Introduction

Open Ocean Aquaculture Conference Summary, Commentary, and Thoughts for the Future

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Summary

The transition to a sustainable global economy that has minimal impact on the global environment is a major challenge for all governments. Adequate food production is a crucial component in this endeavor. Developments in land agriculture have produced enormous gains in food production per unit area in the past five decades. However, this growth cannot be maintained into the future for production is now essentially limited by availability of suitable land and water.

Consequently, we must turn to the sea for our future additions to the food supply. Recent evidence of severe stress in many fisheries suggests that they already are being exploited at or beyond their sustainable capacity. Therefore, we must now apply agricultural practices learned on land to the utilization of the ocean. Cultivation, through open ocean aquaculture rather than simply continuing to harvest wild stocks, appears to be the way of the future.

Great strides have been made in the technology of marine aquaculture in the past decade. It is now possible to produce many species of fish in intensive culture systems at costs that are comparable to, or substantially below, those necessary for the harvesting of wild stocks. The Second International Open Ocean Aquaculture Conference, held on Maui, Hawaii, from which the papers for this volume are derived, addressed a number of key issues that need to be resolved before our move to fully utilize the oceans can take place. This paper, and those following in this volume, are a summary of some of the key issues addressed during the conference.

Introduction

Many fisheries have declined precipitously over the last 20 years. Japan's reported catches from their marine fisheries conducted around the world have declined more than 30% in the last 10 years (MAFF, 1995). In the northeast United States the National Marine Fisheries Service has systematically documented a downward trend in the size of many populations of the principal groundfish species over the last 30 years (NMFS, 1993). In response to these alarming declines, fishery managers have implemented strategies from restricting fishing efforts to outright closure of major fisheries and fishing grounds (e.g., Georges Bank). Although the long-term result of these measures should be recovery of some stocks, many fisheries may never attain their former levels of yield or, at best, will take many years to do so.

As international and domestic fishery landings are declining, demand for fishery products is increasing. In the United States consumption of seafood is about 15 pounds per person per year and, in Hawaii, with the highest per capita consumption of seafood in the country, it is today more than 45 pounds per person per year. The Hawaiian situation is extreme in another way, for despite our mid-ocean location, more than 75% of this seafood being imported. The net result in Hawaii and the rest of the U.S. is a situation of increasing demand coupled with decreasing supply of seafood. Without some positive action the ultimate result will be (1) further imbalance in trade deficits, (2) a loss in economic opportunities for commercial harvesters and processors, (3) a decline in the traditional lifestyles that are central to many fisheries, and (4) declines in the abundance of target species leading to shifts in species dominance with largely unknown ecological impacts.

Economically and ecologically we must reverse these trends. This can only be accomplished by a concerted effort to remove impediments, both social and scientific, to the rapid development of marine aquaculture activities.

Despite the imposition of stringent management regimes in many fisheries, it is conceivable that the necessary level of production to satisfy demand may never again be achieved from only the wild stocks of fishes, even with a substantial recovery of the resource. This is in part due to the little known fact that 98% of the wild catch comes from only 2% of the ocean. Why then can we not expand the area fished?

Wild stock fisheries are present only where there is adequate primary production to support the food chain in sufficient quantity to make the fishery economically feasible. Most of the ocean is oligotrophic, meaning that it is nearly saturated in dissolved oxygen and has inadequate nutrients to support abundant photosynthesis or primary production. With this in mind, one can immediately see how to make these watery deserts bloom, i.e. supply the necessary nutrients. This of course can be done, but maintaining applied nutrients in place in the upper ocean, in a high enough concentration for a time long enough to produce an end product, is a problem that as yet has no solution. Thus, the next best way to make the oceanic desert bloom is to provide the food and use the space in the oceanic desert to extract the other vital ingredient to fish culture, namely, oxygen. This is the focus of virtually all open ocean aquaculture endeavors currently envisaged.

Why haven't these technologies received more attention and been more successful? Among the problems are (1) a stifling regulatory environment which curtails mariculture and stock enhancement development in territorial seas, (2) a lack of commitment of financial resources to address the technical questions that must be resolved, and (3) the perception of many policy makers that when the economics are right, the technology will be developed by private industry. In the interim, while we wait, the wild-stock resources continue to decline.

