editorial

Genetic diversity is a basic requirement in any program for the improvement of aquatic species. Terrestrial animal and crop farmers raise species and breeds that have been bred in captivity for thousands of years. Many of the breeds/strains presently being farmed are quite distinct from their wild relatives and have a much better growth performance. As compared to this, there is very little domestication in the case of aquatic animals, inspite of aquaculture having been practiced for thousands of years. Many of the aquatic species that are being cultured today do not grow as well as their wild populations due to inbreeding. This makes it necessary to go back to nature frequently to obtain wild brood stock or seed. Hence, aquaculture is dependent on natural genetic resources. A classical example is the Nile tilapia which has been introduced to aquaculture in many countries outside its natural habitat. The Genetic Improvement of Farmed Tilapia (GIFT) project implemented by the WorldFish Center and partners, realizing that the stocks of Nile tilapia in Asia were inbred, and therefore collected and used wild germplasm from Africa in the genetic improvement program that resulted in increasing the growth rate of the fish by 85 per cent after five generations of selection.

The last decade has seen some attention being paid to conservation and sustainable development of genetic resources with the establishment of the Convention on Biological Diversity (CBD), the FAO Code of Conduct for Responsible Fisheries, and the inclusion of aquatic genetic resources in the FAO Commission on Genetic Resources for Food and Agriculture. Inspite of the importance of aquatic resources, they do not find a place in some of the Conventions. The Bellagio conference on "Towards Policies for Conservation and Sustainable Management of Aquatic Resources" held in 1998 recognized that the CBD remains relatively undefined with respect to aquatic resources and suggested that national governments should take responsibility for the conservation and sustainable use of aquatic genetic resources. Many countries do not have policies for the conservation of aquatic genetic resources and those that do have no means of implementing these policies.

Transboundary movement of aquatic organisms has also become a concern from the point of view of conservation of biodiversity and introduction of pathogens and parasites. A number of introduced species have become invasive and led to the extinction of indigenous fauna. Even in cases where genetically improved strains have escaped into the wild and come in contact with natural populations of the same species or that of a closely related species, there is the possibility of hybridization and gene introgression and subsequent erosion of biodiversity. The expert Consultation organized by the WorldFish Center in Bangladesh in 2003 suggested ecological risk assessment be made at the national level before improved strains are disseminated. An expert Consultation organized by the WorldFish Center in collaboration with FAO, IUCN, CBD, CTA and UNEP in 2002 in Nairobi recommended that improved tilapia strains from Asia should not be introduced into Africa which is the natural home of the tilapias. In this context, the International Network on Genetics in Aquaculture (INGA) coordinated by the WorldFish Center is assisting its members in germplasm transfer for research following strictly the Material Transfer Agreements and quarantine protocols and recommendations such as those of the INGA workshop.

The giant freshwater prawn (*Macrobrachium rosenbergii*) has become an important aquaculture species in Asia, both for domestic consumption and for export. There is growing interest in genetic improvement of the species and a number of countries in Asia are in the process of initiating research programs for genetic improvement. The paper on genetic diversity of stocks of *M. rosenbergii* by Peter Mather and Mark de Bruyn in this issue brings to attention the low genetic diversity of cultured stocks, while wild stocks are genetically diverse, indicating the importance of understanding and conserving genetic diversity of the species.

Modadugu V. Gupta
WorldFish Center

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Cover photo by K. Broadhurst (right/left), M. de Bruyn (top/bottom/top left): Collection of *Macrobrachium rosenbergii* samples for analysis of genetic diversity.

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Genetic diversity in wild stocks of the giant freshwater prawn (*Macrobrachium rosenbergii*): Implications for aquaculture and conservation

P.B. Mather and M. de Bruyn

Abstract

The giant freshwater prawn (*Macrobrachium rosenbergii*) is cultured widely around the world but little is known about the levels and patterns of genetic diversity in either wild or cultured stocks. Studies have suggested that genetic diversity may be relatively low in some cultured stocks due to the history of how they were founded and subsequent exposure to repeated population bottlenecks in hatcheries. In contrast, wild stocks have an extensive distribution that extends from southern Asia across Southeast (SE) Asia to the Pacific region. Therefore, wild stocks could be an important resource for genetic improvement of culture stocks in the future. Understanding the extent and patterns of genetic diversity in wild giant freshwater prawn stocks will assist decisions about the direction future breeding programs may take. Wild stock genetic diversity was examined using a 472 base-pair segment of the 16S rRNA gene in 18 wild populations collected from across the natural range of the species. Two major clades ("eastern" and "western") were identified either side of Huxley's line, with a minimum divergence of 6.2 per cent, which implies separation since the Miocene period (5-10 MYA). While divergence estimates within major clades was small (maximum 0.9 per cent), evidence was also found for population structuring at a lower spatial scale. This will be examined more intensively with a faster evolving mtDNA gene in the future.

Introduction

Freshwater aquaculture has expanded rapidly in the Asia-Pacific region over the last 30 years, both in terms of the size of the industry and the diversity of species that are cultured. While marine penaeid prawns remain the major crustacean group used in culture in the region, freshwater prawns of the genus *Macrobrachium* have seen a dramatic increase in production. The giant freshwater prawn (*M. rosenbergii*) is the largest species in the genus (Fig. 1) and is by far the most important culture species. In Asia, harvesting of wild stocks also forms a significant industry and production from the wild increased from 5 246 t in 1984 to approximately 130 000 t in 1998, with a value exceeding US $800 million (FAO 2000). Countries producing the largest volume of *M. rosenbergii* (1998 figures) include China (48 per cent), Bangladesh (37 per cent) and Thailand (6 per cent). While Asia accounts for more than 98 per cent of global production, culture of this species has expanded rapidly both within Asia and more widely in regions far removed from the species' natural distribution (e.g. Brazil) (FAO 2000) and it is now cultured in at least 43 countries across five continents.

The natural distribution of *M. rosenbergii* extends from Pakistan in the west to southern Vietnam in the east, across SE Asia, and south to northern Australia, Papua New Guinea, and some Pacific and Indian Ocean Islands. *M. rosenbergii* larvae require brackish water for survival and early development (New and Singholka 1985). Fully mature females migrate from freshwater to estuarine areas to spawn, where free-swimming larvae hatch from eggs attached to the female's abdomen. The larvae metamorphose into post-larvae after three to six weeks and then migrate upstream towards freshwater. While there has been little effort to determine if *M. rosenbergii* is capable of marine dispersal, larvae have been raised to post-larvae stage in 100 per cent artificial seawater, suggesting that the species may be capable of at least limited marine dispersal (Smith et al. 1976; Sandifer and Smith 1979).

M. rosenbergii has been cultured in SE Asia using modern aquaculture techniques since the early 1960s. Early work by Fujimura (1966) at the Anuenue Fisheries Research Center in Hawaii resulted in the development of the successful mass-rearing techniques employed today for commercial-scale hatchery production of post-larvae. Brood stock from Malaysia were introduced to the Center in 1965, but consisted of only 12 individuals (Hedgecock et al. 1979). Later, brood stock from Hawaii (mostly) and SE Asia were introduced into many regions where *M. rosenbergii* was not indigenous, including

Fig. 1. *Macrobrachium rosenbergii,* the giant freshwater prawn

North and South America, Africa, Europe and parts of Asia (most notably China and Taiwan), to initiate culture industries (New 2000). Thus, initial brood stock numbers for many new culture industries were very small and were most likely sourced from only a limited area of the species' natural range. Even in countries where wild stocks occur naturally and are still healthy, little attention has been paid to genetic diversity levels in cultured stocks. While the level of inbreeding in cultured stocks has not been examined to date, it is likely that it may be quite high.

In the early 1990s, commercial stocks in Taiwan experienced productivity declines from 16 000 t to just 7 665 t, which was attributed to inbreeding depression effects. Corresponding declines in production have been described in countries within the species' natural range (e.g. Thailand) and this is believed to result from brood stock commonly being sourced from grow-out ponds rather than from the wild, causing high levels of inbreeding over time (New 2000). Brood stock are also commonly selected on the basis of readiness to spawn, which may lead to a loss of performance as the practice exerts an indirect negative effect on weight-at-harvest. Choosing brood stock for readiness to spawn can result in the smallest females being used, which may lead to a substantial reduction in mean size across generations. This phenomenon was suspected in the hatchery stock at the Anuenue Research Center in the 1980s (New 1995). Thus, while the genetic attributes of cultured stocks worldwide are essentially unknown, many factors are in play that suggest that genetic diversity may be low and declining.

Some wild stocks of *M. rosenbergii* have also seen rapid declines in recent years, largely as a result of over-harvesting, habitat-loss and increased pollution, particularly in SE Asia. Declines have been recorded in Bangladesh, India, Indonesia, Malaysia, the Philippines and Thailand (New et al. 2000), and the species is now believed to be extinct in Singapore, largely as a result of pollution and loss of natural habitat (Ng 1997). Wild stocks can provide an immediate resource for addressing genetic diversity problems in cultured stocks, and consequently require conservation. To this end, the patterns and extent of genetic diversity that are present in wild stocks need to be adequately documented so that we can identify which stocks may carry unique genetic attributes and prioritize conservation efforts.

M. rosenbergii systematics

Systematic studies of *Macrobrachium* species in the past have mainly been based on analyses of external morphological traits. While a single *M. rosenbergii* species is recognized currently across the natural range, two forms of *M. rosenbergii* ("eastern" and "western") have been described independently based on external morphology (De Man 1879; Johnson 1973). Morphological traits, however, have been shown to be strongly influenced by the environment in some *Macrobrachium* species, and may not be indicative of underlying genetic divergence (Dimmock et al. 2002). In addition, allozyme variation in many decapod crustacean species tends to be highly conservative and may not be representative of true molecular levels of divergence. Lindenfelser (1984) analyzed morphometric and allozyme data, and concluded that the boundary for "eastern" and "western" *M. rosenbergii* forms corresponds approximately with Wallace's Line that dissects Indonesia. Further, allozyme and morphological studies of wild *M. rosenbergii* stocks by Malecha and co-workers (1977, 1987 and Hedgecock et al. 1979) recognized three "races": an eastern, a western and an Australian "race".

Mating trials were carried out between geographic "races", with the conclusion that reproductive barriers to gene exchange were not evident among different "races" as most crosses were fertile (Sarver et al. 1979; Malecha 1987). A recent re-analysis of the mating trial data has suggested, however, that mating between individuals from widely separated geographic regions may result in reduced larval survival. In contrast, crosses among mainland Asian wild stocks from different sources (Thailand and Malaysia) have produced evidence for hybrid vigor (heterosis) despite the fact that they belong to the same geographical "race" (Dobkin and Bailey 1979). So, there is circumstantial evidence that *M. rosenbergii* as currently recognized could be polytypic, both regionally and within regions. If true, this has important implications for both conservation of wild genetic resources and also for potential future directions for the culture industry.

Whilst it is surprising that no molecular analyses (DNA-marker studies) have been undertaken on this species to date, the technique has proven very powerful and informative in other decapods where biochemical markers have proven conservative. Variation in the 16S ribosomal RNA mitochondrial DNA (mtDNA) gene has proven useful for addressing evolutionary relationships at both the inter- and intra-specific level in a number of major crustacean groups (Sarver et al. 1998; Crandall et al. 1999; Tong et al. 2000; Wetzer 2001). Thus, patterns of variation in mtDNA among wild stocks of *M. rosenbergii* can provide an independent and informative

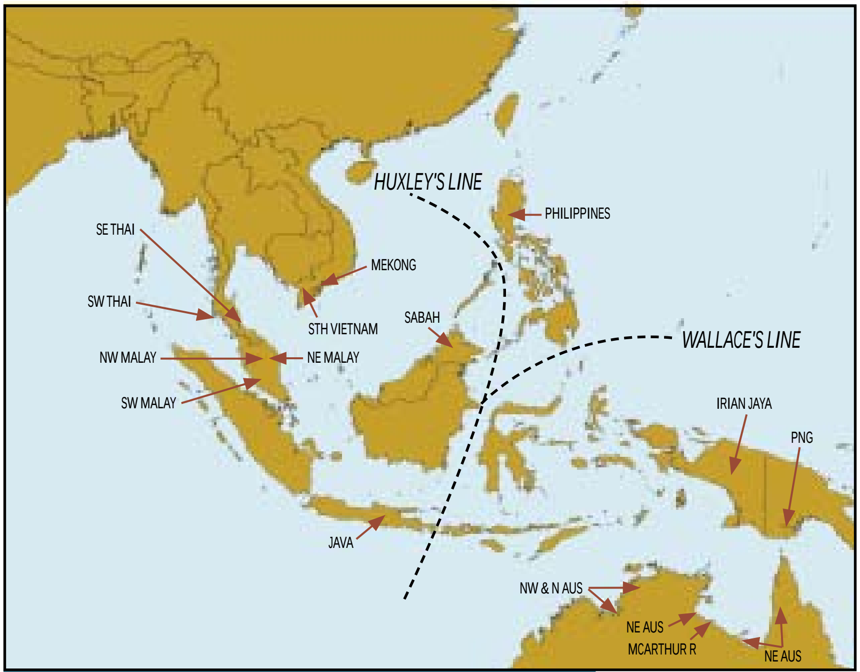

Fig. 2. Locations sampled for *Macrobrachium rosenbergii*

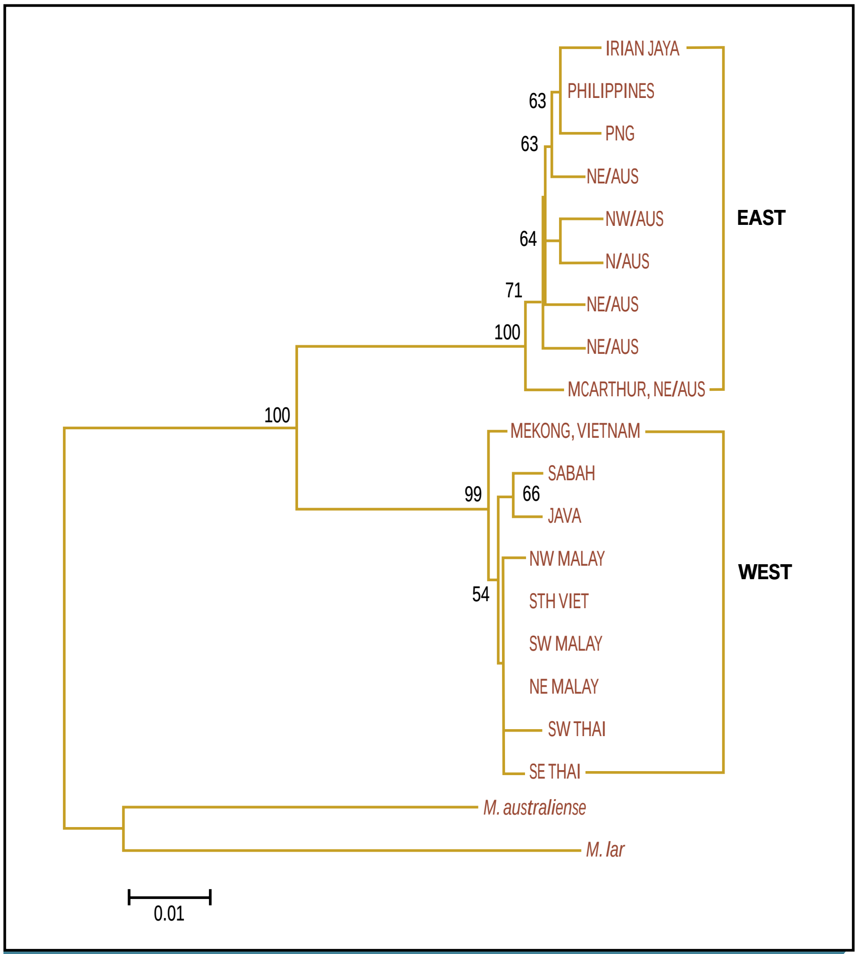

Fig. 3. Neighbour-joining distance tree of the relationships between *Macrobrachium rosenbergii* 16S or RNA haplotypes. Bootstrap values (percentages) are shown for nodes with support >50%

assessment of the significance of natural genetic diversity.

16S rRNA diversity in wild *M. rosenbergii* stocks

We, therefore, set out to document genetic diversity in wild *M. rosenbergii* stocks from across the natural range from southern Asia, to SE Asia and into the Asia-Pacific region. Molecular genetic analysis of a 472 base-pair segment of the 16S rRNA mtDNA gene, sampled from individuals representing 18 wild populations of *M. rosenbergii*, supports previous allozyme and morphological work that has identified two distinct forms of *M. rosenbergii* (De Man 1879; Johnson 1973; Lindenfelser 1984). The boundary between the two major clades corresponds with Huxley's extension (Huxley 1868) of Wallace's Line (Fig. 2), a well-known biogeographical break that runs through Indonesia. The level of divergence present between "eastern" and "western" forms of *M. rosenbergii* identified in this study is in the order of 6.2 per cent for the 16S mtDNA gene (Fig. 3), a level of divergence which is further supported by preliminary COI results indicating divergence levels approaching 15 to 16 per cent for the same stocks. COI evolves more rapidly than 16S RNA, and after calibration of the different rates of evolution of the two molecules, estimates of divergence time since populations shared a common ancestor are similar. The extensive 16S mtDNA divergence between "eastern" and "western" forms indicates they have been separated since at least Miocene times (5-10 MYA; de Bruyn et al. In press). These divergence levels exceed interspecific 16S divergence levels between several penaeid prawn species (Tong et al. 2000), and some freshwater crayfish species (Grandjean et al. 2002).

Divergence estimates among populations within each of the two major clades are relatively small (maximum 0.9 per cent) and appear to have been shaped by eustatic sea-level change, resulting from climatic change in the past, which may have facilitated or restricted gene flow among populations. Within the eastern clade, a surprisingly low degree of divergence (1-2bp) was observed between the Philippines haplotype and all other eastern "race" haplotypes (Papua New Guinea, Irian Jaya and Australia) analyzed. As the Philippines and Australian/New Guinea landmasses have been geographically distant for at least the past 10 million years (Hall 1996), this suggests that some marine dispersal of *M. rosenbergii*, perhaps via larval dispersal, has taken place. The topology of the neighbor-joining tree (Fig. 3) indicates that within the eastern clade, the McArthur River haplotype from the Gulf of Carpentaria, Australia, is ancestral to all other eastern haplotypes identified. Furthermore, it would appear that gene-flow has occurred from a southerly (Australian) to northerly (PNG, Irian Jaya, Philippines) direction. There is also evidence for some finer-scale genetic structuring within Australia, with the northern and north-western stocks genetically differentiated from Gulf of Carpentaria and Cape York stocks in north-eastern Australia (Fig. 3).

Within the western clade, the Mekong River haplotype appears to be ancestral to all others. The Java and Sabah (Borneo) haplotypes are genetically similar but distinct from all other mainland Asian haplotypes (Fig. 3), which are all identical, with the exception of the Kraburi River haplotype from south-western Thailand. The authors have hypothesized elsewhere that this may be the result of past genetic admixture of stocks that are today geographically discrete, as all of these locations were once connected via extensive river drainage basins (Siam or Malacca Straits River Systems; Voris 2000) that covered much of the Sunda Shelf during Pleistocene low sea-level stands (de Bruyn et al. In press). Ongoing gene-flow between these sites, however, could also result in the observed genetic pattern and this will be further investigated using COI population-level analysis.

Whether the "eastern" and "western" forms of *M. rosenbergii* actually represent two distinct species or sub-species is open to debate. However, the levels of divergence identified here do have important implications for both the aquaculture industry and for conservation of wild stocks. A detailed understanding of the molecular relationships among wild stocks should provide a foundation for future genetic improvement of the species in culture via selective "hybridization" of discrete stocks that may show heterosis (hybrid vigor). Similarly, this study has identified genetically distinct populations that should be the focus of increased conservation effort, as this genetic diversity can provide an important resource for the development of sustainable breeding programs in the future. Ongoing work will extend this initial data in a number of ways. Firstly, sampling effort will be increased to include a number of additional sites throughout *M. rosenbergii's* natural range, and population sample sizes increased. Secondly, COI mtDNA and microsatellite variation (a suite of microsatellite primers are presently being developed in our lab) will be utilized to quantify levels of genetic divergence between populations and to estimate relative levels of genetic variation within and among populations for management purposes. Finally, existing *M. rosenbergii* culture stocks will be sampled, allowing for comparisons of genetic diversity levels to be made between wild and domesticated stocks. This will allow us to estimate the relative levels of inbreeding that may be present in these stocks and suggest approaches for developing improved culture strains in the future.

References

Crandall, K.A., J.W. Fetzner Jr, S.H. Lawler, M. Kinnersley and C.M. Austin. 1999. Phylogenetic relationships among the Australian and New Zealand genera of freshwater crayfishes (Decapoda: Parastacidae). Aust. J. Zool. 47:199-214.

de Bruyn, M., J.A. Wilson and P.B. Mather. Huxley's Line demarcates extensive genetic divergence between eastern and western forms of the giant freshwater prawn, *Macrobrachium rosenbergii*. Molecular Phylogenetics and Evolution. In press.

De Man, J.G. 1879. On some species of the genus *Palaemon* Fabr. with descriptions of two new forms. Notes Leyden Museum 1:165-184.

Dimmock, A., I. Williamson and P. Mather. 2002. Environmental effects on morphology of mature male *Macrobrachium australiense* (Decapoda: Palaemonidae), p. 208-209. *In* Seafarming Today and Tomorrow: Extended Abstracts and Short Communications. Special Publication No. 32, European Aquaculture Society, August 2002, Belgium.

Dobkin, S. and D.J. Bailey. 1979. Growth rates of *Macrobrachium rosenbergii* in south Florida. 2. Growth of intraspecific hybrids. Proc. World Maricul. Soc. 10: 571-574.

FAO. 2000. Aquaculture production statistics 1989-1998. FAO Fisheries Circular 815 (Rev. 12). FAO, Rome.

Fujimura, T. 1966. Notes on the development of a practical mass culturing technique of the giant prawn, *Macrobrachium rosenbergii*. Indo-Pacific Fisheries Council Working Paper IPFC/C66/WP47. FAO, Bangkok.

