | 0.29 |
| CH08 | 1.12 | 1.47 | 2.58 |
| CH09 | 0.08 | 0.07 | 0.14 |
| CH10 | 0.08 | 0.16 | 0.24 |
| CH11 | 0.17 | 0.32 | 0.48 |

| Monfalcone | | | |
|---|---|---|---|
| Specimens ≥ 80 mm | | | |
| Transept | A | B | TOT |
| MN01 | 0.3 | - | 0.3 |
| MN02 | 0.4 | - | 0.4 |
| MN03 | 9.4 | **10.7** | **20.1** |
| MN04 | **18.8** | **10.9** | **29.8** |
| MN05 | 0.2 | 0.5 | 0.6 |
| MN06 | 2 | 1.3 | 3.3 |
| MN07 | 8.9 | 2.7 | **11.6** |
| MN08 | 2 | 0.6 | 2.7 |
| MN09 | 1.2 | - | 1.2 |
| MN11 | 0.9 | 3.7 | 4.6 |
| Media | 4.4 | 4.4 | 4.4 |

| Venice | | | |
|---|---|---|---|
| Specimens ≥ 80 mm | | | |
| Transept | A | B | TOT |
| VE12 | - | - | 0 |
| VE13 | - | - | 0 |
| VE14 | - | - | 0 |
| VE15 | 0.08 | - | 0.08 |
| VE16 | - | - | 0 |
| VE17 | - | - | 0 |
| VE18 | - | - | 0 |
| VE19 | - | - | 0 |
| Media | 0.09 | 0.07 | 0.08 |
| St.dev | 0.08 | 0.05 | 0.06 |

| Chioggia | | | |
|---|---|---|---|
| Specimens ≥ 80 mm | | | |
| Transept | A | B | TOT |
| CH12 | 0.3 | - | 0.3 |
| CH13 | 0.83 | 0.67 | 1.49 |
| CH14 | 0.32 | 0.94 | 1.26 |
| CH15 | 0.13 | 0.08 | 0.21 |
| CH16 | 0.15 | 0.11 | 0.26 |
| CH17 | 0.12 | 0.34 | 0.47 |
| CH18 | - | 0.04 | 0.04 |
| Media | 0.32 | 0.37 | 0.34 |
| St.dev | 0.3 | 0.42 | 0.36 |

| Monfalcone | | | |
|---|---|---|---|
| Specimens ≥ 80 mm | | | |
| Transept | A | B | TOT |
| St.dev | 6.1 | 4.6 | 5.4 |

### *7.4.3. 2018 Survey findings*

In 2018, no improvement was achieved, with a high percentage of hauls not even reaching the minimum allowable fishing density (Table 26 and Table 27). Of particular concern is the sharp decline in stocking densities in the only Adriatic district where razor shell fishing is still carried out.

The total average densities show a marked reduction in Naples and Gaeta compared to the previous year, while a substantial recovery, still within the limit of the attention threshold, was recorded in Rome. In the Monfalcone district, the situation deteriorated with a sharp drop in densities, explaining why they had to stop fishing for razor shells in 2018.

Table 26: 2018 Monitoring - Weight densities for standardized commercial size classes (g/m2) of razor shells in the Tyrrhenian Sea Districts. In bold, densities exceeding the limits of proper management of the resource; italics indicate values that fall within the limits of attention for commercial exploitation: A: 1.5 m depth; B: 2.5-3 m depth; C: 4 m depth.

| Naples | | | | |
|---|---|---|---|---|
| Specimens ≥ 80 mm | | | | |
| Transept | A | B | C | TOT |
| NA01 | 0.6 | 1.2 | 0.8 | 2.6 |
| NA02 | 2 | 0.8 | 1.7 | 4.6 |
| NA03 | 1.1 | 2.4 | 1.9 | 5.4 |
| NA04 | 2.1 | 6.6 | 0.6 | *9.3* |
| NA05 | 1.4 | 0.3 | 0.1 | 1.7 |
| NA06 | **16.9** | 1.3 | 0.2 | **18.4** |
| NA07 | 0.3 | - | 0.4 | 0.7 |
| NA09 | 0.3 | 0.1 | 0.04 | 0.5 |
| NA10 | 0.4 | 0.8 | 0.1 | 1.3 |
| NA11 | 2.4 | 7 | 1.7 | *11* |
| NA12 | 0.5 | 4.6 | 0.4 | 5.4 |
| NA13 | 1 | 1.4 | - | 2.4 |