The time is ripe for a global effort to spur the development of new aquacultural technologies which will address declining wild stock fisheries as well as increase the world's food supply. Because declining resource abundance translates into declining sustainability, an immediate effort must be made to include research and technology development, demonstration of economic viability by operation of prototype facilities, and technology transfer to the new generation of ocean farmers.

Summary of Conference

All of the above issues were covered at the Second International Conference on Open Ocean Aquaculture and papers that address many of these issues are presented in this volume. Several presentations focused on key policy issues and the papers by De Alessi, McVey, Corbin, Hayden, Curran, and Young focus on a number of policy topics, such as water tenure, rights of access, and associated regulatory issues.

Other presenters focused on the technology of cage and longline systems that are needed to assure performance of various cage and longline culture systems for both finfish and shellfish under open ocean conditions. Most of the ideas offered by these presentations are given in the papers by Chambers, Condron, Gignoux, Loverich, Merino, Petrusevics, and Savage.

Examples of successes of aquaculture efforts in nearshore and open ocean environments are given in the papers by Bonardelli, McElwee, Mihelakakis, and Tamaru. These papers, and the other presentations and discussions at the meeting, provide a persuasive case for the economic opportunity of this new farming frontier.

The biology of several current and future marine aquaculture species was discussed at the conference and two papers in this volume present some of the issues facing this growing endeavor (Drawbridge and Ostrowski). Finally, a number of speakers addressed provocative new ideas for utilization of ocean space and four of these are presented here as novel approaches to the management and farming of the ocean (Hotta, Liu, Markels, and Rechntenwald).

Setting the stage

Dr. James McVey of the National Sea Grant Office of NOAA set the stage for the conference by presenting the current status of aquaculture in the United States. His paper provides a background for the other presentations and lists a number of problems that need resolution. Among these, the permitting of offshore activities is identified as one of the major impediments. McVey also introduces the new NOAA initiative for Open Ocean Aquaculture that would focus the efforts of many institutions on rapidly developing the technology of offshore production systems, the understanding of the biology of potentially culturable species, and the policy and regulatory regime under which both demonstration and proof of concept experiments and limited production could take place. Several other authors, in addressing issues of marine tenure, ocean leasing, policy development, and enforcement of regulations, reinforce this view. These papers generally indicate that over-regulation of the fledgling industry is having adverse effects but they also generally agree that the emerging offshore aquaculture industry must accommodate the need for regulation and environmental stewardship at all steps in its development.

Public policy and regulatory issues

As pointed out by McVey, marine tenure, or ownership of rights to ocean water is a crucial issue that must be resolved before any substantial investment will be made in open ocean aquaculture. Although the issue of water rights to portions of the ocean needs much more discussion, two types of ownership are generally discussed. Exclusive ownership, in which rights of access by others can be excluded, and multiple use ownership, in which other users such as sport fishermen continue to have access to the site. Either is probably acceptable provided sufficient ownership right is present to assure the aquaculturist that the initial investment in anchoring systems and nearby hatchery facilities is warranted. Inasmuch as most coastal communities have had a past practice of considering the ocean a commons from which all can derive benefits, the path to provide adequate ownership assurance is not clear in many political jurisdictions. In the papers of this volume, ideas ranging from leases from the controlling state to outright ownership are discussed, as is the concept of a non-exclusive easement. Although outright ownership is clearly a favorite, it is the least likely to be achieved. Thus lease and/or easement issues appear to be more expedient and are considered by most authors to be satisfactory.

The regulatory regime in which ocean aquaculture can be undertaken needs rapid clarification. Inshore models for circulation and waste loading appropriate for calculating the carrying capacity of these protected and restricted circulation waters seem to be inappropriate for establishing the carrying capacity of the more open circulation conditions experienced in the open ocean environment. Thus we need new modeling efforts to establish appropriate carrying capacity for offshore areas. These models could then be used to establish guidelines for acceptable environmental impact criteria. But even if the criteria were established, in many cases, it is not clear what agency would do the watching. Thus it is suggested that the fledgling industry should attempt to set some best practice standard that would give guidance to the appropriate or future regulatory body.

