

# ICLARM organizational statement

## **Our commitment**

ICLARM contributes to food security and poverty eradication in developing countries.

We aim for:

- poverty eradication;
- a healthier, better nourished human family;
- reduced pressure on fragile natural resources; and
- people-centered policies for sustainable development.

## **A way to achieve this**

Through research, partnership, capacity building and policy support, we promote sustainable development and use of living aquatic resources based on environmentally sound management.

## **The research objectives are**

- raising and sustaining the productivity of fisheries and aquaculture systems;
- protecting the aquatic environment;
- saving aquatic biodiversity;
- improving policies for sustainable development of aquatic resources; and
- strengthening the capacity of national programs to support sustainable development.

We believe this work will be most successful when undertaken in partnership with national government and international institutions and with the participation of the users of the research results.

# Acronyms

AFSSRN	Asian Fisheries Social Science Research Network
APAARI	Asia-Pacific Association of Agricultural Research Institutes
ASI	Advanced Scientific Institute
CAC	Coastal Aquaculture Centre
CBD	Convention on Biological Diversity
CGIAR	Consultative Group on International Agricultural Research
EEZ	Exclusive Economic Zone
FAO	Food and Agriculture Organization
GCRMN	Global Coral Reef Monitoring Network
GIFT	Genetically Improved Farm Tilapia
IAA	Integrated Aquaculture-Agriculture
ICFM	Integrated Coastal Fisheries Management
ICZM	Integrated Coastal Zone Management
IFPRI	International Food Policy Research Institute
INGA	International Network on Genetics in Aquaculture
IPR	Intellectual Property Rights
LARM	Living Aquatic Resources Management
LIFDC	Low-Income Food Deficit Countries
MPA	Marine Protected Area
NARS	National Aquatic/Agricultural Research Systems
NGO	Non-government Organization
SA	South Asia
SEA	South East Asia
SIDS	Small Island Developing States
SSA	Sub-Saharan Africa
SWBs	Small Water Bodies
SWGRP	System Wide Genetic Resources Program
SWICP	System Wide Initiatives on Common Property
SWIM	System Wide Program for Irrigation Management
WANA	West Asia/North Africa
WTO	World Trade Organization

## Foreword

In the last decade, the knowledge, exploitation, state of health and public concern over aquatic resources have evolved rapidly. The world context for research on living aquatic resources, including the welfare and circumstances of the people dependent on them, has changed since ICLARM developed its last Strategic Plan in 1991-1992 as the Center prepared to join the Consultative Group on International Agricultural Research (CGIAR). ICLARM's priority research has shifted over time as it responds to those rapid changes and major developments. It has been at the forefront of assessing some of these developments—e.g., the status of aquatic resources through global assessments of the decline in trophic levels in fish catches in many regions, and the first thorough assessment of the risk facing coral reefs. Where the previous Strategic Plan was strongly fisheries-oriented, our scope of work today has broadened and has been influenced by equity, sustainability and efficiency considerations. With this Strategic Plan, ICLARM reinforces its commitment to aquatic resource conservation in the coming decades.

In consultation with our stakeholders, ICLARM has adopted an aquatic resource system approach—used for the first time in the earlier Plan—and examined eight different aquatic resource systems, the special resource issues of small island developing states, and the major issues and benefits of each aquatic resource system for the poor in developing countries. These resource systems have been selected largely to respond to the needs in the tropical regions of the world. A companion volume to this Plan is also available (see ICLARM 1999 “Aquatic Resources Research in Developing Countries: Data and Evaluation by Region and Resource System: Supplement to ICLARM Strategic Plan 2000-2020”). It contains population, poverty and aquatic resource profiles of developing countries by regional groupings; and summary data by aquatic resource systems used to frame the priority-setting process as well as in describing the process itself.

ICLARM recognizes that future research advances and new partnerships will stimulate more avenues and opportunities for success in developing country aquatic resources research. It has thus adopted an ‘evergreen’ approach to the current Strategic Plan which will be reviewed periodically. Based on available data and the strategic planning process in 1998, ICLARM is confident that the priorities identified in this Plan represent the optimal approach towards enhancing the role aquatic resources research can play in the lives of people in developing countries in the next two decades. Descriptions of how the Plan will be implemented will be progressively found in ICLARM's rolling three-year Medium Term Plans and our more detailed annual Operational Plans.



**Kurt J. Peters**  
Board Chair



**Meryl J. Williams**  
Director General

## Executive summary

ICLARM's research is conducted with a view to production today and tomorrow and thus aims to promote intergenerational equity of benefits. ICLARM will constantly monitor global aquatic resource issues to establish the 'evergreen' approach in its strategic research agenda. Following an analysis of the circumstances of poverty and dependence on aquatic resources in developing countries, and then noting ICLARM's comparative advantage and track record, our research portfolio in the medium-term will encompass aquaculture and fisheries and living aquatic resources management (LARM).

We will expand our research thrusts from ponds, coral reefs and coastal waters to freshwater systems, namely lakes, small water bodies (SWBs) and floodplains. This strategy will emphasize the development of aquaculture in ponds and SWBs, the sustainable exploitation of coral reefs within integrated coastal zone management (ICZM), and generic contributions to tools and knowledge to augment the performance of developing country fisheries. We will continue our focus on Asia, and enhance activities in Africa and the small island developing states (SIDS) of the Indo-Pacific and Caribbean; work in mainland Latin America will not be a principal priority (see Table 1).

We will adopt an ecosystem approach to formulate integrated models for management and governance of whole resource systems. We will also pursue aquatic genetic research that addresses critical issues in aquatic biodiversity.

Our research outputs will be shared globally as international public goods in the form of new knowledge, databases and models, improved germplasm and aquaculture practices, and underpinning generic fisheries research. We will conduct strategic training and contribute scientific data, analysis and management advice to our various stakeholders, including national aquatic/agricultural research systems (NARS) in developing countries. We aim to help strengthen national capacities to formulate policies for the sustainable management of aquatic resources. Research and capability-building activities will be undertaken in partnership with NARS and other stakeholders, and will draw upon multidisciplinary expertise in the biophysical, socioeconomic, legal/institutional and other relevant fields. Moreover, we will continually assess the impact of ICLARM's research outputs and evaluate the value of our research on the environment, and especially to poor people in the developing world.

Evidence and public awareness of the effects of overfishing and the limitations to harvests from marine and freshwater systems have increased in recent years. Aquaculture has also experienced an unprecedented boost, representing the fastest growing agricultural industry in some developing countries. Human population growth rates are highest in the developing countries, thereby exerting increasing pressures on terrestrial and aquatic environments. Issues of increasing prominence are: degradation of aquatic resource systems due to land-based activities; competition for water and coastal space; multifunctional uses of aquatic resource systems; management and governance of aquatic resource systems; linkages between the private and public sectors with respect to fisheries' markets and ownership of rights to germplasm; linkages between fisheries and aquaculture as a result of fishmeal availability and price, world fish supply and demand; and the role and contribution of women in fisheries. The most important concerns for the future include: sustaining aquatic environments to stabilize or augment production levels for human food; protecting aquatic biodiversity on which future productivity depends; and integrating the biophysical, socioeconomic and policy elements of aquatic resources management. These key areas must be addressed against a background of increasing global concern and dispute about rights over genetic resources, the effects of intermittent or long-term climate change, a widening gap between the rich and poor, increasing globalization and changing development paradigms.

**Table 1. ICLARM's priority research thrusts (2000-2020) by aquatic resource system and regional focus.**

Aquatic resource system	Priority	Research thrusts	Regional focus
Ponds	Very high	<ul style="list-style-type: none"> <li>• Introduce integrated aquaculture systems and impact analysis</li> <li>• Enhance genetic techniques</li> </ul>	Asia, Sub-Saharan Africa (SSA)
Small water bodies, reservoirs, and lakes	Medium	<ul style="list-style-type: none"> <li>• Develop knowledge base</li> <li>• Enhance productivity</li> <li>• Integrate management</li> </ul>	SSA
Floodplains, streams and rivers	High	<ul style="list-style-type: none"> <li>• Enhance yields</li> <li>• Develop appropriate research methods and data to evaluate the resources and improve policy decisions and institutional framework</li> </ul>	Mekong Basin, South Asia
Coastal waters (including estuaries and lagoons)	High	<ul style="list-style-type: none"> <li>• Co-manage coastal and fisheries resources</li> <li>• Plan for integrated resource use</li> <li>• Introduce sustainable coastal aquaculture and stock enhancement</li> </ul>	South East Asia (including Mekong Basin) SSA, SIDS
Coral reefs	Very high	<ul style="list-style-type: none"> <li>• Integrate data on coral reefs to determine parameters of reef health</li> <li>• Practice better management within ICZM context</li> <li>• Encourage sustainable exploitation of coral reef resources through aquaculture and marine protected areas (MPAs)</li> </ul>	SIDS (Pacific, Caribbean) South East Asia, East Africa
Soft bottom shelves	Medium	<ul style="list-style-type: none"> <li>• Conduct policy analysis and study implications of changes in coastal fisheries</li> </ul>	Asia, Africa
Upwelling shelves	Low	<ul style="list-style-type: none"> <li>• Keep watching brief on productivity and influences of catch on trade and other aquaculture development</li> </ul>	
Open oceans	Low	<ul style="list-style-type: none"> <li>• Monitor world catch statistics and trade for their effects on ICLARM's target beneficiaries and other resource systems and global patterns</li> </ul>	

**Very high** represents the heartland of ICLARM's research; it will be allotted between 15-30% each of ICLARM's total financial and human resources and preferentially protected from budget shortfalls. **High** priority research will be pursued by ICLARM, but usually covering not more than 15% of resources. **Medium** priority research will be pursued by ICLARM, normally covering not more than 7.5-10% of resources. **Low** priority indicates that extant data will be used from these systems to contribute to generic research (e.g., fisheries models) and any additional research will generally be conducted by collaborators.