Grandjean, F., D. Bouchon and C. Souty-Grosset. 2002. Systematics of the European endangered crayfish species *Austropotamobius pallipes* (Decapoda: Astacidae) with a re-examination of the status of *Austropotamobius berndhauseri*. J. Crust. Biol. 22:677-681.

Hall, R. 1996. Reconstructing Cenozoic Asia., p. 153-184. *In* R. Hall and D.J. Blundell (eds.) Tectonic Evolution of Southeast Asia. The Geological Society Publishing House, Bath, UK.

Hedgecock, D., D.J. Stelmach, K. Nelson, M.E. Lindenfelser and S.R. Malecha. 1979. Genetic divergence and biogeography of natural populations of *Macrobrachium rosenbergii*. Proc. World Maricul. Soc. 10: 873-879.

Huxley, T.H. 1868. On the classification and distribution of the Alectoromorphae and Heteromorphae. Proc. Zool. Soc. Lond.: 294-319.

Johnson, D.S. 1973. Notes on some species of the genus *Macrobrachium* (Crustacea: Decapoda: Caridea: Palaemonidae). J. Sing. Nat. Acad. Sci. 3(3):273-291.

Lindenfelser, M.E. 1984. Morphometric and allozymic congruence: evolution in the prawn *Macrobrachium rosenbergii,* (Decapoda Palaemonidae). Systematic Zoology 33(2):195-204.

Malecha, S.R. 1977. Genetics and selective breeding of *Macrobrachium rosenbergii,* p. 328-355. *In* J.A. Hanson and H.L. Goodwin (eds.) Shrimp and Prawn Farming in the Western Hemisphere. Dowden, Hutchinson and Ross, Stroudsberg, PA, USA.

Malecha, S.R. 1987. Selective breeding and intraspecific hybridization of crustaceans. p. 323-336. ***In*** Proceedings of the World Symposium on Selection, Hybridization, and Genetic Engineering in Aquaculture. Vol. 1. Berlin, Germany.

New, M.B. 1995. Status of freshwater prawn farming: a review. Aquaculture Research 26:1-54.

New, M.B. 2000. History and global status of freshwater prawn farming, p. 1-11. *In* M.B. New and W.C. Valenti (eds.) Freshwater Prawn Culture: the Farming of *Macrobrachium rosenbergii.* Blackwell Science, Oxford.

New, M.B. and S. Singholka. 1985. Freshwater prawn farming: a manual for the culture of *Macrobrachium rosenbergii.* FAO Fisheries Technical Paper 225.

New, M.B., S. Singholka and M.N. Kutty. 2000. Prawn capture fisheries and enhancement, p. 411-428. *In* M.B. New and W.C. Valenti (eds.) Freshwater Prawn Culture: the Farming of *Macrobrachium rosenbergii.* Blackwell Science, Oxford.

Ng, P.K.L. 1997. The conservation status of freshwater prawns and crabs in Singapore with emphasis on the Nature Reserves. Proc. Nature Res. Surv. Sem. Gardens' Bull. Sing. 49:267-272.

Sandifer, P.A. and T.I.J. Smith. 1979. Possible significance of variation in the larval development of Palaemonid shrimp. J. Exp. Mar. Biol. Ecol. 39:55-64.

Sarver, D., S. Malecha and D. Onizuka 1979. Development and characterization of genetic stocks and their hybrids in *Macrobrachium rosenbergii*: physiological responses and larval development rates. Proc. World Maricul. Soc. 10:880-892.

Sarver, S.K., J.D. Silberman and P.J. Walsh. 1998. Mitochondrial DNA sequence evidence supporting the recognition of two subspecies or species of the Florida spiny lobster *Panulirus argus*. J. Crust. Biol. 18(1):177-186.

Smith, T.I.J., P.A. Sandifer and W.C. Trimble. 1976. Progress in developing a recirculating synthetic seawater hatchery for rearing larvae of *Macrobrachium rosenbergii*, p. 167-181. *In* H.H. Webber and G.D. Ruggieri (eds.) Food-drugs from the Sea, Proceedings 1974. Marine Technology Society, Washington DC, USA.

Tong, J.G., T.-Y. Chan and K.H. Chu. 2000. A preliminary phylogenetic analysis of *Metapenaeopsis* (Decapoda: Paenaeidae) based on mitochondrial DNA sequences of selected species from the Indo-West Pacific. J. Crust. Biol. 20(3):541-549.

Voris, H.K. 2000. Maps of Pleistocene sea levels in Southeast Asia: shorelines, river systems and time durations. J. Biogeog. 27:1153-1167.

Wetzer, R. 2001. Hierarchical analysis of mtDNA variation and the use of mtDNA for isopod (Crustacea: Peracarida: Isopoda) systematics. Cont. Zool. 70(1):23-39.

P.B. Mather and **M. de Bruyn** are from the School of Natural Resources Sciences, Queensland University of Technology, GPO Box 2434, Brisbane, Queensland 4001, Australia.
E-mail: p.mather@qut.edu.au

Growth, mortality and recruitment of Nile perch *Lates niloticus* (L. Centropomidae) in the Nyanza Gulf of Lake Victoria: an evaluation update

C.O. Rabour, J. Gichuki and J. Moreau

Abstract

A reassessment of the estimates of growth, mortality and recruitment patterns of Nile Perch, *Lates niloticus* was made based on data from commercial landings collected during the Catch Assessment Survey Programme. Two sets of length frequency data, one each from beach seining and hook and line fisheries, were analyzed. Values of L_∞ = 169 and 230 (cm TL) and K= 0.18 yr^{-1} and 0.195 yr^{-1} were obtained. The total mortality estimates from the catch curve analysis were Z = 0.72 yr^{-1} and 0.94 yr^{-1}, respectively, with a natural mortality M of about 0.35 for a mean environmental temperature of 27°C. The highest peak for recruitment was in November, December and January with a minor one in June, indicating recruitment of two cohorts per year. These results are discussed and compared to previously available information on *L. niloticus* in Lake Victoria.

Introduction

The Kenyan portion of Lake Victoria is a narrow and shallow gulf, known by several names: Victoria Nyanza (Graham 1929), Kavirondo Gulf (Copley 1953; Muller and Benda 1981), Nyanza Gulf (Rinne and Wanjala 1982; Ogari and Dadzie 1988) and Winam Gulf (Okach 1982) (Fig. 1). It comprises only 6 per cent (4 100 km^2) of the entire lake (68 000 km^2). The gulf has an average depth of 6 to 8 m and an elevation of a 1 136 m above sea level. The maximum depth is about 43 m and the shoreline is about 500 km with flat sandy and muddy beaches, the latter found mostly in sheltered bays (Okach and Dadzie 1988).

The fishery of the Nyanza Gulf is multi-species and is dominated by the Nile perch, *Lates niloticus* (60 per cent), *Rastrineobola argentea* (30 per cent), and Tilapiines (5.5 per cent) (Ogari 1985; CIFA 1987; Asila and Ogari 1988; Rabuor 1991).

Length-frequency analyses on Nile perch specimens from Lake Victoria have been done by Acere (1985) in the Uganda sector. In the Nyanza Gulf, growth parameters and mortality rates have been estimated only by Asila and Ogari (1988) from samples obtained between October 1978 and February 1984. The aim of this study is to update our knowledge of the demographic situation of the stock of Nile perch in the Nyanza Gulf and re-estimate its growth parameters, mortality rates and recruitment patterns.

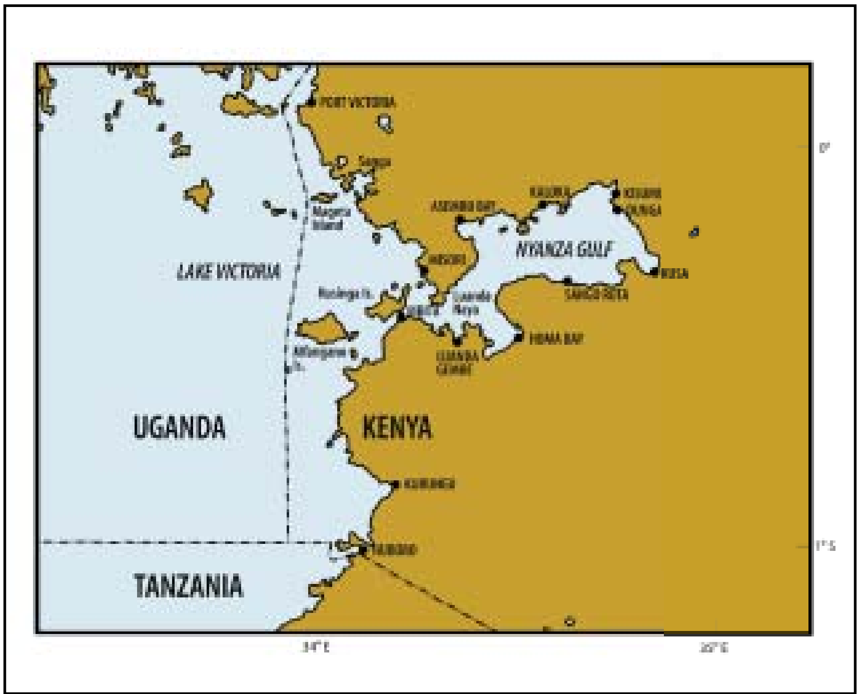

Fig. 1. Lake Victoria (Kenya) showing some of the major landing beaches

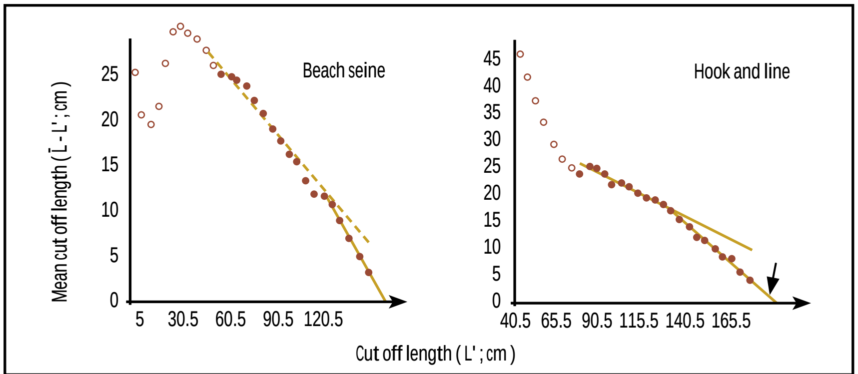

Fig. 2. Preliminary estimates of L_∞ and Z/K obtained from length-frequency data using the Wetherall's method (1986)

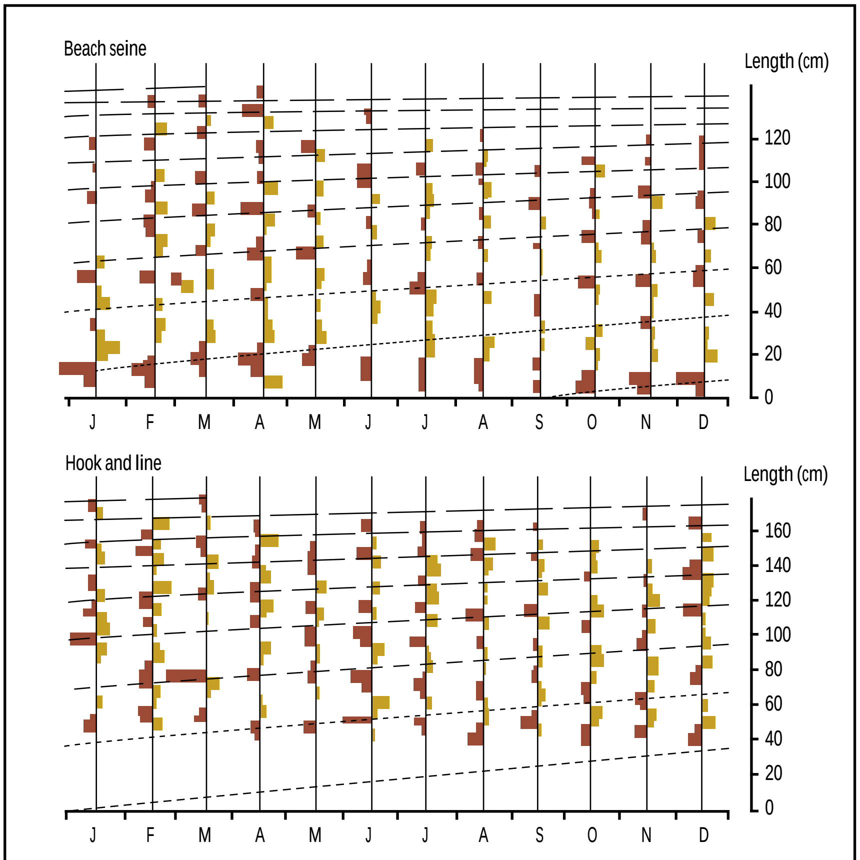

Fig. 3. Evaluation of the growth of *Lates niloticus* in Nyanza Gulf, Lake Victoria, using ELEFAN 1 on length-frequency data (L_∞=228cm, K=0.185)

Materials and methods

Sampling methodology

Length-frequency data for the Nile perch was obtained through the routine Catch Assessment Survey Programme conducted on a monthly basis at 22 fish landing beaches. Two sets of data, both obtained in 1991, were used: one from littoral beach seining and the other one from hook and line fisheries. These were analyzed separately. The purpose of using the two different sets of data was to point out possible differences in the dynamics of *L. niloticus* according to the range of sizes and location in the lake. The samples were grouped into 5 cm length groups, ranging from 3 to 168 cm, based on total length (TL) measurements.

Data analysis

The "COMPLEAT ELEFAN" (Electronic Length Frequency Analysis) software developed by Gayanilo et al. (1991) for IBM/PC compatible microcomputers was used for the analysis of the length frequency data in the following way:

i. ELEFAN 0 was used to create and modify the length frequency data for use with the remaining parts of the program.

ii. ELEFAN I was used to estimate the **growth parameters** based on the Von Bertalanffy Growth Formula (VBGF) expressed in the form (Pauly and Gaschutz 1979):

$$L_t = (L_\infty [1 - e^{-K(t-t_0)}]) \qquad (1)$$

where:

L_t is the predicted length at age t.
L_∞ is the asymptotic length or mean length the fish of a given stock would reach if they were to grow forever.
K is a growth constant, also called "stress factor" by Pauly (1980).
t_0 is the "age" the fish would have been at zero length.

Given the data and the ecological conditions of the lake, no seasonality could be taken into account.

iii. ELEFAN II was used to estimate the **instantaneous total mortality** coefficient Z via a "length-converted catch-curve" analysis as described by Pauly (1984). To compute the natural mortality coefficient M, Pauly (1980) developed an empirical formula using the multiple regression indicated below:

$$\log_{10} M = -0.0152 - 0.279 \log_{10} L_\infty + 0.65431 \log_{10} K + 0.463 \log_{10} T^oC \qquad (2)$$

This formula was used to obtain the estimate of M, given L_∞ (total length in cm), K (the growth constant), and T (the mean environmental temperature °C). Once Z and M were obtained, then fishing mortality (F) was derived from the relationship:

$$F = Z - M \qquad (3)$$

And the exploitation rate (E) was obtained by the relationship:

$$E = F/Z = F/(F + M) \quad (4)$$

iv. ELEFAN II was further used to obtain expressions of the **seasonal changes in recruitment patterns** displayed in a graphical form. It was subdivided into normally distributed recruitment pulses, suggestive of the recruitment seasons for an arbitrary year. Growth parameter estimates L_∞ and K were used as inputs in this analysis in application of the NORMSEP program in ELEFAN II.

v. ELEFAN II has a routine that was used to get preliminary estimates of L_∞ and of the ratio Z/K using the method of Wetherall (1986) as modified by Pauly (1986).

Results

Preliminary estimates of L_∞ using the method of Wetherall (1986) gave the following values: 168 cm for beach seine samples and 211 cm for the hook and line samples (Fig. 2). With ELEFAN 1, the growth parameter estimates are L_∞ = 169 cm and 223 cm, respectively, and K = 0.0195 yr^{1} and 0.180 yr^{1}, respectively (Fig. 3).

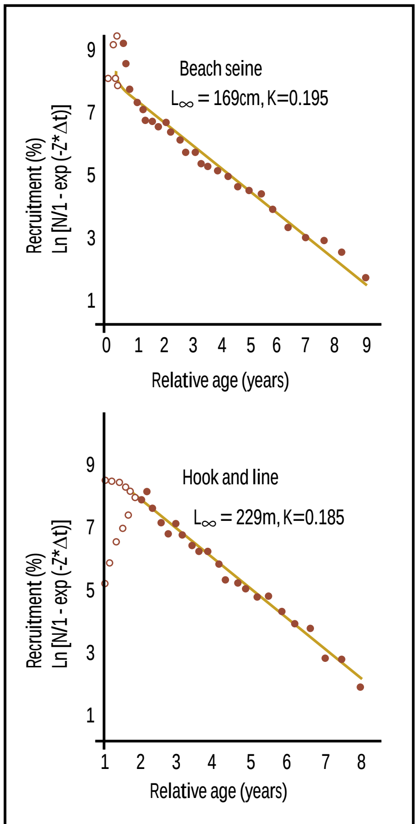

Fig. 4. Length converted catch curve analysis operated using ELEFAN 11 on length-frequency data

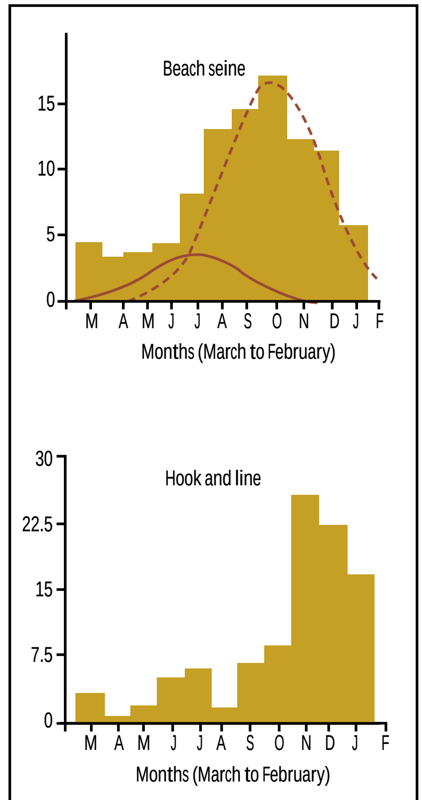

Fig. 5. Recruitment pattern of *Lates niloticus* in Nyanza Gulf, Lake Victoria as provided by ELEFAN 11 using length-frequency data

The length–converted catch–curve analysis produced total mortality estimates of Z = 0.724yr^{1} and 0.975yr^{1}, respectively, in the same ranges of age: 2 to 9 (Fig. 4). The natural mortality estimates were 0.372 yr^{1} and 0.324 yr^{1}, leading to fishing mortality values of 0.352 and 0.633, respectively.

The recruitment pattern (Fig. 5) for *L. niloticus* in the Nyanza Gulf suggests a major peak recruitment from August to December from beach seine data and from October to January from the hook and line data, with a minor one in June in both cases. This suggests two cohorts per year, with one being poorly pronounced.

Discussion

The estimates of the growth parameters are in the range of already available values from the literature (Moreau 1982). Acere (1985) obtained L_∞ = 251 cm and K = 0.091yr^{1} for Nile perch from the Uganda waters of Lake Victoria using the probability paper method. Asila and Ogari (1988) obtained L_∞ = 205 and K = 0.19 yr^{1} for Nile perch in the Nyanza Gulf using the Bhattacharya (1967) and Gulland and Holt (1956) plots. Moreover, the data of Acere (1985) allowed a fitting with the VBGF as modified by Soriano et al. (1992) taking into account a two phase growth curve for juveniles and adults as shown on Fig. 6a. This new curve can be assumed to result from two different growth patterns as shown in Fig. 6b. It shows that the combination of L_∞ and K values obtained in the current study from the beach seining samples are similar to those of juveniles in Fig. 6b. The combination of L_∞ and K values obtained from the samples from hook and line fishing are similar to the ones for adults shown in Fig. 6b. This indicates that the difference between growth parameters calculated from the two sets of length frequency data are acceptable as they can be assumed to come from two slightly different stocks: one living in the littoral areas and exploited by beach seines and one living in more open and deep waters and exploited by hook and line. Those two stocks can also be assumed to have different feeding habits as assumed by Soriano et al. (1992) in their model. The large *L. niloticus* are known to be more piscivorous that the small ones (Ogari and Dadzie 1988) in Lake Victoria.

Concerning total mortality, Acere (1985) provided values of Z that decreased from 2.6 to 0.85 between 1964 and 1977. Similarly, Asila and Ogari (1988) obtained total mortality estimates of Z = 2.2 to 1.6 in 1978 and 1984, respectively. In Uganda, the period of the study of Acere (1985) was one of strong development of the population of *L. niloticus* with a very high initial turnover (e.g. P/B or Z value), which progressively declined after some years. The same situation probably occurred during the study of Asila and Ogari (1988) between 1978 and 1984 when catches of *L. niloticus* increased enormously in the Nyanza Gulf (Ogari 1985; Rabuor 1991). After a similar high turnover (Z = 2.2.), Z tends to decrease to the low values observed in this study (0.72 to 0.96). Note that, even with these low values of Z, the exploitation rate is high: 0.486 in the littoral areas and 0.663 for the hook and lines fishery. This last value is similar to the one estimated by Asila and Ogari (1988).

The period of the main recruitment pulse lasts from September to January of the following year. A minor pulse takes place in June. This is supportive of Gee (1964, 1965) who suggested that Nile perch in Lake Victoria probably spawn twice a year. Gee (1964) suggests that the spawning periods are mainly in the rainy seasons. This is true for the main pulse, which occurs before and during the short rainy season (October to December).

