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MEDAC OPINION ON THE DISCARD MANAGEMENT PLAN FOR VENUS CLAM *CHAMELEA GALLINA* (ART. 15 EU REG. 1380/2013)

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The Mediterranean Advisory Council (MEDAC), officially appointed by the Italian Fisheries Administration by letter, ref. 1820 of 21st January 2019, on the basis of the combined provisions of Articles 15 and 18 of the Regulation (EU) 1380/2013, hereby puts forward the following opinion:*

General introduction

The reform of the Common Fisheries Policy, as defined in Regulation (EU) 1380/2013 (hereinafter referred to as the "Basic Regulation"), envisages the progressive introduction of a discard ban into EC law and the consequent landing obligation for certain target species. The obligation is introduced gradually according to the fishing gear employed and the relative target species, in other words the timing is staggered according to the fishery.

On the contrary to Northern European seas, in the Mediterranean area the landing obligation is applied according to a schedule defined in the Basic Regulation for species that have minimal conservation reference size in the Mediterranean Sea, pursuant to Annex III of Regulation (EC) 1967/06.

Where the Striped venus clam *Chamelea gallina* is concerned, as this is a species that "defines the fishery" (article 15.1 letter d of the Basic Regulation) the landing obligation comes into force on "1st January 2017 at the latest".

This discard management plan for the clam (*Chamelea gallina*) therefore aims to put sector operators in a position to comply with the regulations in terms of minimum conservation reference size, without intervening in any way on the management measures, with particular reference to the technical characteristics of the fishing gear.

The previous MEDAC opinion (ref. 97/2016 of 13th March 2016) already included the regulatory framework, the reasons that made it necessary to prepare a discard management plan, a description of the fishing gears involved, the possible EMFF support for the implementation of the landing obligation, as well as an overview of the main biological aspects of the species involved, reference should be made to this document as there have been no further changes. It is important, however, to bear in mind that the first discard management plan for the *Chamelea gallina* was implemented with Delegated Regulation (EU) 2016/2376 of 13 October 2016 "establishing a discard plan for mollusc bivalve Venus spp. in the Italian territorial waters" as well as at national level by the Ministerial Decree of 27 December 2016, reference n.21946.

The MEDAC was formally appointed to prepare this opinion of the plan by the Italian Administration by official letter ref. 1820 of 21st January 2019, issued by the General Directorate for Fisheries and Aquaculture of the Italian Ministry MiPAAFT.

*FACOPE, CEPESCA, FNCP and WWF voted against. FACOPE, CEPESCA and FNCP deem that there has not been enough time to analyze the report in the working group, with which there are biological discrepancies. It is a management plan that is limited to the fleet operating in Italian waters, but which nonetheless has repercussions of another type in another fleet of the same sea. Moreover, the commercialization of catches of chamelea gallina below the size established by Regulation 1967/2006 has very negative repercussions on other fleets such as the Spanish fleet. WWF deems that the plan is to be submitted to the EC under the art. 18 of the CFP and it should then be focused on a shared stock and involve at least two MS. Moreover, the measures and scientific research are only focusing on Italian fisheries, with no involvement of any other MS apart from the market aspects. EAA abstained due to the short time to find out other papers about mechanised and suction dredges environmental impacts. Furthermore, supports WWF concerns.

Although stocks of the species in question are not shared with other Member States, the MEDAC consulted the other EU States that border the Mediterranean basin nonetheless. Only the Spanish members expressed their interest in managing the resource and, as a consequence, in participating in the preparation of the opinion for the plan, partly to highlight the commercial discrepancies that had arisen over the previous three years due to the reduction of the minimum commercial reference size in Italian territorial waters. With reference to the latter, the MEDAC considers it useful to report commercial aspects to the Market Advisory Council (MAC), with which it plans to hold meetings in order to overcome and solve the matter, thus focusing on aspects related to technical measures in this opinion.

This document includes the available results in relation to the application of the first discard management plan, the current state of the resource as a result of this plan, as well as the management measures implemented by fisheries enterprises to comply with the regulatory requirements.

The discard management plan continues to base its scientific evidence on the coordinated research project "Evaluation of the effects on clam resources of the possible redefinition of the minimum size and the improved biological and commercial management of the product", prepared by Conisma and UNIMAR where the Italian part is concerned and updated as appropriate with the results of the plan.

It is further emphasised that the socio-economic aspects of the implementation of the Plan must be taken into account, with particular reference to the need to foresee measures to stem any impact on employment in the event of failure to implement the Plan or changes that affect the socio-economic aspects.

This opinion for a management plan for *Chamelea gallina* includes the results of the work carried out by the dedicated MEDAC Focus Group, established during the WG1 meeting held in Venice on 19th February 2019, which has only got together online.

Summary of results

- **<u>The bivalve mollusc management consortia have applied the measures envisaged in the discard plan</u>**, conforming to the provisions of this Plan in relation to providing systems for detecting vessel position, defining restocking areas, introducing a certification system to verify conformity of the product to the Minimum Conservation Reference Size (MCRS) at the landing sites. There are a few exceptions, but the consortia which have not fully implemented the Discard Plan have very low levels of the resource in question.
- Given the adjustment of the Minimum Conservation Reference Size to 22 mm, compared to 25 mm established in Reg. EC1967/2006, some details have been provided on the biology of the species. This information was gathered following careful review of the available literature (as already demonstrated in the first opinion on the Discard Plan) together with new biological research.
    - The results obtained with regard to sexual maturity and growth confirm the scientific findings of other authors in previous years. In the samples obtained from surveys in both 2017 and 2018 **<u>it was possible to determine the sex of individuals of 8-10 mm and observe mature gametes in both sexes from a length of 11-12 mm</u>**. From the results of the studies, from March to June it is possible to determine the sex of a large number of individuals, with the lowest percentage of undetermined individuals in the months of May and June, these two months correspond to the reproductive peak with the highest number

of mature individuals found. This reproductive peak is followed by a resting stage until November, which is when the gametogenic cycle begins again for both sexes.
- A size of 22 mm is therefore 22-38% higher than the size in the first stage of maturity (L50 = 16-18 mm) and is therefore aligned with and in full respect of sexual maturity, guaranteeing the sustainability of exploitation of this resource.
- Data relative to growth, on the other hand, have shown that clam size increases by about 1 mm/month. This means that a clam takes just under 2 years to reach a size of 22 mm and that the clams of 22 mm or slightly less, once released back into the sea, reach a size of 25 mm in about 3 months.

- The effects of the technical measures included in the Discard Plan have brought about a **reduction in fishing effort by hydraulic dredges**. On the one hand the potential fishing days per year have decreased, on the other there has been a significant reduction of daily fishing effort for two reasons. The reduction of the maximum daily quota (from 600 to 400 kg) and the possibility to market specimens smaller than 22 mm (although it is currently rare to find clams smaller than 23 mm on the market) have together made it possible to reach the quota set more quickly (on average 1 – 1.5 fishing hours per day), this has also resulted in a **reduction in the areas dredged, thus reducing the environmental impact of dredging gear**. It is clear that the effects will need to be assessed over time. **The reduction in the time spent on fishery operations means that this fishery also has implications of a socially useful nature**.
- With the entry into force of the Discard Plan, the characteristics of the size-selective gear on board (mechanical vibrating sieves) have not been modified. The sieving grids themselves have not been modified either. A recent study on the selectivity of Adriatic dredgers demonstrated unequivocally that, **where compliant vibrating sieves are employed (hole diameter 21 mm), the number of specimens under 22 mm is negligible**. The length-frequency distribution of the clams sampled directly from the collecting box (before sorting) shows a wide range of sizes with a large number of undersized specimens (< 22 mm). However, on considering size distribution after sieving, it is possible to observe that there are very few specimens under 22 mm, sometimes almost none (<1%). It is clear from the results obtained from monitoring activities that, as a consequence of the sorting operations on board with a sieve that is compliant with the regulations in force, there are not sufficient quantities of clams retained on board to allow for reasonable seeding operations for restocking purposes. This explains why, in many Maritime Districts, restocking areas have only been used marginally. In the light of the selective properties described above, the quantity of clams under 22 mm kept on board was often so low that it was completely impractical and unprofitable to discard these specimens in the restocking areas. It will, however, be possible to use these areas to test rotational seeding as envisaged in Ministerial projects that have already been approved.
- The standardised monitoring activities carried out in 2017 and 2018 demonstrate that, **in almost all the consortia, the resource has recovered**, with biomass and densities that are higher than the values registered for previous years. At the end of August 2018, however, clams died in very large numbers in the central-northern Adriatic Sea, probably due to a sudden, exceptional climatic phenomenon and this may have negatively affected the surveys carried out from September onwards.
- The surveys have demonstrated that **good levels of spawning stock have been maintained, which is confirmed by the large quantities of juveniles** in all the areas, proving that recruitment has been excellent and will be able to sustain the future population of commercial clams.
- **The vessel position detection system has enabled the sector to participate in control operations, considerably improving management activities.** This tool can be used to plan fishing activities in relation to the effort applied.
- Hydraulic dredges cause physical disturbance to the seabed, giving rise to a resuspension of the sediment with effects on water turbidity. If on the one hand this remixes the superficial sediments favouring the oxygenation of the deeper layers and the release of organic substance and nutrients, on the other hand it could have negative effects such as the destabilisation and modification of the sediment conditions resulting in a decrease in habitat

complexity, with consequences for the benthic communities. The biological communities present in the fishing areas have undergone a prolonged selection process and the composition of the species currently present is the result of the selective action of dredge fishery activities. **It should, however, be noted that communities living in low-depth and high-energy environments are already naturally subjected to constant environmental stress due to exceptional phenomena (in particular, significant wave movements, strong currents), and for this reason, they demonstrate rapid recovery (resilience).** The fishing areas also enjoy long rest periods that allow the macrobenthonic community to recover for periods of 2-6 months. The ecological effects and the recovery of the benthic community after the action of hydraulic dredge gear can therefore be equated to the recovery that takes place following natural disturbances. No species are caught that present problems related to conservation or which are protected.

- In the light of the studies carried out during the first two years of implementation of the Discard Plan, it is possible to affirm that maintaining the Minimum Conservation Reference Size at 22 mm appears to be a fundamental element towards guaranteeing a positive future for the fisheries sector operating with hydraulic dredges, as it is sustainable from an ecological point of view (the biology of the species and the low environmental impact support this argument) and also from a socio-economic point of view.

Foreword

The venerid clam (*Chamelea gallina* L., 1758), known locally in Italy as “cappola”, “lupino”, “cocciola” etc., is widely distributed throughout the Mediterranean, in the eastern Adriatic and in the Black Sea; in Italy it is particularly abundant along the central and northern Adriatic coast (noteworthy quantities are also caught in the mid and lower Tyrrhenian Sea) and is one of the most commercially important molluscs.

C. gallina is found in high density shoals in the coastal area up to a depth of 12 m on sandy sea beds in which it burrows, leaving only the two siphons protruding on the outside, with which it draws in (inhalant siphon) and expels (exhalant siphon) water. The growth of the clam, as well as other fossorial species, is influenced by various biotic and abiotic factors such as temperature, water trophism, the nature of the sediments and population density. In the presence of high densities (> 500 individuals m^2), phenomena such as increased natural mortality have been demonstrated (especially in the summer when hypoxia can occur more frequently in the area close to the coastline), as well as a reduced growth rate and a slowing down of recruitment. It is therefore not rare for this species to suffer mass deaths, which on several occasions have led to critical periods for the relative fishing industry, these deaths can be caused by changes in the coastal environment due to natural and other causes (anoxia, quantities of fresh water river run-off, storms, pollution, etc.); it would appear, however, that the clam possesses a remarkable capacity for recovery following stressful conditions and its reproductive biology appears naturally predisposed to react to phenomena of sudden mass deaths with subsequent intense recruitment.

The reform of the Common Fisheries Policy, as defined in Regulation (EU) 1380/2013 (hereinafter referred to as the “Basic Regulation”), envisages the progressive introduction of a discard ban into EC law and the consequent landing obligation for certain target species. The obligation is introduced gradually according to the fishing gear employed and the relative target species, in other words the timing is staggered according to the fishery.

On the contrary to Northern European seas, in the Mediterranean area the landing obligation is applied according to a schedule defined in the Basic Regulation for species that have minimal conservation reference size in the Mediterranean Sea, pursuant to Annex III of Regulation (EC) 1967/06.

Where the clam *Chamelea gallina* is concerned, as this is a species that “defines the fishery” (article 15.1 letter d of the Basic Regulation) the landing obligation comes into force on “1st January 2017 at the latest”.

With Delegated Regulation (EU) 2016/2376 of 13th October 2016, the EC established a discard plan for mollusc bivalve Venus spp. in the Italian territorial waters. This plan, by way of derogation from the minimum conservation reference size established in Annex III to Regulation (EC) No 1967/2006 set the minimum conservation reference size of *Chamelea gallina* in Italian territorial waters at 22 mm.

The Italian Ministerial Decree of 27th December 2016 implements the Regulation EU 2376/2016, adopting the National Discard Management Plan for the clam *C. gallina*, establishing a series of additional technical measures.

This document aims to analyse the preliminary results of the implementation of the so-called Discard Plan and to evaluate its possible extension.

In the general part, after a brief chapter on the regulatory framework touching both on the reform and on some aspects relative to the introduction of the landing obligation, the reasons for a discard management plan are clarified. The general part continues with a description of the gears involved, with particular reference to the hydraulic dredger. An analysis of the main biological aspects of the species involved follows, drawing both on bibliographical studies and on *ad hoc* research carried out in the last year. Mention is then made of the size of the stock and its distribution in the various Italian GSAs.

The preliminary results are reported in the text (the Discard Plan is still in progress) relative to the implementation of the Plan itself. Lastly, reference is made to the sustainability of the fishery activities and the selectivity of the vibrating sieves, the impact of dredges and fishing effort.

The legislative framework and the management of fisheries employing dredges

EC Measures

- Regulation (EU) 1380/2013: Article 15 of Reg.(EU) 1380/2013, in force since 1st January 2014, establishes that all catches of species subject to catch limits [1] and in the Mediterranean catches of species subject to minimum sizes as defined in Annex III to Regulation (EC) No 1967/2006, are carried and kept on board the fishing vessels, registered, landed and charged to the quotas, if appropriate, unless they are used as live bait. Therefore, for the Mediterranean EC countries, the obligation is in force:
  a) at the latest from 1st January 2015 for:
  — small pelagic fisheries: Anchovy (Engraulis encrasicolus), Sardine (Sardina pilchardus), Atlantic mackerel (Scomber spp.), Horse mackerel (Trachurus spp.) [because they have a minimum landing size in Reg.1967/06];
  - large pelagic fisheries: Bluefin tuna (Thunnus thynnus) [because it is subject to a catch limit – quota]
  b) by 1st January 2017 for those species that define the fishery.
  c) by 1st January 2019 for all the other species targeted by fishery activities that are not covered by letter a) [that have a minimum landing size in Reg.1967/06] and that is:
  Demersals: Sea bass (Dicentrarchus labrax), Annular seabream (Diplodus annularis), Sharp snout seabream (Diplodus puntazzo), White seabream (Diplodus sargus), two-banded seabream (Diplodus vulgaris), Grouper (Epinephelus spp.), Sand steenbras (Lithognathus mormyrus), Hake (Merluccius merluccius), Mullet (Mullus spp.), Axillary seabream (Pagellus acarne), Blackspot seabream (Pagellus bogaraveo), Atlantic wreckfish (Polyprion americanus), Common sole (Solea vulgaris), Gilthead seabream (Sparus aurata), unless scientific evidence demonstrates high survival rates, "taking into account the characteristics of the gear, of the fishing practices and of the ecosystem; (art. 15, para. 4, letter b);
  Crustaceans: Norway lobster (Nephrops norvegicus), European lobster (Homarus gammarus), Spiny lobster (Palinuridae), Mediterranean deep water rose shrimp (Parapenaeus longirostris), unless scientific evidence demonstrates high survival rates, "taking into account the characteristics of the gear, of the fishing practices and of the ecosystem; (art. 15, para. 4, letter b);

Bivalve molluscs: Scallop (Pecten jacobaeus), Carpet clam (Venerupis spp.), Venerid clam (Venus spp.) unless scientific evidence demonstrates high survival rates, "taking into account the characteristics of the gear, of the fishing practices and of the ecosystem; (art. 15, para. 4, letter b).

Paragraph 4 of article 15 defines the cases in which the landing obligation is not applicable:

a) species in respect of which fishing is prohibited and which are identified as such in a Union legal act adopted in the area of the CFP;

b) species for which scientific evidence demonstrates high survival rates, taking into account the characteristics of the gear, of the fishing practices and of the ecosystem;

c) catches falling under de minimis exemptions.

Recently with article 9 of Regulation (EU) 2015/812, so-called "Omnibus Regulation", the following letter was also introduced

d) fish damaged by predators.

Paragraph 5 establishes that the details for implementation of the landing obligation in the single States must be specified in specific multi-annual plans, with particular reference to the different fishing activities, the species to which the landing obligation applies, including an indication of exemptions from the landing obligation for species with recognised high survival rates.

For the species subject to the landing obligation the use of catches of species below the minimum conservation reference size (Annex III reg. (CE) 1967/2006) shall be restricted to purposes other than direct human consumption, including fish meal, fish oil, pet food, food additives, pharmaceuticals and cosmetics.

Vice versa for species not subject to the landing obligation referred to in paragraph 1 (e.g. those entering into force from 1st January 2019) catches of species below the minimum conservation reference size are not stored on board, they must be immediately discarded at sea.

Finally, to monitor compliance with the landing obligation, Member States shall ensure detailed and accurate documentation of all fishing trips and adequate capacity and means, such as observers, closed-circuit television (CCTV).

- Article 4 of Reg. (CE) 1967/2006 bans the use of hydraulic dredges within 0.3 nautical miles of the coast, over seagrass beds of *Posidonia oceanica* or other marine phanerogams, coralligenous habitats and mäerl beds.
- Delegated Regulation (EU) 2016/2376 of 13 October 2016 that establishes a discard plan for mollusc bivalve Venus spp. in the Italian territorial waters, by way of derogation from the minimum conservation reference size established in Annex III to Regulation (EC) No 1967/2006, set the minimum conservation reference size of *Chamelea gallina* in Italian territorial waters at 22 mm.

- On the basis of the characteristics of the dredges and the towing method, art. 2 of EC Regulation 1967/2006 recognises four key types of dredger:
    - Boat dredge, towed by the vessel, this means gear which are actively towed by the main vessel engine (which corresponds to the Italian term "traino per molluschi" pursuant to DM 26/07/1995);
    - Mechanised dredge, hauled by a motorised winch from an anchored vessel (which corresponds to the Italian term "rastrello da natante" pursuant to DM 26/07/1995);
    - Hydraulic dredge, which are vessels with hydraulic equipment, commonly known as suction dredges;
    - Hand dredge, pulled by hand or by manual winch in shallow waters with or without the support of a vessel.

National regulations

- The maximum daily quantity clams that each vessel can fish was set at 600 kg by DM 22/12/2000 but was recently amended to 400 kg by DM 27/12/2016.
- DM 22/12/2000 established the following characteristics for hydraulic dredges *i)* maximum cage width 3 m *ii*) maximum water pressure from the nozzles 1.8 bar *iii*) maximum gear weight 600 kg. The dredge on vessels targeting clams is also subject to the following limitations: the distance between the metal rods on the lower part of the cage must not be less than 12 mm. Instead of the rods, a metal grid with square mesh not less than 17

mm/side or rectangular mesh with sides of 12 and 25 mm respectively are allowed, or a perforated sheet of metal with holes with a diameter of not less than 21 mm and a full/ empty ratio of less than ½. Once hauled, the contents of the cage are turned out into the collection box then separated with sieves that have grids with the same characteristics as the cage described above.

- The "National Discard Management Plan for clam stocks *(Chamelea gallina)*" of 27/12/2016 (OJ N.8 11/1/2017) established*:*
  - forfeiting the 5% weight tolerance on the minimum conservation reference size;
  - a maximum of 40 sacks per day (400 Kg) per vessel, in order to reduce production by 20%;
  - applying the plan to all clams selected using the sieving gear and kept on board;
  - landing all clams from every fishing vessel at the landing points, where the relative bivalve mollusc consortia will have installed an appropriately-sized sieve;
  - a second inspection in optimal conditions at the landing point, returning all the clams above the new minimum conservation reference size to the fishing vessel (under the control of the clam fisheries management consortia, hereafter referred to by the Italian acronym CoGeVo), issuing the fishing vessel with a certificate confirming the successful second screening with respect to the minimum conservation reference size for the quantity of clams submitted;
  - the CoGeVo collects all specimens below the new minimum conservation reference size that are present in the landed product, before transferring them back to areas of the sea designated for repopulation

- DM 27/12/2016, transposing EU Regulation 2376/2016,
  - adopted the National Discard Management Plan for clam stocks *Chamelea gallina*;
  - blocked the number of vessels at September 2009 levels (DM 28/09/2009);
  - set the maximum number of fishing days per week at 4;
  - reduced maximum catch quantities to 400 kg/vessel/day;
  - made the vessel position detection and monitoring system mandatory;
  - introduced a system of certification of the minimum conservation reference size through the management consortia;
  - introduced the requirement to identify restocking areas in which the undersized specimens landed can be relocated.

For the purpose of preparing this management plan, the legislative procedure to be followed can be found in Regulation (EU) 2015/812, where Article 3 adds an additional article (art.15 b) to Regulation (EC) 1967/2006 (the so-called "Mediterranean Regulation"), which defines the procedure for establishing new minimum conservation reference sizes in the framework of the discard plans and by way of derogation from the provisions of Annex III of the aforementioned Mediterranean Regulation.

This plan therefore follows the same procedure, which led, pursuant to Article 18 of the Basic Regulation, to the drafting of the joint recommendation relative to the discard management plans for small pelagics, acknowledged by the European Commission through the adoption of delegated regulation 1392/2014: in 2014 this recommendation was scientifically motivated by the advisory council (MEDAC) and sent to the national administrations, which, after the text had been shared and approved, sent it to the European Commission for the necessary evaluation.

In the delegated regulation, the new minimum conservation reference size for the clam would be defined together with all the management measures for the implementation of the landing obligation and the consequent actions in support of the environment and sustainability.

Clam fisheries in Italy

Fishing techniques

Dredges are fishing gear with a fixed mouth, they are towed on the sea bed by hand or by vessel and are employed to catch bivalve molluscs. Three key types of dredges can be identified on the basis of the way in which they penetrate the top few centimetres of the sediment (Bombace and Lucchetti, 2011):

1. the "blade" dredge, has a metal frame or rods with a sharp scraper blade on the lower part which sifts the first few centimetres of the sea bed, then both the sediment and the organisms within it are conveyed into the cage;
2. the dredge with "teeth" has a kind of toothed rake on the lower part of the metal frame or rods which penetrates the sediment and selects the organism within it, so that only these organisms enter the cage, separating them from the sand and mud;
3. the dredge "without blade or teeth" which is the most rudimentary of the dredges which only has the metal frame to which a kind of net bag is attached.

All dredges operate in shallow waters (generally less than 15 m) because it is at these depths that it is possible to find the bivalve molluscs that burrow into the sediment. The most important from a commercial point of view, as they permit the most abundant catches, are hydraulic dredges and dredges towed by vessels. On the basis of the new gear classification included in the Italian Ministerial Decree of 26 January 2012, hydraulic dredges are defined by the HDM reference code as ("Mechanical dredges including suction dredges").

Since the 1960s, hydraulic dredges have been used for fishing, in particular targeting venerid clams, razor clams and smooth clams, which live resting on or burrowed into the sediment (Gramitto, 2001). On the basis of the species captured it is possible to identify three types of hydraulic dredger and in Italian the names given to the vessels reflects this: the "vongolara" (Figure 1), to catch Venerid clams (*Chamelea gallina*), Carpet shell clams (*Venerupis aurea*) and Cockles (*Acanthocardia spp* and *Cardium spp*); the "fasolara" to catch Smooth clams (*Callista chione*), mainly used in the central and northern Adriatic; the "cannellara" mainly used along the coasts of the Campania and Lazio regions as well as the northern Adriatic coasts to catch razor clams (*Ensis spp, Solen spp*).

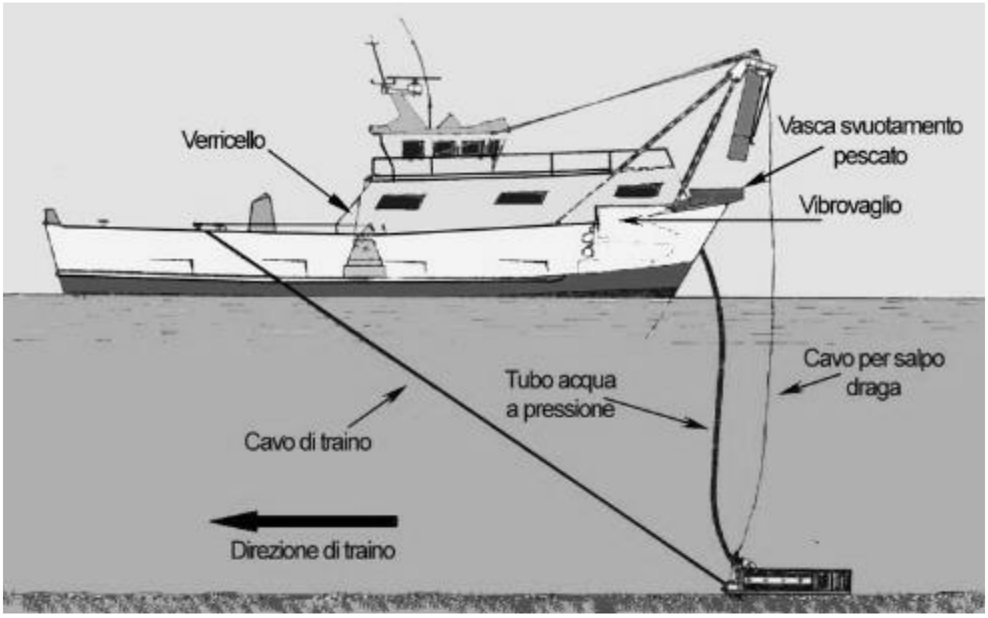


Fig. 1. Illustration of a clam fishing vessel (suction dredger) and the fishing system (source: Lucchetti and Sala, 2012).

The hydraulic dredger for clam fisheries has “blade” dredge gear, i.e. on the lower part in contact with the sea bed there is a sharp metal blade that protrudes under the sledge runners a few cm (4-6 for the “vongolare” dredger), which favours the removal of the top part of the sediment, which is conveyed into the gear along with the bivalves that are in the sediment. The dredge consists of a sort of parallelepiped-shape metal cage, the lower, upper and rear parts of which are made of metal rods (Figure 2). This part of the gear makes the first selection of the molluscs by size. According to Italian legislation, the rods must be spaced at least 12 mm apart to allow the juvenile specimens to escape (Ministerial Decree 22/12/2000). The cage rests on two skid-sledge runners that facilitate the sliding motion on the sea bed; different types of nozzles are mounted on the dredge, arranged in parallel rows, which inject water under pressure, hence the name “hydraulic dredge”. There are further nozzles at the mouth of the dredge which spray water downwards in order to dissolve the sediment in such a way as to make the bivalves emerge that are burrowed into it while at the same time assisting the movement of the dredge in the substrate. Further back there are “washing” nozzles which clear the cage of materials such as sand, mud and debris that could otherwise clog it. The pressurised water pump is almost always located on board the vessel and the water is conveyed into the cage via a rubber hose.

For this kind of fishery the dredge is at the bow, to avoid obvious interference between the cage and the propeller of the fishing vessel during hauling, and accordingly the vessel moves backwards during towing. Until a few years ago, the fishing vessels used for this activity were less powerful than nowadays, so the dredge was towed by applying force on the anchor, which was dropped into the sea before the gear and at a safe distance behind the vessel. Fishery operations took place at the time the anchor cable was retrieved. Currently, the towing methods (with the propeller or pulling on the anchor) are established by the Management Consortia, once the agreement of the Ministry has been obtained, which means that towing takes place practically everywhere using the propeller. However, those vessels that that do not belong to one of the Management Consortia must tow the dredge using the anchor.

After towing the “cage”, is hauled on board and the material gathered is transferred to the sieves on board (there are usually two, one made of metal rods, the other from a perforated metal sheet), which carry out a further selection of the marketable sizes. The sieves, like the dredge, must comply with the legislation that requires a set distance between the rods and specific size for the holes in the case of a perforated metal sheet (DM 22/12/2000).

Figure 2. details of a hydraulic dredge.

General overview of fisheries employing hydraulic dredges

In Italy, fishery operations with hydraulic dredges are carried out in the following regions and for the species indicated in table 1.

Table 1: bivalve mollusc fisheries in the various Italian regions.

Region	Venus clam	Razor clam	Smooth clam
Friuli Venezia Giulia	●	●	●
Veneto	●	●	●
Emilia Romagna	●		
Marche	●		
Abruzzo	●		
Molise	●	●	
Puglia	●	●	
Lazio	●	●	
Campania	●	●	

Hydraulic dredges, depending on the spatial and bathymetric distribution of the target species, operate at depths that rarely exceed 12-15 m.

Fisheries employing hydraulic dredges are carried out along about 1400 km of coastline over a total length of about 8000 km of Italian coasts. The clam is only present in areas with a sandy sea bed.

The fleet of hydraulic dredgers is currently uniform in terms of technology and dimensions. There are around 707 vessels operating with hydraulic dredges (**Error. The original reference has not been found**). The total number of crew members on board is estimated at around 1500, which is equivalent to an average crew of two operators per vessel. 636 fishing vessels are authorised to harvest *Chamelea gallina* and 70 fishing vessels from the Italian regions of Friuli Venezia Giulia and Veneto are authorised to harvest *Callista chione* (smooth clam).

The average number of fishing days per year is around 85.

In economic terms, hydraulic dredgers as a segment contribute about 5.7% to the value of the gross commercial production of the whole Italian fisheries sector. Overall production in 2017 and 2018 was respectively 21 796 tonnes, representing 10.36% of all fisheries production by the Italian fleet.

The fleet is concentrated along the Adriatic coast, with significant production centres in the Marche region (31% of hydraulic dredgers operating in Italy) and in the Veneto region (23%). The dredgers that operate in the Tyrrhenian sea (about 40) mainly target razor clam (*Ensis minor*).

At national level, the number of dredgers declined significantly up to 1998 before stabilising at around 710 units in the first years after 2000 (source EUROSTAT). In terms of catches at national level, landed product quantities have decreased progressively (source EUROSTAT).

Critical issues faced by the hydraulic dredging sector following the implementation of Reg (EC) 1967/2006

The following are the critical issues that the bivalve mollusc fishing sector employing hydraulic dredges has faced following the entry into force of Reg (EC) 1967/2006 (Mediterranean Regulation) and the consequences after four years of implementation.

These are critical issues at national level and have been detected in all the Italian Maritime Districts where fishing with hydraulic dredges is present and in all the different management Consortia, albeit in different degrees where the impact is concerned depending on the nature of the coastal area involved and the target species.