# Introduction

The present state of knowledge of most aquatic resource systems, species and culture systems lags far behind that of terrestrial agriculture and forestry systems. ICLARM has been at the forefront in efforts to improve the knowledge base of LARM and to decrease the overall state of stress on overfished and heavily degraded aquatic resource systems. We seek to contribute to scholarship in tropical fisheries science, raise awareness of key issues, conduct and coordinate international public good strategic research, and be an eminent provider of results and management methods for the sustainable use of aquatic resources by poor people. We also aim to integrate the biophysical, socioeconomic and policy elements of aquatic resources management, taking into consideration their complex issues and interlinkages. Fig. 1 illustrates the wide-ranging contexts and trends within which ICLARM's research on aquatic resource systems is situated.

In this second Strategic Plan, ICLARM has endeavored to address LARM issues in developing countries for the period 2000-2020. Our research outputs will provide the means for increasing food production, sustaining aquatic environments and their diverse biological resources, and enhancing livelihoods and well-being of poor people dependent on aquatic resources. Our stakeholders range from fishers and fishfarmers through NARS and other researchers, fisheries' managers, nongovernment organizations (NGOs) and community leaders to development agencies, donors and the private sector.

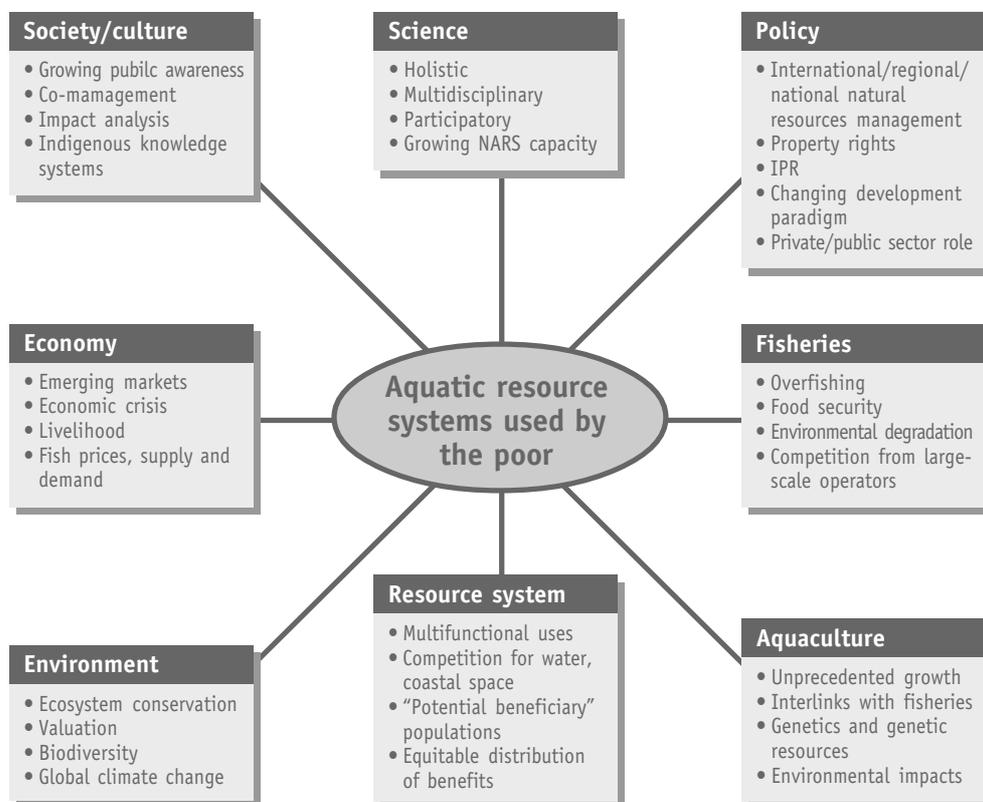


Fig. 1. Aquatic resource systems research: contexts and trends.

At the heart of ICLARM's research priority-setting process is the aquatic resource systems approach (see Fig. 2). This entails an evaluation of the problems and opportunities within eight aquatic resource systems and seven regional groupings in the developing world for the potential application of research (see Annex A). We define an aquatic resource system as the zone of convergence of the resources, their aquatic environment and the human users. We believe that this novel approach, which focuses directly on developing countries and resource system issues, provides more relevant material for analysis than global aggregates, or regional analyses based only on large continental groupings.

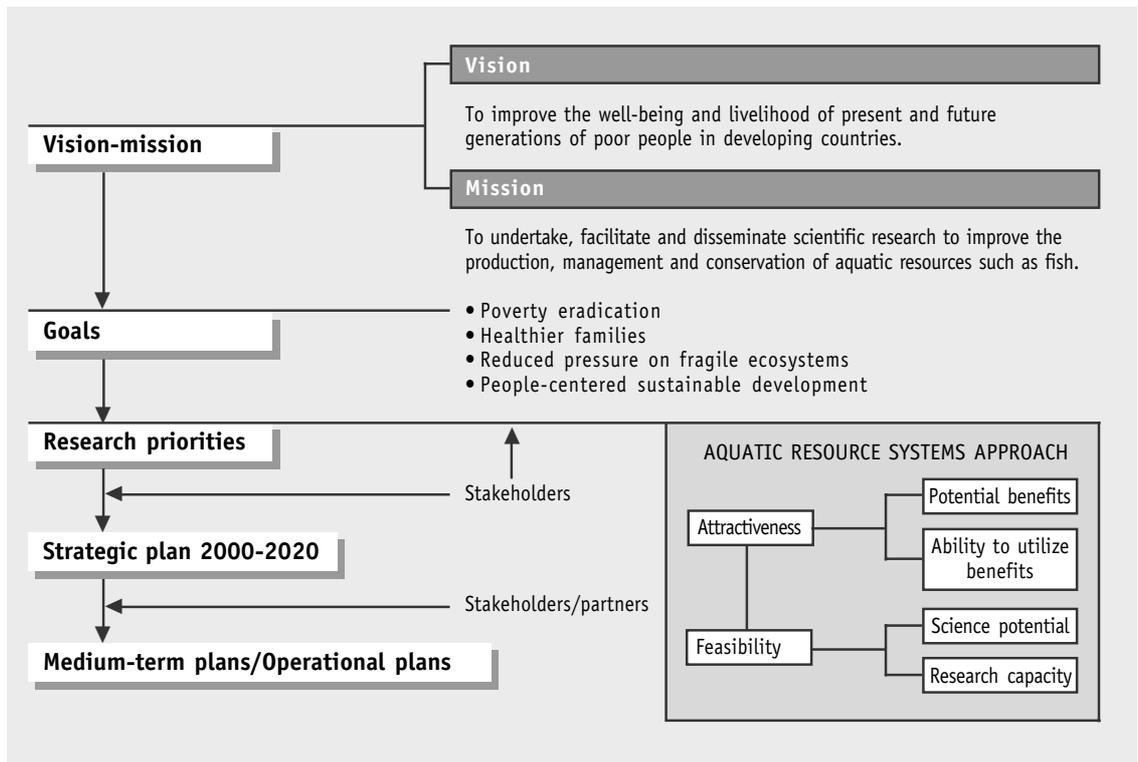


Fig. 2. ICLARM's research priority-setting process.

# World fisheries and aquaculture outlook

Fish is a high quality protein source that can either be used directly as human food (food fish) or for other purposes (e.g., fishmeal). Fish and other aquatic organisms can also be used in a number of different ways, from ornaments to tourism. Fish as food comprises about 16% and 6% of total animal protein and total protein consumed, respectively. In some regions of the developing world, fish can contribute even more to the protein intake. Capture fisheries production, or fish caught from natural stocks, has not been able to keep pace with the demand for fish. Looming shortfalls have been compensated, though not adequately, by better than expected increases in aquaculture production of fish. More than half the present world catch is consumed in developing countries, but international trade is fast changing fish consumption patterns.

According to recent Food and Agriculture Organization (FAO) estimates:

- Global fish production in 1996 reached 130 million metric ton (mt), almost doubling the average per caput food fish supply from 8 kg in 1950 to over 15 kg. Food fish supply per caput in low-income food deficit countries (LIFDCs) is currently about half the world average.
- Aquaculture production contributes about 20% of the total world production of fish.
- The percentage of the world fish production from developing countries has steadily increased to roughly 70% since 1985. Asia currently dominates world fisheries and aquaculture production.
- The value of the global fish catch and international trade has increased in recent times. About 40% of the present global fish production is traded internationally; developed countries are net importers. Trade in reef species (e.g., pearl oysters, bêche-de-mer) and live reef fish has also grown sharply. LIFDCs have an excess of some US\$ 8 billion of exports over imports of fish and shellfish worldwide.

Despite such crucial moves to improve stewardship of fisheries resources as the 1995 FAO Code of Conduct for Responsible Fisheries, it is doubtful that global catches will recover and resume the fairly steady production increases which marked the period from the 1940s through the 1980s. Over the next 25 years, the challenge in fisheries management will be to maintain present or near-present harvest levels while sustainably increasing aquaculture production to meet growing demands for fish and other living aquatic resources.

## Challenges of capture fisheries

A downturn in global fisheries production in the early 1990s brought about by overfishing and continuing environmental degradation generated public alarm and calls for improved management schemes and sustainable utilization of aquatic resource systems. Of the world's 200 fished stocks, for instance, only a third is capable of sustaining increased harvests. An estimated 27 million mt, or about 30% of total marine production, is discarded every year (Alverson et al. 1994).

Overfishing in many areas is leading to harvests of smaller fish and lower catches per unit effort. The removal of longer-lived, piscivorous fish is changing balances within the world catches towards shorter-lived, planktivorous pelagic fish and invertebrates. Despite increases in the price of fish, these trends lower per capita income for fishers. Moreover, inadequate fisheries management has allowed the degradation of the common property resources of the oceans and failed to address the fundamental questions of rights in fisheries.

