

**¹ Harmful Algae Management and Mitigation:
Can WorldFish Center Play a Role?**

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ABSTRACT

WorldFish Center (initially known as ICLARM- International Center for Living Aquatic Resources Management) was founded in 1977 in Manila, Philippines through funds provided by the Rockefeller Foundation. In May 1992, it became a member of the Consultative Group in International Agricultural Research (CGIAR), an organization dedicated to food security and poverty eradication through research, partnerships, capacity building and policy support. In February 2000, the Headquarters of the WorldFish Center was relocated to Penang. WorldFish Center addresses aquatic resources research and is internationally recognized as a center of excellence for many of its aquatic programs. We have developed several databases such as FishBase, Reefbase and TrawlBase which are widely used throughout the world, and several software packages such as FiSat (FAO-ICLARM Stock Assessment Tools) and FiRST (Fisheries Resources Information System and Tools). Apart from our strength in database development, we also have vast experiences in coordinating regional projects and working with, and upgrading skills of national partners. We have the capability to develop a global database for Harmful Algal Blooms (HABs) as well as early warning prediction systems. We are able to provide also information and training to our partners. Our research experiences in coastal zone management and in co-management will enable us to offer useful insights on solutions to policy and management issues pertaining to HAB and to provide advice on the roles of farmers and central agencies in managing HAB, particularly during an outbreak.

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Introduction

ICLARM (International Center for Living Aquatic Resources Management) was founded in 1977 in Manila, Philippines, initially through funds provided by the Rockefeller Foundation, as an autonomous, non-government and non-profit organization dedicated to aquatic resources research. In May 1992, it became a member of the Consultative Group in International Agricultural Research (CGIAR), an organization committed to food security and poverty eradication in developing countries through research, partnerships, capacity building, and policy support, whilst promoting sustainable agricultural development based on the environmentally sound management of natural resources (www.cgiar.org). In February 2000, ICLARM Headquarters was relocated to Penang, Malaysia, where the Malaysian government leased 5.2 ha of land for the establishment of its campus in Batu Maung. In conjunction with this move, the Center decided to adopt a new logo and name-ICLARM- the World Fish Center. Two and a half years later, to overcome the difficulty of a long and complex name, we rename ourselves as WorldFish Center and also adopt a new and more futuristic-looking logo. Besides its headquarters in Penang, it has outreach sites in ten countries, namely the Philippines, Vietnam, Solomon Islands, Bangladesh, Egypt, Malawi, Cameroon, Jamaica, British Virgin Islands and New Caledonia.

Donors to WorldFish Center include the Asian Development Bank, the World Bank, Food and Agriculture Organization (FAO), United Nations Development Programme (UNDP), United Nations Environmental Programme (UNEP), governments and other government agencies, as well as private foundations (see Schiøler 2002).

ICLARM's mission is to enhance the well-being of present and future generations of poor people in the developing world through improved production, management and conservation of living aquatic resources, and has the following objectives:

- improve the biological, socioeconomic and institutional management mechanisms for sustainable use of aquatic resource systems;
- devise and improve production systems that will provide increasing yet sustainable yields;
- help develop the capacity of national partners to ensure sustainable development of aquatic resources.

This paper describes the priority research areas of WorldFish Center and attempts to discuss how it could contribute together with partners, to the research and partnership needs of the global harmful algae management and mitigation (HAMM) programs.

2. Research Programs

WorldFish Center's research program gives approximately equal weight to research on both fisheries and aquaculture, and, in keeping with its focus on people in development,

places, increasing emphasis on socioeconomic and policy research. More than half the Center's research is undertaken in Asia and the Pacific region, where many of the states are dependent on fishing and fish-farming, but increasingly more projects are located in Africa. Asia has the greatest number of the world's poor; however, poverty rates are higher in Africa and are anticipated to remain severe. The Center allocates approximately 58% of resources to Asia, 30% to Sub-Saharan Africa, 4% to the Caribbean and Latin America and 8% to West Asia and North Africa. Research activities are incorporated into four programs:

- biodiversity and genetic resources research;
- coastal and marine resources research;
- freshwater resources research;
- policy research and impact assessment.

2.1 Biodiversity and Genetic Resources Research Program

This program focuses on strategies to maintain biological and genetic diversity in natural populations and on techniques for improving breeds of fish. It has two components, namely: biodiversity and genetic resources research, and germplasm enhancement and breeding research.