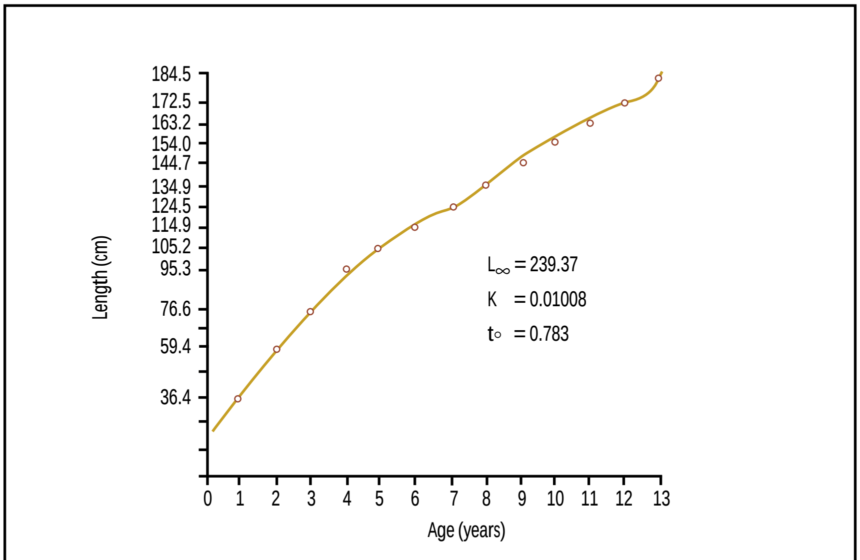

Fig. 6(a). Mean length at age of Nile perch in Lake Victoria: fitted growth curve using the biphasic model of Soriano, (1992)

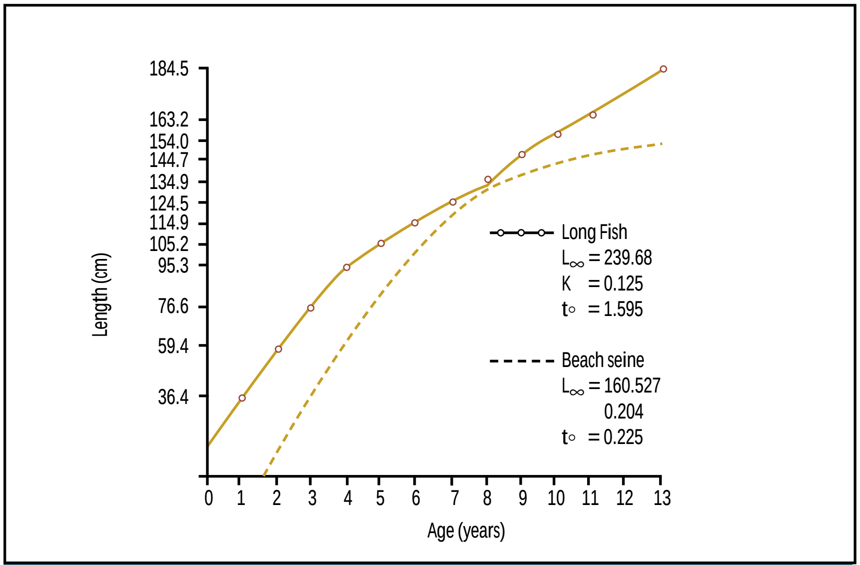

Fig. 6(b). Ordinary Von Bertalanffy growth curves fitted separately for juveniles and adults

Conclusion

It is the first time that a length frequency analysis of *L. niloticus* from Lake Victoria has been made based on two sets of data from two different fisheries. The results suggest different demographic situations for the two sub-stocks concerned. Moreover, low turnover (i.e. low value of Z) means that, after a phase of strong development, this population may now be in some kind of demographic equilibrium. However, further investigations are needed to monitor its demographic evolution and possible over-fishing, as has already been observed in some parts of the Uganda littoral areas of Lake Victoria (A. Kudhogania pers. comm. to Jacques Moreau in 1994).

Acknowledgements

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References

Acere, T.O. 1985. Observations on the biology of the Nile perch (*L. niloticus*) and growth of its fishery in the northern waters of Lake Victoria. FAO Fish. Rep. 335:42–61.

Asila, A.A. and J. Ogari. 1988. Growth parameters and mortality rates of Nile perch (*Lates niloticus*) estimated from length–frequency data in Nyanza Gulf (Lake Victoria). FAO Fish. Rep. 389:272-287.

Bhattacharya, C.G. 1967. A simple method of resolution of a distribution into Gaussian components. Biometrics 23: 115–135.

CIFA (Committee for Inland Fisheries of Africa). 1988. Report of the fourth session of the sub-committee for the development and management of the fisheries of Lake Victoria, Kisumu, Kenya, 6-10 April 1987. FAO Fish. Rep. 388:112.

Copley, H. 1953. The tilapia fishery of the Kavirondo Gulf. J.E. African Nat. Hist. Soc. 94:1-5.

Gee, J.M. 1964. Nile perch investigations. EAFFRO Annual Report 1962/63: 14–24.

Gee, J.M. 1965. Nile perch investigations. EAFFRO Annual Report 1964:13–27.

Gayanilo F., M. Soriano and D. Pauly. 1991. A draft Guide to the Compleate

ELEFAN. ICLARM Software 2, 70 p. International Center for Living Aquatic Resources Management, Manila, Philippines.

Graham, M. 1929. The Victoria Nyanza and its fisheries. Crown Agents, London.

Gulland, T.A. and S.J. Holt. 1956. Estimation of growth parameters for data at unequal time intervals. J. Cons. Int. Explor. Mer. 25(2):215–222.

Moreau J. 1982. Exposé synoptique de données biologiques sur *Lates niloticus* L. FAO Fish Synopsis Mer. 132:39 p.

Muller, R.G. and R.S. Benda. 1981. A comparison of bottom trawl stock densities in the inner Kavirondo Gulf of Lake Victoria. J. Fish. Biol. 19: 399–401.

Ogari, T. 1985. Distribution, food and feeding habits of *Lates niloticus* (L.) in Nyanza Gulf of Lake Victoria (Kenya). FAO. Fish. Rep. 335:68–80.

Ogari, J. and S. Dadzie. 1988. The food of the Nile perch, *Lates niloticus* L. after the disappearance of the haplodichromine cichlids in the Nyanza Gulf of Lake Victoria (Kenya). J. Fish. Biol. 32:571–577.

Okach, J. I. O. 1982. Reproductive biology and feeding of Siluroid catfish *Bagrus docmac* Forskal (Pisces: Bagridae) in the Winam Gulf of L. Victoria, East Africa. University of Nairobi, MSc Thesis

Okach, J.I.O. and S. Dadzie. 1988. The food, feeding habits and distribution of a Siluroid catfish, *Bagrus docmac* (Forskal) in Kenyan waters of Lake Victoria. J. Fish Biol. 32:21–26.

Pauly, D. and G. Gaschutz. 1979. A simple method fitting oscillating length growth data, with a program for pocket calculator. ICES CM 1979/G : 24 Demersal Fish Ctee, 26 p.

Pauly, D. 1980. A selection of simple methods for the assessment of tropical fish stocks. FAO. Fish. Circ. No. 729.

Pauly, D. 1984. Length converted catch-curves. A powerful tool for fisheries research in the tropics (part 3). ICLARM Fishbyte 2(3):9–10.

Pauly, D. 1986. On improving operation and use of the ELEFAN programs. Part II. Improving the estimation of L_∞ Fishbyte 4(1):18–20.

Rabuor, C.O. 1991. Catch and effort sampling techniques and their application in freshwater fisheries management: with specific reference to Lake Victoria, Kenya waters, p. 373–381. *In* I.G. Cowx (ed.) Catch effort sampling strategies. 420 p.

Rinne, J.N. and B. Wanjala. 1982. Observations on movement patterns of Tilapia spp. in Nyanza Gulf, Lake Victoria, East Africa. J. Fish. Biol. 20: 317–332.

Soriano M., J. Moreau, J.M. Hoenig and D. Pauly. 1992. New functions for the analysis of two phase growth of juvenile and adult fishes, with application to Nile perch. Trans. Amer. Fish. Soc. 121:486–493.

Wetherall J.A. 1986. A new method for estimating growth and mortality parameters from length frequency data. Fishbyte 4(1):12–14.

C.O. Rabour is a Research Officer at the Kenya Marine and Fisheries Research Institute, Sangoro Research Centre, PO BOX 136, Pap Onditi via Ahero, Kenya. Fax 035-21461.
E-mail: kmfkisu@net2000ke.com

Dr. J. Gichuki is a Senior Research Officer at the Kenya Marine and Fisheries Research Institute, Kisumu Research Centre, PO BOX 1881, Kisumu, Kenya.
E-mail: gickukij@yahoo.com

Prof J. Moreau is an expert in ecopath modeling and works in the Department of Inland Fisheries, INP, ENSAT, 145 Avenue de Muret, 31076 Toulouse, France.

Spawning and hatching performance of the Silvery Black Porgy *Sparidentex hasta* under Hypersaline conditions

O.M. Yousif, A.A. Ali and K.K. Kumar

Abstract

Abu Al Abyad island is characterized by harsh environmental conditions. A preliminary trial conducted at the island to investigate the spawning and hatching performance of the blue finned sea bream *Sparidentex hasta* indicated that the fish can be successfully bred at high salinity levels exceeding 50 ppt.

Introduction

The silvery black porgy or blue finned sea bream *Sparidentex hasta*, known as subaiti in the United Arab Emirates, is native to the Arabian Gulf, western Indian Ocean and coasts of India. It occurs in habitats varying from shallow (Fig. 1) coastal waters to deep water. The fish feeds mostly on invertebrates and crustaceans (Bauchot and Smith 1984; Kuronuma and Abe 1986; Al-Abdessalaam 1995).

The fish are protandrous hermaphrodites, that is, they possess both female and male gonadal tissue and mature first as males, then become females as they get older (Parvez and Ahmed 2000). They are highly prized in the region. In the 1980s it was recognized that these fish possess characteristics desirable for aquaculture, such as readiness to spawn in captivity, rapid growth, and tolerance to a relatively wide range of culture conditions (Hussain et al. 1981). Hatchery technology for the commercial production of fingerlings of the species was established by the National Mariculture Center, Bahrain (Al-Ansari et al. 1998).

The Abu Al Abyad island is situated west of Abu Dhabi and has low annual rainfall, high evaporation rates, high air temperature and high humidity. These factors have directly contributed to the unusually harsh marine conditions prevailing in the island. The island is characterized by its wide network of natural and artificially dredged channels that are fringed with a substantial expanse of mangrove trees (*Avecinia marina)* and shrubs.

The desirable characteristics for and the success achieved in culturing it have encouraged the introduction of this fish into Abu Al Abyad island. The results of a preliminary trial undertaken in the Abu Al Abyad hatchery to assess whether this species can be spawned and hatched under hyper saline conditions, ranging between 50 and 55 ppt, are presented in this paper.

Fig. 1. A 2.5 kg female *Sparidentex hasta*

Fig. 2. Oval spawning tank with the egg collector placed at the overflow water exit

Table 1. Induced spawning and hatching rate of *S. hasta* in 40 t indoor concrete tanks

Spawning period	Lunar cycle	Collected eggs			Incubation period (hrs)	Hatching rate (%)	Water temp. (°C)	
		Total (10^6)	good (%)	bad (%)			max	min
8 - 13 Jan	2nd quarter	0.99	39.30	60.70	24	6.05	20	19
14 - 27 Jan	1st quarter	3.29	33.70	66.30	30	2.16	19	18
28 Jan - 12 Feb	2nd quarter	3.78	33.40	66.60	42	72.48	19	18
27 Feb - 13 Mar	2nd quarter	16.32	78.80	21.20	22	20.65	23	22

Fig. 3. Separation and volumetric counting of eggs

Brood stock management

The hatchery bred fingerlings were reared to sexual maturity in 5x5x2.5 m floating net cages placed in one of the artificially dredged channels of the island. During the grow-out period the fish were fed to satiation with a combination of 52 per cent crude protein commercial pelleted feed and trash fish (sardines) enriched with fish oil (10 g/kg). At the end of the first year of rearing, the *S. hasta* fingerlings in the net cages reached a size of 500 g in weight and the whole population was observed to have matured as males with thick and glutinous flowing milt. At the end of the second year, the fish had an average weight of 1 kg and some of them were observed to have changed sex but had not attained complete maturity. In the third year, about 10 per cent of the population was easily distinguishable as females.

In mid-December 2000 when the fish were two years old, eighty males with an average weight of 1.9 kg (1.30 to 2.50 kg) and eighty females with an average weight of 2.1 kg (1.60 to 2.75 kg) were segregated into two net cages. Beginning early January 2002, females with swollen abdomens were selected, injected with HCG at 400 IU per kg body weight of fish and kept in a separate net cage. After 24 hours a resolving dose of 100 IU/kg body weight was administered to the females. Immediately after the second injection, females and males with free flowing milt were transferred to the hatchery where they were stocked for spawning, at a sex ratio of 1:1, in an oval 40 t concrete tank at a density of one fish/m^3. Filtered seawater was continuously supplied at 40 l/min, allowing a 200 per cent daily water exchange. Fish in the spawning tanks were fed squid meat at a rate of two per cent body weight. During the spawning season the water salinity was constant at 54 ppt and the average maximum and minimum water temperatures ranged between 18 to 19 ºC and 22 to 23 ºC, respectively. In another identical tank, a second group of spawners was also stocked at a sex ratio of 1:1 and left to spawn naturally.

Spawning and hatching

The induced fish were observed to spawn 48 hrs after the second hormonal injection. The buoyant eggs were directed towards the overflow opening by the gentle inlet water current. Pelagic eggs were collected twice daily (8:00 hrs and 17:00 hrs) in fine-meshed 400µ collection buckets placed at the overflow waters from the spawning tanks (Fig. 2). The eggs were then washed thoroughly with fresh seawater and placed in a measuring cylinder for separation of good buoyant fertilized eggs from sinking bad eggs as well as for volumetric estimates (Fig. 3). To ensure good water quality, about 50 per cent of the bottom water from the tank was drained out daily after the second egg collection in the afternoon through a drain exit located at the bottom of the tank.

The total number of eggs collected from 30 females during the whole spawning period (8 January-13 March) was 24.4 million eggs at an average of 0.39 million eggs per one kilogram of female (Table 1). Each female spawned once during this period. The good floating eggs comprised 64 per cent of the total number of eggs collected. Only buoyant eggs were stocked in 600 µ mesh incubators (70 cm in diameter and 65 cm in height) placed in 5 t rectangular fiberglass tanks with flow-through filtered and sterilized seawater. Eggs were stocked at an average rate of 300 ml/incubator (approx. 600 000 eggs/ incubator). Dead eggs were continuously siphoned out from the bottom of the incubators. The average hatching rate was only 23.17 per cent of the total incubated eggs. The incubation period ranged between 42 hrs (at a minimum water temperature of 18 ºC) and 23 hrs (at a maximum water temperature of 23 ºC).

In the control tank, the first natural spawning occurred at the end of January and continued till the middle of March. The total number of eggs collected from 30 females was 32.6 million eggs at an average of 0.52 million eggs per one kilogram of female. About 81.41 per cent of this number were good eggs. The average hatching rate was only 27.87 per cent of the total incubated good eggs (Table 2).

For both the induced and naturally spawned groups, spawning was continuous at both the first and second quarters of the moon, suggesting that spawning of this species is not synchronized with the lunar cycle. On the other hand, it was observed that fish spawning activity increased following the flushing out and sudden refilling of the spawning tanks. This suggests that there is a correlation between spawning and tidal floods or currents. Further investigations are suggested to test the use of this natural trigger in initiating and controlling the

Table 2. Natural spawning and hatching rate of *S. hasta* in 40 t indoor concrete tanks

Spawning period	Lunar cycle	Collected eggs			Incubation period (hrs)	Hatching rate (%)	Water temp. (°C)	
		Total (10^6)	good (%)	bad (%)			max	min
28 Jan - 12 Feb	2nd quarter	14.46	73.24	26.76	42	20.65	19	18
13 Feb - 26 Feb	1st quarter	3.16	68.35	31.65	30	51.06	21	20
27 Feb - 13 Mar	2nd quarter	14.98	92.05	7.95	22	29.78	23	22

Fig. 4. Newly hatched larvae collection from the 600 µ eggs incubators

spawning activity of *S. hasta*. The incubation period was observed to increase with decreasing water temperature. Owing to limited hatching facilities, spawning activity was discontinued by the middle of March and the spawners were transferred back to their respective net cages.

Conclusion

The husbandry procedures applied in this trial indicate that hormonal injections are unnecessary for spawning induction, especially when the water temperature is above 20 ºC, and fish can spawn naturally. The incorporation of polyunsaturated fatty acids in the brood stock feed improved to some extent the quality of the eggs as well as the hatching rate.

Hormonal treatment resulted in poorer egg quality and a lower hatching rate than natural spawning. However, the spawning performance obtained in this trial is considered low as compared to those reported from other parts of the region (Al-Ansari et al. 1998). The cause for this low performance is not specifically known but high salinity could be a factor. Towards the end of the spawning season, the total number of eggs produced, fertilization and hatchability increased compared to those obtained at the beginning of the season. This might be due either to lower water temperatures in January or to the immaturity of the eggs. These observations suggest that the proper spawning season for *S. hasta* in Abu Al Abyad island is between February and March. In general, these findings indicate that the spawning and hatching of *S. hasta* is possible in the harsh environmental conditions of the island and plans for mass larvae production should be encouraged.

References

Al-Abdessalaam, T.Z.S. 1995. Marine species of the Sultanate of Oman. An Identification Guide. Ministry of Agriculture and Fisheries, Sultanate of Oman, 412 p.

Al-Anasri, A.A., A.A. Al-Bosta, A. H. Al-Shaikh and A.A. Shawoosh. 1998. Production of sobaity bream, *Sparidentex hasta*, larvae and fry at the National Mariculture Center (NaMaC), Bahrain. National Mariculture Center, Directorate of Fisheries, Ministry of Works and Agriculture. State of Bahrain, 25 p.

Bauchot, M.L. and M.M. Smith.1984. Sparidae. *In* W. Fischer and G. Bianchi (eds.) FAO species identification sheets for fishery purposes. Western Indian Ocean (Fishing Area 51). Vol. 4. FAO, Rome.

Hussain, N., S. Akatsu and C. Al-Zahr.1981. Spawning, egg and early larval development, and growth of *Acanthopagrus cuvieri* (Sparidae). Aquaculture 22:181-194.

Kuronuma K. and Y. Abe. 1986. Fishes of the Arabian Gulf. Kuwait Institute for Scientific Research, 356 p.

Parvez L.K. and A.M. Ahmed. 2000. First observations on natural sex reversal in a protandrous bream (*Sparidentex hasta*: Sparidae) from Kuwait. Pakistan Journal of Zoology 32(3):229-243.

O.M. Yousif, **A.A. Ali** and **K.K. Kumar** are from the Fish and Shrimp Farming Project, Abu Al Abyad, P.O. Box 372, Abu Dhabi, United Arab Emirates.
E-mail: onrash@emirates.net.ae

Assessment of the fishing effort level in the shrimp fisheries of the Central and Southern Gulf of California

A.S. Medina and L.A. Soto

Abstract

In view of the concern caused by the declining trend in the annual shrimp yield in the Central Gulf of California, an attempt was made to analyze the fishing effort level exerted upon the shrimp stocks of the blue (*Farfantepenaeus stylirostris*) and the brown shrimp (*F. californiensis*) from 1980 to 1991. For this purpose, both Schaefer and Fox production models were applied. The results from these analyses revealed an economic overexploitation condition, and suggested an imperative need to implement as a regulatory measure, the reduction of the catch per unit of effort level (CPUE) to keep the fishery within acceptable bioeconomic margins of a maximum sustainable yield (Ys). This can only be achieved through the adjustment of the fleet size from 481 vessels down to 250 or 275.

Introduction

The economic importance of offshore shrimp production along the Pacific coast of Mexico has experienced significant fluctuations, especially in the central sector of the Gulf of California. Both landings and catch per unit of effort (CPUE) values in this region have shown a drastic decline in recent years. This has given rise to a great deal of concern amongst government authorities and the fishing industry, since no immediate tendency to recovery is expected. According to the annual production statistics for the central Gulf of California, between 1980 and 1991, the total annual shrimp catch fluctuated between 1 600 to 5 500 t and the fishing effort declined 31.4 per cent by the end of this period with only 330 vessels (from the initial 481) operating in the area. In spite of this reduction in effort, the diminishing trend in shrimp yields seems to continue. Shrimp production in this part of the Gulf is mainly sustained by two species of penaeids: the blue shrimp (*Farfantepenaeus stylirostris*) and the brown shrimp (*F. californiensis*). Both species are captured within the boundaries of the inner continental shelf (10 to 100 m) over clay-sandy bottoms (Fig.1). The general biological characteristics and population dynamics of the stocks of these species are well documented in a series of important contributions (Lluch 1975,1982; Rodríguez de la Cruz 1976, 1978, 1981; Galicia and Garcia 1976; Mathews 1976; Ross 1988; Alonso 1989; Quevedo 1990; Sepúlveda 1991, 1999).

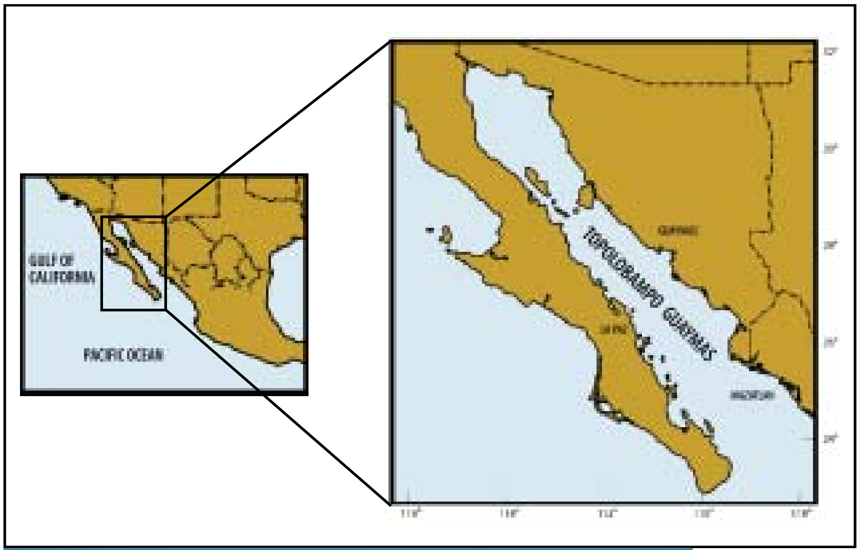

Fig. 1. Fishing areas of the Guaymas' fleet

This study analyzes the fishing effort and yield per vessel of the largest shrimp fishing fleet operating out of the port of Guaymas in NW Mexico in the central and southern sectors of the Gulf of California during the period 1980-91. It is considered vital for this fishery to determine the maximum sustainable yield (Ys) and the optimum fishing effort to assure its sustainable exploitation and adequate management. General criteria for regulatory measures for a reduction of the fleet size to attain equilibrium under the current exploitation levels are also suggested.