ICLARM has joined others in raising global awareness over the sustainability of marine capture fisheries:

*“Present exploitation patterns are unsustainable... Fishing down food webs (that is, at lower trophic levels) leads at first to increasing catches, then to a phase transition associated with stagnating or declining catches.”*

—Fishing Down Marine Food Webs (D. Pauly, V. Christensen, J. Dalsgaard, R. Froese and F. Torres), *Science* 279: 861-863, February 1998.

*“The primary production required to sustain [world fisheries catches for 1988-1991 or 94.3 million mt], plus 27 million mt of discarded bycatch, amounted to 8.0% of global aquatic primary production, nearly four times the previous estimate. By ecosystem type, the requirements were only 2% for open ocean systems, but ranged from 24 to 35% in freshwater, upwelling and shelf systems, justifying current concerns for sustainability and biodiversity.”*

—Primary Production Required to Sustain Global Fisheries (D. Pauly and V. Christensen), *Nature* 374: 255-257, March 1995.

*“Overfishing is a serious problem [in San Miguel Bay, Philippines], with the demersal biomass down to 18.5% of their levels in the late 1940s... The evident biological and economic overfishing persist amidst issues of poor infrastructure, limited financial and organizational capabilities, overlapping institutional functions and lack of stakeholder participation in management.”*

—Integrated Management of Coastal Fisheries: Lessons from Initiatives in San Miguel Bay, Philippines (G. Silvestre), March 1996.

*“Fifty eight percent of the world’s reefs are potentially threatened by human activity—ranging from coastal development and destructive fishing practices to over exploitation of resources, marine pollution, and run off from inland deforestation and farming.”*

—Reefs at Risk. A Map-Based indicator of Threats to the World’s Coral Reefs (D. Bryant, L. Burke, J. McManus and M. Spalding), June 1998.

*“Overfishing is not a recent issue. It was formally recognized internationally in the early 1900s and was the subject of the London Conference on Overfishing in 1947. Subsequently, it has become prevalent in most fishing areas and affects capture fisheries in developing and developed countries, often becoming particularly severe in densely populated coastal areas and in very productive offshore areas.”*

—FAO, *The State of World Fisheries and Aquaculture*, 1996.

*“The meeting urged governments and international organizations, inter alia, to reduce fishing to sustainable levels in areas and on stocks currently heavily exploited or over-fished and to adopt policies, apply measures and develop techniques to reduce by-catches, fish discards and post-harvest losses.”*

—The Rome Consensus on World Fisheries Adopted by the FAO Ministerial Meeting on Fisheries, Rome, 14-15 March 1995.

*“World fish stocks are in crisis. Almost two-thirds of marine stocks in the Pacific and Atlantic oceans are being fully exploited or have already been overfished, even if some are recovering slowly. Future projections predict a steadily widening gap between the world’s demand for fish and the ability of the oceans to meet it.”*

*“Many scientists claim that the situation is the inevitable result of the failure of governments to heed their warnings of the dangers of overfishing, and where they have listened to their message, failing to adopt and forcefully police policies designed to prevent this.”*

—Nature, March 1997.

*“Asia’s fish stocks are dwindling because of over-exploitation and pollution.”*

—Far Eastern Economic Review, March 1997.

In the 21st century, however, new opportunities will abound due to increased pressures to create new management regimes, particularly over coastal and inland fisheries.

- ICLARM’s research in fisheries co-management has generated a large body of knowledge and information of the institutional approaches that are potentially available to developing countries and has demonstrated that co-management may be an equitable, efficient and sustainable management strategy.
- Opportunities for improved management will require research on the resources themselves, establishing historical levels and stock dynamics, on the people who fish, who consume the products and others who affect the quality of aquatic habitats, and on the human institutions which affect resource exploitation including the nature of rights to the resources.
- Opportunities also exist to make a fundamental shift and move from a species by species approach to an ecosystem approach that includes people and their livelihood strategies.
- The widespread establishment of small reserves or MPAs seems promising, and can be facilitated through simple ‘best practice guides’ which ICLARM has developed.

## Growth of aquaculture

An unprecedented boost in aquaculture has occurred in many countries in recent times. Aquaculture appears to be one of the last frontiers to increase contributions to food security in the developing world. It now represents the fastest growing agricultural industry in some countries, with freshwater aquaculture dominating total aquaculture production. Although Asia currently leads aquaculture production, FAO studies (Kapetsky 1994, 1995) show that Africa and Latin America have much potential, indicating an opportunity to improve food security, nutrition and incomes among the poor. Many predict a continued growth of the aquaculture sector well into the next century.

According to FAO estimates in 1996:

- LIFDCs are the dominant producers in aquaculture, with overall statistics heavily influenced by developments in China, which accounts for 68% of world output.
- The total production of cultured finfish, shellfish and aquatic plants reached 34 million mt (valued at US\$ 46.5 billion). Aquaculture contributed between 14 and 62% to national aquatic production in the top 14 producing countries.
- Carps are the major cultured aquatic organisms. Three finfish species groups—carps, salmonids and tilapias—account for 82% of total finfish production.

Research in small-scale aquaculture can make fish more widely available and affordable to consumers. By increasing harvests and improving efficiency of production methods, fish farmers can profit and contribute to the household economy and rural development. Women can also be provided livelihood opportunities through aquaculture. Viable strategies include small-scale integrated aquaculture-agriculture (IAA) practices, integrated approaches to coastal management and genetic improvements in farmed species. Enhanced fish can be consumed locally to increase productivity and ensure food and nutritional security, especially at the household level. Planned intervention, however, is needed to help the poor share the benefits of aquaculture technology more equitably.

Further research needs to be directed at such key issues as ecosystem interactions, indicators of sustainability, resource valuation, extension methods for aquaculture, governance theory and influencing transnational management and equity. Participatory research tools should be developed to ensure that the target beneficiaries of such research are involved and/or consulted in critical stages of the research process.

Research should also address potential threats to the effective use of aquaculture that include the increasingly poor water quality and reduction in fresh water availability globally. Additional factors are land prices and alternative land use, feed costs for developing country practitioners, the competition between aquaculture and livestock feed markets, diseases, and labor costs.

The following are major trends and suggested directions for the growth of aquaculture:

- Freshwater aquaculture as a contributor to food security and rural development will become more important in the less developed countries of Asia.
- Aquaculture in South Asia will raise its profile still further as it provides relatively high returns compared with other agricultural products.
- Environmental factors will continue to play a key role in aquaculture development throughout the East Asian region.
- The crisis in the shrimp culture industry has led either to the adoption of less resource dependent practices or diversification into other high value finfish species in Southeast Asia. These will likely remain beyond the means of the poor unless alternative feeding regimes can be developed.
- Aquaculture in mainland Latin America is highly commercial and not integrated into government structural policy frameworks that might target the poor.
- SIDS have few natural resources other than terrestrial and mangrove forests, and aquatic resources. There is a wide scope for enhancement of coral reef and marine aquaculture, which may have the dual role of protecting important high value species and generating food and income opportunities.
- The West Asia/North Africa (WANA) region is affected by perennial water shortages. Other human/agriculture pressures will mean that aquaculture development should involve the use of water for multiple purposes.
- Smallholder aquaculture in Africa, initially integrated with agriculture, will evolve toward partly or completely commercial systems as the demand for fish increases.
- The number of SWBs and reservoirs brought into fisheries and aquaculture will increase along with pond aquaculture.

## **Emerging issues in aquatic resources management**

The exploitation of aquatic resources generates tension over such issues as trade, local and international market competition, demands for fisheries access by foreign fleets, illegal cross-border fishing, and management of shared stocks. Public alarm raised over genetic technologies and intellectual property rights (IPR), as well as global climate change, have added to the already complex issues.

### **Multifunctional uses of aquatic resource systems**

Aquatic resource systems perform direct functions towards assuring food security, reducing poverty and sustaining the natural environment:

- Produce food and non-food products.
- Provide income and livelihoods.
- Provide valuable ecological services (see Box 1).
- Provide non-fisheries-based uses such as shipping and navigation, subsea mining, communications, industrial siting, waste disposal, and off-shore artificial island construction and recreation.

These human activities create further challenges to the sustainable utilization and management of the coastal zone.

## Increasing conflicts over multiple use

Relieving the anthropogenic threats to aquatic resource systems is the greatest challenge since up to one-third of the world's population lives in proximity to a coastline and the bulk of the population resides close to either freshwater or marine systems.

- Rapid developments in the coastal zone that alter environments for human uses present potential conflicts in its sustainable management.
- Coral reef ecosystems abound in tropical seas but human uses of the reefs are now leading to overexploitation and degradation.
- Freshwater fishes are considered the most threatened group of vertebrates. They are heavily exploited and their habitats are stressed.
- For SWBs, communal management has often been established without including fish production. For large water bodies (reservoirs and lakes), management can be complicated by cross-border issues so that an ecosystem approach must be linked to sociopolitical considerations.

Increasing conflicts due to the multisectoral use of aquatic resources and other related developments have led ICLARM to suggest co-management arrangements as one of the most appropriate governance options for many aquatic resources systems.

## Women in fisheries

ICLARM recognizes that women (and children) make highly significant but undervalued contribution to fisheries, aquaculture, fish processing, retailing and fisheries-sector services. Our research shows that IAA technologies adopted by women's groups of poor rural households led to improved income and nutrition. In developing assistance programs for women (e.g., training, micro-credit, access to water bodies), there needs to be a greater understanding of gender roles and relations within the family or household and the institutional contexts within which these roles have evolved through time.

## Aquatic genetic resources, biodiversity and IPR

Policymaking for aquatic biodiversity and genetic resources is far behind that for exploited plant species and terrestrial animals. Proprietary technology and IPR issues, however, will increasingly affect the poor's access to privately held knowledge in biotechnology, potentially denying them the benefits to be derived from such information.