The entry into force of the new limit from the coast (0.3 nm), within which fishing activities with hydraulic dredges cannot be carried out, has significantly reduced the exploitable areas, as already highlighted, the impact differs in the various management consortia but is always significant and give rise to difficulties in fleet operations in relation to the sustainability of resource harvesting. In general, the application of Art.13 has led to significant reductions in the fishing grounds for this resource, penalising management consortia and reducing the authorised operating areas.

In the following Table 2. the impact at regional level of Reg. EC 1967/2006 on the fishing grounds for hydraulic dredges is quantified.

Table 2. Fishing areas per Italian region and the areas no longer available for fisheries activities after Reg. EC 1967/2006 came into force.

Region	Fishing area (Km^2) before Reg 1967/2006	Fishing area (Km^2) after Reg 1967/2006	% reduction fishing area
Friuli Venezia Giulia	88,0	56,4	35,9
Veneto	148,2	64,7	56,3
Emilia Romagna	127,2	57,8	54,6
Marche	252,2	163,1	35,3
Abruzzo	208,5	139,1	33,3
Molise	51,1	32,3	36,8
Puglia	102,5	10,2	90,0
Lazio	78,2	2,5	96,8
Campania	52,1	0,2	99,6
Total	**1108,0**	**526,3**	**52,5**

Source: first management plan for hydraulic dredgers 2010

Table 2 demonstrates that with the entry into force of the Mediterranean Regulation at national level a reduction in the fishing areas of about 52% can be observed with the highest reductions in Puglia and in the Tyrrhenian Sea (Lazio and Campania, over 90%.

These reductions have resulted in operational and management difficulties for the Consortia, with repercussions on catches and profitability for the operators. As the specific characteristics of the Mediterranean were not taken into account, fisheries activities were further penalised and this continues to create problems both from an economic and a political-social point of view.

With regard to the minimum conservation reference size of 25 mm, this measure actually reflects what has already been established at national level by the D.P.R. 1639/1968, but this was mitigated by the 10% tolerance for undersized specimens in weight or if possible, in volume.

The current Mediterranean Regulation does not allow for any tolerance, which means that even if there is only one specimen on board that is under 25 mm, this constitutes a serious infraction pursuant to Reg. 1224/2009 with the relative fine (in Italy criminal charges too), as well as the accumulation of licence points.

Unfortunately, despite the efforts and good will of the fishers, some undersized specimens are always found in the catch: the current selection equipment on board (vibrating sieves), while highly capable of selection on the basis of the diameter of the specimens, cannot guarantee 100% separation of commercially acceptable specimens from those too small to be marketed. This therefore puts all the operators in the sector at high risk of sanctions, due to the fact that it is always possible that there is specimen present that is under the MCRS, even if it is only one in the whole commercial catch quota (max 600 kg).

A series of factors are reported hereafter that negatively affect bivalve mollusc fishery activities, altering the catch predictions of the single Management Consortia, which are not directly related to fishing effort on the stocks.

The same Regulation then introduced the minimum reference size of 25 mm, without any tolerance for the undersized specimens. The relative Italian legislation (DPR 1639/1968), on the other hand, allowed for a tolerance of 10%. Given the characteristics of the selection of the product harvested, both for the dredge and the vibrating sieve, it is inconceivable only to have specimens above the minimum size on board, following the screening operations.

Results of the first period of experimental application of the Discard Plan

Biology of the target species (*Chamelea gallina*)

Summary of the results

Given the adjustment of the Minimum Conservation Reference Size to 22 mm, compared to 25 mm established in Reg. EC1967/2006, some details have been provided on the biology of the species. This information was gathered following careful review of the available literature (as already demonstrated in the first opinion on the Discard Plan) together with new biological research.

The results obtained with regard to sexual maturity and growth confirm the scientific findings of other authors in previous years. In the samples obtained from surveys in both 2017 and 2018 it was possible to determine the sex of individuals of 8-10 mm and observe mature gametes in both sexes from a length of 11-12 mm. From the results of the studies, from March to June it is possible to determine the sex of a large number of individuals, with the lowest percentage of undetermined individuals in the months of May and June, these two months correspond to the reproductive peak with the highest number of mature individuals found. This reproductive peak is followed by a resting stage until November, which is when the gametogenic cycle begins again for both sexes.

Data relative to growth, on the other hand, have shown that clam size increases by about 1 mm/month. This means that a clam takes just under 2 years to reach a size of 22 mm and that the clams of 22 mm or slightly less, once released back into the sea, reach a size of 25 mm in about 3 months

Studies on the biology and growth of the clam will continue in 2019.

General characteristics

The venerid clam *Chamelea gallina* (L. 1758), is a bivalve mollusc (Lamellibranchiata) which filters using syphons, belonging to the Veneridae family. There are several kinds of bivalve mollusc which have the name "clam": the Cross-cut carpet shell clam (*Tapes decussatus)*, the Carpet clam (*Tapes semidecussatus*), Golden venus clam (*Tapes aureus*) and other similar but less common species.

The bivalve mollusc management consortia also deal with other bivalves, such as Smooth clams (*Callista chione*), Razor clams (*Ensis minor*), Ark clams (Scapharca spp.), and in certain areas of the Tyrrhenian sea they cover Wedge clams (Donax trunculus). This document deals exclusively with the clam *C. gallina*, which is traditionally fished along all coastal areas of the upper and mid Adriatic and is the most important resource targeted by the hydraulic dredgers of the clam management Consortia.

The *C. gallina* clam lives on sandy and sandy-muddy sea beds along the coastal strip at depths ranging from 1 to 18 meters. It does not live on muddy, pebbly or rocky sea beds nor those covered with Posidonia meadows. The depth limit of 18-20 meters is theoretical because the distribution area extends from the shoreline, where coarse sand is present, up to a distance of 1-2 km from the coast. In Italy the species is present in the Adriatic from the Trieste Maritime District to

Barletta-Molfetta in the south, as well as in some limited areas of the Lazio and Campania coasts (Tyrrhenian sea). It has been observed that, over the years, the distribution areas of clams generally follow the distribution of sandy sea beds. In the Adriatic there is spatial continuity of clams, and due to extensive displacements in the larval and planktonic stages, it is believed that there is one single population, even if the biological parameters are different over space and time. As far as the Adriatic is concerned, the direction and intensity of the marine currents play an important role in the distribution of clams and these factors condition where the clams that are carried in the larval and planktonic phase will burrow.

C. gallina has a lenticular equivalent shell, with thick valves and marked concentric lines (Figure 3). The two valves are held together by elastic ligaments and a hinge mechanism with an interlock that has three teeth in each valve. The oval-lenticular valves, are characterised by numerous concentric, irregular ribs (Fischer et al., 1987) and externally are brown-whitish or grey in colour with stripes and darker spots. The Smooth clams (*C. chione*), on the other hand, are oval in shape, with brownish, yellowish and marbled colours, with a raised stripe on the shell. The inner surface of the valves of the Venus clam, on the other hand, is smooth and has a yellowish-white colour with purple spots at the insertion points of the adductor muscles. The function of these muscles is to keep valves closed, opposing the force exerted by an elastic ligament which tends to make the two valves open. The clam can reach a maximum size of 45 mm at 8 years of age. It can be distinguished from the other species due to its rounder shape and for variegated grey colouring.

The biological cycle of the clam involves two distinct phases; a planktonic larva phase, called a veliger, when it is suspended in the water mass and a benthic adult phase, below the surface of the sandy substrates. The fertilised eggs form a larva less than a tenth of a millimeter in size, which lives suspended in the water and is transported by the currents. As the days pass, the larva increases in size and begins to secrete the substances that form the shell. As the shell formation proceeds, while it is still less than 1 mm in size, the shell which is still transparent increases in weight, making it more and more difficult to remain suspended in the water, so the clam slowly descends towards the sea bed. When it reaches the bottom, with an extremely fragile shell, the clam slips between the grains of sand and begins to behave like an adult clam, placing itself vertically in the sediment, with two small openings, the siphons, which remain on the surface. From this moment the filtration of the water begins and the clam retains the organic substances and small planktonic organisms thus beginning growth.

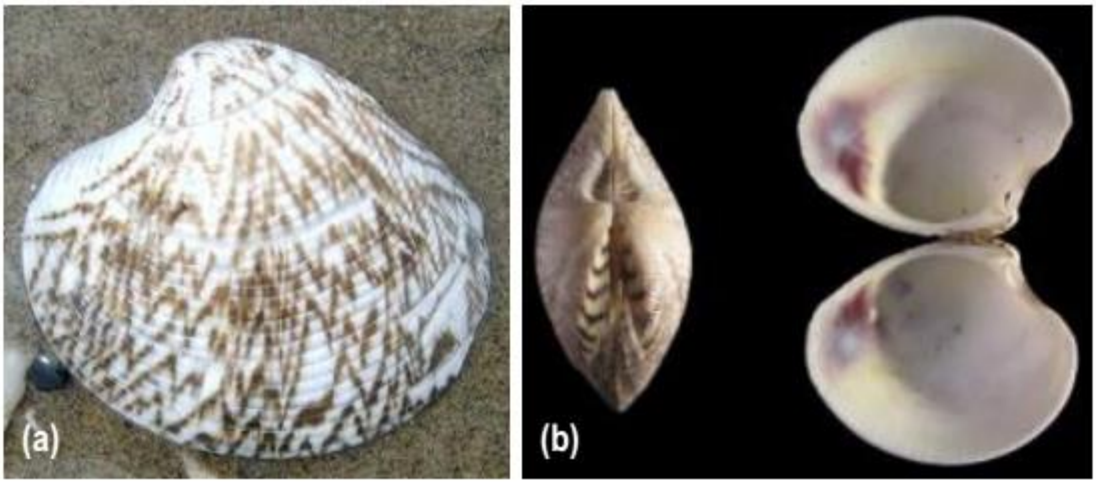


Figure 3. *Chamelea gallina* external view (a); umbo and internal view (b).

As the mollusc grows, its shell increases in size and thickness, becoming progressively more robust. The clams are ready to reproduce even before reaching one year old. The species is sexually separated and fertilisation is external. Each clam produces a very large quantity of eggs and this amount increases significantly as the clams grow, they can exceed a few hundred thousand eggs per clam. Reproduction does not take place throughout the year, it is seasonal and is linked to the thermal cycle of the water. In the Adriatic, reproduction occurs in the late spring - summer period and, in general, eggs are released in July - August.

However, the biological cycle of this species is significantly influenced by the environmental conditions, in particular the temperature, significant differences in the deposition period can therefore be observed in the various geographical areas. In 2016, for example, mature specimens were found from the month of February. Growth is also influenced by various factors such as temperature, water trophism, the nature of sediments and population density. In the Adriatic the clam generally takes one year to reach a size of 16-18 mm and two years to reach the commercial size of 22 mm. The species appears to be mature within the first year of age. The maximum size in the past (in the first years after 2000) could reach 5 cm, with a maximum age of about 8 years.

It is therefore not rare for this species to suffer mass deaths, which on several occasions have led to critical periods for the relative fishing industry, these deaths can be caused by sudden changes in the coastal environment (anoxia, quantities of fresh water river run-off, storms, pollution, etc.); it would appear, however, that the clam possesses a remarkable capacity for recovery following stressful conditions and its reproductive biology appears naturally predisposed to react to phenomena of sudden mass deaths with subsequent intense recruitment.

Gonad analysis of *Chamelea gallina*

The sex of 10 specimens was established for each length class (2 mm, once the valves had been opened with a cutter or scalpel, the gonads were identified. This organ is located in the visceral mass above the foot and hepatopancreas (Figure 4.).

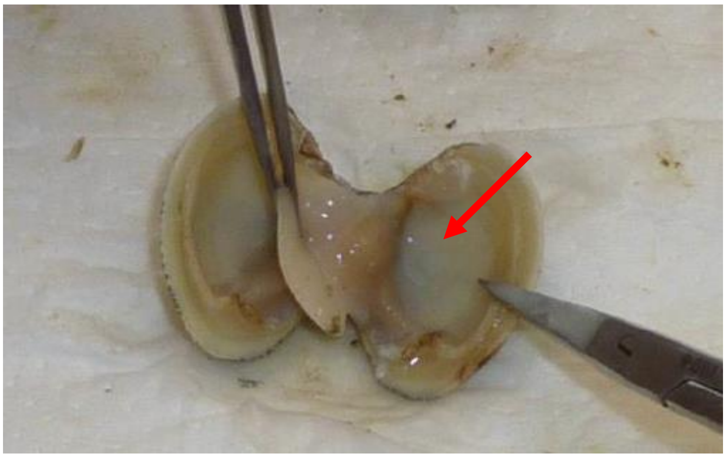


Figure 4. Gonads of *Chamelea gallina*.

Using tweezers, a small incision was made at the base of the gonad and a small amount of gonadal material was removed, a smear was then applied to a slide moistened with sea water.

The material was observed under an optical microscope using 100x and 250x magnification for females and greater magnification for males (400x and 630x). Once the valves were open, the material extracted was observed in a short time (about 15 minutes max), because in the case of male specimens the spermatozoa are distinguishable thanks to the flagellar movement and this mobility is quickly lost (Figure 5). In females, on the other hand, the presence of egg cells could be observed at different stages of development according to the month of the year, for example in the reproductive period the ovary is uniform with mature oocytes that can be identified within the follicles (Figure 14).

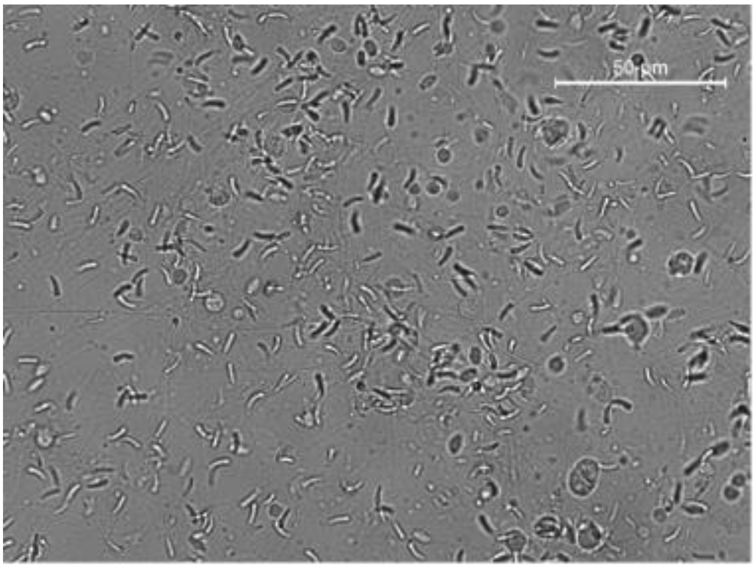


Figure 5. Male spermatozoa during the reproductive period (LT = 20 mm).

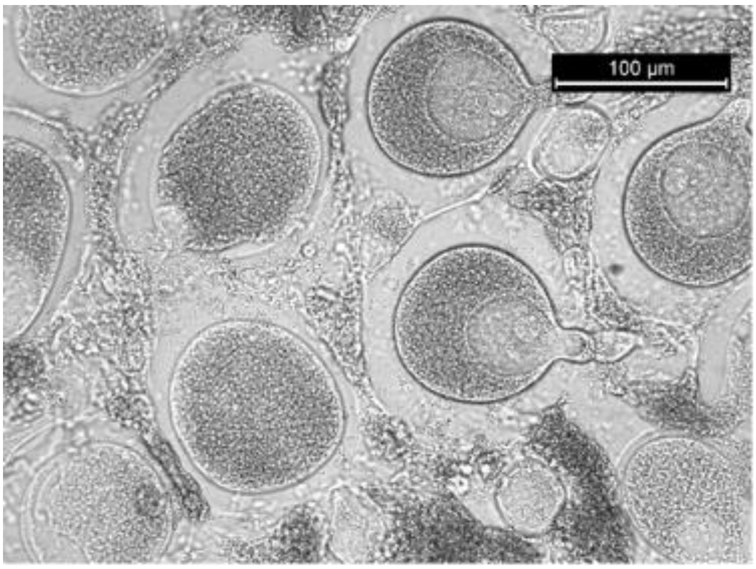


Figure 6. Ovary with mature oocytes (LT = 22 mm).

Biological information gathered during the surveys

For some of the stations sampled during the 2017-2018 surveys, clam specimens were measured and weighed individually, including those above the commercial size and those below it, to establish the type of growth that characterises the population of the area (Figure 7).

Based on the equation obtained with a linear model, growth was found to have negative allometry (slope $b < 3$). This means that the weight of the clams increases more slowly than the length, although in this case, as $b = 2.84$, this type of growth is not easily visible from the graph.

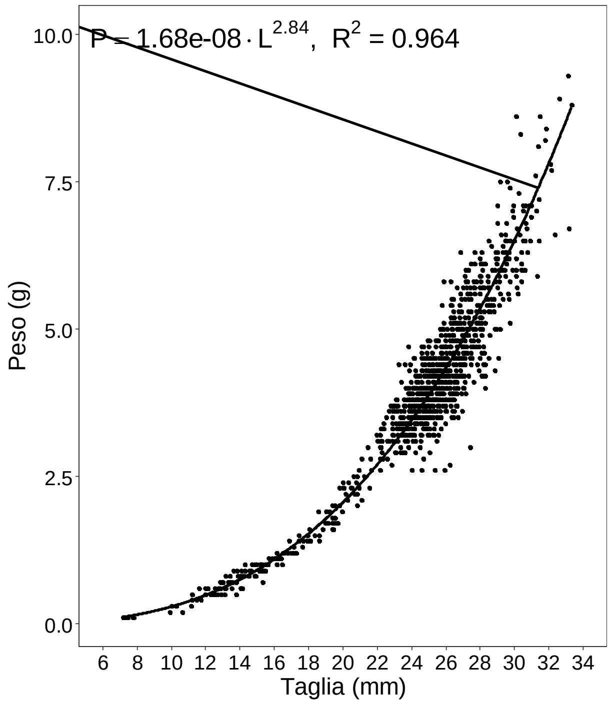


Figure 7. Length weight curve of clam specimens measured and weighed individually from some stations distributed between the Maritime Districts of Ancona and San Benedetto del Tronto. The equation highlighted represents the trend line in black.

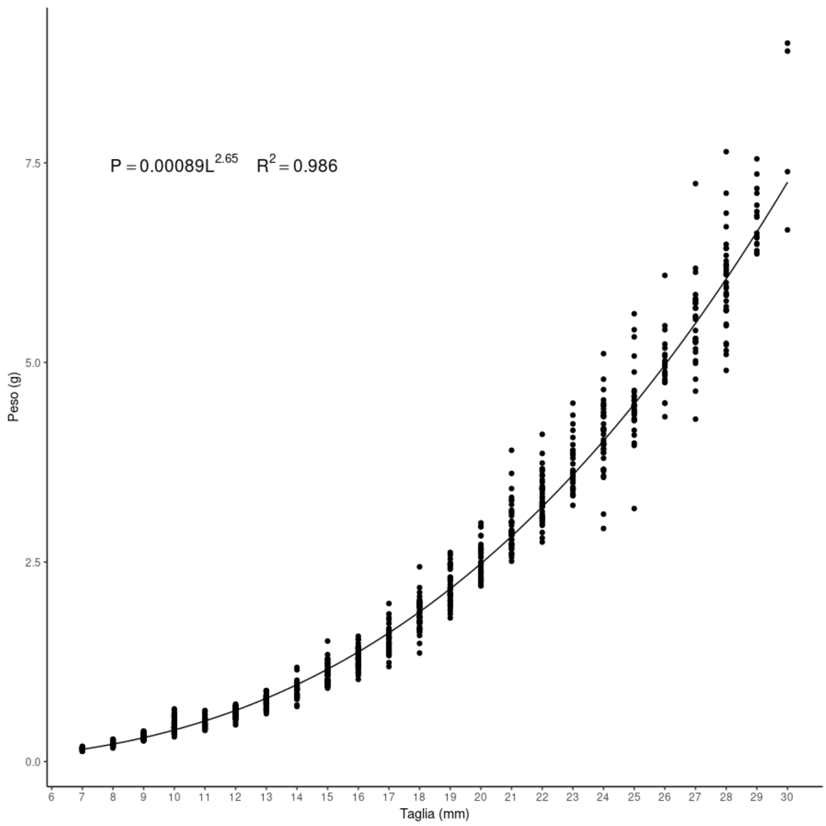
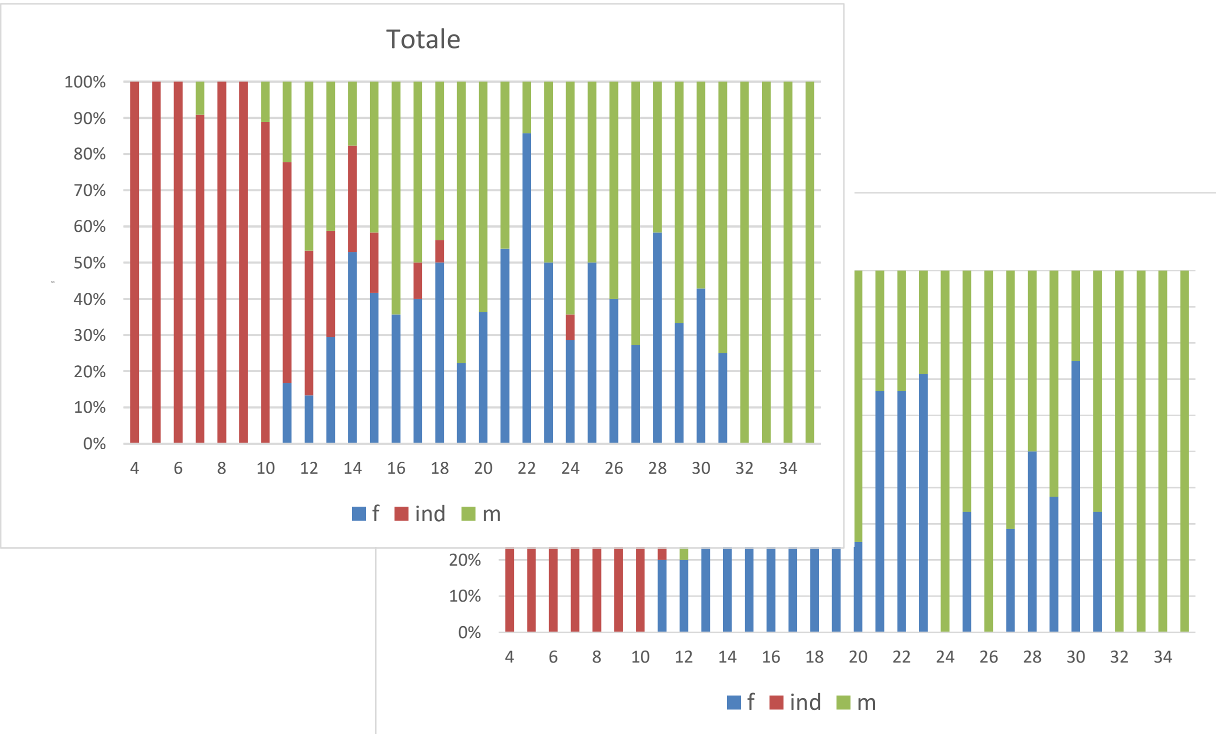
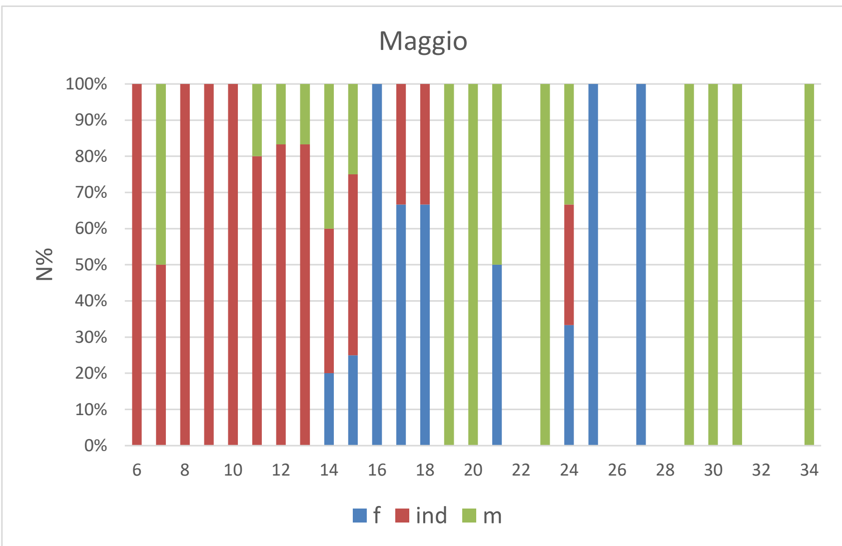


Figure 8. Length weight curve of clam specimens measured and weighed individually from some stations distributed between the Maritime Districts of Ancona and San Benedetto del Tronto. The equation highlighted represents the trend line in black.

Sampling was carried out in the period April-June 2017 in the Maritime Districts of Ancona and San Benedetto to define the sex ratio and identify the mature individuals, this allowed the identification of the reproductive peak of the species, which in the Adriatic is generally from May to September**. In the samples it was possible to determine the sex of specimens from a length of 10 mm and observe mature gametes in both sexes at a length of 11-12 mm** (Figure 9).

In the reproductive period the ovary appears highly uniform with mature oocytes recognisable within the follicles. Macroscopic recognition of the other stages of maturity for both sexes is much more difficult, especially outside the reproductive period, in this case sex determination is only possible by means of a histological analysis of the gonadal tissue.





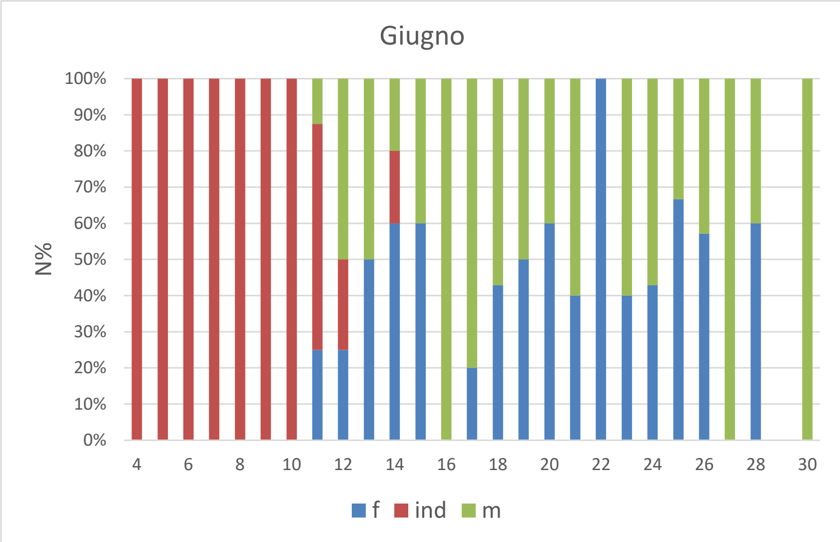


Figure 9. variation in the proportion of the specimens in which it was possible to determine the sex during the sampling period (April – June 2017).

For some of the stations sampled during the 2018 surveys, clam specimens were measured and weighed individually, including those above the commercial size and those below it, to establish the type of growth that characterises the population of the area (Figure 10).

Based on the equation obtained with a linear model, growth was found to have negative allometry (slope b <3 t-test $p<0.05$). This means that the weight of the clams increases more slowly than the length, although in this case, as b = 2.77, this type of growth is not easily visible from the graph.

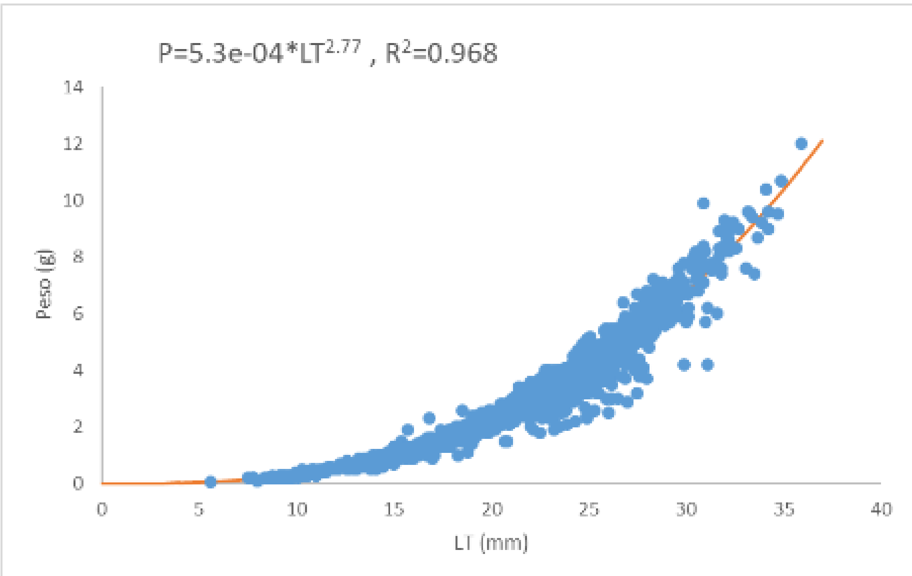


Figure 9: length weight curve for some clam specimens measured and weighed individually at some sampling stations distributed between the consortia of Ancona, Civitanova Marche and San Benedetto del Tronto. The equation represents the trend line in red.

During 2018, from March until November, a sample of clams above and below the reference size was analysed monthly to define the relationship between the sexes and the stage of maturity in the different months (Figure 10). The species is known to reproduce in the Adriatic during the late spring-summer period with a resting stage between September and

November when the gametogenic cycle starts again for both sexes. The results show a high number of individuals whose sex can be determined from March to June, with the lowest percentage of indeterminate individuals in the months of May and June. These last two months correspond to the reproductive peak with the highest number of mature individuals found. In July, the highest number of indeterminate individuals is observed, following the spawning phase of the previous months, the gonads appear empty with no germ cells. The resting period is followed by an obvious recovery of the gametogenic cycle in November, with a percentage of individuals whose main sex can be determined in July.

In the samples it was possible to determine the sex of individuals of 8-9 mm (in the month of June) and observe mature gametes in both sexes from a length of 10-11 mm (Figure 11). In the months outside the reproductive period, sex determination was much more difficult, especially for small specimens, in such cases it is only possible by means of a histological analysis of the gonadal tissue.