2.1.1 Biodiversity and Genetic Resources Component

This component pursues strategic research on biodiversity and genetic resources, and contributes to the development of research methods and policy. The development of a global database for finfishes, and the development of updated tools useful in fisheries management are given priority. FishBase, which provides information on 26,945 species of fish with over 27,175 references, is accessible through the internet (<http://www.fishbase.org/search.html>). The FishBase team stationed in the Philippines is now linked to a new FishBase Consortium with FAO and European institutes. A database to provide information on the morphology and biology of fish larvae is being compiled – LarvalBase – the first version of which was posted on the web in 2000.

2.1.2 Mekong Initiatives Component

The project aims to better appraise the relationship between flooding and annual fish production. Our partner, the International Water Management Institute (IWMI), developed a hydrological model of the Mekong. Annual fisheries production and factors driving the fisheries production are studied, and a decision support model synthesizing the interactions of the drivers on total fisheries production is being developed.

2.1.3 Germplasm Enhancement and Breeding Component

The objectives of this component are to develop and apply breeding methods to improve strains of fish for aquaculture, to build capacity among developing country partners and to disseminate information to national aquatic research systems (NARS). Research to characterize the genetic diversity of important cultured species, such as several carp and tilapia species is under way. A fast-growing strain- the GIFT tilapia has been successfully bred and introduced for commercial farming.

2.2 Coastal and Marine Resources Research Program

Projects under this Program are designed to conserve and manage coastal habitats, restore depleted stocks, improve the productivity of fisheries and valuable species on a sustainable basis, equip managers with the information needed for these tasks, and increase the capacity of NARS. The aquatic ecosystems given priority are coastal inshore and estuarine systems and coral reefs. Research components include coastal aquaculture and stock enhancement, marine protected areas, coral reef resources, fisheries resources assessment and management, and coastal management.

2.2.1 Coastal Aquaculture and Stock Enhancement Component

This component focuses on developing methods to increase the productivity of species associated with coral reefs through aquaculture, restocking and stock enhancement. Species currently given priority include the sandfish (*Holothuria scabra*), the giant clam (*Tridacna* sp.), the black pearl oyster (*Pinctada margaritifera*), and the trochus (*Trochus niloticus*). Experimental farms and stock enhancement sites are located in the Pacific islands – the Solomon Islands, New Caledonia and Tonga, and in Vietnam.

2.2.2 Marine Protected Areas Component

The roles of marine protected areas are being established at two sites, in the Caribbean and in the Arnarvon Islands in the Solomon Islands. Following the Center's initial work in the Caribbean, a significant development has been the decision of the fishing community at Discovery Bay to recommend the extension of the fishery reserve to cover the entire shallows of the Bay, so that more aquatic resources could be protected. The establishment of the Marine Conservation Area (MCA) in the Arnarvon Islands has resulted in increases in the abundance, or prevented further decline in abundances, of *Trochus niloticus* and some species of holothurians.

2.2.3 Coral Reef Resources Component

The development of ReefBase - a global database of coral reef systems, their resources and use by humans, is one of the important outputs of this component. ReefBase (<http://www.reefbase.org>) was launched at the 9th International Coral Reef Symposium in Bali in October 2000, and the ReefBase team has now developed an extensive group of collaborators to ensure that this project meets its objectives. Collaborators include the World Bank, National Oceanographic and Atmospheric Administration (NOAA), United Nations Environmental Program (UNEP), the Australian Institute of Marine Science (AIMS), World Conservation Monitoring Center (WCMC), the Global Coral Reef Monitoring Network (GCRMN) and ReefCheck. The immediate plans for ReefBase include the formation of a group, to advise on the following: the development of a new version with geographical information system input for use on the internet; the development of reef status summaries for all reefs; the development of regional databases; and the development of standard indicators of reef health and economic value.

Projects on coral reef resources undertaken by the Center are integrated into the International Coral Reef Action Network (ICRAN), a unique partnership with UNEP, WCMC, WRI, GCRMN, the International Coral Reef Initiative (ICRI) and the Coral Reef Alliance (CORAL).