Given the increasing private sector involvement in breed development and vaccine research, ICLARM in continuing its highly successful genetics research must work towards benefiting the smallholder and poorer sections of producers/consumers. ICLARM will place emphasis, for instance, on the genetic enhancement of carps and tilapias in Asia and Africa to produce better stocks. The introduction of genetically improved species, however, has raised new concerns about their possible impact on natural genetic diversity. Biotechnology activities must hence follow high standards of biosafety.

Another issue of general importance to enhanced fisheries is the potential loss of biodiversity as the makeup of the stocked fish can be governed by restricted genetic pools of fish selected for grow-out rates and survival in hatcheries.

## Impacts of global climate change

Climate change will impact aquatic resources, and consequently those who depend on them through changes in precipitation patterns and in atmospheric carbon dioxide concentration; increase in temperature/chemical reaction rates affecting aquatic production; changes in wind and ocean circulation patterns affecting fishing operations and the distribution and abundance of aquatic resources; rising sea levels and shifting coastlines; and increasing scarcity of freshwater. Many of these factors are researchable issues and will have as yet unpredictable impacts on aquatic resource systems.

### Box 1 Ecological services from aquatic resources systems

A recent study (Costanza et al. 1997) has indicated that about 83% of the global value of ecosystem services comes from marine waters, wetlands and lakes/ rivers.

The important ecological services derived from these biomes include: habitat, refugia and nutrients for commercially important food and other useful species; protection of adjacent and downstream land such as agricultural land and villages from erosion, siltation, storm damage, floods and droughts; nutrient cycling; tourism and recreational value; carbon sinks and greenhouse gas regulation; and stores of global climate records (e.g., some massive corals).

### **Technology transfer, growing NARS capacity and the global knowledge system**

There is a worldwide trend towards greater participation in research processes by different user groups. Increasingly, ICLARM will expand its own experience in collaborating with various stakeholders, including NARS partners.

## **Changing development settings**

All-encompassing issues in development, and potentially contentious issues, need to be factored into any strategic planning process. Trends towards a global economy and the increasing privatization of public goods and services are redefining the role and functions of the state towards less direct engagement in production activities and more active involvement in enabling regulatory frameworks and governance. These trends will probably continue well into the next century.

Fewer public resources, however, will translate into less financial resources and technical expertise or less ability to address equity and sustainable development concerns. More reliance on market mechanisms favors exploitation and production of high-value species and not subsistence food species. Technology transfer will become more linked to private investment and alliances will be forged between public and private sector agencies using biotechnology research.

Trade and the investments of the private sector now are larger than government expenditures and development assistance in most developing countries. The creation of the World Trade Organization (WTO) and the emergence of regional trading blocs will mean further reductions to tariffs and other trade barriers. World trade in fish and related products will play an increasing role in fish food security. The interplay of domestic needs and international trade will increasingly make fish a politically sensitive commodity. The rising economic value of the erstwhile “poor person’s protein” may both benefit some producers and countries and place stresses on the poor who increasingly find fish less affordable. The price of fish can be lowered by increasing its supply, but this will require new and more efficient production methods.

Economic recession increases unemployment and exacerbates poverty. It may cause more degradation of the aquatic resource base. Any persistent economic downturn will also slow down financial flows from overseas sources for fisheries investments, thus making domestic credit and investment facilities—especially needed in a rapidly growing aquaculture industry—more important in the short term. Consumers, trading partners and the marketplace will become more discerning of product quality and quarantine, placing their own demands on governments and the aquaculture industry.

# ICLARM's strengths

ICLARM has a broad mandate for research to improve the performance and sustainability of a range of aquatic environments and thereby improve the lives of poor people in developing regions of the world. After 22 years, we have attained a high international standing in LARM research and accumulated a wide range of expertise, tools and knowledge (see Table 2). In addition to science skills and institutional attributes, the Center's strengths include our location in developing countries where we tackle issues directly and have beneficial national partnerships. Our new research site in Abbassa, Egypt allows us to implement strategic research with our own facilities, as well as to offer the opportunity for an enhanced focus and activities in Africa and West Asia. Moreover, ICLARM's entry into the CGIAR has afforded us greater collaborative opportunities across the broad range of the strategic research continuum (e.g., national to international, public to private, upstream to applied).

## ICLARM's advantages

### Established skills

These include expertise in the major aquatic resource systems and encompass:

- tropical fisheries stock assessment and modeling;
- fisheries social science (including cooperative governance arrangements for fisheries);
- the development of relational databases for the processing of secondary data;
- aquaculture and genetics of fish species important to developing countries;
- coral reef research; and
- the low-input mariculture of invertebrates.

### Institutional attributes

We have an extensive track record in conducting successful in-country research with strategic partners. Our world-class scientists are highly skilled in running multisite, multicountry projects and research networks. The scientific rigor and quality control of our outputs has established the Center as a premier source of information on tropical fisheries and aquaculture. This brings the breadth of our scientific talent to focus on integrated natural resource management approaches to aquatic resource issues.

### Partnerships

During its 22 years, ICLARM has developed strong partnerships with national systems (government and nongovernment organizations), ASIs, individual scientists, the private sector and farmers/fishers. These collaborative arrangements in research and related activities aim to strengthen NARS, utilize scarce resources efficiently, achieve quicker gains from strategic research and match complementary skills of agencies. The partner institutions number over 300 worldwide.

### Unique role in the CGIAR and various regional/international fora

ICLARM is the only CGIAR Center dealing with aquatic resources and at the nexus of research on fisheries, aquaculture and aquatic genetic resources conservation in developing countries. ICLARM also plays an active role in international debates and programs on fisheries policies and management, food security and sustainable agriculture, in fora within and outside the CGIAR. We will continue this active role in highlighting aquatic resource issues in various international venues.

### Alternative sources of supply and comparative advantage

We are aware of the competitive nature of research supply as more ASIs from developing countries begin to work in our fields. Frequently, however, apparent alternative sources of supply are not focused on low-income beneficiaries but rather on areas of higher commercial potential. Where greater commonality of purpose exists, we will forge strategic alliances to strengthen the delivery of results for our target beneficiaries.

Table 2. ICLARM's established skills, by aquatic resource system and multiple resource issues in SIDS.

Aquatic resource system	ICLARM's established skills and institutional attributes
Ponds	<ul style="list-style-type: none"> <li>• ICLARM is a major resource provider in the fields of genetics, integrated aquaculture, invertebrate mariculture, and socioeconomics</li> <li>• Focus on poverty alleviation and the systems approach to aquaculture and agriculture</li> <li>• High international standing in genetics through the success of GIFT project</li> <li>• Links to the general improvement of genetic analysis capacity in several NARS in developing countries</li> <li>• High international standing in applied socioeconomic and policy research in the field of fisheries and aquaculture</li> <li>• Many new resources (methods, collaborators in national programs, Advanced Scientific Institutes (ASIs) and commercial enterprises, germplasm, new facilities in Egypt)</li> </ul>
Small water bodies, reservoirs and lakes	<ul style="list-style-type: none"> <li>• Extensive contacts through community-based management work in Asia (e.g., Bangladesh, Philippines) and Africa</li> <li>• Substantial links to Malawi which may be site of further work on SWBs</li> <li>• Many collaborators in ecosystem modelling research</li> <li>• Skills in IAA and co-management can contribute to watershed management</li> <li>• Strong linkages with partner institutes in Asia (e.g. Mekong Basin countries)</li> <li>• In-house capacity in fisheries/biological science and in modelling, co-management and socioeconomic issues, and interdisciplinary research approach</li> </ul>
Floodplains, streams and rivers	<ul style="list-style-type: none"> <li>• Legal and institutional policy and co-management work</li> <li>• Community-based fisheries management work</li> <li>• Strong linkages with partner institutes in Asia</li> <li>• Ability to deliver methods for wide-scale application in this resource system</li> </ul>
Coastal waters (including estuaries and lagoons)	<ul style="list-style-type: none"> <li>• Catalytic role in the introduction of ICZM concept</li> <li>• Legal and institutional analysis of coastal resources co-management</li> <li>• Community-based fisheries management</li> <li>• Specialist knowledge in coastal aquaculture and stock enhancement for developing countries</li> <li>• Tropical fish stock assessment and modelling of multispecies fisheries (e.g., ECOPATH, ECOSIM)</li> <li>• Track record in multidisciplinary and multisectoral integrated coastal fisheries management approach (e.g., San Miguel Bay, Philippines)</li> <li>• Links to South and SE Asian nations for coastal fisheries and co-management, and to Solomon Islands and other Pacific Islands for aquaculture</li> </ul>
Coral reefs	<ul style="list-style-type: none"> <li>• ICLARM's Coastal Aquaculture Centre (CAC) is recognized as one of the major aquaculture research facilities in coral reef organisms</li> <li>• Development of ReefBase</li> <li>• Development of FishBase</li> <li>• Work in research sites in Asia, the Pacific and the Caribbean</li> <li>• Stock assessment, modelling</li> </ul>

**Table 2, continued**

Aquatic resource system	ICLARM's established skills and institutional attributes
Soft-bottom shelves	<ul style="list-style-type: none"> <li>• Stock assessment methods developed for tropical assemblages</li> <li>• Continuing focus on data collection and analysis methods</li> <li>• Number of collaborative arrangements in South and SE Asia</li> <li>• ECOPATH</li> <li>• Earlier detailed biological/mathematical evaluation of the Peruvian ecosystem</li> <li>• General fisheries market economics in relation to world food model</li> </ul>
Upwelling shelves	<ul style="list-style-type: none"> <li>• Past knowledge and fisheries and ecosystem modelling that may be offered to international efforts</li> </ul>
Open oceans	<ul style="list-style-type: none"> <li>• Watching brief for inclusion of species data and fisheries statistics into global studies and databases</li> </ul>
SIDS	<ul style="list-style-type: none"> <li>• ICLARM has a major thrust in coral reef, coastal and related research:               <ul style="list-style-type: none"> <li>– Development of ReefBase</li> <li>– CAC work on coral reef invertebrate species</li> </ul> </li> <li>• MPA evaluation and monitoring work (e.g., in the Caribbean and Solomon Islands) is well placed to contribute to global databases and research on MPAs               <ul style="list-style-type: none"> <li>– Development of FishBase</li> <li>– ECOPATH and its further development will enable a series of steady-state trophic models of coral reefs to be elaborated</li> </ul> </li> </ul>

# ICLARM's strategic research priorities

As a result of ICLARM's priority-setting process based on aquatic resource systems, our research portfolio will show major emphasis on the development of aquaculture in ponds and SWBs; the sustainable exploitation of coral reefs within ICZM; and on generic contributions to tools and knowledge to augment the performance of developing country fisheries.