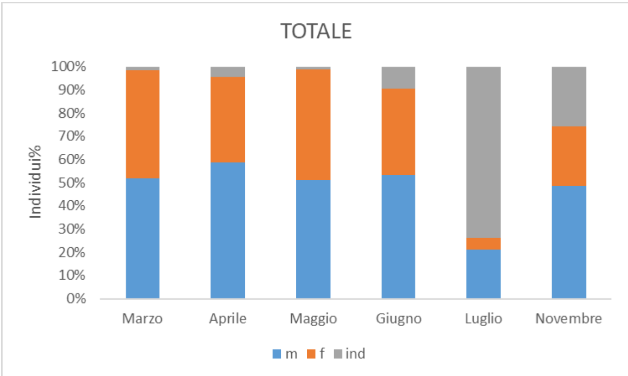
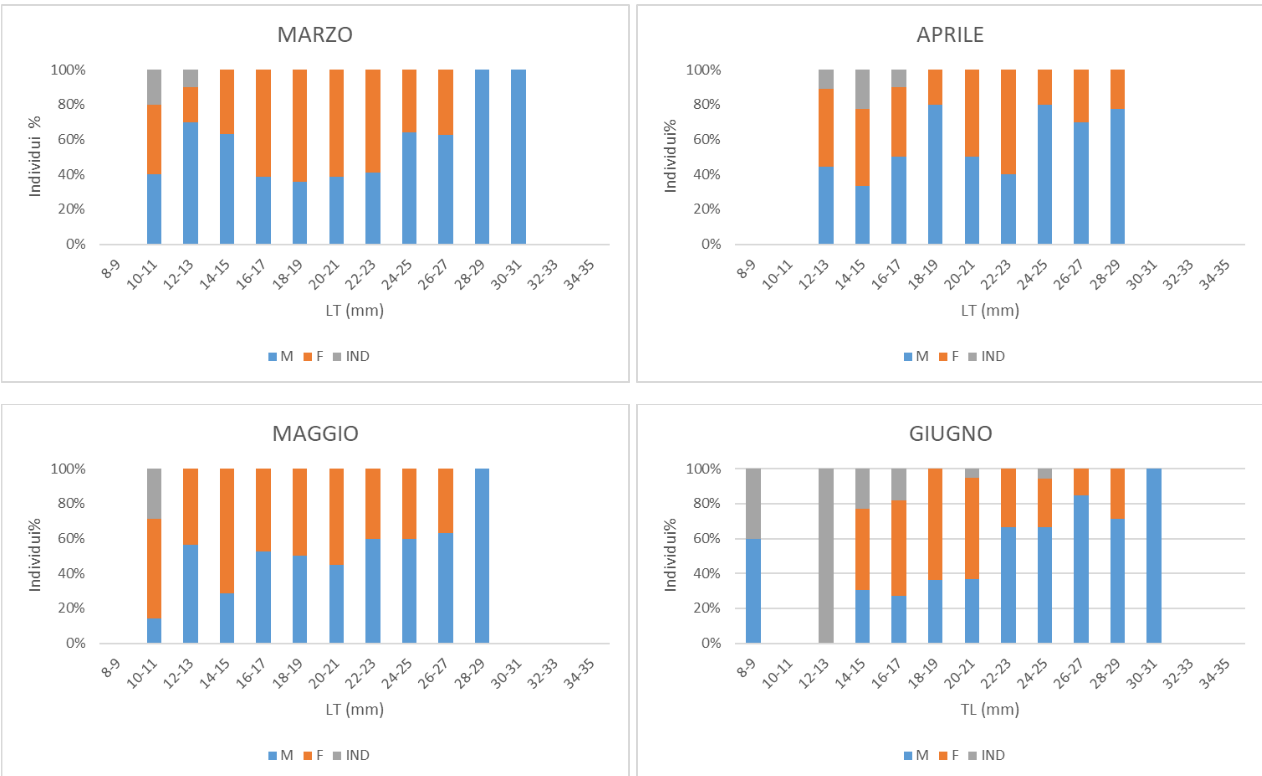
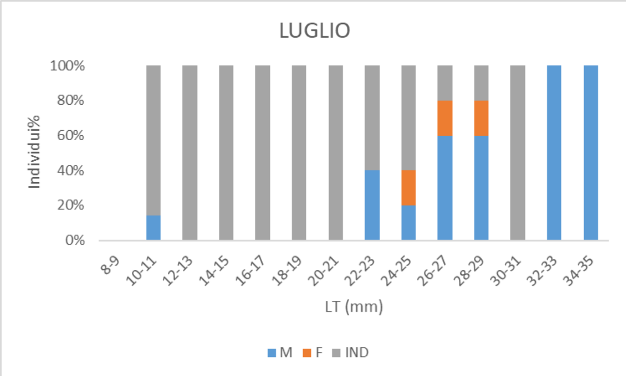


Figure 10: variation in the proportion of the specimens in which it was possible to determine the sex during the sampling period.





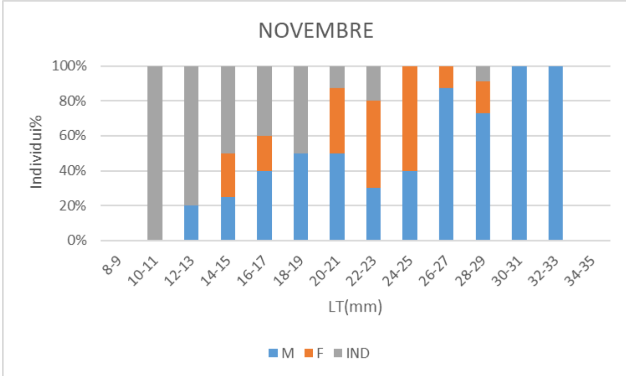


Figure 11: variation in the distribution of the sexes in the specimens of different size class during the sampling period (March-November 2018)

Reproduction of the clam (*Chamelea gallina*): bibliographical analysis

General information and summary on the reproduction of bivalve molluscs

In this chapter, the publications relative to the reproductive cycle of bivalve molluscs and in particular the clam *Chamelea gallina* are considered.

The main text examined for the descriptive phase of the reproductive cycle is Gosling (2003), chapter 5, with references to the fundamental work of Sastry (1979) and the work of Erkan (2009) on oogenesis.

Bivalves in general have an annual reproductive cycle with a period of both male and female gametogenesis followed by one or more release periods. Spermatogenesis in males starts with repeated mitosis of the primordial germ cells giving rise to spermatogonia from which spermatocytes originate (after meiosis), from these spermatids will produce spermatozoa flagellum. Oogenesis in females also starts from the primordial germ cells, from which, after a series of mitotic divisions, the primary oogonia originate, and, after repeated mitosis, give rise to the secondary oogonia that begin meiosis. This process stops at prophase, to be completes in the event of fertilisation. By vitellogenesis, the oocytes accumulate reserve material, such as lipid cells and small amounts of glycogen. The oocytes may undergo lysis throughout the gonadal cycle, however this process seems particularly marked at the beginning of the release phase and at the end of the reproductive cycle. The age of first reproduction is species-specific.

The juveniles grow rapidly and somatic growth completely absorbs all available energy, on approaching maturation of the gonads there is a gradual passage of energy towards conversion in reproduction, this explains the more rapid growth observed in many organisms before reaching the reproductive age. The term reproductive effort is used to indicate the fraction of “energy” channeled to reproduction, this value is expressed as a percentage of total secondary production.

$$RE = Pg / (Pg + Ps)$$

Where:

> *Pg* gametes production
>
> *Ps* somatic production

The sexes of clams are separate, with male clam and female clams, although hermaphroditic clams have been observed. Fertility is related to size and age and is influenced by environmental factors.

Hereunder there is a summary of the publications relative to the reproduction of clams.

The bibliographical analysis is limited to the Adriatic Sea and it is possible to state that the reproductive period can go from March to September with possible extension. *Chamelea gallina* is a gonochoric species and the various studies report substantial equality in the sex ratio with very few cases of hermaphroditism, mostly due to parasitic activity. (Valli, inf. Pers.).

Salvatorelli G. (1967). The period in which the study took place is 1962-63, in total 105 specimens (50 males and 55 females) gathered monthly in the coastal waters of Chioggia. In the months of September, October and November, after release, the testicular follicles are empty and the few mature spermatozoa found are, according to the author, residual from the release that had already taken place. In December spermatogenesis resumes, proceeding slowly during the winter and full maturity is observed in April - May, release is observed in July and at the end of August the cycle ends. significant differences in the maturity stages are observed in specimens sampled at the same time. The ovarian cycle is synchronous, egg release was observed in July and August. In August, eggs not released at the end of the cycle can also be observed. Activity indicating the recovery of the gametogenic process is already observed in October, maturation of the oocytes continues slowly in winter to be completed in spring. Furthermore, differences between individuals collected in the same period have been found and the first empty ovaries are observed in the month of July. It is observed that more than one release cannot be excluded, although this is has not been demonstrated. The role of temperature in governing the cycles is emphasised: increasing temperatures have a significant influence on the maturation and release process. There is no reference to the size of the molluscs analysed.

Poggiani et al. 1973. Sampling period from July 1968 to March 1970. A total of 1847 individuals were examined, 844 of which were tested to determine sex and the stage of gonad maturity. The authors use a 5-stage scale borrowed from surveys performed in other areas. The maximum size of the organisms is 46 mm, the mean is 28/29 mm, while the minimum value is 4 mm. The gonads in the observation period are ripe in July both in 1968 and in 1969 and individuals who have completed the release cycle are observed. The minimum size of mature specimens is reported to be 16-18 mm but at 12 mm a female was observed to be already in the maturation phase. In September and October, the percentage of organisms in the sexual rest period increases. Starting from November there is a recovery of the gametogenic cycle. During the sampling period no evidence of multiple release was detected. In this study the authors also report the temperature and salinity parameters measured in the study area at a depth of 10 m.

Froglia, 1975. Area investigated: mid Adriatic. Two separate periods of gamete release are observed, one between May and June and another between September and October.

Marano et al. 1980 and 1982. The researchers examine the reproductive cycle together with other species in the lower Adriatic, in particular in the Gulf of Manfredonia, with temperature data also recorded. A 5-stage scale was used, borrowed from studies performed in other areas. It is noted that the maturity is reached in the first year of life and that the gametogenic activity is continuous, resuming the cycle shortly after the release, proceeding slowly in the winter months, so that in February and March the first mature gametes appear. It is observed that at 14-15°C the first mature eggs are released into the follicular lumen. In the 1980 research, release was observed towards the end of April with extension until August-September. The staggered release and differentiated stages present in the same individuals are observed. It is emphasised that organisms have been evaluated in the interval between the ages of 1 and 4 years, the age evaluation method is not highlighted as it is explained in the work published in 1982, where the method to break down frequency distributions is employed. This second work refers to the period 1978-1979 an uses a 4-stage scale. The most intense release phase is observed in the months of June, July and August, in the latter month there is evidence in some individuals of a recovery in gametogenesis. A fraction of organisms that did not complete release was also observed in the October-November interval.

Valli and *Zecchini-Pinesich* 1981 (1982). Study period from April 1975 to April 1976. A stage reference divided into 6 phases is proposed. The reproductive period was from April to September with maximum reproductive activity between June and August. Multiple release is detected. Gametogenesis begins in October with a slowdown in the following months. The sex ratio is defined as “balanced” by the authors. The size of the organisms is not reported, but the researchers make it clear that the specimens come from commercial fisheries.

Corni et al, (1985). Data collected between September and December 1982 is processed and a classification that includes 5 stages of gonadal growth and 3 of regression is used. A certain discrepancy (or lack of complete data) is detected on the hypothesis that a second reproduction period is triggered after the significant important summer release. The work was conducted along the Cesenatico coast with sampling between 1.5 and 2 m depth of organisms over 20 mm.

Valli et al. (1985). The study is on the Grado maritime district (over two years 1981 and 1982) and uses a 6-stage scale. The beginning of gametogenesis is detected in September, maturity in April, peak release in July, with evidence of sexual rest in August. The authors point out differences compared to what was found in the study mentioned above. The specimens are from commercial fisheries.

Ambrogi et al. Po river delta 1997. They observe that recruitment is continuous from May to November and they note two peals in August and October.

Cordisco et al. 2003. In this study, data on the presence of larval phases are reported. It is noted that clam larvae are abundant in all the years of sampling activities in the late spring-summer period and a sporadic presence of larvae is also observed in other periods of the year (Molise, northern Puglia).

Cordisco et al. 2005. The Molise coastal areas is studied. At the end of summer-early autumn reproductive activity resumes. The sex cannot be distinguished in organisms smaller than 13 mm. Lazio coast: reproductive or post-release phase from April to November

IZS Abruzzo and Molise 2006. Maritime District of Pescara, size at first maturity 12 mm, reproductive period in summer, larval period 10-15 days. No bibliography.

Romanelli et al. 2009. Gonochoric species, sex ratio is 1:1 release period: April-October in one or two phases, first maturity 13-15 mm, full maturity: 20-25 mm.

IZS Abruzzo and Molise, 2014. Reproduction starts in the spring and continues until the end of the summer with a peak in the month of July (reference to: Nojima & Russo, 1989 in the Tyrrhenian Sea: summer reproduction, difficulty determining the class 0+).

Rizzo et al 2010, Chioggia Maritime District. The highest percentage of mature specimens is observed in June and July (100%) and also between December and February (67/95%).

Rizzo et al 2011, Chioggia Maritime District: the research centres on the commercial size and a possible link between thermal anomalies in the autumn period and early gametogenesis in specimens not in optimal conditions from the point of view of the recovery of the energy budget, with possible impairment of the probability of survival of specimens and severe repercussions on the quality and quantity of gametes.

Franceschini and Bernarello (ISPRA 2013): The clam has a long reproduction period, which goes from April to October intermittently (Poggiani et al., 1973). In the central Adriatic, two distinct gamete release periods were observed, one between May and July and one between September and October (Froglia, 1975). The individuals of *C. gallina* reach the first year of age at 18 mm and the second at 25 mm (commercial size), while the size at first sexual maturity is set at around 13-15 mm and between 20 and 25 mm the clams reach full sexual maturity, where the weight of the gonads can represent around 50% of fresh weight (Poggiani et al., 1973; Froglia, 1975, 1989; Casali, 1984).

Scopa et al. (*IZS Abruzzo and Molise*), 2014. Reproduction begins in spring and continues until the end of the summer, with a peak in July (reference to Njima & Russo, 1989 in the Tyrrhenian sea: summer reproduction, difficulty in determining the 0+ class).

Marin et al. Padua university, various publications edited from 2002, the districts involved are Chioggia and Venice. In short, the studies demonstrate a double release, in spring and autumn, also linked to Condition Index (expressed as dry weight soft tissue * 100/dry weight shell)

Dredge fisheries national management plan 2014: this compendium shows that first reproduction is reached with certainty at the age of one year, in the reproductive season after birth. Clams have been found with mature gonads in 10 mm size classes, but over 50% of the 15 mm clams are able to reproduce.

Portugal: several studies, most recently Joaquim *et al*. 2014: Algarve, there is a correlation between the gonadic index and chlorophyll, extensive reproduction period with annual variations.

Spain:

Ramon 1990, Valencia. Release June-August, but in 1990 release in April (related to temperature). It is noted that the data are consistent with other authors, except Marano *et al*. (1982), who do not observe sexual rest during the study period. Partial disagreement with Vizuete F. and Mas J. (1987), the area coincides more or less but a different method is used and two releases are hypothesised. According to Ramon, based on the size of the eggs over time there are constant releases, with some peaks (the author observes a peak in June).

Rodriguez de la Rùa et al, 2003. They carry out a study on three populations, sampled between 1999 and 2000, one of which is in the Mediterranean, with extended release periods. The number of samples is high (11623 specimens from 5.7 to 35.2 mm), maturity is classified in five stages, but the actual number of samples analysed histologically is not specified.

Delgado et al 2013 Gulf of Cadiz. Partial fecundity, range examined: from 3 to 32 mm (appx), reproduction from March to September, the dimension at first maturity: estimated 10.29 mm length for females, 8.41 mm for males (9.34 mm mean value males and females together), in disagreement with a previous study (sizes: 11-29 mm, L_{50} 16 mm), estimated number of oocytes: 76 835 – 797 424. Females of 30 mm would produce 4.5 times the number of eggs produced by one of 20. The authors report difficulties in evaluating total fecundity, as there were multiple partial releases of different intensities.

Turkey

Oray et al. 1991. Indicate for the Marmara Sea: start of maturation phase in May, deposition between June and July ending in mid-August. In the Western Black Sea there is a two-week lag in the beginning of deposition and its conclusion, reported at the end of August.

Erkan, 2002. Reports for the Marmara Sea, minimum size at reproduction 18 mm.

Dalgiç, 2009, *Erkan*, 2009. Southern Black Sea: deposition begins in June and continues until July. Water temperature 20 °C, size class studied: > 20 mm.

It is important to recall that, in order to define the degree of maturity of a clam, different evaluation criteria have been used, with 4-5 or 6 stages, all the Authors recognise the reproduction stage and the phase following the deposition, in particular for the gametogenic phases, ranging from 4 to 5, according to some authors (Gaspar et al, 1998, *C. striatula*) even propose 6 for both sexes, from Joaquim et al. 2014: (A) Inactive. (B) Early active; (C) Late active; (D) Ripe; (E) Partially spawned. (F) Spent. The work of Delgado appears more complete, however he identifies as many as 3 sub-stages in phase 4. The fifth phase, post-release should be the phase of rest and reabsorption. The size of the oocyte ready for release is 45-50 µ. The size of the specimens studied is not reported.

The reference for the Adriatic can be Poggiani et al. 1973 who consider: rest (stage 1), start of maturation phase (stage 2), mature gonads (stage 3), post-deposition phase (stage 4).

Valli and Zecchini-Pinesich (1981-82) use a six-stage scale: stage 0: gonads at rest, stage 1: start of gametogenesis with growth of follicles, stage 2 the first mature gametes appear, Stage 3 mature gametes, pre-release phase, stage 4 release, stage 5 rare mature gametes, more or less advanced phase of reabsorption.

Some authors have investigated the factors influencing reproduction, including the expansion of the reproductive period to autumn and winter, which occurred in some cases (for example, 1996 and 2011) in areas where there had been sudden mass deaths at the end of the summer.

Research on the relationship between stress and reproduction has been dealt with in numerous works, substantially at the University of Padua. Stress is associated with the appearance of particular molecular markers and/or changes in the function of hemocytes.

Pampanin *et al.* (2002) observe that after three days of exposure to air, the specimens are no longer able to recover, confirming what was observed in 1991 by Brooks et al. (1991), who detected a greater weakness of *C. gallina* compared to *S. inaequivalvis*.

Ballarin et al. (2003) compare stress indicators with different harvest methods and they observe that the concentration of hemocytes is lower during the spring and higher in the autumn-winter period. The researchers associate the evolution of hemocyte concentration with the reproductive cycle and observe that the high autumn values are due to a process of energy accumulation.

Matozzo et al. (2005) observe that anoxia reduces the functional responses of the hemocytes and that it is possible that the reproductive events represent a cause of energy consumption for the species that is comparable to a stressful situation.

Notwithstanding the importance of the reproductive cycle, it is however fundamental to evaluate what happens after release with the complex problems related to fertilisation, in particular the contemporaneity of the release between males and females and the distance between spawning stocks. The subsequent phase of larval planktonic dispersion and the success rate of settlement (mero- meiobenthic phase, starting from 100-120 μ) have not yet been subjected to assessment and are independent of the quantity of spawning stocks.

In summary, scientific literature indicates that the reproductive period of the clam is between April and October, with multiple deposition for the same individuals during the reproductive period.

Reproduction has also been reported in different periods such as late autumn and winter. The period can also be linked to temperature trends above 14°C or to stressful situations.

The size at which gametogenesis begins has been considered differently by the authors, the growth and development processes of the gametes can begin before 10 mm and continue according to seasonality. Gametes were detected at sizes less than 15 mm during the reproductive season. It can be argued that clams of 13-15 mm are in reproduction.

The number of eggs that are released depends on the size of the clams during the reproductive season. The size-fecundity ratio has not been studied in depth. The fecundity of the clams is however very high, according to Delgado et al. 2013, fertility between 11 mm and 29 mm would go from 77.000 to 797.000 oocytes and a 30 mm clam would produce 4.5 times more eggs than a 20 mm clam; this element can be useful in estimating the reproductive potential of the clam population.

It should be remembered that, according to some observations, there are differences in growth and that for the purposes of fertility it would appear to be the age that influences the number of oocytes produced and not just the size.

Table 3. Main bibliographical sources and data on reproduction

Autore	anno	area	durata campionamento	lungh. femm I maturità (mm)	lungh femm piena maturità (mm)	intervallo di taglia (se disponibile)	picco di emissione (se disponibile)	metodo	
Salvatorelli	1967	antistante Chioggia	non ricavabile	nd	nd		07-08	istologico	
Poggiani et al.	1973	Alto e Medio Adriatico	luglio 1968 a-marzo 1970	16-18	nd		07-08	istologico	
Froglia	1975	Medio Adriatico		nd	nd		05-07 e 09-10	macroscopico	
Marano et al.	1980	Golfo di Manfredonia	gennaio-dicembre 1978	nd	nd	media	fine 04-08/09	istologico	
Marano et al.	1982	Golfo di Manfredonia	gennaio-dicembre 78/ 79	nd	nd		07/10	istologico	
Valli e Zecchini-Pinesich	1981 (1982)	Grado	aprile 1975- 1976	nd	nd	commerciale	06/08	istologico	
Corni et al.	1985	Cesenatico	settembre-dicembre 1982	nd	nd	da 20 mm	post emissione	istologico	
Valli et al.	1985	Grado	settembre 81/82	nd	nd	commerciale	04-07	istologico	
Cordisco et al.	2005	Molise e Puglia Tirreno	2000-2001 2003	nd	nd	12,5-38,3	04-07	macroscopico	
IZS Abruzzo e Molise	2006	C.M.Pescara		12	nd				
Romanelli et al.	2009	Adriatico		13-15	20-25				
Rizzo et al.	2010	Chioggia	giugno 2009- febbraio 2010	nd	nd		06-07 e 12-02	macroscopico	
Franceschini e Bernarello	2013	Veneto		13-15	20-25		04-09		
Scopa et al.	2014	Molise	2003-2012	13-15	20-25		04-10		
MIPAAF	2015	CC.MM. Nazionali		15	20		03/04-10/11		
Ramón Herrero	1990	Golfo di Valencia	maggio 1988-maggio 1990	nd	nd	> 20	06-08	macroscopico	
Rodríguez de la Rúa et al.	2003	Atlantico-Mediterraneo	giugno 1999-maggio 2000	16	nd	5,7-35.2	04-07	istologico	
Delgado et al.	2013	Golfo di Cadice (Atlantico)	maggio 2010–aprile 2011	10,29	nd	3-32	03/09	istologico	
Erkan	2009	Mar Nero Meridionale	luglio 2006			> 20	06-07	istologico	

Growth parameters

Among the more commercially important bivalve molluscs, the clam *Chamelea gallina* is distributed on well-calibrated fine sand bottoms along the coastline in several areas of the Mediterranean Sea and the Black Sea and along the coasts of the eastern Atlantic (Fischer *et al*. 1987, Poppe and Goto, 1993).

In Italy, changes in the environmental conditions in the Adriatic coastal areas and the exploitation of the resource have caused a reduction in the quantities of commercial stocks in some areas over the last 20 years, with clear repercussions in economic terms (Relini *et a*l., 1999; al., 2009).

On the other hand, optimal conditions for clam growth depend on a series of often fluctuating environmental factors (temperature, salinity, dissolved oxygen, hydrology, substrate nature, trophism, inter- and intraspecific competition, etc.) (Barillari *et al*., 1979), which must achieve positive synergy with the biological recruiting peaks that occur during the extensive reproductive season described for the species (Poggiani *et al*., 1973; Froglia, 1975; Valli and Zecchini-Pinesich, 1982; 1983; Froglia and Fiorentini, 1988; Ramon and Richardson, 1992; Gaspar *et al*., 2004; Rizzo *et al*., 2011).

Therefore, a knowledge of the biological and ecological aspects, as well as the environmental and anthropic pressure to which the populations are subjected, is extremely important for the sustainable exploitation of *C. gallina*, especially when, as in the case in question, management measures exist for fishery activities and a fixed minimum size has been set for the species in order to market it legally under EC Reg. 1967/2006 (25 mm corresponding to 2 years of age).

In particular, a detailed knowledge of the growth methods of the species and of the growth parameters estimated for localised populations are fundamental in order to construct management models on a local scale, especially in areas where fisheries activities have historical value and where they represent a keystone of the local economy, such as in the Adriatic Sea (Padella and Finco, 2009).

In the varied scenario of methods applied and consequent results obtained for this long-studied species, *C. gallina* (e.g. Relini *et al*., 1999 and included bibliography), it was considered appropriate to proceed with a systematic synopsis of aspects related to age determination and to the estimation of growth parameters that contemplates possible interpretative scenarios, including comparisons.

Methodology for age determination and growth parameters in Chamelea gallina

In recent years, most scientific research conducted to estimate the growth parameters of *C. gallina* have seen the application of different methods to determine age. Consulting the ample bibliography on the subject, it is possible to identify the three main methodologies applied:

- analysis of modal components in length-frequency distribution;
- analysis of growth rings on the outside of the shell;
- analysis of the growth lines on the inside of the shell.

There are also studies in which marking methods and energy budget modeling has been applied to the physiology of *C. gallina*, as well as the methods for observing variations in the isotopic composition of the shell (Keller *et al.,* 2002).

The analysis of the progression of the modal components or pseudo cohorts (Bhattacharya, 1967) in length-frequency distributions is well-known as an indirect method for the estimation of growth parameters according to the von Bertalanffy model, as implemented in the FISAT II software (Gayanilo *et al*., 2005). In particular, this methodology that associates an age with the different pseudo cohorts identified in the size distributions and observed in progression over a defined period of time, was widely used in older studies for the estimation of growth parameters of *C. gallina* in the Mediterranean and Atlantic (Froglia, 1975, 1989, 2000; Ramón, 1993); more recently it has been applied comparatively with other methodologies to allow for appropriate comparison and corroboration (Ramón and Richardson 1992; Gaspar *et al.,* 2004).

Indeed, problems can occur in the variability of the growth parameters estimated for *C. gallina* with this method, due to the relatively long biological recruitment period and/or the highly variable individual growth rates within the pseudo cohorts identified in the length- frequency distributions (Seed, 1976; Cerrato, 1980; Kautsky, 1982).

As an alternative to this indirect method, clam growth parameter estimations can also be obtained through the macroscopic observation of the succession of growth lines on in the outer part of the shell, or by microscopic observation of the stripes inside the shell (Figure 12.A and Figure 12.B).

In general, for bivalve molluscs the formation of the rings on the outside of the shell takes place annually during the winter period when growth slows down (Lutz and Rhoads, 1980). The methodology that envisages the observation of the outer rings of the shell has often been used for *C. gallina* because it is a rapid technique (Vives and Suau, 1962; Massé, 1972; Poggiani *et al*., 1973; Marano *et al*., 1982 ; Royo, 1984; Cano and Hernández, 1987; Ramón, 1993; Deval and Oray, 1998; Gaspar *et al.,* 2004).

However, the main problem with this methodology is that exposure of the surface of the shell to the action of agents that can erode its margins make the traces of deposition indistinguishable or equivocal.

Moreover, in this case it is always possible that the growth rings are irregular due to drastic environmental changes, which make it impossible to decipher the age. This occurs mainly in bivalve molluscs in highly unstable environments such as tropical marine areas rather than in temperate areas. In the same way, the annual growth rings on the outer shell of *C. gallina* could be superimposed with other lines that are formed in periods of reproductive stress, or due to harvesting, dredging and predation attempts by other carnivorous species (for more information see Richardson, 2001).

This interpretative difficulty is partially overcome when we proceed with studies of the deposition lines inside the shell of *C. gallina* under a microscope, counting the annual clefts (Barker, 1964) (Figure 12.B). The advantage of observing of microscopic growth lines is that the structures are not affected by environmental perturbations, which consents greater accuracy in age determination (Richardson 1987, 1989 and 1990; Anwar *et al*. 1990, Bourget and Brock 1990). However, in consideration of the fact that the clefts represent an increase in the density of the micro-lines of growth, coinciding physiologically with the passing of time or with the possible moments of stress for the clam, it is not possible to remove the possible effects of fishing activity, which may affect the estimates.

In any case, although it is more expensive in terms of costs and involves more work, there have been numerous applications of this methodology for age determination and the estimation of growth parameters in *C. gallina* populations in different areas of the Mediterranean. (Arneri *et al*., 1995, 1997; Ramón and Richardson, 1992; Polenta, 1993; Ramón, 1993; Deval, 2001; Dalgic *et al*., 2010; Biondi and Del Piero, 2012).

To date, most of the work that has focused on investigating the growth dynamics of clams and other bivalves has tended to use the methods described above simultaneously, in order to compare the results obtained, as well as to compare recent work with past research in which only one of the aforementioned methods was employed. In general, compared to the use of direct observation methods, the need arises to correlate the formation of rings or micro-lines with environmental variables, such as temperature, to achieve an improved understanding of these influences.

In other words, the situation is similar to the investigation of the age of other organisms, where the reading of the rings on the shell is similar to the reading of bands on otoliths or scales, vertebrae or bones.

In general, each technique demonstrates a certain variability in growth, both between different specimens living together and when comparing growth over several years.

For various species, in particular bivalve molluscs of commercial interest, the different methods to evaluate growth have been compared with the results from breeding hatcheries in which each specimen can be followed in its growth over time.

In mussels, for example, which do not receive artificial food and which grow using the natural environmental and trophic conditions, it has been noted that to reach the size of 6 cm they can take from 10 months to over 24 months. Growth of the Manila clam is equally variable, in the same lot coming from artificial breeding there are specimens that reach 20 mm in a few months while others take more than a year, therefore the commercial values of the clam seed are different between those that grow rapidly and those that grow slowly.

This significant variability in growth is also present in *C. gallina* clams and the parameters reported by the various authors for different areas and different years demonstrate this.

It should be considered that, through the whole reproductive period, there is already a large difference in size with the same number of rings, linked to the slowdown of growth.

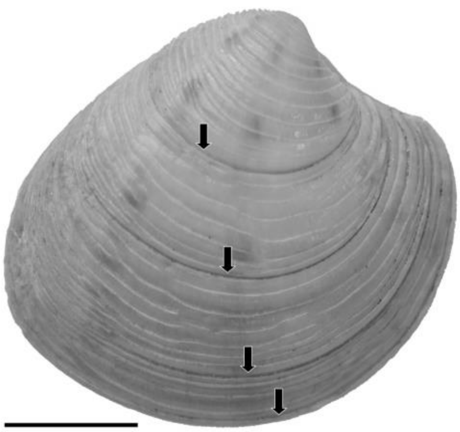


Figure 12a. External growth rings (arrows) visible in the shell of *Chamelea gallina*. Scale bar 1 cm (from Gaspar *et al.*, 2004).

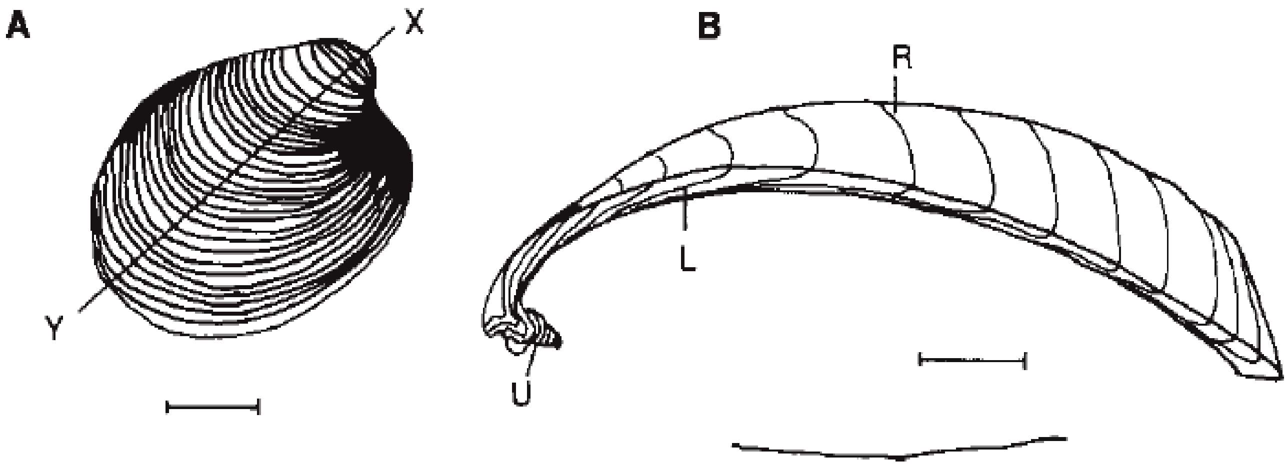


Figure 12b – Diagrammatic representation of a) the external growth rings and the radial shell section taken along the X-Y axis to reveal the internal growth rings (L) in the outer shell layers and umbone (U) surface growth rings (R) (modified from Gosling, 2003).