Materials and methods

The information analyzed in this paper was obtained from two main sources:

the records of catch reported by the shrimp fleet based in Guaymas and the shrimp landing statistics compiled by the Instituto Nacional de la Pesca (INP) for the period 1980-91. The landing data included monthly catches and the fishing effort was estimated from the number of trips and vessels operating per month in the central and southern sectors of the Gulf of California during the period. Additionally, landing data (lbs) from the shrimp processing plants was transformed into kilograms or tonnes.

The Schaefer (1954) production model was applied for both species. This model assumes a linear relationship between the capture per unit of effort and the applied unit of effort. The shrimp trawlers with major operation autonomy, storage capacity and engine-power were used as reference in order to standardize the fishing effort. We followed for this purpose, the procedure suggested by Alonso (1989). The estimated parameters were:

Y_s = maximum sustainable yield

f_{opt} = optimum effort required for Y_s

U_s = capture per unit of effort $C/_f$

U_{max} = capture per unit of effort max

$Y_e = U\infty f^{-bf2}$

$$f_{opt} = \frac{U\infty}{2b}$$

$$Y_s = \frac{U\infty^2}{4b}$$

The Fox (1970) model was run to establish the exponential relationship between the catch per unit of effort and the effectiveness applied annually during the period 1980-91. The number of vessels participating in the shrimp fishery was considered as the total effort unit applied. Once the original data were transformed, the following parameters were estimated:

$Y_s = f U_\infty E^{-bf}$

The values of b and f were estimated from the exponential regression $y = ae^{-bf}$.

Where the intercept is expressed as
$\ln = U_\infty - 1 \therefore U_\infty = E^a$
in which (a) is the intercept and (b) is the slope of the regression.

$$f_{opt} = \frac{1\infty}{b} \;;\; Y_s = \frac{U\infty}{Eb} \;;\; U_{opt} = \frac{U\infty}{E}$$

After the four basic parameters derived from the Schaefer and Fox models were calculated, a time series analysis was then conducted for the shrimp fishery in the central and southern Gulf of California for the period 1980-91.

Results and discussion

Schaefer production model

The application of Schaefer's model to the shrimp fishery statistics for the period 1980-91 from the Gulf of California revealed that the optimum effort (f_{opt}) for the fleet operating during that period involved 275 vessels, with a maximum sustainable yield (Ys) of 907.5 t, which would roughly correspond to an annual yield of 6.81 t per vessel. Based on these results, one may infer that the shrimp fleet was operating with efficiency. However, when the CPUE values for the period were analyzed, there were significant indications that the level of exploitation slightly exceeded the maximum sustainable yield.

This was corroborated by the results obtained from the regression applied to the observed and estimated CPUE values for each fishing season (Figs. 2 and 3). According to this analysis, for nearly 80 per cent of the fishing season the shrimp fleet maintained operating levels well above its maximum sustainable yield (Ys).

Fox production model

The Fox Production Model is used to measure the level of exploitation of the shrimp population. The units of fishery effort that can be used may be either the number of vessels or the effective fishery days. In this case, the former was used. This model is meant to optimize exploited fish populations.

The results generated from the Fox model (Table 1) appear to substantiate our assumption that the shrimp fleet in the Gulf of California was over exploiting the fishery from 1980 to 1991 (Fig. 4). The average f value estimated for the period of study indicated that the optimum fleet size was exceeded by approximately 33 per cent or 122 vessels, i.e., the fishing effort was more than one-third over its optimum level during that period.

Projection of the relationship between observed and estimated yield

In order to estimate the shrimp production levels and the fleet performance, the estimated optimum effort derived from the two theoretical

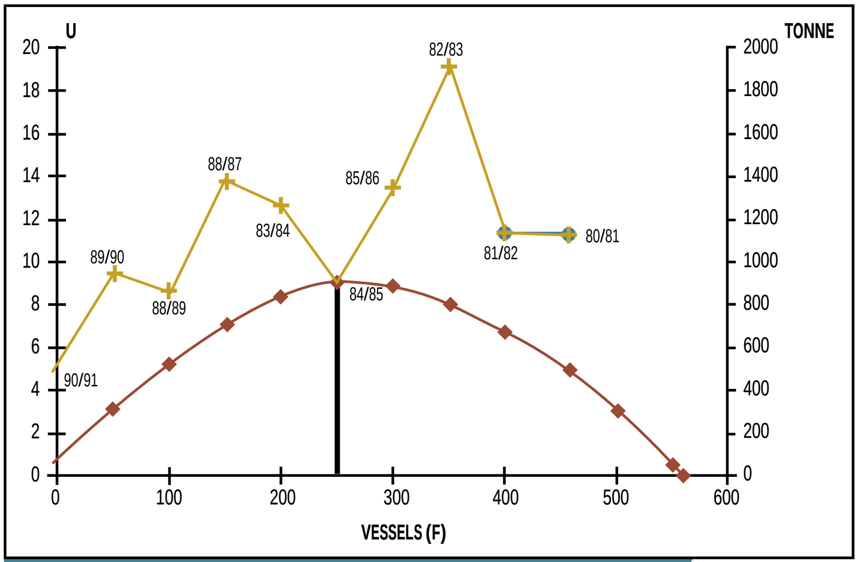

Fig. 2. Guaymas fleet, period 1980-91. *F. stylirostris* and *F. californiensis*

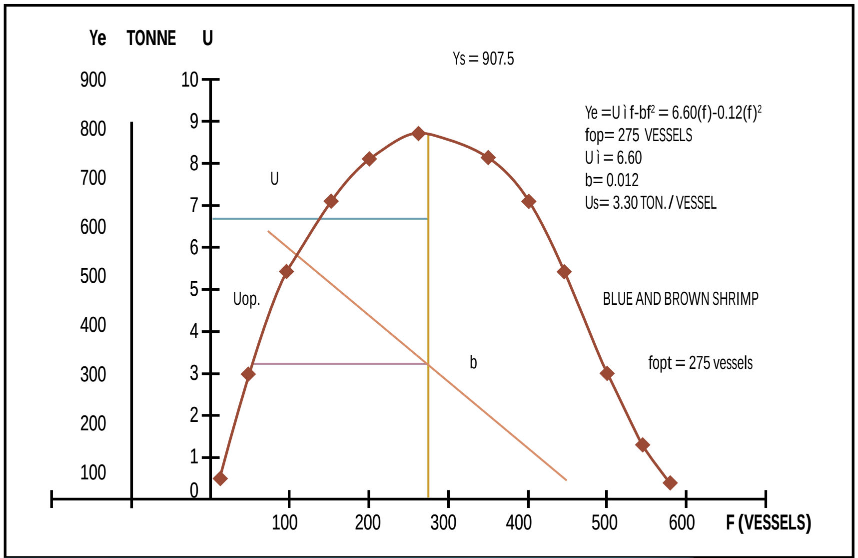

Fig. 3. Schaefer's model

Table 1. Equations and values obtained from the Fox model

		Values	Equation
a	Intersection of the exponential regression	3.381	U∞ = E^a
b	Slope of the exponential regression	0.0040	b = slope
Y_s	Maximum Sustainable Yield	313 t	Y_s = U∞ / bE
f_{opt}	Optimum Effort	250 vessels	f_{opt} = 1/b

Table 2. Main parameters obtained from the Schaefer and Fox models

	Y_s	U_{max}	f_{opt}	U_{opt}
Schaefer model	907.5	6.80	275 vessels	3.30 t/vessels
Fox model	313	1.24	250 vessels	--

fishing models (Schaefer f_{opt}=275 vessels; Fox f_{opt}=275 vessels) was used to estimate the magnitude of annual yield increment from 1980 to 1991, maintaining a fixed Ys of 5.39 t/vessel (Table 2).

The data in Table 3 were obtained from the differential between real and estimated yields according to the f_{opt} of each model, thus obtaining the respective ΔC/f that represents the increment of the catch per unit of effort for each model.

A review of the annual shrimp yield over the period 1980-91 indicates four distinct periods. The first corresponds to the years 1980-82 and is characterized by an intensification of fishing effort accompanied by a high shrimp production of 11 to 12 t/vessel. The second period 1982-84 coincided with a surface temperature disturbance in the Gulf of California, associated with the ENSO phenomena, which apparently promotes a rapid growth rate in tropical species. During this period Lluch and Magallon (1991) recorded shrimp yields of 13.2 to 16.2 t/vessel.

The third period spanned the years 1984-87 (Fig. 5). In this period, the CPUE fluctuated between 8.5 t/vessel during the 1984-1985 season and 13.8 t/vessel in 1987-1988. It is interesting to note that though the fishing effort remained stable, an increase in production per vessel occurred (> 10 t/vessel) towards the end of this period. This condition can be attributed to several factors that may involve a possible high recruitment to the parental stocks favored by local environmental conditions (temperature and precipitation) that promoted spawning and growth (Del Valle 1987; Sepúlveda 1991).

The fourth period, identified here as critical and disturbing, extended from 1987 to 1991. In this period shrimp yields diminished from 10 t/vessel (87/88) to 4.8 t/vessel (90/91) (Fig 5). This could have been due to the excessive fishing effort (>350 vessels) exerted upon the shrimp stocks in the Central Gulf of California. However, one cannot dismiss the deleterious effect on recruitment of extraction of the wild shrimp post-larvae from nursery grounds to stock aquaculture ponds. This is a common practice in the region that deserves further study.

Levels of exploitation

The total shrimp production recorded during the period of study (1980-91) amounted to 44 777 t with an estimated annual yield per vessel of 4 070 t. In this fishery, 366 vessels are involved and their estimated capture per unit of effort (C/f) was 10.88 t. Applying the theoretical optimum effort derived from the Schaefer and Fox models, projections of optimum fishing effort were (Fig. 6, Table 4).

Conclusions

The estimated levels of fishing effort to which the shrimp stocks in the central Gulf of California (1 378 km$^{2)}$ are subjected indicate an economic over-exploitation caused by the activity of 366 to 375 vessels. According to our analysis, a reduction of the fleet size to between 250 to 275 fishing boats could increase the capture per unit of effort (Ac/f) as much as 3.91 t/vessel (if the Schaefer projection is accepted) or 5.39 t/vessel (if the Fox model is accepted). In the first instance, the increment in C/f would amount to an annual yield/vessel of 14.8 t or 36 per cent,

Table 3. Observed and estimated shrimp yields from 1980 to 1991

Year	C/f Observed t / vessel	ΔC/f t / vessel	C / f $_{Opt}$ (275 vessel)	ΔC/f increment	C / f $_{Opt}$ (250 vessel)
80-81	11.34	8.6	19.84	10.4	21.82
81-82	11.25	4.8	16.05	6.4	17.65
82-83	16.20	3.9	20.15	5.9	22.17
83-84	13.60	5.3	18.94	7.2	20.84
84-85	8.65	1.9	10.65	3.0	11.71
85-86	11.89	3.1	15.04	4.6	16.54
86-87	13.84	4.3	18.18	6.1	20.00
87-88	10.49	3.8	14.34	5.3	15.78
88-89	8.49	3.0	11.39	4.1	12.64
89-90	9.16	3.2	12.34	4.4	13.57
90-91	4.80	0.97	5.77	1.5	6.35

ΔC/f = Increment catch per unit effort; C/f = Catch per unit effort; C/f opt = Optimum catch per unit

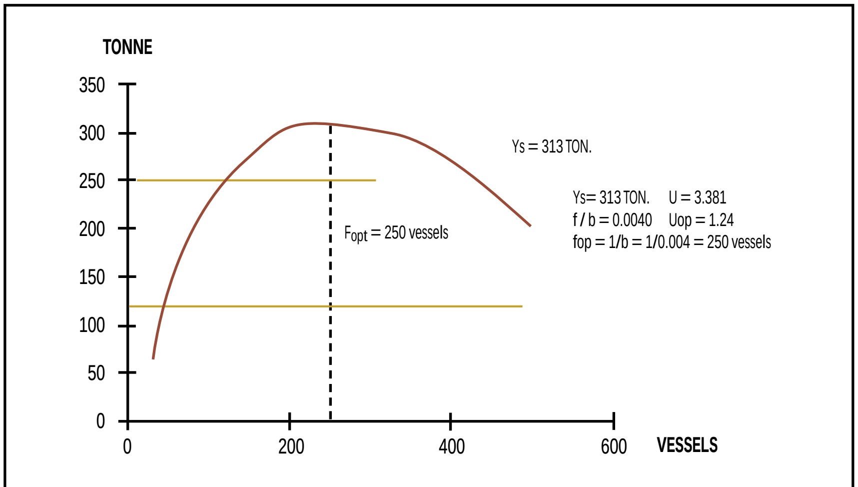

Fig. 4. Fox Production Model for the period 1980-91 Guaymas, Sonora, Mexico

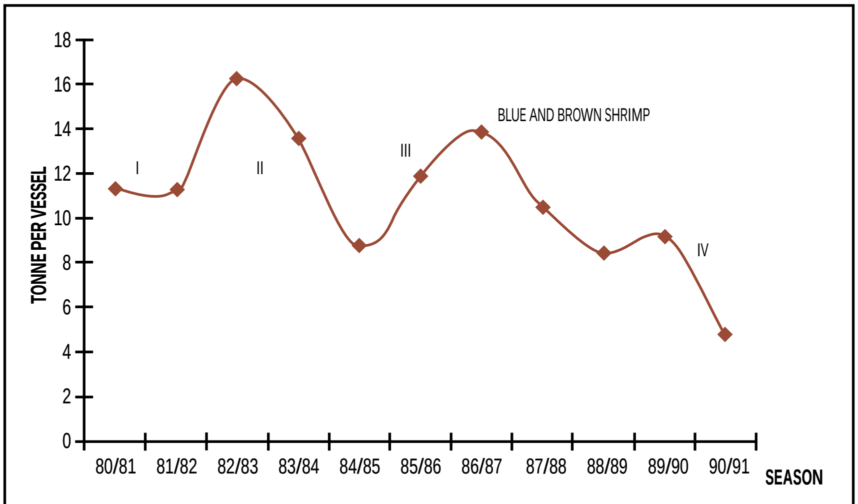

Fig. 5. Shrimp yield of the Guaymas fleet

while in the latter the increment is of 16.7 t or 49 per cent.

The proposed fleet size reduction would not only achieve maximum sustainable yields without reaching over-exploitation limits, but would also serve to attain major economic benefits in terms of ship cost operation. A recommendation of this kind acquires more relevance in light of the severe setbacks in shrimp production recorded during the fishing seasons of 1995-96 and 1998-99 in the southern Gulf of California. During these seasons, the fishing effort fluctuated between 370 to 390 vessels with a 25 per cent reduction in the average annual shrimp yield (4 000 t).

Thus the bioeconomical fishery models must be related to the exhaustive knowledge of the life cycle of the coastal penaeids and their close relation to the applied effort to the resources that are studied (García and Le Reste, 1986).

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References

Alonso, A. M. N. 1989. Aplicación de un modelo bioeconómico al estudio de la pesquería del camarón en Puerto Peñasco, Sonora. Universidad de Baja California, Baja California, p. 1-52. Tesina de especialización de Recursos Marinos.

Del Valle, L.I. 1987. Efecto de la temperatura sobre los niveles de reclutamiento de camarones peneidos a los sistemas estuarinos del Sur de Sinaloa 1:69-84. Simposium sobre Investigación Biológica y Oceanográfica pesquera en México. La Paz, Baja California Sur.

Fox, W.W. 1970. An exponential yield model for optimizing exploited fish

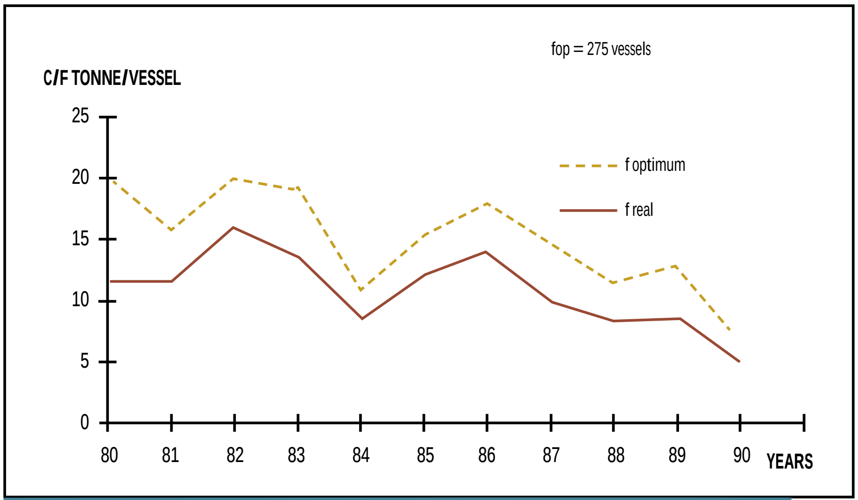


Fig. 6. Protection of relation yield - effort (optimum and real) (Schaefer)

Table 4. Theoretical increases in shrimp yield obtained by assuming different fleet reductions

Level of exploitation (no. vessels)	C/f	∆C/f
366I	10.88	-
275	14.79	3.91
250	16.27	5.30
200	20.53	6.62

∆C/f = Increment catch per unit effort; C/f = Catch per unit effort

populations. Trans. Am. Fish. Soc. 99: 80-88.

Galicia, R. and G.M. García. 1976. Poder de pesca y captura por unidad de esfuerzo de Puerto Peñasco Sonora. 1:164-174. Memorias del Simposuim de Biología y Dinámica Poblacional de Camarones Guaymas, México.

García, S. and L. Le Reste. 1986. Vital cycles, dynamics, exploitation and ordination of the populations of coastal shrimps (peneidos). FAO Doc. Tec. Fish. 203:108.

Quevedo, M.R. García de. 1990. Determinación de algunos parámetros poblacionales y producción máxima sostenible del camarón azul (*P. stylirostris*, Stimpson, 1881) en el Alto Golfo de California. Facultad de Ciencias del Mar, Universidad Autónoma de Baja California, Baja California. 62 p. Tesis de Licenciatura.

Lluch, B.D. 1975. Selectividad de las redes de arrastre camaroneras en el Pacífico Mexicano S.I.C. Serie Científica I.N.P. S.C.: 6, 23 p.

Lluch, B. D., B.F.J. Magallón and M.A. Sepúlveda. 1982. La pesquería del camarón del Pacífico (diagnósis monográfica de los cocimientos existentes). Reunión Nacional sobre Investigación Científica y Pesquera. Cocoyoc. Mor del 26 al 30 de mayo de 1982. 434 p. (inédito)

Lluch, B.D. and B.J. Magallón. 1991. Variación climática y oceanográfica global; sus efectos en el Noroeste Mexicano. Ciencia y Desarrollo. CONACyT 17(98):78-88.

Mathews, C.P. 1976. Cuánto resistirá el camarón. Ciencias Marinas 1(2):86-91.

Rodríguez de la Cruz, M.C. 1976. Sinopsis biológica de las especies del género penaeus del pacífico mexicano. Mem. Sim. Biol. Dinam. Pobl. Camarones. Guaymas, México. del 8 al 13 de agosto de 1976 I:282-316.

Rodríguez de la Cruz, M.C. 1978. Fundamentos y consideraciones para definir la temporada de veda en altamar para el camarón del pacífico mexicano durante 1978. Dir. Gral. Inst. Nal. Pesca. Proy. Camarón del pacífico. México, 10 p.

Rodríguez de la Cruz, M.C. 1981. Estado actual de la pesquería del camarón en el Pacífico Mexicano. Ciencia Pesquera. Instituto Nacional de Pesca, Departamento de Pesca, México 1(1): 53-70.

Ross, T.M.J. 1988. Evaluación poblacional de dos especies de camarón que sostienen la pesca de alta mar en el Norte y Centro del Golfo de California. Universidad Autónoma de Baja California Sur, Baja California Sur. 60 p. Tesis Licenciatura.

Schaefer, M.B. 1954. Some aspects of dynamics of population important to the management of the commercial marine fisheries. Bull. Inter-Am. Trop. Tuna Comm. 1(2):27-56.

Secretaria de Pesca. 1980-1991. Agenda Estadística Pesquera Dirección General de Informática y Estadística Pesquera. México.

Sepúlveda, M.A. 1991. Análisis biológico pesquero de los camarones peneidos comerciales en el pacífico mexicano durante el periodo de veda (1974-1983). U.A.C.P. y P. del C.C.H., Universidad Nacional Autónoma de México, México. 154 p. Tesis de Maestría.

Sepúlveda, M.A. 1999. Dinámica poblacional de los peneidos comerciales en el Alto, Centro Golfo de California, Topolobampo, y Costa Occidental de la Baja California en el litoral del Pacífico Mexicano. U.A.C.P. y P. del C.C.H., Universidad Nacional Autónoma de México, México. 145 p. Tesis Doctoral.

A.S. Medina is from the Instituto Nacional de la Pesca. SEMARNAP. E-mail: dr_adsepulveda@yahoo.com.mx and **L.A. Soto** is from the Instituto de Ciencias del Mary Limnología, UNAM, Mexico D.F. 04510, A.P. 70-310. E-mail: lasg@mar.icmyl.unam.mx

Food and feeding habits of *Synodontis nigrita* from the Osun River, SW Nigeria

E.A.A. Olojo, K.B. Olurin and O.J. Osikoya

Abstract

An investigation was conducted into the food and feeding habits of *Synodontis nigrita* from the Osun River near Epe, Lagos, Nigeria. The food items in the stomach of the *S. nigrita* covered a wide spectrum, ranging from various types of plankton to invertebrates and plants. A seasonal variation was also noted in the stomach contents of *S. nigrita* over the period of investigation. The predominant food items found in the stomach were *Polycystis* spp., *Closterium* spp., *Oedogonium* spp., plant tissues, insect parts and detritus. This suggests that *S. nigrita* is an omnivore.

