

# Mariculture

By Dr. David Secor

## Summary

Mariculture refers to the cultivation of food organisms in coastal or open ocean environments. Relics of ancient coastal ponds and corrals persist from Mediterranean and Hawaiian civilizations, which were originally designed to retain prized species year-round (Kikuchi 1976). During the recent 40 years, technological innovations, intensive coastal development, and seafood demand have fueled geometric growth of mariculture. In 2005, mariculture yield was 19 million tons, world-wide compared to 84 million tons from wild capture fisheries (FAO 2007). Some view aquaculture as an enterprise that will overtake wild capture fisheries providing benefits for food security and employment (Bardach 1997). Mariculture can be extremely effective in supplying lucrative markets with dependable quality seafood. Cultured Atlantic salmon, Japanese eel, and white sturgeon dwarf historical peak fishery yields for these species (Logan et al. 1995; Heinsbroek 2008). On the other hand, critical limits to mariculture include its dependence upon capture fisheries for feed, its reliance on wild juveniles or hatcheries for “seed,” self-pollution, and disease and health risks to ecosystems and human consumers (Panchang et al. 1997; Naylor et al. 2001). In societies without traditional sea-tenure systems, important socio-economic constraints and conflicts can occur related to the procurement and enforcement of sea-tenure rights (Kalland 1994; DeVoe 2000). Interestingly, one of the fastest growing mariculture industries – captive rearing of tunas and other migratory fishes is a return to the historical impetus for mariculture – retaining high value species to control market supply (Lovatelli and Holthus 2008). Most bluefin tuna sold worldwide now originates from huge cage-holding operations in the Mediterranean Sea.

Mariculture can compromise coastal ecosystem services, particularly when practiced intensively (Naylor et al. 2001). For instance, coastal impoundments built for shrimp farms in Southeast Asia and Central America have resulted in destruction of many thousands of hectares of mangrove forests and salt marshes (Paez-Osuna 2001). High density cage culture operations in poorly flushed coastal areas have resulted in severe episodes of hypoxia, harmful algal blooms and disease transmission to wild fish (Rosenthal 1985). Mariculture consumes a substantial fraction of the world’s harvest, particularly the high yield fisheries for small pelagic fishes such as sardines, menhaden, and herrings (c. 24 million tons in 2006; Tacon and Metian 2009). Such demand could potentially deplete forage species, which play a key role in coastal foodwebs (Cury et al. 2000).

Hatchery enhancement programs developed well over 100 years ago as part of European and North American strategies to offset possible effects of overfishing. Indeed, the first marine laboratory at Woods Hole and the American Fisheries Societies were originally established around this premise (Smith 1994). Hatchery enhancement, or sea ranching, persists

as a strategy today despite its high costs and limited evidence that this is an effective strategy (Secor et al. 2000; 2002; Naish et al. 2008). Indeed, substantial research now shows hatcheries can negatively influence wild stocks (Naish et al. 2008). On the other hand, hatcheries have proven effective in support of fisheries research and assessment and in programs of habitat restoration (e.g., Coen and Luckenbach 2000). Additionally for endangered coastal species, artificial propagation is often viewed as central to conservation efforts (NRC 2004).

