7. Productivity of commercial edible mollusks and tigmotropism of submerged structures

Research unit
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Title
Study of the productivity of commercial edible mollusks and determination of the tigmotropism of the structures submerged on the Ridge of Santa Croce.

Introduction
Different structures were submerged on the Ridge of Santa Croce in order to determine the tigmotropic effect, both direct on the fish species, and indirect, evaluating the settlement evolution of the macrofouling potential food source for the fish attracted. For this purpose, some preliminary evaluations through experimental catches, underwater observations and analysis of the macrofouling settled on removable panels (AA.VV., 2000, 2001) were carried out. Particularly in the second phase (AA.VV., 2003) some cultural solutions of edible mollusks (mussels, oysters and grommets) were monitored giving promising results for a possible economic application. After three years of submersion, the structures may well be considered mature to practise a good tigmotropic effect, both direct and indirect. To accentuate this effect, even on demersial-benthonic and necto-benthonic species on hard sea beds, in 2002-03 the cubic cavities of the pyramids were parcelled out with different materials (Figs. 7.7, 7.8).

Programme objective
Verify the settling of animal organisms on the structures particularly the commercial edible mollusks such as *Mytilus galloprovincialis*, *Ostrea edulis* and pectinids. To control, through visual census, the increase of presence of fish species and, with the macrofouling study, the food attraction of sessile species.

Materials and methods

Line 1- Verify the availability of edible mollusks on the Ridge of Santa Croce, consequently even of the results obtained in the previous experiences, we thought it necessary to set in operation in two different seasons (autumn-winter), different types of receivers already experimented on the Gulf of Trieste.

Line 2- In this third phase of studies and experimentations on the tigmotropic effect of the submerged structures, the following were executed: an annual series of experimental fishing catches with the use of setnets; two annual analyses on the presence of fish fauna, through the visual census, complete of underwater observations of the general conditions of the structures; an annual macrofouling sampling on the representative surfaces of the structures. For the visual census analyses both a fixed course along a transept and some on-the-spot investigations on the two wrecks were carried out. For the transept it was possible to utilize the connecting cable between the structures (placed by the F.I.P.S.A.S. group of scuba divers - Federazione Italiana Pesca Sportiva e Attività Subacquee/Italian Fishing Sports and Diving Activity Federation) so as to make the course; thread F2, pyramids D1 ,D2, D3 and last F1 in one immersion. The macrofouling samplings were taken onto two different substrates, that is to say on some FAD (Fish Aggregating Device) components and on the concrete walls of the cubes forming the pyramid. The previous observations led to choose some threads as representative: an horizontal panel place on the upper part (FAD R) (already experimented for the algal samplings) and a cable positioned at a higher depth (FAD C). On account of the presence of parcelling/apportionment structures (Figs. 7.7-7.8), which modify the environment inside the cubes, we preferred to choose extreme situations of the external walls of the pyramids. Both on the horizontal top cube (Cube O), and on the vertical wall of a base cube (Cube V), we sampled on a surface of about 0.32 X 0.32m to obtain a 0.1 square metre minimum surface. In this last case the sample was collected above the metre high from the sea bottom, so as to avoid the sediment abrasive effect, which limits the macrofouling anchoring below this threshold. This was also done for the net panel which had a surface of about 0.1 square metre, while on the cable whatever was anchored on about 0.65 linear m was collected.

Operative diary

20 August 2003

Line 2- An on-the-spot investigation of the structures and a visual census was carried out along the transept previously arranged.

