Fish farming in Grado Lagoon: impacts and dynamics of two fishfarms

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Introduction

According to Ravagnan (1992), aquaculture, similarly to agriculture, can be considered as the activity carried out by man in order to obtain means of sustainment by using the aquatic environment. Following such a principle, fish farming has been developed in Northern Adriatic since the XIX century. This has implied a modification of lagoonal areas, that have been embanked in order to farm the different fish species (Fig. 1).
The importance of coastal lagoons for fish farming is related both to their physical characteristics, as the borders are well defined and fish populations can be easily controlled, and to the richness in nutrients, that can be used to feed the farmed fish.

Fish farming techniques

There are two main types of fish farming: extensive and intensive. Extensive farming is aimed at creating productive systems that can be considered as satellite ecosystems, where human actions are integrated with the natural cycles. Extensive farming uses only the trophic resources that are available in the environment. Intensive farming is aimed at productivity models that are not linked to environmental trophic limits, and thus creates rigid microsystems, strongly controlled by man (Ravagnan, 1992).
According to Cataudella and Bronzi (2001), extensive farming is strongly associated to the knowledge of fish migration in and out of the lagoon, and to water control that follows a simple natural cycle, articulated in the following phases: juvenile gathering in the fish farm area, growth using natural trophic resources, catch of individuals that have reached the commercial size. Fish farmers usually put their efforts in controlling the water regime, choosing the species to farm, safeguarding the natural habitat morphology, adding new juveniles, monitoring them and catching them once they have reached the adult stage.
Other interventions imply maintainance activities and defense from predation, in particular by cormorants (Fig.2). Intensive farming implies the artificial feeding of fish, in order to reach higher productivity levels in shorter times. Intensive farming is more efficient and better controlled, but has a higher impact on the environment. Impacts are mainly caused by the accumulation of organic waste, by the high energetic costs related to the plant use, by the presence of structures that strongly modify the landscape.
A third method has however been developed in recent years, the "integrated fish farming". This method is applied in the two study areas considered in this work: Ara Storta and Noghera. This method implies a differen-

tiation of the plant in different sectors, so that intensive and extensive approaches can be successfully integrated. A first phase uses intensive methods. Fish are gathered in tanks and artificially fed. Then, certain species are kept in such plants until the end of the process (e.g. seabass), other species are released after a period in the extensive areas, where they can feed freely (e.g. gilthead seabream). This method is sometimes called "semintensive" (Boatto e Signora, 1985). Integrated fish farming is particularly interesting, because organic residuals coming from the intensive sectors are put in the extensive areas, where they are recycled as fertilizers. This increases the natural productivity of the environment, and allows to keep the fish at higher densities. Integrated methods thus allow to use energetic resources in a more rational way and to partially recycle the pollutants. Also this model can show problems though, especially in consideration of the environmental complexity of wetland ecosystems.

Aims of the study

The environmental conditions and the natural trophic availability of two integrated fish farms located in Grado lagoon (Ara Storta and Noghera) were assessed. The two fish farm are characterized by very different conditions. Ara Storta is more isolated from the sea and has the typical problems of inner lagoonal areas, including low water circulation and mud sedimentation. It is also of very small size: 33 ha. Noghera covers a surface of 220 ha, and it is much closer to the open sea. It is connected to several sources of freshwater (7 wells with temperatures up to 33 °C) that are used to decrease the salinity in summer and to mitigate the water temperatures in the wintering tanks.

Data were collected once per month in july, november and december 2004 and january 2005, and twice per month in august, september and october 2004 and february and march 2005. Samples for microphytoplancton analysis were also collected. Species diversity was determined following Hasle-Syvertsen (1997) and Steidinger-Tangen (1997) methods, cell abundance per liter was also determined. Chemical-physical parameters were monitored collecting data on the main nutrients (NO_2^-, NO_3^-, NH_4^+, PO_4^{3-} ed SiO_2), temperature and salinity.

Results

Physical parameters – *The temperature trend (Fig.3) is very similar in both cases. There is a strong decrease in november, with 4,8 °C recorded in Ara Storta and 5,8 °C in Noghera. Conversely, the salinity trend is different in the two areas. Ara Storta goes from an initial value of 36.5 to 40.1 (27 august); then decreases progressively from september (abrupt change) on, until it reaches constant values of 32 - 34 in february - march (Fig. 4). In Valle Noghera the values increase strongly during summer, going from 29.8 in july to 43.4 in september. Then the values decrease until november and show a variable trend until march, when a value of 25.3 is recorded.*

