OPEN OCEAN AQUACULTURE IN HAWAII

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For the past four years, the University of Hawaii and the Oceanic Institute have been engaged in research into the feasibility and environmental acceptability of Open Ocean Aquaculture in Hawaii. I would like to convey to your readers some results from that research.

News magazines and newspapers have recently published a series of articles that imply that aquaculture has deleterious consequences on the environment. Indeed, like all things, adverse interactions can occur and have been documented in some parts of the world where over-development, or development without adequate understanding of the environmental consequences, has had negative impacts. This was the reason that environmental monitoring was made a part of Sea Grant's support for our Hawaii Open-Ocean Aquaculture Demonstration Program (HOARP) that was begun 4 years ago.

The initial goals of HOARP were (1) to learn whether or not open ocean aquaculture could be done in Hawaii, (2) if it was feasible, to ask whether the technology was mature enough to warrant the investment in time and effort to develop a farm, and (3) to determine whether the associated environmental impacts to the seafloor, surrounding water, and other nearby elements such as reefs were sufficiently small to be acceptable to the people of Hawaii. We learned that, indeed, it was feasible to grow a local fish in offshore cages, that the technology was mature enough to withstand the rigors of our rough offshore waters, and that the environmental impact was virtually nil. I will elaborate on each of these elements of our work in the paragraphs that follow.

After examining several sites, we chose to do our work at a site about 2 miles off Ewa Beach on Oahu. It was not that this was necessarily the best site, but it was out of the main shipping lanes, it was an adequate one with a sandy bottom where we could deploy anchors, and it was one that was accessible on a daily basis from the University of Hawaii's marine support base in Honolulu harbor. The Oceanic Institute and the UH entered into agreements to pursue the work in the fall of 1998 and research permits from the State were requested and received. We ordered an OceanSpar 3000 cage, a fully submersible cage built by a firm in the Seattle area, in the fall of 1998 and began growing some 90,000 fingerlings at the OI facility in Waimanalo in February 1999. The cage was assembled and deployed in March and by the end of April we had some 50,000 to 70,000 fingerlings in the cage. We began harvesting the moi in the cage in September 1999 and continued until the end of October when the cage was empty (approximately 50,000 fish were harvested). Throughout the 8-month effort, we made observations of the seafloor, sampled the water around the cage, and monitored the health of the nearby reef (about _ mile away). We saw nothing! No change at all.

We decided we must have done something wrong so we repeated the experiment at the same site in 2000, but this time we put twice as many fish in the cage and doubled our monitoring effort. This work was done by a grant from NOAA to the Oceanic Institute. Careful monitoring of the seafloor beneath the cage showed a small change in the abundance of some infauna organisms in the sediments but this returned to normal as soon as the experiment ended. Clearly, some of the critters living there took advantage of the extra food provided by our feeding of the fish in the cage. There was no significant change as the media has so often reported as having occurred beneath salmon pens and with projects developed during the startup of the industry sector in Europe and the Mediterranean areas.

Water quality outside the cage was likewise preserved. We did observe increased ammonium concentrations just outside the cage rim (maximum values of about 70 parts per billion, ppb), but these rapidly decreased downstream of the cage to background values of about 2 ppb at distances of 100 to 300 feet. Feed was also monitored more carefully and we learned that two feedings a day was better than one because the fish grew faster and there was less waste – normally none because we fed the fish the same amount of feed but in two feedings of about half of the satiation ration each time.

Thus the second experiment verified that we had not made a mistake the first time. Indeed, there was no measurable impact once one was a few hundred feet from the cage. How can this be so when the media has reported so many problems? The answer comes from three directions. First, we controlled our rate of feeding so very little, if any, of the food reached the seafloor. Second, we were located in offshore waters where there is adequate current – about 0.2 knots average – is present to carry waste products away from the site. It should be noted that at a current of 0.1 knot more than 217 million gallons of water flow through the cage each day. Thirdly, we are in warm tropical waters where rates of reaction and metabolism are likely to be faster than in colder climates. Thus, our conclusions, based upon good experimental science using a local species, moi, concluded that open ocean aquaculture was a benign activity, appropriate for Hawaii, if good management practices were used. We communicated this in journal articles, abstracts, and reports to the funding agencies and to the Hawaii Department of Land and Natural Resources, Hawaii Department of Agriculture, and the Hawaii Department of Health. We also communicated it to the public via TV and a front-page article in the Honolulu Advertiser.

That would have been the end of our academic pursuit, except for the fact that the company that had been feeding the cage every day decided to apply for a lease and go into the offshore aquaculture farming business. That firm is Cates International Inc (CII). Arrangements were made with CII to continue the benthic assemblage and water quality monitoring studies to see what the long-term impact of a higher density culture would be. Thus, the UH monitoring effort, using their farm as the source of the nutrients to the environment, continues to this day.