Introduction

Nature offers a great diversity of organisms that are used as food by fish and these differ in size and taxonomic group. Various investigations have been conducted into the food and feeding habits of fish with the aim of determining their dietary requirements. Fish (1955) found *Tilapia esculenta* in East Africa to be feeding mainly on diatoms, a mixture of phytoplankton and zooplankton, while algae and diatoms were reported by Fagade and Olaniyan (1978) for the same species. *T. guineenses* and *T. mariae* have been reported to be omnivorous (Fagade 1971; 1978) and *Ethmalosa fimbriata* (African shad) as zooplankton feeders (Fagade and Olaniyan 1973). The food and feeding habits of many predatory species have also been reported. The species *Hydrocynus forskalii* (tiger fish), *Hepsetus odoe* (African pike), *Channa obscura* (snake head) and *Lates niloticus* (Nile perch) were found to be principally piscivorus in all studied habitats (Holden 1970; Aramowo 1976; Adebisi 1981) suggesting they are obligate piscivores and feed mainly on cichlid fish.

Although a sizeable amount of literature exists on the food and feeding habits of fish in most inland water bodies, there is still paucity of information on the dietary requirements of *S. nigrita*, also known as spotted upside down catfish and called *akokoniko* in the Yoruba language. It is noted among the local riverine people as a palatable fish with high protein content and is in great demand. However, its armor-like head makes it bony in structure. The present study aims at investigating the food and feeding habits of *S. nigrita* in the Osun River, Nigeria.

Materials and methods

The Osun River has shallow water with a depth of about 1.5 m proximal to the point where it empties into the lagoon. Samples of *S. nigrita* (321) were obtained from the Osun River near the Epe Lagoon in SW Nigeria during rainy and harmattan (dry) seasons (September-December 2000 and June-July 2001, respectively) using a gill net. The specimens were cut open and the full length of the stomach was immersed in 4 per cent formalin. These were transported to the laboratory for further examination. Each stomach was slit open, the contents poured into a petri dish and observations of the food were carried out with the naked eye. Following this, random samples of the stomach contents were dropped on slides with the aid of a dropping pipette and observed under a light microscope. The stomach contents were analyzed using the Frequency of Occurrence method and the Numerical method (Bagenal 1978). Food items present were identified at the general level, whenever possible, using information provided by Prescott (1954).

In the Frequency of Occurrence method, the number of stomachs containing each food item is expressed as a percentage of all non-empty stomachs (Dunn 1954). Though this method is quick and requires minimal apparatus, it gives little indication of the relative quantities of each food category present in the stomach.

In the Numerical method, the number of individuals in each food category is expressed as a percentage of the total individuals in all food categories (e.g. Crisp et al. 1978). This method has the limitation that it over-emphasizes the importance of small prey items found in a large number of fish (Hynes 1950). For many stomachs, it is difficult to identify the numbers in each food category because of mastication of the food. It is also not suitable for dealing with food items such as fragments and detritus that do not occur in discrete units. Occasionally, some food items were observed crushed and others were at varying stages of digestion. Consequently, it was not possible to identify these at the species level.

Results

The results show that *S. nigrita* has a wide feeding range. The food composition of *S. nigrita* also shows a marked seasonal variation. The food range becomes drastically limited in the dry season (October-December) when the occurrence shows *Polycystis* spp., *Closterium* spp., *Oedogonium* spp., insect parts, detritus and plant tissues as predominant in the stomach contents of *S. nigrita* (Table 1). In the dry season, when the water becomes depleted and less fertile to support the plankton bloom which is characteristic of the rainy season, food items such as insect parts, nematodes, plant tissues and algae become the food items for survival in the diet of *S. nigrita*. Generally, *S. nigrita* has a wide range of food items in the rainy season when there is an abundance of plankton and insects in the water.

The food category "algae" includes all green and blue-green forms, both unicellular and filamentous as well as diatoms. The predominant forms found in the stomach were *Polycystis, Closterium, Oedogonium* and the diatoms *Diatoma sp.,* insect parts, detritus and plant tissues. Monthly variations in stomach fullness and the percentage of empty stomachs are given in Table 2.

Discussion

The food items in the stomach of *S. nigrita* suggest that they are euryphagous (i.e. feeding on a wide range of organisms). It was also observed that *S. nigrita* can be classified as an omnivorous feeder as the diet covers a wide spectrum of food ranging from various types of plankton to invertebrates and plants. The fish also exhibits an overlapping in food and feeding habits in order to avoid inter- and intra-specific competition for available food. This is an important strategy for survival and an advantage over the fish species competing for a specific food item. This explains the availability of *S. nigrita* all year round.

The ventral location of the mouth of *S. nigrita* encourages a detritivorous mode of feeding while the simple horny structures around the mouth enable it to adapt to filter feeding. These structures also help *S. nigrita* to gnaw at any hard plant tissue or insect parts which form part of its rich diet.

Monthly/seasonal variations in feeding habits showed an increase in the stomach fullness during the rainy season and decreases in the dry season. The proportion of empty stomachs was higher in the dry season (Table 1). This may reflect a steady dwindling of food resources in a habitat that is continually decreasing in volume with the onset of the dry season. Some of the variability in the dietary composition of *S. nigrita* may be explained on the basis of the change in water level. During the rainy season, there is a wide variety and abundance of food available due to high nutrient composition of the run-off from land promoting plant growth and increasing invertebrate productivity (Moss 1980). This is reflected in the range of food items found in *S. nigrita* captured from June to September, i.e. in the rainy season (Table 1). As the dry season approaches, the river becomes shallow and the abundance and variety of food decrease. The *S. nigrita* changes its dietary composition to algae, insect parts, nematodes, detritus and plant tissues predominantly from October to December (Table 1). This agrees with the findings of Hyslop (1986).

The seasonal change in temperature as a result of *harmattan* winds from the Sahara desert may also play an important role in reducing food availability and diversity. While the diversity of the *S. nigrita* diet decreases, there are also major changes in its composition. A greater percentage of algae, detritus and insect parts during the dry season and the inclusion of crustaceans and rotifers during the rainy season are the main changes in the dietary composition.

The study indicates the preference of *S. nigrita* for phytoplankton, detritus, plant tissues and insect parts (Table 2), which constituted more than 90 per cent of the stomach contents in the dry season. This preference is probably due to the seasonal predominance of these food items in the environment. The phytoplankton found in the stomach contents were mostly Cyanophyta, represented by *Polycystis* spp. and *Clsosterium* spp., *Oedogonium* spp. (Chlorophyta) and unidentified algae (Table 2). *S. nigrita* is not only a phytoplankton feeder, but it also feeds on a little quantity of zooplankton, like rotifers and crustaceans that are represented by cladocerans (*Daphnia sp*). The ingestion of detritus was earlier observed by Patrick - Dempster et al. (1993) for *Tilapia* species and carp, indicating that part of the ingested materials came from the bottom of the river. Protozoans that are typical of the river bottom fauna were found in the digestive tract of *S. nigrita*. Sand grains were also found.

The overall picture of the diet of *S. nigrita* that emerges from this study is that of a species which is largely unspecialized in its feeding habits. Unspecialized flexible dietary habits are an optimal strategy for survival in habitats where food sources are subject to fluctuation (Welcomme 1979). Similarly, the inclusion of large amounts of detritus in the diet is of survival value. It is derived from the surrounding terrestrial habitats and is abundant in the river throughout the season. It also appears that growth proceeds satisfactorily with a sizeable proportion of plant material in the diet. The maximum size of *S. nigrita* obtained from the Osun River was 110.86 g in the rainy season. Hyslop (1986) made a similar observation in his study of *Clarias anguillaris* from the Sokoto flood plains.

The ability of *S. nigrita* to feed at a number of different trophic levels coupled with the potential for fast growth make this species a promising candidate for commercial culture. As the species is widely used as human food throughout the area in which it occurs, it could easily be incorporated into locally operated polyculture systems with minimal inputs of expensive animal protein in the feed. (Hyslop 1986).

References

Adebisi, A.A. 1981. Analysis of the stomach contents of the piscivorus fishes of the upper Ogun River in Nigeria. Hydrobiologia 79**:**167-177.

Aramowo, G.A. O. 1976. Food and Feeding of three *Citharinus* species in Lake Kainji, Nigeria. J. Fish Biol. 9**:**3-10.

Bagenal, T. 1978. Methods for assessment of fish production in fresh waters. Blackwell Scientific Publications, Oxford.

Crisp, D. P., R. H. K. Mann and J. C. McCormack. 1978. The effects of impoundment and regulation upon the stomach contents of fish at Cowgreen, upper Teesdale. J. Fish Biol. 12**:**287-301.

Dunn, D. R. 1954. The feeding habits of some of the fishes and some members of the bottom fauna of Llyn Tegid (Bala Lake), Merionethshire. J. Anim. Ecol. 23:224-233.

Fagade, S. O. 1971. The food and feeding habits of *Tilapia species* from the Lagos Lagoon. J. Fish Biol. 3:151-156.

Fagade, S. O. 1978. The Biology of *Tilapia guineensis* (Dumeril) from the Lekki Lagoon, Lagos State, Nigeria. Nig. J. Sc. 12**:**73-83.

Fagade, S. O. and C. I. O. Olaniyan. 1973. The food and feeding interrelationship

Table 1. Composition of stomach contents of *Synodontis nigrita* by month

	Sept.		**Oct.**		**Nov.**		**Dec.**		**Jun.**		**Jul.**	
No. examined	53		45		34		34		70		85	
% empty stomach	7.6		26.7		35.3		47.1		27.1		30.6	
Food items	%N	%0	%N	%0	%0	%N	%N	%0	%N	%0	%N	%0
BASCILLARIOPHYCEAE												
Diatoma sp.	6.4	71.4	-	-	4.6	96.7	-	-	1.5	84.3	1.6	66.1
Synadra sp.	2.2	30.6	-	-	-	-	-	-	1.0	33.3	1.0	25.4
Gymnodium sp.	2.4	30.7	-	-	-	-	-	-	0.9	31.4	0.9	27.1
Nitzchia sp.	1.0	20.4	-	-	-	-	-	-	0.6	19.6	0.6	25.4
Stephanodiscus sp.	1.0	26.5	-	-	-	-	-	-	0.3	17.7	0.3	32.2
CYANOPHYCEAE												
Lyngbya sp.	0.4	28.6	-	-	-	-	-	-	0.3	19.6	0.4	18.6
Polycystis sp.	10.2	100.0	23.6	100.0	17.1	100.0	26.8	100.0	10.8	100.0	10.5	100.0
Aphanocapsa sp.	1.9	40.75	-	-	-	-	-	-	3.0	58.8	3.0	69.5
Closterium sp.	8.5	71.4	14.8	100.0	14.0	100.0	19.1	100.0	10.4	94.1	10.0	100.0
Coelosphaerium sp.	2.9	59.2	-	-	-	-	-	-	4.5	70.6	4.4	55.6
Microcystis sp.	1.7	26.5	-	-	-	-	-	-	2.3	23.5	2.3	28.8
Oscillatoria sp.	0.9	14.3	-	-	-	-	-	-	0.3	11.8	0.3	15.3
Spirotaenia sp.	0.02	6.1	-	-	-	-	-	-	0.3	5.9	0.4	11.9
CHLOROPHYCEAE												
Oedogonium sp.	8.1	91.9	17.4	75.8	10.7	100.0	-	-	10.4	96.1	10.0	96.6
Ulothrix sp.	2.1	61.2	-	-	-	-	-	-	3.3	60.7	3.6	59.3
Sphaeoplea sp.	1.0	67.4	-	-	-	-	-	-	4.1	62.8	3.9	76.3
Unidentified algae	7.2	100.0	-	-	-	-	-	-	9.8	100.0	9.3	100.0
ROTIFERS												
Polyarthra sp.	1.6	20.4	-	-	-	-	-	-	1.1	39.2	1.0	47.5
Kerattela sp.	1.3	20.4	-	-	-	-	-	-	1.2	39.2	1.2	40.7
Epiphanes sp.	0.6	28.6	-	-	-	-	-	-	0.5	52.9	0.4	50.5
Synchaeta sp.	0.8	24.5	-	-	-	-	-	-	0.3	49.0	0.9	45.8
Asplanchna sp.	0.7	12.3	-	-	-	-	-	-	0.5	59.4	0.4	28.8
Philodina sp.	0.8	36.7	-	-	-	-	-	-	0.3	54.9	0.3	44.1
CRUSTACEA												
Cladocerans												
Daphnia sp.	2.9	59.2	-	-	-	-	-	-	3.3	39.2	4.3	39.0
Eurycerus sp.	0.08	24.5	-	-	-	-	-	-	0.2	24.5	0.1	22.0
Ceriodaphnia sp.	3.0	26.5	-	-	-	-	-	-	-	-	0.1	17.00
Decapods												
Syncaris sp.	0.1	40.8	-	-	-	-	-	-	-	-	0.1	8.5
Copepods												
Cyclops sp.	-	-	-	-	-	-	0.7	88.9	-	-	-	-
PROTOZOA												
Frontonia sp.	0.4	26.5	-	-	-	-	-	-	0.3	25.5	0.1	6.8
Paramecium sp.	0.5	10.2	-	-	-	-	-	-	0.2	9.8	-	-
Nematodes NEMATODA	0.5	30.6	0.7	90.9	0.3	50.0	1.2	100.0	3.8	54.8	3.7	35.0
Insect parts	7.3	71.4	28.4	100.0	17.1	100.0	14.5	100.0	2.3	29.4	2.4	33.9
Detritus	11.2	100.0	14.1	100.0	-	-	13.3	100.0	9.0	98.0	8.5	88.1
Unidentified food	5.1	93.9	1.0	60.7	-	-	7.4	50.0	3.3	76.5	4.3	72.9
Plant tissues	5.3	98.0	-	-	9.9	100.0	-	-	10.2	100.0	10.0	100.0

%N - percentage number
%O - percentage occurrence

of the fishes of the Lagos lagoon. J. Fish Biol. 5:205-227.

Fagade, S. O. and C. I. O. Olaniyan. 1978. The food of Tilapia species in Lake Kainji. J. Fish Biol. 4:138-150.

Fish, G. R. 1955. The food of Tilapia in East African Uganda. J. Fish Biol. 19:85-89.

Holden, M. J. 1970. The feeding habits of *Alestes baremose* and *Hydrocynus forskahlii* (Pisces) in Lake Albert, East African. J. Zool. London. 161:137-144.

Hynes, H. B. N. 1950. The food of freshwater sticklebacks (*Gasterosteus aculeatus and Pygosteus pungitius*), with a review of methods used in studies of the food of fishes. J. Anim. Ecol.19: 36-58.

Hyslop, E. J. 1986. The growth and feeding habits of *Clarias anguillaris* during their first season in the flood plain pools of the Sokoto-Rima River Basin, Nigeria. J. Fish Biol. 30:183-192.

Moss, B. 1980. Ecology of fresh waters. Blackwell Scientific Publication, Oxford.

Patrick-Dempster, P. G. M. Mallon and D. B. Beveridge. 1993. Production de peces herbivoros en sistemas semi-intensive, p. 224-246. *In* XII Reunion Asso. Latino - Americana de production animal, Santiago de Chile.

Prescott, G. W. 1954. The Freshwater Algae. W. M. C. Brown Company Publishers, Dubuque, Iowa.

Welcomme, R. L. 1979. Fisheries Ecology of flood plain rivers. Longman, London.

E.A.A. Olojo, K.B. Olurin and O.J. Osikoya are from the Department of Biological Sciences, Olabisi Onabanjo University, P.M.B. 2002, Ago-Iwoye, Ogun State, Nigeria.
E-mail: emmanuelolojo@yahoo.co.uk

Table 2. Summary of the stomach contents of the total number of *Synodontis nigrita* sampled

	Frequency of occurence method		**Numerical method**	
Food items	No. of occurrences	%0	No.	%N
BASCILLARIOPHYCEAE				
Diatoma sp	137	59.1	4186	2.7
Synadra sp.	47	20.3	1.8	1.2
Gymnodinium sp.	47	20.3	17.8	1.1
Nitzchia sp.	35	15.1	960	0.6
Stephanodiscus sp.	41	17.7	658	0.4
CYANOPHYCEAE				
Lyngbya sp.	35	15.1	528	0.3
Polycystis sp.	232	100	17863	11.5
Aphanocapsa sp.	91	39.2	3892	2.5
Closterium sp.	215	92.7	160.1	10.3
Ceolosphaerium sp.	98	42.2	58.1	3.7
Microcystis sp.	42	18.1	3	1.9
Oscillatoria sp.	22	9.5	627	0.4
Spyrotaenia sp	110	47.4	4593	2.9
ROTIFERS				
Polyarthra sp.	58	25.0	1676	1.1
Keratellla sp.	54	23.3	1719	1.1
Epiphanes sp.	71	30.6	677	0.4
Synchaeta sp.	64	27.6	931	0.6
Asplanchna sp.	38	16.4	712	0.5
Philodina sp.	72	31.0	583	0.4
CRUSTACEA CLADOCERANS				
Daphnia sp.	72	31.0	5145	3.3
Eurycerus sp.	39	16.8	186	0.1
Ceriodaphnia sp.	23	9.9	1133	0.7
Decapodes				
Syncaris sp.	25	10.8	107	1.0
Copepods				
Cyclops sp.	16	6.9	22	0.01
PROTOZOA				
Frontonia sp.	30	12.9	367	0.2
Paramecium sp.	10	4.3	236	0.2
Nematodes NEMATODA	125	53.9	4261	2.7
Insect parts	143	61.6	7804	5.0
Detritus	202	87.1	14500	9.3
Unidentified Food	157	67.7	6155	3.9
Plant tissues	180	77.6	13530	8.7

%O - percentage of occurrence
%N - percentage of number
Percentage empty stomachs: 27.73%
Percentage of full stomachs: 72.27%
Total number examined: 321 stomachs

Influence of music on the growth of Koi Carp, *Cyprinus carpio* (Pisces: Cyprindae)

L. Vasantha, A. Jeyakumar and M. A. Pitchai

Abstract

An experiment was carried out to investigate the influence of music on the growth of Koi Carp (*Cyprinus carpio*) by subjecting the fish to music. Weekly growth in weight was recorded and used to calculate the growth rate and specific growth rate. The difference in growth between the control and experiment groups of fishes was statistically tested for significance. It was observed that the growth of fish subjected to music was significantly higher.

Introduction

Rhythmic or systematic sound is called music. Music is the mother of languages and it is used by organisms, including human beings, to express feelings. It is a form of energy that can be utilized for many purposes. Hardworking people use the energy of music to ease their task. Music is used to wind up the nerves of warriors and sportsmen. Music has a therapeutic effect. It relaxes both mind and body and alleviates tension and worry. Trehub (2001) stated that a mother's lullaby decreased stress hormones in a baby. Black (2001) found that music lowered blood pressure. Music, that is sound, is an abiotic component of the ecosystem which has its own effect on biological systems, as to other environmental factors do. Ramakrishna (1974) reported that sound interferes with the physiological functioning of the body and the sociological behavior of human beings. It has been noted that music reduces stress in poultry and increases yield. North and Mackenzie (2001) showed that milk output increased by three per cent when Holstein Friesian cattle were made to listen to slow music.

Materials and methods

Two rectangular glass tanks (marked Tank 1 and Tank 2), each with a capacity of about 33 l, were taken and filled with potable water. Three Koi Carps (*Cyprinus carpio*) were introduced in each tank. Fish in each tank were given serial numbers (1, 2 and 3) that could be recognized by a color pattern. A loudspeaker was fixed inside a drum with an open bottom. This drum was suspended inside the experimental tank in such a way that the lower part of the drum was submerged in the water. The speaker was connected to a cassette player. Both tanks were covered with hoods. The tank water was aerated by a diaphragm pump that was switched off while the music was being played. The water was exchanged once in three days. Pelletized feed with 45 per cent protein was used to feed the fish at the rate of 5 per cent of the body weight.

The experiment was started after a fortnight of acclimatization. The experiment was carried out for a period of four months in two stages, each with a duration of eight weeks. In the first stage, Tank 1 was kept as control (A) and Tank 2 was used for the experiment (D). The speaker was placed inside Tank 2 and a prerecorded tape of violin music (the raga Nalinakanthi) was played daily for three hours, from 6 am to 9 am. In the second stage, Tank 1 was kept as the experiment tank (B) and Tank 2 as the control (C), with the same fish. The speaker was placed inside Tank 1 and the experiment was repeated.

The weekly increase in the weight of each fish was recorded and the growth (gain in wet weight) was derived (Table 1). The growth rate (G.R.%) and specific growth rate (S.G.R.%) were calculated by using the following formulae:

$$\text{G.R. \%} = \frac{w_2 - w_1}{w_1} \times 100$$

$$\text{S.G.R. \%} = \frac{\ln w_2 - \ln w_1}{t} \times 100$$

Where, w_1 = initial body weight; w_2 = final body weight; t= no. of days of culture = 56.

The difference in average growth between the control and experiment fish was tested for significance by performing the t-test between the samples with different combinations.

Observations

The behavior of the fish was observed during the experiment. When no music was being played, all the fish in the two tanks were actively swimming in all directions and playing with each other. However, when music was being played, the fish in the experiment tank became inactive and remained together below the speaker as if they were listening to the music. From time to time they moved very slowly, but only vertically. The fish in the control tank with no music were as active as usual.

Results and discussion

The growth of all the fish subjected to music was higher than that of the control fish. The growth rate of fish in the Tank 1 experiment (B) was about 18 per cent more than the growth rate of fish in Tank 1 control (A). Likewise, the growth rate of fish in the Tank 2 experiment (D) was about 50 per cent more than the growth rate of fish in Tank 2 control (C) (Table 1).