Chemical parameters – *The macronutrients NH_4^+, NO_3^-, NO_2^-, PO_4^{3-} e SiO_2 are related to seaweed development. In both fish farms NH_4^+ shows the highest values, and especially in Ara Storta, where values reach 479,00 µg/l on 19/07/2004 and 677,05 µg/l on 22/01/2005 (Fig. 5), whereas in Noghera the highest recorded value is 303,65 µg/l during the last monitoring (Fig. 6). Ara Storta is characterised also by higher nitrate values: in Noghera the maximum is 91,59 µg/l on 11/02/2005, whereas in Ara Storta it is 142,02 µg/l on 27/10/2004. Conversely, phosphates have a similar trend in the two farms. The values are higher in summer and lower in winter. Nitrites are low in Ara Storta, ranging between 0,98 µg/l and 21,14 µg/l. In valle Noghera, values over 23 µg/l are recorded twice from september to december. Silicates have rather high values in both cases and throughout the study period: the highest values are 702,12 µg/l (19/07) and 520,97 µg/l (august) in Ara Storta, 700,15 µg/l and 521,53 µg/l in Noghera.*

Biological parameters – *In the two fish farms 105 microphytoplancton taxa were observed. From july 2004 to march 2005 the community is composed in both areas by diatoms, dinoflagellates and nanoplancton (Figg. 7–8) with the classes chlorophyceae, cryptophyceae, prasinophyceae, euglenophyceae and in valle Noghera cocco-lithinae. In Ara Storta 39 taxa of diatoms and 32 of dinoflagellates have been recorded. Dinoflagellate density is higher than 1000 cell/l in august, october and march (Tab. 1). In Noghera diatom diversity is higher and it is the most abundant component. In particular, in july Gonyaulax fragilis has a density of 236000 cell/l (Tab. 2).*

Data elaboration

Both data collected in the two farms and in lagoonal channels by ARPA-FVG were considered. Data were hye-rarchically organized, and a dendrogram was obtained (Fig. 9). Four groups of station can be recognized, and a seasonal trend is apparent, with the summer period (group 1 july-october) well divided from the winter one (november to march). Winter data from lagoon channels (group 2), mouths (group 3) and fish farms (group 4) are well divided. In particular, Natissa river mouth forms a single group in winter.

A principal component analysis was then applied. As shown in table 3, the first axis can be interpreted as an increasing nutrient gradient ($P\text{-}PO_4^{3-}$, $N\text{-}NO_3^-$ e $N\text{-}NO_2^-$) and a decreasing salinity gradient. The second axis represents an increasing temperature gradient. The diagram obtained from the interpolation of the first two axes is shown in Fig. 10. The four groups are well separated.

The second axes separates summer samples (group 1, up and left) from winter samples. These are scattered from left to right along an increasing nutrient gradient, going from lagoon samples (group 2), to fish farm sam-ples (group 4) to Natissa river samples (group 3). The different groups can thus be separated according to their chemical-physical parameters. In addition, the average values for each group are shown in table 4. Cluster 1 has the highest temperature and salinity values and low nutrient values. Winter lagoon stations (group 2) have low nutrient and temperature values, but salinities similar to the summer ones. Winter fish farm stations (group 4) have intermediate salinity values, low nutrient values and temperatures. Only ammonium shows the highest values in this group. Winter river mouth stations (group 3) show the highest values for all parameters (nitrates are particularly high: 2271 µg/l) except salinity.

Discussion

The two fish farms have different conditions than the rest of the lagoon especially with reference to salinity and ammonium. Salinity is especially affected by the enclosed water conditions. In particular Ara Storta is small, does not have any freshwater source and is close to the land. Salinity is always higher than in Noghera, that is bigger and has several freshwater sources.

More complex is the ammonium situation. The artificial food impact is limited, as it is given only for a short period and only to seabass and gilthead seabream juveniles Hence, the source of NH_4^+ does not seem to be the artificial food. The high ammonium concentration is more likely to be linked to the high fish densities, being the main fish catabolite. It is important to monitor this phenomenon, as ammonium derivates are toxic and can be even mortal for fish (Tibaldi, 1983). In Ara Storta they are always high, and always higher than in Noghera. This is probably related to the smaller size of the farm and to the proximity of the river Natissa. Such a river has a strong impact on the lagoon, as it is an important source of NH_4^+ and NO_3^-. Phytoplancton is not particularly abundant nor diverse in the two fish farms, and especially in Ara Storta. This is probably due to the complexity of factors that affect the fish farm contest (e.g. absence of tides, enclosed environment, higher fish densities). Noghera phytoplancton community is richer and more affected by the marine environment, as indicated by the higher biodiversity and the presence of microalgae.

Conclusions

The environmental conditions of the two fish farms are half way between the open lagoon situation, partially affected by the sea, and the Natissa river mouth situation, characterised by high nutrient inputs. This highlights the presence of compatible farming methods, that are integrated with the lagoonal ecosystems. It is important to enhance this type of fish farm development, as farmers can help maintaining good environmental quality standards, still carrying out their economic activities. In particular, the alteration of both marine and river waters recorded in Northern Adriatic has an impact also on the lagoonal ecosystems and on fish farms. The requirements of fish farmers in terms of environmental and fish health could help to enhance the attention for environmental quality matters.

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