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MARICULTURE IN ISRAEL

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Israel is a long narrow country occupying 180 km of the eastern shore of the Mediterranean and 12 km of the shore of the Gulf of Aqaba/Eilat, Red Sea. More than half of the country, the southern half, is desert and receives less than 200 mm of rain annually. Therefore, the country suffers from a chronic shortage of fresh water and it is not surprising that governmental agencies encourage the development of food production systems using sea water. Governmental activities began in the early 1970s with the establishment of the National Center for Mariculture (NCM) in Eilat, as part of the Israel Oceanographic and Limnological Research Institution (IOLR).

Research focused on the gilthead seabream, *Sparus aurata,* mainly because of its high price on markets in Israel and Europe and the availability of fingerlings in nature. The assumption was that a species with such economic value would return the high R&D investment needed to domesticate a wild fish. It took a few years before the concepts and functions of the NCM were established. In the early 1980s, the Institute moved to its permanent campus with facilities and personnel that allowed interdisciplinary and elaborated R&D. The new campus is located 600 meters north of the edge of Gulf of Eilat, near the Israeli-Jordanian border. The NCM operates eleven scientific departments: reproduction control of finfish, larviculture, physiology, food chain, nutrition, disease control, genetics, mollusk culture, water quality macro-alga and biofilters, mariculture production systems, and mariculture and the environment. The NCM is an interdisciplinary institute that generates synergism among scientific disciplines (departments).

Commercial mariculture in Israel started in the early 1990s with the establishment of a commercial hatchery and a cage farm in the Gulf of Eilat. Earlier attempts to use conventional extensive fishponds on the Mediterranean coast, to grow shrimps and fish, were unsuccessful mainly because the very energetic sea-land interactions (high waves, suspended sand, etc.) made it difficult to supply fresh sea water to the ponds. Now, three major cage farms provide the bulk of Israel's mariculture production, two in Eilat that produce over 2000 tons of fish annually and one just inside the main breakwater of the port of Ashdod on the Mediterranean coast that produced about 500 tons in 2003. Seabream represents 90% of the production; seabass, red drum and striped bass constitute the remaining 10%.

There are three marine hatcheries in Israel, one in Eilat and two on the Mediterranean coast. The total production capacity in the early 2000s was around 12 million fingerlings per year. However, production does not meet demand. Therefore, a couple of million fingerlings are imported from Cyprus and Greece almost every year. All three hatcheries produce seabream fingerlings and

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each specializes in one or two of the other marine species.

Farmers are continuously seeking new species to produce to satisfy market demand and generate export options. The natural export market for Israeli products is Europe, however, the Israeli farmer has a disadvantage due to customs and airfreight to Europe. Therefore one of the challenges to the Israeli R&D establishment is finding new species with which the Israeli farmer can better compete on the European market.

Because mariculture activity in the Gulf of Eilat is limited by environmental constraints and because of the need to produce more mariculture products for local and export markets, mariculture R&D is pursuing three major directions:

1. Offshore farms in the Mediterranean Sea. Several technological approaches were tried in the past but none was economically viable due to the high-energy state of the sea in winter along the Israeli Mediterranean coast. Long and high waves required locating the farms in deep waters, far from the shoreline. Such locations increase production costs and are hard to protect against poachers. Successful technology will have to find a way to avoid the storm by submerging the farm beneath the high-energy zone or by making the cages able to withstand the wave energy and ocean currents (e.g., by using a large mesh which is suitable only for large fish such as the bluefin tuna). Offshore fish farming is presently considered a high-risk enterprise, requiring entrepreneurs with a strong economic basis and substantial governmental help (at least for the first few farms). If such technology is at all possible, then the production potential may be immense.