## Box 2 'Potential beneficiary' populations.

The potential beneficiaries of our research, i.e., poor aquatic resource producers and consumers in the developing world, are likely to be clustered around aquatic habitats, as fish is a perishable commodity subject to post-harvest losses.

- Statistics for developing countries (1994-95 World Bank projections) show 1.2 billion people living in South Asia. A similar number is found in East Asia (but a much higher population growth rate is anticipated in South Asia with projections for this region currently up to 1.83 billion by 2020), and 440 million in Southeast Asia.
- In Sub-Saharan Africa, 53% of the current population of 518 million live in poverty, with total population projections of over 1 billion people in this region by 2020.
- Current populations are lower in Latin America (434 million) and WANA (345 million). In the SIDS, there are approximately 43 million people but as many as 44% of the population live below the poverty line.

ICLARM's evaluation of 'potential beneficiary' populations living within major watersheds or within 60 km of the coast shows that:

- Overall, 50% of developing country populations live within the world's major watersheds.
- Approximately 24% live in the coastal zone. (This latter figure is close to the global percentage when the estimate is conducted on a 60 km buffer zone.) The peninsular and archipelagic countries of Southeast Asia have a high proportion (roughly 80-100%) of their populations living in coastal environments.
- As anticipated, the SIDS have almost their entire populations dependent upon the coastal zone. We will pay special attention to aquatic resource issues in the SIDS and demonstrate the likely spillover effects to other regions with high dependence on aquatic resources.
- In terms of total populations, greater numbers of people in East Asia, South Asia and Sub-Saharan Africa live in proximity to large river and freshwater lake systems than to coastal environments. We will therefore pursue research on inland waters and floodplains and the promotion of freshwater aquaculture of most benefit to these regions. We also recognize that each region would still have substantial numbers of people living in coastal regions and that marine catches contribute to the nutritional support of their populations.

ICLARM will expand its present research focus on ponds, coral reefs and coastal waters, to include other freshwater systems such as lakes, SWBs and floodplains. Our assessments show that these resource systems support large numbers of poor people in developing countries (see Box 2). We will fully exploit the high potentials of these systems for increases in productivity, mainly through the sustainable intensification of aquaculture. We are also constantly aware that all these resource systems are under threat of losing valuable productivity unless better managed.

ICLARM will continue to give priority to Asia, with an expected increasing emphasis on our African regional research. Given a realistic projection of our size and the added reach of our strategic partners, we cannot extend a global coverage to all aspects of our research, except in those studies which will obtain the best predictive viewpoint on behalf of developing countries.

Annex B gives a summary of the current and new research thrusts and outputs of ICLARM based on the priority-setting process.

## Resource system priorities

### Ponds

ICLARM's analysis shows that research on pond aquaculture can provide controllable flows of benefits to the poor if

resource and environmental issues are carefully accounted for. There is a huge unexploited potential for expansion worldwide, not only in terms of area for fish production, but also in fish production per unit area. Pond aquaculture provides fish and other high quality products that can contribute to human protein intake and food security. The fish can be grown near the market. Integrated with agricultural systems, aquaculture provides opportunity to harvest, conserve and store water resources while deriving other benefits. Aquaculture production techniques are relatively simple for communities used to the management of water in agriculture. Production systems can also be diversified to reduce economic risk, while species utilized can be rapidly changed to adapt to tastes or changing market trends. Moreover, there are many potentially valuable species in developing countries that have not been evaluated.

### Small water bodies, reservoirs and lakes

ICLARM has estimated that lakes and reservoirs in developing countries produce about a third of the inland freshwater catch and a relatively small percentage of total aquaculture. With the inclusion of SWBs, however, this resource system is identified as a key area for possible expansion both in extent and productivity. Research impacts on national systems are likely to be high either through increased fish supply and integrated water resource management, or through the development of cooperative management schemes at the village level in countries that have traditionally exploited reservoirs for human and agricultural uses. Key users will be African nations with large lake areas, southern and western Africa for the exploitation of the “new resource” of SWBs, and many Asian countries having extensive reservoir and SWB systems. The principal outcome in large lakes will be cooperative management schemes; with SWBs, the extension of the resource and increased productivity; and with reservoir fisheries, appropriate aquaculture techniques for improved production and sustainability.

### Floodplains, streams and rivers

ICLARM's focus will be on the evaluation and management of floodplain aquatic resources, which contribute substantially to food security of the poor. In floodplains, fish production can be increased considerably. Besides direct benefits from production and income, substantial gains may be derived through system improvements and positive off-site impacts. Since the system is part of a natural resource continuum, both natural and propagated fisheries will have to integrate with agriculture, forestry, agro-forestry and tourism. When focused on floodplain issues, major relevance will be to South Asia and the Mekong Basin countries. Small-scale fishers will be the key beneficiaries of the research on these systems as they are the main harvesters of resources from rivers and floodplains.

### Coastal waters, including estuaries and lagoons

The physical extent of this resource system cannot be enlarged but intensification of use of the coastal zone and its fisheries is likely. Maintaining productivity and diversity in the face of population and multisectoral development pressures will be a challenge. If water quality problems and challenges from land-based activities can be avoided, mariculture can benefit from increasing biological research and technological sophistication. However, effective management in the coastal zone rests on social,

## How fisheries research can benefit the poor

Fisheries and aquatic resource management research can help by:

- conserving and rebuilding fish stocks through providing better information on the sustainable catch levels for the resources
- providing policy advice on management arrangements for common resources
- providing insights into the many external factors impinging on aquatic resource use and management
- providing information which can empower communities to manage their own resources and protect biodiversity and
- creating alternative livelihoods in the coastal zone

Aquaculture research can help by:

- making fish more affordable to consumers through increasing production and improving efficiency of production methods
- adding to the diversification of agriculture and producing a range of products, from food staples to pharmaceuticals and luxury ornaments
- producing profits and income for the farmer and thus assisting rural development
- creating jobs
- rebuilding wild stocks by taking the pressure off over-exploited natural resources and
- contributing to environmental conservation

institutional and legal issues and cooperation. Useful products would therefore be frameworks for conceptualizing research problem hierarchies or identifying key individual biophysical constraints for further research. Key research beneficiaries are likely to be NARS, NGOs and development agencies in Asia and the Pacific where ICLARM has the most contacts.

### **Coral reefs**

The productivity of coral reef systems is extraordinarily high. The global extent of this area has been estimated at between 620,000 km<sup>2</sup> and 2.6 million km<sup>2</sup>. Coral outcrops make use of trawls and most other modern industrial fishing gears infeasible. Coral reef systems are therefore the domain of the artisanal fisher using a wide variety of small-scale fishing gears. Different systems of tenure, ownership or access to coral reef resources have evolved, leading to a wide range of problems in conserving and managing the resources. Gender and age-related issues are important, particularly where degradation of reef systems leads to a major loss of food and income derived from gleaning shallow reef areas, an activity which is normally undertaken by women and children. Overexploitation can be countered by effective management of the fishery, including the use of stock enhancement techniques and by the development of marine fishery reserves or MPAs.

### **Multiple resource issues in SIDS**

Most SIDS are dependent upon coastal, coral reef and offshore aquatic resources. The selling of tuna licenses for fishing rights in their exclusive economic zones (EEZs) to overseas fishing fleets is a major national income-earner. Overfishing of coral reef species, particularly invertebrates (e.g., trochus, green snail, giant clams, and sea cucumber) has endangered these species, to the extent of being extinct in some states. The threats may alter coral reef community structures irreversibly. Climatic disturbances (e.g., hurricane, monsoons, global warming) can also have exacerbating effects on coastal and coral reef resources already stressed by terrestrial pollution and sedimentation and over-exploitation (e.g., coral reef bleaching). Moreover, the lack of substantial alternative livelihood generation increases pressure on coastal and coral reef resources.

## **Regional distribution of effort**

We based our regional priorities on a balance of existing production systems and NARS capacities, as well as the imperatives for research in the developing regions. In Asia, fisheries and aquaculture production is large, bringing benefits and in some cases, environmental risks to several sectors of society. ICLARM is well-established in the region where we have strong NARS partnerships. In Africa, on the other hand, there is intensive production from West African coastal fisheries and from lakes. In a continent where food security is paramount, there is an unrealized potential for greater fisheries and aquaculture production; NARS aquatic resource research capacities, however, are relatively weak.

### **Asia**

We will maintain our focus on Asia which is the major producer and consumer of aquatic produce and has a burgeoning population at the greatest risk from damaging the environmental base on which sustained productivity depends. ICLARM recognizes the benefit of integrated approaches to analyse and provide equitable sharing of the common property resources utilized by poor people (e.g., in Mekong Basin and Bangladesh). Floodplains will be an additional area of interest following the heightened awareness of the subsistence use of these resources by the poor countries in the region (e.g., Bangladesh, eastern India, and Mekong Basin countries).

**Africa**

We will continue to add new directions to our work in Africa. On this continent, we will take advantage of new opportunities to introduce aquaculture and to exploit SWBs with the principal aim of enhancing food security. We will commence new research on lakes/large reservoirs, SWBs and coral reef systems. We will also undertake capacity building as a key activity.