| Rome | | | |
|---|---|---|---|
| Specimens≥ 80 mm | | | |
| Transept | A | B | TOT |
| RO01 | 0.3 | 4.9 | 5.2 |
| RO02 | 2 | 2 | 4 |
| RO03 | 1.2 | 2.3 | 3.5 |
| RO04 | 0.5 | 0.4 | 0.8 |
| RO07 | - | 2.9 | 2.9 |
| RO08 | 5.2 | 5.2 | *10.4* |
| RO09 | 7.7 | 3.1 | *10.8* |
| RO10 | 3.7 | **21.8** | **25.5** |
| RO11 | 3.2 | 6 | 9.3 |
| RO12 | *10* | *9.4* | **19.4** |
| RO15 | 1.2 | 0.1 | 1.3 |
| Media | 3.5 | 5.3 | 8.5 |

| Gaeta | | | | |
|---|---|---|---|---|
| Specimens≥ 80 mm | | | | |
| Transept | A | B | C | TOT |
| GA01 | *10.5* | 1.3 | - | *11.8* |
| GA02 | 1.8 | 4.7 | - | 6.5 |
| GA03 | 1 | - | - | 1 |
| GA04 | 0.5 | 0.2 | - | 0.7 |
| GA05 | 3.8 | 1.3 | - | 5.1 |
| GA06 | 1.6 | 1 | - | 2.6 |
| GA07 | 2.7 | 6 | - | *8.8* |
| GA08 | *9.4* | 2 | - | *11.3* |
| GA09 | **19** | 5.8 | - | **24.8** |
| GA10 | *14.1* | 0.4 | - | *14.5* |
| GA11 | 0.1 | 0.1 | 0.2 | 0.5 |
| GA12 | 0.1 | 0.1 | - | 0.2 |

| Naples | | | | |
|---|---|---|---|---|
| Specimens ≥ 80 mm | | | | |
| Transept | A | B | C | TOT |
| NA14 | 2.2 | 6.2 | 0.1 | *8.6* |
| Media | 2.4 | 2.7 | 0.6 | 5.5 |
| St.dev | 4.4 | 2.6 | 0.7 | 5.2 |

| Rome | | | |
|---|---|---|---|
| Specimens≥ 80 mm | | | |
| Transept | A | B | TOT |
| St.dev | 3.2 | 6.1 | 7.8 |

| Gaeta | | | | |
|---|---|---|---|---|
| Specimens≥ 80 mm | | | | |
| Transept | A | B | C | TOT |
| GA13 | - | 0.1 | - | 0.1 |
| GA14 | - | 0.5 | 0.3 | 0.8 |
| GA15 | - | 0.4 | 0.04 | 0.4 |
| Media | 5.4 | 1.7 | 0.2 | 5.9 |
| St.dev | 6.3 | 2.1 | 0.1 | 7.2 |

Table 27: 2018 Monitoring - Weight densities for the standardized commercial size classes (g/m2) of razor shells in the Monfalcone Maritime District. A: 1.5 m depth; B: 2.5-3 m depth; C: 4 m depth.

| Specimens≥ 80 mm | | | |
|---|---|---|---|
| Transept | A | B | TOT |
| MN01 | - | 0 | - |
| MN03 | 1.0 | 0 | 1.0 |
| MN04 | - | 0.2 | 0.2 |
| MN05 | 0.1 | 0.1 | 0.3 |
| MN06 | 0.2 | 0 | 0.2 |
| MN07 | 5.5 | - | 5.5 |
| MN08 | 3.6 | - | 3.6 |
| MN09 | 0.8 | 0.2 | 1.0 |
| Media | 2.1 | 0.2 | 1.3 |
| St.dev | 2.2 | 0.1 | 1.9 |

It would appear that the high percentage of recruits observed in 2017 has not increased to a commercial size. Moreover, in 2018 the proportion of juveniles seems to be lower than the previous year (at least in the Naples district), while in the districts of Gaeta and Rome, the proportion is still quite favorable to undersized individuals.