2.2.4 Fisheries Resources Assessment and Management Component

Under this component, several fisheries assessment software packages such as FiSat (FAO-ICLARM Stock Assessment Tools), and FiRST (Fisheries Resources Information System and Tools) were developed; the Center has supported and trained resource persons in NARS in the use of these packages. At the ecosystem level, Ecosim has been developed by partners in Canada (University of British Columbia) for evaluating human and environmental impacts on aquatic resources. The new version of this software also allows the following assessment: the prediction of optimal harvesting patterns based on economic, social and ecological criteria; the evaluation of the impact of uncertainty in the management process; the optimisation of the effect of protected areas, and the development of circulation models.

Results from the three-year, 8 country study on Sustainable Exploitation of Tropical Coastal Fish Stocks in Asia initiated in 1999, indicated substantive declines in catch rates and biomass, compared to earlier biomass levels in selected fishing areas. Analyses of trawl survey data shows assemblage boundaries at depths of about 50 m and 100m, and Species composition changes were observed in some countries, with declines in mean trophic level, due to the current high level of fishing effort.

2.2.5 Coastal Management Component

Development of appropriate strategies for the productive and sustainable use of the coastal zone by various stakeholders, is a major challenge in many countries. WorldFish Center is actively working with NARS partners to integrate approaches to the coastal zone to reduce the risk of pollution and degradation of existing coastal resources.

The project on resource assessment, social issues and management of Honda Bay and Puerto Princess Bay, Palawan, Philippines, was initiated in February 2000. Rapid Resource Assessment (RRA) methods, and Participatory Rapid Appraisal (PRA) tools, were used to describe the prevailing situation in the two bays. The Center and Philippine partners provided training in integrated coastal management in Indonesia and Vietnam in 2001 and 2002. Through the training projects, the Center will establish networks of coastal management practitioners, will identify existing coastal management-related projects underway by governments and NGOs, and will design training to meet cultural, socioeconomic, institutional and biophysical needs.

2.2.6 PISCES Component

The Population Interdependencies in the South China Sea Ecosystems (PISCES) project is an initiative to investigate the degree of connectivity among selected reefs in the South China Sea. Genetic variation is evaluated with the use of isozyme and DNA microsatellite markers. Apart from using genetic markers, studies on surface circulation, tagging, recruitment and life history strategies of selected species are carried out. Initial results indicate that the major water bodies in Southeast Asia are not as open as initially thought.

2.3 Freshwater Resources Research Program

WorldFish Center is developing new approaches to integrate biological, climatic and socioeconomic variables in the evaluation of best practices for the introduction of aquaculture into farming systems. The Center links its own field experience in integrated aquaculture-agriculture systems, developed in Asia and Southern Africa, with those of others. New initiatives are being taken to extend field activities to the humid zone of West Africa with CGIAR and regional NARS partners. Project sites are located in Bangladesh, Vietnam, Malawi and Cameroon.

2.4 Policy Research and Impact Assessment Program

This Program focuses on policies and options in fisheries, aquaculture and coastal resources management to ensure wider adoption and benefits of research by the poor in the developing world. The three main components of this Program are:

- economic monitoring and evaluation of developing countries fisheries;
- aquatic resources planning and impact assessment;
- legal and institutional analysis for fisheries management.

2.4.1 Economic Monitoring and Evaluation of Fisheries Component

Research in this component focuses on the economic value of goods and services from aquatic resources, and the effects of macro-level policy on food security. Economic and ecological evaluation techniques for coral reef and wetland ecosystems will be given priority.

Research ongoing includes the project with the International Food Policy Research Institute (IFPRI) and FAO. The objective of the project is to develop a model for the project "Fish to 2020: the effects of aquaculture". A joint project with INFOFISH "Database on prices and market for fish and seafood products in developing countries" is aimed to benefit the small-scale suppliers and producers of fish and seafood products in the developing countries. Another collaborative project with partners from the International Institute for Rural Reconstruction (IIRR), Philippines, Can Tho University, Vietnam, and Pakse Southern Agricultural College, Lao, PDR will assess, manage and monitor the local aquatic resources system for improved food security in the Mekong Basin.

2.4.2 Aquatic Resources Planning and Impact Assessment

This component evaluates the impact of research completed by the Center (ex post analysis) and, where appropriate, other technological impacts on the aquatic resources sector. Completed studies include the analyses of the impact of fisheries co-management initiatives and the potential benefit at the farm-level of introductions of genetically improved tilapia. The project will increasingly provide ex-ante analysis of research areas of potential importance to developing country fisheries, and to augment the Center's strategic planning process.