The farm currently consists of two cages, with a third to be deployed soon. There are now about 300,000 fish on the site most of the time with a daily feed ration of up to 3000 pounds. We continue to monitor the sea floor on a quarterly basis, and we take a monthly sample of the water downstream of the cage out to the Department of Health approved NPDES zone of mixing boundary (3,000 feet from the cages). The studies of the benthic biota have shown increases in the abundance of some organisms immediately beneath the cage (water depth 120 feet) but virtually no change in the overall assemblage characteristics. Clearly, some species are more opportunistic than others and these are taking advantage of the extra food supply that the cage is providing. So far, after more than a year of continuous operation by CII, following the two years of episodic operation by UH and OI, there is no evidence of anaerobic sediments or even of any food accumulation beneath the cages.

The water column measurements show an equally null result. We can occasionally observe elevated (above 3.5 parts per billion) ammonium downstream of the cage to distances of 200 to 400 feet but we have observed no unusual changes in plankton or bacteria abundance. Chlorophyll-a and turbidly remain at background levels. Nutrients such as phosphorous, silica, nitrate and total nitrogen show no systematic change even at sites very near the cage. For the past sixteen months we have recorded no samples (out of more than 370 taken) that have exceeded the Department of Health's allowed limit at the zone of mixing boundary. Even within the zone of mixing most samples are within the water quality standards and only 7 are above 8.5 ppb ammonium limit that applies to the zone of mixing boundary. Five of these samples are 'effluent samples' taken adjacent to the cage and the others are on the streamline just downstream of the cage.

I believe I should comment about several of the other statements that are often made by aquaculture detractors. The first is genetics. We use wild caught fish, and their first generation offspring, as the broodstock in the hatchery. These are the same fish being used for stock enhancement efforts. Managed in this way, there can be no adverse genetic interaction with the wild fish, even if fish were to get loose.

Second, it is often said that aquaculture is damaging to the environment. I have discussed this above and we have shown that it is not the case. There is also the often voiced concern about fish feces washing up on shore. But this cannot happen for the feces is very fluid, consists of small particles, and is quickly dispersed in the environment and we have not identified any in our water quality samples. Moreover, the waters around the cage now have hundreds of fish in residence. The cage provides habitat in an otherwise pelagic desert realm, a place where no fish were observed during our initial site surveys. I must emphasize that the majority of these fish are pelagic or semi-pelagic fish, not reef fish. Thus one could even say that our cage has had a beneficial impact on the environment.

Third, it is said that we are just feeding fish to fish because our feed for the fish comes from fishmeal. This of course, is true – but only partially so. Our feed is 50 percent protein. Half of that protein comes from fishmeal and half from soybeans or other protein-rich plant material. So yes, we are using fishmeal to grow fish but that same fishmeal, produced from anchovies, sardines, menhaden, krill, and various fish byproduct sources including some by-catch, would otherwise go to producing feed for poultry or swine. These two other meats are the two largest industrial consumers of fishmeal. It takes 1.3 to 1.8 pounds of dry pellets to produce a pound of fish. It takes 3.5 pounds of comparable protein-rich feed to produce a pound of chicken and even more to produce a pound of pork. Thus, the feeding of fishmeal to fish, particularly when half is plant protein, is a far more efficient use of a wild caught fish resource than feeding it to chickens, swine, or cattle. Cattle even get more fishmeal than fish in the US and in this case it takes 7 pounds of protein to produce 1 pound of cow!

Fourth, aquaculture is a far more efficient utilization of the food web than is fishing. To produce a pound of wild caught tuna it is estimated that ten pounds of smaller fish are eaten. Each pound of these small fish have consumed 10 pounds of smaller fish or zooplankton before being eaten by the tuna. And the zooplankton has consumed comparable amounts of algae or other plankton during their short life. Thus for a pound of wild caught tuna, more than 100 pounds of biomass (probably even more) has been consumed. If that same pound of tuna were to have been grown by aquaculture methods, only a tenth as much primary production would have been consumed.

Fishing, particularly trawl fishing, is probably the most damaging activity currently going on in the ocean. We harvest the large fish, thereby removing the broodstock from the ocean. We target some species and not others, thereby totally upsetting the balance of the ecosystem. We catch unwanted fish and return them (dead or dying most of the time) to the ocean. Fishing has been documented to be responsible for major ecosystem problems for whole ecological provinces. Yet aquaculture is being criticized as being environmentally damaging rather than fishing. Aquaculture, properly done, is far better way to supply marine protein to the table and should be encouraged to preserve a healthy ecosystem in the ocean.

Finally, a comment needs to be made about economics. The declining wild fisheries catch requires that we seek solutions that provide marine protein from acceptable alternatives. Marine aquaculture is clearly one of these alternatives. Perhaps one needs to look at offshore cage culture as an economic alternative to fishing where fishermen, when they are not fishing, can nurture fish stocks in a cage. The value added by increasing the fat content of a wild caught fish is substantial and this is why the tuna project has targeted supplying a Japanese market, rather than a local one that seems adequately supplied by wild caught tuna. Moreover, creation of an offshore aquaculture industry could lead to diversification of Hawaii's economy and perhaps even lead to a greater opportunity for export of Hawaii fishery products. But it must be remembered that offshore aquaculture requires substantial investment in cages, vessels, and food and that it also entails substantial risk. Thus, an opportunity for economic gain or profit for the aquaculturist must be considered along with the responsibility for minimizing environmental and societal impacts.