In the Maritime District of Monfalcone, not only the size classes of adults, but also those of juveniles, seem to have collapsed in density.

# 8. Summary of Scientific Surveys for the smooth clam (*Callista chione*)

## 8.1. Smooth clam biology (*Callista chione*)

### *8.1.1. Morphology and habitat*

The smooth clam is a bivalve mollusc present in the whole Mediterranean and in the eastern Atlantic, from the coasts of Morocco up to Great Britain.

Common in the Mediterranean waters and very common in the Northern Adriatic, *Callista chione* is a filtering organism (it feeds on small plankton and organic material). It lives in the superficial part of the sediment (infauna), on sandy bottoms in fairly deep waters. The shoals subject to fishing in the Northern Adriatic are located 8-10 nautical miles from the Venetian coast, at a depth of 18-22 m, while along the Friulian coast they form large populations at bathymetry of 10-15 m about 5-8 nautical miles from the shore.

The shell, rather sturdy and thick, is made up of two identical smooth valves, slightly elongated in shape, pinkish or reddish-brown with thin concentric stripes and radial bands. A strong red foot allows the body to sink into the sediment, from where it is able to feed itself through the two long siphons fused together that emerge from the sand. Vibrating eyelashes ensure movement inside the niche, generating currents that pump water from outside (through the inhalant siphon), pass it through the mantle cavity and, once filtered, expel it through the exhaling siphon. Water, in addition to bringing food, is essential for breathing: the oxygen-carbon dioxide exchanges (O2 and CO2) take place mainly through the mantle, rather than in the gills. Smaller specimens are lighter and have a more elongated shape, while adult individuals reach a maximum size of 10 cm and have a more rounded shape.

### *8.1.2. Life cycle*

Like other venerides, smooth clams, after a juvenile stage during which they develop the reproductive system in an undifferentiated way, reach sexual maturity at a size less than 40 mm in length and at the age of about 3-4 years they have therefore reproduced several times. Both males and females, when they are mature for reproduction, have well developed gonads, of milky appearance in both sexes. The distinction between genders is not macroscopically obvious; it is necessary to examine it in depth under the microscope, and despite this, in some specimens it is not possible to distinguish the sex in certain periods of their life cycle. However, evaluations carried out in several studies (Valli et al., 1994 and Tirado et al., 2002) report a sex ratio of 1:1.

If environmental conditions permit, gametogenesis begins in September and continues until January; gamete release extends from February to September, especially between May and August. From July to September, you can see specimens at the end of the reproductive cycle, but since gametogenesis starts again immediately after the first release, another reproductive cycle follows the end of the first. It is for this reason that in this species it is difficult to distinguish a period of sexual rest, because while a fraction of the population ends the reproductive cycle, the other begins the new one.

Like all bivalves, also the smooth clam allows larval stages from planktonic to benthic to fix the small bivalve as last, which grows sunk in the sand.

The smooth clam is characterized by a rather slow growth, and takes about 3-4 years to reach the size of first catch (40 mm) and between 11 and 14 years to reach the size of about 85 mm.