Length-age keys and estimation of growth parameters in Chamelea gallina.

Growth of bivalve molluscs is allometric and is characterised by a progressive change in the proportions of the shell along a radial axis. Specifically, in *C. gallina* a negative allometric growth relationship was observed in the Atlantic along the coasts of Portugal (Gaspar *et al*., 2001) and in the Mediterranean (Froglia, 1975; Cano and Hernández, 1987; Deval, 2001; Çolakoğlu and Tokaç) (Tab. 3.a).

Table 4. size/age ratio estimated for *C. gallina* in different geographical areas.

Area	a	b	r	Bibliographical reference
Mid Adriatic	0,555	2,780		Froglia *et al*., 1975
Manfredonia district (north Gargano area)	0,000646	2,733	0,982	Vaccarella *et al*., 1996
Manfredonia district (south Gargano area)	0,000541	2,780	0,997	Vaccarella *et al*., 1996
Upper Adriatic	0,62	2,300	0,816	Valli *et al*., 1982
Upper Adriatic	0,000715	2,747		Pellizzato and Vendramini, 2002
Central Tyrrhenian sea	0,00092	2,701	0,940	Costa *et al*., 1987
Atlantic (Portugal)	0,0007	2,801		Gaspar *et al*., 2001
Marmara Sea (Turkey)	0,3593	2,8908	0,98	Çolakoğlu and Tokaç, 2014

As far as the length-age relationship is concerned, a wide list of estimated values for the growth parameters is reported, obtained from various studies conducted on samples of *C. gallina* gathered in Mediterranean and Atlantic areas and published from 1962 to 2010 (Table 5). Comparing the results obtained with the application of the different methods, it results that the estimated length/age using external growth rings is greater than that obtained with other techniques (Ramón and Richardson, 1992) (Fig. 3.C). In particular, Ramón and Richardson (1992) demonstrate that the sizes estimated at age 1 and 2 correspond to about 18 and 25 mm, respectively. However, the sizes estimated at more advanced age appear to be underestimated and undermined by a flattening trend of the growth curve.

Regardless of the different methodological aspects, the main divergences between the various results obtained in the different scientific studies considered are found above all in the first year of age. Therefore, reaching the commercial size of 25 mm takes place in a range that varies between the second and the fourth year of age, depending on the geographical area and the method used to estimate growth.

The local differences in the growth dynamics of *C. gallina* are attributable to a series of endogenous factors, such as metabolism and life cycle, and exogenous, such as environmental agents and the impact of human activities.

The growth rate of the clam tends to decrease with age, showing annual variations attributable to the synergic action of various factors. In particular, periods of slowing down and interruption of growth coincide with reproductive events in the summer period, which however determine conditions of stress (Ramón and Richardson, 1992; Gaspar *et al*., 2004).

These results are also supported by the studies conducted by Keller *et al.* (2002) on changes in oxygen isotopes that confirm both seasonal variations in growth and a reduction of calcium carbonate deposition with increasing age (Ramón and Richardson, 1992; Gaspar *et al*., 2004).

Fishing pressure also seems to have a negative influence on growth, since greater speed of growth has been demonstrated in areas not affected by fisheries with hydraulic dredges compared to those targeted in the Black Sea (Dalgiç *et al*., 2010). Effects of mechanical impact on *C. gallina* were also studied in the Northern Adriatic Sea (Moschino *et al*., 2003), identifying the different types of damage suffered by the shells and the disturbance in growth.

Lastly, among the anthropogenic disturbances with a potential effect on the growth of *C. gallina*, water acidification should be considered (Fabry *et al*., 2008) which has been shown to contribute to a reduction in shell thickness (Bressan *et al*., 2014).

The variability of growth between different areas can be partly explained by very different productivity situations, which is demonstrated for mussels and Manila clams bred in hatcheries, but there are also elements that cause growth to vary between different years in the same area.

The fact that the clams live in a narrow coastal strip, subject to anthropic impact and the ecological variations associated, for example, with different annual amounts of fresh water with nutrients that affect productivity. This is at the root of the different growth rates between clams of the upper Adriatic and those of the Tyrrhenian coast.

Another element that conditions the growth of clams where food is equally available is the density of clams; there are areas in which the density of clams exceeds 1000 specimens per m² and other areas with dozens of clams per m². In areas with greater competition for food, slower growth is observed. The fact that the growth takes place at a different speed in the course of the year also indicates that ecological factors influence growth, among which water temperature has an important role, causing growth to slow both when temperatures are coldest and when they are highest at the end of summer.

On the whole it can be said that clams demonstrate fairly variable growth rates between different areas and different years and that growth is strongly influenced by numerous ecological parameters and this variability must be kept in mind for management purposes. In addition, it is often the case that the value assumed by parameters of the von Bertalanffy growth model, indicates that the analyses mainly aimed at estimating the L_∞ and k parameters in the growth curve, were conducted leaving the fitting algorithm to guide the procedure, without any kind of critical constraint, often providing perfect estimates from the point of view of simple mathematical calculation, since they minimise the data gap, but at the cost of unrealistic values, especially in t_0.

Table 5. Growth parameters (length-age, k e L_{inf}) of *C. gallina* obtained using different methods in different geographical areas.

Area	Method	L_{max}	L_{inf}	k	Age (L_{25mm})	t_0	Bibliographical reference
Eastern Adriatic, mouth of the Neverta (Croatia)	Thin section	46,0	39,50	0,52	-	-0,13	Arneri *et al.*, 1997
Mediterranean, Gulf of Marseille (France)	Length frequency distribution	23,00	-	-	-		Bodoy, 1983
Mediterranean, Gulf of Marseille (France)	External rings	32,00	-	-	2		Massè, 1972
Tyrrhenian sea		-	39,11	0,50	-	-0,30	Costa et al., 1987
Central Adriatic, Ancona (Italy)	Length frequency distribution	50,00	-	-	2		Froglia, 1975, 1989, 2000
Central Adriatic, Ancona (Italy)	Acetate peel	49,00	52,20	0,21	2	-0,97	Polenta, 1993
Central Adriatic, Ancona (Italy)	Thin section	-	41,60	0,48	-	-0,01	Arneri *et al.*, 1995
Central Adriatic, Fano - Pesaro (Italy)	External rings	46,00	-	-	3		Poggiani *et al.*, 1973
Southern Adriatic, Bari (Italy)		-	42,82	0,79	-	-0,03	Vaccarella *et al.*, 1996
Southern Adriatic, Bari (Italy)	External rings	47,00	-	-	3		Marano *et al.*, 1982
Atlantic, Algarve coast (Portugal)	Length frequency distribution	40,00	37,55	0,71	2		Gaspar *et al.*, 2004
Atlantic, Algarve coast (Portugal)	External rings	40,00	38,95	0,47	2	-0,24	Gaspar *et al.*, 2004
Atlantic, Algarve coast (Portugal))	Acetate peel	40,00	42,15	0,32	3		Gaspar *et al.*, 2004
Western Mediterranean, Ebro (Spain)	External rings	41,00	-	-	3		Vives and Sau, 1962
Western Mediterranean, Valencia (Spain)	Acetate peel	-	36,12	0,35	2		Ramón and Richardson, 1992
Western Mediterranean, Valencia (Spain)	Length frequency distribution	-	40,05	0,40	-		Ramón, 1993
Atlantic, Huelva (Spain)	External rings	-	-	-	3		Royo, 1984
Mediterranean, Bay of Mazarrón (Spain)	External rings	-	-	-	2		Cano and Hernández, 1987
Northern Black Sea (Turkey)	Thin section	27,10	27,50	0,61	-	-0,14	Boltachova and Mazlumyan, 2001
Northern Marmara Sea (Turkey)	External rings	34,50	34,17	0,43	3	-0,49	Deval and Oray, 1998
Marmara Sea (Turkey)	Thin section	34,30	33,46	0,37	4	-0,69	Deval, 1995
Northern Marmara Sea (Turkey)	Acetate peel	34,30	33,46	0,37	4	-0,69	Deval, 2001
Western Marmara Sea (Turkey)	Length frequency distribution	39,00	33,00	0,39	-	-0,43	Çolakoğlu and Tokaç, 2010
Black Sea – areas not dredged (Turkey)	Thin section	31,50	28,88	0,21	-	-1,29	Dalgic *et al.*, 2010
Black Sea - areas dredged (Turkey)	Thin section	28,70	26,0	0,16	-	-1,96	Dalgic *et al.*, 2010
Black Sea – areas where fisheries are banned (Turkey)	Thin section	29,10	26,6	0,22	-	-1,21	Dalgic *et al.*, 2010

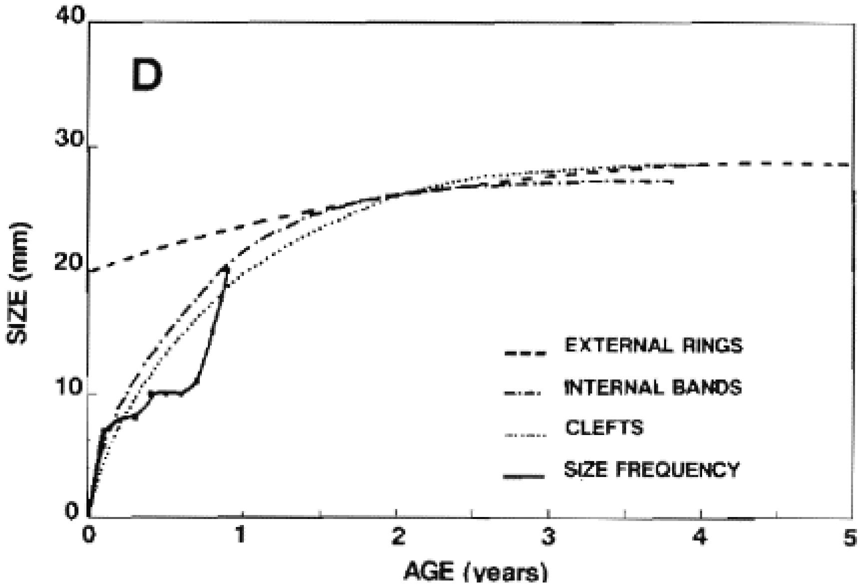


Figure 13. Comparison of growth curves obtained with different methods and estimated using the von Bertalanffy equation (modified by Ramón and Richardson, 1992).

Sexual maturity

A clear indication of the size at which sexual maturity is reached is available in a study Rodriguez de la Rua *et al*. (2003), which shows that 50% of individuals are sexually mature around a size of 16 mm in length (Figure 3). At 22 mm the percentage of mature individuals rises to 85%, reaching 93% at 25 mm.

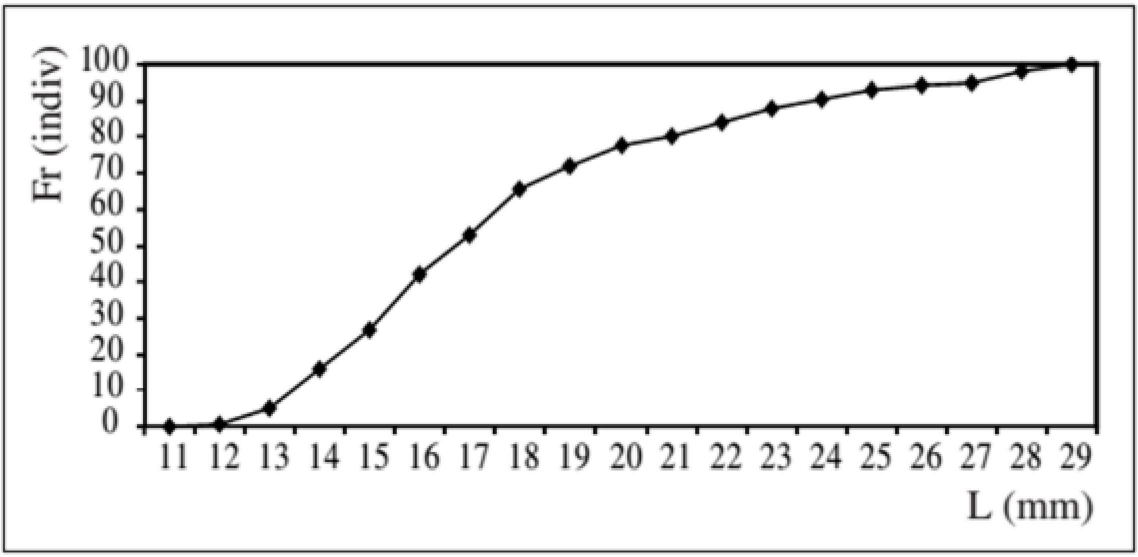


Figure 14. Frequency of mature specimens in relation to the length.

To make the inverse calculation, in order to obtain an estimate of the reproductive potential from the size distribution, the same curve was used, correcting it where necessary to make the relation monotonic.

In this regard it should be underlined that data on the populations in Italian waters are not available in a similarly structured form, although the sources available seem to provide slightly different indications from those of Rodriguez de la Rua *et al*. (2003). These researchers, *inter alia*, provide data on a geographical area that is not directly comparable with the Adriatic. However, these authors provide the only example of a curve or function that expresses the fraction of sexually mature individuals in relation to their size that is currently available in literature. For this reason, despite the limits mentioned above, this source has been adopted as a reference in this study. As the estimates available for Italian waters seem to indicate greater reproductive potential depending on size, the use of the curve reported by Rodriguez de la Rua *et al*. (2003) also appears to respond to the precautionary principle.

Furthermore, as reported in the Italian Management Plan for dredge fisheries and also in the European Parliament (PECH Committee) study on the Clam Fishing sector (2016), the results confirm that *Chamelea gallina* reaches sexual maturity at dimensions that vary between 13 mm and 18 mm. Adult clams are defined as specimens that are larger than 18 mm in size (pages 14, 42, table 1, source: European Parliament study on the Clam Fishing sector - the case of the Adriatic Sea, January 2016).

A size of 22 mm is therefore 22% higher than the size at the first stage of maturity (18 mm) and is therefore in line with and in respect of sexual maturity, ensuring the sustainability of the exploitation of these resources.

State of implementation of the discard plan

This chapter provides a summary of the state of implementation of the National Discard Management Plan for the Venerid clam (*Chamelea gallina*) adopted with DM 27/12/2016 “Adoption of the National Discard Management Plan for the Venerid clam (*Chamelea gallina*)”, an in-depth analysis is provided in Annex II.

Verification of the state of implementation was carried out by verifying documentation produced by the single Management Consortia and through the communications received from the Port Authorities, specifically, compliance with the schedule of the actions indicated in D.M. 27/12/2016 was analysed.

The activities to be carried out by the Management Consortia that are necessary to achieve the general objective are:

- **within ninety days** of the entry into force of the National Discard Management Plan for stocks of the Venerid clam (*Chamelea gallina*):
  - all units authorised to harvest clams must be equipped with a system to monitor and record vessel position at sea (VMS - AIS - GPS);
  - at the designated landing sites, the equipment for the selection of the product must be operational, fixed or mobile structures, on land or floating can be used;
  - the management consortia must introduce a certification system to certify conformity of the product to the minimum conservation reference size.
- **within one hundred and eighty days** of the entry into force of the National Discard Management Plan for stocks of the Venerid clam (*Chamelea gallina*):
  - restocking areas must be identified, in order to relocate the undersized specimens previously caught. In these areas appropriate measures shall be taken to limit and regulate clam fisheries (*C. gallina*) as well to ensure the rotation of the areas for the repopulation of the species;
  - a continuous scientific monitoring system must be adopted for the restocking areas to monitor survival and growth of the specimens transferred there; scientific assessment must take place on a regular basis and in any case in the three months following the repopulation period of the undersized specimens;
  - A control plan must be implemented in cooperation with the European Fisheries Control Agency (EFCA).
- **within twelve months** of the entry into force of the National Discard Management Plan for stocks of the Venerid clam (*Chamelea gallina*):
  - a pilot project will be implemented with the aim of increasing the selectivity of the sieving gear, which will be carried out in two maritime districts designated for this purpose.

Lastly, **on a yearly basis**, in order to evaluate the Plan, a monitoring programme will be implemented in order to evaluate the state of the clam stocks, the efficiency of the technical measures adopted and the state of implementation of the national control programme.

The fleet of hydraulic dredgers authorised to harvest bivalve molluscs in Italian territorial waters has 706 units, the breakdown is shown in the table below.

Bivalve mollusc fisheries in Italy		
Region	*Management consortium*	*Number clam vessels*
Friuli Venezia Giulia	Co.Ge.Mo. Monfalcone	42
Veneto	Co.Ge.Vo. Venezia Co.Ge.Vo. Chioggia	163
Emilia Romagna	Co.Ge.Mo. Ravenna Co.Ge.Mo. Rimini	54
Marche	Co.Ge.Mo. Pesaro Co.Ge.Vo. Ancona Co.Ge.Vo. Civitanova Marche Co.Vo.Pi. San Benedetto del Tronto	221
Abruzzo	Co.Ge.Vo. Abruzzo Pescara Co.Ge.Vo. Frentano Ortona	103
Molise	Co.Ge.Vo. Termoli	9
Puglia	Consorzio Molluschi Nord Gargano Co.Ge.Mo. Il Colosso di Barletta	76
Campania	Co.Ge.Mo. Napoli	14
Lazio	Co.Ge.Mo. Gaeta Co.Ge.Mo. Roma	24
Total		**706**

It should be noted that in the Maritime Districts of Friuli Venezia Giulia and Veneto 71 fishing vessels are authorised to harvest *Callista chione* (smooth clam) in the open sea and they are also managed by the Management Consortia.

The state of implementation of the measures carried out by the Italian Consortia for the Management of Bivalve Molluscs is reported hereafter.

The system to monitor and record vessel position at sea (VMS - AIS - GPS)

D.M. of 27/12/2016, relative to the adoption of the National Discard Management Plan for Venerid clam stocks (*Chamelea gallina*), states in art. 3 letter a): “all the units authorised to harvest clams are equipped with a system to monitor and record vessel position at sea (VMS-AIS-GPS)”.

As shown in brackets, the system can be based on data transmission by means of traditional VMS systems, blue box, or AIS, (Automatic Identification System), which use radio wave transmission, or with the use of GPS systems that rely on data transmission via GSM, similar to those that are used to transmit data with mobile phones.

Some Consortia have adopted *ad hoc* systems, others used existing systems, such as AIS or those used for vehicle tracking.

Regardless of how data is transmitted and acquired, the systems adopted have some common basic characteristics, to which additional features can be added, summarised as follows:

- the system must operate independently from the will of the fisher(s). Activation therefore occurs when the vessels starts and ends when engines are switched off. This is to ensure that it is always active during fishing operations;
- the data transmitted include the following, at least:
    - Vessel number, EU number or other identification code;
    - Date
    - Time (hour, minutes, seconds)
    - GPS position in geographical coordinates
- The transmission of data to the receiving station that has the recording system takes place with a frequency of between 60 and 120 seconds;
- The receiving station records the data and stores them for the duration of the experimentation (about 3 years);
- The Consortium can view the position of the vessels operating in the entire district on a special map as well as the relative data in real time;
- The visualisation map shows the perimeter of the discard zones where fishing is prohibited;
- When the discard area is violated, this is automatically and immediately reported to the Consortium managers;
- The system allows access to data, on a read-only basis, by technicians appointed by the Consortium to monitor the progress of fishery activities periodically.

Depending on the type of system adopted, additional functions are possible that allow further observations and checks on fishing activities. In some specially-designed systems, it is possible to assign different colors to the vessels in relation to a certain speed range, for example red if it is in navigation, green if it is fishing. On the map it is possible to manage the areas in which fishing is prohibited, create, rename, delete or enable/disable areas of interest. Circles, rectangles or polygons can be created. Graphics tools are provided for the correct positioning and sizing of the areas.

When a vessel enters a prohibited area at a speed compatible with fishing activities, the system records the infringement keeping track of it in the database. Information on any infringements is shown in chronological order in a dedicated table, which shows: the name or code of the vessel, the name of the area infringed, the date and time of infringement began and the date and time it ended. It is also possible to display the vessel’s route within the prohibited area by clicking on the infringement line.

A daily report is also issued detailing any infringements, which is sent by e-mail to the Consortium's managers, in addition to the generation of alarms sent via email, text message, etc.

The state of implementation of the monitoring and recording systems relative to vessel position at sea present on board hydraulic dredgers is provided below.

Table 6. Type of vessel position detection system adopted by the various Management Consortia.

Monitoring system and of position at sea (VMS-AIS-GPS)			
Management consortium	*n. vessels*	*VMS-AIS-GPS*	*Notes*
Co.Ge.Mo. Monfalcone	42	yes	All units have GPS systems
Co.Ge.Vo. Venezia	86	yes	All units have AIS systems
Co.Ge.Vo. Chioggia	77	yes	All units have AIS systems
Co.Ge.Mo. Ravenna	18	yes	All 18 vessels that are members of the consortium have GPS geolocalisation systems
Co.Ge.Mo. Rimini	36	yes	GPS system provided by Visirun
Co.Ge.Mo. Pesaro	65	yes	All 65 vessels have GPS registration systems
Co.Ge.Vo. Ancona	74	yes	73 vessels have GPS and12 vessel has an AIS system
Co.Ge.Vo. Civitanova Marche	25	yes	23 vessels have GPS and 2 vessels have AIS systems
Co.Vo.Pi. San Benedetto del Tronto	57	yes	46 units have GPS systems, 11 vessels have AIS
Co.Ge.Vo. Abruzzo Pescara	82	yes	All 82 vessels have AIS or GPS systems.
Co.Ge.Vo. Frentano Ortona	21	yes	3 vessels have AIS systems and 18 vessels have GPS systems
Co.Ge.Vo. Termoli	9	yes	All 9 vessels have GPS MOPE systems
Consorzio Molluschi Nord Gargano	51	yes	48 vessels have GPS systems
Co.Ge.Mo. Il Colosso di Barletta	25	yes	All 25 vessels have GPS systems
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	

Landing sites

There are 63 landing sites along the coasts of the Maritime Districts involved in clam fisheries.

Landing sites		
Consortium	*n.landing sites*	*Location*
Co.Ge.Mo. Monfalcone	2	Grado (banchina Riva Dandolo c/o Mercato Ittico) Marano Lagunare (Banchina Nord-Ovest c/o mercato ittico)
Co.Ge.Vo. Venezia	5	Caorle (zona Sansonessa lungo riva fiume Livenza) Cortellazzo (riva adiacente ponte di Cortellazzo) Porto di Piave Vecchia (banchina vicino alla ditta Azzurra pesca) Punta Sabbioni (località Saccagnana - riva della ricevitoria) Malamocco (loc. S. Pietro in Volta - strada comunale dei Murazzi 1250)
Co.Ge.Vo. Chioggia	5	Chioggia (zona Punta Poli banchina Nord) Chioggia (zona Punta Poli (banchina Est) Porto Tolle (Porto Barricata località Scardovari) Pila di Porto Tolle (approdo laguna di Barbamarco) Porto Levante (banchina antistante caserma GDF)
Co.Ge.Mo. Ravenna	6	Porto di Cervia (Banchina portuale Nord) Porto di Ravenna/Marina di Ravenna (Darsena pescherecci) Porto di Portogaribaldi (banchina portuale Mercato ittico) Porto di Goro (banchina portuale c/o mercato ittico) Riva Sud del Po di Volano
Co.Ge.Mo. Rimini	4	Porto di Cesenatico (banchina dei pescatori lato di Ponente) Porto di Cattolica (Tratto della banchina dalla Madonnina al ponte) Porto di Rimini (banchina piazzale Boscovich) Porto di Bellaria-Igea Marina
Co.Ge.Mo. Pesaro	3	Fano (Banchina 11 e testata Banchina 12) Pesaro (Banchina "Filippini Maria") Gabicce-Cattolica (Molo Madonnina)
Co.Ge.Vo. Ancona	3	Senigallia (Darsena Nino Bixio) Ancona (Banchina 18) Civitanova Marche (Banchina Martello)
Co.Ge.Vo. Civitanova Marche	1	Porto di Civitanova Marche (Banchina Martello)
Co.Vo.Pi. San Benedetto del Tronto	2	Porto di San Benedetto del Tronto (Banchina di Riva Malfizia) Porto di San Giorgio (Molo Sud)
Co.Ge.Vo. Abruzzo Pescara	3	Giulianova (radice molo Laudadio) Roseto (banchina Est) Pescara (banchina Sud)

Landing sites		
Co.Ge.Vo. Frentano Ortona	2	Porto di Ortona (banchina commerciale molo Nord) Porto di Vasto (banchina di Levante)
Co.Ge.Vo. Termoli	1	Porto di Termoli (banchina del molo Nord-Est e del molo Sud-Est)
Consorzio Molluschi Nord Gargano	4	Porto Punta Pietre Nere Porto Canale di Capoiale Porto di Peschici Porto di Manfredonia
Co.Ge.Mo. Il Colosso di Barletta	2	Porto di Barletta (porto commerciale, molo di Tramontana) Porto Canale di Margherita di Savoia (molo di ponente)
Co.Ge.Mo. Napoli	1	località Monte di Procida - Porto di Acquamorta
Co.Ge.Mo. Gaeta	7	Fiume Garigliano Porto di Formia Porto di Gaeta Porto di Sperlonga Porto di Terracina Porto di San Felice Circeo Canale Rio Martino Sabaudia Latina
Co.Ge.Mo. Roma	13	Passoscuro (stabilimento Paloma) Maccarese (spiaggia tra stabilimenti Isola e Eco Mare) Fregene (spiaggia tra gli stabilimenti Singita e Onda Anomala) Fiumicino (molo Nord altezza Torre Piloti) Ostia Lido (canale dei pescatori) Torvajanica (SP 601 km 11.600) Torvajanica (lungomare delle Meduse) Torvajanica (Viale Spagna) Ardea (via Avellino) Ardea (passo a mare n. 25 lungomare dei Troiani 75/77) Ardea (consorzio Lido Tor San Lorenzo) Anzio (porto di Anzio) Nettuno (porto di Nettuno)

Restocking and monitoring areas

Overall, 27 restocking areas have been identified by 13 Management Consortia.

Restocking areas to relocate undersized specimens landed and monitoring			
Management Consortium	*n. restocking areas*	*location*	*Monitoring of the areas*
Co.Ge.Mo. Monfalcone	2	Lignano Sabbiadoro Grado	Foreseen but not applied, because the areas have not been used. Agriteco sc is in charge of monitoring
Co.Ge.Vo. Venezia	3	Caorle Jesolo Lido di Venezia	Three-monthly monitoring is carried out in collaboration with Agriteco sc
Co.Ge.Vo. Chioggia	3	Chioggia Levante Port Pila di Porto Tolle	Three-monthly monitoring is carried out in collaboration with Agriteco sc
Co.Ge.Mo. Ravenna	3	Tagliata di Cervia-Porto Canale di Cervia Marina di Ravenna-Punta Marina The area off scanno di Goro	Monthly monitoring in collaboration with the Marine Biology and Fisheries Laboratory of the University of Bologna – located in Fano (PU). Monitoring will be carried out if the areas are used.
Co.Ge.Mo. Rimini	1	About one mile north of the port of Rimini at about one Km from the coast	Three-monthly monitoring is carried out in collaboration with MARE scarl
Co.Ge.Mo. Pesaro	2	Near Fano Port Cattolica Port	At least twice a year with the Marine Biology and Fisheries Laboratory of the University of Bologna – located in Fano (PU).
Co.Ge.Vo. Ancona	3	Senigallia Ancona Porto Recanati	Monitoring is every two months in collaboration with CNR-IRBIM Ancona
Co.Ge.Vo. Civitanova Marche	1	Civitanova Marche	Three-monthly monitoring is carried out in collaboration with CNR-IRBIM Ancona
Co.Vo.Pi. San Benedetto del Tronto	2	San Benedetto del Tronto Port; Porto di San Giorgio	*Ad hoc* survey if needed, carried out by CNR-IRBIM Ancona. Three-monthly monitoring system.
Co.Ge.Vo. Abruzzo Pescara	3	Giulianova Roseto Pescara	Three-monthly monitoring system in collaboration with the Istituto Zooprofilattico Sperimentale dell’Abruzzo e del Molise
Co.Ge.Vo. Frentano Ortona	2	South of Ortona port	Foreseen but not implemented as the restocking areas are not active

Restocking areas to relocate undersized specimens landed and monitoring			
		North of Vasto port	
Co.Ge.Vo. Termoli	1	Termoli near the port	Monitoring carried out in collaboration with ASREM – Regional Prevention Department – animal hygiene and foodstuffs of animal origin
Consorzio Molluschi Nord Gargano	0	Not yet identified	Not present
Co.Ge.Mo. Il Colosso di Barletta	0	Not yet identified	Not present
Co.Ge.Mo. Napoli	1	Castel Volturno località Lavapiatti	carried out in collaboration with CNR Ancona
Co.Ge.Mo. Gaeta	0	Not yet identified	Not present
Co.Ge.Mo. Roma	0	Not yet identified	Not present

Certification system to confirm product compliance with the minimum conservation reference size

12 Consortia have an Operational Plan to certify product compliance with the minimum conservation reference size.

Certification system to confirm product compliance for sale		
Management Consortium	*System present*	*Reference documentation*
Co.Ge.Mo. Monfalcone	yes	Discard Management Plan for the species *Chamelea gallina* in the Maritime District of Monfalcone - Organisation of the Management and Control System. Definition of the methods to certify product compliance with the minimum conservation reference size
Co.Ge.Vo. Venezia	yes	Experimental Discard Management Plan for the species *Chamelea gallina* in the Maritime District of the Veneto region- Organisation of the Management and Control System. Definition of the manual of procedures for the certification of product compliance with the minimum conservation reference size
Co.Ge.Vo. Chioggia	yes	Experimental Discard Management Plan for the species *Chamelea gallina* in the Maritime District of the Veneto region- Organisation of the Management and Control System. Definition of the manual of procedures for the certification of product compliance with the minimum conservation reference size
Co.Ge.Mo. Ravenna	yes	Operational - Procedural Plan for the adoption of a certification system confirming product conformity to the minimum size of 22 mm
Co.Ge.Mo. Rimini	yes	Operational - Procedural Plan for the adoption of a certification system confirming product conformity to the minimum size of 22 mm
Co.Ge.Mo. Pesaro	yes	Operational - Procedural Plan for the adoption of a certification system confirming product conformity to the minimum size of 22 mm
Co.Ge.Vo. Ancona	yes	Procedural document for the adoption of a certification system confirming product conformity to the minimum size of 22 mm

Certification system to confirm product compliance for sale		
Co.Ge.Vo. Civitanova Marche	yes	Procedural document for the adoption of a certification system confirming product conformity to the minimum size of 22 mm
Co.Vo.Pi. San Benedetto del Tronto	yes	Procedural document for the adoption of a certification system confirming product conformity to the minimum size of 22 mm
Co.Ge.Vo. Abruzzo Pescara	yes	Operational methods adopted by the Co.Ge.Vo. Abruzzo of the Pescara Maritime District implementing DM 27/12/2006 relative to the adoption of a certification system confirming product conformity to the minimum size of 22 mm
Co.Ge.Vo. Frentano Ortona	no	The minimum size of 25 mm is observed (DM 22/12/2000)
Co.Ge.Vo. Termoli	yes	Operational Plan of the Termoli Co.Ge.Vo.
Consorzio Molluschi Nord Gargano	no	
Co.Ge.Mo. Il Colosso di Barletta	no	
Co.Ge.Mo. Napoli	yes	Operational Plan for discards of *Chamelea gallina* stocks of the Naples Co.Ge.Mo.
Co.Ge.Mo. Gaeta	no	
Co.Ge.Mo. Roma	no	

State of the resource: scientific surveys

Vessels and equipment used

Assessment of the state of the clam population in the various maritime districts involved a series of sampling activities, in both years, in the spring-summer period. On board there were crew, at least 2 people, and two scientific operators with the task of gathering fisheries data and coordinating the activities. The sampling operations were carried out with the support of two vessels used for professional clam fisheries with hydraulic dredges.