**WANA**

We aim to be a source of fisheries, biodiversity and holistic management advice for the whole of the African region, drawing on our new infrastructure in Egypt. We are cognizant that countries of the WANA region are constrained by water availability, and that fish production will be but one of the multipurpose uses of freshwater in a region which is not highly dependent upon fish. Our presence in the Egyptian delta will ensure that the results of our aquaculture enhancement research will be rapidly made available to countries of the region able to exploit such integrated approaches.

**SIDS**

We will continue to consider the SIDs (largely the nations and territories of the Caribbean and Indo-Pacific) as critical clients for our research outputs because of their near complete reliance on aquatic resources for food security, livelihood and income generation. From past experience, we are confident that the results from our applied coral reef studies and coastal management will be directly applicable to similar habitats in other countries, particularly to regions of Southeast Asia.

**Latin America**

We have not prioritized mainland Latin America as a principal area of research as both offshore fisheries and rapidly emerging aquaculture industries are highly commercialized, often akin to those in developed countries. We will, however, seek to extend our generic technologies (e.g., trawl data analysis, economic analysis, and small-scale aquaculture approaches) to NARS of the region as appropriate.

# Implementation

ICLARM outputs will be in the form of new knowledge (made freely available as international publicgoods), global databases and models of fisheries and other aquatic ecosystems, improved germplasm and aquaculture practices for species useful to poor people. To meet the challenges to the year 2020, ICLARM must anticipate the supply and demand for aquatic resources research, and continue to explore and promote appropriate roles for aquatic resources in economic and social development. As we shift from a technology perspective towards a more holistic understanding of the aquatic resource development process, we will draw upon our experience of a resource systems approach to research and management. We will conduct research with a view to production today and tomorrow, i.e., aiming to preserve the environment and thus the intergenerational equity of benefits.

Towards this end, ICLARM will continue its role in facilitating and coordinating the conduct of multi-country and multisite projects in tropical aquaculture and fisheries appropriate to developing countries. Our research will provide the scientific underpinning for policy or management advice in aquatic resources geared towards relevant decision-makers. We will augment our research capacity and expand our access to laboratory facilities through increased collaborative research with ASIs and visiting scientists in complementary disciplines. We will link research to regional foci in relevant in-country studies and catalyze internationally relevant work through collaboration and partnerships with NARS. The general research areas outlined in the Strategic Plan will be addressed through a series of research programs and project activities to be specified in ICLARM's regular Medium Term Plans and annual Operational Plans.

## Modes of action

### Research approaches

These include the following:

- Ecosystem approach. Over the past 22 years, we have developed, in partnership with others, ecosystem models which can now be used to simulate the effects of fishing and other anthropogenic or biophysical interventions on productivity and catches in multispecies tropical fisheries. We will apply these skills to habitats within resource systems or, eventually, to whole resource systems with the development of appropriate integrated methods. This approach will also depend upon information from genetic, population and community structure levels of analysis. We will continue to develop FishBase, ReefBase and TrawlBase as on-line providers to ecosystem analysis. Together with resource valuation techniques, these databases will be central to ICLARM's research in the next decade.
- Development of integrated aquaculture technology. We will adopt a systems approach to aquaculture technology development, especially on ponds, SWBs and coral reef resource systems, including constraint analysis. The wider adoption of aquaculture practices will lead towards the diversification of fisheries and agricultural products and more sustainable management efforts. Aquaculture has a major role to play in food security in the coming decades and research will be structured to maximize contribution to this goal.

- **Aquatic genetic research.** We believe that aquatic biodiversity is the key to the productivity and services offered by many differing marine, coastal and freshwater habitats to numerous users. We recognize that the evaluation, conservation and appropriate use of aquatic genetic biodiversity are critical to many issues we seek to address, including aquaculture improvement, stock enhancement, definition of ecosystem parameters and the sustainable size of stocks under fishing pressure, among others. We will build upon the success of our work on genetically improved fish tilapia (i.e., the GIFT project) to strengthen our genetic research capacity, maintain our contributions to guidelines for such issues as species introductions and IPR, and provide expert advice to developing countries.
- **Governance.** We intend to continue our research contributions in community-based and co-management methods, as well as into the legal and institutional governance frameworks in developing countries. ICLARM will disseminate its scientific findings to assist policymakers. The equitable exploitation of aquatic resource systems, and the extension of the resource base for fisheries and aquaculture, depend upon access, tenure and governance arrangements.
- **Impact analysis.** We will continue to expand our approaches to impact assessment as a planning tool to evaluate new technologies, the importance of aquatic resources, the value of our research and to help set future priorities on a continuous basis. Our ex ante impact assessment of new genetic technologies has led to insights into research priority-setting, aquaculture practices and market preferences. In the next decade, we will construct indicators and methodological approaches to effectively evaluate the impacts of our research and management activities.
- **Monitoring future global issues.** We will maintain our special interest in globally important issues such as IPR and climate change. Our strategic approach, however, has been predicated on addressing immediate issues of productivity and sustainability in developing countries under current laws and climate regimes. Nevertheless, in the same way that better genetic knowledge and appreciation of aquaculture and resource issues can help inform debates about IPR over aquatic genetic resources, so will we continue to implement several programmatic and generic approaches which could contribute to climate change research in the coming decades. Constant awareness and monitoring of global aquatic resource issues will allow us to establish periodic review of parts of our Strategic Plan in an 'evergreen' approach.
- **Multidisciplinarity.** Our research will involve multidisciplinarity, the weaving together of the relevant biophysical, socioeconomic, legal and institutional influences. We will remain flexible and introduce knowledge from new fields (e.g., information technology, social science, hydrodynamic flow models, fish immunology, molecular biology, genomics) to contribute to the development of complete management scenarios.

### **Balance of research portfolio**

ICLARM currently expends approximately 25% of its research funds on generic research (to underpin knowledge gathering, model-building, awareness and dissemination) and about 75% on regional research, i.e., research with a more direct regional application and impact. We intend to maintain this distribution in the Plan period. We also expect to increase our African research portfolio to approximately one third of total regional research activities by 2005. We will continue to operate a headquarters at which the bulk of generic analyses, database development, policy formulation work and information dissemination will be carried out.

### **Partnerships and strategic alliances**

We believe that our research work will be most successful when undertaken in partnership with NARS and other key stakeholders, and with the participation of the users of the research results. Our partnerships are formally recognized, collaborative, mutually beneficial research and research-related

undertakings (e.g., training, information dissemination, publication exchange). We will maintain our strong alliances with a large number of ASIs (both from developed and developing countries) and regional and international organizations in fisheries science and management. We will also continue to coordinate international networks geared to address discipline-based issues on management and sustainable development of living aquatic resources. We regard and will actively seek private sector partnership as an important means for furthering our research, helping to disseminate the products and results of our research, and as a source of financial and resource support.

### **Capacity-building in partnership with NARS**

We have become increasingly aware that our products must be geared for fisheries and resource managers and policy makers if they are to reach target beneficiaries. We will continue to provide expert management or policy advice focused on the aquatic resources sector. Through collaborative research projects and training, we will endeavor to form a cadre of NARS researchers and managers who are better able to make decisions based on the newer paradigms and approaches to fisheries management for long-term benefits to developing countries.

### **Communication with stakeholders**

ICLARM will make use of new information technology, conferences, workshops, scientific publications, networks and the public media, to publicize its research approaches and findings for enhanced management of tropical aquaculture and fisheries and the preservation of the environment for the future. New knowledge and evolved practices will be utilized in the development of integrated management plans for a number of aquatic resource systems. ICLARM is aware that, increasingly, its products must be geared for fisheries and resource managers and policy makers if they are to benefit from the holistic approach. The dissemination of new knowledge and improved technologies will be undertaken in tandem with opportunities to enhance the managers' capacity to make decisions. The World Wide Web offers new opportunities to link partners, access remote information and increase powers of analysis.

### **CGIAR links and contributions**

ICLARM's entry into the CGIAR has expanded the CGIAR's research portfolio into the management of fisheries and other aquatic resources, an area which was not previously addressed. We will continue to highlight issues regarding the interaction of terrestrial (including agricultural and forestry practices) and downstream effects on coastal and marine systems and the fishers whose livelihoods depend on these systems. We will also maintain our links and collaborative efforts within the CGIAR System since we believe that inter-Center collaboration promotes synergies, as well as results in harmonized policies and standards.

### **Governance of the Center**

We seek to have a Board of Trustees and Management Team of high competence, appropriately diverse in its human make up and skills base, who will responsibly carry out its task of guiding the Center through planning, policy making and the monitoring of performance.

### **Developing internal capacity**

In pursuing aquatic resources research, we will develop, implement and administer programs and activities designed to attract, motivate and retain an excellent scientific and corporate staff complement. We recognize and encourage the development of individual scientific career paths in line with ICLARM's research mission. We will seek to provide a supportive environment for career advancement of staff irrespective of gender and cultural background. We will augment our institutional knowledge base through programs involving visiting scientists, continuous contacts with our 'alumni', research contracts with ASIs, and generally enhancing scientific collaboration and interchange.

## **Resource mobilization**

We will endeavor to mobilize sufficient resources in an effective and efficient manner to meet our research and management objectives as described in this Plan, and to achieve the program goals that will be formulated in greater detail in the interim Medium Term Plans. We will improve our interactions with donors (currently numbering 40) to ensure their awareness of the Center, our accomplishments and the contribution aquatic resources research can make to international development. We will seek to broaden our donor base, past the traditional donors, to include, e.g., private industry and foundations, and work with these donors to evolve new development strategies. Correspondingly, we hope to become better aware of donor priorities and constraints so as to develop research appropriate to donor concerns within the framework of the Center's vision, mission and goals. To be effective, we will take steps to enhance the skills of our staff in fundraising.