Basically it was possible to notice a similar situation to the one observed during the previous on-the-spot investigations. As a matter of fact a predominance of mussels on the F1 and F2 threads existed where both the cables and the various FAD panels resulted almost covered by mussels; particularly, on the horizontal panels, previously thinned out, the mussels expanded thanks to the thinning, but remained anyway of a smaller size compared to those kept on the supporting cable which were almost covered by epibionts (especially serpulids, colonial ascidiums and sponges). Even on the pyramids the predominant species *Ostrea edulis* (Fig. 7.1) showed a remarkable epibiosis which favoured also the presence of interstitial species. The parcelling structures on the other hand, showed a limited macrofouling presence, especially hydrozoans and bryozoans settlements. Probably the settlement of other species was limited, both for the significant presence on the surrounding cement walls of filterers (these live also on planktonic larvas before they manage to settle), and for the most presence of sediments, which cover the different surfaces. The shelter effect of the parcelling structures, particularly those lying on the base, already gave its fruits, since in two pyramids the presence of two little groups of black umbras (200-350g) which found shelter amongst the cement blocks, was noticed. In the other pyramid, instead, amongst the parcelling structures, 3 larger (700-1000g) sea brasses, compared to those belonging to the numerous shoals of sea brasses (200-400g) swimming around the pyramids and the threads, were noticed. Around the pyramids, groups of grey mullet were also found besides the usual ox-eye bream, blotched picarel etc.).
Amongst the FADs, instead, different sparids, both isolated and in shoal, Tab. 7.V.03) were found. In the list of species collected it was thought to mark with a **#** also the expect species, that is to say individuals not directly seen but found by their characteristic digging of their den conger eels, dormice, gobies, etc).

14 November 2003

Line 1- some F2 threads (at about 7m sea level on a bottom of about 13m) were placed on the supporting cable: 3 cables with 4 collector-bags each, 1 cable with 3 series of 10 “Chinese hats” in plastic, 1 cable with 4 series of 3 plastic plates(Figs. 7.2-7.3) and two tubular polyethylene nets with about 30mm meshes and kept open by 6 PVC rings.
Line 2- macrofouling samplings were executed and a *visual census* transept was carried out.
FAD R = The 20mm meshed net, because of the remarkable presence of mussels, which obstructed with the byssus the entrances, could be compared to an horizontal wall with two different populations: the upper part constituted essentially of a thick

mussels cover, which due to the excessive crowding, grow little, and by a lower part formed by bigger and more occasional mussels, but covered by a larger quantity of epibionts (serpulids, anthozoans Tab. 7.M.03). The upper layer constituted of 1.93Kg of mussels (average size – 9.4g, weighed 20 individuals for 188g), the lower layer weighing 0.612Kg of mussels (average size 14.6g, weighed 20 individuals for 292g). Different interstitial species were also found.
FAD C = From the cable for 65cm long Kg 5.430 mussels were collected weighing on average g 38.4 (20 individuals were weighed for g 768) different epibionts and interstitial species were present (Tab. 7.M. 03).
Cube O = From the surface of about 0.1 square metre, with some difficulties since they were well cemented, 21 oyster shells and 17 live samples, for a total of 1130g (average weight 66.5g) were collected, moreover, 19 mussels (total weight 970g average weight 5g) together with different epibiont and interstitial species including some algal species (Tab. 7.M. 03).
Cube V = from the surface of about 0.1square metres, collected more easily than the previous sample, 10 oysters shells and 24 live species were taken, for a total of 1.945g (average weight 81.0g), moreover 9 *Chlamys varia* (total weight 223g – average weight 24.8g) together with numerous epibiont and interstitial species (Tab. 7.M. 03).
Along the transept no groups of fish were collected, a part from a frightened sea bass, and its usual sedentary species (wrasses, gobies and blennies). This may be due, both to the significant torbidity of the intermediate waters (visibility from a metre from the sea bottom for a 4-5m layer was less than 3m), and to the sudden temperature drop (temperatures lower than 12°C were recorded), since not even inside the parcelling structures interesting species were observed (Tab. 7.V.03).

