

MARICULTURE IN CROATIA, HISTORY AND PERSPECTIVES

B. Skaramuca, Z. Teskeredžić, E. Teskeredžić

Summary

Croatia is the country where the sea was used as a food source about a thousand years ago. The tradition of some forms of collection and culture of marine organisms is very long along the Adriatic coast. The farming of marine organisms has a long tradition on the eastern Adriatic coast dating back to the 19th century. Lorini (1903) mentioned a figure of 116 such fish ponds on the eastern Adriatic coast. Long tradition of shellfish and fish breeding and particularly a growing fund knowledge recently provided a mariculture development at a growing pace. The eastern Adriatic coast with a number of bays, coves and channels protected from the wind and waves by chains of islands provide marvelous conditions for intensive farming on floating platforms.

Key words: mariculture, history, perspectives

HISTORY

Croatia is the country where the sea was used as a food source about a thousand years ago. The first written document on croatian harvest fishery in the Adriatic Sea dates back to 1000 years ago (Čolak, 1962). The tradition of some forms of collection and culture of marine organisms, particularly the Mediterranean oyster (*Ostrea edulis*), is very long along the Adriatic coast as shown by number of written documents and prehistoric findings (Basioli, 1984). From some documents it appears that the people living around Bay of Mali Ston (near Dubrovnik) began the oyster culture first in the Mediterranean. Dubrovnik nobleman Jakov Sorokočević (Jakobus Sorgo, 1534–1604) who was Ston duke for some time, described some fish species and special fishing methods as well as oyster species and their breeding in Ston in this letters to Guililemo Dondini, the chancellor of the Dubrovnik Republic and the bisho's secretary Antonio Giganti. The letters were in fact addressed to the famous Italian naturalist Ullisse Aldrovandi but they never reached him.

Dr. sc. Boško Skaramuca, Institut za oceanografiju i ribarstvo, Biološki laboratorij, Dubrovnik; dr. sc. Zatica Teskeredžić i dr. sc. Emin Teskeredžić, Institut »Ruder Bošković«, Centar za istraživanje mora, Zagreb.

Sorkočević then made personal contact with Aldrovandi and sent him the report on fishes from Dubrovnik with specimens and colour pictures (Grmek, manuscript, personal communication).

Of two European methods of shellfish breeding, the so called »Tarentine system« was long practiced in Croatia. It was the only suitable method for the conditions of small tidal differences in sea level (Lorini, 1903). Ston breeders modernized this practice in 1920 and first used an »I« from rods seeded with four oysters each, all resting on portable frames. This is an originally Ston breeder's method. In 1942 the breeder from Ston, Luko Maškarić also first introduced iron — concrete piers from which the ropes with oysters were suspended or the so called »pergolari«. Of several tenths of more or less successful farms of mussel (*Mytilus galloprovincialis*) and oyster (*Ostrea edulis*) on the eastern Adriatic coast during the last century, no more than 5–6 have remained with a total yield of about 3000 t of mussels a year and about 2 million pieces of oysters. The most important is the farm in the Lim Channel in Istria along with the shellfish farms near Šibenik and in Bay of Mali Ston which are relatively successful.

The farming of marine organisms has a long tradition on the eastern Adriatic coast dating back to the 19th century. Fish were reared for consumption in specially made fish ponds in the inner yards of nobleman houses which were close to the sea. Smaller fish entered the ponds whereas bigger fish were captured in the sea and put into the ponds. Lorini (1903) mentioned a figure of 116 such fish ponds on the eastern Adriatic coast, reporting on their very bad state and recommending larger number and bigger ponds to be build, particularly in the Neretva River Estuary. Similar was reported by the Tzar Fishery Commissions from Vienna which visited and inspected all the fish ponds along the coast of Austrian Illyria and Dalmatia (Valle et al., 1898). Such fish ponds may still be found in the Dubrovnik countryside. Fish were bred in these fish ponds for personal needs only.

During the fifties of this century the development of aquaculture was seriously considered having in mind that in Italian lagoons (Morović, 1951, 1956). However, such a fish culture have never been established in Croatia. Morović (1974) explained it by inappropriate geomorphology of Croatian coast, steep and relatively deep with small river estuaries.

The collection of corals and sponges has long tradition on the eastern Adriatic coast. People from Dubrovnik collected corals as in the 14th century. The trials of Oskar Schmidt, the professor of zoology at the University of Graz, Austria to culture sponges in Zlarin in Dalmatia in 1863 was the first attempt in the world. Later on in 1867, Grgur Bučić from Hvar continued with sponge culture experiments in some coves of the Hvar Island. Even though Bučić was self — educated naturalist, he was awarded a number of times by the scientists of that time. His work was highly awarded and acknowledged at the exhibitions in Graz in 1870 and Vienn 1871. Naturalist society of Paris awarded him the diploma of honour and the University of

Graz the doctorate of honour. His methods of sponge farming were later accepted all over the world, in France, on Florida in the USA, in Japan and later on the Great Barrier Coral Reef in Australia (Basioli, 1984).