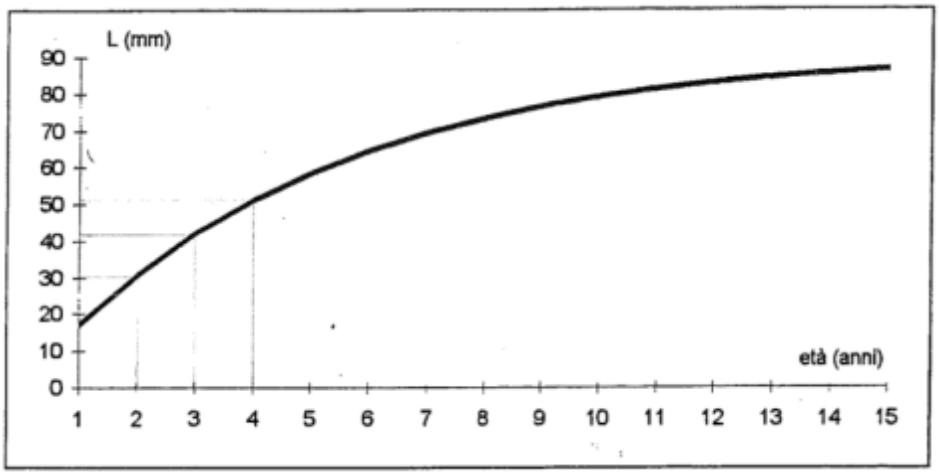



Figure 44: Growth curve of Callista chione (Source: Marano et al., 1998)

The weight-length ratio reflects the location where the specimens were found: growth is faster in the Mediterranean Sea (Marano et al., 1998) and much slower in the much colder waters of the British coast (Forster, 1981). In particular, in the Northern Adriatic Sea, the specimens fished in Trieste and those caught in Chioggia have an almost identical growth rate.

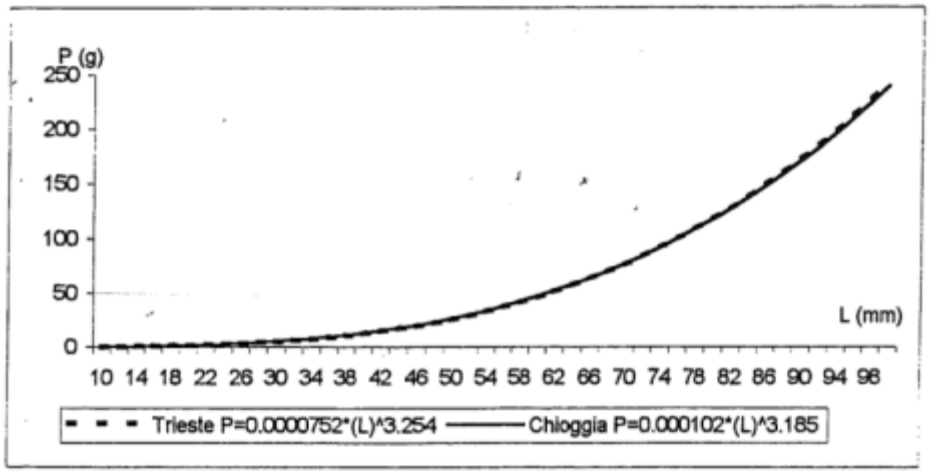



Figure 45: weight-length ratio of Callista chione (Source: Marano et al., 1998)

## 8.2. *C. chione* fishing data

The species is not subject to a minimum size; moreover, it lives in thousands of shoals scattered in the northern Adriatic. Therefore, no ad hoc survey has been planned for this species, but since 2017 biological information has been collected.

This species lives in environments with rough sand at depths of more than 10 meters and is mainly distributed in the upper Adriatic where there are outcrops of residual sands of the old coastline with very different shape and size. There are hundreds of bumps scattered from Friuli to Chioggia and off the coast of Istria. The location of the bumps up to 8-10 miles from the coast is considered an important element for the development of fishing; the Consortia members of the O.P. Fasolari have prepared a map of the bumps where they carry out fishing in rotation.

The biology of smooth clams shares some aspects with other bivalve species, such as the pelagic life phase and the settlement on muddy bottoms with no active movement of adults. The smooth clams reproduce already at the age of 3 years at a size of 40 mm; they can live more than 10 years and reach a size of more than 9 cm. The growth is fast enough in the first 4 years to slow down in the following years; fishing mainly catches specimens between 45 and 6° mm after they have reproduced.

The distance between bumps and the small size of each bump result in very different situations in the individual areas. Typically, fishing is carried out in one area until catches of commercial size are considered economically viable; then, they move to another bump and leave small smooth clams grow above the commercial size.