18 April 2004
Line 1- winter receivers were collected: 3 series of 4 *collector-bags* (depth -7.5, -9, -10.5 and -12m), 1 series of 3 piles of 10 “Chinese hats” (depth -8, -10 and –12m), 1 series with 4 piles of 3 plates (depth -7.5, -9, -10.5 and –12m). The tubular nets were left in situ, as they presented only some CH (*Chlamys varia*), few CR (pink grommets) and the net resulted still intact by macrofouling (few serpulids and bryozoans); moreover, on the wider surface of other receivers a good presence of ascidiums (lower part Chinese hats and plates), hydrozoans, bryozoans and serpulids (on deeper receivers) this was to the detriment of bivalves settlement of which only CR (*Aequipecten opercularis)* were collected (Figs. 7.2, 7.3, 7.4). The presence of CR was not high if compared to those recorded in 1997. In order to carry out the quantitative evaluation, there were counted the CR collected from the

three different types of receivers, divided in 3 classes according to size (P <14mm, M 14-22mm and G >22mm – Tab. 7.1-CR1).

12 June 2004

Line 1- Some F2 thread (at about 7m sea level on a sea bottom of about -13m) 3 cables with 4 collector-bags each, 1 cable with 3 series of Chinese hats, 1 cable with 3 series of 4 plates were positioned on the supporting cable. During the cleaning of the supporting cables, some oysters, which eventually showed to be mother oysters (Fig. 7.3c) were collected.

Line 2- an on-the-spot investigation of the structures and the visual census along the set transept was carried out.

The monitored structures had a benthonic population more "mature". As a matter of fact, no noticeable new settlements were found; for instance on the left mussels, of those thrived before 2003, no presence was found of young mussels but a major epibiosis from other filterer species. The mussels on the threads are more infrequent, both for the thinning and for the natural detachment. On the sea bottom around the FADs nets, partially lying on them, a high number of mussels was found which in some cases formed piles. Sometimes these piles favoured the presence of dens species (conger eels and European lobster) under the ducts counterbalanced, which showed the two openings partially obstructed by mussels aggregates and other sessile filterers detached by the impending FADs. Even around the pyramids some filterers exoskeletons ruins were forming, in this case especially of *Ostrea edulis*. These piles favoured the presence of interstizial species and a higher number of dens dug under the base of the pyramids was recorded (conger eel, dormice, European lobsters, gobies, etc). This phenomenon of deposit and pile, both of exoskeleton and organic particles, due not only to the excrement and alike of impending filterers, but also to the reduction of the current intensity because of the turbulences due to the presence of the pyramid itself, and it was particularly clear on the bases of the cubes inside the pyramids. As a matter of fact on the supporting bases of the 4 sea-bottom cubes a mud layer very little compact, perforated by filterers exoskeletons on the walls of the pyramids was noticed. In the hollows where the parcelling was carried out, the pile is obviously consistent, both due to the biomass settled on the parcelling structures (even if of limited intensity compared to the one belonging to the fluctuating FADs), and to the den settlement made of little cement blocks. From the planning point of view, these FADs were positioned in two overlapping layers, so as to give protection to the den species. These species tended to stand near the sea bed even in the presence of muddy deposits, which exceeded 40cm before beginning to cover the parcelling structures

leaning on the little blocks. The tendency of larger black umbras and sea brasses to stand in the lowest and darkest tortuous gorges, was confirmed also during this on-the-spot investigation, requiring a thorough survey from the operator. It is enough to think that in fact a docked of an escaping fish makes the water torbid as well as every movement not well calibrated by the scuba diver, that, always with greater difficulty, manages to find the presence of prestigious inquilines inside the parcelling structures, without confusing them with the shape most of the time fleeing of the omnipresent labrids. Around the threads and pyramids the now usual presence of groups of sea brasses (200-500g), sparids, grey mullets, as well as the usual ox-eye breams, blotched picarels, etc.

3 September 2004

Line 1- the receivers did not show a significant settlement so they were left submerged. The absence of settled bivalves was noticed on the cables and on the tubular nets (no mussels and rare CH - *Chlamys varia* – and oysters).

Line 2- A visual census was carried out on one part of the transept (F2 thread and D1 pyramid) and on the Sub Sea wreck; a reduction of the fish population compared to June was noticed both around the threads and around the pyramids, even if the presence of species substantially remained unchanged (Tab. 7.V-04).