The results of t-test performed between A and B, A and D and between B and C showed significant differences at the 1 per cent level (d.f. = 4; t value = 4.604),

Table 1. Growth and growth rate of fish

	Initial weight g	Final weight g	Average growth per fish g	GR %	SGR %
Tank 1 Control (A)	24.600	29.340	1.580	19.3	0.32
Tank 1 Experiment (B)	29.340	40.35	3.670	37.53	0.57
Tank 2 Control (C)	14.890	18.760	1.323	25.99	0.41
Tank 2 Experiment (D)	8.420	14.890	2.156	76.84	1.02
Control (A + C)	39.490	48.100	1.435	21.8	0.35
Experiment (B + D)	37.760	55.240	2.914	46.29	0.68

whereas the difference between the growth of C and D was significant at the 5 per cent level (d.f. = 4; t value = 2.776). Thus, the results of the significance test showed that the growth of fish subjected to music was significantly higher than the growth of the control fish. This was further confirmed by the t-test performed between the pooled data, i.e. A + C and B + D, which was also significant at the 1 per cent level (d.f. = 10; t value = 3.169). (Table 2).

Table 2. Results of t-test performed between the average growth of control and experiment fishes

A vs. B	A vs. D	B vs. C	C vs. D	A+C vs. B+D
53.5486*	7.7541*	12.1281*	3.4048**	6.0342*

** significant at the 1 per cent level*
*** significant at the 5 per cent level*

These results indicate that the growth increased when fish were made to listen to music. Hence, it can be concluded that music enhanced growth in Koi Carp, *C. carpio*. As noted earlier, music is also an environmental factor, like temperature and light, that can interfere with the physiological functions of fish.

Summary

Since music seems to enhance growth in fish, the use of music as one of the growth promoters, in addition to feed and other environmental factors, can be applied in the field of aquaculture. Music is eco-friendly and cost-effective. Aquarium watching relaxes the mind and body and reduces stress, thus having a therapeutic effect on human beings. So it is with music. Hence, combining music with an aquarium should certainly double their therapeutic effect on human beings.

Acknowledgement

We are thankful to Prof. A.S.R. Kalaniketan (Cultural Academy), Tuticorin, India for providing financial assistance and other facilities.

References

Black, H. 2001. Music for your health. New Indian Express, 4 September 2001.

North, A. and L. Mackenzie. 2001. Milk yields affected by music tempo. New Indian Express, 4 July 2001.

Ramakrishna, B.S. 1974. Noise is the new enemy. Science Today 9(4):11-20.

Trehub, S. 2001. Mobydick or Madonna, the Music is the same. The Hindu, 11 October 2001.

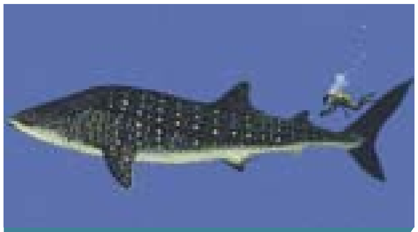
L. Vasantha (Principal), **A. Jeyakumar** [Department of Zoology (Aquaculture)] and **M.A. Pitchai** (Research Scholar) are from V.O.C. College of Education, Tuticorin - 628 008, Tamil Nadu, India.

FishBase species profile: *Rhincodon typus* (Smith, 1828)[1] Whale shark

Prepared by the FishBase team

Common names: Whale shark (FAO English); Requin baleine (FAO French); Tiburón ballena (FAO Spanish); 79 names in 29 languages from 39 countries are listed in FishBase. **Importance**: fisheries, commercial. Utilized fresh, frozen and dried salted for human consumption, liver processed for oil, fins used as soup base, offal probably for fish meal, cartilage for health supplements and skin for leather products. Highly valued commodity in ecotourism operations. **Distribution**: cosmopolitan in tropical and warm temperate seas, except in the Mediterranean. **Ecology**: world's largest fish, highly migratory, often seen offshore but coming close inshore, sometimes entering lagoons or coral atolls; solitary or forms aggregations of over 100 individuals; often associated with groups of pelagic fish, especially scombrids. **Environment**: pelagic; marine; surface water temperature 18-30°C; salinity 34-35 ppt. **Food**: feeds on planktonic and nektonic prey, such as fish (sardines, anchovies, mackerel, small tunas and albacore), small crustaceans and squids. **Trophic level:** 3.6. **Predators**: sharks, blue marlin and killer whale. **Reproduction**: ovoviviparous, litter size is over 300 pups; mean length at maturity 922–1 000 cm TL. **Growth/mortality parameters**: max. size: 20 m TL (male/unsexed); 34 tonnes; L infinity = 20 m TL; K = 0.02/yr; t_0 = -2.9 yrs.; Phi prime = 4.99; Natural Mortality (M) = 0.03/yr; L_m = ca. 10 m TL. **L/W relationship**: W = 0.0043 * $L^{3.0}$. **Resilience**: very low, minimum population doubling time more than 14 years (K = 0.02/yr; **Fecundity** = 16-300; T_m = ca. 20-30 yrs. IUCN **Red List status[1]**: vulnerable A1bd+2d. The life history of this relatively scarce but cosmopolitan tropical and warm temperate species is poorly understood, but it may be relatively fecund and migrates extremely large distances. Catches have declined and populations apparently been depleted by harpoon fisheries in several countries targeting localized concentrations of this huge, slow-moving and behaviorally-vulnerable species, and there is incidental capture in other fisheries. Directed fisheries, high value in international trade, a K-selected life history, highly migratory nature, and low abundance make this species vulnerable to exploitation. In recent years dive tourism involving this species has developed in a number of locations around the world. **Conservation and management measures**: this species is included in the following: Appendix II of the Bonn Convention for the Conservation of Migratory Species of Wild Animals in 1999; Annex I of the 1982 United Nations Convention on the Law of the Sea (UNCLOS) which called for "coordinated management and assessment to better understand cumulative impacts of fishing effort on the status of the shared populations" of these sharks; Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) since May 2003 which regulates international trade of this species; FAO International Plan of Action for the Conservation and Management of Sharks (IPOA-Sharks); however, international trade still exists. Protected in Australia, Belize, Honduras, India, the Maldives, Mexico, the Philippines, South Africa, Thailand and USA.

Fig. 2. Global distribution of *Rhincodon typus*. Orange squares indicate countries where it has been reported. Yellow dots indicate geo-referenced localities where it has been collected or sighted



R. Cada

Fig. 1. *Rhincodon typus* Smith, 1828

For further information: contact the WorldFish Center FishBase Project Team, Los Baños, Philippines (fishbase@cgiar.org).

FishBase online sources used in producing the above species profile:

[1] http://www.fishbase.org./Summary/SpeciesSummary.cfm?ID=2081&genusname=Rhincodon&speciesname=typus

[2] http://www.redlist.org/search/details.php?species=19488

Coral spawning information

Y. Yusuf, M. Noordeloos and J. Oliver

The timing of reproduction in reef corals has received considerable attention in recent years. Understanding the reproductive behavior of corals can be an important factor in helping to preserve coral reef ecosystems. Coral spawning and reproduction allows corals to inhabit other geographic areas and recover from damage or stressful events. During their larval stage, corals can travel hundreds of kilometers and can eventually settle on reefs quite far from where they were spawned. Depending on ocean currents, some reefs could be dependent on upstream reefs for most of their new recruits. Thus, the destruction of a single coral reef area can have devastating consequences for other reefs that are connected to it.

The sexual reproduction of corals can be classified as either *brooding* or *spawning*. In *brooding*, only male gametes are released into the water and these are then taken in by female corals containing egg cells. *Brooding* happens when those eggs are fertilized and develop internally into fully developed larvae, which are released in a process known as planulation. *Spawning,* on the other hand, refers to the process in which corals release sperm and eggs to be fertilized outside of the individual (i.e. in the water column).

Brooding

In *brooding* coral eggs are fertilized internally and fully developed larvae are released in a process known as planulation. Many brooding species have several reproductive cycles through the year, usually with a monthly periodicity. Planulae of brooding species that are released at an advanced developmental stage may be able to settle quickly near the parent colony compared with the planulae of spawning species. Planulae in brooding species usually have limited dispersal rates and they settle quickly near the parent colony, although some studies have shown that they are also capable of dispersing over long distances.

Spawning

It was previously thought that the majority of the scleractinian corals are viviparous or brooders. Recent studies suggest that the majority of coral species are hermaphroditic (dual sex) or gonochoric (single sex) broadcasters in which egg fertilization and development are external. Mass spawning occurs when many individuals and species release their eggs and sperm simultaneously. Mass spawning first gained worldwide attention as a result of studies on corals on the Great Barrier Reef (GBR), where most species are now known to participate in

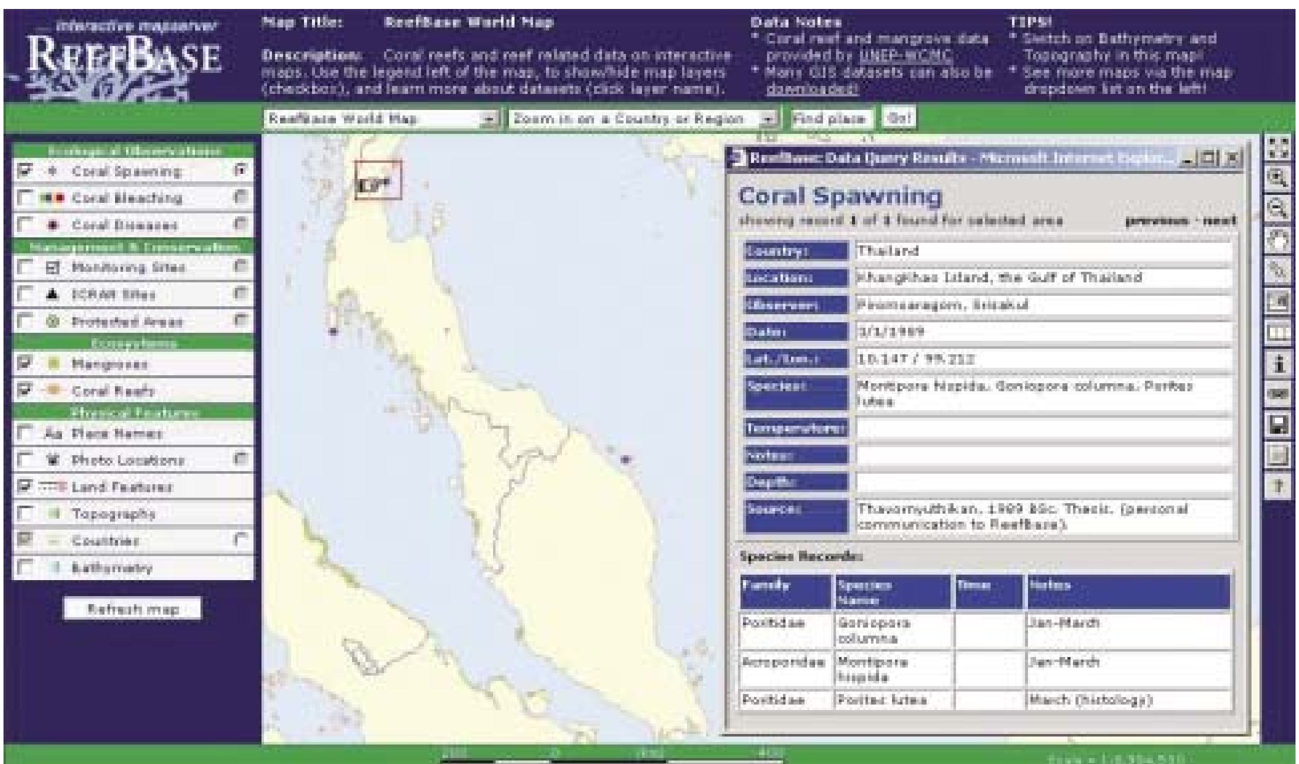


Fig. 1. Coral spawning datasets query using interactive map

mass-spawning events to some extent. Elsewhere, many species have been observed participating in mass spawning events, e.g. in Okinawa, Taiwan, Hong Kong, the high latitudes of Australia, the Mediterranean Sea, the Gulf of Mexico, Bermuda, other parts of the Caribbean, the eastern Pacific Ocean, Galapagos Islands, and Brazil.

In many areas, spawning is generally predictable and highly synchronous among colonies and species. It is thought that a variety of environmental factors help corals to synchronize the timing of spawning events. Maturation of gametes has been linked with an increase in water temperatures in the months prior to spawning. The main nights of spawning coincide with neap tide periods when tidal currents are minimal, increasing the chance of fertilization.

The timing and degree of mass spawning within and among coral species varies widely among coral communities in different locations. Fautin (2002) provides some spawning "rules of thumb":

- On the GBR, over 140 broadcast spawning coral species reproduce during annual mass spawning events over 4-5 day periods, a few nights after the full moon, during spring or early summer.
- In Western Australia, corals at both tropical and subtropical latitudes mass spawn in the late summer.
- In southern Japan, mass coral spawning occurs on reefs at Akajima Island, although spawning is less synchronous, with the main period of spawning extending over 2-3 lunar months in some species.
- In the Caribbean, coral spawning usually occurs from July to September and corals on northern reefs spawn earlier than those on southern reefs. Spawning is concentrated during periods of 2-9 nights after the full moon. Some multispecific spawning on the same night within a site has also been recorded.

Fig. 2. Coral spawning: *Favia sp.* releasing eggs

- At Eilat in the northern Red Sea, spawning within each species is synchronized at particular lunar phases each year; however, spawning among species is asynchronous and is staggered over a four-month period.
- Extended reproductive seasons with less synchronization of spawning among coral species have also been recorded in Hawaii, the Gulf of Mexico and the central and eastern Pacific.

Source: Fautin, D.G. 2002. Reproduction of Cnidaria. Can. J. Zool. 80:1735-1754.

Coral spawning in ReefBase

As a result of recent interest within the scientific community in coral spawning, ReefBase started compiling spawning observations into a standard database. This database currently holds information on 99 coral spawning observations. This dataset is regularly updated and expanded, using scientific publications, the CoralList email-group, and other sources. The Coral Spawning dataset can be downloaded from ReefBase's *Download Section* (http://www.reefbase.org/download.asp), and can also be automatically displayed in ReefBase's GIS. This allows you to view and query coral reef datasets using interactive maps (Fig. 1). In addition, ReefBase's Photo Gallery currently contains 35 photos on coral spawning, and the Literature Database lists some 100 references related to coral spawning.

How you can help

If you observe(d) coral spawning (Fig. 2), we are keen to hear from you. There are several ways in which you can contribute to ReefBase and help the wider scientific and management community to get a better overview of this important phenomenon. Spawning observations can be sent to us via e-mail, or entered into our *Spawning Form* (http://www.reefbase.org/input/inp_spawning.asp), which will feed directly into the ReefBase database. In addition, if you have any copyright-free photos and/or publications related to coral spawning, you can use the *Photo Upload* and/or *Literature Upload* facilities on the ReefBase website.

WorldFish Center bids farewell to longest serving Director General

It will soon be time to bid farewell to Dr Meryl J. Williams who has been the Director General of the WorldFish Center since April 1994. Dr Williams will depart after serving the maximum term of 10 years as Director General of the Center. She is the longest serving Director General in the Center's 27-year history (Table 1).

Dr Williams' term coincided with a very significant period in the recognition of the importance of fisheries and aquatic resources and in the development of the Center after its entry into the Consultative Group on International Agricultural Research (CGIAR) in 1992. The period began in light of the first Earth Summit at Rio de Janeiro in 1992 and also saw the culmination of the second Earth Summit (the World Summit on Sustainable Development – WSSD) at Johannesburg in 2002. The WSSD Plan of Implementation fully recognized the urgency of restoring fisheries resources and set a key timetable to achieve this[1] . In 1996, noting the far-reaching impacts that worldwide changes wrought on people in developing countries relying on aquatic resources, Dr Williams highlighted the major transition in the contribution of these resources to sustainable food security[2].

To address the transitional challenges, Dr Williams helped spur the growth and revitalization of the WorldFish Center by encouraging a balanced institutional approach. This article highlights the Center's approach during this exciting period, describing directions and initiatives with which she is proud to have been associated. Dr Williams does not take credit for any of these, but pays tribute to WorldFish partners, donors,

staff members and Trustees from around the world for making the difference.

During the last 10 years, the directions of the research program of the Center have become more multi-disciplinary, especially with the addition of a strong policy research program and a biodiversity element. Although WorldFish had always had a mandate for multi-disciplinary work and even fostered some ground-breaking studies in its early days[3], its focus on the sociological and economic aspect was limited, as was the case with most other aquatic resource research agencies at that time. In the early 1990s, research agencies were focusing on biological and technology research to the exclusion of the sociological issues. Today the social, economic, governance, and policy dimensions of fisheries issues are central to WorldFish - as is appropriate for a research agency addressing poverty, livelihood and food security.

This was engineered by creating a new Policy Research and Impact Assessment Program in 1996. This Program is now the largest of the four research programs at WorldFish.

Aquatic biodiversity studies were also given more emphasis as a consequence of the signing of the Convention on Biological Diversity. WorldFish now boasts a unique Biodiversity and Genetic Resources Research Program that covers the spectrum of biodiversity issues, from the science of conserving natural aquatic biodiversity to selective breeding for aquaculture and the biosafety of new fish strains.

During Dr Williams' term, WorldFish attracted additional funding and expanded the geographical scope of its activities. In Africa, it accepted the offer of the Government of Egypt and took over a large freshwater aquaculture research facility to establish a regional research center for Africa and West Asia. In the Asia-Pacific, the Center's work focused more on the poverty hot-spots of South Asia and the Mekong region. Projects were established in the Caribbean and are being planned for Latin Ameria.

In 2000, the WorldFish Center moved its global headquarters from rented offices in Manila, Philippines, to Penang, Malaysia. On land and infrastructure provided by the Government of Malaysia, the Center built a modern new campus. Some programs are still conducted out of the Philippines, from offices now located at the headquarters of the International Rice Research Institute in Los Baños, Laguna.

Partnerships were another driving

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[1] See: http://www.fishforall.org/wssd/wssd_plan.asp for details.

[2] Williams, M. J. 1996. The transition in the contribution of living aquatic resources to food security. International Food Policy Research Institute: Food Agriculture and the Environment Discussion Paper No. 13 (April 1996), 41 p.; *Ibid.*, The transition in the contribution of living aquatic resources to sustainable food security, p. 1-58. ***In*** S.S. De Silva (ed.) Perspectives in Asian fisheries. Asian Fisheries Society, Manila, Philippines. (Special 10th Anniversary publication of the Asian Fisheries Society.)

[3] See Scientific Highlights of a Quarter of a Century in the 2002 Annual Report.

Table 1. WorldFish Center Director Generals

Center Director: Dr Philip Helfrich (USA)	January 1975 – November 1976
Director General: Dr John C. Marr (USA)	November 1976 – March 1979
Director General: Dr Ziad H. Shehadiah (Lebanon)	July 1979 – January 1982
Acting Director General: Dr James C. Johnston (USA) (also Board Chair)	January – October 1982
Director General: Dr Richard A. Neal (USA)	November 1982 – March 1985
Director General: Dr Ian R. Smith (USA)	June 1985 until his untimely death on 31 October 1989
Acting Director General: due to the serious illness of Dr Ian R. Smith (Director General), Mr Jay L. Maclean (Australia) appointed Acting Director General	November 1988 – April 1991
Director General: Dr Kenneth T. MacKay (Canada)	April 1991 – April 1993
Interim Director General: Dr Larry D. Stifel (USA)	July 1993 – April 1994
Director General: Dr Meryl J. Williams (Australia)	April 1994 – April 2004
Director General designate: Dr Stephen Hall (UK)	March 2004 -

force in positioning WorldFish to make greater contributions. Since the WorldFish Center joined the CGIAR in 1992, the number, diversity and strength of its partnerships has enabled it to better understand the needs of its beneficiaries and facilitate improved research performance and delivery (see box). Guided by a formal Partnership Policy adopted in 1996, WorldFish emphasizes complementary linkages with national research systems, regional and international bodies, non-governmental and community agencies and the private sector. An example of a unique partnership created by WorldFish, governmental agencies and private sector agencies is the non-profit, non-stock GIFT Foundation International Inc. in the Philippines. This was created to continue the success of the GIFT project in developing a fast-growing breed of tilapia and to ensure that the new breed is widely available to farmers. Dr Williams has chaired the Board of the Foundation since its inception in 1997. The Center is participating with nearly 300 program partners. In addition, over 30 donors support WorldFish and its field personnel are hosted by nine developing countries. Twenty-five countries are now implementing projects jointly with WorldFish.

Several highly visible initiatives were developed during Dr Williams' term. Two examples are: the new public name (WorldFish Center) and image of the Center; and the launch of the *Fish for All* initiative. Both initiatives were undertaken to bring fish issues into clearer focus within the mandate of the CGIAR and in the global community. Both the catchy name and trendy image of WorldFish have already led one other CGIAR Center, the World Agroforestry Center (formerly ICRAF), to simplify and clarify its own public image.

To ensure that fish issues, in all their complexity, are given importance by a wider constituency and are adequately addressed, Dr Williams played an instrumental role in establishing and launching the *Fish for All* initiative in November 2002. This 10-year initiative offers an excellent opportunity to forge long-term partnerships amongst all types of stakeholders. Through meaningful dialogue and multi-sectoral interactions, often on a national scale, it is expected that viable and flexible policies will emerge on such topics as fish and development, fish and nutrition, health, livelihoods, gender, trade, economic growth, etc. The *Fish for All* initiative won the CGIAR Science Award in October 2003.

The WorldFish Center convenes high profile events and has a well-respected publications series with nearly 1 700 publications. Its conference and publication products are well received in both developing as well as developed countries. Dr Williams has added to the wealth of information by submitting over 80 articles on tropical fisheries and aquaculture to international scientific and development journals, including those produced by WorldFish.

Through her catalytic role at the helm of WorldFish, Dr Williams has spearheaded several international conferences, workshops and symposia, with a wide dissemination of their proceedings and declarations. For example, on behalf of the Asian Fisheries Society, she was co-convenor of the Asian Women in Fisheries Symposium held in Chiangmai, Thailand in 1998. In 2001, she took the lead at the Global Women in Fisheries Symposium conducted in Kaohsiung, Taiwan. She also fostered the Kaohsiung Declaration of the Society to the World Summit on Sustainable Development, the first that the Asian Fisheries Society has published.