In other words, sub-area and rotational fishing is a normal situation in smooth clam fisheries.

At national level, hydraulic dredger fishing (dominated by the Chioggia, Venice and Monfalcone marinas) has also experienced a progressive decrease in total landings from 2011 to 2017 (Table 28).

Table 28: Total annual landings (tons) of smooth clams along the Italian coasts.

| Year | January | February | March | April | May | June | July | August | September | October | November | December | TOT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2011 | 75.7 | 69.8 | 112.7 | 135.7 | 128.5 | 159 | 155.8 | 185.1 | 145.7 | 110.7 | 117.5 | 307.8 | 1703.9 |
| 2012 | 60.2 | 50.9 | 86.3 | 109.4 | 118.1 | 130.6 | 138.8 | 171.5 | 106.5 | 104.9 | 69.5 | 281.8 | 1428.6 |
| 2013 | 81.8 | 63.5 | 87.1 | 76.1 | 138.5 | 128.6 | 146.7 | 169.3 | 111.8 | 125.4 | 78.4 | 285.7 | 1493.1 |
| 2014 | 27.3 | 27.7 | 25.5 | 44 | 37.6 | 127.8 | 142.3 | 157.9 | 117.2 | 93.9 | 75.6 | 260.5 | 1137.1 |
| 2015 | 59 | 64.2 | 69.4 | 91.1 | 77.2 | 104.8 | 106.9 | 133.9 | 82.9 | 67.4 | 60.8 | 242.2 | 1159.9 |
| 2016 | 53.2 | 66 | 77.6 | 65.2 | 97.8 | 106.7 | 102.6 | 128.4 | 102.2 | 73 | 67.7 | 229.7 | 1170.0 |
| 2017 | 27.6 | 45.6 | 57.3 | 68.6 | 85.4 | 118.1 | 145.7 | 155.5 | 89.5 | 53.7 | 43.9 | 140.4 | 1031.3 |

In the same way, sales fell progressively from 2011 to 2017, as shown in Table 29.

Table 29: Turnover (Euro x 1000) concerning the sale of smooth clams at national level.

| Anno | January | February | March | April | May | June | July | August | September | October | November | December | TOT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2011 | 340.6 | 314.0 | 507.3 | 604.1 | 578.1 | 715.7 | 690.3 | 833.0 | 655.5 | 498.2 | 528.8 | 1385.0 | 7650.4 |
| 2012 | 271.1 | 223.5 | 388.4 | 492.5 | 531.4 | 581.7 | 624.6 | 771.8 | 479.1 | 472.1 | 312.8 | 1268.2 | 6417.1 |
| 2013 | 363.9 | 279.2 | 385.7 | 341.4 | 629.2 | 550.8 | 636.8 | 740.9 | 491.5 | 557.9 | 353.2 | 1312.8 | 6643.3 |
| 2014 | 122.7 | 124.5 | 114.9 | 198.1 | 169.1 | 567.9 | 624.2 | 730.0 | 527.3 | 422.4 | 340.1 | 1093.0 | 5034.1 |
| 2015 | 265.4 | 289.0 | 312.3 | 410.2 | 347.4 | 471.8 | 481.1 | 602.4 | 372.9 | 303.5 | 273.6 | 1090.0 | 5219.6 |
| 2016 | 239.4 | 296.9 | 349.1 | 293.2 | 440.3 | 480.0 | 461.7 | 577.7 | 459.8 | 328.4 | 304.8 | 1033.8 | 5265.1 |
| 2017 | 124.1 | 205.1 | 257.8 | 308.6 | 384.3 | 531.6 | 655.8 | 699.8 | 403.0 | 241.7 | 197.5 | 631.6 | 4640.9 |

Despite the decline in profit, the average price of C. chione remained almost constant over the years, ranging between 4.4 Euro/kg in 2013 to 4.5 Euro/kg in 2015, 2016 and 2017, as also evident in Figure 46, that shows the average price and the average trend of standardized catches on the day of fishing (kg / day).

