Effective and sustainable management of inshore fisheries resources is a goal of many countries. It is now apparent, however, that such aspirations cannot always be met nationally. The paper by Ablan et al. in this issue entitled “Meso-Scale Transboundary Units for Management of Coral Reefs in the South China Sea” makes this point well. Even for relatively site attached coral reef fish, their data show genetic affinities among individuals at scales that transcend national boundaries. The implications are clear: nations must be prepared to co-operate to manage coastal fisheries resources. The alternative is that good management practice by one country may be undone by a neighbor.

The importance of reliable information on the genetic structure of stocks should not be under-estimated. Different population units can have varying rates of growth and reproduction, and there is often limited scope for an overfished population unit to be replenished from an adjacent one. Unless we know what we are managing, efforts to involve communities in decision making, develop access rights, reduce catch to restore spawning biomass, etc. may miss the mark. In particular, if we do not know the area used by a ‘stock’ (population unit) we cannot reliably identify the stakeholders and invite them to the table to develop co-operative management measures.

In tropical multi-species fisheries, the task of identifying the number and extent of discrete populations units for each species is daunting. But is there any alternative? Ablan et al. considered whether the Large Marine Ecosystem units identified for Asia may simplify the process, but then go on to show that the South China Sea LME may need to be subdivided into at least four management units for coral reef fishes. They also point out that the spatial distribution of their sampling was not fine enough to determine whether these four areas should be subdivided further. This raises the possibility that more intense sampling may lead to identification of several population units within national boundaries. Indeed, there is a growing body of information to suggest this may be the case for some tropical marine invertebrates. In such situations, the co-operation needed to manage the fishery is at the scale of coastal communities, not nations. The important point, however, is that we need to know the size and distribution of the population unit we are managing – only then can we identify whether the resource needs to be managed together with a neighboring country. When there are multiple population units within national borders, it will be important to determine whether they have such similar characteristics that they can be managed nationally, or whether they are best regulated individually.

Fortunately the tools to discriminate among ‘stocks’ are now readily available. All that remains is to apply them to provide a solid foundation for the sustainable management of coastal fisheries.

Johann Bell
WorldFish Center

World population is expected to increase in the next 25 years to 8.5 billion from the present 6 billion and to meet the demand from increasing population and expected higher consumption of fish with improved lifestyles, meat and fish production have to double to meet the demand. While fish is the fastest growing source of food in developing countries and contribute to over 73% to global production of food fish, the ability of the resources in their present condition in meeting the future demand is being questionable. The resources are already under stress and depleted from over-exploitation, pollution, destruction of habitats, rapid changes in land use patterns and other environmental stresses. Coupled with this the increasing demand and higher prices is encouraging greater investments in fishing to the detriment of the industry. Increasing export trade in fish is shifting food resources from the poor in developing countries who are highly dependent on fish in their diets and for livelihoods, increasingly making them insecure.

There is increasing recognition of the need for the sustainable management of resources. This is evident from the several goals and targets set by the recently concluded World Summit on Sustainable Development, which made a commitment to restore where possible fish stocks to their maximum sustainable yields by 2015. However the action to date does not commensurate with the seriousness of the situation or the urgency of the commitment. This is not an issue that can be addressed by a single institution or State but needs the commitment of all those involved in the use and management of resources. Realising this, the WorldFish Center launched the Fish For All initiative at the Fish For All Summit on 3 November 2002 in Penang, which was attended by over 300 participants from 40 countries, representing fisheries specialists, development assistance experts, fishers organizations and civil society representatives. The Summit has highlighted the challenges the world is facing today in managing the resources and stressed the need for consolidated efforts in addressing the problems that restrain the sustainable management and use of resources. The initiative is being coordinated by the WorldFish Center with the guidance of a global Steering Committee chaired by Prof. M.S. Swaminathan, winner of the first World Food Prize and Chair of UNESCO Cousteau Chair in Ecotechnology and eminent personalities all over the world as members. Preliminary outcomes of the Summit are presented in this issue. More details will follow in the Summit proceedings that will be released early in 2003.

Modadugu V Gupta
Our commitment: WorldFish Center is committed to contributing 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 thrusts are:
• improving productivity;
• protecting the environment;
• saving biodiversity;
• improving policies; and
• strengthening national programs.

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

Our corporate makeup: WorldFish Center is an autonomous, nongovernment, nonprofit organization, established as an international center in 1977. The center is an operational entity with programs funded by grants from private foundations and governments.

WorldFish Center is governed by an International Board of Trustees and policies are implemented by the Director General.

Visit our home page: www.worldfishcenter.org

CONTENTS

4 Meso-scale Transboundary Units for the Management of Coral Reefs in the South China Sea Area
• M.C.A. Ablan, J.W. McManus, C.A. Chen, K.T. Shao, J. Bell, A.S. Cabanban, V.S. Tuan and I.W. Arthana

10 Aquaculture in Jamaica
• K.A. Aiken, D. Morris, F.C. Hanley and R. Manning

16 Integration of Freshwater Prawn Culture with Rice Farming in Kuttanad, India
• B.M. Kurup and K. Ranjeet

20 Length-weight Relationship of Mudskippers (Gobiidae: Oxudercinae) in the Coastal Areas of Selangor, Malaysia
• M.Z. Khaironizam and Y. Norma-Rashid

23 Diet Composition of Fish Species from the Southern Continental Shelf of Colombia
• R.H. López-Peralta and C.A.T. Arcila

30 Fisheries of the Farasan Islands (Red Sea)
• W. Gladstone

35 African Freshwater Fisheries: What Needs to be Managed?
• E. Jul-Larsen and P. van Zwieten

News

41 NAGA News

43 NTAFP News

44 WorldFish Center News

INGA News

54 AFS News

55 Announcements

57 New Publications

Information

58 Bibliography

61 Indexes

62 Selected Websites

Special section on Fish for All Summit and launch of Fish for All Initiative

Cover photo, Prof. M.S. Swaminathan, chair of the Fish for All Steering Committee. (WorldFish Center Library Collection)

WorldFish Center is one of the 16 international research centers of the Consultative Group on International Agricultural Research (CGIAR) that has initiated the public awareness campaign, Future Harvest.
Meso-scale Transboundary Units for the Management of Coral Reefs in the South China Sea Area

M.C.A. Ablan, J.W. McManus, C.A. Chen, K.T. Shao, J. Bell, A.S. Cabanban, V.S. Tuan and I.W. Arthana

Abstract

Local communities and local government units are recognized as the primary stakeholders and participants in the management of coral reef resources and the primary beneficiaries of small-scale fishing activities in the nearshore areas of the coastal zone. The issues relating to the management of the coastal zone are multi-faceted and some issues are largely intertwined with national policy and development goals. Thus, national governments have jurisdiction over these nearshore coastal resources to harmonize policies, monitor resource use and provide incentives for sustainable use. However, the natural boundaries of these reef resources, the processes that support reef ecosystems, and the local or national affiliation of the people who benefit from them may transcend the boundaries of the local and national management units. Therefore, efforts to arrest the decline in fish catch and loss of biodiversity for reefs require management interventions and assessment activities to be carried out at varying scales. In Southeast Asia, some aspects of reef and reef resources management — particularly in deciding the allocation of catch among competing fisheries, development of sustainable harvest strategies, use of broodstock for restocking or stock enhancement programs, protection of nursery and spawning areas, designation of systems of marine protected areas, and the identification of representative, adequate and comprehensive areas for biodiversity conservation in the region — may require the definition of larger management units. At the regional level, multi-country initiatives will need to define units for the transboundary management of resources. The use of large marine ecosystems (LMEs) to identify and manage fisheries resources may be a starting point; however, given the relatively sedentary nature of coral reef-dwelling and reef-associated organisms compared with other pelagic and demersal species, meso-scale transboundary units within the LMEs have to be defined. This paper provides suggestions for transboundary management units for coral reef and reef-associated resources in Southeast Asia based on information from genetic structures of model organisms in the region. In addition, specific reef areas are identified, which may be important beyond their national boundaries, as potential sources of recruits.

Introduction

Much of the biodiversity and reef fisheries resources in Southeast Asia are unlikely to survive without active management. Coral reefs of the region are the most threatened with more than 80% at risk primarily from coastal development and fishing-related pressures (Bryant et al. 1998). Millions of coastal dwellers rely on reef resources for food and livelihood. As economies continue to grow and demands on the environment multiply, degradation and unsustainable use of this resource also increase.

Coastal communities in Southeast Asia are heavily dependent on fisheries. Catch from the reef fishery is estimated to comprise up to 20-25% of the total production from marine fisheries in countries like the Philippines and Indonesia (McManus 1997). Longhurst and Pauly (1987) have documented the occurrence of overfishing in east Malaysia, the Philippines, Vietnam and southern China. Reports show that the maximum sustainable yield (MSY), the limit reference point beyond which immediate and substantial action should be taken to protect harvested stock (Caddy and Csirke 1983), has already been exceeded for demersal (Silvestre et al. 1987), pelagic (Dalzell and Ganaden 1987; Trinidad et al. 1993) and reef fisheries (McManus and Meñez 1997) in the Philippines. Similar cases occur elsewhere in the region but are less well documented. The situation is apparently the same in Vietnam (Long in press) and eastern Malaysia (Abu Talib et al. in press) as growing populations turn to fishing as a source of livelihood.

Aside from being unsustainable, overfishing in the region has implications for species diversity and abundance for both pelagic (Christensen 1998) and reef fisheries (McManus 1992). Biodiversity loss due to harvest is apparent in the local-scale extinctions of reef-associated species such as the sea urchin Tripneustes gratilla (Talaue-McManus and Kesner 1995) and the giant clams Tridacna derasa and Tridacna gigas (Meñez et al. 1997).

Reef Connectivity and Implications for Management

Conceptually, rehabilitation and sustainability of a reef subject to intense fishing pressure hinge on the availability of new recruits and their
success in replenishing resources removed from a reef. Eggs of most reef organisms are fertilized externally, and the majority have a larval phase when the larvae drift or swim for several days through the ocean. Resource managers need information on the dynamics of the source and eventual sink of recruits to design marine reserves, estimate the potential contribution of restocking to rehabilitation efforts, understand mechanisms that maintain biodiversity and maximize gains from a fishery. An area which is highly dependent on another area has to be managed differently from one that is primarily self-recruiting (Tuck and Possingham 2000). Connectivity among reef systems may lead to situations where different local or national groups harvest the same stock of resources. Thus, management regimes in one area may be ineffective because of competing uses of the resource elsewhere. Such connectivity also has implications for the vulnerability of sink reefs, when the relative sources which supply recruits experience massive damage.

There may be a disparity between boundaries of reef resources and the jurisdictional limits of resource managers. The natural boundaries of reef resources, and the processes that support these ecosystems, are defined by the physical structure of the reef, the distribution of particular species of interest, and the variable scales at which processes and interactions that support the system operate. However, management boundaries usually correspond to existing political and administrative systems. There is always a possibility that management goals may be inconsistent among different areas and at different scales. This discrepancy between boundary definitions and management goals requires an approach where management interventions and assessment activities are carried out from the local to the regional scale.

In Southeast Asia, very little is known about the source and sink dynamics of recruits that enter reef areas. In spite of this, resource managers in the region acknowledge the need for regional and multilateral management of coastal resources. This was articulated by the participants in the special session on marine protected areas at the International Coral Reef Initiative (ICRI) Regional Workshop for the East Asian Seas1. Participants to the regional workshop on the Sustainable Management of Coastal Fish Stocks in Asia2 also recommended the identification of commonly exploited fish stocks, and the establishment of systems of marine protected areas, as some of the actions required to ensure sustainability of fisheries in the region. To date, management efforts for coral reefs are implemented at the local to the national levels, mostly guided by national programs. Bilateral and multilateral management programs have yet to commence although the agreement on the need for such action exists.

The term “transboundary management units” refers to resource areas beyond any defined management entity. The rest of this paper focuses more on the definition of units for management which are larger than areas covered by national boundaries.

Large-scale units for fisheries: the LME approach

Transboundary management initiatives for coral reefs will require an agreement on the definition of larger-scale units. A possible approach will be to adopt the large marine ecosystem (LME) boundaries defined for the management of coastal fish stocks. LMEs are regions with unique hydrographic regimes, sub-marine topography and trophically linked populations (Sherman 1986).

Four LMEs have been identified for Southeast Asia, the largest being the South China Sea, bounded by parts of China, Taiwan, Vietnam, Cambodia, Thailand, the Philippines, Singapore, Brunei, Indonesia and Malaysia. The Gulf of Thailand and the Gulf of Tonkin are two subsystems which open to the main LME. Two adjacent LMEs are the Sulu-Celebes Seas, bounded by east Malaysia and the island chains of Indonesia and southern Philippines, and the Indonesian or Banda Sea area which falls largely within the jurisdiction of Indonesia. A fourth ecosystem, the Straits of Malacca, to the west of the region is the southern part of the Bay of Bengal LME.

Meso-scale management units within LMEs

Case studies on the use of the LME approach have focused on the management of coastal pelagic species. Although LMEs may be a starting point to define transboundary management units for coral reef fisheries and habitat management, there is still a need to define smaller-scale units a step below the LMEs. This is because the primary target for management are reef-dwelling or reef-associated fish and invertebrate resources with adults that do not travel as widely as their pelagic counterparts. Transfers among reefs are mainly through propagules (i.e., eggs and pre-settlement juveniles) that remain in the pelagic phase for a few days to more than a month. Successful recruitment of these propagules on to a

---

1 The International Coral Reef Initiative (ICRI) Regional Workshop for the East Asian Seas was held on 2-4 April 2001 in Cebu, Philippines. A special session on marine protected areas was held in which participants from South Korea, Japan, the Philippines, Vietnam, Thailand, Malaysia, Singapore and Indonesia discussed the need for more effective management of marine protected areas in the region.

2 The International Workshop on Sustainable Management of Coastal Fish Stocks in Asia was held on 23-25 March 2001 in Penang, Malaysia. As part of the discussions, participants were asked to identify the major management actions required to ensure sustainable management of coastal fisheries at the regional scale.
reef is dependent on a number of local factors (Doherty 1991). Furthermore, reef ecosystems may not actually be as open as previously perceived (Cowen et al. 2000). Retention of reef larvae may be a high 85% for the leeward side and a low 35% for the windward side of small islands (Swearer et al. 1999).

Available data on species composition of fish communities present additional evidence of spatial heterogeneity in environmental conditions and also indicate spatial affinities of reef habitats (Shao et al. 1997; Vo 1998, Chen 1999). This is not surprising considering physical factors significantly influence both the composition of recruits that enter the system as well as the conditions for survival of the species. Veron (1995) used the high correlation between sea surface temperature and circulation patterns as the basis for analysis of the distribution of hermatypic corals in the Indo-Pacific region.

**Genetics and the Identification of Transboundary Management Units**

Genetic markers in conjunction with phenotypic characters may be a powerful means to identify spatial structures of reef populations. This is because the relationship between the marine ecosystem and the species that inhabit it is mediated by the genetic variability contained in the component species and the interaction of this variability with the environment. Climatic and oceanic factors that affect marine ecosystems will also affect the nature and organization of genetic information in species assemblages. Genetic changes within and between populations, in turn, can profoundly influence the distribution, abundance and persistence of marine species. Understanding of the complex interaction between the genetic material in marine species and the environment is rather rudimentary. Nevertheless, genes play an important and central role in shaping morphological phenotypes and behavior. Genetics also provide a biological basis for the identification of transboundary management boundaries because the persistence of genes through generations of populations identifies relationship.

Care must be exercised in deriving conclusions entirely from genetic data. Data on the biology and life history of a species have to complement genetic analysis. Genetic homogeneity between populations of different regions does not always signify that separate fishery stocks do not exist. Populations may not have been isolated long enough to establish differences in allele frequencies; or else exchange, however small, between individuals occurs and this is sufficient to maintain the same alleles between populations and contribute to genetic similarity between the fishery stocks (Grant and Waples 2000). Genetic analyses are generally ‘one-way’ tests of the hypothesis of heterogeneity and the null hypothesis of homogeneity is never proven.

**Genetic structuring for model reef species in the South China Sea: transboundary reef groups**

Evidence from a large-scale genetic study of 16 sites in six countries, namely Malaysia, Philippines, Indonesia, Vietnam, Taiwan and the Solomon Islands, suggests the occurrence of four major sub-provinces in the South China Sea and adjacent areas. This result is based on the observed genetic structuring in the populations of the damsel fish *Dascyllus trimaculatus* based on 12 polymorphic allozyme markers (Ablan et al. 1999). The groups identified are: (1) a West Pacific group to the east of the Philippines and southeast of Taiwan; (2) a north central group composed of northwest Taiwan, northern Vietnam and northwestern Philippines; (3) a southwestern group which includes southern Vietnam and the eastern coast of mainland Malaysia; and (4) a southern group which includes the south and central Philippines, east Malaysia and central Indonesia (Fig. 1). The study has been limited by the number of sites surveyed; however, the patterns observed are highly correlated with the general flow of surface currents in the South China Sea, and the results for two other reef fish species, the false Moorish idol *Heniochus acuminatus* and the six bar wrasse *Thalassoma hardwickii*, from the same study which are very similar to the patterns observed for *Dascyllus trimaculatus*. Although these two species were not sampled as extensively as the damsel fish and have longer larval duration, the combined results clearly present spatial structuring for three model species with different pelagic larval duration (Table 1). In addition, the convergence of three of the geographical groupings on the Spratly Islands suggests a high degree of genetic diversity at this location and provides further support for the potential importance of the Spratly Islands to the reef sources of several countries in the region.

If these patterns of affinity were to be considered as typical for reef areas, they will have some implications for current multilateral discussions on management actions for reefs and reef-associated fishery resources. Issues would include the identification of comprehensive, adequate and representative reef areas for biodiversity conservation in the region, the establishment of regional systems of marine protected areas, transfer and restocking of depleted populations and the management of fish stocks which are reef-dwelling or reef-associated at some point of their life history.

**Examples of regionally important reef areas**

Specific reef areas may be noted as being important beyond their national boundaries. Well preserved reef areas, areas which have been successfully
managed, or areas that have been subject to limited human intervention, may maintain natural ecosystems, which may be critical for the survival of some species, recovery of neighboring reefs and replenishment of the fishery.

In the South China Sea, large reef areas are found off the island of Palawan to the west of the Philippines, in the Spratlys and Paracel Islands and the Anambas and Natuna group to the northwestern side of Kalimantan (Burke et al. 2002). The reversing monsoons create wind and surface currents that may establish connectivity between oceanic shoal reefs and fringing reefs. This is true particularly on the windward side of the island groups where retention is less likely (Swearer et al. 1999). Strong currents transport water masses to and from Indonesia and the South China Sea through the southeastern sections of mainland Malaysia and Singapore (Meith and Helmer 1983) at speeds of at least 1 m s⁻¹ (Wyrtki 1961).

The average duration of the pelagic phase is about 26 days for coral reef fish species (Brothers and Thresher 1985) and 7-10 days for coral larvae (Fadlallah 1983). For the Spratly Islands, the important ecological considerations have been suggested to include pelagic larval duration, timing of larvae release, favorable current patterns and associated oceanographic features, and the distribution of plankton masses during spawning seasons (McManus and Meñez 1997).

The same authors present the possibility that the reefs in the islands

**Table 1. Differences in some life history strategies of the species used as models to determine affinities among reef areas.**

<table>
<thead>
<tr>
<th>Species</th>
<th>Dascyllus trimaculatus</th>
<th>Heniochus acuminatus</th>
<th>Thallasoma hardwicki</th>
</tr>
</thead>
<tbody>
<tr>
<td>Habitat</td>
<td>Rocky coral often commensal with anemones and corals</td>
<td>Deep protected lagoons, channels and outer slopes</td>
<td>Shallow lagoons and seaward reefs</td>
</tr>
<tr>
<td>Depth range</td>
<td>1-55 m</td>
<td>2-75 m</td>
<td>0-15 m</td>
</tr>
<tr>
<td>Occurrence</td>
<td>Highly territorial</td>
<td>Juveniles are solitary while adults occur as heterosexual pairs</td>
<td>Solitary</td>
</tr>
<tr>
<td>Pelagic larvae duration</td>
<td>21-25 days</td>
<td>30-34 days</td>
<td>44-47 days</td>
</tr>
</tbody>
</table>
may be a major source of recruits to reefs in Southern China, Vietnam, Taiwan, the Philippines and Malaysia. Using similar arguments, the Anambas and Natuna Islands and the outer reefs of Palawan may potentially be important to more than just one country.

The occurrence of meso-scale genetic structuring in coral reef organisms has also been reported elsewhere. For the mantis shrimp *Haptosquilla pulchera* in the Makassar Strait of the Indonesian Seas, Barber et al. (2000) suggest the possible existence of a marine Wallace line based on genetic data which differentiated populations to the east and west of the Makassar Strait. They have also identified the occurrence of unique fauna in Kepulauan Tongian. Populations from 11 reef systems of central Indonesia have shown highly distinctive genetic structures on either side of this line. These results, if typical for reef organisms, suggest further division of the Banda Sea LME to the west and east of the Makassar Strait.

**Conclusion**

Transboundary management units for coral reef ecosystems have to be identified to initiate multi-country initiatives that will halt and reverse the decline in reef resources in Southeast Asia. Definition of the geographical boundary of coral reef systems is not straightforward because this will depend on the boundaries of the physical structure of the reef, the distribution of particular species of interest and the variable scales at which processes and interactions that support the system operate. For a multi-country program on fisheries, previously defined LMEs may be used in the first instance, given the rationale behind the designation of these LMEs. However, meso-scale management units, a step below the LME, have to be defined for transboundary management of coral reef habitats and reef or reef-associated fishery resources. This is because recruitment of organisms that make up the reef and the reef-dwelling or reef-associated species of interest to the fishery is highly dependent on local factors. In addition, local retention of recruits differ between the windward and leeward reefs (Swearer et al. 1999) making some reefs more open to exchange than others within the same LME.

Data from genetic variation in populations of species are useful to identify the possible meso-scale transboundary management units. The data from unexploited reef species that were used as model organisms to explore patterns of affinity so far, suggest that the South China Sea LME may be divided into: (1) a West Pacific group to the east of the Philippines and southeast of Taiwan; (2) a north central group composed of northwest Taiwan, northern Vietnam and northwestern Philippines; (3) a southwestern group which includes southern Vietnam and the eastern coast of mainland Malaysia; and (4) a southern group which includes the south and central Philippines, east Malaysia and central Indonesia (Fig. 1). Genetic data from the study of the mantis shrimp *Haptosquilla pulchella* divides the Indonesian Seas LME into two areas to the east and west of the Makassar Strait. It is conceivable that smaller-scale divisions may exist within each of these sub-groups identified.

Aside from the identification of meso-scale transboundary management units, regional coral reef related management initiatives need to consider large reef areas which may be sources of recruits to countries beyond their national boundaries. The Palawan archipelago, the Spratlys and Paracel Islands, the Anambas and Natuna Islands, and the Kepulauan Tongian reef areas are a few of those identified as areas that are significant beyond their national boundaries.