For the sampling operations a professional hydraulic dredge was used both years, with a front skid runner and two small side skid runners. The mouth had a width of about 3 m (variable from Consortium to Consortium), while the grid had a space between the rods of 12 mm. For the purposes of the research, the commercial sieve with hydraulic movement on board was modified (Figure 15a). The various metal grills used during commercial fishing operations were replaced by a single 19 mm grill (Figure 15b).

Figure 15. vibrating mechanical sieve used on board hydraulic dredgers to select the size classes of product that can be marketed, and the 19 mm grill used during the surveys (b).

Sampling methodology

All information on the catch quantities, coordinates and depth of each haul were reported on specially-prepared forms. Each individual haul was tracked and recorded with GPS equipment and then analysed after landing by computer. Sampling took place with fishing operations on equidistant transects and perpendicular to the coast, with stations at 0.25, 0.50, 0.75 and 1 nautical mile from the coast and, where necessary, even further, in relation to the presence of clams.

According to the operational protocol, the dredge was lowered when the vessels was almost at a standstill and after the water pump had started, the starting position of the haul was recorded as soon as the two lateral warps tightened. The end of the haul was recorded when the water pump shut down, the propeller stopped and when there was no longer any tension in the two side warps. Attempts were made at each haul to explore exactly the same area (the length of the area swept by the dredge was 100 m). To this end, considering that the speed of the vessel was not a reliable parameter to define the length of the haul precisely (operating at a speed of 1-2 knots it is easy to make mistakes even of a few dozen metres), the researchers opted for the use of GPS equipment, which was able to mark 100 metres accurately. The data detected with the GPS allowed for standardiation of the catches a precise manner, even if the haul lasted longer than established in the protocol. At each station, at the end of the haul the dredge was opened over the collection box and the product was rinsed to remove the mud. Once washed, the catch was screened using a single sieve with 19 mm holes (Figure 15). All the clams held in the sieve at each haul were weighed on board with motion compensation marine scales (Marelec W50 / 50-D4 marine scales with precision 50 g and maximum load 50 kg). When catches were abundant, a sub-sample (about 2 kg) was taken for subsequent analysis of the size distribution.

One of the purposes of biological sampling was to study the fraction of juvenile clams that would have reached commercial size in the following months, and their distribution. To sample the juveniles of 8-16 mm (1 year of age, commonly called seed) and 17-24 mm (2nd year of age), it was necessary to use a sampling net, consisting of a stainless-steel frame and a nylon net with a 12 mm opening. The sampling net frame size is shown in Figure 16. The net was fixed inside the dredge (Figure 16) with ties and the catch (benthic organisms, other fauna and clams of all sizes) was weighed and, when it exceeded 10 kg, sub-sampling was carried out.

Figure 16. sampling net made of a stainless-steel frame (40 cm internal length, 20 cm internal width with a thickness of 1 cm) and a nylon net with 12 mm mesh.

Survey data processing

The samples from the dredge and from the sampling net were marked with labels placed inside watertight tubes, showing the code indicating the relative maritime district, the transept number and the station number. At the end of the fishing trip the samples were transported in a refrigeration unit (-18° C) awaiting the biometric measurements in the laboratory. After having been defrosted, each sample was weighed again, the clams were sorted and measurements were taken.

The biometric analysis was carried out by video. Details of the procedures are reported in Stagioni (2010). The clam samples were then divided into groups and positioned one at a time on an illuminated photographic table (Figure 17) over which (at the same height for all the assessments) a digital camera was mounted (Canon EOS Digital 20D) with 8.2 Megapixel resolution and a 28/80 mm lens.

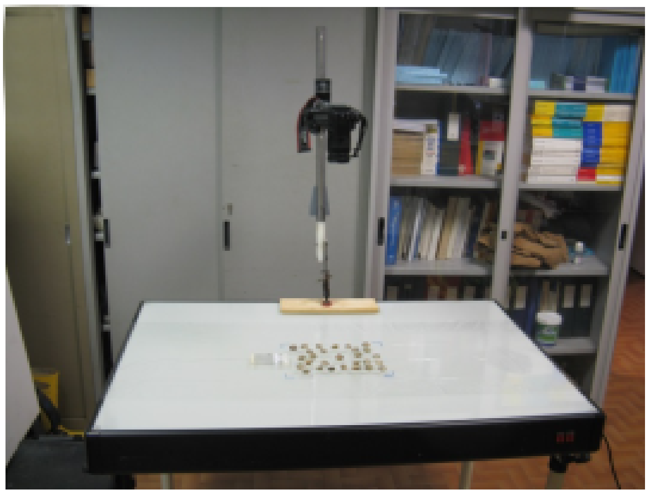


Figure 17. A camera over an illuminated stand for photographic assessment

The photos were processed using video analysis software *ImageJ* (Rasband, 2010), that is able to determine the maximum width of the single clams, which is described using the Feret X parameter (*the longest distance between any two points* *along the selection boundary, also known as maximum caliper*). The calibration was carried out each time on the central clam, measured manually with a laboratory caliper (Figure 18) to limit error as far as possible, due to the distortion of the lens. The biometric readings were made with an accuracy of 0.5 mm and subsequently, during data processing, they were rounded up to the next unit.

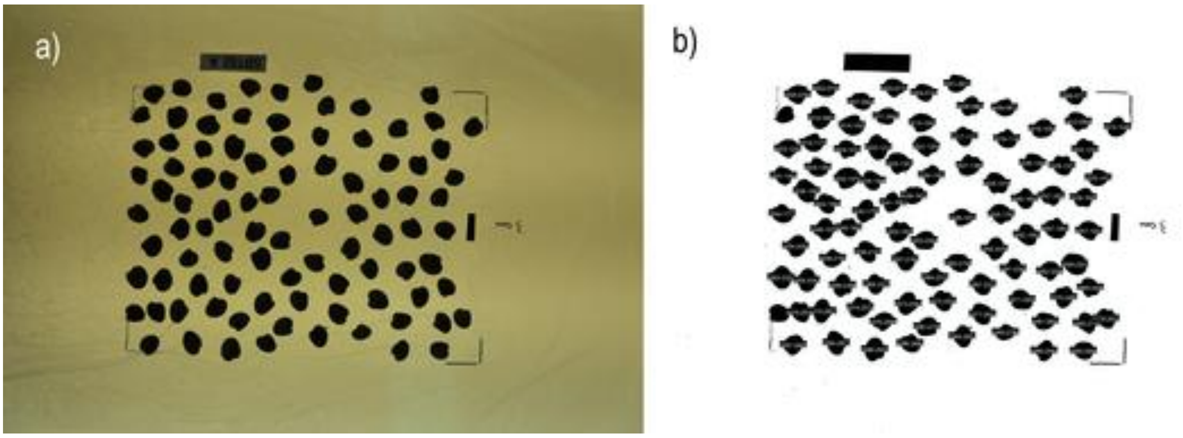


Figure 18. Detail of a photo of a sample of clams photographed on the illuminated stand, with a metric reference (3 cm) on the right with the central clam emphasised and used as a calibration to measure the others (a); (b) the image following post-production using filters and graphic overlays with ImageJ software and the automatic numbering of each single clam.

Sampling methodology used in the survey in Veneto

The monitoring activities were carried out with a fishing vessel with the Co.Ge.Vo. of Venice and Chioggia, equipped with gear with set dimensions, prepared commercial fishing operations, pursuant to the Ministerial Decree of 22nd December 2000.

The fishing operations were carried out along 26 transects in the Venice district and 17 transects in that of Chioggia, spaced about every 2 nautical miles and were conducted starting at a depth of 2 metres (where possible) and ending where the resource was very scarce, or where the safety conditions on board the fishing vessels were not guaranteed (possible presence of submerged rocky outcrops or fixed structures such as dams), or where there were important environmental elements (e.g. seagrass meadows). The catches were carried out parallel to the shoreline, while reversing and towing the dredge that had been lowered onto the seabed, using the system currently employed by the vessels that harvest *C. gallina*, as manoeuvres are simplified and safety on board is greater.

Each haul, which lasted for about 4 minutes at a speed of 2-3 knots, was geo-referenced with a GPS system, while the depth of the seabed was recorded using the on-board instrumentation (Echosounder). At the end of each haul, the same transept was followed to reach the next station, located at greater depth.

The harvested product was conveyed to the selection area consisting of a rotating steel screw conveyor and a vibrating sieve that is set up in all vessels as follows:

- Metal rods at 21 mm to separate the commercial fraction (≥22 mm).
- Metal rods at 18 mm to select the sub-commercial fraction (approximately 20-21 mm).

Using the coordinates at the beginning and the end of the fishing operations, the length of the haul was calculated, which, when calculated together with the width of the gear, provides an estimate of the dredged area. This makes it possible to report a biomass value in grams per square metre of the commercial (≥22 mm) and sub-commercial (approximately 20-21 mm) fractions.

Reference points

To comprehend the state of the clam populations it is necessary to establish objective indicators to be able to compare the situation of the resource from year to year. The volumes caught on a daily basis do not necessarily reflect the abundance of the resource, it is also linked to price dynamics and the quantity of commercial clams available and what will be available on the market in the following months. In light of this, the average density per unit area has been identified as an abundance index. This indicator is fisheries-independent and is based on standardised harvests, which determine the average density of the resource through sampling conducted on transects and equidistant stations. The dimensions of the dredge and the length of dredging are known, therefore the area explored is known too, it is thus possible to obtain the average density and biomass values per unit area, as well as the size distributions. Since this species (like other bivalve species targeted by fishery activities), once it has descended to the sea bed after the larval stage, does not move if not in a limited way, it becomes possible to follow mortality for the different sizes over time and space.

The mechanical vibrating sieves currently used on professional vessels retain almost exclusively specimens over 22 mm, while they release the smaller sizes at sea, with very high survival rates. Therefore, fishing activity would seem to affect clams of over a year, while smaller clams are mainly affected by natural mortality. In particular, sudden mass deaths seem to be triggered where there is high clam density per unit area.

The minimum density of clams in order to carry out commercial fishing is identified in the National Management Plan for Hydraulic Dredgers (Ministerial Decree 24/7/2015) and is at least 1 ind m^{-2} of commercial size, corresponding to about 5 g m^{-2}. This index, which was based on biological but also on economic aspects, makes it possible to define the areas managed in an efficient manner and those which are suffering and require management actions. This is the reference point to attempt to achieve in order to ensure optimal returns. Quantities below the limits should suggest that closing an area to fishing activity could be necessary. Slightly higher values are compatible with fishing activities, but still require a certain level of attention, with more frequent monitoring; in a precautionary manner, after monitoring, the continuation of fishing can be envisaged, with possible changes to the daily quota, or the subsequent closure if the biomass decreases below this threshold. Density values above the maximum limit indicate that the resource is managed correctly. Moreover, the study of length-frequency distribution makes it possible to define which areas have clams of dimensions that indicate commercial size will be reached in the following three months, or longer. Once the areas characterised by the presence of juveniles are known, it is possible to plan fishery operations and re-seeding of the resource in low-density areas.

Currently, the reference points for clam resources in Italian waters, as defined in the National Management Plan for Hydraulic Dredgers (Ministerial Decree 24/7/2015) are those in Table 7.

Table 7. Clam density reference points in the different GSAs (Geographical Sub Areas, FAO; source Regulation 1967/2006).

Clams			
Density of commercial biomass			
	Well managed	Attention range	Fishing banned
GSA 17	> 10 g/m^2	5 - 7.5 g/m^2	< 5 g/m^2
GSA 18	> 8 g/m^2	4 - 6 g/m^2	< 4 g/m^2
GSA 9-10	> 8 g/m^2	4 - 6 g/m^2	< 4 g/m^2

The commercial size in force is considerably above the size at first sexual maturity, so that the biomass which is targeted has already reproduced at least once.

Assessment of effectiveness of the discard plan

Case study: Marche Region

To assess the effectiveness of the entry into force of the Discard Plan, also considering the resource, comparative results are reported of the surveys carried out in 2017 and 2018 in some sampled areas.

Table 8. Ancona maritime district: total catches standardised by area explored in [g/m²] by dredges and sampling net for each station (ID).

		2017	
Area	**ID**	**Catch [g/m²]**	
		Dredge	**Net**
AN2	AN04A	6.1	557.2
	AN04B	11.8	19.8
	AN04C	13.8	14.4
	AN04D	1.2	0.3
	AN05A	15.7	27.3
	AN05B	4.9	9.2
	AN05C	3.7	8.5
	AN05D	3.6	21.2
	AN06A	3.1	3.1
	AN06B	0	0.1
	AN06C	0	0
	AN06D	0	0
AN1	AN07A	5.9	196.9
	AN07B	17	874.4
	AN07C	6.2	552.5
	AN07D	8.7	148.6
	AN08A	27.2	105.3
	AN08B	13.8	237.8
	AN08C	4.1	30.6
	AN08D	2.1	33.4
	AN09A	20.3	209.2
	AN09B	16.6	653.5
	AN09C	19.2	47.9
	AN09D	4.1	14.6
	AN10A	60	378.8
	AN10B	13.8	671.5
	AN10C	6.2	85.2
	AN10D	10	2.3
	Mean	**10.7**	**175.1**

		2018	
Area	**ID**	**Catch [g/m²]**	
		Dredge	**Net**
AN1	AN01A	142.9	352.4
	AN01B	159.8	879.1
	AN01C	80.9	1148.5
	AN01D	18.3	662.2
	AN02A	94.5	563.5
	AN02B	153.8	809
	AN02C	49.5	904.1
	AN02D	13.6	822.4
	AN03A	196.6	757.1
	AN03B	202.4	642.2
	AN03C	46.8	1061.6
	AN03D	15.1	872.3
	AN04A	137.9	495.1
	AN04B	102.2	935
	AN04C	173.3	780.2
	AN04D	24.2	857.2
AN2	AN05A	80.4	189.8
	AN05B	0.4	12.6
	AN06A	9.3	72.2
	AN06B	39.3	111.5
	AN06C	7.5	126.1
	AN06D	18.1	39.7
	AN07A	82.6	744.7
	AN07B	59.2	78
	AN07C	46.5	328.9
	AN07D	49.2	83.5
	Mean	**77.1**	**551.1**

Table 9. Civitanova Marche maritime district: total catches standardised by area explored in [g/m²] by dredges and sampling net for each station (ID).

		2017				2018	
Area	ID	Catch [g/m²]		Area	ID	Catture [g/m²]	
		Dredge	Net			Dredge	Net
CIV	AN01A	24.6	616.8	CIV	AN08A	88.2	502.1
	AN01B	4.6	185		AN08B	102.3	265.1
	AN01C	12.2	20		AN08C	149.2	319.2
	AN01D	14.4	148.7		AN08D	90.8	152.1
	AN02A	7.5	630.1		AN09A	259.3	715.3
	AN02B	9	123.1		AN09B	181	356.7
	AN02C	8.2	9.7		AN09C	170.6	787.6
	AN02D	1.8	12.4		AN09D	126.3	349.8
	AN03A	6.6	779.9		AN09E	281.6	447.9
	AN03B	2.2	83.1		AN09F	26.7	39.3
	AN03C	7.7	21.1		AN10A	192.1	134.3
	AN03D	3.1	4.3		AN10B	109.3	351.5
	Mean	**8.5**	**219.5**		AN10C	25.5	27
					AN10D	25.8	27.6
					Mean	**130.6**	**319.7**

Table 10. San Benedetto del Tronto maritime district: total catches standardised by area explored in [g/m²] by dredges and sampling net for each station (ID).

		2017				2018	
Area	ID	Catch [g/m²]		Area	ID	Catch [g/m²]	
		Dredge	Net			Dredge	Net
SBT2	SBT01A	16.3	142.2	SBT1	SBT01A	374.5	292.9
	SBT01B	6.7	23.9		SBT01B	409.8	1030.2
	SBT01C	1	8.4		SBT01C	94.8	61.7
	SBT01D	1.5	108.6		SBT01D	31.8	16.6
	SBT02A	14.2	25.8		SBT02A	215.8	293.3
	SBT02B	20.9	56.9		SBT02B	266.8	477
	SBT02C	3.4	12.7		SBT02C	148.8	62.8
	SBT02D	0.8	4		SBT02D	0.8	1.5
	SBT03A	17.9	50.7		SBT03A	231.4	461
	SBT03B	26.4	51.2		SBT03B	226.1	536.2
	SBT03C	17.5	99.6		SBT03C	149.1	438.5
	SBT03D	44.8	152.6		SBT03D	114.3	225.3
	SBT03E	12.6	59.7		SBT03E	22	9.3

	SBT04A	62.3	182.3
	SBT04B	24.4	72.5
	SBT04C	18.6	68.9
	SBT04D	3.7	25.3
	SBT05A	118.9	197.2
	SBT05B	13.7	506
	SBT05C	34.1	111.4
	SBT05D	42.5	78.5
	SBT05E	69.9	135.7
	SBT05F	16.6	32.4
	SBT06A	2	65.2
	SBT06B	25.8	58.2
	SBT06C	239.4	258.1
	SBT06D	30.6	42.1
	SBT06E	6.8	7.6
SBT1	SBT07A	2.2	6.7
	SBT07B	4	7.6
	SBT07C	19.8	25.9
	SBT07D	12.7	31.4
	SBT07E	144.2	165.7
	SBT07F	6	43.7
	SBT08A	5	19.5
	SBT08B	18.1	23.8
	SBT08C	73.5	88.8
	SBT08D	54.9	55.3
	SBT08E	10.6	11.4
	SBT09A	20.7	49.5
	SBT09B	23.9	46.7
	SBT09C	12.2	27.5
	SBT09D	0.2	2.5
	SBT10A	29.8	237.5
	SBT10B	14.1	31.5
	SBT10C	5.7	14.8
	SBT10D	9.6	21.3
	Mean	**28.9**	**75.5**

	SBT04A	103	330.4
	SBT04B	414.2	566.5
	SBT04C	326.6	918.9
	SBT04D	83.7	172.4
	SBT04E	119	196.4
	SBT04F	5.8	8
	SBT05A	286.2	272.5
	SBT05B	112.6	202.5
	SBT05C	99	156.3
	SBT05D	33.8	79.8
SBT2	SBT06A	163.2	83.9
	SBT06B	526.7	1184
	SBT06C	361.1	871
	SBT06D	202.3	869.2
	SBT06E	291.1	641.3
	SBT06F	51.7	64.8
	SBT07A	128.1	298
	SBT07B	282.4	1116.8
	SBT07C	91.8	1105.9
	SBT07D	393	443
	SBT07E	47.2	84.7
	SBT08A	208.5	599.7
	SBT08B	241.8	1039
	SBT08C	207.8	1125.2
	SBT08D	356.6	1097.4
	SBT08E	74.2	109
	SBT08F	31.7	35.2
	SBT09A	180.4	735
	SBT09B	119.1	761.1
	SBT09C	173.3	967.8
	SBT09D	70.6	1395.3
	SBT09E	205.8	372.2
	SBT09F	0.6	0.6
	SBT10A	231.2	415.4
	SBT10B	424.4	236
	SBT10C	215.6	256.9
	SBT10D	15.2	3.9
	Mean	**183.3**	**454.4**

For the Districts of Pesaro, Rimini and Ravenna, monitoring has been carried out continuously over the years by the Laboratory of Marine Biology and Fisheries in Fano and the results concerning the number of clams and biomass are reported for the three maritime Districts, obtained both with the sampling net and with the sieved catch.

Table 11. Pesaro Rimini and Ravenna maritime district: total catches standardised by area explored in [g/m²] and number [n/m²] by dredges and sampling net for each station (ID).

DISTRICT	**2017**				**2018**			
	DREDGE		NET		DREDGE		NET	
	n/m²	g/m²	n/m²	g/m²	n/m²	g/m²	n/m²	g/m²
PESARO	4,84	22,39	94,60	165,44	15,00	65,20	288,26	415,80
RIMINI	12,40	49,88	69,31	147,62	6,41	26,95	104,11	176,33
RAVENNA	3,90	15,37	13,31	26,88	2,65	10,19	26,58	44,08

It should be recalled that the sampling net collects the present material without the selectivity of the dredge while the sieved sample represents the amount that would be caught using the vibrating sieve with holes of a set size.

The results obtained with the sampling net show an increase both in the number of clams/m² and in the biomass in the three Districts, while confirming the differences that exists between the Districts.

Where the sieved portion is concerned, which includes the largest clams, there is a difference between the trend in the Pesaro District and the other two Districts of Rimini and Ravenna. The difference can partly be attributed to the sudden mass death that occurred in 2018, which affected the northern-most areas. Research is underway to identify primary and secondary causes of sudden mass death.

Case study: Veneto region (Venezia and Chioggia Maritime Districts)

To assess the effectiveness of the entry into force of the Discard Plan, also considering the resource, comparative results are reported of the surveys carried out in 2016 and 2018 in the two Maritime Districts in Veneto.

The state of *C. gallina* biomass ≥20 mm in the 2016 survey, divided into the commercial and sub-commercial fractions, is reported in the table and graphs below.

Table 12. Venezia Maritime District: *Chamelea gallina* biomass, commercial size and sub-commercial size, autumn 2016.

Mean biomass of *Chamelea gallina* in the Venice MD per area - 2016		
Macro area	*Biomass (g/m^2) ≥22 mm*	*Biomass (g/m^2) 20-21 mm*
Bibione-Caorle	7,0	10,4
Duna Verde-Eraclea	7,7	17,4
Cortellazzo-Jesolo	16,8	50,3
Cavallino-Treporti	7,7	36,8
Lido di Venezia	15,4	21,6
Pellestrina	31,4	69,0
Total Venice MD	**16,9**	**38,2**

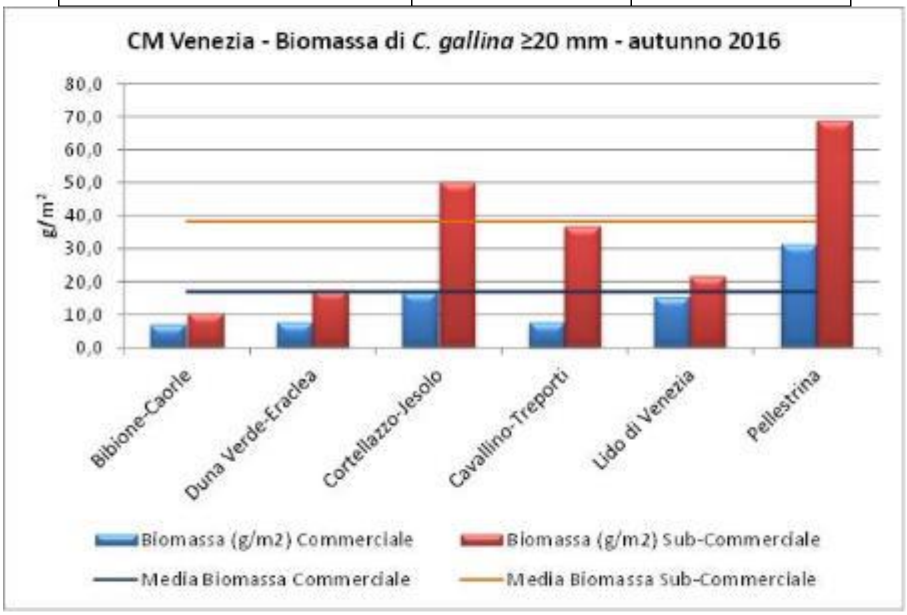


Figure 19. Venice Maritime District: biomass trend of commercial size and sub-commercial size *C. gallina,* autumn 2016.

Table 13. Chioggia District: *Chamelea gallina* biomass, commercial size and sub-commercial size, autumn 2016.

Mean biomass of *Chamelea gallina* in the Chioggia MD per area - 2016		
Macro area	*Biomass (g/m2) ≥22 mm*	*Biomass (g/m2) 18-21 mm*
Sottomarina - Caleri	52,4	125,9
Porto Levante	28,9	87,0

Delta Nord	39,2	41,4
Delta Sud	35,0	35,7
TOTAL Chioggia MD	**40,1**	**69,7**

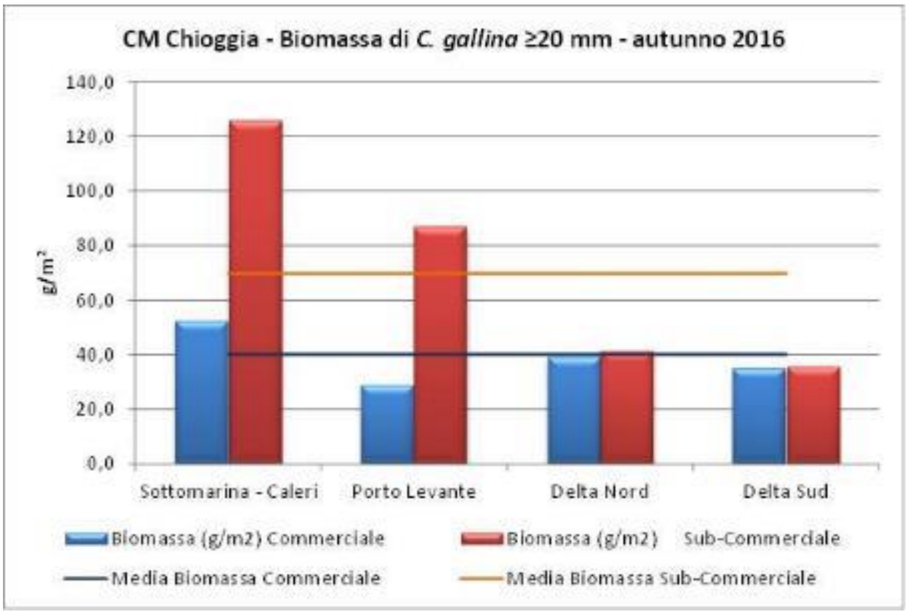


Figure 20. Chioggia Maritime District: biomass trend of commercial and sub-commercial size *C. gallina*, autumn 2016.

2018 monitoring data relative to C. gallina biomass in the two Maritime Districts in Veneto is reported below.

Table 14. Venice Maritime District: *Chamelea gallina* biomass of commercial and sub-commercial size in autumn 2018.

Mean biomass of *Chamelea gallina* in the Venice DM per area - 2018		
Macro area	*Biomass (g/m²) ≥22 mm*	*Biomass (g/m²) 18-21 mm*
Bibione-Caorle	10,6	19,5
Duna Verde-Eraclea	2,5	3,3
Jesolo	10,0	10,5
Cavallino-Treporti	3,6	62,6
Lido di Venezia	36,0	60,5
Pellestrina	6,1	25,8
Total Venice MD	**13,9**	**38,8**

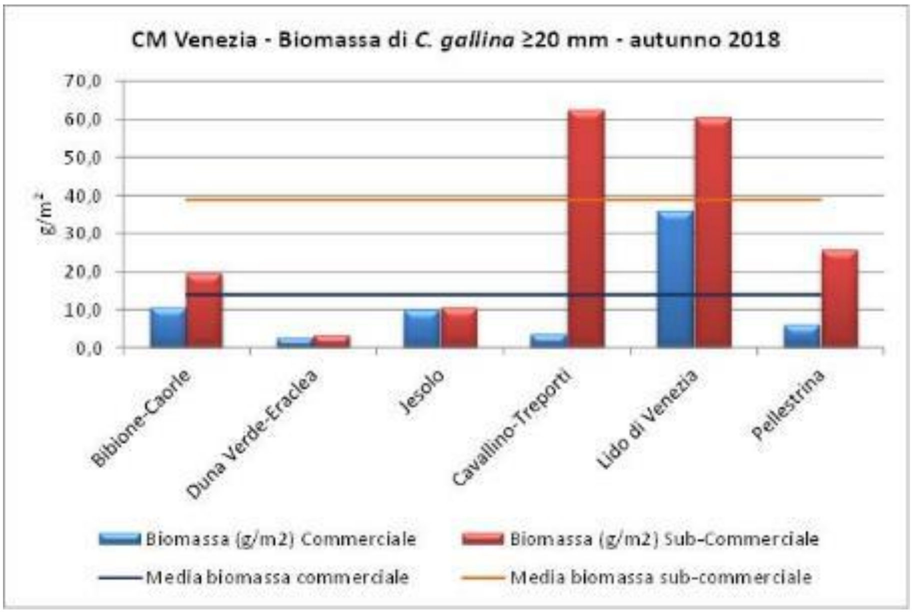


Figure 21. Venice Maritime District: biomass trend of commercial and sub-commercial size *C. gallina*, autumn 2018.

Table 15. Chioggia Maritime District: *Chamelea gallina* biomass of commercial and sub-commercial size in autumn 2018.