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# Annexes

## A. Definitions of resources and regional groupings

### Resource systems

- Ponds: PONDS are small freshwater bodies, usually artificial, occasionally natural, in rainfed and irrigated areas where aquaculture, particularly integrated with agriculture, is possible. Flooded rice fields are hence considered as ponds. Ponds are normally characterized as being under private individual or group ownership or leasing arrangements.
- Small water bodies, reservoirs and lakes: SMALL WATER BODIES are bodies of water of less than 200 ha that are permanently or seasonally filled with water. RESERVOIRS are natural or artificial water bodies, primarily used for irrigation, hydroelectric power and domestic water supply. LAKES are natural water bodies. The latter two are usually freshwater bodies and have high potential for aquaculture and conventional or enhanced capture fisheries. They are usually considered common property and may offer free access for fishing or aquaculture sites. However, in some cases, rights are leased from the government or from other authorities, groups or individuals.
- Floodplains, streams and rivers: STREAMS and RIVERS are flowing waters while FLOODPLAINS are the lowland areas, adjacent to watercourses that are subject to periodic or near-permanent inundation and sediment deposition. Streams, rivers and floodplains support substantial inland fisheries and have potential for enhanced fisheries. Normally all these systems are common property and have open access, except where access and/or ownership attached to surrounding lands restricts this.
- Coastal waters, including estuaries and lagoons: ESTUARIES are semi-closed coastal water bodies with free connection to the open sea and within which seawater is diluted with freshwater from land drainage (i.e., brackishwater). LAGOONS are shallow water bodies resembling ponds or lakes, which usually have one or more shallow restricted outlets to the sea. This grouping includes the key habitats, such as mangrove, that support coastal fisheries. It also has potential for aquaculture and for enhanced fisheries. COASTAL WATERS out to 10 m in depth are included here to encompass most fishing grounds of small-scale fishers. These areas are usually directly adjacent to soft-bottom shelves, leading to conflicts with the (trawl) fisheries operating there. Brackishwater ponds are included in this system. They are either natural or human-made; often the result of conversion of mangrove swamps. This resource system interfaces with terrestrial land use in the coastal zone and is often an area of intense intersectoral conflict over competing uses.
- Coral reefs: CORAL REEFS are areas of continental and island shelves in tropical oceans in which reef-building corals are dominant features, forming scattered patch reefs, fringing reefs or barrier reefs and usually large areas of shallow coralline enclosed waters. The latter have potential for aquaculture. This is often an area of intensive fishing and gleaning. There may be traditional use rights but reefs are often considered open access.
- Soft-bottom shelves: SOFT-BOTTOM SHELVES are relatively shallow (up to 10-200 m deep) productive areas surrounding continents. In the tropics, it is mainly the upper, nearshore parts (10-50 m) of the shelves which sustain marine fisheries. There are strong interactions (and conflicts) between nearshore small-scale fisheries and large-scale commercial operations.
- Upwelling shelves: UPWELLING SHELVES are regions of the continental shelves characterized by upwelling—the process in which cold, nutrient-rich water is brought to the surface of the sea from deeper layers. This process mainly occurs on the eastern side of oceans, driven by interaction of strong

and steady winds directed towards the equator and the earth's rotation. The upwelled water fertilizes the sea, enabling the support of large populations of a few species of small (anchovies and sardines) and large (bonitos, mackerels) pelagic fishes. These areas also support large populations of sea birds and sea mammals. In addition to the four major upwelling areas (off Peru, California, North West Africa and Angola/Namibia), scattered smaller upwellings occur throughout the tropics, e.g., in the Arabian Sea and Indonesia. In most cases, upwellings are fished by medium- to large-scale industrial fishing vessels.

- Open oceans: OPEN OCEANS are defined as the open seas beyond 200 m depth, where mainly oceanic resources such as tuna and large squid are fished by commercial or large-scale enterprises.

### **Regional groupings (of developing countries adopted for planning purposes)**

- South Asia: This grouping includes Bangladesh, Bhutan, India, Nepal, Pakistan, Sri Lanka and Myanmar.
- East Asia: The region is confined to the Democratic People's Republic of Korea, Mongolia, China and the Republic of Korea.
- South East Asia: The countries of Southeast Asia include Brunei, Indonesia, Malaysia, Philippines, Taiwan, Thailand, Kampuchea, Laos and Vietnam.
- Sub-Saharan Africa: The region covers the African continent and Madagascar, except for the North African states bordering the Mediterranean (including Morocco).
- West Asia/North Africa (WANA): The region encompasses 19 states from Afghanistan in the east, Turkey in the north east; and the North African States to Morocco in the west.
- Latin America: This grouping includes all countries of peninsula South America from Mexico southwards to Argentina.
- Small Island Developing States (SIDS): The SIDS is not a contiguous region but a collection of 29 states, largely from the Caribbean, and Indian and Pacific Oceans (although Cape Verde and Cyprus are included).

## B. ICLARM'S current and new research thrusts and outputs

Ponds				
Main features	Main issues and opportunities	Current research	New research	Outputs
<ul style="list-style-type: none"> <li>• Small freshwater (sometimes brackishwater) bodies</li> <li>• Usually artificial</li> <li>• Occasionally natural</li> <li>• In rainfed and irrigated areas where aquaculture is possible, particularly integrated with agriculture.</li> <li>• Most "manageable"</li> <li>• Normally characterized under private individual or group ownership or leasing arrangements.</li> <li>• Farmers usually exercise rights.</li> </ul>	<ul style="list-style-type: none"> <li>• Intensify aquaculture or increase productivity with-out environmental consequences</li> <li>• Ensure equity of benefits to small-holder/poor sectors</li> <li>• Overcome adoption failures</li> <li>• Structure input supply and markets</li> <li>• Integrate aquaculture with multipurpose use of water</li> <li>• Develop quarantine guidelines</li> <li>• Conform germplasm transfer with national codes of practice</li> <li>• Husband existing biodiversity</li> </ul>	<ul style="list-style-type: none"> <li>• Improvement of freshwater pond aquaculture</li> <li>• Strategic genetic enhancement research in member countries of INGA network</li> <li>• Field assessment and introduction of integrated aquaculture systems to countries in Asia and SSA</li> <li>• Rice-field systems research</li> </ul>	<ul style="list-style-type: none"> <li>• Extension of aquaculture research to Africa, including linkages with regional networks</li> <li>• Genetic improvement for adaptive traits, including disease resistance</li> </ul>	<ul style="list-style-type: none"> <li>• New and improved breeds of freshwater fish species</li> <li>• Better management of fish health and institutional advances to be incorporated into sustainable management schemes for pond aquaculture</li> <li>• Policy advice on the means to establish aquaculture according to biophysical and social parameters</li> </ul>

Small water bodies, reservoirs and lakes				
Main features	Main issues and opportunities	Current research	New research	Outputs
<ul style="list-style-type: none"> <li>• Includes large freshwater lakes (of great importance to SSA)</li> <li>• Includes reservoirs (which provide important inland fisheries in both African and Asian countries)</li> <li>• Includes SWBs (50,000-100,000 in East and Southern Africa alone)</li> <li>• In some cases, rights are leased from government or other authorities, groups or individuals</li> </ul>	<ul style="list-style-type: none"> <li>• Initiate aquaculture and conventional/enhanced capture fisheries</li> <li>• Enhance yields from reservoirs</li> <li>• Promote additional uses of SWBs</li> <li>• Consider SWBs as large aquaculture ponds-research on fertilization, harvest techniques, species mix and ecosystem modification</li> <li>• Introduce and adopt community management practices</li> </ul>	<ul style="list-style-type: none"> <li>• Management and introduction of new approaches on seasonal water bodies in Bangladesh and Malawi</li> </ul>	<ul style="list-style-type: none"> <li>• Development of knowledge about these systems through involvement in key areas</li> <li>• Focus on lake management for Lake Nasser as an example of the reservoirs/great lake system of Africa</li> <li>• Focus on small water bodies in Southern Africa</li> <li>• Adoption of appropriate practices</li> </ul>	<ul style="list-style-type: none"> <li>• Additional water bodies for fish production</li> <li>• Recommendations on appropriate management schemes</li> </ul>

Floodplains, streams and rivers				
<p><b>Main features</b></p> <ul style="list-style-type: none"> <li>• Inland water bodies already in use or have potential for enhanced fisheries</li> <li>• Often become part of a single fishery production system during rainy season, but with different biophysical characteristics and property rights regimes</li> <li>• Normally common property and have open access, except when restricted by ownership attached to surrounding lands</li> </ul>	<p><b>Main issues and opportunities</b></p> <ul style="list-style-type: none"> <li>• Develop potential for capture fisheries, culture-based/enhanced fisheries and various forms of aquaculture</li> <li>• Build up the knowledge base on floodplain systems and their access rights to reverse inappropriate policies and strengthen institutional support</li> <li>• Address threats of reduction in catches</li> <li>• Prevent loss of biodiversity due to habitat alteration</li> </ul>	<p><b>Current research</b></p> <ul style="list-style-type: none"> <li>• Burgeoning work in Bangladesh</li> <li>• Resource analysis in Mekong Basin countries</li> </ul> <p><b>New research</b></p> <ul style="list-style-type: none"> <li>• Studies to arrest biodiversity loss, and to increase or maintain fish production</li> <li>• Research methods and data appropriate to improve policy decisions and establish adequate institutional frameworks</li> <li>• Improved access to and use of flood-</li> </ul>	<p>plain resources to gain high gender benefits</p> <ul style="list-style-type: none"> <li>• Appropriate ecological-economic models</li> <li>• Integration of ecological, institutional and policy analyses</li> <li>• Valuation of resources</li> <li>• Action plans to mitigate threats</li> <li>• Technical, policy and legal research governing intersectoral use allocation</li> <li>• Focus on Mekong Basin countries and humid South Asia</li> <li>• Appropriate methods and models applicable to SSA</li> </ul>	<p><b>Outputs</b></p> <ul style="list-style-type: none"> <li>• Evaluation of key water basin resources and their uses</li> <li>• Enhanced knowledge of threats and opportunities to the productive exploitation of these resources</li> <li>• Policy advice based on legal and institutional analyses for the multisectoral use of specified floodplain resources</li> <li>• Action plans for conservation and sustainable use</li> </ul>