**References**


M.C.A. Ablan and J. Bell are from the WorldFish Center; J.W. McManus is from the Rosenstiel School of Marine and Atmospheric Sciences, University of Miami, USA; C.A. Chen and K.T. Shao are from the Institute of Zoology, Academia Sinica, Taiwan; A.S. Cabanban is from the Borneo Marine Research Institute, University of Malaysia Sabah, Malaysia; V.S. Tuan is from the Department of Living Aquatic Resources, Institute of Oceanography, Vietnam; and I.W. Arthana is from Undayana University, Indonesia. The authors are project partners from six countries in the Population Interdepen-dencies in the South China Sea Ecosystems (PISCES) project coordinated by WorldFish Center and funded by the John D and Catherine T MacArthur Foundation.
Aquaculture in Jamaica

K.A. Aiken, D. Morris, F.C. Hanley and R. Manning

Abstract

Jamaica, with its overfished marine resources, has become a major tilapia producer in Latin America led by a small number of large farms practicing tilapia culture with considerable commercial success. Across the country, however, aquaculture is typically practiced by a large number of small-scale fish farmers who own less than 1.0 ha of land. Production is constrained by lack of credit, finite land space and suitable soil type, but larger existing aquaculturists are expanding further for overseas markets. Inspired by pioneering tilapia fish culture demonstration projects funded by the USAID and the government of Jamaica, fish culture production rose from a few hundred kg of *Oreochromis niloticus* in 1977, to about 5 000 t of processed fish mainly red hybrid tilapia, in 2000. Most of this quantity was exported to Europe and North America.

Development of Aquaculture

Jamaica, located in the north central Caribbean Sea, is the third largest island in the Greater Antilles chain. The first aquaculture species to be introduced into Jamaica was the *Oreochromis mossambicus* in 1949 from St. Lucia to supply rural communities with subsistence protein. Subsequently, tilapia was forgotten until 1976 when *O. niloticus* was introduced by the USAID/Government of Jamaica project from Auburn University in Alabama. This species met with some success with farmers who generally preferred the smaller, darker, more prolific-spawning *O. mossambicus*. Production increase between 1976 and 1980 was mainly from *O. niloticus*. The project was rated as very successful and culture prospects were then quite attractive (Popma et al. 1984; Hanley 1991a, 1991b).

Table 1. Species introduced into Jamaica for aquaculture.

<table>
<thead>
<tr>
<th>Species (date of introduction)</th>
<th>Common name in Jamaica</th>
<th>Source/suppliers</th>
<th>Importance</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Oreochromis mossambicus</em> (1949)</td>
<td>African perch</td>
<td>St. Lucia, West Indies</td>
<td>Unpopular, relegated to rivers and smaller ponds</td>
</tr>
<tr>
<td><em>O. niloticus</em> (1976)</td>
<td>Silver tilapia</td>
<td>Auburn Univ., USA</td>
<td>Limited success, still used by some farmers</td>
</tr>
<tr>
<td><em>Ctenopharyngodon idellus</em> (1978)</td>
<td>Grass carp</td>
<td>Auburn Univ.</td>
<td>Rejected by public, used for aquatic weed control</td>
</tr>
<tr>
<td><em>Aristichthys nobilis</em> (1978)</td>
<td>Bighead carp</td>
<td>Auburn Univ.</td>
<td>Rejected by farmers</td>
</tr>
<tr>
<td><em>Hypophthalmichthys molitrix</em> (1978)</td>
<td>Silver carp</td>
<td>Auburn Univ.</td>
<td>Rejected by farmers</td>
</tr>
<tr>
<td><em>Colossoma macropomus</em> (1978)</td>
<td>Tambaqui</td>
<td>South America</td>
<td>Used for broodstock</td>
</tr>
<tr>
<td><em>O. mossambicus</em> x <em>O. hornorum albino</em> (1984)</td>
<td>Florida red</td>
<td>Florida</td>
<td>Used for broodstock</td>
</tr>
<tr>
<td><em>O. mossambicus</em> x <em>O. aureus?</em> (species uncertain) (1984)</td>
<td>Red hybrid tilapia (Israeli strain)</td>
<td>Israel</td>
<td>Very successful, now widely cultured</td>
</tr>
<tr>
<td><em>O. aureus</em> (red strain) (1985)</td>
<td>Cherry tilapia</td>
<td>Florida</td>
<td>Used for broodstock</td>
</tr>
<tr>
<td>Multiple crosses of Tilapia (variously <em>O. mossambicus</em> x <em>O. hornorum</em> and <em>O. aureus</em> (beyond1986)</td>
<td>Red hybrid tilapia</td>
<td>Various (includes Florida, Auburn University, Taiwan, Israel)</td>
<td>Very successful, now widely cultured</td>
</tr>
<tr>
<td><em>Cherax quadricarinatus</em></td>
<td>Redclaw cray fish</td>
<td>Australia</td>
<td>Interest of farmers low</td>
</tr>
</tbody>
</table>

Annual production

Annual production of food fish from aquaculture has risen from a low of 0.1 t in 1976 to just over 5 000 t in 2 000 (Fig. 2). Much of the post-1985 production is based on red hybrids of tilapia. There was some reduction in production between 1991 and 1996, due to a slowing of national economic growth and natural disasters involving flooding (Hanley 2000).

The largest producer is Aquaculture Jamaica Ltd. comprising some 20 ha surface area in western Jamaica and a sister farm of 22 ha in the central part of the island. Details of the semi-intensive and intensive...
commercial tilapia culture are provided by Carberry and Hanley (1997). Of the 10 000 km² total land area, only approximately 14% is suitable for aquaculture due mainly to the dominance of porous limestone and a relatively limited water supply. Most tilapia farms are located on the south-central plains where clay soils and an extensive system of irrigation canals installed by the sugar cane industry provide the water supply infrastructure (Hanley 2000). The total aquaculture area is estimated at 526 ha in 2001. Of this, some 90% is under tilapia farming. Of the total production of 5 000 t, 4 500 t is tilapia, approximately 150 t of Chinese carp and 150 t of Colossoma macropomus. It also includes 120 t of penaeid shrimp, 25 t of freshwater prawn (Macrobrachium rosenbergii) and a small quantity of mangrove oyster and ornamental fishes. Most of the ornamental fishes are for export to the United States. Of the other products, all except tilapia are almost exclusively for local markets.

**Levels of aquaculture**

Aquaculture operations in Jamaica can be classified into: a) small-scale; b) medium-scale and c) large commercial operations. Small-scale aquaculture dominates with an estimated 300 farmers at the end of 2001 culturing mainly red tilapia hybrids. A few farmers also culture Chinese carps or *C. macropomus* in polyculture with tilapia. Only one farm cultures freshwater prawn (*M. rosenbergii*) at a significant level. Small-scale farmers have not been successful with marine shrimp farming. The expansion of small-scale fish farming is constrained by land ownership. Small-scale farms have an area of 1–4 ha (75% of farms) usually with ownership of the land. Fishponds are often not the only source of income for the family. Stocking rates are lower than practiced by medium-size producers, while food conversion efficiencies, survival and final average weight of the fish are similar (Hanley 2000). Yields are reported to be lower than achieved by medium-size farms in large part due to the lower stocking densities and the absence of aeration and contribute less than 10% of aquaculture production. Medium-size farms range from 5
to 20 ha (19% of farms) and may be owned or leased by the farmers. Harvests may be sold at farm site or to distributors or are under a contract-farming system (sold to large-scale operators who have processing facilities). Most medium-scale farmers have other agricultural income, e.g. from dairy or sugar cane plantations (Hanley 2000).

Large farms or industrial scale farms range from 21 to 45 ha (6% of farms) and are owned either in partnership or are part of a large firm engaged in other business. Thus, they often have other commercial interests whose profits can sustain longer-term investment in aquaculture.

**Tilapia culture**

On larger commercial farms, ponds are usually rectangular with a mean depth of 1.0-1.5 m. Most are equipped with concrete monks for draining. Most of the larger farms maintain their own broodstock of red tilapia hybrids (Fig. 3). Various phenotypes with differing pigmentation patterns are observed on the farms including red/gold-scalloped, zebra-mottled, white and speckled varieties.

Monosex male tilapia culture is the main practice and 17α-methyltestosterone is the preferred androgen for treating fry to produce “all-males”. Success rates approaching 97% males are reported. Tilapia fingerlings are cultured in a single phase system. The nursery ponds on larger farms are about 0.8 ha each with phytoplankton blooms maintained and with nightly aeration from paddlewheels (Fig. 4). Ponds are stocked with hatchery-produced fry at 36 000-50 000/ha and fed 35% protein feed. After 100 days, fry attain 70 g.

Grow-out pond sizes vary but 0.20 ha ponds are common. The grow-out may be in a single phase stocked directly from the nursery or a two-phase system. The first phase grow-out is in aerated green-water ponds producing 200 g fish. Second phase production ponds raise fish of 200 to 600 g and these are harvested for processing. Fish in grow-out ponds are fed with 28-32% protein feeds, containing 10% fishmeal. The most productive ponds are aerated flow-through ponds producing 45 t/ha/yr (Hanley 2000). Grow-out is for 150 days to produce 0.5 kg fish and 350 days to produce 1.0 kg fish. The harvest is transported for processing in aerated tractor-drawn carts. Strict sanitary practices and careful handling at all stages are in force at the processing facilities and the continued success of the operations is perhaps testimony to that ethos. This is the usual procedure followed at larger culture facilities. Small-scale farmers carry out similar exercises on their farms.

Table 2 shows production parameters for the three categories of tilapia producers.

Generally, farm-raised tilapia larger than 200 g are well received by consumers and much of the small-scale production is sold at pondside by the farmer, or fresh on ice through a network of vendors operating from small roadside locations and from vehicles.

**Other aquaculture fish species**

*Ornamental fish:*

The prospects for ornamental fish farming in the late 1990s seemed to be relatively bright. However, the interest has diminished to a few species cultured on approximately 60 ha (Hanley 2000). Production figures for these species are not available.

*Australian redclaw crayfish:*

*C. quadricarinatus* was introduced in 1997 and was being investigated by a few aquaculturists for its culture potential. Since the increases in freshwater prawn production occurred at about the same time, interest in this crustacean has waned considerably. It may now be of local biodiversity concern, as it has accidentally escaped into streams near farms and may be displacing native crustacean species.

*Giant freshwater prawn culture:*

*M. rosenbergii* is cultured by only a few farms, always in polyculture with tilapia, the latter always as the major crop. Adults are harvested at approximately 100 g. The species has proven quite popular and is tending towards replacing marine shrimp in many hotels and restaurants.

*Oyster culture:*

Oyster culture began in 1977 with studies to assess feasibility. Initial culture efforts
centered on Bowden, St. Thomas in eastern Jamaica in an area that had high density of mangrove oyster, *Crassostrea rhizophorae*. There was previously a small, well-established traditional market for raw oysters in Kingston, the capital. The plan was to better service this market and to provide a new employment option. The initial technology was adapted from Cuban techniques (Wade et al. 1981). Naturally produced spat settle on the artificial rubber tyre cultch during the spawning season, and grown for eight weeks. Afterwards they are transferred to deeper water for a grow-out phase of 4-5 months on either racks or rafts. Culture was attempted at several coastal sites, but the most successful location has been on the east coast. There were few parasites and growth rates were relatively good. The industry has suffered from pollution and theft. A review of the methods, production and problems is provided by Richards (1992).

Marine shrimp culture. Haughton and King (1992) reviewed mariculture potential and reported it useful to investigate a range of marine fish and crustacean species including groupers (Serranidae), snappers (Lutjanidae) as well as penaeid shrimps and queen conch (*Strombus gigas*). In 1996, a small-scale project which investigated the spawning, larval culture and growth rate of marine shrimp (*Penaeus vannamei*) started with the financial assistance initially from the University of the West Indies, and later, from South Korea. Small hatchery facilities are at the Port Royal marine laboratory, near Kingston, and grow-out ponds are 30 km west of Kingston. Results have been unclear, but seem to hold some promise. Limitations locally, however, include a very small tidal fluctuation (20 cm) and high water pumping costs.

**Diseases, parasites and predation**

Jamaica is fortunate that parasites and diseases are rare. In 1984, the gill fluke *Gyrodactylus* was reported from an experimental fish farm in the central south coast. This species entered the country with Israeli tilapia broodstock. There has been no recurrence since. There are short-term outbreaks of *Trichodina* and *Ichthioptihirius* and ‘cold snaps’ between December and February sometimes causing mortalities when fish are stressed. Small gastropod snails such as *Thiara granifera* are rated as nuisance species and they are presently free from parasites. During marine cage culture of red hybrid tilapia, these could be infected with a parasitic flatworm, *Neobenedenia melleni* (Monogenea: Capsalidae) as reported by Robinson et al. (1992). A variety of avian predators, mainly egrets and herons, affect culture systems. Bird numbers on larger farms may be high, forcing farmers to use bird-snagging wires.

**Economic Aspects**

Historically, various economic aspects of fish culture are given by Street (1978), and Ross (1983). Some government departments have produced analyses (e.g. Agro-21 1983a, 1983b), while economic issues concerning integrated fish farming were reported by Wright (1995). Table 3 shows the comparative costs of inputs for tilapia culture for 1984, 1991 and 1998.

With the costs varying in 1984 and 1998, it is a challenge for Jamaican fish farmers to stay in business. However, when the USS is adjusted for inflation for those years (by a point factor of 1.564), it shows that despite increases of 16% and 8% respectively, in the costs of feed and fingerlings and increases of 29% for transport, 33.8% for labor and a decline of 30% in the cost of diesel fuel, the cost of producing a kilogram of fish declined by 8.5% (Hanley 2000). This suggests improved efficiencies in operation, which have been assisted by an increase in the selling price of fish of 21% in the same period. The increase in the selling price has been greater than the increases in the major cost factors (Table 3).

Prices are presently high on the international market, especially for value added products. Not surprisingly, major tilapia producers are already into the market for fillets and frozen whole fish in Europe. The principal constraints for development include lack of credit, limited land space, inadequate water supply and water quality, and distribution and marketing ability. The tight quality controls have, in the opinion of the authors, greatly benefited the efficiency of fish farms.

---

**Table 2. Production parameters for small, medium and large tilapia producers. Data based on interviews with selected farmers. Figures are rounded averages (adapted from Hanley 2000).**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Small farm (1-4 ha)</th>
<th>Medium farm (5-20 ha)</th>
<th>Large farm (21-45 ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phases of production*</td>
<td>1</td>
<td>2</td>
<td>3-4</td>
</tr>
<tr>
<td>No. of crops/year</td>
<td>2.0</td>
<td>2.0</td>
<td>1.4</td>
</tr>
<tr>
<td>Aeration (Hp/ha)*</td>
<td>0</td>
<td>5</td>
<td>20</td>
</tr>
<tr>
<td>Water exchange (%/d)*</td>
<td>0</td>
<td>0-10</td>
<td>150</td>
</tr>
<tr>
<td>Stocking density (Fish/ha)*</td>
<td>16 000</td>
<td>25 000</td>
<td>120 000</td>
</tr>
<tr>
<td>Survival (%)</td>
<td>90</td>
<td>90</td>
<td>92</td>
</tr>
<tr>
<td>Market size (g)*</td>
<td>315</td>
<td>360</td>
<td>585</td>
</tr>
<tr>
<td>FCR</td>
<td>1.5-1.6</td>
<td>1.6-1.7</td>
<td>2.0-2.1</td>
</tr>
<tr>
<td>Yield (kg/ha/yr)*</td>
<td>9 000</td>
<td>16 000</td>
<td>45 000</td>
</tr>
</tbody>
</table>

---

* Post-hatchery;
* Data from final grow-out phase;
* Average over total area of farm.
Investment environment

A major disincentive to investment in aquaculture for private investors is the high interest rates, varying 60-35% annually in 1995-2000. These rates by international standards are punitive. Therefore, it is not surprising that there have not been a lot of overseas or local entities investing in Jamaican aquaculture. The major culturists are, in fact, major feed and poultry producer/suppliers. Aquaculture therefore, represented for them, logical expansions, as feed supplies were neither problematic nor requiring of additional capital outlay.

Education and Research

The University of the West Indies, Mona campus (UWI) has offered a final year 6-week course in aquaculture from 1984. The course is now combined with fisheries as Fisheries and Aquaculture Technologies since the 1996/97 academic year (see also Aiken and Steele 1986). The private sector has also allowed useful interactions with the practical component of the course. Applied research led by the Life Sciences Department, Mona has centered on the acclimatization of red tilapia hybrids to seawater in cages (Hall 1991; Grant 1995), stocking density variation and effects on growth rates (Morris 1995; Barrett 2001) and protein digestion (Hanley 1986). Some success has been achieved with cage mariculture, although growth rates are slower than those obtained in ponds. Feeding and stocking rate trials in dug-out ponds revealed that red hybrids responded rapidly to improvements in feed type and protein content. Aquaculture Jamaica Ltd. has an active program of research and development with a focus on improving feed conversion and growth, water quality consistency, genetics and market appearance. A useful handbook for fish farmers and potential investors was prepared by Hanley (1990). There is great potential for increases in research linkages between the UWI and private aquaculturists, which could contribute to improved production.

Future Prospects

Much valuable experience in aquaculture has been gained since 1977. Culture technologies have been tested, a trained cadre of technical expertise exists and the economics well understood. High interest rates, limited land and water supply are hindering growth of the industry. If the internal investment environment becomes less hostile and external markets remain strong, the future of Jamaican aquaculture could be quite good.

Acknowledgement

The authors thank John Carberry of Aquaculture Jamaica Ltd. for comments on this draft.

References


Table 3. Costs of selected inputs, costs of production and selling price of tilapia, 1984-1998 in US$/kg. (% increase from 1984; adapted from Hanley 2000).

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Feed (US$/kg)</td>
<td>0.328</td>
<td>0.359</td>
<td>0.380</td>
</tr>
<tr>
<td>Fingerlings (US$/1,000 @ 20 g)</td>
<td>3.988</td>
<td>3.731</td>
<td>4.310</td>
</tr>
<tr>
<td>Labor (US$/hr)</td>
<td>1.564</td>
<td>1.659</td>
<td>6.850</td>
</tr>
<tr>
<td>Transport (US$/kg)</td>
<td>0.031</td>
<td>0.024</td>
<td>0.040</td>
</tr>
<tr>
<td>Diesel fuel (US$/l)</td>
<td>0.485</td>
<td>N/A</td>
<td>0.340</td>
</tr>
<tr>
<td>Cost of production (US$/kg)</td>
<td>1.736</td>
<td>1.770</td>
<td>1.620</td>
</tr>
<tr>
<td>Selling price (US$/kg)*</td>
<td>2.190</td>
<td>3.133</td>
<td>2.650</td>
</tr>
</tbody>
</table>

* Data from Popma et al., (1984), Hanley (1991) and interviews with farmers;
  ** Medium-size farm.
  ** Selling price at pondside; N/A = Data not available.
of the West Indies, Zoology Department, Mona. PhD thesis.

K. Aiken is with the Department of Life Sciences at the University of the West Indies, Mona, while R. Manning, D. Morris and F. Hanley are with the Jamaica Broilers Group, owners of the Aquaculture Jamaica farm.
E-mail: kaaiken@uwimona.edu.jm.
Integration of Freshwater Prawn Culture with Rice Farming in Kuttanad, India

B. M. Kurup and K. Ranjeet

Abstract

The integration of paddy cultivation with prawn/fish culture can become a viable alternative to effectively utilize the vast area of derelict polders (embanked coastal flood plains) in Kuttanad, India. Nearly 55 000 ha of wetlands in Kuttanad are available for paddy cultivation year-round. Around 5 000 ha of the polders are utilized for Macrobrachium rosenbergii culture as a follow-up crop. Of the total area, about 250 ha of fallow polders are utilized for monoculture of M. rosenbergii from March to October, while in 4 750 ha polyculture with Indian and exotic carps is practiced from November to June. Stocking density is 5 000 to 20 000/ha for monoculture of M. rosenbergii, while in polyculture with carps, it is 5 000 to 20 000/ha of prawn and 5 000 to 10 000/ha of fish. Production from monoculture varies from 95 to 1 297 kg/ha whereas production from polyculture systems it is 70 to 500 kg/ha of prawn and 200-1 200 kg/ha of fish. Profits range from Rs. 5 000 to 20 000/ha. An evaluation is made of how the present polders of Kuttanad are best utilized for culture of M. rosenbergii following different systems of integrated farming and how the integration is useful in the aquaculture sustainability of Kuttanad, a tropical wetland ecosystem.

Introduction

In recent years in India, shrimp culture has faced a crisis due to rampant outbreaks of viral diseases. The situation has been further aggravated by the implementation of the Coastal Regulation Zone Act under the Environmental Protection Act of 1986 that imposed restrictions on setting up of industries including aquaculture activities within an area of 500 m from the high tide. The pursuit of alternate eco-friendly and sustainable freshwater aquaculture has led to the recognition of the giant freshwater prawn (Macrobrachium rosenbergii) as a prime candidate species for freshwater aquaculture. Considerable understanding of the biology of the species, its rapid growth, large size, greater disease resistance and good demand in both domestic and export markets has made it a prime species for freshwater aquaculture in India. Kerala state in India is endowed with large freshwater resources and low-lying paddy fields, which have been traditionally exploited for rice cultivation. The integration of rice farming in these polders (embanked coastal flood plains) with M. rosenbergii culture has given a new thrust to the economy of traditional farming in Kuttanad district. Rice and prawn/fish farming has turned out to be a viable alternative to effectively utilize the vast amount of fertile water available in Kuttanad.

Materials and Methods

Data on farming of M. rosenbergii under different culture systems in Kuttanad were collected from April 1998 to March 2001. The total area utilized for M. rosenbergii cultivation in Kuttanad was apportioned into five agronomic zones: Upper Kuttanad, Lower Kuttanad, North Kuttanad, Kayal lands (reclaimed part of the lake for rice cultivation) and Purakkad (an area characterized by peaty soil) (KWBSP 1990). Details on duration of rice cultivation, duration of prawn culture, type of farming, culture area, pre-stocking, stocking and post-stocking management measures adopted are given by Kurup (1996). A successful integration of fish/prawn with other livestock was analyzed by Huat and Tan (1980).

Results and Discussion

Rice cultivation in Kuttanad

The total area of Kuttanad region is around 110 000 ha comprising 28%
dry land, 60% wetlands and 12% other water bodies such as lakes, rivers, channels, etc. Wetlands in Kuttanad are mainly used for rice cultivation with a total extent of 55 000 ha. Traditionally, rice is cultivated in two seasons: summer (November to February) and monsoon (July to October). Summer contributes to the bulk of the rice cultivated in this region. Of the total 55 000 ha utilized for rice cultivation in Kuttanad, nearly 35 000 ha is utilized during the summer season while only about 3 000 ha is used during the monsoon season. During recent years, farmers in Kuttanad have been inclined to abandon rice cultivation either partly during any of the two seasons or to fully leave the polders fallow. Diminishing returns from cultivation, acute labor shortage and severe crop loss due to flood and pest infestation etc. are the major reasons for this. As a result, nearly 36 000 ha of land remain fallow during the monsoon season.

Prawn culture in Kuttanad

Three types of grow-out systems are presently employed for M. rosenbergii culture: polders, homestead ponds and coconut plantation channels. Table 1 gives the total area of each grow-out system in the five zones of Kuttanad for the monoculture and polyculture of M. rosenbergii. The farming of M. rosenbergii is mostly carried out in the polders (65-75%), followed by coconut plantation channels (15-25%) and homestead ponds (10-15%). The water spread of each polder used for prawn culture varied from 0.6 to 125 ha where the culture of M. rosenbergii is done on a rotational basis after a crop of paddy mostly from November to August. Around 5 000 ha of polders are currently utilized for M. rosenbergii farming in Kuttanad, of which monoculture of M. rosenbergii is done in 250 ha while in 4 750 ha culture is done with carps. Among fallow polders utilized for prawn culture, the maximum area was in Upper Kuttanad (1 351 ha) followed by Lower Kuttanad (1 298 ha), North Kuttanad (818 ha), Kayal lands (695 ha), while it was least in Purakkad (537 ha).