2.4.3 Legal and Institutional Analysis for Fisheries Management

This component examines the linkage between society, economic and natural systems and policy to develop adaptive and flexible solutions for the sustainable use of aquatic resource systems. Current research is conducted as part of a collaborative worldwide

project on fisheries co-management strategies focusing on institutional aspects of sustainable governance. Institutional research extends to the governance of common property aquatic resources, especially inland fisheries in Bangladesh and the multiple use of the wetlands in the lower Mekong Basin countries.

Inputs from this component include the following:

- resource assessments in the Philippines describing the constraints on the supply of milkfish fry for aquaculture;
- aquatic resource use by smallholder households in Cambodia and Vietnam. Results suggest that official statistics underestimate aquatic resource use in these countries substantially (up to tenfold in Cambodia).

3. WorldFish Center- partner in HAMM Studies

With 25 years of research experience in marine resources management, WorldFish Center has the resources to coordinate and to collaborate in regional projects on HABs. It has the capability to develop databases and models for harmful algae bloom predictions, together with other partners. Studies on the effects of exotic harmful algae on biodiversity, and also effects of nutrients and eutrophication on HABs can be incorporated as part of the Centers's coastal management projects. We can also provide insights and suggestions on HAMM issues, with our wide experience in coastal zone management and co-management research.

3.1 Development of Databases

WorldFish Center has vast experiences in database development as elucidated in our FishBase, ReefBase and TrawlBase projects. We can collaborate with partners to develop similar databases for the HAMM project. Structured knowledgebases are very powerful and popular with users. FishBase receives an average of 4 million hits/month, while ReefBase, since its launch in the Web in April 2002, average around 403,000 hits/month. Like in ReefBase (see Williams and Choo 2002), a repository of information on HABs can be structured into a database, acting as a computerized encyclopedia, Geo-referencing of events and information also enable scientists the opportunity to collate all information by location.

3.2 Development of Early Warning and Prediction Systems

With our experience in the Mekong project, where a model to establish the relationship between annual flooding and fish production was developed together with partners, the WorldFish Center can utilize the same expertise to develop an early warning and prediction system for HABs. Models are effective tools for describing complex relationships among physical, chemical and biological variability in ecosystems (GEOHAB 2001). The development of such a tool should be given priority since incidences of HAB have been reported to be on the increase worldwide.

3.3 HAB species: biodiversity and biogeography

The invasion of harmful algal species in areas previously with no known records of the invading species have been reported in increasing numbers (Anderson 1989; Smayda 1990; Hallegraeff 1993) and ballast waters discharged by ships at their ports of call have been widely implicated (Hallegraeff and Bolch 1991, 1992). WorldFish Center can use its experience from the PISCES project (see Ablan et al. 2002), where together with its partners, studied the degree of connectivity among selected coral reefs in the South China Sea. The genetic variability of HAB species and their biogeography can be studied using the genetic and ecological tools used in the PISCES project.

3.4 Mitigation Measures through Coastal Zone Management

HAB incidences are often associated with controversial coastal land use, such as the clearing of mangroves for shrimp farming which may cause hypernutrification or eutrophication (see Choo 2001). Concerns over incoherent and often contradictory policies made outside the fisheries and aquaculture sector, including development plans that bring further congestion to the coastal zone are other causes of marine ecosystem degradation (Williams and Perez-Corral 2000). WorldFish Center's experiences in coastal zone management in the Philippines offers useful guidelines for mitigation and risk reduction of pollution and ecosystem destruction by the use of holistic approach to management. WorldFish Center also has the experience to design and organize training courses to meet cultural, socioeconomic, institutional and biophysical needs.

3.5 Co-management and conciliatory decision-making

HAB incidences require problem solving and decision-making not only by government officials but also by stakeholders who are the farmers and the middlemen who bring the produce for sale to the market. A top-down approach without consultation with the stakeholders usually meets with stakeholder resistance and lacks transparency. A more conciliatory co-management approach could be a better option. WorldFish Center's experiences in co-management of fisheries resources may offer useful guidelines to the management of stakeholders and resources, especially during a HAB crisis.

4. Conclusion

WorldFish Center has vast experiences accumulated over 25 years in aquatic resources management. Their skills in database development and management, their ability in modeling, and their expertise in co-management and coastal zone management would be beneficial to providing answers to issues related to HAMM. Solutions from science span a wide range of expertise from many institutions. WorldFish Center looks forward to working with partners to provide answers and to deliver our work programs.

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