2. Land-based seawater culture systems. As a result of competition for available land near the shore and the difficulties in transporting sea water to land-based facilities, future technology will have to be intensive. Intensive mariculture must compete with production costs in conventional cage technology practiced elsewhere in the Mediterranean (Greece, Turkey, Spain, etc.). Among other themes presented at the 7th Annual Dan Popper Symposium of the NCM in Eilat in May 2003, the importance of this topic was strongly sensed. Experimental recirculating aquaculture systems (RAS) have shown that seabream can be grown at a very high density with acceptable oxidation of toxic ammonia/ammonium to nitrate, removal of solids (mainly feces) and water use (less than 4 m^3 per kg fish). In the future, such systems will be improved by reduction of nitrate to N_2 through anaerobic processes and polishing nutrients from water returning to the sea by macro-algal culture. By increasing the yield and efficiency (FCR, energy, removal of pollutants, etc.), the profitability of the RAS will improve, making them economically viable. Coupling land-based mariculture systems to power station effluents has two advantages: effluents from power stations are relatively easy and inexpensive to pump; power station effluents are several degrees warmer than ambient waters in the winter, allowing fish to continue growing throughout the cold season and reach market size more quickly.

3. Integrated mariculture systems. In this system, water cascades from crop to crop, carrying nutrients from one step to the next. However, this very environmentally friendly technology has not yet been proven economical for growing finfish. One such system in Israel is located a few hundred meters from the Mediterranean. Its main product is abalone; micro-algae and finfish are by-products. The macro-algae utilize the nutrients produced by the abalone and fish and serve as food for the abalone. The system is perfect but, were it not for the abalone, it would not be economically viable. Hopefully, in the future, macro-algae will be engineered to produce high value bio-active compounds such as pigments, drugs and antibiotics for use as food additives or in the pharmaceutical industry.

Israel's mariculture R&D is also busy improving technology. Continued technological development will allow the Israeli farmer to keep a competitive edge on the market. A few examples to illustrate this point:

a. Monosex or sterile populations. The European seabass, *Dicentrarchus labrax*, and the gray mullet, *Mugil cephalus*, are important species in Israeli aquaculture. In both species, the female reaches market size much faster than the male. Current research is directed at producing all-female populations or sterile fish that will be able to spend more energy on growth and less on reproduction. Such work involves genetic selection or blocking sexual development by genetic or hormonal manipulation.

b. New species. Development of new mariculture species such as grouper and bluefin tuna. The grouper appears to adjust very well to pond culture conditions at a very high biomass density. The tuna seems very suitable to open sea pen culture in large-mesh cages that are unaffected by the energy of waves and currents. The culture of new species will create new market opportunities for Israeli farmers and allow high scale production.

c. Feed. Feed is one of the most expensive production costs in mariculture. There is an increasing worldwide shortage of fishmeal, the main protein source in artificial fish feed. Most cultured species are predatory and require a high level of protein in their diets which, in turn, increases the amount of polluting nutrients secreted by the fish to the environment. Efforts to identify plant substitutes for fishmeal have already yielded promising results. We believe that, in the near future, plant meals such as soy, rapeseed and wheat will be incorporated (after industrial processing) into fish feeds in large quantities.

d. Disease control. Disease control in intensive culture is crucial due to the very high fish density in the farming unit. In the RAS, where the standing fish biomass can reach 70-100 kg/m^3, a disease can cause immense damage if not prevented or controlled. Aquaculture loses up to 30% of its crops due to disease. Hence, enormous research efforts are being directed towards studying disease vectors and developing preventive methods and cures. We believe that even greater efforts on a national level will have to be spent on disease control.

e. Molecular biology. We believe that molecular biology will increasingly be used to improve our understanding of the organisms we culture and produce new products such as bio-active compounds, sterile fish, monosex fish, feed ingredients, etc. Molecular biology is a powerful tool that should be employed in the service of aquaculture.

Given adequate resources and under proper direction, Israel has a good chance of developing its mariculture industry. In less than a decade, Israel's mariculture grew from nonexistent to over 3000 tons. Now, as the production level in the Gulf of Eilat has reached its maximum due to environmental constraints, Israeli mariculture must move to the next phase of technology: offshore farms and land-based culture systems. If successful, total production may reach 10,000 tons in five to seven years.