<table>
<thead>
<tr>
<th>Nature of the culture area</th>
<th>Upper Kuttanad Monoculture</th>
<th>Lower Kuttanad Monoculture</th>
<th>North Kuttanad Monoculture</th>
<th>Kayal lands Monoculture</th>
<th>Purakkad Monoculture</th>
<th>Total Monoculture</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polders</td>
<td>3 (26)</td>
<td>11 (1 325)</td>
<td>8 (110)</td>
<td>8 (550)</td>
<td>2 (28)</td>
<td>20 (248)</td>
</tr>
<tr>
<td>Homestead ponds</td>
<td>2 (2)</td>
<td>6 (4)</td>
<td>1 (2)</td>
<td>2 (4)</td>
<td>1 (1)</td>
<td>5 (6)</td>
</tr>
<tr>
<td>Coconut plantation channels</td>
<td>1 (12)</td>
<td>3 (125)</td>
<td>4 (90)</td>
<td>3 (62)</td>
<td>1 (6)</td>
<td>7 (116)</td>
</tr>
<tr>
<td>Total</td>
<td>6 (40)</td>
<td>20 (1 454)</td>
<td>13 (202)</td>
<td>13 (616)</td>
<td>4 (35)</td>
<td>32 (370)</td>
</tr>
</tbody>
</table>

Number in parenthesis is area of land in ha.

In 122 farms surveyed in 1998-2001, 75 farmers used polders for M. rosenbergii culture alternating with rice. Monoculture was practiced in 20 farms with a total area of 248 ha. North Kuttanad accounted for a maximum number of farmers (8) who switched to monoculture of M. rosenbergii. The water spread of farms used for monoculture was 1 to 25 ha each with stocking density varying from 15 000 to 60 000/ha postlarvae. Production of M. rosenbergii from these polders ranged from 95 to 1 300 kg/ha. About 4 750 ha are utilized for polyculture comprising Indian major carps such as catla (Catla catla) and rohu (Labeo rohita) and grass carp (Ctenopharyngodon idella) and M. rosenbergii. The polders, which were utilized only once a year for the paddy cultivation, were the major sites for the polyculture of M. rosenbergii. Such polders ranged from 5 to 230 ha each and the stocking density of M. rosenbergii was 2 000 to 15 000/ha postlarvae while that of fish was in the range of 1 000 to 5 000 fingerlings/ha. The culture period extended from 6 to 8 months and the production from such a system was 70 to 500 kg/ha of M. rosenbergii, and 200 to 1 200 kg/ha of fish. Apart from this, small areas are utilized for other types of integration: pig/fish in 10 ha, poultry/fish in 22 ha, duck/fish in 48 ha and livestock/fish in 28 ha.

Comparison of production from mono and polyculture

Table 2 shows information on farming and production of five polders where mono and polyculture were practiced in the summer season. Stacking density in the monoculture polders was 14 000 to 45 000/ha and production was 95 to 1 297 kg/ha. Similarly, in the polders where polyculture was adopted, production was 70 to 492 kg/ha of prawns and 200 to 1 200 kg/ha of fish. Results of the present study are complementary to Huat and Tan (1980) who reported an average production of 800 kg from polyculture ponds in Southeast Asia where M. rosenbergii and carps were cultured. The survival rate in all the
ten polders was higher under lower stocking densities and was comparable to the retrieval rates reported by Jhingran and Sharma (1980) in the paddy fields. The net returns from the polders were basically governed by the size structure of *M. rosenbergii* at the end of the culture. The present study shows that revenue and production from monoculture ponds were perceptibly higher compared to polyculture ponds supporting the promotion of monoculture of *M. rosenbergii* as a rotational crop in the rice fields of Kuttanad.

One of the major bottlenecks for the successful farming of *M. rosenbergii* is the size disparity seen particularly in male populations. This results in a diverse population structure at the time of harvest that classifies the prawns into different morphotypes based on their weight. The harvested prawns are marketed under different weight classes and the price that each weight class fetches is different. Two market structures are prevalent in Kuttanad (two-grade and six-grade) that divide the final catch into two or six different weight groups (see Table 2). A definite marketing system does not exist in Kuttanad. Hence, the tariff employed for each grade of prawn is different from time to time and is decided by the procuring companies. The percentage of weight group <50 g was found to adversely affect the final profit. In lesser-stocked ponds, the average weight and survival of prawns were comparatively higher. Moreover, the positive shift in the predominance of larger weight group prawns in these ponds yielded better results. These findings are in full agreement with Siddiqui et al. (1997) in Saudi Arabia. Based on the trend noticed in the production in the ten polders, it can be inferred that biomass, marketable yield structure and profit from these polders can be improved by optimizing stocking density, improving post-stocking management measures and adopting an innovative system of culture of *M. rosenbergii* (Karplus et al. 1986, 1987).

### Conclusion

In Kuttanad, double cropping of rice may not always be feasible due to floods during the monsoon and this combined with low returns from rice cultivation due to the high cost of land lease and labour has tempted the farmers to abandon one crop of rice and instead culture fish and/or prawn during the season, leading to increased benefits. Utilization of polders for fish and/or prawn culture will not only be helpful in improving the revenue for the farmer but will also provide additional employment. Integration increases benefits by reducing the cost for pond fertilization, maintains soil fertility, avoids accumulation of waste products, enhances better pest control from the agricultural viewpoint and enables farmers to continue with their traditional norms of livelihood. Since rice and fish/prawn are grown in different seasons, the deleterious effects of pesticide accumulation, seen as a result of simultaneous culture of rice-prawn, can be reduced. The ideal season for rearing fish and prawns in the ricefields of Kuttanad appears to be March to October. According to Nair (1994), production from such a system on an average would be 1 000 kg/ha of fish and around 750 kg/ha of prawn. This arrangement also reduces the production cost of rice since the soil is soft and clean after the fish/prawn harvest and allows immediate seeding and transplanting. It appears that the polders of Kuttanad can be utilized for culture of *M. rosenbergii* and that rotational farming of rice and *M. rosenbergii* can be popularized in suitable polders when they are fallow for six months.

### Acknowledgments

The authors are grateful to Prof. (Dr.) C. Hridayanathan, Director, School of Industrial Fisheries, Cochin University of Science and Technology, India for providing necessary facilities. This work was done as part of an Indian Council of Agricultural Research ad hoc project and the financial support received is

---

**Table 2. Summer season production of *M. rosenbergii* under different management strategies.**

<table>
<thead>
<tr>
<th>Polders</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of culture</td>
<td>Mono</td>
<td>Mono</td>
<td>Mono</td>
<td>Mono</td>
<td>Poly</td>
<td>Poly</td>
<td>Poly</td>
<td>Poly</td>
<td>Poly</td>
<td>Poly</td>
</tr>
<tr>
<td>Area of polder (ha)</td>
<td>11.1</td>
<td>2.5</td>
<td>2.1</td>
<td>2.1</td>
<td>2.5</td>
<td>4.2</td>
<td>1.3</td>
<td>3.5</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>Stocking density (ha)</td>
<td>14 000</td>
<td>35 000</td>
<td>40 000</td>
<td>45 000</td>
<td>10 000</td>
<td>12 000</td>
<td>20 000</td>
<td>15 000</td>
<td>20 000</td>
<td>10 000</td>
</tr>
<tr>
<td>Survival (%)</td>
<td>25</td>
<td>26</td>
<td>36</td>
<td>38</td>
<td>35</td>
<td>22</td>
<td>42</td>
<td>31</td>
<td>37</td>
<td>52</td>
</tr>
<tr>
<td>Duration of culture(months)</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>8</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>Total yield(kg/ha)</td>
<td>177</td>
<td>1297</td>
<td>1250</td>
<td>70</td>
<td>180</td>
<td>492</td>
<td>450</td>
<td>143</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Market yield structure</td>
<td>95</td>
<td>168</td>
<td>1279</td>
<td>1250</td>
<td>180</td>
<td>492</td>
<td>450</td>
<td>143</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>

Naga, WorldFish Center Quarterly (Vol. 25, No. 3 & 4) July-Dec 2002
greatly acknowledged.

References


B. M. Kurup and K. Ranjeet are from the School of Industrial Fisheries, Cochin University of Science and Technology, Fine Arts Avenue, Kochi-16, India.

E-mail: madhukurup@hotmail.com
Length-weight Relationship of Mudskippers (Gobiidae: Oxudercinae) in the Coastal Areas of Selangor, Malaysia

M. Z. Khaironizam and Y. Norashid

Abstract

Parameters \(a\) and \(b\) of the length-weight relationship (LWR) were estimated for eleven species of mudskippers caught in the coastal areas of Selangor, Malaysia. The values of \(b\) ranged from 2.56 to 3.50 with the mean \(b\) equal to 2.95 \((n=11; \text{sd}=0.302)\). A normal distribution of the calculated LWR exponent \(b\) was obtained.

Introduction

Oxudercine gobies are euryhaline fishes commonly referred to as mudskippers. They are amphibious, highly active during low tides and spend most of their time out of water in mangrove habitats. Mudskippers are a delicacy among the people of Taiwan and Japan and are highly priced, selling for as high as US$20/kg (Ip et al. 1990). The mudskippers have a high density on tidal mudflats that are formed in creeks and estuaries and on mangrove forest floors. Mangrove forests and their waterways are important in supporting the fish population because they provide organic matter and detritus as food sources (Sasekumar and Chong 1998).

Ricker (1968) expressed the importance of length-weight relationships in population assessments. Some examples of studies on LWR include King 1996a; Kulbicki et al. 1993; Garcia et al. 1998; Haimovici and Velasco 2000. A similar study on the mudskipper Periophthalmus barbarus was conducted by King and Udo (1996) in Nigeria. Aspects of population dynamics were investigated by King (1996b) and Etim and Arntz (1996). The objective of this paper is to make available LWR parameters for mudskippers caught in coastal waters of Selangor, Malaysia.

Materials and Methods

Specimens were obtained from intensive field samplings, conducted from October 1998 to July 2000 in the mangrove areas of the Selangor coast (Fig. 1). Fishes were caught by hand net on mudflats, riverine areas and mangroves. The species description given in Murdy (1989) and Murdy and Takita (1999) were used for taxonomic identification. Fish samples were preserved in 10% formalin and washed with water and dried before measuring. The total length (TL) and standard length (SL) were measured to the nearest 0.1 mm using a caliper. Fish were weighed to the nearest 0.1 g.

The length-weight relationship was calculated using the formula:

\[ W = a \cdot L^b \]  \hspace{1cm} (1)

and transformed to:

...
\[ \log W = \log a + b \log L \]  
\[ \text{...(2)} \]

where \( b \) is an exponent with the value nearly always between 2 and 4, and often close to 3. The value \( b=3 \) indicates that the fish grows symmetrically or isometrically (provided its specific gravity remains constant). Values other than 3 indicate allometric growth: if \( b>3 \), the growth is called positive allometric and if \( b<3 \), it is called negative allometric. Pauly (1993) reported that \( b \) values must be equal to 3 if fishes have to maintain their shape as they grow, but there is no theory that says in which case the estimated \( b \) values can be expected to be negatively or positively allometric. Garcia et al. (1998) reported that biological interpretation of the numerical values of the parameters \( a \) and \( b \) is not straightforward, except that when growth is isometric, \( a \) can be interpreted as a condition factor. When growth is allometric, the role of \( a \) as the condition factor is questionable. The length-weight data pairs were analyzed using ordinary least squares regression (95% confidence), using STATISTICA version 5.0.

### Results and Discussion

Results of the LWR analysis of eleven species of goby are summarized in Table 1. The \( b \) value estimator indicates that *Periophthalmus schlosseri* and *Boleophthalmus boddarti* followed isometric growth, while

<table>
<thead>
<tr>
<th>Species</th>
<th>( n )</th>
<th>Equation ( W=a \cdot L^b )</th>
<th>( r )</th>
<th>Min SL (mm)</th>
<th>Max SL (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Periophthalmus chrysoptilus</em></td>
<td>315</td>
<td>( W=6.546 \times 10^{-5} \cdot L^{2.56} )</td>
<td>0.982</td>
<td>18.2</td>
<td>83.2</td>
</tr>
<tr>
<td><em>Periophthalmus gracilis</em></td>
<td>110</td>
<td>( W=3.296 \times 10^{-5} \cdot L^{2.80} )</td>
<td>0.974</td>
<td>20.5</td>
<td>42.7</td>
</tr>
<tr>
<td><em>Periophthalmus novemradiatus</em></td>
<td>299</td>
<td>( W=5.117 \times 10^{-5} \cdot L^{1.67} )</td>
<td>0.989</td>
<td>18.3</td>
<td>70.2</td>
</tr>
<tr>
<td><em>Periophthalmus argentinensis</em></td>
<td>15</td>
<td>( W=4.375 \times 10^{-5} \cdot L^{2.34} )</td>
<td>0.990</td>
<td>43.0</td>
<td>71.6</td>
</tr>
<tr>
<td><em>Periophthalmus spilotus</em></td>
<td>29</td>
<td>( W=2.660 \times 10^{-5} \cdot L^{2.53} )</td>
<td>0.995</td>
<td>40.3</td>
<td>71.4</td>
</tr>
<tr>
<td><em>Periophthalmus septemradiatus</em></td>
<td>22</td>
<td>( W=2.710 \times 10^{-5} \cdot L^{2.30} )</td>
<td>0.989</td>
<td>79.5</td>
<td>207.0</td>
</tr>
<tr>
<td><em>Boleophthalmus boddarti</em></td>
<td>128</td>
<td>( W=1.556 \times 10^{-5} \cdot L^{3.00} )</td>
<td>0.977</td>
<td>47.1</td>
<td>88.5</td>
</tr>
<tr>
<td><em>Scartelaos histophorus</em></td>
<td>97</td>
<td>( W=4.325 \times 10^{-5} \cdot L^{2.62} )</td>
<td>0.984</td>
<td>30.0</td>
<td>128.4</td>
</tr>
<tr>
<td><em>Pseudapocypretes elongatus</em></td>
<td>84</td>
<td>( W=2.541 \times 10^{-5} \cdot L^{2.81} )</td>
<td>0.991</td>
<td>20.1</td>
<td>133.6</td>
</tr>
<tr>
<td>Unidentified species</td>
<td>70</td>
<td>( W=8.994 \times 10^{-5} \cdot L^{3.25} )</td>
<td>0.996</td>
<td>34.7</td>
<td>132.4</td>
</tr>
</tbody>
</table>

### Acknowledgments

This work was partially funded by PJP SF113/2000A for the first author and R&D 09-02-03-0674 for the second author, both grants awarded by University Malaya.

### References


**M.Z. Khaironizam** and **Y. Norma-Rashid**
are from the Institute of Biological Sciences, Faculty of Science, University Malaya, 50603 Kuala Lumpur, Malaysia.
E-mail: zayon1410@hotmail.com
**Diet Composition of Fish Species from the Southern Continental Shelf of Colombia**

**R.H. López-Peralta and C.A.T. Arcila**

## Abstract

The diet composition of 30 fish species belonging to 16 families from the Pacific Coast of Colombia is described. Benthic crustaceans (37.5%) and bony fishes (23.7%, chiefly demersal) were the most important food items for the fish species analyzed. Data on diet composition of the fish species are presented for the first time which can be a source of information for trophic modeling.

## Introduction

The marine communities in the Pacific Coast of Colombia have been poorly investigated and require a comprehensive research program that includes population analysis and marine ecology. This paper provides information about food habits of fishes to provide better understanding of trophic relationships among different species in the continental shelf ecosystem of Colombia.

Information about the food habits of fishes is useful in defining predator-prey relationships. A compilation of different food items consumed by a fish species may eventually result in identification of stable food preferences, and in a preliminary estimate of trophic level (Sa-a et al. 1997). Data on diet composition are useful in the creation of trophic models as a tool to understand complex coastal ecosystems.

In the Pacific Coast of Colombia, Rubio (1987) enumerates 172 families of fish (26 Chondrichthyes and 135 Osteichthyes) with 491 genera and 954 species (84 Chondrichthyes and 870 Osteichthyes). In a more recent paper, Álvarez-León et al. (1999) reported a total of 1,110 species. Stomach content studies on fish fauna in this region are almost nonexistent and deal mainly with qualitative information.

## Materials and Methods

### The study area

The Pacific Coast of Colombia has a high socioeconomic importance. Its ecological characteristics are remarkable (Vargas et al. 1969; Andrade 1986; Meindiger 1987; PRC 1989; Urbano and Castillo 1991; Flóres and Rodríguez 1992). For example: 1) it is one of the regions of the world with a substantial amount of rainfall; 2) there is an occurrence of an upwelling during the first months of the year particularly in coastal areas north of Cabo Corrientes; (3) the general area is influenced by El Niño and La Niña events; and (4) there is a large tidal variation (maximum 6 m).

The study area has a mean depth of 60 m covering 6,870 km² located on the Pacific coast of Colombia from 01°56’N to 03°33’N latitude, and to about 12 nm offshore (Fig. 1). The most important fishery banks in the Pacific Coast of Colombia are found in this area. The largest urban centers, the Buenaventura and Tumaco harbors, and Gorgona Island (site of the most important coral reefs in the Pacific Coast of Colombia) are located in this area.

Fish samples for analysis of diet composition were collected in December 1997 by means of demersal trawls (30 feet LOA vessels at mean speed of 3.3 knots) in the southern continental shelf of the Pacific Coast of Colombia (Fig. 1).

Diet composition of each species or group of species was defined by the fraction of each prey species consumed to the total consumption following Moreau et al. (1993). The hierarchical structure in FishBase 1997, with the levels of precision for Food I, Food II and Food III, was used to build the diet composition table (Froese and Pauly 1997) to standardize the entries in the food items and related trophic ecology.

Due to conflicting classification of fish species in terms of their habitat, especially for the benthos and demersal species (Rubio 1987; FAO 1992; Froese and Pauly 1997; INPA 1997; Velasco 1998; Velasco and Wolff 1999), FishBase (Froese and Pauly 1997) was used to classify the fish species into their habitat types as follows: pelagic, benthopelagic, demersal, reef-associated, bathypelagic and bathydemersal.
Results and Discussion

A total of 665 fish samples were analyzed, 456 of which had stomach content. However, only 282 (38%) individuals representing 30 species belonging to 16 families were analyzed for stomach content (Table 1 and 2).

Of the 30 fish species, 53% are demersal, 33% are reef-associated, 10% are pelagic and 3% are benthopelagic (Table 1). Except for *Diodon holocanthus*, all other fish species have commercial importance (Fitch and Lavenberg 1971; Hutchins 1984; Leis 1984; FAO 1992; Coppola et al. 1994; Bussing 1995; Hensley 1995; McKay and Schneider 1995; Smith-Vanz 1995; Sommer 1995; all references are from Froese and Pauly 1997). Some species are by-catches

---

**Table 1. List of fishes sampled from the southern continental shelf of the Pacific Coast of Colombia in December 1997.**

<table>
<thead>
<tr>
<th>Family</th>
<th>Species</th>
<th>Local name</th>
<th>Habitat*</th>
<th>N°</th>
<th>TL (cm)</th>
<th>N°</th>
<th>Fisheries importance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carangidae</td>
<td>Alectis ciliaris</td>
<td>Pámpano de hebra</td>
<td>d</td>
<td>9</td>
<td>23.5 - 55.0</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Carangoides otrynter</td>
<td>Pámpano</td>
<td>d</td>
<td>17</td>
<td>20.3 - 50.0</td>
<td>13</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Chlorocymbus orqueta</td>
<td>Arecava</td>
<td>d</td>
<td>38</td>
<td>13.4 - 0.3</td>
<td>38</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>Oligopiltes altus</td>
<td>Trancanil</td>
<td>d</td>
<td>1</td>
<td>33.5</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Selar crumenophthalmus</td>
<td>Ojón</td>
<td>ra</td>
<td>28</td>
<td>13.2 - 22.0</td>
<td>23</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>Selene brevoorti</td>
<td>Carecabo</td>
<td>d</td>
<td>62</td>
<td>16.5 - 44.0</td>
<td>38</td>
<td>33</td>
</tr>
<tr>
<td></td>
<td>Selene oerstedii</td>
<td>Jorobado</td>
<td>d</td>
<td>8</td>
<td>20.5 - 39.0</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Selene peruviana</td>
<td>Espujojel</td>
<td>d</td>
<td>122</td>
<td>13.7 - 4.0</td>
<td>89</td>
<td>61</td>
</tr>
<tr>
<td>Diodontidae</td>
<td>Diodon holocanthus</td>
<td>Pez erizo</td>
<td>ra</td>
<td>1</td>
<td>28.0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Ephippidae</td>
<td>Chaetodipterus zonatus</td>
<td>Palma rayada</td>
<td>d</td>
<td>12</td>
<td>20.5 - 98.0</td>
<td>11</td>
<td>2</td>
</tr>
<tr>
<td>Gerreidae</td>
<td>Diapterus aureolus</td>
<td>Mojarra</td>
<td>d</td>
<td>27</td>
<td>7.6 - 13.3</td>
<td>8</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Diapterus peruvianus</td>
<td>Mojarra</td>
<td>bp</td>
<td>102</td>
<td>15.5 - 0.2</td>
<td>88</td>
<td>54</td>
</tr>
<tr>
<td></td>
<td>Eucinostomus gracilis</td>
<td>Palometra</td>
<td>ra</td>
<td>10</td>
<td>8.7 - 16.4</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>Haemulidae</td>
<td>Pomadasys panamensis</td>
<td>Pargo blanco</td>
<td>d</td>
<td>21</td>
<td>10.5 - 9.2</td>
<td>11</td>
<td>5</td>
</tr>
<tr>
<td>Lutjanidae</td>
<td>Hoplopleurus guntheri</td>
<td>Pargo</td>
<td>ra</td>
<td>2</td>
<td>61.0 - 61.0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Lutjanus colorado</td>
<td>Pargo liso</td>
<td>ra</td>
<td>6</td>
<td>64.0 - 76.0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Lutjanus guttatus</td>
<td>Pargo lunarejo</td>
<td>ra</td>
<td>69</td>
<td>16.8 - 8.5</td>
<td>48</td>
<td>34</td>
</tr>
<tr>
<td></td>
<td>Lutjanus jordani</td>
<td>Pargo rojo</td>
<td>ra</td>
<td>11</td>
<td>23.0 - 65.0</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>Monacantidae</td>
<td>Aluterus monoceros</td>
<td>Chancholo</td>
<td>ra</td>
<td>16</td>
<td>33.0 - 48.0</td>
<td>11</td>
<td>7</td>
</tr>
<tr>
<td>Paralichthyida</td>
<td>Ancylopsetta dentricula</td>
<td>Lenguado</td>
<td>d</td>
<td>1</td>
<td>41.0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Hippoglossina tetrophthalmus</td>
<td>Lenguado</td>
<td>d</td>
<td>1</td>
<td>36.5</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Polyactylidae</td>
<td>Polyactylus approximans</td>
<td>Barbeta blanca</td>
<td>d</td>
<td>16</td>
<td>17.5 - 29.0</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Polyactylidae</td>
<td>Polyactylus opercularis</td>
<td>Barbeta amarilla</td>
<td>d</td>
<td>2</td>
<td>22.0 - 22.3</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Sciaenidae</td>
<td>Lariaus pacificus</td>
<td>Cajero</td>
<td>p</td>
<td>29</td>
<td>16.2 - 0.5</td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td>Scrombidae</td>
<td>Scomberomorus sierra</td>
<td>Sierra</td>
<td>p</td>
<td>23</td>
<td>39.0 - 88.5</td>
<td>18</td>
<td>12</td>
</tr>
<tr>
<td>Serranidae</td>
<td>Dipllectrum eumelum</td>
<td>Caguas</td>
<td>d</td>
<td>6</td>
<td>74.0 - 8.0</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Sparidae</td>
<td>Calamus brachysomus</td>
<td>Pluma marotilla</td>
<td>ra</td>
<td>2</td>
<td>51.0 - 2.0</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Sphyraenidae</td>
<td>Sphyraena ensis</td>
<td>Picuda</td>
<td>p</td>
<td>17</td>
<td>19.2 - 4.5</td>
<td>12</td>
<td>5</td>
</tr>
<tr>
<td>Sphyridae</td>
<td>Sphyrina tiburo</td>
<td>Cachuda</td>
<td>ra</td>
<td>2</td>
<td>97.0 - 100.0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Trigidae</td>
<td>Priodonotus stephanophrys</td>
<td>Pez callina</td>
<td>d</td>
<td>4</td>
<td>32.0</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

* = Sample details: bp = benthopelagic, N = individuals caught, d = demersal, p = pelagic, ra = reef-associated, n = specimens for analysis, TL = total length, S = subsistence fisheries, X = observed in more than three market centers, Y = observed in more than two market centers, Z = observed in one market center.