The internal organizational development of WorldFish saw many changes during Dr Williams' term, all aimed at creating a strong and strategic agency, capable of operating efficiently and effectively in a challenging international environment. An executive management team was formed in 1996, consisting of the Deputy Director General for Research Programs, Associate Director General for Corporate Services, Assistant Director General for International Relations and Partnerships, Deputy Director General for Africa and West Asia, and the Director General. Improved financial, staff and infrastructure management policies and processes were introduced in a comprehensive process of institution building, under the strong supervision of the Board of Trustees. Over the last 10 years, the Board was led, successively, by the late Professor John L. Dillon, Professor Kurt Peters, and Professor Robert E. Kearney (current Board Chair). WorldFish conducts a regular staff opinion survey across all its sites and uses the confidential results obtained to improve its internal communications, staff consultations and operations.

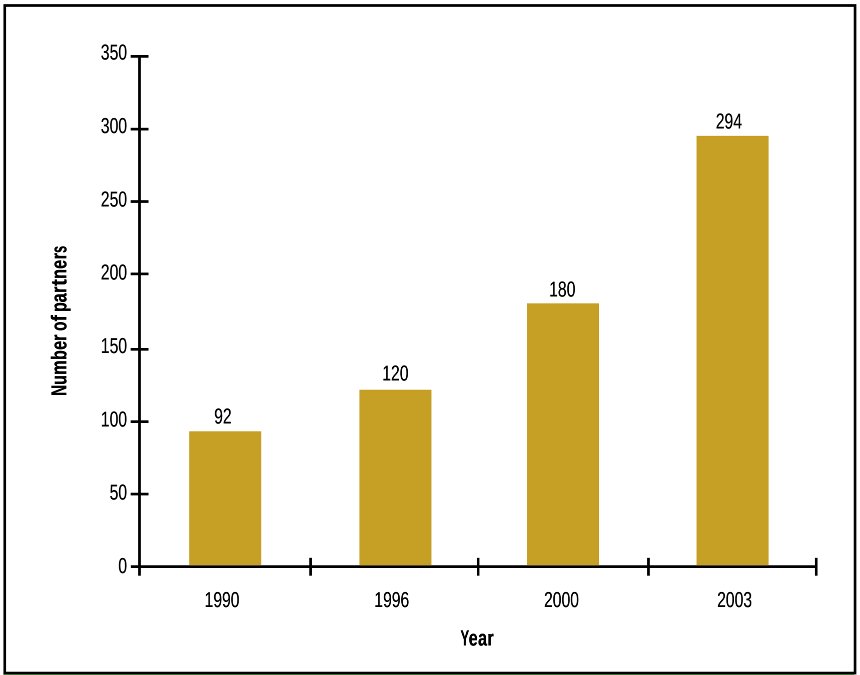


Fig. 1. Increase in the number of partners, 1990-2003

Another important feature of the last decade has been the integration of the WorldFish Center into and its contribution to the CGIAR System, an international alliance of 63 members (countries, multilateral aid agencies and foundations) supporting 15 international research centers. The Center benefited from access to the expertise and processes of the larger System, and from the prestige of gaining entry. WorldFish has also made a significant contribution to the System, bringing knowledge of aquatic resources into its terrestrially based agricultural agenda and supporting many organizational initiatives. Since joining the CGIAR System in 1992, WorldFish has actively participated in cross-Center research programs such as the Systemwide Genetic Resources Program, the Water and Food Challenge Program, and organizational service programs and activities such as the Gender and Diversity Program, and the Internal Audit service, among others.

Dr Williams believed from the start that WorldFish could gain much from being a CGIAR Center and has steered the Center to be an active contributor. She has also played a prominent role in the System. For instance, she chaired the Advisory Board of the Gender and Diversity Program, the Board of the Association of International Agricultural Research Centers, and was the Center Director's Committee (CDC) representative of the new System Office of the CGIAR. During 2001-2003, she was on the Executive Committee of the CDC and chaired the CDC in 2002.

Dr Williams has also accepted invitations to sit on various external committees associated with the work of WorldFish. To name a few, she has been a member of the FAO Advisory Committee on Fisheries Research since 1997 and is now its chair. Throughout the 1990s, she was active in Australia in various capacities in the effort to find ways to prevent the introduction of exotic invasive species via ship ballast water. Presently, she is on the Steering Committee of DIVERSITAS, the international research program on biodiversity loss and its impacts, and on the Scientific Steering Committee of the Census of Marine Life. She has also contributed to the Millennium Ecosystem Assessment and represented the CGIAR on its Board.

Prior to joining WorldFish, Dr Williams was briefly the Director of the Australian Institute of Marine Science (AIMS). She also served as a member of the AIMS Council from 1989 to 1997. She was a member of the first Board of the Australian Fisheries Management Authority and, from 1989 to 1993, was a member of the Council of the Australian Maritime College. Before joining AIMS, Dr Williams was the Executive Director of the former Bureau of Rural Resources in the former Department of Primary Industries and Energy, Canberra, Australia, and conducted fisheries research for the Queensland government and for the South Pacific Commission.

She received her Ph.D. in zoology and a master's degree in literary studies (mathematical statistics) from the University of Queensland. In recognition of her contributions to fisheries and marine science in Australia, Dr Williams was elected a Fellow of the Australian Academy of Technological Sciences and Engineering in 1993. In 2003 she was awarded the prestigious Australian Centenary Medal in recognition for her outstanding contributions to Marine Science.

From 1 May 2004 Dr Williams will serve as the first Executive Officer of the new Future Harvest Alliance Office, a creation of all the CGIAR Centers to better support their collaborative actions.

In the next phase of her life, she will continue to be involved in a number of other pursuits, including chairing the FAO Advisory Committee on Fisheries Research, and being a member of the Scientific Committee of DIVERSITAS, the International Scientific Steering Committee of the Census of Marine Life, and the Working Group to Promote a Representative System of Marine Protected Areas in the High Seas.

Workshop on Biosafety Science of Aquatic Genetically Engineered Organisms

Transgenic fish are probably the first genetically engineered animal to be approved for human consumption, yet scientific data to assess and manage their potential risks to aquatic biodiversity are very inadequate.

The Department of Aquatic Sciences, Burapha University, Thailand and the Institute for Social, Economic and Ecological Sustainability (ISEES), University of Minnesota, organized a **Workshop on Biosafety Science of Genetically Engineered Organisms** (GEOs) at Burapha University, Chonburi, Thailand during 27-28 October 2003. The Workshop was organized through a Biotechnology-Biodiversity Interface competitive grant from the U.S. Agency for International Development and the Pew Fellows Program in Marine Conservation. The objectives of the Workshop were to: build capacity of different interested parties for conducting locally-relevant and scientifically reliable biosafety assessment and management; stimulate biosafety scientific research on GEOs; and stimulate future networking and information exchange among workshop participants. The participants at the Workshop were from academia, government, business, and public interest organizations. Although the regional focus of the Workshop was Thailand and neighboring countries, there were several participants from other regions who are involved in developing genetically engineered fish or biosafety assessment and management.

The Workshop emphasized a forward-looking, preventative 'Safety First' approach that differs from the reactive, risk-based approach to biosafety. Through interactive presentations and discussions, the Workshop introduced the participants to scientific and technical principles and methods of the 'Safety First' approach to biosafety of GEOs: planning and managing safety from early-stage design (e.g. gene construct elements and tissue-specific expression) through testing and monitoring; different scientific assessment methods; and risk management strategies.

For additional information, please contact Dr Anne Kapuscinski (kapus001@umm.edu) or Dr Wansuk Senanan (wansuk@buu.ac.th).

INGA member scientist Dr M.G. Hussain awarded gold medal by Prime Minister of Bangladesh

INGA congratulates Dr M.G. Hussain, Director, Research and Planning, Bangladesh Fisheries Research Institute (BFRI) on being awarded the prestigious **National Fish Fortnight 2003 Gold Medal Award** in recognition of his outstanding contributions to the development of a genetically improved strain of silver barb (*Barbonymus gonionotus*) and further improvement of the GIFT strain Nile tilapia (*Oreochromis niloticus*). The award was presented by the Prime Minister of Bangladesh in an award ceremony for the National Fish Fortnight held on 12 August 2003. Dr Hussain was also awarded the silver medal of the National Fish Fortnight 2000 for his numerous publications in the field of fisheries and aquaculture.

BFRI is a member of INGA. Dr Hussain has been actively involved in the implementation of fish genetic improvement programs in Bangladesh in collaboration with the WorldFish Center and INGA.

BFRI, as a member of INGA, has undertaken further improvement of the GIFT strain obtained from the WorldFish Center. The improved strains of *B. gonionotus* and GIFT strain are being widely disseminated among farmers in Bangladesh.

Advanced course on quantitative genetics for developing country scientists

With the objective of strengthening the capacity of developing country scientists in the field of quantitative genetics, especially in the analysis and interpretation of genetic data, the WorldFish Center/INGA, with financial support from the Norwegian Agency for Development Cooperation (NORAD), organized a training course on **Quantitative Genetics and its Application to Aquaculture** during 20-31 October 2003 in Penang, Malaysia. A total of 20 participants from 11 member countries of INGA (Bangladesh, China, Ghana, India, Indonesia, Malaŵi, Malaysia, and the Philippines), Brazil and the WorldFish Center completed the course. The course program introduced the participants to high caliber lectures and taught them to analyze fish breeding data using the ASREML computer program. The training program comprised lectures and practical exercises with emphasis on hands-on analysis of actual breeding/genetic data sets. The course curriculum covered the following topics: (i) general overview of the design and implementation of genetic improvement programs; (ii) strain choices and comparisons; (iii) estimation of phenotypic and genetic parameters (heritability, phenotypic and genetic correlations); (iv) breeding objectives and selection indices; (v) estimation of breeding values; (vi) incorporation of DNA fingerprinting into selection schemes; (vii) mate allocation strategies in genetic improvement programs; (viii) importance of population size in selection programs; (ix) estimating genetic change; and (x) potential of biomolecular techniques in fish breeding.

Participants of the training course on Quantitative Genetics and its Application to Aquaculture

Training on brood stock management and sex reversal of tilapia

Training government and private hatchery personnel on the management of brood stock and production of good quality fry is essential, particularly for those who are rearing and managing the improved fish stocks. As part of INGA's strategy to assist member countries in effective dissemination of improved fish, the WorldFish Center, in collaboration with GIFT Foundation International, organized two separate training programs in Bangladesh and Malaysia on **Brood stock Management and Sex Reversal of Tilapia Using Genetic Improvement of Farmed Tilapia (GIFT) Protocols**.

Participants of the training on brood stock management and sex reversal using GIFT protocols in Malaysia

Participants of the training on brood stock management and sex reversal using GIFT protocols in Bangladesh

In cooperation with the Department of Fisheries in Malaysia, the training program was held during 29 September – 2 October 2003 at Jitra Aquaculture Station, Kedah. Thirty-three participants from the government and private sectors completed the course. In Bangladesh, the training program was conducted in collaboration with the Bangladesh Fisheries Research Institute (BFRI) and was held during 6-9 October 2003 at BFRI, Mymensingh. The program was attended by 19 participants from private hatcheries and NGOs.

The course comprised lectures and hands-on/practical sessions. It focused on practical applications of tilapia breeding and fry/fingerling production using GIFT protocols; rearing and management of brood stocks including techniques on how to avoid inbreeding; and production of all male tilapia using the sex reversal technique.

Manual on Strain Comparison Trials

Comparison and evaluation of fish strains is important for policy makers, government agencies, breeders and farmers for making well informed decisions on breeding. In aquaculture, strain comparison and evaluation are mainly utilized to design breeding experiments, e.g. selective breeding or cross breeding, etc.

A number of strain evaluation experiments have been carried out for various fish species in the past. A majority of them failed to answer the desired questions with the required degree of accuracy. A manual on 'Strain Comparison Methods' is being developed for member countries of INGA to help fish geneticists design and carry out more useful and accurate strain comparison experiments. Dr Shrinivas Jahageerdar, a Senior Scientist from the Central Institute of Fisheries Education, Mumbai, India spent seven weeks at the WorldFish Center, Malaysia to help develop the manual. The manual will provide: a review of breed and strain comparisons (with emphasis on methodology used); theoretical and practical aspects of strain comparisons; and recommendations, ranging from situations in which full pedigrees are available to those in which no parentage information is available.

ADB Approves Funding for Second Phase of Carp Genetics Project

The Asian Development Bank (ADB) has approved funding for the second phase (2004-2006) of the project for genetic improvement of carps in Asia. The new project called **Achieving Greater Food Security and Eliminating Poverty by Dissemination of Genetically Improved Carp to Fish Farmers** will be undertaken by the WorldFish Center in collaboration with national institutions in six carp producing countries in Asia (Bangladesh, China, India, Indonesia, Thailand and Vietnam).

Unlike the first phase of the project, which focused on determining research priorities and initiating research leading to development of high yielding carp strains, the second phase will concentrate on: continued development of improved strains; dissemination and evaluation of the improved carp strains; and establishment of national carp breeding programs. The project is expected to result in improving the nutritional status and economic conditions of fish farmers in Bangladesh, China, India, Indonesia, Thailand and Vietnam through the culture of genetically superior carp strains that better utilize feed resources in common production systems.

EIFAC Symposium on Aquaculture Development - Partnership between Science and Producer Associations

Producers are recognized as key players in the development of sustainable aquaculture, being the direct users of resources for the production of food. However, more interaction and better communication and coordination between producers, scientists and other stakeholders in aquaculture are required. There is a continuing trend towards creating partnerships and collaboration between aquaculture producers and scientists, government officials and other stakeholders. The European Inland Fisheries Advisory Commission (EIFAC) will hold a **Symposium on Aquaculture Development – Partnership between Science and Producer Associations** in Weirzba, Mazurian Lakeland, Poland during 26-29 May 2004 as part of its 23rd Session. The main objective of the Symposium is to define the complementary roles of science and production in the development of the aquaculture sector in the EIFAC region. The participants are expected to be from aquaculture producer's associations, government agencies, research and education institutions, environmental and social non-governmental organizations, including consumer protection groups, private sector and scientists.

For additional information, contact: Mr Uwe Barg, Technical Secretary of EIFAC Sub-Commission II – Aquaculture, Fishery Resources Division, FAO, Viale delle Terme di Caracalla, 00100 Rome, Italy. Fax: (39) 0657053020; E-mail: uwe.barg@fao.org
Source: http://www.fao.org/fi/meetings/eifac/eifac23/symposm/default.asp

International Symposium on Fish Nutrition and Feeding

The **International Symposium on Nutrition and Feeding of Fish** will be held in Phuket, Thailand during 3-7 May 2004. This Symposium will promote scientific discussions on all aspects of fish nutrition, including current knowledge and future perspectives, in plenary sessions, workshops and oral presentations. Emerging issues that relate to food quality and safety will also be addressed. There will be opportunities to organize meetings to discuss issues that may lead to the formation of networking groups for promoting the advancement of aquaculture nutrition science, technological developments and discussions where nutritionists can provide suggestions for policy development.

Source: http://www.enaca.org/Events.htm

New Website for Greater Access to Agriculture Science Data

The United Nations Food and Agriculture Organization (FAO) is developing a new computer-based system to provide students and researchers in some of the world's poorest countries access to scientific literature on agriculture, nutrition and related biological and environmental sciences. This public-private initiative is expected to provide information on research and data from 400 scientific journals at little or no cost. For more information on this new website, visit http://www.digitalopportunity.org/link/gotarticle/addhit/70448/1138/525

Source: Marine Finfish Aquaculture Network e-news.

AFS news

AFS Journal Volume 16 Issues 1&2, Off the Press

Copies of the AFS Journal Volume 16 1 and 2 are now being sent out to members and subscribers. Galleyproofs of articles included in Issues 3 and 4 were already sent out to authors for final editing and approval.

New OIC at the AFS Secretariat in Manila

Miss Elsie Tech is no longer connected with the Asian Fisheries Society effective August 2003. Communications can be addressed to the President, Dr Clarissa Marte or to the Officer-in-Charge, Ms Aida R. Rubiano. afs@compass.com.ph

Membership Updates

For several months now, we have been plugging our call for membership updates in our website as well as in our column in *NAGA*. We would like to reiterate our invitation once again to members to activate and/or upgrade their membership status. Those, for instance, who have been accepted as student or associate members before, may upgrade their status to Full Members upon submission of documents certifying additional or higher educational merits/degrees obtained (in the case of student members) or list of scientific publications (in the case of associate members). To activate membership, the Society calls on all members to update payment of their annual dues. This invitation also aims to reach out to our inactive members, whose correspondence addresses on our file are no longer current. Please contact us and be counted. Current members who wish to submit their updated information may fill up the standard membership form on the web and send this via e-mail (afs@compass.com.ph). The Society looks forward to providing better service and support to its members.

AFS Council Meeting

The 26th Council Meeting of the Asian Fisheries Society was held in Bangkok on 21 September 2003. Among the important matters discussed was the upcoming 7th Forum, to be hosted by the Universiti Sains Malaysia. Co-hosts of the Forum include Universiti Putra Malaysia (UPM), the Malaysian Ministry of Agriculture, the Malaysian Fisheries Society, the WorldFish Center, the Department of Fisheries and the Fisheries Development Authority of Malaysia.

AFS - SLAFAR Agreement of Affiliation

The Asian Fisheries Society (AFS) and the Sri Lanka Association for Fisheries and Aquatic Resources (SLAFAR) have signed an Agreement on 27 June 2003 to form an administrative arrangement to enable a cooperative exchange of publications, enhance the benefits available to the members of each Society, and broaden the international exchange of information among fisheries scientists. The signatories to this Agreement are Dr Clarissa Marte, AFS President, and Dr A. Hettiarachchi, SLAFAR President. AFS looks forward to a more fruitful partnership between the two Societies.

SEAFDEC Hosts AFS Website

In addition to the present website, which is being hosted by the World Fish Centre, the AFS website can now also be accessed thru the SEAFDEC website (http://www.seafdec.org.ph/afs). This will allow additional access to members and potential members.

Dr I Chiu Liao Represents Asian Fisheries Society in World Aquaculture 2003 Meeting

Dr I Chiu Liao, together with two Asian Fisheries Society (AFS) – Taiwan Branch members (Dr Nai-Hsien Chao and Dr Shi-Yen Shiau), attended the recently held World Aquaculture 2003 meeting in Salvador, Brazil held during 19-23 May 2003. Dr Yang Yi, AFS councilor from Thailand, also attended the meeting. It was a huge success with more than 4 000 participants from all over the world. The exhibition also attracted 300 exhibitors, and 900 technical papers and 38 special lectures were presented. Dr Liao presented a paper titled Cobia Culture in Taiwan: Current Status and Problems. He also took this opportunity to announce the forthcoming 7th Asian Fisheries Forum in Penang to be held during 29 November - 3 December 2004. He posted and distributed posters on a preliminary announcement for the forum and also distributed complimentary copies of AFS Special Publication No. 12 (Post Retirement Careers in Fisheries and Aquaculture).

A souvenir photo (from left to right: Dr N.H. Chao, Dr I C. Liao, current WAS President Dr Geoff Allan, and the only elected WAS Honorary Life Memeber Dr P. Sorgeloos)

The 7th Asian Fisheries Forum

The 7th Asian Fisheries Forum, to be held in November 2004, will be hosted by Universiti Sains Malaysia and will be organized by the School of Biological Sciences. The Universiti Putra Malaysia (UPM), the Malaysian Ministry of Agriculture, the Malaysian Fisheries Society, the Malaysian Department of Fisheries, the WorldFish Center and the Fisheries Development Authority of Malaysia are co-hosts of the Forum. A carefully selected panel of world-renowned experts in fisheries will address the Forum in a series of plenary and concurrent sessions. Comprehensive aspects of fisheries, both in the Asian and global contexts, will be discussed. Associated activities and events will include: workshops, discussions, special symposia, trade exhibitions, related tours and field trips. Announcements regarding submission of Abstracts/Papers and preliminary registration details have been published in the AFS Journal since December 2002. Brochures have been distributed since October 2003 and important details can be accessed from the AFS websites.

Whose values count? Whose decisions matter?

Researching governance of wetlands in the Mekong region

Why do government statistics systematically overlook information about the uses of wetlands resources essential to poor people's livelihoods? Why are the ecosystem services of wetlands consistently undervalued when decisions are made to develop roads, dams, irrigation and other infrastructure? What strategies are most promising for improving inter-agency coordination for wetlands management? How can the interests of poor farming and fishing communities be more effectively represented in policy decisions?

These and other such questions provided a focus for a lively dialogue at a panel discussion held at the WorldFish Center's Penang headquarters on 6 November 2003. The panel discussion was the culminating event of a three-day writing workshop that brought together partners from Thailand, Cambodia, the Lao PDR, and Vietnam, who have been working together under the project, Legal-Institutional Analysis and Economic Valuation of Resources and Environment in the Mekong River Region: A Wetlands Approach. The project was financed by the Swedish International Development Cooperation Agency (Sida).

Dr Blake Ratner, the project leader for the above project, was joined in the panel discussion by four colleagues who are cooperating in producing a regional synthesis report on the themes of economic valuation and legal-institutional analysis of wetlands management: Dr Dang Thanh Ha (Nong Lam University, Vietnam), Mam Kosal (Wetlands International, Cambodia), Somphanh Chanphengxay (Dept. of Livestock and Fisheries, Lao PDR), and Dr Ayut Nissapa (CORIN, Thailand).

This writing workshop activity builds directly on the results of a Regional Synthesis Workshop held during 19-21 August 2003 near the Nam Ngum reservoir in Vientiane province, Lao PDR. That Workshop was attended by 30 participants from partner institutions in the four countries as well as representatives from regional partners, the Mekong River Commission, Asian Institute of Technology – Aqua Outreach Program, and IUCN (World Conservation Union).