16 December 2004

Line 1- the summer receivers were collected: 3 series of 4 *collector-bags* (depth -7.5, -9, -10.5 and -12m), 1 series of 3 piles of 10 Chinese hats (depth. -8 -10 and -12m), a series with 4 piles of 3 plates (depth -7.5, -9, -10.5 and -12m).

The receivers were covered by sponges, ascidiums, barnacles and serpulids (Figs. 7.5 and 7.6), only some rare specimens species commercially interesting (OST *Ostrea edulis*, CH *Chlamys varia* and CB *Protopecten glaber*); no specimen of OST, CH and CB was found on the plates (Tab. 7.2).

Line 2- macrofouling samples were carried out and a visual census transept was executed

FAD R = the net panels showed a predominance or mussels, but in a less bulky way than the previous year; the mussels were of a larger size and the presence of specimens from swarming subsequently the initial one was not found.

On the 0.1 square-metre horizontal panel the following were collected: on the upper layer Kg 1.65 mussels of an average weight of 16.5g (20 individuals 330g) and on the lower one 25 individuals for a total weight of Kg 0.690 (average weight 27.5g) greatly covered by epibionts (serpulids, anthozoans Tab. 7.M-04).

FAD C = the majority of the cables were set free by mussels to lighten the thread; the sampling was then carried out in an area pretty much near the anchoring blocks where the mussels are less rare and the epibiosis is greater. From the cable for 65cm long 2.680Kg, for an average of 54g (20 individuals 1080g) of mussels were collected, the weight was conditioned also by the presence of many epibionts especially serpulids and balanids. Different sponges and interstitial species were also present (Tab. 7.M.04), which covered also 6 OST for a total of 680g and 4 CH, total weight 112g.
Cube O = from the surface of about 0.1 square metre the following were collected: 28 OST for a total weight of 2744g (average weight 96g); 9 OST smaller size and partially attached to the others or on the ruins of 6 oysters shells for a total weight of 430g (average weight 47.5g); 22 mussels were then found (total weight 1740g – average weight 79g) together with different epibiontic and interstitial species (Tab. 7.M.04).
Cube V = from the surface of about 0.1 square metre the following were found more easily than the previous sampling: 18 oyster shells and 26 live specimens for a total weight of 1.838g (average weight 16 OST 89,5g and 10 OST 41g); 3 *Chlamys varia* were also collected (total weight 95g – average weight 31.8g) together with numerous epibiontic and interstitial species (Tab. 7.M.04).
Along the transept rare fish were observed, also due to the high torbidity especially around the sea bed. A part from the usual sedentary species (labrids, gobies, blennies), both around the threads and the pyramids, as well as inside the parcelling structures, only a fleeing sea bass was seen (Tab 7.V-04), despite the temperatures were higher than the seasonal averages (see surveying with a multiparametric probe carried out the same day).

18 March 2005
Line 2- a on-the-spot investigation of the structures and the visual census along the set transept was carried out.
The winter stormy seas eradicated 2 components of the metal net parcelling structure covered by a black piece of cloth, placed to increase the dark den areas, favoured by den fish (white breams, black umbras, etc.).

> The black piece of cloth, though, even if positioned horizontally and inside the blocks, supplied a good surface to the bottom currents triggered during the stormy seas and caused the breaking of conjunction points of the metal net components, which were dragged at a higher depth towards the pontoon.

On the connecting cable and at bow of the pontoon two setnets and a relative cable were found tangled. The FAD threads did not show any signs of stormy seas, but all their final parts were leaning to the bottom and covered by sediments, of mussels and other species detached from the above nets. Different ducts, though, were left or partially kept empty and gave shelter to the only species found such as librids, 2 conger eels and probably also some European lobsters considering the type of digging of the entrance passage.
Those totally free from sediments, only put on the sea bed (at the beginnig of the thread), did not show any inquilin. Even in the pyramids and in the pontoon the fish species observed were all stationary and sheltered in the tortuous gorges, particularly some sea brasses weighing 1-1.5Kg and two black umbras weighing almost 1Kg, hidden in the base of the parcellings and in the two TECNOREEF pyramids, placed between the cube pyramids. Inside the pontoon instead, 30-40 black umbras were stationing weighing around 200g with some even 500g, potentially night preys of 3 conger eels hidden among the bow bulkheads and different ruins deposited on the sea bed of the pontoon.
The benthonic populations flourished on different surface did not show any new mussel settlements while a consistent epibiosis of sponged colonial ascidiums which rose on the large cable mussels and the oysters on some walls of the pyramids was observed; only on the horizontal cover it was possible to observe a predominance of mussels still forming a quite uniform meadow of average size mussels.