Vigorous development of mariculture and the science of aquaculture all over the world were also reflected in Croatia in the seventies of this century and interest in marine fish culture. This was accompanied with the mariculture research in some laboratories and institutes. Morović (1970) recommended the extension of shellfish farming and introduction of fish culture. The author (1972) published the paper on sea bass (*Dicentrarchus labrax*) biology pointing to the possibilities of their rearing. Gamulin and Marchi (1972) reported on a successful trial of keeping amberjack (*Seriola dumerilli*) in aquaria in Dubrovnik. Bego (cit. Teskeredžić and Fijan 1977) put the first cages into Adriatic sea at Cres in 1974. Morović (1976) discussed the problem of artificial fertilization of marine fish. Teskeredžić and Fijan (1980) worked on the preparation of some marine fish for cage culture in Croatia near island Krapanj in 1976–1979. In 1977 Teskeredžić E. and Teskeredžić Z. (1979) carried out controlled spawning of white bream (*Diplodus sargus*). Vodopija (1978) reported on the results of the first trials of cage culture of sea bass and mullet in the bay Novigradsko more. Katavić (1980) reported on the induced spawning and larval culture of sea bass. During the eighties the Biological laboratory in Dubrovnik began the studies of live food rearing (phytoplankton and zooplankton) for food of larvae and postlarvae of marine fish. Skaramuca and Bolotin (1983) established semi — continuous phytoplankton cultures of phytoplankton (*Phaeodactylum tricornutum*) and zooplankton (*Brachionus plicatilis*) and Bohač and Medaković (1983) published a paper on the own modified method of rotifer culture as food for sea bass.

Like in other Mediterranean countries (Italy, France, Spain) hatcheries were built for spawning of sea bass and gilthead sea bream (*Sparus aurata*). Building of the first commercial hatchery in Nin near Zadar in 1982 provided potentials for intensive commercial culture of sea bass. With its capacity of 2.5 million pieces hatchery production contributed on fifth to the total Mediterranean production of sea bass fingerling. The floating cage culture of fish began at the same time. Later a number of smaller hatcheries were built in Rovinj, Split, Sućuraj on Hvar Island, Drače on Pelješac Peninsula and small experimental one in Dubrovnik.

Experiments of introduction of new fish species in aquaculture of Croatia followed the building of experimental hatcheries. Teskeredžić E. (1981) made trials to culture atlantic salmon (*Salmo salar*) in the estuary of Krka River near Šibenik and amago salmon (*Oncorhynchus masou rhodurus*) in 1984 (Teskeredžić E. and Teskeredžić Z., 1990). Glamuzina et al. (1989) worked experimentally on the dog's teeth (*Dentex dentex*). However nothing went further than the experimental level with the exception of sea bass and gilthead sea bream culture of which has developed like in other

Mediterranean countries. Very successful results were obtained with the experiments, and later on with commercial production of rainbow trout (*Oncorhynchus mykiss*) which grows 4–10 time faster in the sea than in the freshwater (Teskeredžić et al., 1989). During the period 1982–1991 the experimental production of coho salmon (*Oncorhynchus kisutch*) in the seawater became the commercial one (Teskeredžić et al., 1989).

Studies and rearing of live food for juvenile fish stages kept pace with the development and modernization of techniques and technology of fish farming. Katavić et al. (1985) reported the results of biochemical analysis of brine shrimp *Artemia salina* as affected by the food they were fed during rearing. These studies were particularly intensified in the Laboratory in Dubrovnik. Sanko and Skaramuca (1986) studied the effects of salinity and food on the growth of the population of rotifer (*Brachionus plicatilis*) and Carić et al. (1989, 1990, 1993) the effects of different feeds on biochemical structure of rotifers. Skaramuca (1994) made a significant contribution to the solution on the problem of amitosis and mitosis of rotifers and effects of some abiotic factors by constructing an aeration system of the entire bottom of culture tanks of faster production of higher quality food.

Even though the sea bass and gilthead sea bream farming as well as live food rearing have almost reached the level of industrial production the quantities produced are still below the satisfactory level. In 1994 about twenty fish farms yielded about 1000 tons of high quality fish. Compared to other Mediterranean countries the contribution made by aquaculture is still insufficient with respect to marvelous natural resources for mariculture provided by the Adriatic coastline and with respect to market requirements. To tell the truth there has been more interest recently in an intensive marine fish farming both by home and foreign private enterprises. This is no doubt due to still ecologically preserved Adriatic Sea and hydrographic properties particularly of its central and southern parts.

PERSPECTIVES

All the available data point to the exceptional natural resources for culture of both sea bass and gilthead sea bream and other marine fish species provided by the central and southern Adriatic coastline. This particularly applies to temperature, an essential factor for culture and growth. The results seasonal studies of hydrography of the entire open Adriatic by the r/v ANDRIJA MOHOROVIĆIĆ in 1974–1976 showed that from bottom to surface temperature never below 13 °C (Vučak et al., 1982), neither in the southern nor in the central part of eastern Adriatic. This provides quite normal conditions for fish feeding throughout the year. Parallel three-month studies of subadult sea bass growth rate in farms in Bay of Mali Ston (Near Dubrovnik) showed that these fish grew considerably faster and that their culture takes less time than in the farms near Zadar (Kožul, 1990).