Mean biomass of *Chamelea gallina* in the Chioggia DM per area - - 2018		
Macro area	*Biomass (g/m2) ≥22 mm*	*Biomass (g/m2) 18-21 mm*
Sottomarina - Caleri	18,7	27,0
Porto Levante	15,6	65,9
Delta Nord	8,4	59,6
Delta Sud	19,2	42,9
TOTAL Venice MD	**15,9**	**45,6**

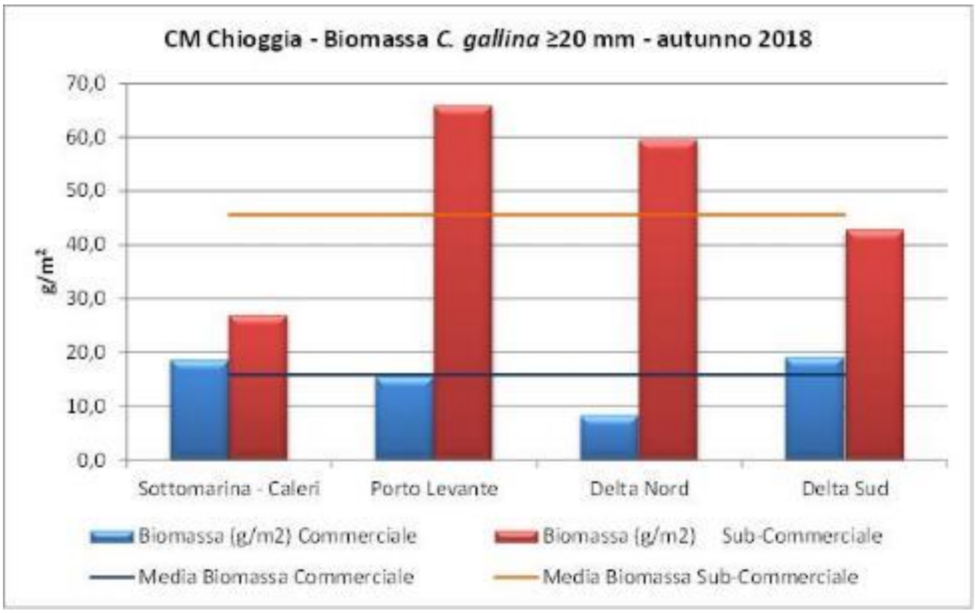


Figure 22. Chioggia Maritime District: biomass trend of commercial and sub-commercial size *C. gallina*, autumn 2018.

From the data reported, it can be observed that in the Maritime District of Venice the biomass of the natural shoals of *C. gallina* remains at similar levels after two years, while in the Chioggia District there has been a slight contraction of the biomass which is ascribable to some external variables, among which a sudden mass death episode in the area of Sottomarina and the adverse weather and sea conditions at the end of October 2018, which affected the entire Veneto coastline.

Fishing effort

Implementation of the National Discard Management Plan for clam resources (*Chamelea gallina*) (DM 27/12/2016, OJ N.8 11/1/2017) brought about a significant reduction in fishing effort, applied through two measures:

- the effective reduction of fishing days/week: partial modification of art. 5 paragraph 2 of Ministerial Decree 22/12/2000, the units authorised to fish clams must suspend fishing activities on Saturday, Sunday and set holidays plus another day established by the Consortia, so as not to exceed 4 fishing days/week. This effectively implied a reduction of about 20% in fishing days, given that Ministerial Decree 22/12/2000 art. 5 set a maximum of 5 fishing days/week;
- the reduction of catch quantities per day: art. 7 of Ministerial Decree of 22/12/2000 set the daily fishing limit at 600 kg/vessel. The Ministerial Decree of 12.27.2016 reduced the daily catch limit per vessel to 400 kg, approximately 33%.

The effects of the measures contained in the Discard Plan, therefore, resulted in a considerable reduction in fishing effort exerted hydraulic dredgers. On the one hand, the overall fishing days have been reduced, on the other daily fishing effort has been reduced significantly in two ways. The reduction in the maximum daily quota (from 600 kg to 400 kg) and the possibility to market clams smaller than 25 mm (although it is currently rare to find clams smaller than 23 mm on the market) have together made it possible to reach the daily quota set more quickly, which implies a reduction of the areas dredged.

Furthermore, all vessels authorised to fish for clams with hydraulic dredges are currently equipped with a vessel position detection system which allows fishing effort to be verified from a spatial point of view, and also makes it possible for appropriate management measures to be adopted based on the degree of exploitation of the areas (e.g. rotation of fishing areas.

Selectivity of hydraulic dredges

General characteristics

The knowledge of the selectivity of a fishing gear, on different species and on different sizes, represents a crucial point to guarantee rational management of marine resources. The selectivity of gear has, for half a century now, been one of the main technological aspects considered indispensable by modern population dynamics, to achieve correct levels of exploitation of fishery resources (Sala, 2011).

Control and improvement of selectivity, in synergy with responsible management of fishing effort, represent the necessary, but the only, conditions to achieve the aim of correct management of resources.

The main aim of technical measures for the conservation of fish stocks is to increase the selectivity of fishing gears and reduce the capture of juveniles and other juvenile phases (Sala, 2011, Sala and Lucchetti, 2010, 2011). The term **selectivity** defines the selection process of a fishing gear or of the process that leads to the catch, the composition of which shall differ from the composition of all the organisms actually present in the area where fishing is carried out (Sala, 2011; Sala *et al.,* 2006; 2007; 2008). In other words, selectivity is the probability that the different sizes and species of fish will be caught by the fishing gear.

In practice, with this term we can express both the capacity of a gear to catch only certain sizes of a given species, and the selection of the different species present at sea. In the first case, in order to have gear that allows the juvenile forms of a given species to escape, meshes of appropriate opening and shape are generally used. In the second case, however, the selectivity of a gear cannot be improved just by the use of appropriate mesh sizes and shapes, since it depends mainly on how the vessels and the gear are structured and any devices installed on the gear that modify its functioning (Sala *et al*. 2007; 2011).

Therefore, selectivity is a function both of the technical characteristics of a given fishing gear and of the ethological properties of the species to be captured. Since the clam, being a bivalve, cannot actively escape capture by the dredge, the selection process can take place either on the sea bed by the dredge itself or on board with sieves that separate the catch mechanically. As in trawl fisheries, where the selection process is mainly a function of the mesh opening, in the case of the dredge, selectivity depends on the distance between the rods (Figure 23) or the diameter of the holes in the case of the perforated grid of the sieve (Figure 24). **Since the material collected by the dredge is subsequently selected by the vibrating sieve, this can be considered to be the main selection process for clams.**

Figure 23. There are national laws that define some aspects of the capacity of the gear to select the size of the clams caught. The D.M. of 22/12/2000 states that the distance between the metal rods on the lower part of the dredge must not be less than 12 mm.

Some studies have demonstrated that even minute variations in the diameter of the sieve holes result in significant changes in selectivity (Froglia and Gramitto, 1981). According to the D.M. of 22/12/2000 the sieves must respect certain characteristics, in order to allow the specimens below the minimum size for first capture and marketing to escape, which for the clam (*C. gallina*) is 22 mm.

The sieves, according to the regulations, can be made of metal rods, with characteristics similar to those of the cage, or of a perforated metal grid (Figure 24). It should be borne in mind that, in the case of the rods in the dredge or in the sieves, selection takes place on the basis of the thickness of the clams, while with the perforated grid selection is mainly due to the diameter of the clams. For this reason, the rods and the holes are subject to different regulations: 12 mm minimum distance between the rods and 21 mm minimum hole diameter (D.M. 22/12/2000). The latter (perforated grid with a minimum diameter of 21 mm for the holes) is the solution that is adopted almost everywhere.

The material collected by the dredge is transferred on board and emptied into a stainless-steel collection box at the bow (Figure 25), then by means of a rotating screw conveyor it is dropped onto the plates of a vibrating sieve that is on a slight slope. The vibrations make the clams move down slowly from one sieve to another (Figure 26). These sieve plates can be different depending on the vessels, they are sometimes made by local artisans. In general, however, all the vibrating sieves have a series of plates one above the other with decreasing hole sizes (Figure 26). The top layer of this filter, onto which water is sprayed, receives all the material and this one has large holes, usually over 32 mm, through which all the clams and organisms of similar diameter pass (Figure 26). From the second sieve onwards, the fisher is free to use sieves with different hole sizes, but pursuant to the D.M. of 22/12/2000 they must have a diameter of not less than 21 mm. in some cases, the Management Consortia set the minimum diameters of the sieve holes to ensure uniformity of sampling between the boats in the same district and sometimes they then fasten and seal the sieve so that it is not possible to replace the sieve plates.

Figure 24. Detail of the vibrating sieves with a perforated metal grate, the holes must not be smaller than 21 mm.

Figure 25. Detail of the dredge consisting of cage made entirely of metal (left). All clam dredgers have the dredge at the bow of the vessel; at the end of each dredging operation, the dredge is hauled on to the bow with the hauling warp and the material gathered is transferred into a collection box (right) and then to a sieve for the selection of the marketable sizes.

Figure 26. Details of the vibrating sieve used on board clam dredgers to select the clams of marketable sizes (≥22 mm).

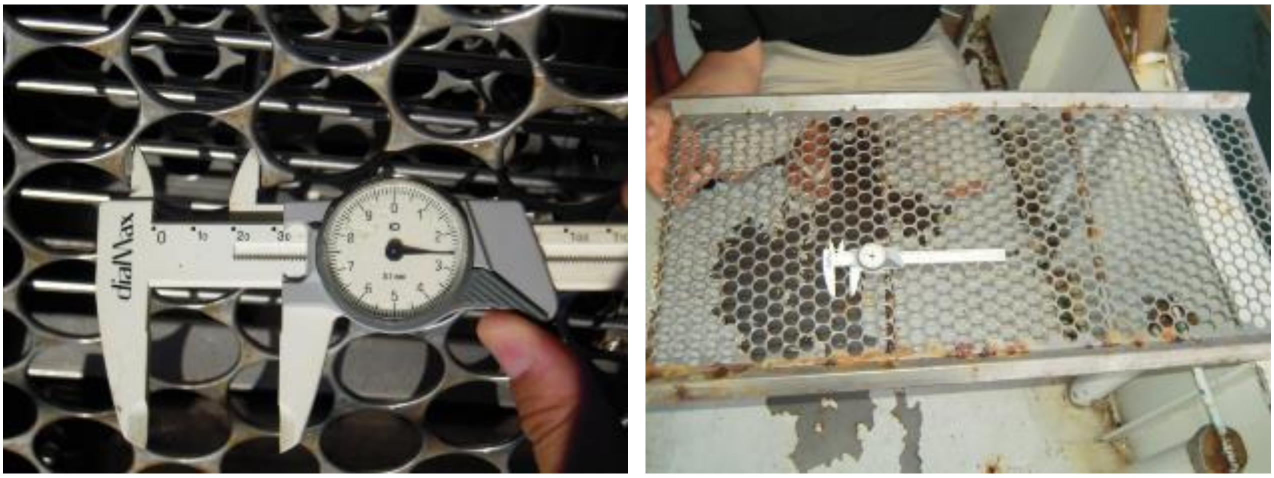


Figure 27. measurement of the filters and of the sieves used in the selection process during the surveys.

In the Discard Plan, the characteristics of the vibrating sieves have not been modified.

Study on the selectivity of mechanical vibrating sieves

A recent study conducted in the Adriatic (Sala *et al*., 2017) made it possible to verify the selectivity of mechanical vibrating sieves currently in use.

The screening process was carried out with the vessel at a standstill, the catch held in each container was screened using each of the single sieves that made up the complete on-board vibrating sieve equipment. As illustrated in Figure 28, following selection, the contents of each collection box (*P0*) was separated into 6 fractions (*debris, r1-r5* and *P5*), which were then weighed and, when quantities were abundant as usually was the case for the *P5* fraction, a sub-sample (about 3 kg) was removed for subsequent analysis of the size distribution: 1) *debris*: the fraction retained by the first filter (32.5 mm holes) containing coarse material and some large specimens of clam; 2) *r1*: the fraction retained by the first sieve (holes of 21.5 mm) containing commercial-size clams; 3) *r2*: fraction retained by the second sieve (holes of 21.1 mm) contained sub-commercial size clams; 4) *r3*: fraction retained by the third sieve (holes of 20.3 mm, not used for commercial purposes but useful for research); 5) *r4*: fraction retained by the final filter with metal bars (slats) 10.5 mm apart; 6) *P5*: the fraction not retained by any of the sieves.

All 54 sieving selection operations analysed (*e.g.* 3 hauls x 2 collection boxes x 3 speeds x 3 sieves, see Table 16) were deemed valid and used in the assessment of mean selectivity of each sieve. From Table 17 to Table 19 the selectivity parameters are reported for the single sieving operations replicated for each of the three sieves, obtained with the *Covered Codend method.* An accurate analysis of the robustness of each of the logistic models (*p*-value and derivation vs. DOF) indicates that no problems were encountered with the adoption of the logit curves to describe the data on materials retained at each sieving operation, based on the adoption of the procedures dictated by the *Covered Codend method*.

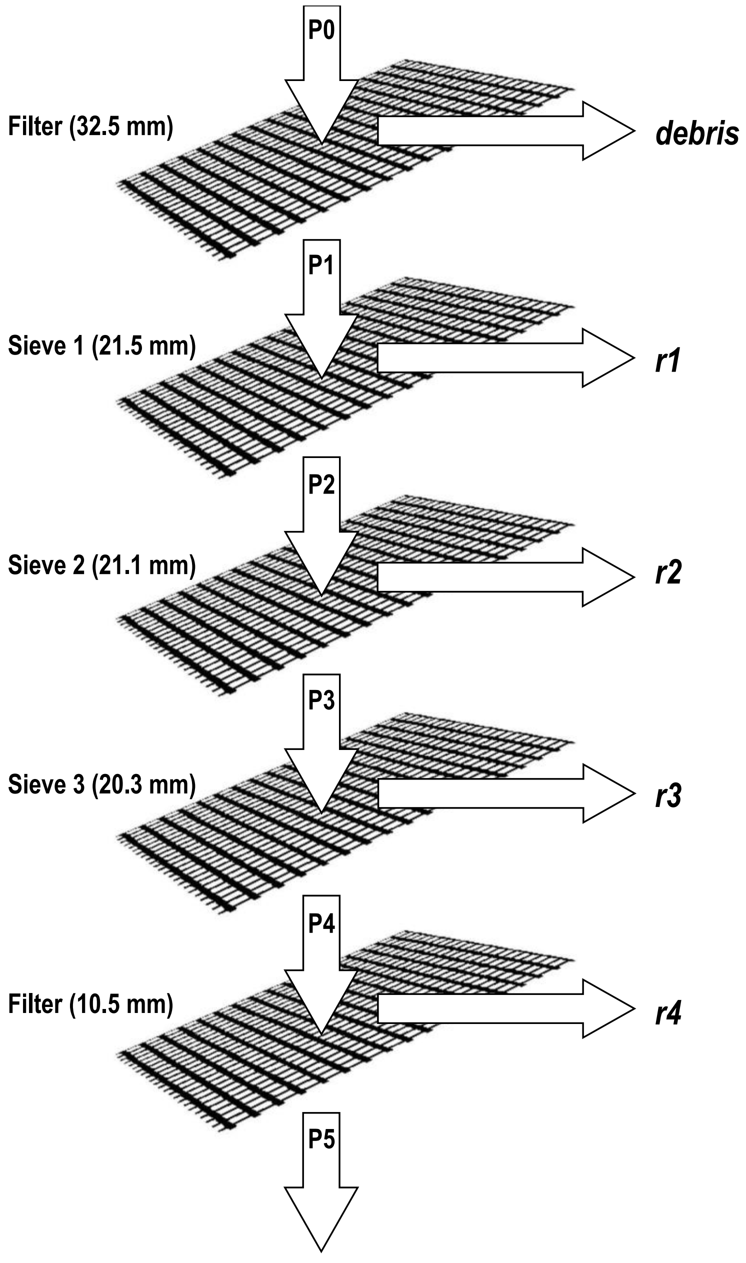


Figure 28. Selection process of the clams using the three sieves and filters that make up the system of vibrating sieves on board. The samples obtained following sieving of a single collection box were: *debris*: the fraction retained by the first filter (32.5 mm holes) containing coarse materials and a few large clam specimens; *r1*: fraction retained by the 1st sieve (21.5 mm holes) containing commercial size clams; *r2*: fraction retained by the 2nd sieve (21.1 mm holes) containing sub-commercial size clams; *r3*: fraction

retained by the 3rd sieve (20.3 mm holes); *r4*: fraction retained by the last filter made of metal bars (slats) 10.5 mm apart; *P5*: fraction not retained by any of the sieves or filters.

The rotation speed of the screw conveyor was also included in the study, a parameter that could influence selective properties. The estimated selectivity parameters were significant for all the screenings carried out at all three rotation speeds of 1180, 1210 and 1230 RPM.

For a description of the statistical methodology applied to the selectivity study please refer to Sala *et al*. (2017).

Table 16. number of repetitions obtained for each sieve assessed *(e.g. 3 hauls x 2 collection boxes)* at the three different speeds: 1180, 1210 and 1230 RPM.

Sieve n. *(diameter of the holes)*	**Speed (RPM)**			**Total screenings**
	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 screenings	**18**	**18**	**18**	**54**

The mean selectivity parameters, calculated for each sieve according to the methodology proposed by Fryer (1991), which takes into account, in this case, the variability between the screening operations (between-haul variation), are reported in Table 20 and Figure 30. In this case, the mean values of each sieve were calculated both as an average at each sieving rate and with all the sieving operations aggregated without taking into account the speed parameter. The highest mean value of L50 was found to be that of the 2nd sieve (L50=25.30 mm), which however was not significantly different from that of the 1st sieve (24.91 mm), on the contrary the best SR (lowest value) was that of the 1st sieve with 1.12 mm against 1.76 mm of the 2nd sieve. The mean value of L50 relative to the 3rd sieve (L50=22.87 mm) was significantly lower than the other two ($p < 0.001$; Table 20).

The comparative analysis of the selectivity parameters of the three sieves, illustrated in the graph *L50*-versus-*SR* in Figure 30 makes it possible to appreciate better that, although there has been an increase in both the retention length (L50) and the selection interval (SR) passing from the first to the second sieve, these increases are not significant as the projections of the two ellipses, which represent the confidence intervals of L50 and SR, overlap in both the x and y dimensions. On the contrary, observing the ellipse relative to the third sieve, it can be seen that there was a significant decrease in the retention length, which fell to 22.87 mm from 24.91 and 25.30 mm of the first and second sieves (Table 20).

From the results of the study, and in particular from the mean selectivity curves, it is possible to observe that with the legally compliant sieve size (Grid 2 in the study) retention of specimens under 22 mm is irrelevant (Figure 30).

Table 17. selectivity parameters estimated for the 1st sieve, D1(215), with hole diameter 21.5 mm. the individual values were calculated at the three different speeds of 1180, 1210 and 1230 RPM. The data were analysed using the methodology proposed by Fryer (1991). Retention length at 50%, 25% and 75% (L50, L25 and L75), selection interval (SR), test Akaike's Information Criterion (AIC), degrees of freedom (DOF), *p*-value, confidence interval of L50 and SR (±DelL50, ±DelSR), standard deviation of L50 and SR (SdL50, SdSR), between-haul variation {D}, minimum and maximum retention length (MinL, MaxL), total number of clams screened, retained and released (NrTot, NrTes, NrCov).

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 18. estimated selectivity parameters for the 2nd sieve, D2(211), with a hole 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 19. estimated selectivity parameters for the 3rd sieve, D3(203), with a hole diameter of 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

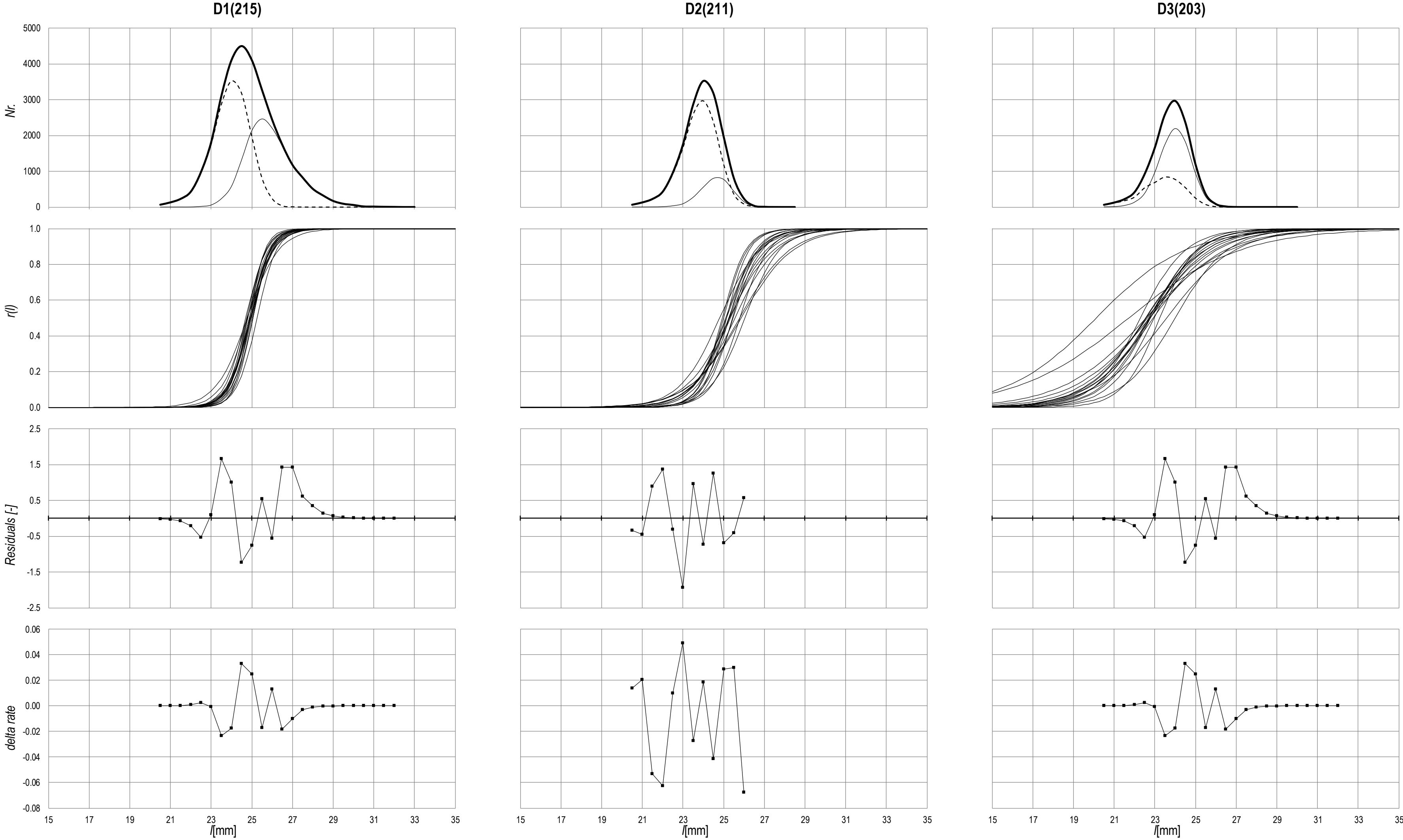


Figure 29. size distribution of the screened clams: total (▬), retained (—) and released (---) from the 1st sieve D1(215) with a hole diameter of 21.5 mm, 2nd sieve D2(211) hole diameter 21.1 mm and 3rd sieve D3(203) hole diameter 20.5 mm; selectivity curve of the individual sieves; graphs of the residuals and delta rate. These last two graphs represent the robustness of the approximation of the logistic model given the set of experimental observations obtained during the sieving tests.

Table 20. mean selectivity parameters estimated for the 1st sieve, D1(215), with hole diameter 21.5 mm, the 2nd sieve D2(211) hole diameter 21.1 mm and 3rd sieve D3(203) hole diameter 20.5 mm. The individual values were calculated using the methodology proposed by Fryer (1991) at the three different speeds of 1180, 1210 and 1230 RPM and with all of the speeds combined *pooled data* (*All.P.*), highlighted in grey. Retention length at 50%, selection interval (SR), with mean values (estimated), standard error (S.E.), confidence interval at 95% (C.I.95%) and *p*-value, selection factor (SF), curve estimators that best approximate the data *(v_1, v_2)*, within-haul variation *{R_{ij}} (WHV),* between-haul variation *{D} (BHV)*, test Akaike's Information Criterion (AIC), delta Log-Likelihood (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

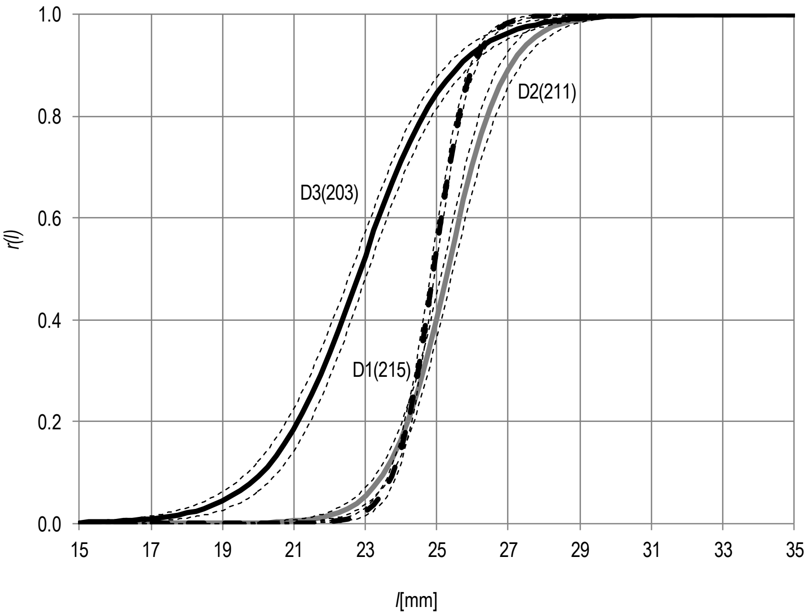


Figure 30. mean selectivity curves estimated for the 1st sieve D1(215) with hole diameter 21.5 mm, the 2nd sieve D2(211) hole diameter 21.1 mm and 3rd sieve D3(203) hole diameter 20.5 mm. The individual values were calculated using the methodology proposed by Fryer (1991) with all the speeds combined. The dotted curves represent the confidence intervals in graphic form.

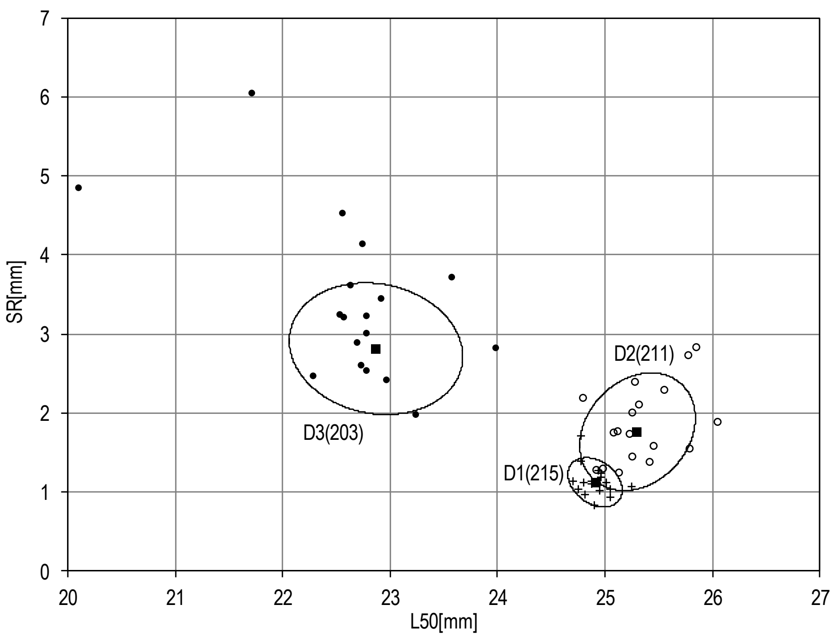


Figure 31. *L50* versus *SR*, the ellipses were calculated on the basis of the variation of the parameters estimated and represent graphically the confidence intervals of both *L50* and *SR* of each sieve: 1st sieve D1(215) with hole diameter 21.5 mm, the 2nd sieve D2(211) hole diameter 21.1 mm and 3rd sieve D3(203) hole diameter 20.5 mm.

Selectivity from commercial samples (Marche)

Since the Discard Plan entered into force, to assess the effectiveness of the selection process and to verify that the product complied with the minimum conservation reference size (MCRS - 22 mm) periodic sampling on the commercial clam catch was carried out. In particular, random sampling was carried out (samples collected from different Maritime Districts): a sample was taken before the selection process, directly from the collection box at the bow of vessel, in which all the catch was transferred immediately after the haul. Then from the same haul, a commercial sample was also taken after the selection process with the mechanical vibrating sieve.

The length-frequency distributions of the clams sampled directly from the collection box demonstrate a wide range of sizes, with a considerable quantity of undersized specimens (< 22 mm; Figure 32). This means that the population present in the areas sampled was well structured. However, taking the size distributions after screening, it is possible to observe that the number of specimens under 22 mm was extremely small and sometimes almost zero (< 1%; Figure 33; Table 21). In terms of weight, as the clams were small in size, their contribution to the total commercial catch quantity was even less relevant. Furthermore, it was possible to observe that the commercial catch was mainly made up of clams of 24-25 cm (modal classes).

The results obtained from the monitoring activities demonstrate that, as a consequence of the screening operations on board with a legally compliant sieve, the quantities of clams currently retained are not sufficient to allow practical seeding operations for restocking purposes. Over 95% of undersized clams (<22 mm) are immediately returned to sea following the selection process. Considering the growth rates of the species, described in the chapter dedicated to the biology *C. gallina*, it can be envisaged that clams of 22 mm or similar can reach commercial sizes of 24-25 mm within 3-4 months.

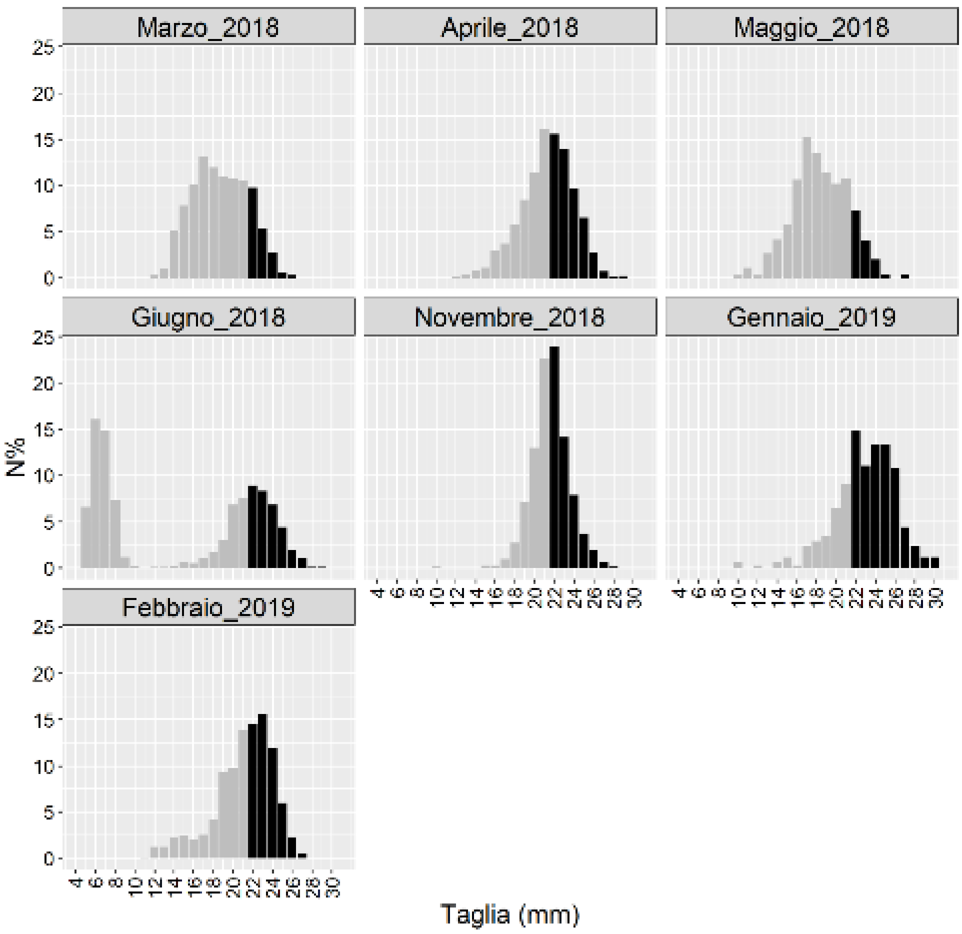


Figure 32. Density of specimens of *C. gallina* caught with hydraulic dredgers and not subjected to on-board screening operations in order to retain the undersized specimens. The specimens above the commercial size are indicated in black. Samples gathered at random from the Maritime Districts of Ancona, Civitanova and San Bendetto del Tronto.