Technology of cage and longline culture systems

The technology of growing fish and shellfish in open ocean environments received considerable attention at the conference and in the papers in this volume. Although no definition of the term "open ocean" was enunciated, many existing operations are exposed in at least one direction to a fetch of a thousand kilometers or more. Moreover, these facilities have withstood storms of major proportion and have survived. Facilities up to 10 km offshore are described and there appears to be general agreement that the added problem of higher sea state is acceptable in exchange for the benefit of better water quality that generally goes along with the increased exposure. Better water quality translates into better growth rates, less disease, and the minimization of the environmental impact of the waste products from the intensive culture systems.

Several authors exploit finite element modeling to examine the deformation of various cage types under high current and wave conditions. Anchor systems also are examined, as are the benefits and shortcomings of various cage designs. Structurally supported cages seem to have advantages (other than, perhaps, their cost) to gravity cages of more conventional design.

Examples of success or failure of open ocean aquaculture

Several examples of success were presented and discussed at some length at the conference and are included as papers in this volume. One (Petrusevics) involves the southern bluefin tuna operation in Boston Bay, South Australia, where more than 2,000 tons of fish are being raised in cages which were stocked with juveniles captured in the wild. Another (Bonardelli) involves experiences in offshore shellfish production and examines the economies of scale of a scallop-growing operation in eastern Canada.

Culture of salmon in offshore regions of Ireland is used as a model for offshore open ocean aquaculture of the future (McElwee). This paper is of particular significance for it demonstrates the ability to grow up to 300 tons of fish in a single cage in heavy sea states.

Mihelakakis discusses an extensive cage culture operation in the offshore waters of Greece. He also examines the economics and cost breakdown of the production of fish in the Mediterranean region.

Finally, the ups and downs of the Taiwan experience in aquaculture were summarized at the conference but are not presented in this volume. These sobering experiences provide a lesson on the cost of a too rapid expansion to high stocking densities before the culture of an organism and its diseases are fully understood, or without adequate development of the market.

Future directions

The biology, economic potential, and required physical environment for a number of potentially culturable open ocean species, varying from white sea bass to yellowfin tuna, moi (Pacific threadfin), mahimahi, pearl oysters, and seaweeds, were examined by various authors during the conference and most are considered in the papers of this volume. Of these, moi, Hawaiian pearl oysters, and mahimahi seem closest to being viable new commercial species for tropical waters at this time, but yellowfin tuna caught the attention of many with a more distant vision.

One of the clearest needs for the future will be the need to identify and resolve social and economic problems that are unique to marine aquaculture. Foremost among these is the social/political issue of rights to the water. This is critical to the financial viability of any open ocean aquaculture effort. We will also need to evaluate local and regional economic cost/benefit ratios of full-scale development.

In the more distant future we need to examine, and perhaps test, the feasibility of fertilizing the oligotrophic ocean by means, such as artificial upwelling or even the dispersal of nutrients from a ship. Either method appears to have potential for greatly increasing the production of biomass, and, indirectly, food fish, in regions of the ocean that are otherwise of little productive value. Finally, we must begin to address the economies of scale that may be available when aquaculture is used in conjunction with other oceanic endeavors, such as the use and reuse of oil drilling platforms or the use of very large floating structures as fish husbanding devices.

Recommendations

Based on the conference discussions, the near-term scientific and engineering objectives should include:

1. Selecting appropriate local species in a number of ecologically distinct regions for consideration for use in open ocean aquaculture programs and assessment of the status of available information for each of these species;
2. Obtaining adequate biological knowledge to remove impediments to the development of aquaculture for each of the selected species from spawning through the juvenile stage;
3. Developing conceptual designs, analysis, model testing and fabrication of containment systems appropriate for ocean mariculture;
4. Developing harvesting and feeding systems for use in open ocean environments;
5. Demonstrating the viability of regional ocean mariculture at appropriate scale(s);
6. Investigating the question of the dilution of wild-stock genetic pools by accidental releases of fish from offshore aquaculture systems.

References

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