---

**References:**

1. Froese and Pauly (1997)
5. McKay and Schneider (1995)
6. FAO (1992)
12. Without reference
<table>
<thead>
<tr>
<th>Species</th>
<th>n</th>
<th>Stages</th>
<th>% composition</th>
<th>Food type</th>
<th>Taxa</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alectis ciliaris</td>
<td>4</td>
<td>juveniles</td>
<td>65.23</td>
<td>Zoobenthos</td>
<td>Benthic crust.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>30.77</td>
<td>Nekton</td>
<td>Bony fish</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>4.00</td>
<td>Detritus</td>
<td>Shrimps</td>
</tr>
<tr>
<td>Aluterus monoceros</td>
<td>7</td>
<td>juveniles/</td>
<td>41.53</td>
<td>Zoobenthos</td>
<td>Benthic crust.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>adults</td>
<td>33.54</td>
<td>Nekton</td>
<td>Crabs</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>23.61</td>
<td>Detritus</td>
<td>Crustacea (Decapoda)</td>
</tr>
<tr>
<td>Ancylopsissetta</td>
<td>1</td>
<td>adults</td>
<td>100.00</td>
<td>Nekton</td>
<td>Bony fish</td>
</tr>
<tr>
<td>dendrifica</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Lepophidium (Ophidiidae)</td>
</tr>
<tr>
<td>Calamus brachysomus</td>
<td>7</td>
<td>adults</td>
<td>39.68</td>
<td>Zoobenthos</td>
<td>Mollusks</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>27.78</td>
<td>Nekton</td>
<td>Bony fish</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>27.42</td>
<td>Detritus</td>
<td>Shrimps</td>
</tr>
<tr>
<td>Ceranogrides otrynter</td>
<td>10</td>
<td>juveniles/</td>
<td>27.58</td>
<td>Nekton</td>
<td>Bony fish</td>
</tr>
<tr>
<td></td>
<td></td>
<td>adults</td>
<td></td>
<td></td>
<td>Decapoda</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Trachypeneus</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Sicyonia</td>
</tr>
<tr>
<td>Chaetodipterus zonatus</td>
<td>2</td>
<td>juveniles</td>
<td>52.42</td>
<td>Nekton</td>
<td>Bony fish</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>47.58</td>
<td>Detritus</td>
<td>Benthic algae/weeds</td>
</tr>
<tr>
<td>Chloroscombrus orqueta</td>
<td>7</td>
<td>juveniles/</td>
<td>66.51</td>
<td>Zoobenthos</td>
<td>Mollusks</td>
</tr>
<tr>
<td></td>
<td></td>
<td>adults</td>
<td>20.15</td>
<td>Nekton</td>
<td>Bony fish</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>13.04</td>
<td>Detritus</td>
<td>Crabs</td>
</tr>
<tr>
<td>Diapterus aureolus</td>
<td>3</td>
<td>juveniles/</td>
<td>74.46</td>
<td>Zoobenthos</td>
<td>Benthic crust.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>adults</td>
<td>19.10</td>
<td>Nekton</td>
<td>Ostracods</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>5.95</td>
<td>Zoobenthos</td>
<td>Squid/cuttlefish</td>
</tr>
<tr>
<td>Diaperius peruvianus</td>
<td>54</td>
<td>juveniles/</td>
<td>29.94</td>
<td>Zoobenthos</td>
<td>Echinoderms</td>
</tr>
<tr>
<td></td>
<td></td>
<td>adults</td>
<td>18.59</td>
<td>Nekton</td>
<td>other echinoderms</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>17.10</td>
<td>Detritus</td>
<td>Bivalves</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>15.78</td>
<td>Detritus</td>
<td>Shrimps</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>7.78</td>
<td>Detritus</td>
<td>Bony fish</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>7.59</td>
<td>Zoobenthos</td>
<td>Benthic crust.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>4.76</td>
<td>Zoobenthos</td>
<td>Crabs</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>4.76</td>
<td>Zoobenthos</td>
<td>Benthic crust.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1.64</td>
<td>Zoobenthos</td>
<td>Crabs</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1.43</td>
<td>Zoobenthos</td>
<td>Crabs</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.23</td>
<td>Zoobenthos</td>
<td>other echinoderms</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.08</td>
<td>Zoobenthos</td>
<td>Sea cucumbers</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.06</td>
<td>Zoobenthos</td>
<td>Isopods</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1.02</td>
<td>Zoobenthos</td>
<td>Ostracods</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>21.76</td>
<td>Zoobenthos</td>
<td>Crabs</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>57.43</td>
<td>Zoobenthos</td>
<td>other benthic crust.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>20.11</td>
<td>Zoobenthos</td>
<td>Crabs</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>6.79</td>
<td>Zoobenthos</td>
<td>Benthic crust.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2.10</td>
<td>Zoobenthos</td>
<td>Crabs</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1.02</td>
<td>Zoobenthos</td>
<td>other echinoderms</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>20.81</td>
<td>Zoobenthos</td>
<td>Crabs</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>4.00</td>
<td>Nekton</td>
<td>Bony fish</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>98.50</td>
<td>Zoobenthos</td>
<td>Benthic crust.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.92</td>
<td>Zoobenthos</td>
<td>Shrimps</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.58</td>
<td>Zoobenthos</td>
<td>Crabs</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>50.55</td>
<td>Zoobenthos</td>
<td>Benthic crust.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>23.70</td>
<td>Zoobenthos</td>
<td>Crabs</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>25.55</td>
<td>Zoobenthos</td>
<td>sea stars</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2.20</td>
<td>Zoobenthos</td>
<td>Sea cucumbers</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Leiolebiasm pacificus</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(Ophidiidae)</td>
</tr>
<tr>
<td>Larimus pacificus</td>
<td>12</td>
<td>juveniles/</td>
<td>87.13</td>
<td>Nekton</td>
<td>Bony fish</td>
</tr>
<tr>
<td></td>
<td></td>
<td>adults</td>
<td>8.79</td>
<td>Zoobenthos</td>
<td>Benthic crust.</td>
</tr>
</tbody>
</table>

Table 2. Diet composition (in % weight) of fish species from the southern continental shelf of the Pacific coast of Colombia (December 1997).
<table>
<thead>
<tr>
<th>Species</th>
<th>n</th>
<th>Stages</th>
<th>% composition</th>
<th>Food type</th>
<th>Taxa</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>I</td>
<td>II</td>
<td>III</td>
</tr>
<tr>
<td>Lutjanus colorado</td>
<td>1</td>
<td>adults</td>
<td>4.07</td>
<td>Nekton</td>
<td>Finfish</td>
</tr>
<tr>
<td></td>
<td></td>
<td>34.70</td>
<td>0.01</td>
<td>Zoobenthos</td>
<td>Benthic crust.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>29.37</td>
<td>0.01</td>
<td>Detritus</td>
<td>Detritus</td>
</tr>
<tr>
<td></td>
<td></td>
<td>24.65</td>
<td>0.01</td>
<td>Zoobenthos</td>
<td>Benthic crust.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>11.28</td>
<td>0.01</td>
<td>Zoobenthos</td>
<td>Benthic crust.</td>
</tr>
<tr>
<td>Lutjanus guttatus</td>
<td>34</td>
<td>juveniles/</td>
<td>28.99</td>
<td>Zoobenthos</td>
<td>Echinoderms</td>
</tr>
<tr>
<td></td>
<td></td>
<td>adults</td>
<td>11.63</td>
<td>Zoobenthos</td>
<td>Benthic crust.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>9.98</td>
<td>0.01</td>
<td>Zoobenthos</td>
<td>Benthic crust.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8.26</td>
<td>0.01</td>
<td>Nekton</td>
<td>Finfish</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6.63</td>
<td>0.01</td>
<td>Nekton</td>
<td>Finfish</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5.77</td>
<td>0.01</td>
<td>Nekton</td>
<td>Cephalopods</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4.81</td>
<td>0.01</td>
<td>Nekton</td>
<td>Finfish</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4.62</td>
<td>0.01</td>
<td>Zoobenthos</td>
<td>Benthic crust.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4.26</td>
<td>0.01</td>
<td>Zoobenthos</td>
<td>Benthic crust.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.51</td>
<td>0.01</td>
<td>Nekton</td>
<td>Finfish</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.78</td>
<td>0.01</td>
<td>Detritus</td>
<td>Detritus</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.74</td>
<td>0.01</td>
<td>Zoobenthos</td>
<td>Benthic crust.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.53</td>
<td>0.01</td>
<td>Zooplankton</td>
<td>Other planktonic</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.50</td>
<td>0.01</td>
<td>Zoobenthos</td>
<td>Benthic crust.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.33</td>
<td>0.01</td>
<td>Zoobenthos</td>
<td>Benthic crust.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.32</td>
<td>0.01</td>
<td>Zoobenthos</td>
<td>Benthic crust.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.17</td>
<td>0.01</td>
<td>Zoobenthos</td>
<td>Benthic crust.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.15</td>
<td>0.01</td>
<td>Zoobenthos</td>
<td>Benthic crust.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.12</td>
<td>0.01</td>
<td>Zoobenthos</td>
<td>Benthic crust.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.02</td>
<td>0.01</td>
<td>Zoobenthos</td>
<td>Benthic crust.</td>
</tr>
<tr>
<td>Lutjanus jordani</td>
<td>4</td>
<td>juveniles/</td>
<td>96.97</td>
<td>Nekton</td>
<td>Finfish</td>
</tr>
<tr>
<td></td>
<td></td>
<td>adults</td>
<td>1.83</td>
<td>Detritus</td>
<td>Detritus</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.20</td>
<td>0.01</td>
<td>Zoobenthos</td>
<td>Benthic crust.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>65.28</td>
<td>0.01</td>
<td>Zoobenthos</td>
<td>Benthic crust.</td>
</tr>
<tr>
<td>Oligopontes altus</td>
<td>1</td>
<td>adults</td>
<td>34.72</td>
<td>Zoobenthos</td>
<td>Benthic crust.</td>
</tr>
<tr>
<td>Polydactylus approximans</td>
<td>3</td>
<td>juveniles/</td>
<td>88.50</td>
<td>Zoobenthos</td>
<td>Benthic crust.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>adults</td>
<td>7.00</td>
<td>Zoobenthos</td>
<td>Benthic crust.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3.70</td>
<td>0.01</td>
<td>Nekton</td>
<td>Finfish</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.60</td>
<td>0.01</td>
<td>Detritus</td>
<td>Detritus</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.20</td>
<td>0.01</td>
<td>Nekton</td>
<td>Finfish</td>
</tr>
<tr>
<td></td>
<td></td>
<td>41.67</td>
<td>0.01</td>
<td>Nekton</td>
<td>Finfish</td>
</tr>
<tr>
<td></td>
<td></td>
<td>21.10</td>
<td>0.01</td>
<td>Detritus</td>
<td>Detritus</td>
</tr>
<tr>
<td></td>
<td></td>
<td>18.30</td>
<td>0.01</td>
<td>Zoobenthos</td>
<td>Benthic crust.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>14.72</td>
<td>0.01</td>
<td>Zoobenthos</td>
<td>Benthic crust.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4.21</td>
<td>0.01</td>
<td>Zoobenthos</td>
<td>Benthic crust.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>42.76</td>
<td>0.01</td>
<td>Zoobenthos</td>
<td>Benthic crust.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>22.04</td>
<td>0.01</td>
<td>Zoobenthos</td>
<td>Benthic crust.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>20.91</td>
<td>0.01</td>
<td>Zoobenthos</td>
<td>Benthic crust.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>14.29</td>
<td>0.01</td>
<td>Detritus</td>
<td>Detritus</td>
</tr>
<tr>
<td></td>
<td></td>
<td>63.71</td>
<td>0.01</td>
<td>Zoobenthos</td>
<td>Benthic crust.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>23.47</td>
<td>0.01</td>
<td>Zoobenthos</td>
<td>Benthic crust.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>9.20</td>
<td>0.01</td>
<td>Zoobenthos</td>
<td>Benthic crust.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3.62</td>
<td>0.01</td>
<td>Zoobenthos</td>
<td>Benthic crust.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>81.85</td>
<td>0.01</td>
<td>Nekton</td>
<td>Finfish</td>
</tr>
<tr>
<td></td>
<td></td>
<td>13.15</td>
<td>0.01</td>
<td>Nekton</td>
<td>Finfish</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.08</td>
<td>0.01</td>
<td>Nekton</td>
<td>Finfish</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.40</td>
<td>0.01</td>
<td>Nekton</td>
<td>Finfish</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.28</td>
<td>0.01</td>
<td>Zoobenthos</td>
<td>Benthic crust.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.07</td>
<td>0.01</td>
<td>Zoobenthos</td>
<td>Benthic crust.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.17</td>
<td>0.01</td>
<td>Zoobenthos</td>
<td>Benthic crust.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>74.67</td>
<td>0.01</td>
<td>Nekton</td>
<td>Finfish</td>
</tr>
<tr>
<td></td>
<td></td>
<td>22.48</td>
<td>0.01</td>
<td>Zooplankton</td>
<td>Other planktonic</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.74</td>
<td>0.01</td>
<td>Detritus</td>
<td>Detritus</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.11</td>
<td>0.01</td>
<td>Zoobenthos</td>
<td>Benthic crust.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>30.47</td>
<td>0.01</td>
<td>Nekton</td>
<td>Finfish</td>
</tr>
<tr>
<td></td>
<td></td>
<td>22.83</td>
<td>0.01</td>
<td>Zooplankton</td>
<td>Other planktonic</td>
</tr>
<tr>
<td></td>
<td></td>
<td>14.86</td>
<td>0.01</td>
<td>Zoobenthos</td>
<td>Benthic crust.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10.13</td>
<td>0.01</td>
<td>Zoobenthos</td>
<td>Benthic crust.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4.47</td>
<td>0.01</td>
<td>Zoobenthos</td>
<td>Benthic crust.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4.39</td>
<td>0.01</td>
<td>Zoobenthos</td>
<td>Benthic crust.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4.15</td>
<td>0.01</td>
<td>Detritus</td>
<td>Detritus</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.91</td>
<td>0.01</td>
<td>Nekton</td>
<td>Finfish</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.83</td>
<td>0.01</td>
<td>Nekton</td>
<td>Benthic crust.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.14</td>
<td>0.01</td>
<td>Nekton</td>
<td>Benthic crust.</td>
</tr>
<tr>
<td>Species</td>
<td>n</td>
<td>Stages</td>
<td>% composition</td>
<td>Food type</td>
<td>Taxa</td>
</tr>
<tr>
<td>-------------------------</td>
<td>-----</td>
<td>--------</td>
<td>---------------</td>
<td>--------------------</td>
<td>---------------------------</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>I</td>
<td>II</td>
</tr>
<tr>
<td>Selene oerstedii</td>
<td>2</td>
<td>juveniles/</td>
<td>0.13</td>
<td>Nekton</td>
<td>Finfish</td>
</tr>
<tr>
<td></td>
<td></td>
<td>adults</td>
<td>1.11</td>
<td>Zoobenthos</td>
<td>Benthic crust.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.76</td>
<td>Zoobenthos</td>
<td>Benthic crust.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.64</td>
<td>Zoobenthos</td>
<td>Benthic crust.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.10</td>
<td>Zoobenthos</td>
<td>Benthic crust.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.04</td>
<td>Zoobenthos</td>
<td>Benthic crust.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.03</td>
<td>Zoobenthos</td>
<td>Benthic crust.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.01</td>
<td>Zoobenthos</td>
<td>Worms</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>89.24</td>
<td>Zoobenthos</td>
<td>Benthic crust.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>10.76</td>
<td>Detritus</td>
<td>Detritus</td>
</tr>
<tr>
<td></td>
<td>64</td>
<td>juveniles/</td>
<td>35.13</td>
<td>Nekton</td>
<td>Finfish</td>
</tr>
<tr>
<td></td>
<td></td>
<td>adults</td>
<td>18.51</td>
<td>Nekton</td>
<td>Cephalopods</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>13.44</td>
<td>Nekton</td>
<td>Finfish</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>12.31</td>
<td>Nekton</td>
<td>Finfish</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>5.96</td>
<td>Zoobenthos</td>
<td>Benthic crust.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3.69</td>
<td>Detritus</td>
<td>Detritus</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3.11</td>
<td>Zoobenthos</td>
<td>Benthic crust.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2.46</td>
<td>Zoobenthos</td>
<td>Benthic crust.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1.85</td>
<td>Zoobenthos</td>
<td>Benthic crust.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1.75</td>
<td>Zooplankton</td>
<td>Other planktonic</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.66</td>
<td>Zoobenthos</td>
<td>Benthic crust.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.66</td>
<td>Zoobenthos</td>
<td>Benthic crust.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.34</td>
<td>Nekton</td>
<td>Finfish</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.12</td>
<td>Plants</td>
<td>Other planktonic</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.01</td>
<td>Zoobenthos</td>
<td>Benthic crust.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>95.18</td>
<td>Nekton</td>
<td>Finfish</td>
</tr>
<tr>
<td>Sphyraena ensis</td>
<td>5</td>
<td></td>
<td>4.82</td>
<td>Zoobenthos</td>
<td>Benthic crust.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>61.50</td>
<td>Zoobenthos</td>
<td>Benthic crust.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>38.50</td>
<td>Nekton</td>
<td>Cephalopods</td>
</tr>
<tr>
<td>Sphyrma tiburo</td>
<td>1</td>
<td>adults</td>
<td>61.50</td>
<td>Zoobenthos</td>
<td>Benthic crust.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>38.50</td>
<td>Nekton</td>
<td>Cephalopods</td>
</tr>
</tbody>
</table>

in shrimp fisheries (Rubio 1988) and are caught in artisanal and industrial fisheries (INPA 1997).

The diet composition shows that the main food items were benthic crustaceans (crabs 15.1%, shrimps 13.8% and stomatopods 8.6%) and bony fishes (23.7%), mostly demersal species (Table 2).

Amphipods, isopods and ostracods are usually designated as zoobenthos (benthic crustaceans) within the hierarchy of food items table in FishBase (Froese and Pauly 1997), hence in this study they were grouped in the same way for consistency. It can be noted, however, that amphipods belonging to family Hipperidae are usually pelagic and those species belonging to Gammaridae are essentially found on the bottom, but most of them are able to swim (Ruppert 1996). In addition, ostracods mainly inhabit near the bottom, even though most of the species are planktonic, while isopods are mainly benthic (bottom-dwelling) animals.

In some fish samples, sand and mud were found in the stomach contents. However, it was not possible to separate and weigh them. For this reason, they were not included as food items. The food item “worms” included organisms such as annelids, sipunculids and nemertines, and they were collectively measured. Detritus is defined as decomposing organic debris, small pieces of dead and decomposing plants and animals. Hence, organic detritus considered in the diet composition includes debris (carcasses) as in the ecology and food item tables from FishBase (Froese and Pauly 1997).

Identification of stomach content of fishes is not easy since the food items are usually completely digested or unidentifiable. In addition, most of the fish samples have empty stomachs. In this study, due to the low catches of some species or the relatively low number of fish samples with identifiable stomach contents, the diet composition of several species obtained is not representative and must be considered as preliminary. It is therefore suggested that a vigorous research program should be developed to increase the number of species studied for their natural diets and the results of the studies documented with a series of papers describing the diet composition of a variety of fish species.

It is also interesting to note that fishes that feed on phytoplankton were absent in the samples. Apparently, El Niño events may...
indirectly influence the presence of these fishes. The phytoplankton biomass in the study area was low (Medina 1988), compared with the rest of the coastal waters off the Pacific Coast of Colombia. This is also attributed to the great river runoff in the central and southern parts of the continental shelf. During the El Niño event, a decrease in chlorophyll a (used as an indirect measure of phytoplankton biomass) has been reported (Arntz and Fahrbach 1996). Abiotic parameters and qualitative phytoplankton variation corroborated the occurrence of El Niño event in the Pacific Coast of Colombia in December 1997 (Medina 1988; Lópe-Peralta et al. 1998a, 1998b, 1999). This El Niño episode is considered the strongest of the last century. Positive and negative biological consequences of this event include quantitative and qualitative changes on marine communities, as well as alterations in geographical distribution of some populations (Arntz and Fahrbach 1996). This points out the occurrence of changes in finfish food habits as well; therefore it is necessary to analyze diet composition of fishes in other periods in order to establish food consumption variability of fish stocks in the Pacific Coast of Colombia.

Acknowledgments

This work was supported by the Ministry for the Environment of Colombia and was carried out at the Instituto de Investigaciones Marinas y Costeras (INVEMAR). The authors thank their colleagues at INVEMAR: Alba Idalia Mosquera, Manuel Alejandro Ramírez, Anabella Zuluaga, María Isabel Criales, Augusto Angulo and Carlos Fernández.

References


R.H. López-Peralta is from Universidad Militar ‘Nueva Granada’, Colombia and C.A.T. Arcila is from Fundación Sila Kangama, Colombia.

Email: rlopez@santander.umng.edu.co
Fisheries of the Farasan Islands (Red Sea)

W. Gladstone

Abstract

The fisheries of the Farasan Islands (Saudi Arabia, Red Sea) are described. The fishery resources are exploited by artisanal, investor and industrial sectors. The artisanal fishery consists mostly of line fishing around coral reefs and about half the fishing effort occurs within the proposed marine protected area (MPA). Activities by investor and industrial fisheries sector include line fishing, gill netting, fish trapping and demersal fish trawling. The relevant resource management issues that need to be addressed as part of a planning study for the establishment of a MPA are also presented. The major issues are: (1) the decline in the catch of the artisanal fishery; (2) by catch and habitat degradation; (3) sustainability in the collection of giant clams and pearl shells; and (4) the lack of information such as the importance of MPA to fisheries, stock assessment and catch and effort data. A significant role in the future management of the fisheries has been identified for the traditional representatives of the artisanal sector.

Introduction

The Farasan Islands (Fig. 1) are a high priority in terms of conservation and management of marine resources. Most of the marine environment is undisturbed by human activities other than fishing. There is a high diversity of marine ecosystems and the area is nationally and internationally significant for seabirds and marine mammals, and is the site for a unique annual aggregation of parrotfish (Gladstone 1996; Gladstone and Fisher in press). The dramatic urban, industrial and commercial development of Saudi Arabia in recent decades has led to rapid population growth, development of coastal areas, and the rise of relatively new industries, such as commercial fishing (Gladstone et al. 1999). The sea between the Farasan Islands and the coast is Saudi Arabia’s major fishing ground in the Red Sea, and continued growth in fishing is expected as demand for seafood increases. If unmanaged, these factors are a potential threat to the resource sustainability, conservation status and cultural values of the Farasan Islands. In view of this, it was decided to establish a marine protected area (MPA) around the Farasan Islands. This region of the Red Sea is poorly documented and the fisheries have not been studied in detail. More detailed studies (e.g., stock, catch and effort assessments) are planned for the future as part of a regional fisheries assessment (Gladstone et al. 1999).

The aim of this study was to gather preliminary information on fisheries activities within the proposed Farasan Islands MPA. This paper describes the types of fisheries that used the proposed MPA, the areas utilized, the intensity of usage, current issues facing the artisanal fishers and their perception of the proposed MPA.