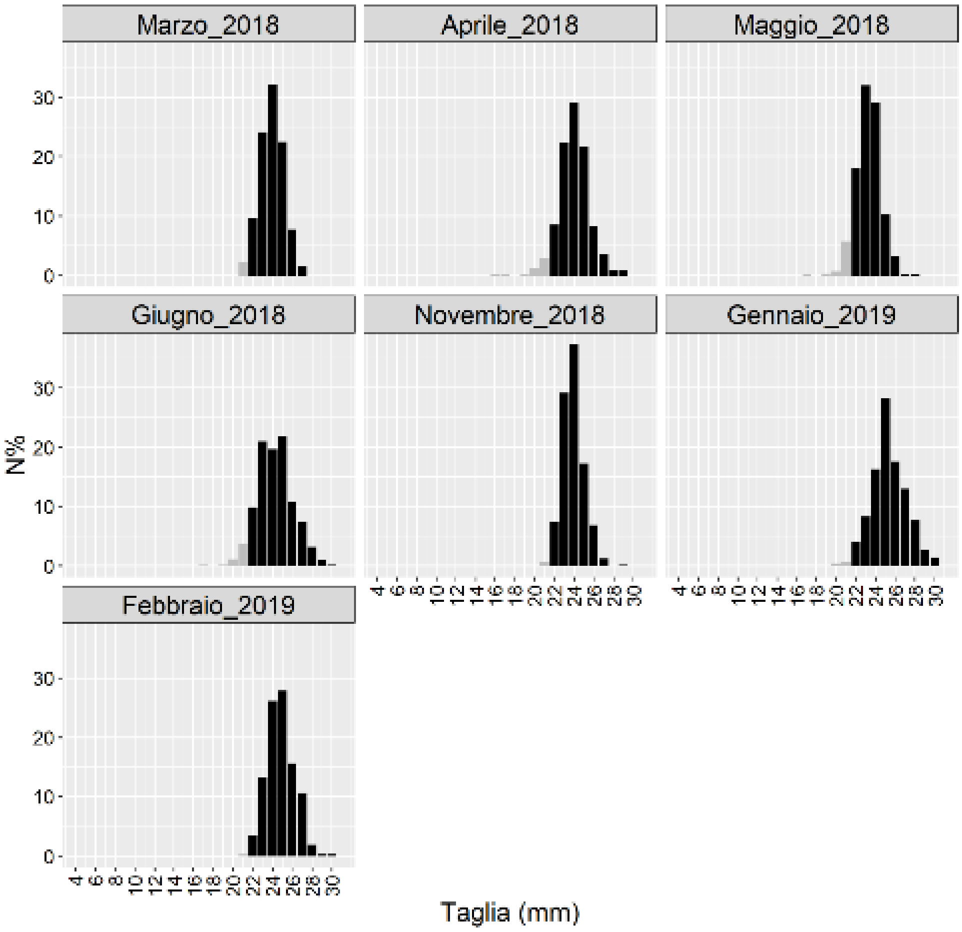
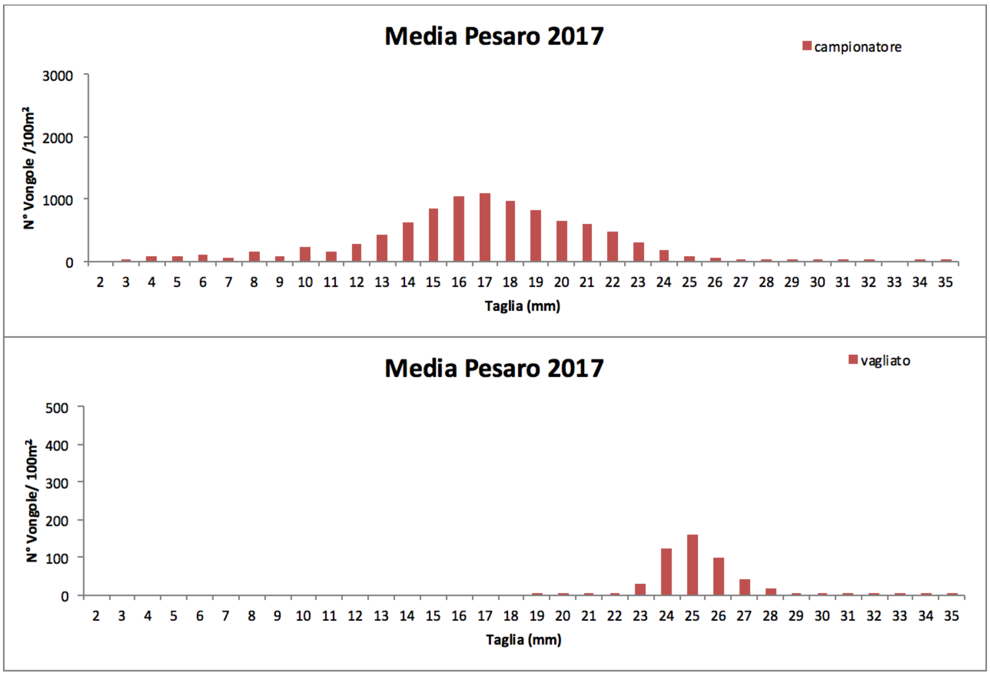


Figure 33. Density of specimens of *C. gallina* caught with hydraulic dredgers and subjected to on-board screening operations. The specimens above the commercial size are indicated in black. Samples gathered randomly from the Maritime Districts of Ancona, Civitanova and San Bendetto del Tronto.



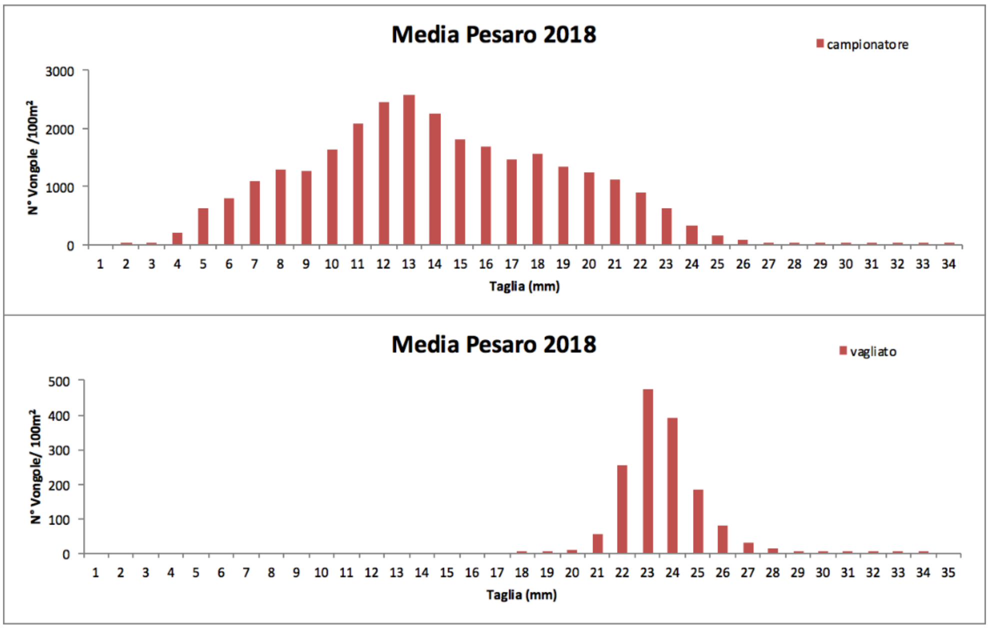


Figure 34. size distribution of the clams obtained using the sampling net and clams selected by sieve in the Maritime District of Pesaro. It is possible to observe the very small portion of clams screened that were under 22 mm.

Table 21. percentage of specimens under the minimum conservation reference size observed during monitoring. The percentages are given both for the commercial sample obtained following on-board selection operations and for the portion that was not screened. Samples obtained randomly from the Maritime Districts of Ancona, Civitanova and San Bendetto del Tronto.

		Mar-18	Apr-18	May-18	Jun-18	Nov-18	Jan-19	Feb-19
Screened	**Ind < 22mm**	2.30%	4.66%	6.98%	5.19%	0.68%	1.16%	0.35%
Not screened	**Ind < 22mm**	81.34%	50.60%	85.92%	68.47%	47.34%	27.11%	49.12%

Selectivity from commercial samples (Emilia Romagna)

If, for the two Districts, we observe the size composition of the samples obtained with the sampling net, which covers a wide range of sizes intervals, and the composition of the screened product for the same years and Districts, the information acquired is interesting. Firstly, the screened product does not include, if not in negligible quantities (less than 1%), clams that are smaller than 22 mm. The incidence of some smaller clams in the Ravenna District is due to the presence of sediment with a greater amount of mud, which alters the selectivity of the sieve. This problem has been discussed with the Consortia (Co.Ge.Mo.) fishers and has led to the decision to equip all vessels in the District with a second on-board sieve for selection purposes, in order to carry out the screening operations in two stages so as to guarantee compliance with the minimum size of 22 mm.

The project for a second on-board sieve for selection has already been presented to and approved by the Fisheries Directorate pursuant to the EMFF 1.39.

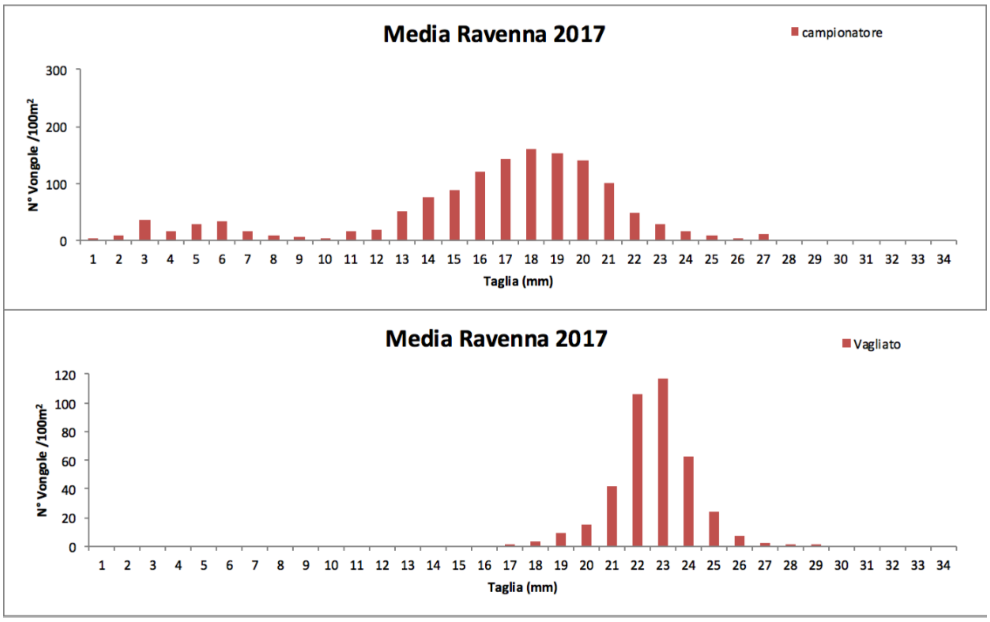
A second aspect highlighted concerns the high quantity of clams under 22 mm, which is always present, but considering the growth rate of 1 mm per month, in a few months can reach and exceed the permitted size for compliance with the MCRS, thus guaranteeing continuity of activities.

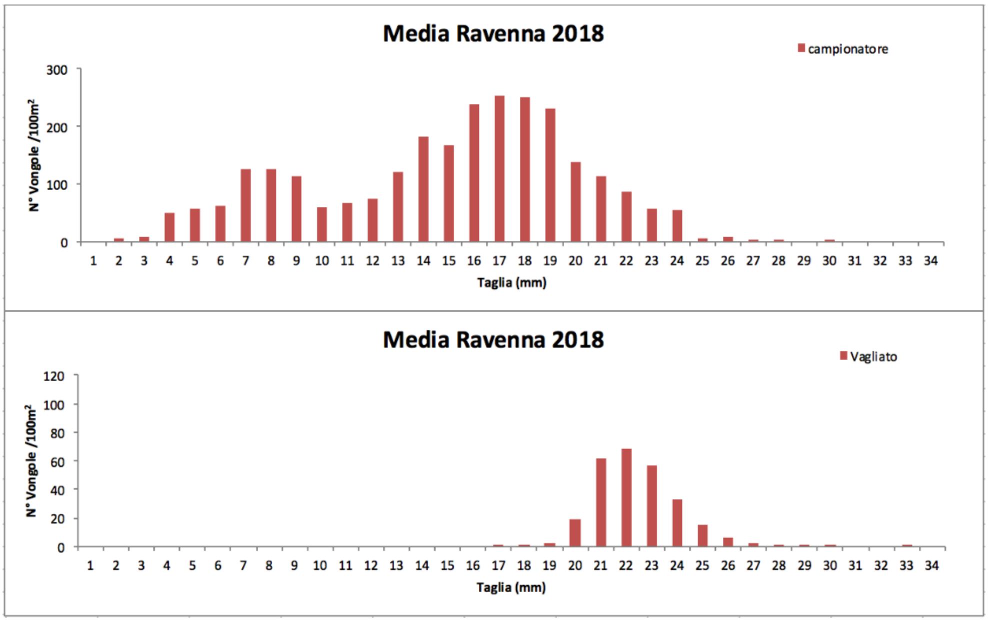
It is also observed that the reproductive period is extensive and clams born in several different months can be found at the same time, this suggests the possibility of developing parallel research on the reproductive period through gonad analysis, study in progress.

Finally, on the basis of the reference points indicated in the management plan in force, in all three Maritime Districts the average commercial biomass is above 10 g/m² indicating good management.

In the Ravenna District, where the values are lower, the Consortium reduced fishing days and increased increasing the number of months in which fisheries activities are suspended.

Although the resources in question are highly variable, the synergy between the scientific research community and the fishers' consortia has given rise to some positive aspects, at least in the two Maritime Districts of Ravenna and Rimini.





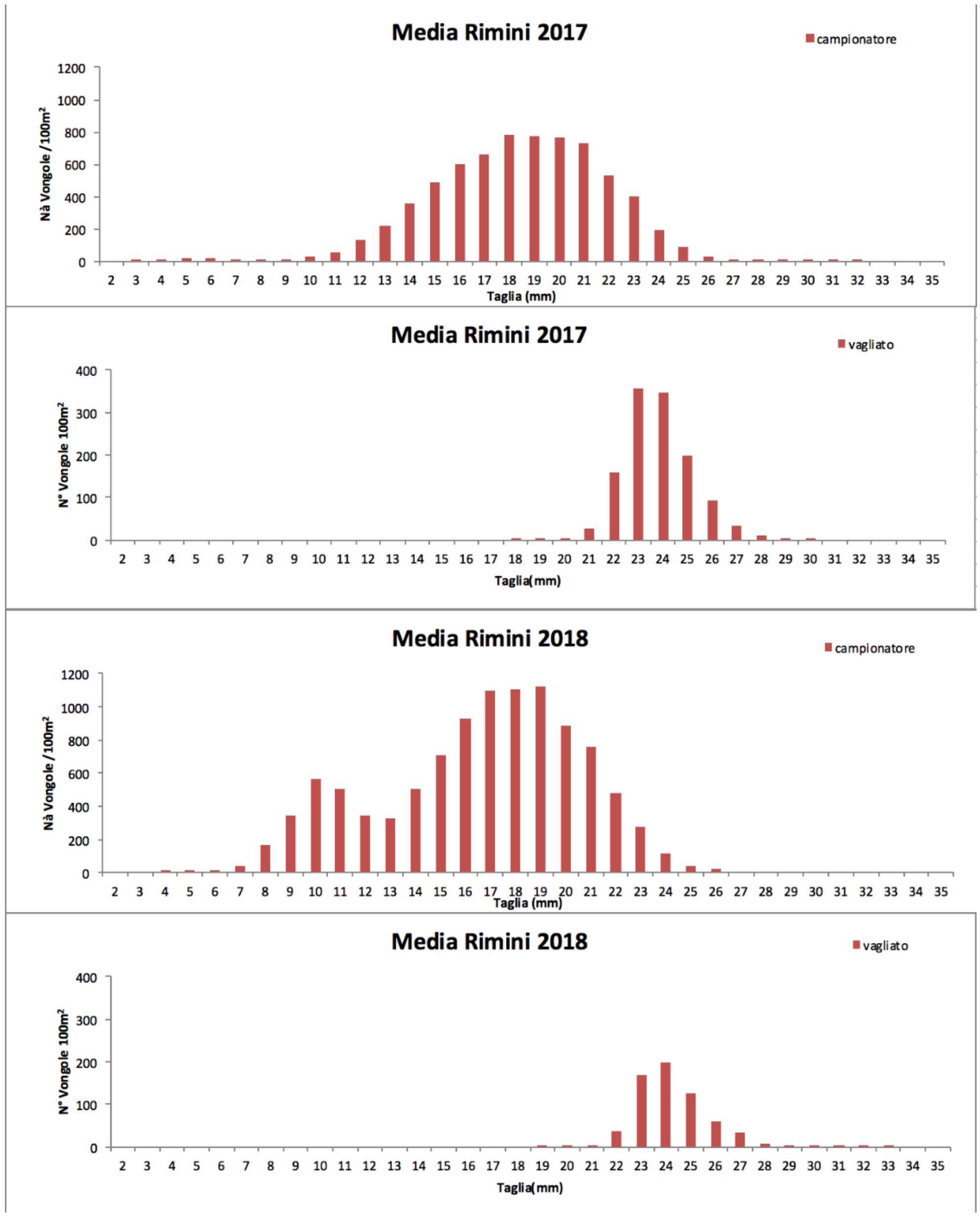


Figure 35. size distribution of the clams obtained using the sampling net and clams selected by sieve in the Maritime District of Rimini and Ravenna. It is possible to observe the very small portion of clams screened that were under 22 mm.

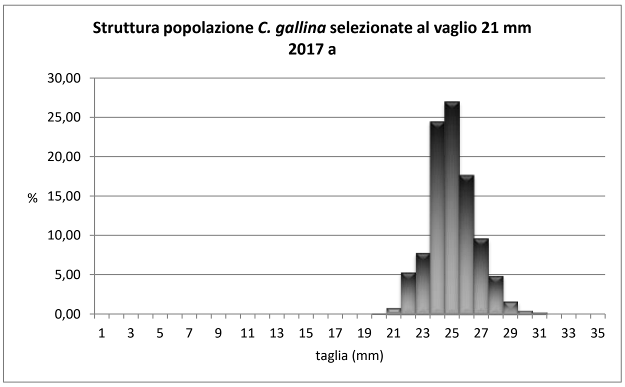
Selectivity from commercial samples (Veneto)

Some cases are reported below of samples of *C. gallina* selected on board the fishing vessels using sieves with a 21 mm grill (single sieving operation), as normally used for commercial fisheries.

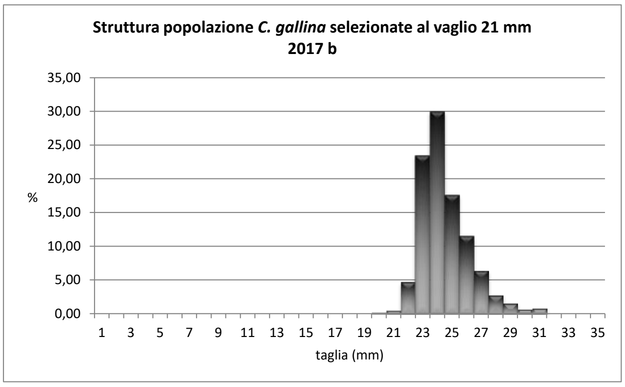
The cases reported refer to the years 2017 and 2018.

Selection with a 21 mm grill

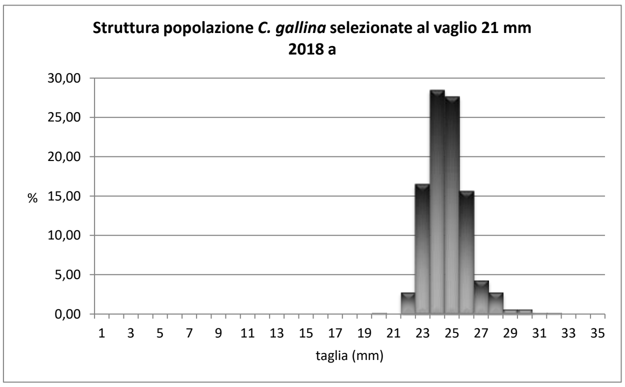
Subdivision of specimens by size with a 21 mm sieve in 2017	
Size	**%**
1-15 mm	0,00
16-21 mm	0,97
≥22 mm	99,03



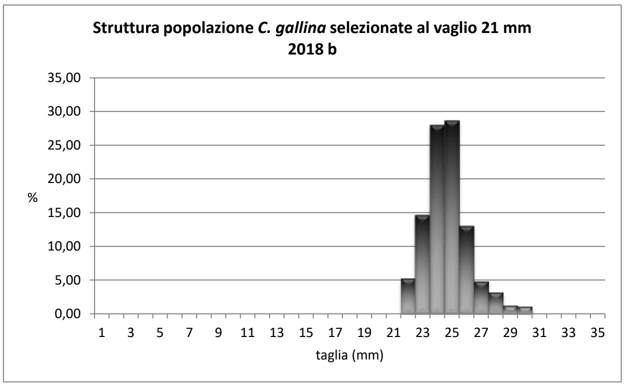
Subdivision of specimens by size with a 21 mm sieve in 2017	
Size	**%**
1-15 mm	0,00
16-21 mm	0,78
≥22 mm	99,22



Subdivision of specimens by size with a 21 mm sieve in 2018	
Size	**%**
1-15 mm	0,00
16-21 mm	0,21
≥22 mm	99,79



Subdivision of specimens by size with a 21 mm sieve in 2018	
Taglia	**%**
1-15 mm	0,00
16-21 mm	0,00
≥22 mm	100,00



After the introduction of the Discard Plan, it can be observed that the fraction of C. gallina <22 mm following selection with a 21 mm grid is very small, roughly estimated at 0.5%. This percentage, albeit low, is completely eliminated with the second screening procedure.

Pilot project to increase the selectivity of the on-board screening equipment

The equipment currently used for on-board selection operations on the catch (mechanical vibrating sieves), while highly selective in function of the diameter of the specimens, is not, unfortunately, able to guarantee a 100% separation of commercial and non-commercial specimens.

The Italian Ministry for Food, Agriculture, Fisheries and Tourism Policies (MiPAAFT) therefore deemed it appropriate for the sector operators and in particular the Management Consortia, to focus their efforts and their expertise on the introduction of innovative technological solutions, applicable to and capable of increasing the selectivity of the current screening equipment. To achieve this, the European Maritime and Fisheries Fund (EMFF), with specific reference to art.39 of Reg. (EU) 508/2014 "Innovation linked to the conservation of marine biological resources", may support interventions aimed at developing or introducing new technical or organisational knowledge that reduce the impact of fishery activities on the environment, including more effective and increased selectivity of fishing gear.

In order to pursue the objectives defined in the CFP and in particular those related to the implementation of conservation measures and the development of sustainable models of stock exploitation, the MiPAAFT has financed 15 initiatives for the realisation of project proposals, aimed at increasing the selectivity of screening equipment in relation to the national discard management plan for clam resources, adopted with DM 03/12/2018.

These projects are ongoing.

The following table shows the Consortia authorised to carry out the projects proposed to increase the selectivity of screening equipment, financed by MiPAAFT through Measure 1.39 "Innovation linked to the conservation of marine biological resources" of the EMFF 2014-2020.

Pilot project to increase the selectivity of the on-board screening equipment		
Management Consortium	*Protocol reference*	*Amount eligible for funding*
Co.Ge.Mo. Monfalcone	n. 15650 of 13/07/2018	EUR 298 872.46
Co.Ge.Vo. Venezia	n. 15648-15649 of 13/07/2018	EUR 600 00.00
Co.Ge.Vo. Chioggia	n. 15647-15651 of 13/07/2018	EUR 600 00.00
Co.Ge.Mo. Ravenna	n. 15732 of 16/07/2018	EUR 282 950.00
Co.Ge.Mo. Rimini	n. 15731 of 16/07/2018	EUR 239 600.00
Co.Ge.Mo. Pesaro	n. 15730-15733 of 16/07/2018	EUR 510 800.00
Co.Ge.Vo. Ancona	n. 15635 of 13/07/2018	EUR 299 817.00
Co.Ge.Vo. Civitanova Marche	x	x
Co.Vo.Pi. San Benedetto del Tronto	n. 15588 of 12/07/2018	EUR 136 000.00
Co.Ge.Vo. Abruzzo Pescara	n. 11340 of 23/05/2018	EUR 299 493.00
Co.Ge.Vo. Frentano Ortona	x	x
Co.Ge.Vo. Termoli	n. 15632 of 13/07/2018	EUR 298 312.00
Consorzio Molluschi Nord Gargano	x	x
Co.Ge.Mo. Il Colosso di Barletta	n. 15774 of 17/07/2018	EUR 300 00.00
Co.Ge.Mo. Napoli	x	x

Pilot project to increase the selectivity of the on-board screening equipment		
Co.Ge.Mo. Gaeta	x	x
Co.Ge.Mo. Roma	n. 15634 of 13/07/2018	EUR 298 312.00

Restocking areas

In the light of the selectivity data illustrated herein, it is clear that the use of the restocking areas, as defined by the Discard Plan and identified by the Bivalve Mollusc Management Consortia on the basis of the environmental and sedimentological characteristics of the fishing areas and in agreement with the relative Maritime Authorities, has been limited. Indeed, using the legally compliant 21 mm sieves (hole diameter), the under-sized part of the catch retained on board after the selection process was so small that any reseeding operations would not be economically viable and would ultimately be of little use.

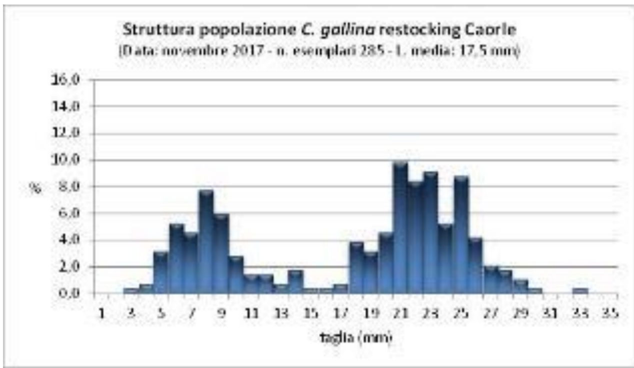
It can be added, however, that in the short time available it was possible to observe growth in the clams in the restocking areas, in line with the growth rates already described in the chapter on the biology of the species.

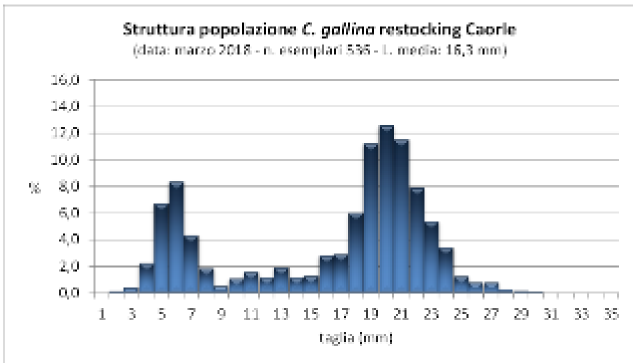
Pilot study: restocking areas in Veneto

Six restocking areas were identified in Veneto, which have not been used to date for the release and reseeding of undersized specimens caught; they have, however, been the subject of protection and periodic monitoring activities, the results are reported below.

Table 22. Caorle restocking area: biomass values for *Chamelea gallina* detected during periodic monitoring.