Coastal waters (including estuaries and lagoons)				
<p><b>Main features</b></p> <ul style="list-style-type: none"> <li>• Includes estuaries, lagoons and immediate inshore coastal waters and interface with terrestrial influences on coastal zone</li> <li>• Often an area of intense intersectoral conflict over competing uses</li> <li>• Brackishwater ponds are included (ICLARM has considered production from marine aquaculture to come from this resource system rather than coral reefs)</li> </ul>	<p><b>Main issues and opportunities</b></p> <ul style="list-style-type: none"> <li>• Redress lack of institutional coordination and integrated policies/actions</li> <li>• Examine high levels of fishing effort and overfishing of coastal stocks</li> <li>• Investigate increase in aquaculture/mariculture activities leading to mangrove deforestation</li> <li>• Reduce stress on coastal environments from land-based activities</li> <li>• Address inadequate information and research inputs, policy and legal framework</li> <li>• Overcome constraints in technical development of aquaculture technologies</li> </ul>	<p><b>Current research</b></p> <ul style="list-style-type: none"> <li>• Co-management of coastal and fisheries resources</li> <li>• Planning for integrated resource use</li> <li>• Coastal aquaculture</li> <li>• Stock enhancement</li> <li>• Train-Sea-Coast program node for ICZM training</li> </ul> <p><b>New research</b></p> <ul style="list-style-type: none"> <li>• Institutional and legal analyses</li> <li>• Validation of governance mechanisms over common resources</li> <li>• Definition of appropriate use of degraded habitat (e.g., mangroves/shrimp ponds) and means to introduce</li> </ul>	<p>sustainable aquaculture</p> <ul style="list-style-type: none"> <li>• Development of operating policy frameworks to reduce resource use conflicts and improve productivity</li> <li>• Focus on SEA (including Mekong Basin countries)</li> <li>• Transfer of experience to regions supporting critical fisheries in SSA</li> <li>• Evaluation of the evolution and development of aquaculture systems</li> <li>• Application of genetic enhancement techniques to marine species in future</li> </ul>	<p><b>Outputs</b></p> <ul style="list-style-type: none"> <li>• Methods for sustainable aquaculture and/or stock enhancement of species at risk in developing countries</li> <li>• Social analysis of the means to maintain cooperative management arrangements</li> <li>• Policy advice based on framework analysis for the multisectoral use of coastal resources in tropical areas</li> </ul>

Coral reefs				
Main features	Main issues and opportunities	Current research	New research	Outputs
<ul style="list-style-type: none"> <li>• Areas of continental and island shelves in tropical oceans with dominant reef-building corals</li> <li>• Corals form scattered patch reefs, fringing reefs or barrier reefs</li> <li>• Usually large areas of shallow coralline enclosed waters</li> <li>• Generally the domain of the artisanal fisher using a wide range of small-scale fishing gears</li> <li>• Often are areas of intensive fishing and gleaning</li> <li>• Often considered open access although traditional rights regimes may exist</li> <li>• Provide fish and invertebrates important for low income groups</li> </ul>	<ul style="list-style-type: none"> <li>• Examine overfishing and degradation of reefs caused by land-based practices</li> <li>• Implement integrated coastal area management properly</li> <li>• Develop appropriate use of protected areas for conservation and restoration of key resources</li> <li>• Document the resilience and recovery of the reefs</li> <li>• Develop aquaculture systems within coral reef lagoons</li> <li>• Impress the impacts of increases in sea level and water temperatures on coral reefs and dependent people</li> </ul>	<ul style="list-style-type: none"> <li>• Sustainable exploitation of coral reef resources by and for poor people</li> <li>• Storage of available data and information on global reefs initiated in Reef-Base</li> <li>• Knowledge of coral reef biodiversity and stock enhancement measures</li> <li>• Development of scientific basis for MPAs</li> <li>• Sustainable offtake levels to avert degradation</li> <li>• Alternative livelihood strategies for coastal dwellers</li> </ul>	<ul style="list-style-type: none"> <li>• Coral reef management within ICZM</li> <li>• Development of culture, farming and stock enhancement systems for selected species</li> <li>• Indicators of reef health for improved management of MPAs</li> <li>• Size and siting of MPAs and their ability to rehabilitate the ecotrophic structure of coral reef communities</li> <li>• Regional focus on SIDS of the Pacific and Caribbean and on coral reef areas of Southeast Asia and East Africa</li> </ul>	<ul style="list-style-type: none"> <li>• Indicators of coral reef health and their incorporation into global analyses and databases</li> <li>• Knowledge of reef interconnectivity and coordinated management requirements</li> <li>• Monitoring of selected coral reefs and awareness of sustainable management options</li> <li>• Scientific guidelines for the deployment and use of MPAs</li> <li>• Management advice for the cooperative management of fisheries conservation areas and the sustainability of coral reefs and their fisheries</li> </ul>

Soft-bottom shelves				
Main features	Main issues and opportunities	Current research	New research	Outputs
<ul style="list-style-type: none"> <li>• Relatively shallow (10-200 m deep) productive areas surrounding continents in the tropics, mainly the upper, near-shore (out to 50 m) of the shelves which sustain marine fisheries</li> </ul>	<ul style="list-style-type: none"> <li>• Reduce overfishing and rebuild fish stocks needed in many areas</li> <li>• Develop methodologies for improved fisheries management</li> <li>• Monitor biological interactions and environmental impacts with other resource systems</li> <li>• Maintain efficiency despite bycatch and postharvest losses</li> <li>• Research on how fluctuations affect availability and cost of fish for poor people and influence opportunities for aquaculture in developing countries</li> </ul>	<ul style="list-style-type: none"> <li>• Study major contributions to trade and consumption statistics</li> </ul> <p><b>Current research</b></p> <ul style="list-style-type: none"> <li>• Development of ecosystem models applicable to different types of fisheries globally</li> <li>• Collaborative data analysis of trawl surveys in Asia aimed at predicting sustainable biomass targets for coastal fisheries</li> </ul>	<ul style="list-style-type: none"> <li>• Consolidation, analysis and broad dissemination of trawl research results and other fishery information to partner NARS</li> <li>• Trawl study analysis concentrated largely in Asia</li> <li>• Methodologies to be extended to collaborating NARS and ASIs in Latin America and Africa</li> <li>• Methods and approaches arising from underpinning generic research</li> </ul>	<ul style="list-style-type: none"> <li>• An ecosystems approach to fisheries management</li> <li>• Management plans for selected coastal fisheries including tools for the evaluation of biological and economic trends</li> <li>• Supply and demand evaluation and their implications for poor coastal dwellers</li> </ul>

Upwelling shelves				
Main features	Main issues and opportunities	Current research	New research	Outputs
<ul style="list-style-type: none"> <li>Upwelling is a process in which cold, nutrient-rich water is brought to the surface of the sea from deeper layers</li> <li>Mainly occurs on eastern side of oceans</li> <li>Driven by interaction of strong and steady winds directed towards the equator and earth's rotation</li> <li>Upwelled water fertilizes the sea, enabling the support of large populations of pelagic fishes</li> <li>Areas also support large populations of sea birds and sea mammals</li> </ul>	<ul style="list-style-type: none"> <li>Gross production from major upwelling regions in developing countries is estimated at 38% of total developing country marine catch</li> <li>Overfishing and oceanographic phenomena are major influences</li> <li>High investments in fishing gear needed to exploit the resource</li> <li>Little direct benefit for the poor</li> <li>Roughly one third of catch is converted to oils and fish meal for livestock and aquaculture feeds</li> </ul>	<ul style="list-style-type: none"> <li>Monitoring of production and trade statistics for effects on world catches and knock-on effects on the aquatic resources sector</li> </ul>	<ul style="list-style-type: none"> <li>No direct research on aquatic resource system</li> <li>Watching brief on productivity of upwelling systems (particularly in Africa)</li> <li>Monitoring influences of catch on trade and other developments in aquaculture nutrition</li> </ul>	<ul style="list-style-type: none"> <li>Generic ecosystem models incorporating data from upwelling systems</li> <li>Supply and demand models incorporating data from upwelling systems</li> </ul>

Open oceans				
Main features	Main issues and opportunities	Current research	New research	Outputs
<ul style="list-style-type: none"> <li>Vast in extent</li> <li>Relatively unproductive per unit surface area</li> <li>Mainly exploited by industrial fishing nations</li> </ul>	<ul style="list-style-type: none"> <li>Need major research resources and capacity to gain good knowledge of fish populations, population dynamics and ecosystem functioning of open ocean proficiently</li> <li>Prevent extinction of top predators</li> <li>Develop novel methods to ensure sustainability of catch</li> <li>Safeguard territorial waters, which enclose open ocean territory, as a major resource base in SIDS</li> <li>Derive income from</li> </ul>	<p>fishing access fees and some oceanic catch from domestic fleets, a dominant source of national income for most SIDS</p> <ul style="list-style-type: none"> <li>Prepare for large-scale events, such as El Niño, that have major effects on distribution and abundance of fish and success of fishing</li> </ul> <p><b>Current research</b></p> <ul style="list-style-type: none"> <li>Included in global fisheries models</li> </ul>	<ul style="list-style-type: none"> <li>No open ocean research directly</li> <li>Monitoring world catch statistics and trade</li> <li>Opportunities to utilize secondary data in ecosystem and fisheries analyses</li> <li>Information on advances in ecosystem modelling, stock detection and management advice to benefit SIDS and NARS in relevant developing countries</li> </ul>	<ul style="list-style-type: none"> <li>Global models of biodiversity and fisheries incorporating open ocean fisheries data</li> <li>Global economic demand and supply models including open ocean fisheries data</li> </ul>