12 June 2005
Line 1- considering that, recently the CB were present almost everywhere on the sea bottom of Trieste, probably due to the always higher presence of thriving surfaces (on mariculture plants and on aggregates of species encrusting on the soft sea bed), we thought of testing particularly the presence of new oysters, given the poor result of the previous year. For this reason only 2 cables with 3 series of 10 “Chinese hats” were deployed each on the supporting cable of the F2 thread (about 7m sea level on a sea bottom of about 13m). To determine the gonadic state of the oysters, see the experience of the previous year (Fig. 7.3c), 40 oysters were collected from a vertical wall of the cube base. Amongst these, 4 still showed gonads full of sexual products (a clear whitish liquid which dispersed in the lower valve by the simple pressure of the soft parts), 2 were mother oysters, while the others showed gonads empty or nearly empty.

8 October 2005

Line 1- the two cables were all tangled up and lying on the bottom were the, together with an anchor and its rope. No receiver was left undamaged by frictions or mud covering to the whole lot was collected with no analyses at all as it thrived.

Line 2- A visual census on a part of the transept was carried out (F2 thread and D1 pyramid), on the pontoon and "*Giuliana*" wrecks; furthermore, macrofouling samplings were executed.

No interesting presence of prestigious species was recorded, except one only frightened, little sea bass, among a group of grey mullets and two escaping little black umbras, and a conger eel (Tab 7.V-05).

To still be in the summer period, with good visibility, an impoverishing situation so accentuated, could witness the incidence of disturbing and collecting actions (partially confirmed by a great number of anchor and nets groundings during the different on-spot investigations and by a great number of boats observed and anchored, in our presence, just outside the reserve area, though not well defined as the external buoys were missing). During the on-spot investigation the benthonic population confirmed what was observed in the previous samplings, that is to say no new settlement from the first colonizer species (mussels – oysters) and an increase of epibionts on them. All the bases of the submerged structures revealed a pile of sediments particularly around the threads whose lowest panels were stable component of piles of mingled sediments to the incrusting species fallen from the FAD.

FAD R = the side facing the net panel surfaces revealed a mussels predominance, with few epibionts (Kg 2.120 corresponding to 116 mussels weighing 18.2g) while on the internal side few individuals (g 530 = 12 individuals weighing 44,1g) and covered by different epibionts (serpulids, sponges, ascidiums, Tab. 7.M-04).

FAD C = no mussels were seen on the cables, but particularly around the fastenings of the aggregates covered by sponges, sea anemones, colonial ascidiums and other. One of these aggregates around the fastening of a distance piece pole was collected. 68 specimens were counted for a total weight of Kg 4.620 (g 67,9/ind); the weight was conditioned though by many epibionts especially serpulids and balanids. Different sponges and interstitial species were also present (Tab. 7.M.05), which covered also 4 OST for a weight of 312g.

Cube O = from the surface of about 0.1 square metre the following were collected: 20 OST for a total weight of 1870g (average weight 93.5g), 12 oyster shells and only 4 mussels, all showing a remarkable epibiosis particularly sponges, which rose from the mid level and numerous specimens of *Chama griphoides* (Tab. 7.M.05).

Cube V = from the surface of about 0.1 square metre the following were collected: 14 oyster shells and 27 live specimens for a total weight of 2540g (average weight 94g), as well as 4 *Chlamys varia* (total weight 118g – average weight 29.5g) together with numerous epibiontic and interstitial species (Tab. 7.M.05).