Long tradition of shellfish and fish breeding, and particularly a growing fund of knowledge recently provided a mariculture development at a growing pace. The eastern Adriatic coast with a number of bays, coves and channels protected from wind and waves by chains of islands provide marvelous conditions for intensive farming on floating platforms (Katavić and Skaramuca, 1989). New, modern technology makes possible the farming out of the bays, coves and channels in semienclosed areas particularly around island. This will facilitate the solution of ecological problems encountered in mariculture. It would be difficult to plan any definite quantity of tons of fish to be produced since it will depend on the market requirements and interests of the investors.

Already mentioned favourable natural resources of, particularly, southern and central Adriatic for mariculture justify not only the already existing intensive farming of sea bass and gilthead sea bream but also the introduction of some new species in Croatian mariculture. At the present stage of a new national concept of development of the so called industrial mariculture all the potentials should be taken in to considerations, from the tradition, long experience and the fund of knowledge to geomorphological and physical characteristics of the eastern Adriatic and the possibility of introduction of some new species for which existing conditions are quite suitable. Most cultured fish in Japan, *Seriola quinqueradiata*, the production of which 250,000 tons per year, is a relative of our amberjack (*Seriola dumerili*) successfully kept under aquarium conditions in Dubrovnik for years. The distribution and main natural habitats of this species in the Adriatic (Grubišić, 1988) coincide with the 13 °C isotherm. The first trials to rear this fish during the seventies (Gamulin and Marchi, 1972) have not been continued, since at that time there was no interest and the experience and fund of knowledge of mariculture were minor.

Recent research of the possibilities of amberjack farming at the Laboratory in Dubrovnik have not yet passed the phase of capture of natural fingerlings at the stage of »ŽUTEJ«, of 2 to 3 months and 200 g average weight. However they have shown good adaptability to pond culture, food consumption and rapid growth, on the average 300 gr over 7 months.

Extensive fundamental studies of artificial controlled spawning and larval and postlarval survival of this fish species will show the possibilities and perspectives of its farming.

Catch of subadult specimens of this species for the past years shows that its stock has considerably increased in the southern Adriatic for the past years. Experiments on the hatching of the dusky grouper (*Epinephelus marginatus*) were carried out in the middle and southern part of the Adriatic sea. Apart from this species recent years have seen the landings of considerable quantities of lampuga (*Coryphaena hippurus*) experimentally cultured in Hawaii. Both these species are pelagic or epibenthic that is they inhabit deep open waters which will require special conditions of maintenance and conditioning

of brood stocks as well as creation of other conditions for their successful controlled spawning and growth.

CONCLUSIONS

— Fishing and culture of edible and non-edible marine organisms have long tradition in Croatia — on the eastern side of the Adriatic Sea.

— Shellfish were collected for human consumption as early as in the Roman age.

— Croatians (in Bay of Mali Ston) contributed to the modernization of shellfish breeding.

— Corals were collected in the area of Dubrovnik as in the 14th century.

— The trials of sponge breeding in the Adriatic Sea were first in the world. Grgur Bučić from Hvar developed sponge breeding technique which was applied worldwide.

— Fish farming began in Croatia in 19th century.

— During the eighties of this century the science of mariculture kept pace with that in other European countries but the quantities of produced fish were far below the satisfactory level due to the lack of initiatives and investments.

— Present fund of knowledge and equipment of scientific institutions along with the interests of investors justify the extension of fish farming of already cultured fish as well as the introduction of some new species.

— Sea water temperature, particularly in the southern and central Adriatic point to the fact that amberjack (*Seriola dumerilli*), dusky grouper (*Epinephelus marginatus*) and lampuga (*Coriphaena hypurus*) could be of interest for Croatian mariculture. Initial laboratory studies of amberjack farming confirm these assumptions.

Sažetak

MARIKULTURA U HRVATSKOJ, POVIJEST I PERSPEKTIVE

Hrvatska je zemlja u kojoj se more kao izvor hrane iskorištavalo prije tisuću godina. Tradicija sakupljanja i uzgoja morskih organizama vrlo je duga duž jadranske obale. Uzgoj morskih organizama ima u tim krajevima dugu tradiciju, koja datira još iz 19. stoljeća. Lorini (1903.) spominje 116 takvih ribnjaka na istočnoj obali Jadranskog mora. Znanje stečeno dugogodišnjim radom na mriješćenju, a napose uzgoju školjkaša i riba, omogućilo je razvoj marikulture u sadašnjemu stanju. Istočna obala Jadranskog mora s brojnim zaljevima, uvalama i kanalima izvrsno je mjesto za intenzivan uzgoj morskih

organizama, budući da su naši otoci povezani tako da ih štite od udara valova i vjetrova.

Ključne riječi: marikultura, povijesni razvoj, perspektive

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