### References Cited

- Bardach, J.E. 1997. Sustainable Aquaculture. John Wiley and Sons. 251 pp.
- Coen L.D., and M.W. Luckenbach. 2000. [Developing success criteria and goals for evaluating oyster reef restoration: Ecological function or resource exploitation?](#) Ecological Engineering 15:323-343
- Curry, P., A. Bakun, R.J.M. Crawford, A. Jarre, R.A. Quinones, L.J.L. Shannon and H.M. Verheye. 2000. [Small pelagics in upwelling systems: patterns of interactions and structural changes in “wasp-waist” ecosystems.](#) ICES Journal of Marine Science 57:603-618.
- DeVoe., M.R. 2000. [Marine aquaculture in the United States: A review of current and future policy and management challenges.](#) Marine Technology Society Journal 34:5-17.
- FAO 2007. [The State of World Fisheries and Aquaculture. Fisheries and Aquaculture: 2006.](#) Department, Food and Agriculture Organization of the United Nations. Rome. 180 pp.
- Heinsbroek, L.T.N. 2008. [A review of eel culture in Japan and Europe.](#) Aquaculture Research 22:57-72.
- Kalland, A. 1984. [Sea tenure in Tokugawa Japan: the case of Fukuoka Domain.](#) Senri Ethnological Studies 17:11-45.
- Kikuchi, W.K. 1976. [Prehistoric Hawaiian fishponds.](#) Science 193:295-299.
- Logan, S.H., W.E. Johnston, and S.I. Doroshov. 1995. [Economics of joint production of sturgeon \(\*Acipenser transmontanus\* Richardson\) and roe for caviar.](#) Aquaculture 130:299-316.
- Lovatelli, A. and P.F. Holthus. 2008. Capture-based aquaculture. FAO Fisheries Technical Paper No. 508. Department, Food and Agriculture Organization of the United Nations. Rome. 314 pp.
- Naish K.A., J.E., P.S. Levin, T.P. Quinn, J.R. Winton, D. Huppert, R. Hilborn. 2008. [An evaluation of the effects of conservation and fishery enhancement hatcheries on wild populations of salmon.](#) Advances in Marine Biology 53:61-194.
- National Research Council (NRC) 2004. Atlantic salmon in Maine. National Academy Press, Washington, DC. 275 pp.
- Naylor, R. L., R.J. Goldberg, J. Primavera, N. Kautsky, M.C. Beveridge, J. Clay, C. Folke, J. Lubchenco, H. Mooney, M. Troell. 2001. [Effects of Aquaculture on World Fish Supplies.](#) Issues in Ecology. Volume 8. Ecological Society of America. 12 pp.

- Paez-Osuna, F. 2001. [The environmental impact of shrimp aquaculture: Causes, effects, and mitigating alternatives.](#) Environmental Management 28:131-140.
- Panchang V., G. Cheng, and C. Newell. 1997. [Modeling hydrodynamics and aquaculture waste transport in coastal Maine.](#) Estuaries 20:14-41
- Rosenthal, H. 1985. [Constraints and perspectives in aquaculture development.](#) GeoJournal 10:305-324.
- Secor, D. H., V. Arefjev, A. Nikolaev and A. Sharov. 2000. [Restoration of sturgeons: lessons from the Caspian Sea Sturgeon Ranching Program.](#) Fish and Fisheries 1:215-230.
- Secor, D.H., A.H. Hines, and A.R. Place. 2002. [Japanese Hatchery-based Stock Enhancement: Lessons for the Chesapeake Bay Blue Crab.](#) MD Sea Grant Report UM-SG-TS-2002-02. College Park, MD. 44pp.
- Smith, T.D. 1994. [Scaling Fisheries, the science of measuring the effects of fishing, 1855-1955.](#) Cambridge University Press. Cambridge, England. 392 pp.
- Tacon, A.G.J. and M. Metian. 2009. [Fishing for aquaculture: non-food use of small pelagic forage fish – a global perspective.](#) Reviews in Fisheries Science 17:305-317.

### **Web Resources**

FAO 2007. The State of World Fisheries and Aquaculture. Fisheries and Aquaculture: 2006.

<http://www.fao.org/docrep/009/a0699e/A0699E00.HTM>

Lovatelli, A. and P.F. Holthus. 2008. Capture-based aquaculture. FAO Fisheries Technical Paper No. 508.

<http://www.fao.org/docrep/011/i0254e/i0254e00.htm>

NOAA 10-year Plan for Marine Aquaculture. 2007.

<http://aquaculture.noaa.gov/pdf/finalnoaa10yrrweb.pdf>

Effects of Aquaculture on World Fish Supplies. Issues in Ecology, Ecological Society of America

[http://www.esa.org/science\\_resources/issues/FileEnglish/issue8.pdf](http://www.esa.org/science_resources/issues/FileEnglish/issue8.pdf)

## Image Gallery



Production of juvenile red sea bream at Japanese Fisheries Seed Production Center, Nagasaki



Commercial red sea bream cage culture in Kagoshima Prefecture, Japan



Bluefin tuna pens in Italy (courtesy J. Rooker, TX A&M, Galveston)