Observations

Line 1- the thriving tests revealed a lower presence of individuals belonging to commercially interesting species and an higher predominance of macrofouling on receivers, predominance composed by epibiontic species and competitors of the target species (trend partially cofirmed also by the macrofouling observations and samplings on the cement wall and on the cables and net pannnels of the FAD). As a matter of fact in the last on-spot investigation (October 2005) no young populations were recorded, neither oysters nor mussels: despite the significant thriving of *Protopecten glaber* (white grommet - CB) on the FAD just submerged (August 200 – fase II) in no macrofouling sampling was possible to collect a specimen. This observation confirms once again what was previously found in the phase II and that, when we want to effectively increase the biomass of the commercially interesting species, clean surfaces at level must be employed and at a suitable period.

In this connection, a study must be planned, taking into consideration also the slow climatic changes, to determine better the period and the level of immersion most suitable or through plankton samplings or with the deploying of a major number of receivers to test more periods and more levels.

If there is to be an economically sustainable production we must structure submerged devices with floating surfaces and periodic maintenance interventions. The presence of an underwater oasis, besides being an experimental field for fish repopulation, acts as tanks for reproducers of filterer species such as the oysters. In this case where whitebaits are available it is possible to leave out the receivers and hope to spot the right swarming, collecting the mother oysters (see diary June 2004 and 2005) in order to thrive the larvas almost ready inside the mother valves, in a controlled environment, so as to obtain a number extremely higher than little oysters, in relations to the receivers action in a natural environment.

The experiences and investigations should be connected to the realization of pilot plants managed by people that intend to start production plants or with management consortiums who wish to start passive repopulation actions. A presence which would also reduce accidents or acts of vandalism such as those occurred on the receivers in 2005.

Line 2- even in this line the unwanted presence may have conditioned the evaluation of the tigmotropic effect. We then suggest to continue with the

monitoring actions and interventions to increase the dissuading structures to abusive fishing be installed and to awaken to a greater extent the institutions to a more of a control.

> For example, it is important to highlight on the external buoys the existing prohibitions with suitable tables and a suitable number of buoys, which simply play a very important passive role of dissuaders for the use of trawling nets or not. It is very efficacious as a means of dissuaders, even the employment of chains and cables stretched amongst the structures. It has been found that the external cable placed as a connections of the different mooring of the buoys in many places has been cut both by grounding actions which due to the friction on the borders of the mooring or on the little oysters thrived. It would be opportune activate once again possibly with pieces of chain in the fastening points and intermediate buoys to keep it detached from the bottom even just to have thriving surfaces available and improve the tigmotropic effects.

Starting from the necessary interventions, the on-spot investigations needs intensifying and the visual census analyses is particularly needed to verify if the observed reduction in October of the fish population may have been accidental or due to the abusive fishing or traceable to the evolution of the sediments around and inside the structures (even if previous experiences showed the contrary: Bombace 1990, 1992; Bombace *et al*., 1998). At this point it is noteworthy to point out that, even if the floating SSML had not been conditioned by the sedimentation and the parcellings have a little base formed by little cement blocks, just for not being also conditioned by the pile of sedimentation, the bottom deposits have formed in little time due to the populations thrived on the above surfaces, both because of the slow deposit of the alike-excrements, and of the aggregates detached probably in a bulky way during the stormy seas and not scattered. In order to be able to have different situations available, comparable, providing the need to reduce to the minimum the external interference (abusive fishing), it would be ideal to clean a thread so as to have it at the previous level and/or deploy a new one. The evolution study of sediments would supply better details obtained by the study of benthonic populations and macrofouling.

The macrofouling samplings and in particular the quantitative analyses of the edible species, have revealed, as previously mentioned, a reduction the two young species considered and an increase of those interstitial ones, probably towards a *climax* situation, which should produce less sediment and aggregates. It is to be evaluated even if the most presence of interstitial species such as polychaetes and crustaceans attracts a greater presence of prestigious species in connection to high biomasses of young populations of mussels and oysters.