Also for this species, the daily catches cannot indicate the state of the resource as the catching activity is mainly conditioned by the market requests (a resource is taken depending on how much the markets require it).

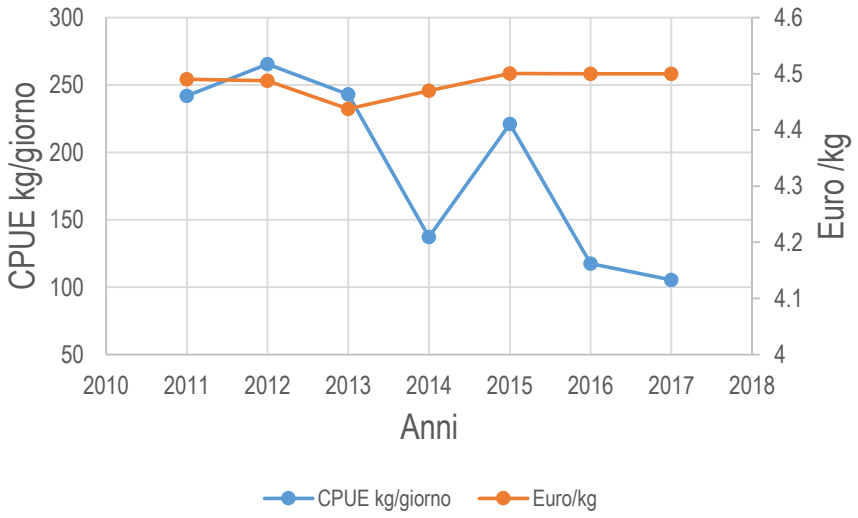



Figure 46: Annual trends in standardized catches (CPUE; kg / day) and average price trends for *C. chione*.

The main production of fasolari (*Callista chione*) comes from Veneto. The regional production has decreased over time to comply with an agreement between the management consortia of Monfalcone, Venice and Chioggia, which decreases the Venetian boats and increases those of Friuli, which have difficulties in fishing for *Chamelea gallina*.

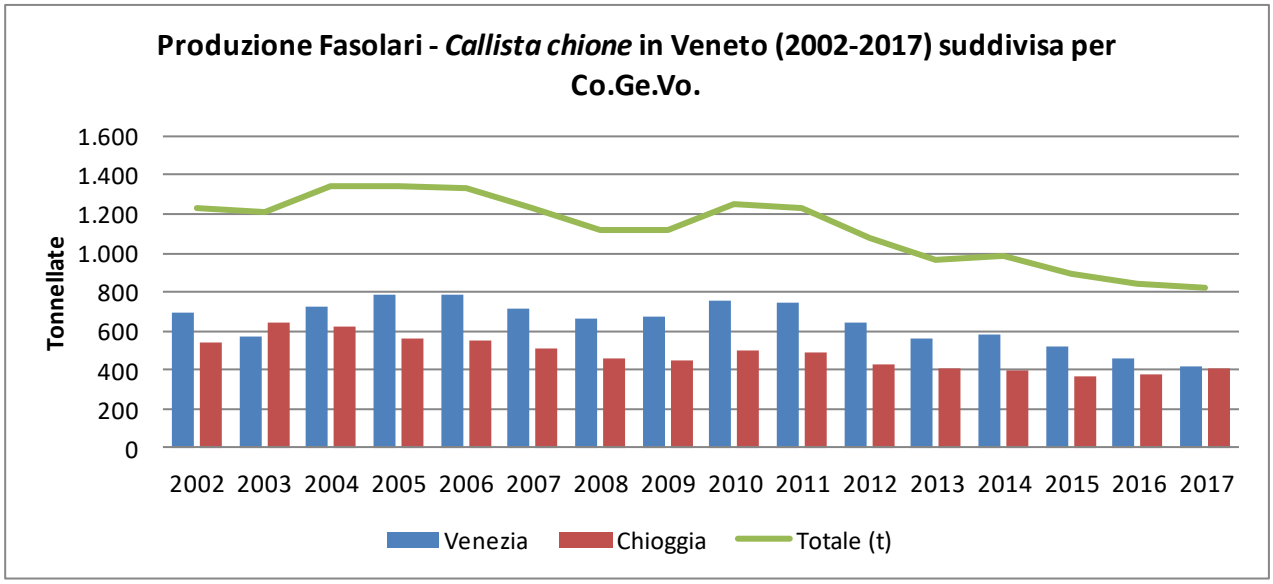



Figure 47: Total annual catches (tons) of *C. chione* of the Veneto Consortia between 2002 and 2017