Methods

The Farasan Islands (16°40’N and 42°00’E) are located in the southern Red Sea within the borders of the Kingdom of Saudi Arabia, 42 km offshore of the coastal city of Jizan. The proposed Farasan Islands MPA encompasses 128 islands and a total area of 3 310 km² (Fig. 1). Farasan Island (four villages), Saqid Island (four villages) and Qummah Island (one village) have a total population of 5 000. The locations of fishing grounds and camps were determined...
by aerial and boat surveys and interviews with fishers. Differences in the level of use of particular reefs were quantified by inspection of Coast Guard records of all trips made by artisanal fishers from two launch sites. Species caught were determined by inspection of catches during fishing or clearing of nets and when the catch was being landed at the markets, as well as by diving on fish traps. Artisanal fishers and pearl divers were interviewed at sea, in fishing camps, at fish markets, and in their homes for information on income, perceived conflicts, and traditional management.

**Results**

**Artisanal Fishing**

At the time of the study there were 381 artisanal fishers, aged 22-75 years and representing about 20% of the male workforce. All artisanal fishers were Saudi nationals and all worked solely as fishers. There were 442 licensed fishing boats, of which 396 were factory-made fiberglass boats (mostly 5-8 m length) powered by outboard motors and 46 were traditional, hand-built wooden boats. Fishing trips began from launch sites throughout the Farasan Islands, usually near the fishers’ village (Fig. 1). Fishers worked around the islands and reefs within the vicinity of their launch site for 1-6 days, living in island camps. There was a Coast Guard camp at the larger villages where fishers reported prior to their departure and again upon their return.

A significant amount of fishing effort occurred within the boundaries of the proposed MPA and some reefs were fished more intensively than others. An average of about five fishing trips per day were made from the Jinabah Bay launch site, whereas an average of one and a half fishing trips per day were made from the Tobtah launch site. Combining fishing trips from both launch sites, the most frequently fished reefs in the vicinity of these launch sites were those around Solubah Island, Domosok Island and Ra’s Shida, with visitation rates of 1.4, 1.1 and 0.8 trips/day, respectively. All other locations within the proposed MPA in the vicinity of these launch sites were only fished on 1-4 occasions during the month. About 76% of fishing trips from the Jinabah Bay launch site and 59% from the Tobtah launch site were to destinations within the proposed MPA. This depiction of the significance of reefs within the proposed MPA for the artisanal fishery is probably representative because the Jinabah Bay and Tobtah launch sites accounted for 23% of all fishing boats, and the numbers of potential fishing sites were about evenly distributed around the Farasan Islands.

**Table 1. Fish species caught in the artisanal fishery of the Farasan Islands.**

<table>
<thead>
<tr>
<th>Class Chondrichthyes (sharks and rays)</th>
<th>Family Carcharhinidae</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carcharhinus, C. melanopterus</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Class Osteichthyes (bony fishes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Family Belonidae</td>
</tr>
<tr>
<td>Tylosurus choram</td>
</tr>
<tr>
<td>Family Chanidae</td>
</tr>
<tr>
<td>Chanos chanos</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Family Serranida</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aethaloperca rogaa, Cephalopholis hemistiktos, C. miniata, C. ogispicida, Epinephelus areolatus, E. fuscoguttatus (<em>), E. summana (</em>), Plectropomus maculatus, P. truncatus, Variola louti</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Family Carangida</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carangoides bajad, Caranx melampygus, C. sexfasciatus, Gnathanodon speciosus, Rachycentron canadus, Scomberoides commersonianus, Seriola dumerili</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Family Scombridae</th>
</tr>
</thead>
<tbody>
<tr>
<td>Euthynnus affinis, Gymnosarda unicolor, Scomberomus commerson</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Family Lutjanidae</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lutjanus bohar, L. kasmira, L. gibbus , L. ehrenbergi, L. sebae, Pristipomoides typus</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Family Haemulidae</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plectorhynchus flavomaculatus, P. gaterinus</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Family Lethrinidae</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lethrinus lentjan (<em>), L. mahnena (</em>), L. microdon (*), L. nebulosus</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Family Epinephelida</th>
</tr>
</thead>
<tbody>
<tr>
<td>Platax orbicularis</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Family Gerreidae</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gerres argyreus (<em>), G. oyena (</em>)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Family Mugilidae</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crenimugil crenilabris (<em>), Oedalechilus labiosus (</em>)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Family Sphyraenida</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sphyraena barracuda</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Family Labridae</th>
</tr>
</thead>
<tbody>
<tr>
<td>Epipulus insidator</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Family Scaridae</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hipposcus carthus (<em>), Scarus ferrugineus (</em>), S. ghobban</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Family Siganae</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sigana rivulatus (*)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Family Platycephalida</th>
</tr>
</thead>
<tbody>
<tr>
<td>Platycephalus sp.</td>
</tr>
</tbody>
</table>

(*) species also caught by industrial fisheries.
Islands.

A total of 42 species of fish were noted during the study (Table 1), with emperors (Family Lethrinidae) being the favored catch. The most common technique for catching reef fishes was line fishing by a single fisher from a boat. The fishers claimed they no longer hunted dugong or turtle, and no evidence contrary to this was observed. Typically, artisanal fishers reported they were paid approximately 500 Saudi Riyals (SR) (about US$133) for their catch after 3-4 days fishing.

A single person within each village, translated from Arabic as the ‘chief fisherman’, was the focus for all fishing activities. There were six chief fishermen and each was a respected person in the village, the best fisher, and a source of much local information about fishing. Chief fishermen performed duties on behalf of the artisanal fishers that were recognized by relevant government authorities, such as representing them in any dealings with the Fisheries and Coast Guard, approving and submitting applications for fishing licenses, and signing letters written by fishers to the Coast Guard and government. Traditional management practiced in the Farasan Islands involved the practice of rotating fishing grounds. When catches declined from a reef, the artisanal fishers stopped fishing there for up to three months and concentrated their efforts on another reef. This activity was coordinated by the chief fishermen.

Pearl shells (Pinctada radiata) were collected at only one location in summer, Rogbain Island (Fig. 2), by a group of four divers. Mounds of discarded pearl shells are very common along the shorelines of most of the Farasan Islands, indicating that pearling was a significant local industry in the past. Underwater observations indicated that large numbers of P. radiata were still present in the shallow waters around Rogbain Island. Current activities of this fishery are probably sustainable, owing to the small number and age (50-60 years) of participants and the absence of new divers.

Clams (Tridacna maxima) were abundant on shallow reef tops on many reefs. At the time of this survey, clam tissues were being harvested from shallow reefs in the Kharij As Sailah and Kharij Al Qabr areas (Fig. 2). They are for sale in Farasan village for SR1 each (about US$0.27). Surveys of this collection revealed that a significant number of clams were collected. Living clams were picked from the reef by breaking the surrounding coral, removing the living tissue, and discarding the empty shell at the same site. The open spaces created by collectors smashing the coral were invaded by zooanthids, which appeared to limit the re-growth of the surrounding corals. Although clam collection occurred only in a few locations, it reduced local stocks and destroyed the surrounding coral. The long-term sustainability of this activity needs to be assessed in more detail.
Investor Fishing

The investor fishing sector consisted of 161 fishers (106 Saudi nationals and 55 foreigners) employed by nine local business people (the ‘investors’). Investors had obtained an interest-free government loan to buy and equip their fishing boats. Compared with the artisanal fishery, the boats were larger (not less than 10 m), had bigger engines (at least twin 75 hp), and had crews of 2-4 men who often lived on the boat. They fished with gill nets or hook and line or both. Employed fishers fished in the same locations and caught the same species as artisanal fishers. They also fished reefs that were deeper and further offshore than those frequented by the artisanal sector, and consequently caught additional species including lutjanids (such as Lutjanus bohar, L. gibbus, L. sebae, L. elongatus and lethrinids (such as Lethrinus nebulosus and L. elongatus)).

Industrial Fishing

Industrial fishing was undertaken by a single company, Saudi Fisheries, of which the government was the majority shareholder. Its operations involved demersal fish trawling, gill netting and fish trapping. Demersal fish trawling mostly occurred in the deeper shelf waters of the Red Sea and was only recorded twice (based on positions recorded in skippers’ logs) in 12 months within the proposed MPA (Fig. 2). Gill netting and fish trapping were done from a fleet of 17 fiberglass boats based in Jizan that taken daily to the Farasan Islands. Each boat had a crew of three foreign workers who were employed by Saudi Fisheries on two year contracts and were paid a flat rate for their catch of SR 3-4/kg (about US$ 0.93/kg). Surveys within the proposed MPA boundaries revealed that these boats concentrated their fishing activities on the shallow reef flats. However, it was not possible to determine the significance of the proposed MPA for this fishery. The largest component of the catch (Table 1) was rabbitfish (Siganus rivulatus, Family Siganidae). Fish traps, called gargoor, were introduced to the area by foreign fishers in the industrial sector and were deployed in several locations throughout the proposed MPA (Fig. 2). Traps were not historically used by artisanal fishers in the area and had not been adopted by them since their introduction. The industrial fishers deployed traps in the areas fished by artisanal fishers and caught similar species (Table 1), as well as non-commercial species, including angelfishes (Family Pomacanthidae), butterflyfish (Family Chaetodontidae), and surgeonfish (Family Acanthuridae).

Table 2. A preliminary list of species that are found in the fish nursery habitats within the Farasan Islands Marine Protected Areas.

<table>
<thead>
<tr>
<th>Nursery habitat</th>
<th>Month</th>
<th>Taxa utilizing nursery</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mangroves</td>
<td>October</td>
<td>Herklostichys quadrimaculatus, Gerres oyena</td>
</tr>
<tr>
<td></td>
<td>November</td>
<td>Atherinomorus lacunosus, Lutjanus ehrenbergi, Gerres oyena</td>
</tr>
<tr>
<td></td>
<td>January</td>
<td>Lutjanus ehrenbergi, Gerres oyena, unidentified mugilids</td>
</tr>
<tr>
<td></td>
<td>February</td>
<td>Lutjanus ehrenbergi, Gerres oyena</td>
</tr>
<tr>
<td></td>
<td>March</td>
<td>Acanthopagrus bifasciatus</td>
</tr>
<tr>
<td></td>
<td>April</td>
<td>Atherinomorus lacunosus, Lutjanus ehrenbergi, Gerres oyena, Sargassum</td>
</tr>
<tr>
<td>Patch reefs</td>
<td>November</td>
<td>Lutjanus ehrenbergi, unidentified lethrinids</td>
</tr>
<tr>
<td></td>
<td>December</td>
<td>Lutjanus ehrenbergi, Gerres oyena, Scarus ferrugineus, Acanthurus nigricans, Siganus rivulatus</td>
</tr>
<tr>
<td>Beaches</td>
<td>December</td>
<td>Atherinomorus lacunosus, Gerres oyena</td>
</tr>
<tr>
<td></td>
<td>January</td>
<td>Gerres oyena, unidentified mugilids</td>
</tr>
<tr>
<td></td>
<td>February</td>
<td>Atherinomorus lacunosus, Gerres oyena</td>
</tr>
<tr>
<td></td>
<td>March</td>
<td>Gerres oyena</td>
</tr>
<tr>
<td>Reef flat</td>
<td>November</td>
<td>Lutjanus ehrenbergi, Gerres oyena</td>
</tr>
<tr>
<td></td>
<td>December</td>
<td>Lutjanus ehrenbergi, Gerres oyena, Acanthurus nigricans, Siganus rivulatus</td>
</tr>
<tr>
<td></td>
<td>January</td>
<td>Lutjanus ehrenbergi, Gerres oyena, Acanthurus nigricans</td>
</tr>
<tr>
<td></td>
<td>February</td>
<td>Unidentified lethrinids, unidentified mugilids, Siganus rivulatus</td>
</tr>
<tr>
<td></td>
<td>April</td>
<td>Lutjanus ehrenbergi, unidentified lethrinids, Gerres oyena, Siganus rivulatus</td>
</tr>
<tr>
<td>Winter-inundated areas</td>
<td>January</td>
<td>Atherinomorus lacunosus, Gerres oyena, unidentified mugilids</td>
</tr>
<tr>
<td></td>
<td>February</td>
<td>Unidentified lethrinids</td>
</tr>
<tr>
<td>Seagrass</td>
<td>September</td>
<td>Unidentified lethrinids</td>
</tr>
<tr>
<td></td>
<td>November</td>
<td>Lutjanus ehrenbergi, Gerres oyena</td>
</tr>
<tr>
<td></td>
<td>January</td>
<td>Unidentified lethrinids</td>
</tr>
<tr>
<td></td>
<td>February</td>
<td>Lutjanus ehrenbergi, unidentified lethrinids, Gerres oyena, Siganus rivulatus</td>
</tr>
<tr>
<td></td>
<td>March</td>
<td>Siganus rivulatus</td>
</tr>
<tr>
<td></td>
<td>April</td>
<td>Unidentified lethrinids, unidentified siganids</td>
</tr>
</tbody>
</table>

Discussion

This study identified a number of issues that need to be addressed and studied in more detail in planning the management of the proposed MPA. Artisanal fishers reported that catches, sizes of fish, and income from fishing had all declined in recent years, and that more time was needed and larger areas covered to catch the same number of fish as in the past. The artisanal fishers claimed that the ease of gaining government loans had led to an increase in the size of the investor fishery and that foreigners did not follow the traditional system of rotating reefs nor felt any responsibility for maintaining the resources. Although the number of artisanal fishers had increased from 195 in 1976/1977 (Sanders and Morgan 1989) to 381 in 1993, the
majority of artisanal fishers interviewed did not believe that this growth, or improvements in their own equipment, had contributed to the decline in catches. Developing a sustainable artisanal fishery will be a priority in the management of the proposed Farasan Islands MPA in order to maintain the economic livelihood of the Farasan Islanders, to diversify the national economic base and to maintain socio-cultural identity. Artisanal fishers expressed support for the concept of an MPA as a tool for sustaining fisheries, as long as there were limited restrictions on their own activities and stricter controls of the investor and industrial fisheries.

Potential issues associated with industrial fisheries within the proposed MPA include by-catch and habitat damage from gill netting and fish trapping, and a lack of stock assessment and catch-effort data. The industrial fishers set their gill nets in the shallow reef flat areas that occupy a large area of the MPA and are used as nursery grounds by some species of fish. The artisanal fishers recognized this activity as a potential problem from their knowledge of the significance of this habitat for juvenile fishes. Table 2 presents a preliminary list of species using the fish nursery habitats in Farasan Islands MPA. Management of the activities of the industrial sector within the proposed MPA could involve limitations on the areas they fish through zoning. Although there are large areas of alternative fishing grounds outside the MPA, restrictions on this fishery could be constrained by government-ownership and conflicting management priorities between the National Commission for Wildlife Conservation and Development (responsible for managing protected areas) and the Ministry for Agriculture and Water (responsible for fisheries management).

All artisanal fishers in the Farasan Islands were Saudi nationals. However, most of the fishing in the investor and industrial sectors is now done by foreign employees. The strong sense of custodianship expressed by the Farasan artisanal fishers could be utilized in the management of the proposed MPA, e.g., as employed or voluntary marine rangers and in public education programs. Management will benefit from the direct involvement of chief fishermen (e.g., as stakeholder representatives on a consultative committee) because of their knowledge of the local marine environment, local customs and politics, their esteemed position amongst artisanal fishers, and for communication between the management and the community. This is especially critical because of the size of the proposed MPA and the associated difficulties in enforcement of restrictions, as well as the decline in financial support for conservation in Saudi Arabia associated with declining oil prices. The level of participation of the artisanal sector in planning the MPA will determine their support for it and hence its future success.

In summary, this study identified the following issues for the management of the proposed MPA: declines in catches by the artisanal fishery, by-catch and habitat damage from gill netting and fish trapping, lack of stock assessments and catch-effort data for all fisheries, lack of information on the significance of the MPA for industrial gill netting and the sustainability of clam collecting, and lack of detailed information on the socio-economic significance of fishing activities. Additional research and monitoring are required to provide this information. It is, therefore, necessary to adopt a precautionary approach in planning of the MPA until such information is available.

Acknowledgements

The author gratefully acknowledges HE Dr. A.H. Abuizinada (NCWCD) for his support and encouragement of the work on the Farasan Islands, and also the assistance of Dr. E. Joubert (IUCN) and Mr. M. Sulayem (NCWCD). Assistance in the field was provided by G.M. Ali, R. Al Khuzaiym and M. Al Saneti. The author’s work on the Farasan Islands was facilitated by F. Parakatil (IUCN, Gland).

References


W. Gladstone is with the National Commission for Wildlife Conservation and Development, PO Box 61681, Riyadh 11575, Kingdom of Saudi Arabia. His current address is Sustainable Resource Management and Coastal Ecology Unit, School of Science and Technology, University of Newcastle, Central Coast Campus, PO Box 127, Ourimbah NSW 2258, Australia. E-mail: wgladsto@mail.newcastle.edu.au; Tel: 61 2 4348 4123; Fax: 61 2 4348 4145.
African Freshwater Fisheries: What Needs to be Managed?

E. Jul-Larsen and P. van Zwieten

Abstract

The management of African freshwater fisheries in Southern African Development Coordination (SADC) countries is discussed. Changes in catch and fishing effort in the SADC freshwater fisheries in the past 50 years, the main causes behind the patterns of change in fishing effort, the effects of fishing effort and environment on the regeneration of fish stocks, as well as existing and proposed fisheries management regulations are investigated.

Introduction

During the past decade, the debate on how to manage African freshwater fisheries, as has occurred in many fisheries worldwide, has centred on possibilities for co-management. In reaction to conventional (top-down), centralized management, an increasing number of documented cases show that locally based, access-regulating mechanisms can effectively regulate the intensity of exploitation. A clear distinction between free access and common property is now established in the literature and most people seem to think that fisheries management is best performed in a collaborative sharing of responsibilities between local people and state authorities. ‘Co-management’ is proposed as a way to move away from the failures of past management approaches, or simply as a way to make fisheries management cheaper, even though it is admitted that the notion is ambiguous and often difficult to define.

A characteristic that the co-management alternative continues to share with more conventional management is the fundamental assumption that fish resources are under pressure from increased fishing effort and that this represents the major challenge for the sustainability of fisheries in terms of biological and/or economic overfishing. Regulation of fishing effort therefore remains the essential means to avoid ‘tragedies’ and improve efficiency and peoples’ living conditions. Where it differs from conventional thinking is that the promoters of collaborative management assume that once people are convinced of the positive effects of effort reduction as trends in catches and catch rates are reversed, fisheries will come to some form of self regulation.

Recently, research on other common property resources in tropical ecosystems is challenging underlying assumptions of both conventional management and co-management. Some ecologists and social scientists in the fields of pastoralism and forestry in Africa now question to what extent and how anthropogenic variables affect the regeneration of pastures and forests (see, e.g., Scoones 1995; Fairhead and Leach 1996). Abiotic variables related to climate variability and change may be much more important to the dynamics of the ecosystem. Such dynamics at least obscure the possibility to perceive trends resulting from human activity and may even outweigh anthropogenic impacts.

Only to a minor extent have the same questions been raised in relation to African fisheries.

In 1997, a group of researchers, with experience in African freshwater fisheries initiated a research project entitled ‘Management, co-management or no management? Major dilemmas in sustainable exploitation of freshwater fisheries in the SADC countries’. The project was funded by several sources, the principal one being the Norwegian Research Council. It ended in 2001. Researchers from Europe and the SADC countries and with backgrounds in biology and social sciences have been involved in undertaking case studies and synthesis analyses. The project has mainly focused on medium size waterbodies in Malawi, Zambia and Zimbabwe, although it also draws upon material from the other fisheries in the region. The questions addressed are:

- How have catches and fishing effort changed over the last 50 years?
- What are the main causes behind these changes?
- How does fishing effort influence the regeneration of the stocks?
- To what extent are existing and proposed management regula-
tions in fisheries consistent with the needs derived from the answers of the previous questions.

**Changes in Catch and Fishing Effort in SADC Freshwater Fisheries in the Last 50 Years**

Obtaining reliable catch and effort data in African small-scale fisheries is problematic. According to FAOSTAT (FAO 2000), freshwater catches in the 12 mainland SADC countries steadily increased from 168 000 t in 1961 to 598 000 t in 1986. Since then, catches have stabilized between 600 000 and 700 000 t and in 1997, it is reported to have been 635 000 t. The Democratic Republic of Congo, Malawi, Tanzania and Zambia catch more than 90% of the total freshwater landings in the region. The increases over time have resulted partly from exploitation of new water bodies, for example, Lakes Kariba and Cabora Bassa, and partly from fishing for previously untouched stocks, especially small pelagics. Fishing effort on already exploited stocks has continued to increase during the same period although this varies according to the water body. For example, in Lake Mweru, numbers of fishers have steadily increased while in the Bangweulu swamps it has probably remained fairly stable over a long time. In both the Zambian and Zimbabwean parts of Lake Kariba, fishing effort on the inshore stocks has varied considerably and is probably not much higher today than it was just after the lake was filled in the late 1950s. Intermittent lakes like Chilwa, Chiuta and Mweru Wa Ntipa also appear to be subject to considerable fluctuations in effort. In Lake Malombe, the number of fishers has steadily increased through the 1970s and 1980s, stabilized in the 1990s but seems to have decreased in recent years.

Equally, we find large differences in effort dynamics with reference to ‘population-driven’ and ‘investment-driven’ changes of fishing effort. The first concept refers to changes in the number of harvesters, while the latter relates to changes in technology, diversification of methods and/or in number of gears per unit. All fisheries have elements of both types of change, but their relative importance varies considerably and in SADC freshwaters it is the population-driven changes of effort which have been the dominating characteristic during the last 50 years. This means that harvest technology and overall production costs per fishing unit in most cases have remained relatively stable, while the number of harvesters has grown or fluctuated. It is only in Lake Malombe and in some historical cases connected to the (unsuccessful) development of so-called ‘modern’ fisheries by foreign entrepreneurs that investment-driven changes in effort dominate. Here, it is technological change and number of gears per production unit which constitute the most important element of the effort development.

The variation in effort levels is most dramatic in fisheries dominated by population-driven changes. For instance, in Lake Kariba the number of fishers decreased by 75% in less than five years after 1963. Later, it increased by 150% in seven years during the 1980s. These fisheries are dominated by simple and capital-extensive technologies. This entails low entry fees which facilitate the mobility of people in and out of the fisheries. Economically speaking, anyone can become an independent fisher within a few years. Perhaps it is this mobility that is the reason for Pauly’s argument (1994, 1997)— that the entry of people who have been marginalized in terms of other resources or occupations causes the biggest worries in African (as well as Asian and Latin American) small-scale fisheries at present. According to Pauly, the small-scale fisheries have become a “last resort” and the accumulation of destitute people in the sector ultimately leads to “Malthusian overfishing”.

Our results indicate an even greater mobility. In most fisheries people not only move into fisheries, but equally move out of them as well. In the inshore fisheries of Kariba, fishers from all over the region came to establish themselves in the 1980s only to move away again at a later stage. It is also in fisheries where effort is steadily growing where people move out of the fisheries. For instance, in Mweru, more than 3 000 fishers left the fisheries in a period where the total number of producers grew by 2 300. Until now, the fisheries in SADC freshwaters have not functioned as a last resort, but as an occupation that people can join and leave whenever they judge they need to.

**Causes Behind the Patterns of Change in Fishing Effort**

The findings regarding effort development confront us with a series of questions related to the causes. Conventional management thinking tends to consider growth of

---

1 The distinction is inspired by Brox (1990) who demonstrates very different social and economic consequences of population-driven and investment-driven growth of effort in the North Norwegian cod fisheries.
effort as inevitable and relates it to social factors such as demographic growth (population-driven) and an expanding demand for fish (investment-driven). Such explanations are problematic. It does not explain the variation over time since the demographic growth has been fairly stable in most places. Neither does it explain the differences between water bodies since there is little accordance between high demographic growth and increases in fishing effort. Finally, investment-driven growth seems to be the exception, despite a general increase in demand for fish in the whole region.