Caorl area	Biomass (g/m2) ≥22 mm	Biomass (g/m2) 18-21 mm
Initial state	5,4	17,0
1° quarter 2018	4,4	15,4
2° quarter 2018	4,2	11,9
3° quarter 2018	6,4	7,7
4° quarter 2018	10,9	14,5





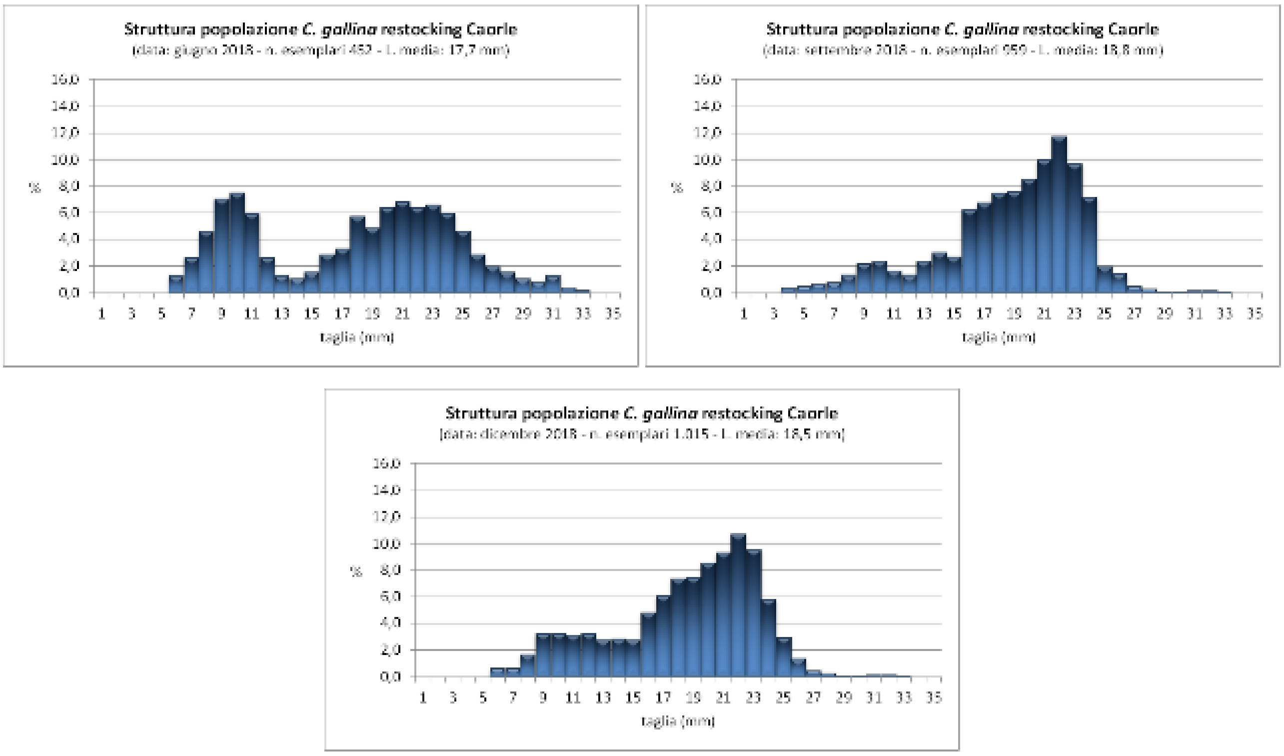
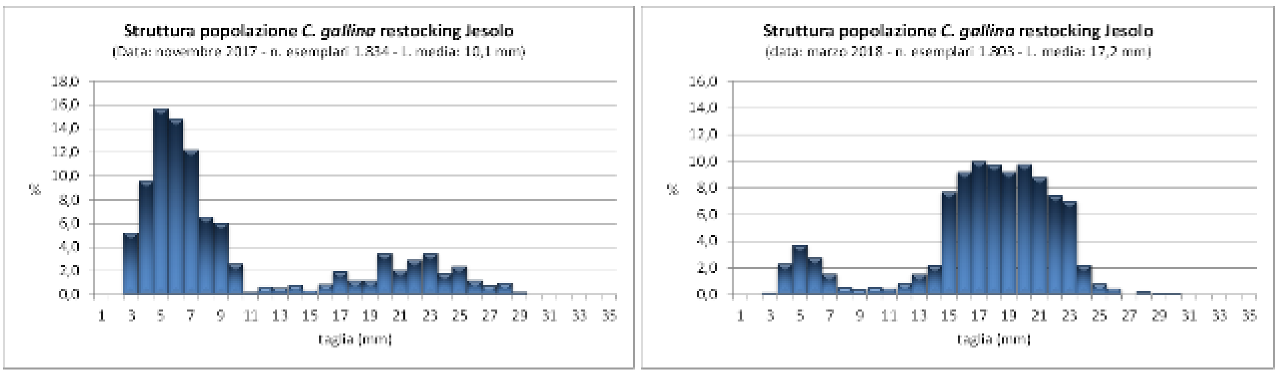
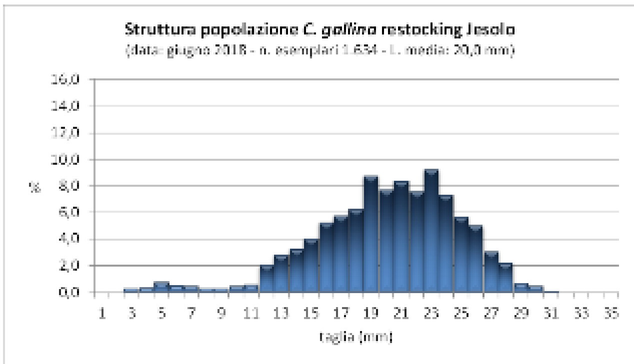


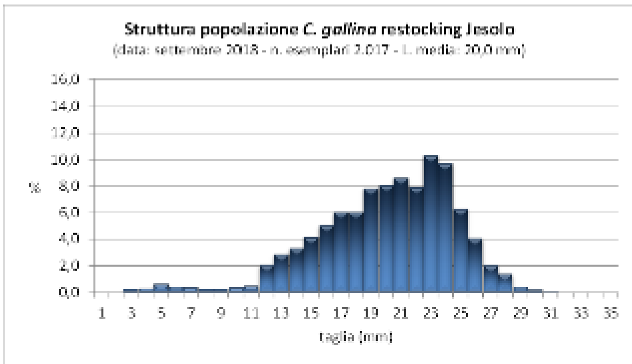
Figure 36. size distribution found in the Caorle restocking area.

Tabella 23. Jesolo restocking area: biomass values for *Chamelea gallina* detected during periodic monitoring.

Jesolo area	Biomass (g/m2) ≥22 mm	Biomass (g/m2) 18-21 mm
Initial state	16,0	37,5
1° quarter 2018	16,7	33,4
2° quarter 2018	19,8	36,0
3° quarter 2018	21,7	30,1
4° quarter 2018	24,2	20,9







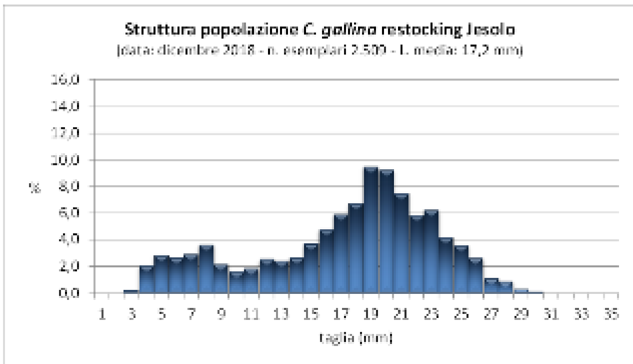
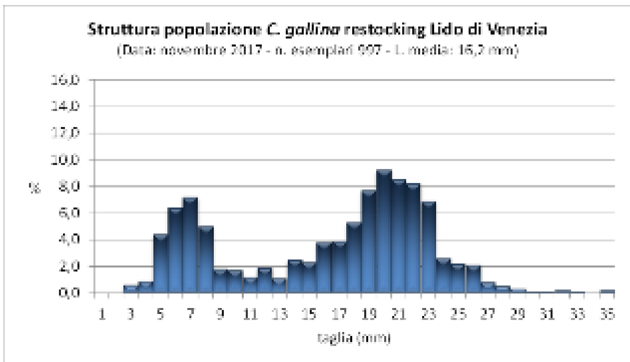
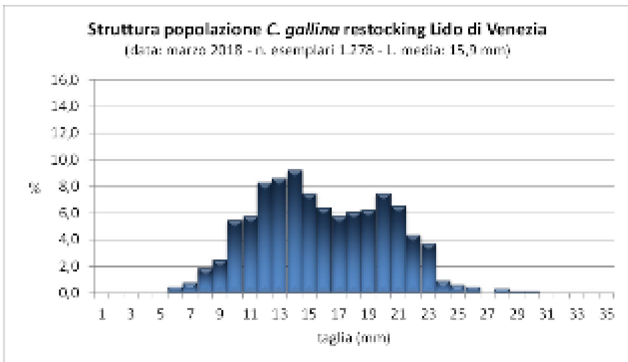


Figure 37. size distribution found in the Jesolo restocking area.

Table 24. Lido di Venezia restocking area: biomass values for *Chamelea gallina* detected during periodic monitoring.

Lido di Venezia area	Biomass (g/m2) ≥22 mm	Biomass (g/m2) 18-21 mm
Initial state	29,5	18,7
1° quarter 2018	13,2	34,1
2° quarter 2018	20,6	44,4
3° quarter 2018	31,3	35,8
4° quarter 2018	42,7	27,6





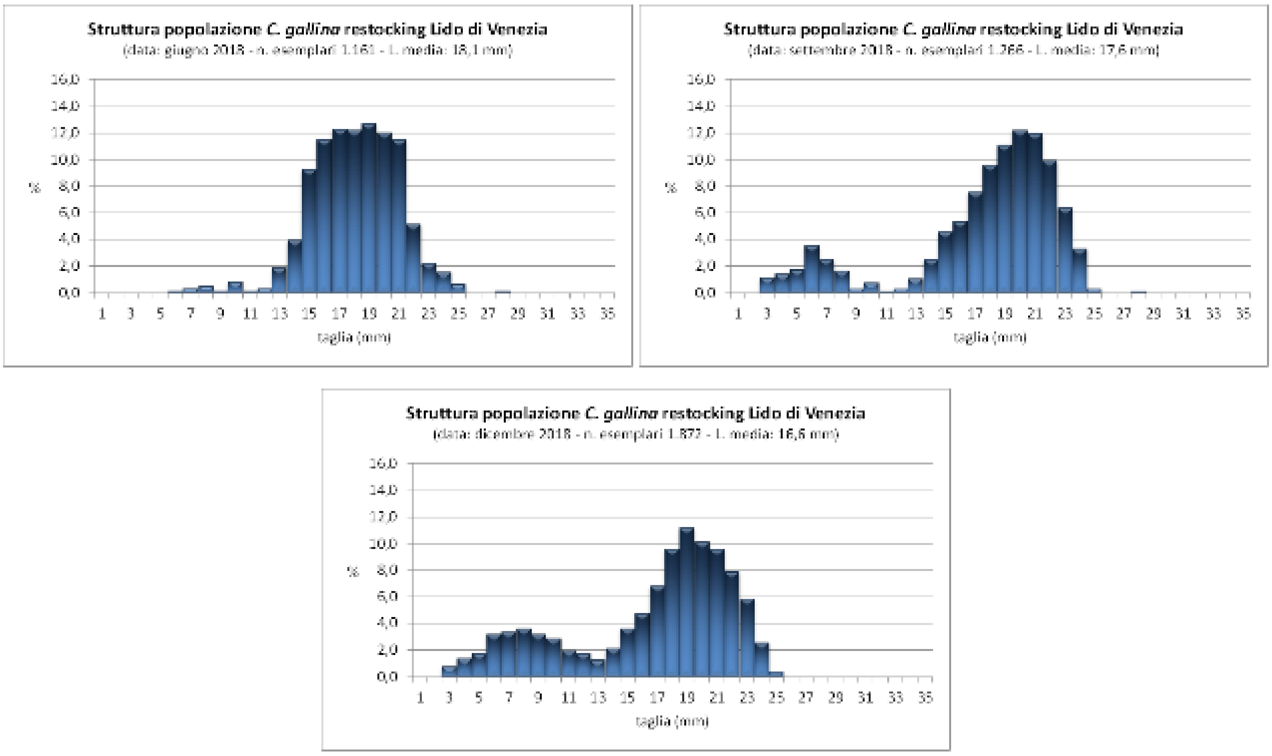
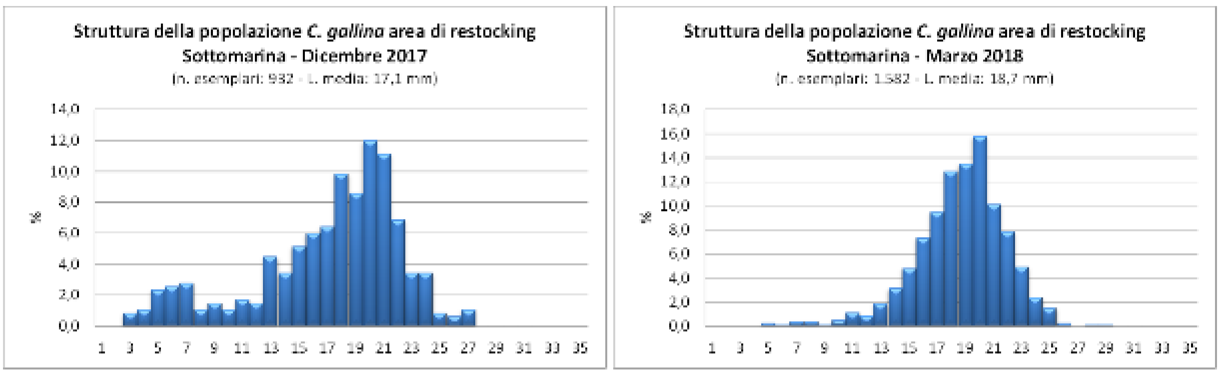
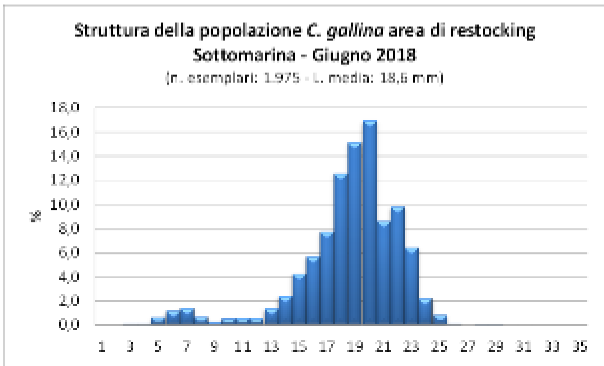


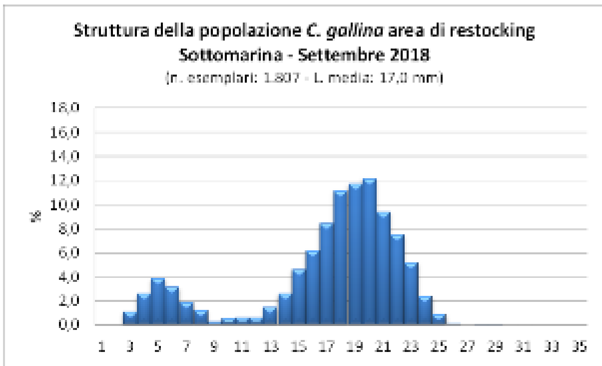
Figure 38. size distribution found in the Lido di Venezia restocking area.

Table 25. Sottomarina restocking area: biomass values for *Chamelea gallina* detected during periodic monitoring.

Sottomarina Area	Biomass (g/m2) ≥22 mm	Biomass (g/m2) 18-21 mm
Initial state	25,3	49,1
1° quarter 2018	37,8	57,1
2° quarter 2018	23,1	40,9
3° quarter 2018	21,5	36,8
4° quarter 2018	17,5	36,9







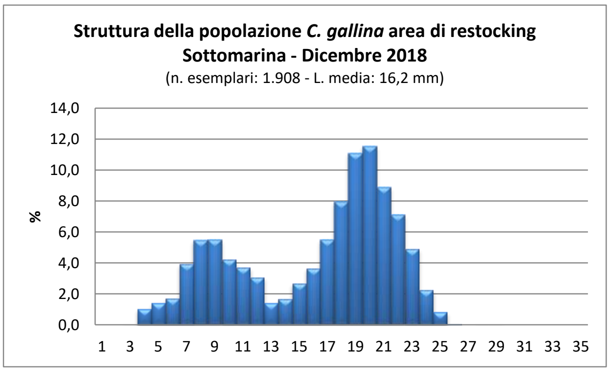
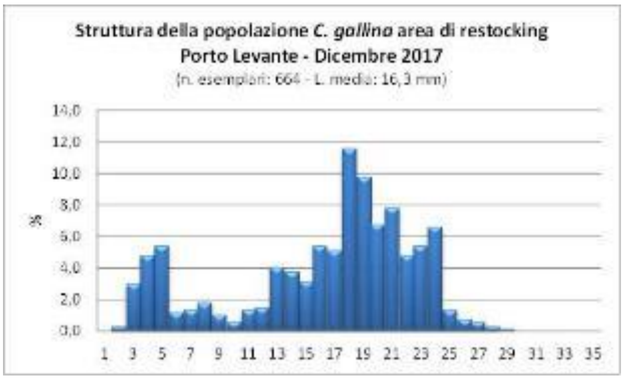
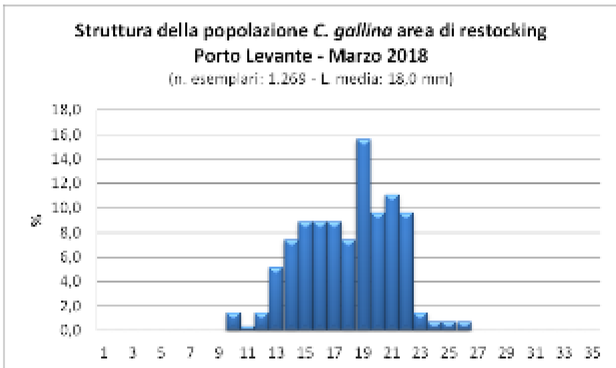


Figure 39. size distribution found in the Sottomarina restocking area.

Table 26. Porto Levante restocking area: biomass values for *Chamelea gallina* detected during periodic monitoring.

Porto Levante Area	Biomass (g/m2) ≥22 mm	Biomass (g/m2) 18-21 mm
Initial state	22,1	66,4
1° quarter 2018	18,5	56,2
2° quarter 2018	8,7	49,9
3° quarter 2018	17,8	49,8
4° quarter 2018	32,0	56,2





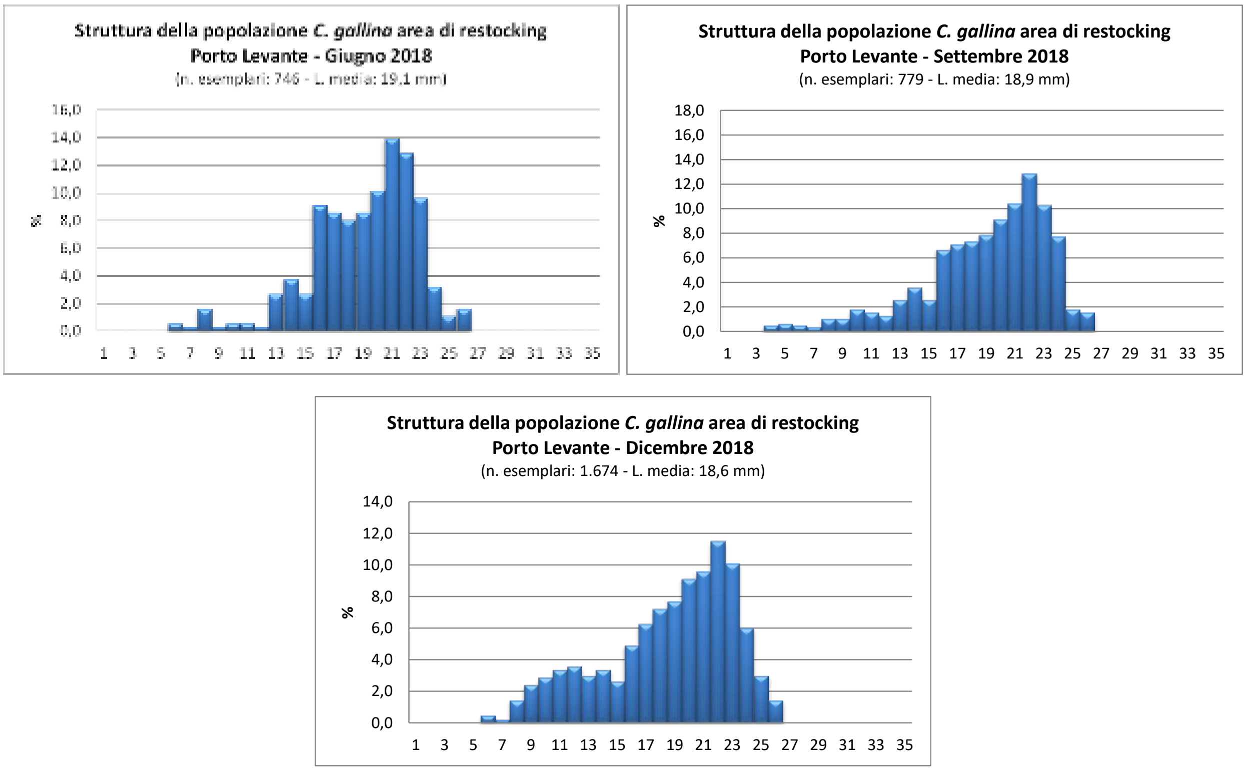
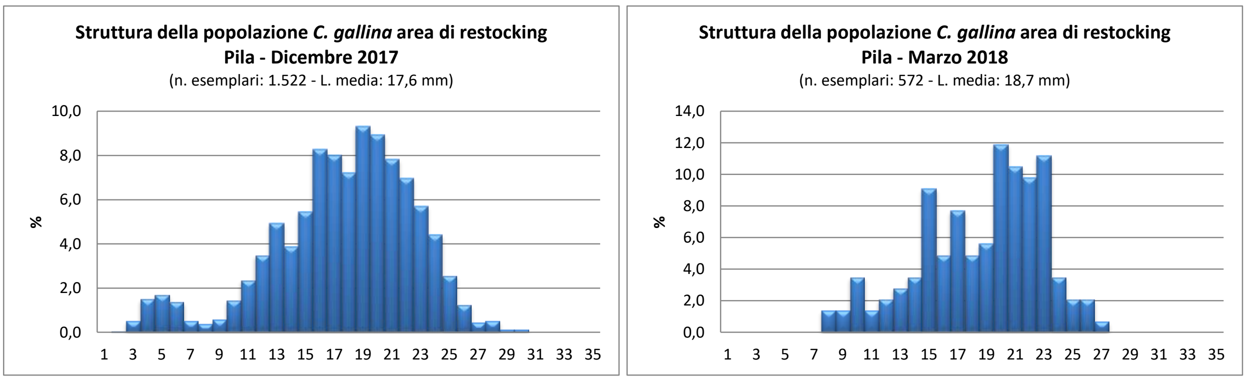
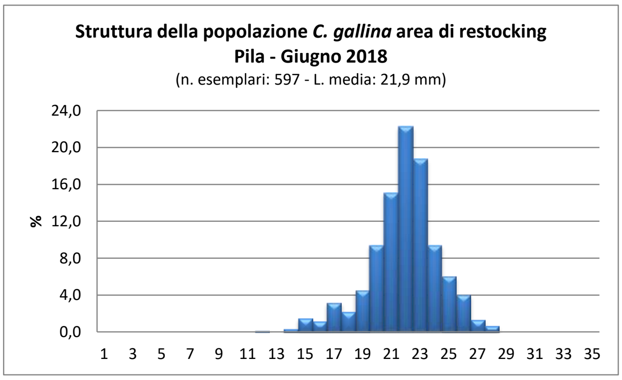


Figure 40. size distribution found in the Porto Levante restocking area.

Table 27. Pila di Porto Tolle restocking area: biomass values for *Chamelea gallina* detected during periodic monitoring

Pila di Porto Tolle Area	Biomass (g/m2) ≥22 mm	Biomass (g/m2) 18-21 mm
Initial state	35,7	43,8
1° quarter 2018	29,1	44,7
2° quarter 2018	27,0	75,5
3° quarter 2018	31,2	70,3
4° quarter 2018	Not sampled	Not sampled





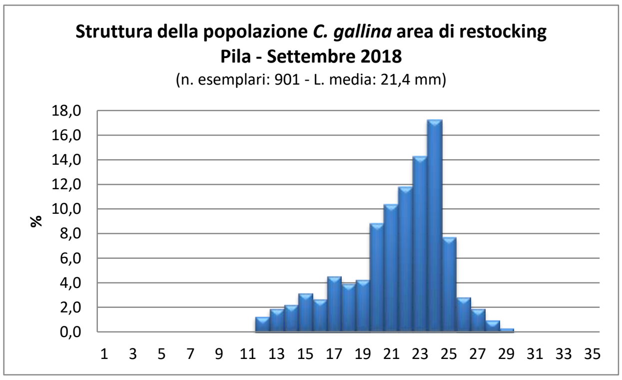


Figure 41. size distribution found in the Pila di Porto Tolle restocking area.

Monitoring of the restocking areas along the Veneto coast highlighted that the areas, in which fishery activities are prohibited, maintain abundance levels of *C. gallina*. The only significant changes can be attributed to external factors, in particular the Lido di Venezia area, which in March 2018 was monitored in non-optimal marine conditions (the day before a deterioration in the weather conditions with south-easterly winds); the Porto Levante area where monitoring in June 2018 was hampered by the presence of pots, and the Pila di Porto Tolle area, in which the last controls (December 2018) were not carried out because the substrate was covered with muddy sediments following flooding in late October 2018.

The impact of hydraulic dredgers

Hydraulic dredgers operate on the sea bed and this inevitably causes physical disturbance to the benthic communities. In particular, the action of the dredges causes a resuspension of the sediment with effects on water turbidity. On the one hand this remixes the superficial sediments favouring the oxygenation of the deeper layers and the release of organic substance and nutrients, on the other hand it could have negative effects such as the destabilisation and modification of the sediment conditions resulting in a decrease in habitat complexity, with consequences for the benthic communities

Between 1960 and 1975, fishery activities with hydraulic dredges gradually substituted the techniques used previously.

The biological communities present in the fishing areas have undergone a prolonged selection process and the composition of the species currently present is the result of the selective action of dredge fishery activities.

However, it should be noted that the communities that inhabit the areas exploited by dredgers are those that are typical to low-depth, high-energy environments are therefore already naturally subjected to constant environmental stress due to exceptional events (in particular large wave movements, strong currents), and they demonstrate resilience with rapid recovery, also depending on the duration of the event. Due to their adaptation to environmental stressors, these communities would seem less susceptible to the disturbance caused by fishing, which could in some ways exacerbate effects of environmental stressors. The short-term effects of dredges on benthic communities of sandy sea beds have been described in several works (Hall and Harding, 1997; Tuck *et al*., 2000). Morello *et al* (2005) demonstrated that, in the short term, the impact seems to be especially significant on mollusc and crustacean communities. Environmental impact studies carried out in the past by the Laboratory of Marine Biology and Fisheries of Bari, have shown that on sandy sea beds over 90% of the species that make up the community recolonise the area where the dredge has passed within a month. The fishing areas in question are limited to the Maritime Districts in which each vessel is registered, and as the number of fishing vessels per District is fixed, it is not possible for fishery activities with hydraulic dredges to be carried out in new areas. Morello *et al*. (2006) observed that in the medium term the communities manage to recover as long as fishing effort decreases over time. The authors indicated a period of 6 months as the threshold for recovery.

For several years, research has been carried out on the fishing areas exploited by dredges, to study the benthic species caught in dredges at macrozoobenthos level during clam fishing operations.

The effects on the marine environment, and in particular the physical impact on the sea bed, are not negligible, however the information available on bycatch from dredges makes it possible to observe that the most represented species are molluscs followed by crustaceans then others. The species caught accidentally by dredges are those typical of coastal environments. No species were detected that are in critical conditions nor ones for which there are stock conservation issues. Capture of fish species has proved so sporadic and limited that the use of dredges does not seem to cause problems. It goes without saying that the consequences to the ecosystem of the impact of fisheries with dredges are not easy to define, nor are there exhaustive studies on this matter. In any case, towing speeds are such that vagile species capable of swimming can easily escape capture.

During the standardised surveys to monitor the state of resources, a small-mesh net was fixed into the dredge to gather the organisms intercepted. See Annex VII for detailed discussion of the results.

Table 28 lists the taxa present in over 5% of the samples collected with the clam dredge, with an indication in the right-hand columns of the degree to which the species would seem to be affected by fishery activities with dredges: not affected (N) a little affected (L) or seriously affected (S). Table 29 lists the species intercepted in razor clam fisheries with dredges.

Table 28. A list of the species caught with dredge gear targeting venerid clams and an indication of the impact on the species (N= no impact) (L= a little impact) (S= serious impact).

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 29. A list of the species caught with dredge gear targeting razor clams and an indication of the impact on the species (N= no impact) (L= a little impact) (S= serious impact)).

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

Final considerations

In the light of the investigations conducted in the first two years of application of the Discard Plan, it has been possible to observe that the Management Consortia have applied the measures envisaged in the Discard Plan adequately, adopting systems to detect the position of vessels, defining the restocking areas according to the established schedule, introducing a certification system attesting the conformity of the product to the minimum conservation reference size at the landing sites. There are a few exceptions, but the consortia which have not fully implemented the Discard Plan have very low levels of the resource in question.

Where the minimum conservation reference size of 22 mm is concerned, it was considered appropriate to investigate some aspects of the biology of the species. This information was gathered following careful review of the available literature together with new biological research. The results obtained with regard to sexual maturity and growth confirm the scientific findings of other authors in previous years. In the samples obtained from the survey it was possible to determine the sex of individuals of 8-10 mm and observe mature gametes in both sexes from a length of 11-12 mm. The reproductive peak for the species would appear to be in the months of May and June, this period is followed by a resting stage until November, which is when the gametogenic cycle begins again for both sexes

A size of 22 mm is therefore larger than the size in the first stage of maturity (L50 = 16-18 mm) and is therefore aligned with and in full respect of sexual maturity, guaranteeing the sustainability of exploitation of this resource. Data relative to growth, on the other hand, have shown that clam size increases by about 1 mm/month. This means that a clam takes just under 2 years to reach a size of 22 mm and that the clams of 22 mm or slightly less, once released back into the sea, reach a size of 25 mm in about 3 months.

The technical measures included in the Discard Plan have brought about a reduction in fishing effort by hydraulic dredges. The potential fishing days per year have decreased, the maximum daily quota per vessel has been reduced (from 600 to 400 kg) and lastly the possibility to market specimens from a minimum length of 22 mm has been conceded (although it is currently rare to find clams smaller than 23 mm on the market). As a direct result has been possible for vessels to reach the daily quota more quickly, this has also resulted in a reduction in the areas dredged, thus reducing the environmental impact of dredging gear. The reduction in the time spent on fishery operations means that this fishery also has implications of a socially useful nature.

With the entry into force of the Discard Plan, the characteristics of the selection gear on board have not been modified. Therefore the properties of the sieving grids themselves have not been modified either. The research carried out has demonstrated that with the use of the correct vibrating sieves (hole diameter 21 mm), the number of specimens below 22 mm retained is irrelevant. Therefore, the number of individuals under 22 mm in the catch after selection is so low that it is impractical and unprofitable to return these specimens to the restocking areas. This explains why in many Districts the areas of restocking have only been used marginally.

The standardised monitoring activities carried out 2017 and 2018 demonstrate that in almost all the Consortia the resource has recovered, with higher biomass and density values recorded in comparison with previous years. At the end of August 2018, however, there was an episode of sudden mass death in the central-north of the Adriatic, probably due to a severe climatic event that may have negatively affected the surveys conducted from September onwards.

The surveys demonstrate high levels of spawning stocks, with a large number of juveniles in all areas, proving that recruitment has been excellent and this will ensure the future quantities of commercial clams.

The vessel position detection system has enabled the sector to participate in control activities, significantly improving its management activities. This tool can be used to plan fishing activities in relation to the effort applied.

Hydraulic dredges have a physical impact on the sea bed. However, it should be noted that communities living in low-depth, high-energy environments are already naturally subjected to constant environmental stress due to exceptional events (in particular large wave movements, strong currents), and they demonstrate resilience with rapid recovery, also depending on the duration of the event. The areas of the shoreline affected by *Chamelea gallina* fishing activities are not chronically disturbed as management planning differentiates harvesting activities by area, closing areas in rotation, or reducing fishing effort. In advanced management planning, large areas of the coast are subject to bans on fishing activities for average periods of 4-5 months, up to a maximum of 8-9 months (also applied by means of Orders issued by the local Port Authorities). These rest periods for the production areas allow the macrobenthonic community to recover over a 3-6 month period as indicated by Pranovi and Giovanardi (1994), or over about 2 months for areas with predominantly sandy characteristics used for commercial fishing (Pranovi *et al*.,1998). According to Goldberg *et al*., 2012, in a specific assessment of the effects of the hydraulic dredger used to harvest *Mercenaria mercenaria* in Connecticut, it appears that the ecological effects and recovery of the benthic community after the action of hydraulic dredgers can be assimilated to those which intervene after natural disturbances.

Keeping the Minimum Conservation Reference Size at 22 mm therefore appears to be a crucial to guarantee a positive future for the sector operating with hydraulic dredges, because it is sustainable from an ecological point of view (the biology of the species and the low environmental impact support this theory) but also from a socio-economic point of view.

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