Table 30: Total annual catches (tons) of *C. chione* along the Veneto coast.

| *Mese* | *2002* | *2003* | *2004* | *2005* | *2006* | *2007* | *2008* | *2009* | *2010* | *2011* | *2012* | *2013* | *2014* | *2015* | *2016* | *2017* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **January** | 72,5 | 89,7 | 61,9 | 72,0 | 72,6 | 64,7 | 65,4 | 49,6 | 62,8 | 55,7 | 45,6 | 49,8 | 52,4 | 39,6 | 39,9 | 27,3 |
| **February** | 63,3 | 53,0 | 65,1 | 71,8 | 71,1 | 70,1 | 63,0 | 54,1 | 63,5 | 49,0 | 37,0 | 43,5 | 48,7 | 38,0 | 46,9 | 53,5 |
| **March** | 63,7 | 79,9 | 82,9 | 109,5 | 79,4 | 63,8 | 71,2 | 62,6 | 72,0 | 79,1 | 69,6 | 65,5 | 50,8 | 57,7 | 57,5 | 54,3 |
| **April** | 97,2 | 87,8 | 89,1 | 96,2 | 101,7 | 100,3 | 87,5 | 83,3 | 77,5 | 83,9 | 85,6 | 64,6 | 80,9 | 77,0 | 50,2 | 44,9 |
| **May** | 130,4 | 104,0 | 100,9 | 123,5 | 117,2 | 110,6 | 92,9 | 79,9 | 92,7 | 102,8 | 88,0 | 73,3 | 76,3 | 60,1 | 63,5 | 83,5 |
| **June** | 103,7 | 118,7 | 124,6 | 139,3 | 120,9 | 99,6 | 89,7 | 108,5 | 106,7 | 119,5 | 101,3 | 73,2 | 82,9 | 80,6 | 77,5 | 76,2 |
| **July** | 104,9 | 144,2 | 122,9 | 121,3 | 113,1 | 109,2 | 101,1 | 112,0 | 120,6 | 117,0 | 93,8 | 101,1 | 91,2 | 72,0 | 74,4 | 89,6 |
| **August** | 161,9 | 157,7 | 190,4 | 150,4 | 148,1 | 142,0 | 117,4 | 119,2 | 141,0 | 143,2 | 134,4 | 113,8 | 133,4 | 116,1 | 88,6 | 94,4 |
| **September** | 73,8 | 84,1 | 118,0 | 90,9 | 109,5 | 93,5 | 90,1 | 99,2 | 107,7 | 110,7 | 81,7 | 77,1 | 94,4 | 68,6 | 88,1 | 50,5 |
| **October** | 118,0 | 77,8 | 93,1 | 88,7 | 98,2 | 81,8 | 78,0 | 65,2 | 83,1 | 76,9 | 73,1 | 57,3 | 66,7 | 51,8 | 45,2 | 65,1 |
| **November** | 64,8 | 64,1 | 97,1 | 72,6 | 75,6 | 74,5 | 61,0 | 59,6 | 74,9 | 66,0 | 46,0 | 46,6 | 42,8 | 39,8 | 46,5 | 40,9 |
| **December** | 180,8 | 149,7 | 198,5 | 209,0 | 230,5 | 217,0 | 206,0 | 227,0 | 253,3 | 228,0 | 221,3 | 200,5 | 166,0 | 188,5 | 161,6 | 140,3 |
| **TOTALE** | **1.234,9** | **1.210,6** | **1.344,6** | **1.345,1** | **1.337,9** | **1.227,1** | **1.123,2** | **1.120,1** | **1.256,0** | **1.231,8** | **1.077,2** | **966,2** | **986,5** | **889,7** | **839,9** | **820,5** |

The main distribution zones of the resource are referable to the areas of the old North Adriatic coast line where there are the fossil dunes formed during the last glaciation.