Fluctuations in population-driven changes are mainly induced by a combination of variations in ecological productivity and opportunities in other sectors. The sudden reduction in productivity after Lake Kariba was filled, combined with good opportunities in other sectors, led to the dramatic reduction of numbers of fishers after 1963. Similarly, the crisis in the Zambian economy after 1974 led many people to join the Kariba fisheries after the end of the Zimbabwean War of Independence in 1980. More than 80% of fishers who arrived in Kariba in the 1980s previously worked in the Copperbelt or in Lusaka. It was also the same crisis which in many ways led people who had lost their jobs in the Copperbelt to introduce the new fishery for chisense in Lake Mweru. There is little doubt that the SADC freshwaters serve as an important buffer or safety-valve for numerous people in times of economic distress, but entering the fisheries is not an irreversible process.

Local access-regulating mechanisms based on ethnic or community identity are found everywhere, although they may differ in effectiveness in controlling recruitment of new fishers. In Malombe, such mechanisms have, for long, excluded owners coming from outside the fishery. In Lake Kariba, it was only in the early 1960s and during the last decade that local access regulations have been effective in excluding outsiders; elsewhere they seem to have been of little relevance to exclude newcomers.

In contrast, important investment-driven changes in the form of more capital-intensive harvesting methods seem to reduce population-driven growth. In Lake Malombe, the shift from gillnets to various, much more capital-intensive seining methods, have substantially increased the entry fees into the fishery and thereby reduced the number of potential operators.

Many studies, also from outside the SADC area, indicate that the overall constraint related to more capital intensive fishing methods (and to investment-driven growth of effort) is connected to access to financial capital. No cases were found where fishing activities are in themselves sufficient to trigger further technological development based on higher levels of investment. There always seems to be a need for financial resources from outside. In Lake Mweru, the financial needs in the mpundu (Labeo altivelis) fishery, initiated in the early 1950s, were met by European entrepreneurs. In Lake Malombe, the need for capital to buy seines was mainly met through surpluses generated in international labor migrations. It is interesting to note how the macro-economic factors seem to affect vertical changes of effort in an opposite direction compared to population-driven changes. While improved macro-economic conditions will tend to reduce the population-driven growth by more people seeking livelihood in other sectors, it may facilitate investment-driven growth by increasing the surpluses from outside being reinvested into fisheries.

But the lack of financial resources and of investment-driven growth in the SADC freshwaters are merely a reflection of much more basic aspects in the societies and of the functioning of institutions, both at central and local level, supposed to regulate fisheries. Analytical approaches such as those developed by the new institutional economy may be very useful to understand why institutions (e.g., to cover financial needs) do not develop as easily as one could expect. But the analyses of the existing institutional landscape in SADC freshwater fisheries also demonstrate the weaknesses of this type of approach. They demonstrate how difficult it is, at the local level, to identify institutions with well-defined social rules and with underlying norms which are commonly shared. Such difficulties may be observed if we, e.g., in Malombe, study the relation between active fishers and gear owners for whom they work: it shows the complexity of what often is believed to be a straight employer/employee relationship. However, closer analysis proves that the underlying norms supposed to stabilize the relationship are far from commonly shared and that the rules therefore often emerge as ambiguous and even contradictory.

The result is that the owners only control their labor with great difficulty and that fishers often feel betrayed and/or exploited by the owners. As well as controlling access to financial resources, the control and management of the labor force also seem to constitute an effective constraint for investment-driven growth in effort.
Effects of Fishing Effort and Environment on the Regeneration of Fish Stocks

Classic stock assessment models, commonly in use in many African fisheries, give a major role to fishing effort in explaining and predicting changes in the regeneration of fish stocks. However, setting limits on fishing mortality based on model-information has met with limited success. Apart from being unenforceable in many instances, a number of reasons more intrinsic to the fisheries and ecosystems contribute to this failure. In the lakes studied, environmental drivers are often more significant than effort in explaining changes in fish production. For instance, even on a highly aggregated level, variations around the trend in total catch of the SADC area are related to lake level fluctuations of the African Great Lakes. Next, total yields in these multispecies and multi-gear fisheries are surprisingly stable over a large range of effort, but with considerable changes in species and size composition, both as a result of fishing and as a result of environmentally driven processes. Many, but not all stocks appear to be highly resilient, with a large capacity to bounce back after release of pressure. Lastly, variations in effort levels are found to be to some extent a reflection of the variations in the productivity of the ecosystems, a result also found in other research (Allison and Ellis 2001).

Biological management of fish stocks has to be pragmatic and adaptive, based on knowledge of long-term system variability and the reactions of both fish and fishers on those dynamics. Three elements of the information base are needed to provide such knowledge:

1. **System variability**

Long-term changes in water levels, associated with climate change, are at least as important as effort in explaining stock changes. This is immediately clear for lakes like Mweru Wa Ntipa, Chilwa/Chita and Liambezi that regularly dry up completely. After refilling, fast increases in productivity take place. But such effects are not restricted to these extreme examples. In Lake Mweru, declines in total catch rates are associated with periods of extremely low water levels and catch rates stabilize, albeit at a lower level, when water levels rise again. In Lake Kariba, differences in size composition and catch rates between fished and unfished areas in the lake can be attributed to fishing. But a close relation between overall fish production and lake levels indices strongly suggests that the environment, more than the fishery, is the dominant factor affecting change, a result also found in Lake Turkana (Kolding 1995). Lastly, in Lake Tanganyika, large changes in catch rates of clupeid species over 40 years seem to be mainly environmentally driven (van Zwieten et al. 2002).

Freshwater lakes and rivers can be classified over a range from pulsed to constant environments. For any particular system, changes in water levels as the dominant environmental driver can provide a number of indices that can be related to changes in stocks. By monitoring catches, catch rates, fishing effort and water levels and evaluating their trends and variability, knowledge will accumulate on the particular behavior of a system under various conditions.

2. **Susceptibility of species to fishing**

The SADC freshwaters have remarkably stable overall system yields. Underneath such apparent stability a bewildering array of changes can take place, while high variability in total yield may obscure possible trends (Fig. 1). Many examples of serious declines of single stocks can be found. Resource character plays a role here and specific life histories are particularly ‘susceptible’ to fishing, e.g., large, slow growing species or species with particularly vulnerable stages. For example, large predatory *Lates* species in Lake Tanganyika clearly declined as a result of fishing, while stocks of large *Barbus* species in Lake Tana, Ethiopia, are seriously endangered due to heavy fishing during spawning migrations. This, despite the overall extremely low effort levels that even decreased over the past decade (L. Nagelkerke, M. de Graaf pers. com). The more resilient a species is to increases in fishing pressure, the less relevant management becomes from a biological perspective. ‘Resilient’ species like tilapias have been dominant for ages in many African freshwater systems, while recent shifts towards faster growing ‘highly resilient’ species like freshwater herrings and small barbs species have taken place. In Lake Mweru, a fishery on clupeids (chisense, *Microthrissa moeruensis*) started in the middle of the 1980s, while in Bangweulu a similar fishery on a pelagic cyprinid started in the 1990s. In Lake Malombe, the shift towards smaller species took place after the collapse of the chambo (*Oreochromis spp.*) fishery, largely replacing it.

3. **Selectivity and scale of operation of fishing patterns**

Small-scale fisheries, i.e., where the scale of individual day-to-day
fishing operations is small, are able to adapt rapidly to changing circumstances. In Mweru, the drop in catches of tilapia (*Oreochromis macrochir*) and disappearance of larger size classes of species in the 1970s was followed in just a few years by a decrease in mesh size in the whole gillnet fishery. Strong year-classes formed after favorable conditions and large *O. macrochir* reappeared despite increased effort, not being caught by the dominant smaller mesh sizes, and formed the base of a renewed seine fishery. Even in this heavily fished lake, some species became exploited only very recently with, for the fishery, newly developed methods. Although invariably multispecies, many fishing methods are species selective: in Lake Bangweulu, some active methods forbidden by the formal regulations catch stocks of *Tilapia rendalli* that otherwise remain unexploited. The artisanal fishery in northern Lake Tanganyika out-competed the industrial fishery through its apparent capability to address the highly variable dynamics of the pelagic stocks (van Zwieten et al. 2002). In general, limited danger seems to exist in increased diversification of fishing patterns at small operational scales, i.e. when fishers use methods that catch the ubiquitous bucket of fish per day. By hedging the inherent variability in relative abundance of multispecies stocks, and opting to target many species simultaneously, they are developing an overall fishing pattern that could be ecosystem conserving in principle.

The danger increases where instead the scale of operations override the inherent variability in stocks, in an attempt to maintain catch rates at the same level through increased gear efficiency, either arising from investments in better technology or from more intensive use of existing technology.

**Conclusion**

Since the beginning of the 1900s, fisheries regulations in the region are mainly related to how colonial powers and later independent states have invested in building up management systems based on accepted wisdom regarding the relationship between fishing effort and biological productivity.

However, ecological changes are quite complex and effort may be less important for the control of yields than generally anticipated. An increased perception of the natural variability in the systems with vulnerable stages during periods of low productivity and increasing uncertainty, connected to growth in effort, indicates the need for more adaptive management and dynamic ‘early warning systems’ - elements of which have been outlined here.

The findings that effort dynamics depend as much on the general economic and social development in the region as on the fishing economy imply a much broader focus for monitoring fisheries. Economic analyses based on how they react and respond to macro-economic changes are as important to understanding fisheries development as those based on current biological monitoring.

As long as changes in effort remain population-driven, general regulations of effort are problematic. It will be very hard to show that reduced effort leads to improvements in catch rates.

---

*Fig. 1. Generalised development of fishing yield and catch rate of a fishery with increasing effort. The broken lines represent increasing variation around the mean yield and catch rates over time (vertical arrows). The five characteristics below the plot changing with increased effort refer to total fish biomass system (a, b and c) and to the fishery (d and e).*
Adaptive effort reduction may nevertheless be of crucial importance, either in particularly vulnerable periods, or as a means to cope with natural variations which will occur under any type of management system. However, if effort dynamics turn to become more investment-driven, the need for regulations increases considerably. The monitoring of investment-driven changes of effort is therefore of great importance.

Any management regime is political in the sense that it includes some and excludes others from access to valuable resources - this is an ongoing struggle in all types of fisheries. It should not be too difficult to decide upon the question of whether the SADC freshwaters are to continue to serve as an economic safety-valve and a buffer for the common people of the region, or whether its fisheries should develop into more industrial enterprises (and thereby exclude many). In a situation with serious and long lasting macro-economic recessions, the buffer function must be upheld. Besides, our studies have also shown that the freshwater fisheries hardly will become a driving force in the process for much needed economic reforms.

Locally based access-regulation mechanisms already exist, and sometimes they prove to be very effective means to exclude people from the fisheries. From the perspective of keeping the fisheries open to the small-scale fishers, the great interest shown by governments and NGOs to establish local institutions that can cooperate with central authorities in managing the fisheries should be handled with some care. Rather, co-management must imply a process of mutual adaptation where local people try to coordinate existing access-regulating mechanisms (and the underlying interests they represent) and central authorities’ priorities into some form of coherent system. To what extent such coordination, within short time perspectives, is possible and to what extent it will lead to more efficient use of natural resources is not evident. In any case, such attempts imply an exercise where both local populations and governments are forced into some sort of genuinely democratic process.

References


E. Jul-Larsen is a social anthropologist from the Chr. Michelsen Institute, Norway and P. van Zwieten is a fisheries biologist from the Wageningen University, The Netherlands.

E-mail: Eyolf.Jul-Larsen@CMI.NO
The 9th International Association for the Study of Common Property Biennial Conference

Held in the beautiful landscape of Victoria Falls along the banks of the mighty Zambezi River in Zimbabwe, academics, donors, practitioners, policymakers, government decision-makers and NGOs met on 17 to 21 June 2002 to discuss the development and challenges of studying and managing common pool resources (more commonly known as the commons). More than 200 delegates from various countries came to present papers and discuss ‘The Commons in an Age of Globalization’, the conference theme. The discussions tackled several important issues including:

- governance, economic systems and hidden values, tourism and global ideology;
- trade regimes and globalization; issues of carbon sinks and climatic change;
- diversity versus uniformity and the prescriptive rules of joining the global market (liberal democracy);
- scale issues and nested hierarchies;
- intellectual property rights and tenure;
- problems of acceptance and resistance of globalization and the role of international markets as drivers;
- globalization - in the state versus local common property resource (whose interest does the state serve?);
- globalization as econo-centric and its relationship to sustainable use; and
- cultural diversity, marginalization and globalization links.

Globalization as a theme was chosen because of its pervasiveness in the domain of the world’s political economy especially in the new millennium. Economic and political reconfiguration followed in its wake resulting in potentially social and environmental disruptive impacts. Globalization is putting new pressures on how the commons, such as fisheries, forest, pastoral lands, oceans, and air, are to be used and managed and how local institutions response to challenges intrinsically brought about by global forces unaccustomed to local and indigenous realities. Common pool resources are not immune to these challenges. Its resilience and sustainability will be seriously tested in the years to come. Thus, studying how common pool resources are shaped or affected by this development is important.

Established in 1984, the International Association for the Study of Common Property (IASCP) is an eminent body of common property scholars and natural resource managers encouraging the exchange of knowledge among diverse disciplines, areas, and resource types; fostering mutual exchange of scholarship and practical experience; and promoting appropriate institutional design. The next IASCP Biennial Conference will be held in Oaxaca, Mexico.

Planning Workshop for the Challenge Program
Increasing Productivity in the Coastal Zone: Reversing Habitat Degradation and Advancing Livelihood Options

The Consultative Group on International Agricultural Research (CGIAR), of which WorldFish Center is a part, has recently announced the establishment of collaborative “Challenge Programs” to address environmental, food security and livelihood problems of regional or global significance.

Challenge Programs are designed to support research partnerships among international and national agencies, and CGIAR Centers. The programs are expected to have a longer-term horizon (seven to ten years), and to receive funding at the level of US$ 5-10 million per year. Details of the approach can be found at www.cgiar.org

A concept note submitted by WorldFish Center to the CGIAR for a Challenge Program to address problems facing the coastal zone has been recommended for development as a pre-proposal.

As part of the pre-proposal development for the Coastal Challenge Program, a workshop entitled “Increasing Productivity in the Coastal Zone: Reversing Habitat Degradation and Advancing Livelihood Options” was organized on 3 to 4 June 2002 at WorldFish Center, Penang, Malaysia. A total of 28 delegates participated in the workshop of which 19 from national/regional institutions (e.g., AIMS, SEAFDEC, NACA, SEARCA, IRRI, IWMI, MEA, UNEP/GEF, UNEP-WCMC, TRAIN-SEA-COAST, PCAMRD, Indonesia, Cambodia, Thailand, Malaysia, Philippines, United Kingdom, Vietnam).

At the workshop, the participants identified two broad research areas where they felt the joint efforts of CGIAR centers and their partners could best meet their needs. These two research areas involve finding ways to:

1. **Reverse degradation of coastal resources due to land-based activities** (The main concern here was to find ways of reducing transfers of the chemicals, nutrients and sediments that originate from agriculture, aquaculture and forestry in catchments, to coastal waters), and
2. **Enhance livelihood opportunities for coastal communities** (Determining
2002 Naga Award Competition

The 2002 Naga Award Competition is on!

You can nominate candidate(s) for the competition by sending us a scientific paper or book on any aspect of fisheries including aquaculture published in the last five years by developing country scientist(s), which might win the prestigious award. Tell us in your view the important contribution the paper/book has made to science and sustainable management of aquatic resources. Your nomination can win the author(s) of the paper/book the prestigious NAGA Award given by ICLARM, which includes a plaque of appreciation and US$ 500. You as nominator of the winning submission will be rewarded with a book prize.

The conditions: The scientific paper or book should have been authored by a developing-country scientist(s)—that has made significant contribution to any area of fisheries science (capture fisheries/ aquaculture/resource management/ policy) within the last five years. Please include the curriculum vitae of the author(s) in your nomination. You cannot nominate yourself or colleagues from the same institution.

Send your entries to:
The Communications Unit,
WorldFish Center, P.O. Box 500 GPO,
10670 Penang, Malaysia.

Deadline for submission for the 2002 Naga Award is 30 November 2002. Please note that submissions received after this date will be considered for the 2003 Naga Award.

the factors that underpin livelihoods, and identifying the measures and technologies that will create alternative and supplementary livelihood opportunities from coastal resources, were the issues here.

The participants then outlined eight “Research Projects” within the two broad research areas to be addressed by the Challenge Program.

1. Understanding, modeling and evaluating material transfers from catchments, and their ‘downstream’ effects on sustainability and productivity of coastal aquatic ecosystems.
2. Identifying, developing and promoting improved management practices to reduce ‘down-stream’ effects resulting from agriculture and forestry.
3. Evaluating existing policies and institutional arrangements at different levels relating to use of water and land, and their effects on coastal zones.
4. Socio-economic evaluation of the impacts of resource flows between interrelated resource systems.
5. Understanding the factors determining livelihood options for poor coastal people.
6. Developing and promoting strategies for increasing production from aquatic resources, especially from capture fisheries.
7. Developing and promoting feasible technologies for alternative or supplementary livelihood options for coastal communities.
8. Identifying and promoting feasible strategies to rehabilitate critical coastal habitats.

Based on the outcomes of the workshop, a draft pre-proposal for the Challenge Program has been prepared and circulated for review. The final draft of the pre-proposal is due for submission to CGIAR by 31 August 2002.
57 farmers, 6 local NGOs and 4 micro-credit agencies participated in a one-day micro-credit seminar held at the Humid Forest Ecoregional Centre in Yaoundé. Organized by WorldFish Center and the Ministry of Research in collaboration with IRAD and MINEPIA, the seminar presented the results of an economic viability appraisal of integrated and non-integrated aquaculture farming systems and brought together farmers and financiers to discuss the potential for increasing investment levels in order to achieve acceptable profit margins for IAA farmers. Discussions were open and lively, with NGOs and credit agencies stressing the need for community organization to facilitate the administration of credit and offered assistance. The WorldFish Center-DFID project in Cameroon is focusing on methods to implement small-scale commercial IAA in periurban Yaoundé.

**Small-scale Aquaculture Credit Seminar**

Yaoundé, 2 October 2002

All the services of the Fish Health Section of Southeast Asian Fisheries Development Center/Aquaculture Department (SEAFDEC/AQD) is now accepting shrimp samples for white spot syndrome virus (WSSV) and marine finfish samples for viral nervous necrosis (VNN) detections. The Fish Health Section of SEAFDEC/ AQD uses the Polymerase Chain Reaction (PCR) in the diagnosis of shrimp and fish diseases.

**Conference on organic aquaculture and sea farming**

For details, please contact: E. Lacierda, Head, Fish Health Section, SEAFDEC Aquaculture Depart-ment, Tigbauan, 5021, Iloilo, Philippines; Tel: (63-33) 336-2937; Fax: (63-33) 336-2891; E-mail: eclacier@aqd.seafdec.org.ph
New NTAFP Members

Dr. Pathira Arachchilage Aruna Taranatha Jayawardane. Research Officer. Marine Biological Resources Division, National Aquatic Resources Research and Development Agency (NARA), Crow Island, Mattakuliy, Colombo 15, Sri Lanka. (Major: Population dynamics, Reproductive biology; Minor: Aquaculture; Species: shrimp; Geographical areas of interest: Western Indian Ocean)

Dr. Siti Azizah Mohd. Nor. Lecturer, School of Biological Sciences, University Sains Malaysia, 11800 Minden, Pulau Pinang, Malaysia. (Major: Resources/stocks - genetics, evolution, molecular biology, biotechnology, stock assessments; Minor: resources/stocks – taxonomy, morphology; biodiversity; ecology; Species: Carps, barbels and other cyprinids, miscellaneous freshwater fishes, cods, hakes, haddocks, redfishes, basses, congers, jacks, mullets, miscellaneous marine fishes, turtles; Geographical areas of interests: Asia; Eastern Indian Ocean)

Dr. Pratap Chandra Das. Scientist, Central Rice Research Institute (CRRI), Bidyadharpur, Cuttack – 753006 (Orissa), India. (Major: Fish culture; Culture technology/systems. Minor: Shellfish culture; Integrated Fish Culture; Water quality, aquatic pollution. Species: Carps, barbels, and other cyprinids; Miscellaneous freshwater fishes; Freshwater crustaceans; Shrimps, prawns, etc; Freshwater aquatic plants. Geographical areas of interests: Asia; Eastern Indian Ocean)

Dr. Joseph Cheikyula Orkuma. Assistant Lecturer. University of Agriculture, Makurdi (UAM), P.M.B 2373, Makurdi, Nigeria. (Major: Ecology, Geography, Water quality/aquatic pollution; Minor: Stock assessment, post-harvest technology, biodiversity; Species: Miscellaneous freshwater fishes, freshwater crustaceans, zooplankton; Geographical areas of interest: Africa)

GIFT Foundation Board meets in Penang

The GIFT Foundation Board of Trustees held its 15th Board of Trustees and Annual Members’ meeting at the WorldFish Center Headquarters, Penang, Malaysia on 17 September 2002. The meeting was chaired by Dr. Meryl J Williams, Chair of Board of Trustees and attended by Members of the Board: Drs. R. Undan and T. Abella of the Central Luzon State University, Mr. M. Tayamen of National Freshwater Fisheries Technology Center/Bureau of Fisheries and Aquatic Resources, Mrs. Simeona Aypa, representative of the private sector and Mr. Basilio Rodriguez Jr. and Ms. Ravelina Velasco of the GIFT Foundation International Inc. from the Philippines and Dr. Modadugu V Gupta of WorldFish Center.

Tropical marine ecologist and conservationist passes away

Robert “Bob” Johannes, a noted tropical marine ecologist and an international expert on live reef food fish trade and on the effects of cyanide fishing passed away on 4 September 2002 at the age of 66. Bob was also a 1993 Pew Fellow.

Bob pioneered an approach to the conservation of marine biodiversity that integrates the specialized ecological knowledge and traditional marine resource management systems of community-based tropical fishing peoples with Western-based scientific management in order to improve marine resource management. His efforts in this arena have helped highlight the importance of indigenous knowledge and community-based systems as key factors in marine conservation.

His findings on Palau published in the book ‘Words of the Lagoon’ is considered a classic work in community based marine resource management and has been adopted as a supplemental text in a number of graduate fisheries, ocean policy and maritime anthropology courses around the world. With his Pew Fellowship and funds from Nature Conservancy and South Pacific Forum Agency, he conducted a nine-country study of cyanide fishing trade and promoted its environ-mental, economic and social effects. The findings from this study were covered by international media, resulting in significant attention to the issue.

He will be remembered for his exemplary contributions to applied conservation of global marine environment and for his dedication in combining science with traditional knowledge to support sound policy for the oceans and for society.

Management of Broodstock and Quality Control of Fish Seed in Hungary

L. Varadi, S. Gorda, J. Bakos and Z. Jeney

Abstract

Common carp (Cyprinus carpio) breeding has a long tradition in Hungary. However, recent economic changes in Eastern Europe and new developments in aquaculture necessitated the need for ensuring quality of the brood stock used in hatcheries and the legal and institutional frameworks needed to implement the program. In addition to good research and development programs and gene banking, it became essential to establish an appropriate legal framework, organize, coordinate and control breeding activities, and provide financial support. It was a major breakthrough for carp breeding when C. carpio was recognized as one of the cultivated animals in the Animal Breeding Act in 1993. The Carp Breeding Section of the Hungarian Fish Producers Association plays an important role in carp breeding programs. Thirteen breeding farms of the Carp Breeding Section have 24 certified C. carpio varieties. In Hungary, about 80% of the seed used as stocking for commercial production are from high quality certified breeders.