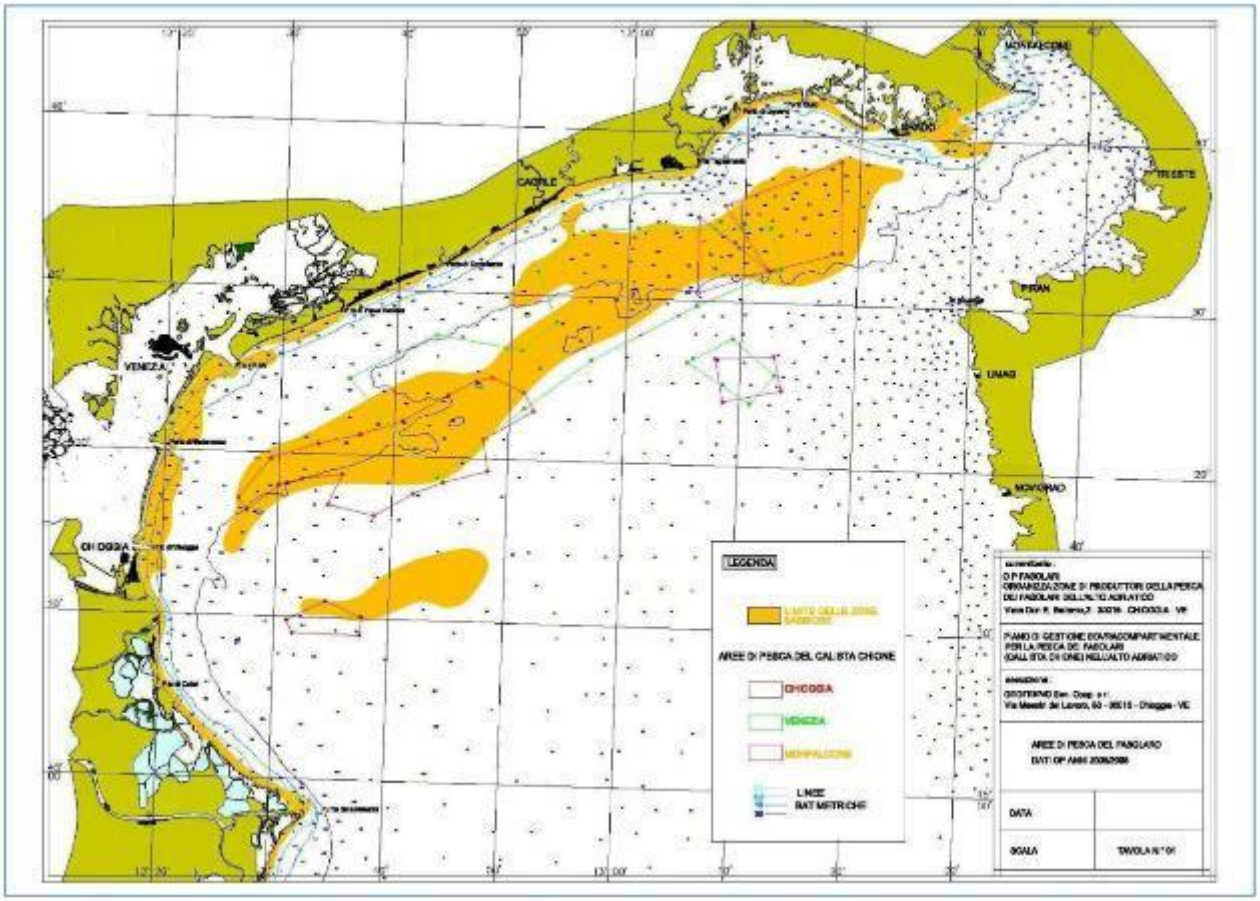



Figure 48: Main areas of *Callista chione* in the North Adriatic.