Introduction

Breeding and cultivation of common carp (Cyprinus carpio) is the backbone of fish farming in Hungary. Sixty seven percent of the total aquaculture production (19,904 tons) was accounted for by C. carpio in the year 2000. C. carpio breeding has a long tradition in Hungary and its techniques have been known and applied worldwide in carp breeding programs. However, recent economic changes in Eastern Europe and new developments in aquaculture have necessitated the development of carp breeding programs that ensure quality of seed as well as the legal and institutional frameworks to support them.

Broodstock Management

The main elements of the efficient management and maintenance of broodstock in Hungary are the following:

- appropriate legal framework (Ministry of Agriculture and Regional Development);
- good research and development programs, gene banking (research institutions);
- quality control (National Institute for Agricultural Quality Control);
- efficient organization and coordination (Hungarian Fish Producers Association);
- financial support (Ministry of Agriculture and Regional Development).

Legal Framework

After the political and economic changes of the early nineties in Hungary, new laws and regulations were established to provide the appropriate legal framework for carp breeding programs. The main Acts and regulations relevant to carp breeding are the following:

- Animal Breeding Act (1993 CXIV);
- Ministry decree on approval and registration of breeding organizations (30/1994);
- Ministry decree on certification of breeders (31/1994);
- Ministry decree on the performance of progeny testing (32/1994);
- Ministry decree on the maintenance of indigenous species stocks (37/1994);
- Ministry decree on the operation of fish hatcheries (41/1994).

Research and Development

Research and development activities for a good national carp breeding program have been well established in Hungary, mainly through the activities of the Research Institute for Fisheries, Aquaculture and Irrigation (HAKI) at Szarvas, and the Saint Stephen University (SZIE) at Godollo. Broodstock management technologies have been elaborated and tested for many years and are now available for practical application. A live C. carpio gene bank (consisting of 17 Hungarian and 15 foreign strains and races) has been
in operation since 1962 in HAKI. The aerial view of the ponds for the *C. carpio* gene bank is shown in Fig. 1. Advanced research has been ongoing, with the cryopreservation of sperm, at both HAKI and SZIE. In-situ gene banking of wild carp strains such as the Tisza wild carp (Fig. 2) has also been undertaken.

Breeding farms have to pay for most of the services of OMMI. However there is State support for the certification process of the high quality breeders from a special fund established by the Ministry of Agriculture and Regional Development.

**Organization and Coordination**

Efficient breeding programs and quality control cannot be accomplished without the appropriate organization of complex activities and coordination between farms and the relevant organizations and institutions. A breakthrough in the development of carp breeding programs and the improvement of broodstock management in Hungary was the establishment of the Carp Breeding Section within the Hungarian Fish Producers Association (HOSZ) in 1995. HOSZ encompasses more than 70 member farms, which account for about 60% of the total aquaculture production in Hungary. The Carp Breeding Section has 14 member farms that are registered as carp breeding organizations. These farms have their own carp varieties that are certified by OMMI. At present, the 13 breeding farms have 24 certified *C. carpio* varieties. Through its Carp Breeding Section, HOSZ organizes standardized carp performance tests, annual meetings, occasional expert consultations, and provides consultancies and other services. With the assistance of HOSZ and its Carp Breeding Section, broodstock nucleus comprising of 25 males and 25 females in each of the breeding farms are being marked with PIT tags since 2002 (Fig. 3).

**Financial Support**

The two-year carp performance test, basic precondition for the certification of a carp variety is a major cost for breeding farms. OMMI contributes 50% of the total cost, using funds from the Ministry of Agriculture and Regional Development. The cost of the full two-year test for one carp variety is about US$5,000. Special funds are also available for the maintenance of registered gene banks of indigenous carp varieties. The financial support is about US$7 per breeder for up to 100 individuals of a recognized indigenous carp variety. Funds are also available for the improvement of the infrastructure and technical conditions for breeding activities. R&D funds are also used for breeding works and for the development of broodstock rearing technologies. It is becoming a common practice for farms and the research institutions to jointly apply for such funds and implement R&D projects together.

**Carp Seed Distribution**

Quality carp seed production is based on the use of high quality broodstock and good broodstock management practices as described above. All fish hatcheries in Hungary that produce seed for their own use and for sale are obliged to get the hatchery certified by OMMI. Certification also includes
veterinary inspection and approval.

Fish farms that produce seed for their own grow-out can do it without complying with any special regulations on seed distribution. However, fish farms that sell the seed to other farms are obliged to produce the seed from certified breeders. There are 23 certified fish hatcheries in Hungary, most of them for carp seed production. These hatcheries propagate mainly the farm’s own certified carp varieties. The hatcheries have to monitor the propagation and sales activities using standard forms issued by OMMI. They also provide a Certificate of Origin when the seed is sold to another farm. The hatcheries are inspected occasionally by OMMI and they have to renew the certification of operation every three year.

In order to encourage the wide use of seed from certified breeders and to improve the production, only the fish farms that produce seed from certified breeders are entitled to apply for financial support from the FVM budget.

As a result of all these efforts aimed at the improvement of carp breeding, and thus for increasing of quality and competitiveness of the carp breeding sector, about 80% of the seed used as stocking material for commercial production are from high quality certified breeders.

L. Varadi, S. Gorda, J. Bakos and Z. Jeney are from the Research Institute for Fisheries, Aquaculture and Irrigation, (HAKI), Szarvas, Hungary.
Genetic Enhancement and Conservation of Aquatic Biodiversity in Africa

M.V. Gupta

Abstract

There is a pressing need to enhance fish production in Africa through improved farm management and the use of improved fish breeds and/or alien species in aquaculture while at the same time conserve the aquatic genetic diversity. This paper presents the outcome of the Expert Consultation on Biosafety and Environmental Impact of Genetic Enhancement and Introduction of Improved Tilapia Strains/Alien Species in Africa held in Nairobi, Kenya on 20-23 February 2002. The main topics discussed were status of aquaculture in Africa and the role of genetic enhancement; potential benefits and risks involved in introduction of genetically improved strains and/or alien species with specific reference to tilapias; existing policies and legislation for the conservation of biodiversity, their strengths and weaknesses; capacity for undertaking genetic enhancement research and implementation of policies for the conservation of aquatic biodiversity.

Introduction

Africa is the world’s repository of diverse freshwater fish fauna and the home of tilapias. With the increasing interest in aquaculture and the initiatives in progress for genetic enhancement of tilapias, the possibility exists that improved strains and alien species introduced for aquaculture will escape into natural waters. While there is a need to enhance fish production through use of improved fish breeds and/or alien species, it is imperative that valuable aquatic genetic diversity is conserved/protected.

This has been the subject of an expert consultation organized by WorldFish Center in collaboration with the Technical Center for Agriculture and Rural Cooperation (CTA), the Food and Agriculture Organization of the United Nations (FAO), the World Conservation Union (IUCN), the United Nations Environment Program (UNEP) and the Convention on Biological Diversity (CBD) in Nairobi, Kenya on 20-23 February 2002. The consultation meeting was attended by 45 fishery and conservation experts, resource managers, geneticists and policymakers from 10 African countries (Cameroon, Cote d’Ivoire, Ghana, Kenya, Malawi, Nigeria, South Africa, Tanzania, Uganda and Zambia), advanced scientific institutions and regional and international organizations. The major findings from the meeting are presented here in brief while full proceedings are being published separately.

The Issues

The meeting concluded that there is high potential for aquaculture development in Africa with some regional variations. However, to achieve this potential, a number of constraints such as lack of knowledge of indigenous species, shortage of fish seed due to poor hatchery infrastructure, lack of credit facilities,
lack of incentives from existing policies, etc. need to be addressed. While in small-scale aquaculture improvements in farm management are more important, in commercial aquaculture operations the need/demand for improved strains is high.

Genetic improvement programs have been initiated in some countries, but institutional capacity for undertaking the research is inadequate. Alien species/strains are being introduced for aquaculture and impacts of these introductions are not fully known, but are likely to pose threats to biodiversity especially in regions where there is rich diversity of indigenous aquatic species.

**Policies**

Many African countries have formulated policies, enacted laws and established agencies to conserve biological diversity. In addition, there are a number of sub-regional and regional conventions. While their existence is acknowledged, these are not specific to conservation of aquatic biodiversity and strategies for their implementation are lacking. Implementation is constrained by lack of human capacity, political will and accountability. Responsibilities for implementation of policies are split among ministries and agencies that are poorly funded and coordinated resulting in poor compliance. There is conflict of interest between development and conservation and the public is not aware of the issues as the stakeholders have not been involved in formulation of these policies and instruments.

A number of international codes of practice and protocols have been developed to deal with the introduction of alien species, but these have no legal status until governments pass relevant national legislation to bring such laws into effect. Where these exist there is lack of clarity and capacity to implement. The voluntary nature of protocols makes them non-binding.

The participants of the consultation, after deliberating the issues for three days, came out with a formal statement, the *Nairobi Declaration: Conservation of Aquatic Biodiversity and Use of Genetically Improved and Alien Species for Aquaculture in Africa* (see Box 1). The document, which represents the main conclusions and recommendations of the workshop, is expected to serve as guidelines that will help foster the development of aquaculture in the region while maintaining biodiversity.

### Conservation of Aquatic Biodiversity and Use of Genetically Improved and Alien Species for Aquaculture in Africa

**Nairobi Declaration**

Fish are a critical source of animal protein to the people of Africa, and fishery resources play a central role in sustaining rural and urban livelihoods across much of the region. Yet for the continent as a whole per capita supply is declining and current projections of supply and demand indicate that this gap will continue to grow in the coming decades.

If this gap is to be bridged capture fisheries need to be sustained and the potential of aquaculture developed. In doing so, attention needs to be given to protecting the rich aquatic biodiversity of Africa especially the freshwater fish biodiversity and its role in sustaining capture fisheries and providing species for aquaculture.

Aquaculture is a relatively new farming activity in much of Africa and the region’s production of farm-raised fish remains low. While there are many reasons for this, amongst the most important are poor management practices and the use of undomesticated stocks. This contrasts with crops, livestock and poultry where large increases in production have been achieved through application of breeding programs and other genetic improvement procedures.

To address these constraints, a greater range of management practices and approaches need to be considered. These should include improved pond and broodstock management and better performing breeds/strains. In doing so, however, these approaches need to be adapted to local social, economic, institutional and biophysical context. While the improved strains/alien species have potential to improve production there is clear risk of these improved/alien species escaping into the wild and contaminating the native population and affecting the biodiversity.

In light of these considerations, an Expert Consultation on Biosafety and Environmental Impact of Genetic Enhancement and Introduction of Improved Tilapia Strains/ Alien Species in Africa was convened in Nairobi, Kenya from 20-23 February 2002 under the sponsorship of WorldFish Center, CTA, FAO, IUCN–The World Conservation Union, UNEP and the CBD to discuss and develop guidelines that will foster the development of aquaculture while maintaining biodiversity. The meeting was attended by aquaculturists, geneticists and conservation specialists from Africa and from international organizations. The recommendations of the expert consultation follow hereunder.

**Recommendations**

1. Given that aquaculture from small-scale, low-input systems to large-scale intensive systems can achieve potential benefits from genetic enhancement, quality seed should be made available and used in conjunction with proper broodstock and farm management.
2. Since genetic resources in cultured populations can be degraded as a result of captive breeding, genetic aspects of broodstock management need to be a basic element within all types of aquaculture and stock enhancement systems.
3. Introductions of fish, including genetically improved (altered) strains and alien species, may have a role in the development of aquaculture. Any movement of fish between natural ecological boundaries (e.g. watersheds) may involve risk to biodiversity and...
there is need for refinement and wider application protocols, risk assessment methods, and monitoring programs for introductions of fish, including genetically improved (altered) species and alien species. States have important responsibility in the development and implementation of such protocols and associated regulations, the establishment of clear roles and responsibilities, and capacity building. Such efforts should be linked to obligations pursuant to the Code of Conduct for Responsible Fisheries, the Convention on Biological Diversity, and other relevant international agreements.

4. Unique wild stocks of important tilapia species still exist in many parts of Africa. Priority areas should be identified and managed as conservation areas in which introductions of alien species and genetically altered species should be prevented.

5. The majority of issues and problems associated with movement of fish and the use of genetically altered species are common to most African countries and they are encouraged to (a) look beyond borders for examples of workable policies and legislation, adopt them where appropriate to fill national policy gaps, and harmonize them where necessary; and (b) use existing regional bodies or form new bodies to assist in coordinating management activities and taking into account ecological realities, in particular transboundary watersheds.

6. Baseline information on fish genetic diversity, environmental integrity and aquaculture practices exist, but it is neither comprehensive nor easily accessible. The existing mechanisms for collection and dissemination of information on fish genetic diversity, environmental integrity and aquaculture practices need to be strengthened.

7. Internationally accepted codes and protocols for reducing the risk of transboundary movement of pathogens (including parasites) through movement of fish including alien species do exist, but they do not address any specific needs regarding genetically improved (altered) species. States and other relevant bodies should evaluate the existing codes and protocols for reducing the risk of transboundary movement of pathogens (including parasites) through movement of fish including alien species and genetically improved (altered) species, and adapt them for African conditions.

8. Policymakers, enforcement agencies, stakeholders and the general public need to be made aware of issues related to, and the need for, policy on the movement of alien species and genetically improved (altered) species, and this should be high on national agendas.

9. Some policies relevant to movement of fish seem difficult to implement, are unknown to users, create conflicts of interest, or are viewed as restrictive; in part because they have been developed with limited consultation and participation. Formulation of policy and legislation concerning fish movement should seek to engage all stakeholders in a participatory process. In addition, governments should establish advisory groups with links to independent and scientifically competent expert bodies such as FAO, IUCN, and WorldFish Center.

10. Although economic benefits can be derived through the use of alien and genetically altered fish species in aquaculture, in many cases, those to whom benefits accrue do not bear the costs associated with adverse environmental impacts. In view of this, there should be provision for liability, compliance (e.g., incentives), and restoration within policies and legislation concerning the movement and use of alien and genetically altered fish species in aquaculture.

---

**Expert Consultation to Develop Strategies and Plans for Dissemination of Improved Fish Breeds**

In recent years, genetic improvement has progressed with the development of national breeding programs in member countries of the International Network on Genetics in Aquaculture (INGA). Improved carp and tilapia breeds now exist in some of the member countries (e.g. Bangladesh, China, Fiji, India, Indonesia, Malaysia, Philippines, Thailand and Vietnam) and some of these breeds are being disseminated to farmers. However, strategies and plans for dissemination of these strains are lacking in most of these countries. The ultimate benefits of a genetic improvement program can only be achieved if improved breeds are effectively disseminated to targeted beneficiaries without losing, due to inbreeding, the genetic gains. Further, the member countries have been facing constraints in implementing genetic management protocols that will minimize inbreeding and maintain the characteristics of the breed during the process of dissemination. Sustaining the program and farmer confidence will require the demonstration and monitoring of impacts. Unlike in crops, there are no proven dissemination strategies for fish breeds and different social, economic and institutional set-ups in member countries makes it difficult for a single system to work. In view of this, the need for guidelines that will help the member countries in maintenance and dissemination of improved fish breeds was felt necessary.

With funding support from the Norwegian Agency for Development Cooperation (NORAD), WorldFish Center, in collaboration with National Aquaculture Genetics Research Institute (NAGRI) of the Thailand Department of Fisheries organized an Expert Consultation on Strategies/Plans for Dissemination of Improved Fish Breeds from 4-7 June 2002 in Pathumthani, Thailand. Thirty nine participants from member countries of INGA, advanced scientific
A preliminary genetic study of Vietnamese common carp (Cyprinus carpio) using mtDNA sequencing.

Although a significant number of genetic studies have been undertaken in common carp (Cyprinus carpio) using a range of approaches, none has examined in detail the genetic variation in mitochondrial (mt) gene regions using direct sequencing. Under a collaborative program between Deakin University, Victoria, Australia and Research Institute for Aquaculture No. 1 (RIA1) in Vietnam preliminary study on molecular genetic variation in Vietnamese C. carpio strains using mtDNA sequencing was completed in 2001. Using samples obtained from stocks maintained at the Research Institute for Aquaculture No. 1, Vietnam and specimens from feral populations in Australia, genetic variation was assessed using direct sequencing of fragments amplified from the mitochondrial 16S rRNA and cytochrome b gene regions and from the control regions. As is typical for fish species, the 16S rRNA gene region showed the least variation and the control region the greatest variation (average nucleotide diversity 0.00966, haplotype diversity 0.842).

Genetic variability among 4 indigenous Vietnamese strains, along with Hungarian, Indonesian, Australian and the RIA No. 1 improved strain, was investigated. All three mtDNA gene regions identified a ‘Hungarian’ or ‘European’ lineage; however only data from the control region was useful for the identification of indigenous Vietnamese strains. Three distinct indigenous mtDNA haplotypes were identified, however mixing of stocks also appears to have occurred as European and Indonesian haplotypes were also found within indigenous strains. Overall, the level of divergence between samples originating from European and Asia was found to be surprisingly low considering their original geographic isolation. No differences were detected between the samples of Vietnamese and Australian C. carpio derived independently from European stocks.

Generally, results indicate that the analysis of certain mt DNA gene regions has the potential to be a useful additional tool for studying genetic diversity within and between C. carpio populations and strains. As part of ongoing collaboration between RIA 1 and Deakin University this project will be extended, using funds provided by AusAID. This will be done through detailed survey of mtDNA variation in indigenous Vietnamese C. carpio stocks and sequencing a wider range of C. carpio samples from different countries. The latter
Training on quantitative genetics

With the objective of strengthening the capacity of scientists from INGA member country institutions in the field of quantitative genetics, especially in analysis and interpretation of genetic data, INGA and WorldFish Center with financial support from Norwegian Agency for Development Cooperation (NORAD) organized a three week training course on "Quantitative Genetics and its Application to Aquaculture" during 1-21 October 2001 in Bangkok, Thailand. A total of 28 participants from 12 member countries of INGA (Bangladesh, China, Egypt, Fiji, Ghana, India, Indonesia, Malawi, Malaysia, Philippines, Thailand and Vietnam) attended the course. The course program was developed specifically to meet the needs of the participants and was based on needs assessment survey undertaken prior to the training. The course curriculum covered the following modules: strain comparisons and crossing, estimation of heritability, phenotypic and genetic correlations, selection index methodology for single and multiple traits, selection methods and prediction response, BLUP methodology, breeding program design and use of statistical softwares (SAS, ASREML). The training program comprised lectures and practical exercises but emphasis was placed on hands-on analysis of actual breeding/genetic datasets. The three-week training also included presentations by participants on the status of genetic improvement/breeding programs in their countries and a visit to aquaculture station/farms in Chonburi Province, Thailand. Each participant who completed the training was provided a CD-ROM copy of non-commercial software (ASR, GPEX, SIP and KUNZI) to assist them in analysis of breeding datasets.

Contributed by Chris Austin¹, Pham Tuan², T.T. Nguyen¹, ²

¹Head of Aquatic Ecology, Coordinator of Postgraduate Aquaculture Courses, School of Ecology and Environment Deakin University, PO Box 423, Warrnambool, 3280, Victoria, Australia; ²Research Institute for Aquaculture No. 1, Dinh Bang, Bac Ninh, Hanoi, Vietnam
Developing the capacity on fish molecular genetics in Vietnam

Through a grant from the Australian government (AusAID), Deakin University and its partner institution in Vietnam, the Research Institute for Aquaculture No. 1 (RIA 1) are undertaking a collaborative project that focuses on capacity building in molecular genetic research and education in Vietnam. The project aims to heighten awareness of and skills of young researchers in the application of molecular genetic approaches in a range of fields relating to the management of fish biodiversity and genetic improvement of fish for aquaculture. These will be achieved through a range of activities that will include short-term and Masters level training of technicians and researchers at Deakin University and in-country workshops and research activities that focus on genetics of wild and cultured populations of catfish of the genus *Pangasius* and grass carp (*Ctenopharyngodon idellus*).

The first of two planned workshops was held on 1-7 July 2002 at RIA1 (Vietnam). Twenty young Vietnamese researchers and a researcher from Thailand, an INGA sponsored participant, attended the workshop. The workshop provided an introduction to basic theory relating to the application of molecular genetic techniques and population genetics and an introduction to protein-based (allozyme) and DNA-based (RFLPs, SSCP and RAPDs) techniques for assaying and measuring genetic variation.

For further information please contact either Chris Austin, Senior Lecturer, Head of Aquatic Ecology, Coordinator of Postgraduate Aquaculture Courses, School of Ecology and Environment Deakin University, PO Box 423, Warrnambool, 3280, Victoria, Australia; Tel: 03 55633518; Fax: 03 55633462; email; cherax@deakin.edu.au; or Pham Anh Tuan, Research Institute for Aquaculture No. 1, Dinh Bang, Bac Ninh, Hanoi, Vietnam; e-mail: patuan@fpt.vn

National genetics meeting in Malaysia

The Malaysian national network of INGA held its second national genetic workshop on 19 April 2002 in Kuala Lumpur. The meeting was hosted by University of Malaya and was attended by 31 participants from Malaysian national research institutions involved in fish genetic research and WorldFish Center. The workshop identified three research priority areas for collaborations: invasive species and their impacts, population genetics and genetic improvement of *Macrobrachium rosenbergii*, and use of markers in tilapia selective breeding research.

Training on analysis of genetic data

Through the project ‘Transfer of Selective Breeding Technology for Aquaculture Improvement from Asia to Sub-Saharan Africa and Egypt, a 5-day training course on the Analysis of Breeding Data was organized for 17 scientists from Cote d’Ivoire, Egypt, Ghana, Kenya, Malawi and South Africa at the WorldFish Center Regional Center for West Asia and Africa, Abbassa, Egypt on 12 – 16 May 2002. The training focused on analysis of data from selective breeding experiments and estimation of genetic parameters.

Publication of Interest

A special issue on genetics

The proceedings of the Seventh International Symposium on Genetics in Aquaculture (ISGA) hosted by the Australian Institute of Marine Science (AIMS) and held in Australia in July 2000 has been published in a special issue of *Aquaculture* (volume 204, nos. 3-4). The 517-page journal which was edited by J.A.H. Benzie and G. Hulata contains abstracts and 21 full papers under 6 topic areas: (i) gene expression, transgenesis and molecular techniques; (ii) application of molecular markers; (iii) gene/genome mapping; (iv) ploidy manipulation; (v) breeding and quantitative genetics; and (vi) wild and farmed genetic resources.

For further information, contact: J.A.H. Benzie, Centre for Marine Coastal Science, University of New South Wales, Sydney, New South Wales 2052, Australia; or G. Hulata, Agriculture Research Organization, Volcani Centre, Department of Agriculture, P.O Box 6, Bet Dagan 50250, Israel.
Indian Branch to hold Sixth Indian Fisheries Forum

The Sixth Indian Fisheries Forum is scheduled to be held 17-20 December 2002 at the Central Institute of Fisheries Education (CIFE), Versova, Mumbai in the State of Maharashtra. This activity is being organized in collaboration with the Indian Fisheries Association and the Central Institute of Fisheries Education.

Scientific Sessions will cover the following topics: Fish and Environment; Aquatic Pollution; Aquaculture; Ornamental Fish; Genetics and Stock Improvement; Germplasm Conservation; Fish Pathology; Biotechnology; Fisheries Resources & Management; Aquaculture Engineering; Harvest & Postharvest Technology; Fisheries Economics, Trade and Laws; Computer Application & Modeling; Fisheries Education & Administration; Fish & Human Health; Fisheries Extension & Information technology; WTO and IPR in Fisheries. A Special Symposium on Policy Issues in Fisheries is scheduled on 19 December 2002.

Submission of Abstracts
Abstracts must be submitted only in the official abstract form. It must be typed in double space and should be within 300 words. Preference may be indicated whether papers would be presented orally or through poster sessions. Abstracts must be sent no later than 30 September 2002 to: Dr. S. Ayyappan, Convener, Sixth Indian Fisheries Forum, Central Institute of Fisheries Education (CIFE), Versova, Mumbai-400 061, Maharashtra, India.

For further information of the forum, please contact: The Forum Convener, Dr. S. Ayyappan, Convener, Sixth Indian Fisheries Forum, Central Institute of Fisheries Education (CIFE), (Deemed University), ICAR, Fisheries University Road, Andheri (W), Versova, Mumbai-400 061. Tel.: 091 22 6361446 (to 48); Fax: 091 2222-6361573; Email: cife@x400.nic.in; AFSIB Secretariat: Dr. P. Keshavanath, Secretary, AFS Indian Branch, College of Fisheries, Mangalore 757-002, Karnataka, India. Tel.: 091 824 439322; Fax: 091 824 438366

Fish Health Experts support 5th Symposium on Diseases in Asian Aquaculture

The Fish Health Section of the Society has been getting tremendous support from various sectors in fisheries and aquaculture not only in the region but the world over. There has been an increasing interest in the forthcoming 5th Symposium on Diseases in Asian Aquaculture (25-28 November 2002, Surfers Paradise, Queensland, Australia).

For details on symposium, please contact: Daniel Havas, Event Manager, OzAccom Conference Services 5th Symposium on Diseases in Asian Aquaculture, PO Box 164 Fortitude Valley QLD 4006, Australia. Tel: +61 (0) 7 3854 1611; Fax: +61 (0) 7 3854 1507; E-Mail: daa5@ozaccom.com.au; Internet: http://afs-fhs.seafdec.org.ph For further information about the workshops, please contact: Dr. Chris Baldock - Tel: +61 7 3255 1712 (Epidemiology and Risk Assessment); Dr. Rob Allard - Tel: +61 7 3840 7723 (Molluscan Health)

7th Asian Fisheries Forum all set for 2004

The Society will be holding the 7th Asian Fisheries Forum in Penang, Malaysia on 29 November to 3 December 2004. The Forum venue is at the Hotel Equatorial. The Forum is being organized with support from the Universiti Sains Malaysia (USM), WorldFish Center, the Universiti Putra Malaysia (UPM), the Fisheries Development Authority (FDA) and the Malaysian Fisheries Society (MFS).

The Forum theme is centered on New Dimensions and Challenges in Asian Fisheries in the 21st Century.

To run in tandem with scientific sessions are special symposia on: (1) Gender and Fisheries; (2) Shrimp Technology (with clinics); (3) Aquatic Health Ecosystems; and (4) Stock Enhancement in Asia and the Pacific.

For more details, please contact: The Secretariat, 7th Asian Fisheries Forum, School of Biological Sciences, Universiti Sains Malaysia, 11700 Minden, Penang, Malaysia. Tel: +60-4-6577888 (Ext. 4005); Fax: +60-4-6565125; Email: wkng@usm.my
**Council names new Co-opted Member**

At its recent Council Meeting held in Penang, Malaysia, the Council named Mr. Gopinath Nagaraj as co-opted member to the Society Council. As a member of the scientific community and former office bearer of the Malaysian Fisheries Society, Mr. Nagaraj has been involved as member of the Steering Committee in the organization of the 7th Forum. Mr. Nagaraj is an active figure in the fisheries sector and is presently associated with Fanli Marine & Consultancy Sdn. Bhd.

**Post-Retirement Careers in Fisheries and Aquaculture**

AFS Special Publication No. 12
Edited by M.B. New and I.C. Liao

This book contains papers presented during a special session on “Post-Retirement Careers in Fisheries and Aquaculture held during the 6th Asian Fisheries Forum. The session speakers were invited because of their contribution to the development of fisheries and aquaculture in Asia. After reviewing his pre-retirement career, each author describes his continuing involvement in his specific professional field, as well as new promising activities. The book comprises six chapters, each author contributing views and perspectives intended to be useful to younger scientists and encouraging other scientists to continue contributing to the development of fisheries and aquaculture even after their formal retirement age. These include Post-retirement experiences of a fisheries administrator by Deb Menasveta; From shrimp to fish by Alain Michel; Post-retirement opportunities after a career in Southeast Asia by Herminio Rabanal; My second 25 years in fish nutrition research and development (1975-2001) by John Halver; Administration-free aquaculture by Michael B. New; Circumnavigating the small world of fisheries science by Roger S.V. Pullin.

For details of another publication – from a special symposium held at the 6th Asian Fisheries Forum in 2001, Global Symposium on Women In Fisheries, please see next section.
ORGANIC AQUACULTURE AND SEA FARMING 2003
Global Technical and Trade Conference and Infofish/Vietfish Aquaculture Expo
In conjunction with VIETFISH 2003 INTERNATIONAL FISHERIES EXHIBITION

15-17 June 2003
Legend Hotel, Ho Chi Minh City, Vietnam

The Global technical and Trade Conference is organized by FAO, INFOFISH, Vietnam Association of Seafood Exporters and Producers VASEP in collaboration with SIPPÖ, Naturland and a number of International and inter governmental organizations.

Sea farming is a significant contributor to organic aquaculture production. This international technical and trade conference will take a closer look at the latest developments in important areas such as:
- Industry Situation and Outlook: The Latin America experience in organic aquaculture;
- Markets and Marketing: Focusing on European and American markets, Japanese organic aquaculture products, markets in Asia, Australia and New Zealand;
- Technological Developments and Issues: the UK experience in developing standards for organic fish farming.

The VIETFISH exhibition is an annual trade show that will showcase the goods and services of those involved with the aquaculture sector. This exhibition is expected to be the largest ever, attracting exhibitors from the global fisheries industry.

For more information, please contact: Website: www.infofish.org Email; infish@po.jaring.my Tel: (603) 2691 4466. Fax: (603) 2691 6804

AAPQIS - Africa Chapter

At this point we need:
- Names and contact information of scientists/others interested in aquatic animal health in Africa.
- Names and contact information of laboratories, research centers, university research departments, national institutions, regional bodies and networks, etc., working on aquatic animal health in Africa.

Let’s advance Africa’s aquatic animal health information exchange and networking capabilities.

Please send the information to: Fernando A. Gonzalez, WorldFish Center, Regional Research Center for Africa and West Asia, Abbassa, P.O. Box 2416, Cairo, Egypt. Tel: (+20-5)-534-04226; 534-04227; Fax: (+20-5)-534-05578; E-mail: fishealthafrica @iclarm.org.eg; Website: www.worldfishcenter.org

NEW PUBLICATIONS

Prawns and Prawn Fisheries of India

By C.V. Kurian and V.O. Sebastian

After four bestseller editions and several reprints, now the 5th edition has been further enlarged with updated description of species based on their most recent international nomenclature. From 1976, this study has evolved from its marine origin to freshwater culture. This book relates Shrimps through its traditional name “Prawns and Prawn Fisheries of India” due to the wide popularity and readership of the name of this book.

“Principally written for students in fishery science, this book also gives a fair amount of material of a higher level about the prawn fishing methods used in India. For that reason, it should be consulted by scientists involved in prawn fishing in tropical countries, particularly in the Indo-pacific area.” -Bulletin of Marine Sciences

To order: Hindustan Publishing Corporation, 4805/24 Bharat Ram Road, Darya Ganj, New Delhi – 110002, India. Email: hpcpd@vsnl.com; Website: www.hpc.cc
A Lasting Catch
By Ebbe Schiøler

How do you make a decent living if you have a partner and four children but only one-fifth of an acre of land? Ask Sumitra Biswas from southeastern Bangladesh. She will advise you to follow the route she did, and take a training course in fish farming especially for women. This made her the local fish-farming expert, and led her and her husband to change their farm routines totally, securing a stable future for the family.

Now and again, in the middle of the depressingly dry Malawian countryside, you might stumble across green and bountiful farmsteads. Why? Probably because the owners, like Friday Nikoloma who farms in the area bordering Mozambique, have irrigated their land with surplus water from fish ponds. This means that the fields are productive all year round, and has enabled the owners to do more than survive in drought-stricken years.

A few years ago, small farmers suddenly began queuing up to buy fingerlings (baby fish) from the Nawatrilap hatchery in central Thailand. They wanted to fatten them up at home and sell them. But why the sudden change in demand? Because an improved type of tilapia was introduced a few years back, meaning that fish farmers can now depend on seeing faster growth, a better survival rate, and even a better market price. So, little wonder that two out of three farmers are now going for the new fish.

These and the many other stories told in this book stand modern science in action in the field. Meet fishers and fish-farmers in African and Asian villages, women, men and even children, and see how their improved livelihoods are linked to a quarter century of targeted work by the WorldFish Center in A Lasting Catch. To order: Communications Unit, WorldFish Center, Jalan Batu Maung, Batu Maung, 11960 Bayan Lepas, Penang, Malaysia. Tel: (60-4) 6261606; Fax: (60-4) 626 5530; Email: worldfishcenter@cgiar.org

Released on the occasion of the 25th Anniversary of WorldFish Center, “A Lasting Catch” also provides an overview of significant milestones in the past 25 years of the history of WorldFish Center formerly ICLARM - The World Fish Center.

Global Symposium on Women in Fisheries


The role of women in fisheries has often been looked at from a post harvest perspective. The notion that women are not just marginal players but active participants in the fisheries production process is not new. However, the fact that there exists little information, about women and their existing roles in the fisheries sector, is something that cannot be denied. Further, the shift in thinking from women in fisheries to gender in fisheries is also an area that deserves attention. It was with the idea of examining these issues and addressing gender related concerns in the sector that a Global Symposium on Women in Fisheries was convened by the Asian Fisheries Society as part of the 6th Asian Fisheries Forum held in Kaohsiung, Taiwan between 25 to 30 November 2001.

After the failures in many of the development projects planned by international agencies in the 1960s and 1970s, where women were excluded in the planning and implementation phase, experts realized that the sustainability of projects require the participation from both men and women—not as man or woman per se, but as a community.

While most of the papers presented provided baseline information on women in fisheries across the world, this Symposium provided opportunities for discussion on the pertinent issues, and planning the way to take these issues forward. This Symposium and the earlier one, although largely focusing on women, raised several gender issues, among which were the involvement of communities in the sapyaw fishery in the Philippines, and the vulnerability of fishers and their families to HIV/AIDS.

This Proceedings is by no means the definitive work on women in fisheries at the global level. Such a work is not yet possible given the dearth of data and lack of developed methods for studying the field. Nevertheless, it is hoped that this Proceedings will be another waypoint along the road, contributing towards better comprehension of some of the issues.
This section contains a list of selected recent publications on fisheries, aquaculture and aquatic resources management available at the WorldFish Center library. The subject, taxonomic and geographic indexes to this are given on pages 61-63.

Please write to the senior author if you require reprints of any article or monograph.


10998 - Checklist of the parasites of coral reef fishes from French Polynesia, with considerations on their potential role in these fish communities. Rigby, M.C.; Lo, C.M.; Cribb, T.H.; Euzet, L.; Faisse, E.; Galzin, R.; Holmes, J.C.; Morand, S. 1999. Cybium 23 (3): 257-284. ETH Zurich, Laboratory of Ichthyology, B-3080 Zurich, Switzerland. (Email: witte@rulsfb.ethz.ch)


Subject Index continued

INFORMATION

Research programmes 019071
Reservoir fisheries 019075
Resource conservation 019128, 019135
Resource management 019135
Retinas 019080
Rice field aquaculture 019083, 019112, 019119
River basins 019117
Rural development 019138
Scientific personnel 019081
Sea cucumber 019051, 019066
Sea grass 019085, 019086
Sea pollution 019125
Seafood 019065, 019130
Seasonal variations 019099
Seaweeds 019085
Seasonal variations 019099
Seaweeds 019085
Selective breeding 019076
Seed production 019104
Selective breeding 019076
Seed production 019104
Selective breeding 019076
Sex 019109
Shrimp culture 019050, 019059, 019123, 019132, 019142
Shrimp nutrition 019100
Simulation 019121, 019124
Social behaviour 019144
Sodium chloride 019109
Soil organic matter 019111
Spawning 019086
Species 019134
Species diversity 019080
Species extinction 019080
Stock 019103, 019133
Stock assessment 019094
Stocking density 019050, 019077, 019144
Stocks 019128, 019129
Survival 019085
Suspended particulate matter 019092
Sustainable development 019136
Swine 019107
Tanks 019072
Taxonomy 019053, 019087, 019089
Temperate zones 019121
Thyroid 019109
Tilapia 019057, 019077, 019082, 019084, 019091, 019104, 019107, 019108, 019109, 019111, 019113, 019114, 019144, 019146, 019149
Trade 019065, 019066, 019093
Trade agreements 019056
Transport 019106
Tropical fish 019145
Tropical species 019052, 019071, 019095, 019121, 019124
Tuna fisheries 019098, 019121, 019131
Turbot 019092
UN 019129
Valuation 019132
Vitamin C 019105
Vitamin E 019105
Wastewater aquaculture 019063
Water circulation 019072
Wetlands 019139
Women 019064
Yield 019050, 019077

Taxonomic Index

Anguilla 019052, 019099
Apogon nigripinnis 019086
Catharops spixii 019095
Catla catla 019139
Chaetodontoidei 019079
Chanos chanos 019105, 019106, 019147
Chrysiptirhys 019118
Cirrhitus mirglass 019139
Clarias batrachus 019115
Clarias ebrinus 019117
Clarias gariepinus 019115
Clarias macrocephalus 019089
Diadema 019090

Geographic Index

Africa 019077
Africa, Ghana 019118
Africa, Nigeria 019117
Africa, South 019110
Africa, Victoria L. 019080
Algeria 019074
Anguilla I. 019093
Asia 019064, 019066
Asia, East 019127
Australia 019071, 019101
Bahrain 019074, 019078
Bangladesh 019085, 019115, 019119
British Virgin I. 019093
Cameroon 019138
Central Pacific 019131
Colombia 019050
Cyprus 019074
East Pacific 019133
Egypt 019074
France 019130
French Polynesia 019088
Great Barrier Reef 019070
Guam 019096
Hawaii 019126
India 019059, 019061, 019063, 019065, 019129, 019140, 019143
Indian Ocean 019127
Indonesia 019052, 019057, 019069
Indonesia, Sulawesi I. 019099
Iran 019074
Israel 019074
Jordan 019074
Kenya 019090
Kuwait 019074
Lebanon 019074

Selected Website

ACLM
A regional community-based aquatic resource management programme, executed by the Food and Agricultural Organization (FAO). Activities comprise: field work on small scale fisheries (Malawi, Zambia and Zimbabwe); field work on integrated irrigation-aquaculture (Tanzania and Zambia); establishment of a SADC Water Resource Database; training and workshops on water resource management issues; and provision of information on water resource issues through hardcopy and electronic publications.

Aquatic Network
http://www.aquapanet.com/
Information service for the aquatic world. Subject areas include aquaculture, fisheries, limnology, maritime heritage, oceanography, ocean engineering and seafood. The network includes databases, news, articles, employment and business opportunities, an online store and a products/services directory.

Asia Pacific Economic Cooperation. Fisheries Working Group
http://www.apsec.org.sg/workinggroup/fish.html
FWG aims to promote the conservation and sustainable use of fisheries resources, sustainable development of aquaculture and habitat preservation, development of solutions to common resource management problems, the enhancement of food safety and quality of fish and fisheries products, and sector-specific work relating to trade and investment liberalization and facilitation.

Asia-Pacific Regional Cooperation in Aquaculture of Groupers and Coral Reef Species
http://www.enaca.org/Grouper/
A web page for grouper and coral reef fish aquaculture.

Asian Aquatic Resources
http://www.agri-aqua.ait.ac.th/AQUA/index.htm
This server provides information about aquaculture.
and aquatic resources in Asia and aims to promote exchange and cooperation between researchers, planners, and practitioners. The server hosts three collaborators that furnish information about their organization, publications, and databases and thematic sites which focus on timely aquatic issues (AARM, AAHRI, NACA). The site covers the following themes: Mangroves; Grouper Aquaculture; and Fish-Poultry systems.

Bay of Bengal Programme (BOBP)
A regional United Nations multi-agency programme that tries to improve the conditions of Bay of Bengal communities through sound and systematic fisheries management practices. The BOBP is based in Madras. It operates in seven countries around the Bay of Bengal - Bangladesh, India, Indonesia, Malaysia, Maldives, Sri Lanka and Thailand. It is funded presently by Denmark and Japan and executed by the FAO (Food and Agriculture Organization of the United Nations)

Catch and Culture
http://www.mrcmekong.org/info_resources/infores002a.htm
A quarterly newsletter produced and distributed by the Fisheries Programme of the MRC Secretariat.

Commercial Fisheries: Why co-management?
http://www.spc.org.nz/aotcomffishmg.htm
‘A Manual for the Co-management of Commercial Fisheries in the Pacific’ is an attractive colour book written by Peter Watt, in collaboration with Michel Blanc. It aims to promote and facilitate stakeholder involvement in the development and management of commercial fisheries in the Pacific region.

Fish Posters of the World
http://www.fishposters.com/index.html
Exactly what it says on the label

IUCN Red List of Threatened Species
http://www.redlist.org/
The 2000 IUCN Red List of Threatened Species provides taxonomic, conservation status and distribution information on taxa that have been evaluated using the 1994 IUCN Red List Categories.

Korea Oceanographic Data Center
http://kodc.nfrdi.re.kr/e-index.html
A resource center for Korean marine data.

Live Reef Fish Information Bulletin
http://www.spc.org.nz/reef/reef.htm
The newsletter of the Secretariat of the Pacific Community (SPC) developed under its Coastal Fisheries Programme for the live reef fish export and aquarium trade in the Asia-Pacific Region.

International Marineinfo Alliance
http://www.marine.info/
IMA focuses its attention on mitigating three particular threats to the coral reef ecosystems of Southeast Asia and the Pacific, based on the organization’s particular strengths. These are destructive fishing practices; habitat destruction; and overfishing. The website provide some valuable reports which can be downloaded.

The International Society for Reef Studies (ISRS)
http://www.isrs.org/
Its principal objective is to promote for the benefit of the public, the production and dissemination of scientific knowledge and understanding of coral reefs, both living and fossil. To achieve its objectives the Society holds annual meetings and co-sponsors other gatherings, prints and distributes the journal Coral Reefs and the newsletter Reef Encounter, and raises funds and receives contributions by way of subscriptions and donations.

Mangrove Conservation and Development
http://www.agri-aqua.ait.ac.th/mangroves/main.html
Aims to provide accurate information and informed opinion relating to all these issues, including up to date information on the current state of mangrove forest throughout the world.

Marine Finfish Aquaculture Newsletters
An electronic newsletter of NACA, in cooperation with ACIAR, APEC, Queensland DPI, and SEAFDEC Aquaculture Department. It contains the latest and selected news on grouper aquaculture, coral reef fisheries and aquaculture research and development.

Mekong River Commission for Sustainable Development
http://www.mrcmekong.org/index.htm
It aims to promote and co-ordinate sustainable management and development of water and related resources for the countries’ mutual benefit and the people’s well-being by implementing strategic programmes and activities and providing scientific information and policy advice

OneWorld
http://www.oneworld.org/guides/fisheries/front.html
Guide to fisheries.

Pond dynamics/Aquaculture
http://www.orst.edu/Dept/crep/homepage.html
The Pond Dynamics/Aquaculture Collaborative Research Support Program (PD/A CRSP) represents an internal-ational, multi-disciplinary effort to improve human nutrition through pond aquaculture research. It focuses on Oreochromis niloticus culture but is also active in other locally important aquaculture types.

The Program on the Lakes of East Africa
http://www.isp.msu.edu/AfricanStudies/Plea/pleasop.htm
(PLEA) is a research, training, and service program of the African Studies Center of Michigan State University in collaboration with the fisheries research institutes of Kenya, Malawi, Tanzania, and Uganda. PLEA does research on Lakes Victoria and Malawi on the Anthropology and Sociology of fisheries management and development, women and gender, environmental policy, the socioeconomic impacts of species introductions, and relations of production. PLEA trains African and international scholars in fisheries socioeconomics and provides bibliographic databases, conferences, and consultancies.

SeaWeb Aquaculture Clearinghouse
http://www.seaweb.org/resources/sac/
An independent, not-for-profit ocean information center that reaches out to government officials, the media, and interested public.

The Support unit for International Fisheries & Aquatic Research was founded in March 1998 and is based alongside the Fisheries Department of the Food and Agriculture Organisation (FAO), in Rome. SIFAR’s mission statement is responsive research for responsible fisheries, reflecting both the need to address demand-led activities and the principles laid out in the Code of Conduct for Responsible Fisheries.

STREAM - Support to Regional Aquatic Resources Management
http://www.streaminitiative.org/
Founded by NACA, DFID, FAO, VSO and AusAID, it aims to offer support to the livelihoods of poor peoples who manage aquatic resources (via management of aquaculture or capture of fish or aquatic resources).

UN Atlas of the Oceans
http://www.oceansatlas.org/index.jsp
An Internet portal providing information relevant to the sustainable development of the oceans. It is designed for policy-makers who need to become familiar with ocean issues and for scientists, students and resource managers who need access to databases and approaches to sustainability. It can also provide the ocean industry and stakeholders with pertinent information on ocean matters.

Worldcatch
http://www.worldcatch.com/
Contains global fisheries and aquaculture news, market and industry reports.
WHAT’S IN THE NAGA?

Naga, WorldFish Center Quarterly, publishes information on all aspects of fisheries and other living aquatic resources, including research on project summaries, news, notices of new publications and upcoming workshops, conferences, symposia, summary reports of meetings and news of personnel.

Articles appearing in the quarterly may be quoted. We would appreciate a reference made to the source and receipt of a copy of any reprinted material.

WHY NAGA?

The Naga is an underwater creature from Asian mythology. Superior to humans, it inhabits sub-aquatic paradises, living at the bottom of rivers, lakes and seas in resplendent palaces studded with gems and pearls. It is the keeper of the life-energy that is stored in the waters of springs, wells and ponds. It is also the guardian of the riches of the seas – corals, shells and pearls. Naga represents the very focus of WorldFish Center, namely protecting the wealth and productivity of tropical waters.

WHO GETS THE NAGA?

The quarterly is distributed free* of charge to institutions associated with fisheries and aquaculture in developing countries. For those who would like to subscribe, the fee is US$20 per annum. To include your institution in our free mailing list or to subscribe, contact us at naga@cgiar.org or NAGA, Communications Unit, WorldFish Center.

Payment should be made to ICLARM in US dollars by bankdraft or check from a US-based bank.

You are invited to contribute:

The editor invites articles and reviews, but reserves the right to accept or reject papers and to shorten them to meet space requirements. Authors may order reprints of articles published. Opinions expressed in a signed article are those of the author/s and not necessarily those of the management of WorldFish Center. Naga comes out in January, April, July and October of each year. Articles may be submitted at any time during the year. Once they are reviewed and accepted, it will take three months to publish them.

WHO PUBLISHES THE NAGA?

Managing Editor: Janet-Maychin
Cover Designer and Layout Artist: Catherine Tan Lee Mei
Aquabyte and INGA Editor: Modadugu V. Gupta; Assistant Editor: Belen Acosta
Fishbyte Editor: Geronimo Silvestre; Assistant Editor: Len Garces
Socscience Editor: Kuperan K. Viswanathan
Printed by: Prinforce(M) Sdn Bhd

Mail: P O Box 500 GPO, 10670 Penang, Malaysia.
Tel: (+60-4) 626 1606 Fax: (+60-4) 626 5530
E-mail: worldfishcenter@cgiar.org
Visit our home page at www.worldfishcenter.org

*Subject to change without prior notice.