For further information contact:
Dr Blake Ratner, Scientist/Project Leader, Policy Research and Impact Assessment Program, WorldFish Center.
E-mail: b.ratner@cgiar.org

Announcements

Marine Ornamentals '04

Marine Ornamentals '04 (MO'04), the third in a series of conferences for the marine ornamental fish community, will be held at the Hawaii Convention Center, Honolulu, Hawaii during 1-4 March 2004. This is a special session of Aquaculture '04 (AQ'04), the Triennial Meeting of the National Shellfisheries Association (the Fish Culture Section of the American Fisheries Society) and the World Aquaculture Society. The entire event is scheduled during 1-5 March 2004. Those who attend MO'04 will have the opportunity to participate in the AQ'04 sessions, as the MO'04 sessions will run concurrently with AQ'04 for three days (2-4 March 2004). The registration also includes entry to the Trade Show and Exposition. More information regarding the conference and program developments may be found on the website: http://www.hawaiiaquaculture.org/marineornamentals04.html

Current updates are also available from:
Marine Ornamentals '04
Conference Manager
2423 Fallbrook Place
Escondido, CA 92027
USA
Tel: +1-760-432-4240
Fax: +1-760-432-4275
E-mail: worldaqua@aol.com

Towards participatory fisheries management

The International Agricultural Centre (IAC, Wageningen, Netherlands) is organizing a training program in co-operation with Wageningen University. The title of the program is "Towards participatory fisheries management" and it consists of two modules. The first module on "Fisheries management: perspectives, information and co-management" will be held during 4-22 October 2004. The second module on "Tools for fisheries co-management" will be held during 25 October-19 November 2004. Interested applicants may apply for either one or both modules. Further information and application forms may be obtained from:

International Agricultural Centre
P.O. Box 88
6700 AB Wageningen
Netherlands
Tel: +31-317 495 495
Fax: +31-317 495 395
E-mail: training@iac.agro.nl
URL: www.iac.wageningen-ur.nl

SEA OF CHANGE IN FISHERIES

Fish exports from developing countries to developed ones are expected to decline by 2020, despite the fact that people in developing countries will produce, consume and trade a greater share of the world's fish.

Developing countries will produce 79 per cent and consume 77 per cent of the world's total production of fish by the year 2020.

These projections are made in "Outlook for Fish to 2020: Meeting Global Demand", a report released on 3 October 2003, simultaneously in Washington DC, Hamburg and Penang, by the International Food Policy Research Institute (IFPRI) and the WorldFish Center.

The study uses state-of-the-art computer modeling to provide a comprehensive economic analysis of conditions facing the fisheries sector in the rapidly changing business and social environment up to the year 2020.

The report projects that fish consumption in developing countries will increase by 57 per cent, from 62.7 million t in 1997 to 98.6 million in 2020. By comparison, fish consumption in developed countries will increase by only about 4 per cent, from 28.1 million t in 1997 to 29.2 million t in 2020.

We can expect major shifts in supply and demand for animal protein from livestock and fish as a result of rapid population growth, increasing affluence and urbanization in developing countries on one hand, and stagnant population combined with a saturated market for fish in the developed countries on the other.

Fish farming or aquaculture, an already booming industry, will continue to expand to meet this growing demand for fish in developing countries, especially as most of the world's existing wild fisheries are already, or will soon be, over-fished. It is projected that by 2020, aquaculture will account for 48 per cent of the total production of fish as compared to 31 per cent in 1997.

The study also notes that more than 40 per cent of fish consumed in 2020 will come from fish farms. World aquaculture production is expected to nearly double, from 28.6 million t in 1997 to 53.6 t in 2020.

The inevitable expansion of fish farming in the developing countries could cause increased pollution, greater damage to already vulnerable wild fisheries, and competition for water and land use. This poses a potential threat to the environment as well as the livelihoods and food security of poor people in developing countries.

According to the report, trade among the developing countries will intensify. To ensure a greater market share, there will be heightened urgency for governments to put in place prudent policies and measures to ensure that fish products meet new hygiene and food safety requirements and environmental needs. Technologies and management practices adopted will have to be efficient and cost-effective for developing countries to remain competitive.

Speaking at the launch of the report, Dr Mark W. Rosegrant, Director of the Environment and Production Technology Division, International Food Policy Research Institute (IFPRI), said:

"It is possible to avoid trade-offs to the environment and the poor, while meeting growing global demand for fish over the next two decades. Environmental impacts of aquaculture can be minimized through environmentally friendly technologies and by increasing the efficiency with which fish meal and fish oil are used to feed farmed fish."

Dr Mahfuzuddin Ahmed, Principal Social Scientist, WorldFish Center, and co-author of the report said:

"Countries must take drastic measures to improve the management of wild fisheries. By-catch and wastage must be minimized. Innovative product development and marketing strategies must be encouraged to enhance the value of processed fish food products."

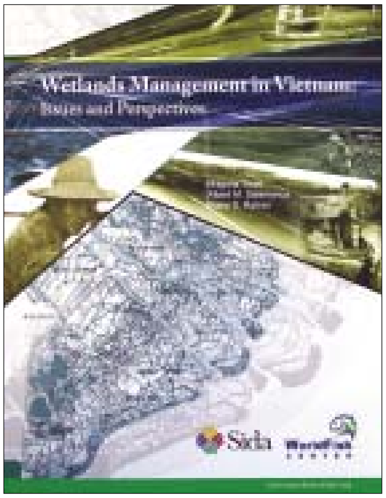
The report presents several possible scenarios. If wild fish stocks in the world are allowed to be fished to depletion, by 2020 the price of low value food fish will increase by 35 per cent. This will effectively remove fish from the food bowls of the poor. If the current annual aquaculture growth of 10 per cent is maintained, fish prices will increase in real terms by about 6 per cent. However, if this growth rate were to face any setbacks (such as disease outbreaks) the price of low value fish will go up by 25 per cent.

According to Dr Ahmed, "aquaculture must grow faster than the current rate in order to supply up to 48 per cent of the total food fish production, so as to maintain a stable or lower price affordable by the poor and the lower income groups."

The International Food Policy Research Institute (IFPRI) seeks sustainable solutions for ending hunger and poverty. The WorldFish Center contributes to food security and poverty eradication through research, partnership, capacity building, and policy support on living aquatic resources. IFPRI and the WorldFish Center are two of 15 Future Harvest Centers and receive their principal funding from 62 governments, private foundations, and international and regional organizations known as the Consultative Group on International Agricultural Research.
Please visit the websites at www.ifpri.org and www.worldfishcenter.org

Wetlands Management in Vietnam: Issues and Perspectives

Wetlands Management in Vietnam: Issues and Perspectives
Edited by M. Torell, A.M. Salamanca and B.D. Ratner. 2003. WorldFish Center Technical Report 61, 89 p.



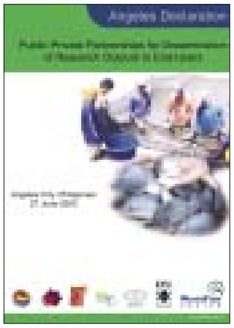
In Vietnam, wetlands directly provide a source of livelihood for millions of people, yet the health of these fragile ecosystems is under threat. In this new publication of WorldFish, several experts, mostly Vietnamese, identify the pressures and trends driving the transformation of wetlands ecosystems. They point to a number of strategies for responding to these pressures by addressing policy, institutional reform, and information management challenges.

Wetlands in Vietnam are much more than places of aesthetic beauty or sites for the conservation of wildlife habitats. The wetlands are the lifeline of the rural economy – essential to the livelihoods of millions of Vietnamese, particularly in the Mekong Delta. Wetlands include not only mangrove forests on the coast and inland marshes and swamps, but also the country's rivers and lakes as well as the areas that they flood seasonally. Thus, many different groups of stakeholders influence the way that wetlands are managed. These range from local fishers and farmers to private businesses and government agencies with diverse mandates, including those related to fisheries, agriculture, tourism, the environment, rural development, and public works, along with a host of national and international development organizations. Rarely, however, does such a range of actors perceive themselves as linked together, let alone share the responsibility for stewardship of a vital national resource.

Making progress towards the sustainable management of wetlands demands a systematic, holistic perspective, precisely because wetlands defy boundaries. They do not lie within the domain of any one agency's management authority; they are both publicly and privately owned; and their extent fluctuates seasonally, especially during the rainy season. Moreover, resource use decisions in one part of the system directly impact upon other parts, sometimes in complex ways. By presenting the range of perspectives on a number of key facets of the overall challenge of wetlands management in one volume, this collection of papers aims to broaden the platform for dialogue and debate about the importance of wetlands, trends affecting their health and productivity, and priority actions required in response to these.

The papers in this volume were initially prepared for workshops organized by WorldFish in March 1999 and November 2000. These workshops laid the groundwork for the project called "Legal-Institutional Framework and Economic Valuation of Environment and Resources in the Mekong River Region: A Wetlands Approach." The project, financed by the Swedish International Development Cooperation Agency (Sida) and coordinated by WorldFish, aims to contribute towards environmentally sound development decisions that sustain and improve the livelihoods of those who depend upon wetlands resources. Working in the four countries of the Lower Mekong Basin, the project fosters networks of partners engaged in assessing the value of wetlands and analyzing the legal and institutional challenges of improved governance. The network approach builds domestic capacity for such analysis while at the same time strengthens the ties among professionals in a range of institutions – government agencies, nongovernmental organizations and universities – whose collaboration is essential for institutionalizing new practices over the long term.

Improving the governance of Vietnam's wetlands is an important task. WorldFish hopes that this volume presents a range of perspectives on the challenges ahead for Vietnam, and lays the groundwork for more thorough investigations of its valuable wetlands.



Angeles Declaration: Public-Private Partnerships for Dissemination of Research Outputs to End-Users

The genetic research programs undertaken by the Philippines national institutions and international organizations have resulted in the development of technologies for and improved strains of tilapia that are now being disseminated to farmers. As these institutions move towards further development and widespread dissemination of improved tilapia strains, it has become necessary for some of them to establish partnerships with the private sector. Partnerships between public and private agencies in undertaking research on tilapia genetics and in the dissemination of products of such research are expected to bring benefits to the tilapia industry. However, unlike for crops where the implications of such partnerships have been well studied and established, in the case of fish the subject is still new and knowledge of the changes resulting from evolving partnerships is sparse.

With financial support from the International Development Research Centre of Canada, WorldFish Center and national institutions in the Philippines (Freshwater Aquaculture Center/Central Luzon State University - FAC/CLSU, National Freshwater Fisheries Technology Research Center/Bureau of Fisheries and Aquatic Resources - NFFTC/BFAR, and GIFT Foundation International Inc - GFII) are conducting studies to evaluate evolving public-private partnerships and to determine their impact on research on fish genetics and its development objectives. As part of this initiative, a Workshop for stakeholders was convened in Angeles City, Philippines during 25-27 June 2003.

The Workshop noted that there are issues and concerns relating to the dissemination of research outputs and the development of the Philippines tilapia industry that need to be addressed and given focus. This can best be achieved by providing an environment that promotes stronger partnership between the public and private sectors. The Workshop participants made recommendations that have been published under the title *Angeles Declaration: Public-Private Partnerships for Dissemination of Research Outputs to End-Users*. The objective is to create awareness of the issues among policy-makers. The following is a summary of the recommendations emerging from the Workshop:

- Public and private sector institutions need to work together for the delivery of improved tilapia breeds and technology to achieve the maximum benefits from genetic research. These linkages and partnerships are needed for effective, efficient and equitable distribution of products and benefits.

- The needs of farmers and how these are being met require evaluation, based on geographical areas, socio-economic conditions and other relevant factors. While the public sector caters to needs of small farmers in general, it is essential that government line agencies place greater emphasis on providing services to the small-scale, poor, and geographically isolated farmers, as well as to those who do not have access to private sector hatcheries, to ensure that they are not marginalized and have access to improved tilapia breeds.

- Public sector policy should recognize and promote greater public awareness of all improved tilapia breeds available in the country and target public sector dissemination efforts on poor and geographically isolated farmers. Effective implementation of such policy should minimize competition between the public and private sectors.

- Breeding nucleus stations (private/public) should be given the responsibility of providing the necessary technical services for effective management and maintenance of seed quality of improved tilapia breeds. Private sector breeding nucleus stations, in partnership with public sector institutions, should also provide the specialized extension services needed by the multipliers and the grow-out farmers. The public sector has to continue providing the traditional type of extension services needed by small-scale hatcheries and the grow-out farmers, especially those not reached by existing distribution systems for genetically improved seed. The private sector breeding nucleus stations can also act as conduits for traditional types of extension information.

- The government should ensure that existing policies for conserving biodiversity and safeguarding the tilapia industry are implemented and, where necessary, develop new policies for effective implementation.

- The government should take the lead in collecting/monitoring/disseminating information on markets, prices, etc., of fingerlings and table fish. An effective mechanism should be established for collecting this information and disseminating it to the producers.

- The Philippines Government should establish a fish seed certification system.

For copies of the Angeles Declaration please contact: The Communications Unit, WorldFish Center, P.O. Box 500 GPO, 10670, Penang, Malaysia

Bibliography

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 43-46.

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

19755 - Haemocytic defence in black tiger shrimp (*Penaeus monodon*) van de Braak, C.B.T. 2002. Wageningen, The Netherlands: Wageningen Institute of Animal Sciences, Wageningen University. 159 p. Dissertation (Ph.D.) 90-5808-651-8. SH210 2002 V36.

19756 - Aquaculture of coral reef fishes: proceedings of the workshop. Cabanban, A.S.; Phillips, M. (eds.) 1999. Sabah, Malaysia: Institute for Development Studies. ix, 274 p. 967-9910-56-3. SH3 A68 1999.

19757 - Institutional issues and perspectives in the management of fisheries and coastal resources in southeast Asia. Torell, M.; Salamanca, A.M. 2002. Penang, Malaysia: ICLARM - The World Fish Center and Swedish International Development Cooperation Agency (Sida) 983-2346-07-X. SH207 TR4 #60.

19758 - ASEAN marine environmental management: towards sustainable development and integrated management of the marine environment in ASEAN. Proceedings of the Fourth ASEAN-Canada Technical Conference on Marine Science. Watson, I.; Vigers, G.; Ong, K.S.; McPherson, C.; Millson, N.; Tang, A.; Gass, D. (eds.) 1999. North Vancouver, Canada: EVS Environment Consultants Ltd. 584 p. Jointly organized by EVS Environment Consultants Ltd. and Department of Fisheries Malaysia. GC1023.72 A73 1998.

19759 - Status of the Mekong *Pangasianodon hypophthalmus* resources, with special reference to the stock shared between Cambodia and Viet Nam. van Zalinge, N.; Lieng, S.; Ngor, P.B.; Kong, H.; Jorgensen, J.V. MRC Tech. Pap. (1): 29 p. SH328 M42 #1.

19760 - Status of *Pangasiid* aquaculture in Viet Nam. Trong, T.Q.; Nguyen, V.H.; Griffiths, D. 2002. MRC Tech. Pap. (2): 16 p. SH328 M42 #2.

19761 - Deep pools as dry season fish habitats in the Mekong Basin. Poulsen, A.; Poeu, O.; Viravong, S.; Suntornratana, U.; Nguyen, T.T. MRC Tech. Pap. (4): 24 p. SH328 M42 #4.

19762 - National workshop: potential of artificial substrate based microbial biofilm in aquaculture. Shankar, K.M.; Mohan, C.V. 2001. Mangalore, India: University of Agricultural Sciences. 90 p. SH157.85 F52S52 2001.

19763 - Financial analysis and risk assessment of selected aquaculture and fishery activities in the Mekong Basin. Hambry, J. 2002. MRC Tech. Pap. (5): 66 p. SH328 M42 #5.

19764 - Proceedings: Philippines-Indonesia workshop on community-based marine sanctuaries in the Philippines: a report on focus group discussions. Balgos, M.; Bayer, T.G.; Crawford, B.; Pagdilao, C.R.; Tulungen, J.; White, A.T. (eds.) 2001. Rhode Island, USA: Coastal Resources Center, University of Rhode Island. vi, 106 p. 1-885-454-42-2. QH91.75 A1P44 2000.

19765 - Proceedings of the 11th Congress & Workshop of the Tropical Marine Mollusc Programme. Hylleberg, J.; Nateewathana, A. (eds.) 2001. Spec. Publ. Phuket Mar. Biol. Cent. 25 (1): 311 p. QH90 A1P59 v. 25 pt. 1.

19766 - Proceedings of the 11th Congress & Workshop of the Tropical Marine Mollusc Programme. Hylleberg, J.; Nateewathana, A. (eds.) 2001. Spec. Publ. Phuket Mar. Biol. Cent. 25 (2): 621 p. QH90 A1P59 v. 25 pt. 2.

19767 - ASEAN-SEAFDEC conference on sustainable fisheries for food security in the new millennium: "fish for the people": technical document. 2002. Bangkok, Thailand: SEAFDEC. 208 p. SH329 S87T42 2001.

19768 - Conservation of freshwater fishes: options for the future. Collares-Pereira, M.J.; Cowx, I.G.; Coelho, M.M. (eds.) 2002. Oxford, UK: Fishing News Books. x, 461 p. 0-85238-286-3. QL624 C64.

19769 - Agricultural development and the opportunities for aquatic resources research in China. Zhang, L.X; Liu, J.; Li, S.F.; Yang, N.S.; Gardiner, P.R. WorldFish Center Conf. Proc. (65): 58 p. 983-2346-11-8. SH207 CP6 #65.

19770 - Atlas of the Persian Gulf molluscs. Hosseinzadeh, H.; Daghoghi, B.; Rameshi, H. 2001. Tehran, Iran: IFRO. xi, 208 p. 965-91741-4-1. QL426 A84.

19771 - The freshwater palaemonid prawns (Crstacea: Decapoda: Caridea) of Myanmar. Cai, Y.; Ng, P.K.L. 2002. Hydrobiologia 487: 59-83. Department of Biological Sciences, National University of Singapore, Lower Kent Ridge Road, Singapore 119260, Singapore.

19772 - Primary production in a tropical reservoir in Sri Lanka. Amarasinghe, P.B.; Vijverberg, J. 2002. Hydrobiologia 487: 85-93. Write to: J. Vijverberg, N100-KNAW, Centre for Limnology, 3600 BG Maarssen, The Netherlands. (E-mail: j.vijverberg@nioo.knaw.nl).

19773 - Aquatic pollution assessment based on attached diatom communities in the Pinang River Basin, Malaysia. Wan Maznah, W.O.; Mashhor, M. 2002. Hydrobiologia 487: 229-241. School of Biological Sciences, Universiti Sains Malaysia (USM), Penang, Malaysia.

19774 - Revision of the cyprinid genus *Placocheilus Wu*, 1977 in China, with description of a new species from Yunnan. Zhang, E.; He, S.P.; Chen, Y.Y. 2002. Hydrobiologia 487: 207-217. Department of Ichthyology, Institute of Hydrobiology, Chinese Academy of Sciences, Wuhan 430072, Hubei Province, P. R. China.

19775 - A new species *of Neodiaptomus* (Copepoda, Diaptomidae) from temporary waters in northeast Thailand. Sanoamuang, L.; Athibai, S. 2002. Hydrobiologia 489:71-82. Applied Taxonomic Research Center, Department of Biology, Faculty of Science, Khon Kaen University, Khon Kaen 40002, Thailand.

19776 - Aquaculture in Egypt and issues for sustainable development. El-gayar, O.F. 2003. Aquacult. Econ. Manage. 7(1-2):137-154. College of Business & Information Systems, Dakota State University, 820 N. Washington Avenue, Madison, SD 57042, USA (E-mail: omar.el-gayar@dsu.edu).

19777 - Recent advances in hormonal induction of sex-reversal in fish. Pandian, T.J.; Kirankumar, S. 2003. J. Appl. Aquacult. 13(3-4): 205-230. School of Biological Sciences, Madurai Kamaraj University, Madurai-625 021, India.

19778 - Disease problems affecting fish in tropical environments. Karunasagar, I.; Karunasagar, I.; Otta, S.K. 2003. J. Appl. Aquacult. 13(3-4):231-249. Department of Fishery Microbiology, College of Fisheries, Mangalore-575 002, India.

19779 - Grow-out production of carps in India. Ayyappan, S.; Jena, J.K. 2003. J. Appl. Aquacult. 13(3-4): 251-282. Central Institute of Fisheries Education, Seven Bungalows, Versova, Mumbai-400 061, India.

19780 - The potential and sustainability of aquaculture in India. Jana, B.B.; Jana, S. 2003. J. Appl. Aquacult. 13(3-4): 283-316. Aquaculture and Applied Limnology Research Unit, Department of Zoology, University of Kalyani, Kalyani-741 235, West Bengal, India.

19781 - Applied nutrition in freshwater prawn, *Macrobrachium rosenbergii*, culture. Mukhopadhyay, P.K.; Rangacharyulu, P.V. ; Mitra, G.; Jana, B.B. 2003. J. Appl. Aquacult. 13(3-4): 317-340. Central Institute of Freshwater Aquaculture, Kausalyaganga, Bhubaneswar-751 002, India.

19782 - Freshwater pearl culture technology development in India. Janakiram, K. 2003. J. Appl. Aquacult. 13(3-4):341-349. Central Institute of Freshwater Aquaculture, Bhubaneswar-751 002, Orissa, India.

19783 - Enhancing the resilience of coral reef resources. Ablan, M.C.A.; McManus, J.W.; Chen, C.A.; Shao, K.T.; Bell, J.; Cabanban, A.S.; Tuan, V.S.; Jarayabhand, P.; Suharsono; Alcala, A.; Arthana, I.W. 2003. IHDP Update (2): 10-11. Write to: WorldFish Center, P.O. Box 500, GPO, 10670 Penang, Malaysia.

19784 - Fish pathogens and diseases in India: a bibliography (1898-2001) Abidi, R. (comp.) 2002. Lucknow, India: National Bureau of Fish Genetic Resources. xx, 500 p. 81-901014-4-7. SH171 F24 2002.

19785 - Focusing small-scale aquaculture and aquatic resource management on poverty alleviation. Friend, R.; Funge-Smith, S. 2002. Bangkok, Thailand: FAO Regional Office Asia and the Pacific. vii, 24 p. 974-7313-62-6. SH103 F74.

19786 - Guide to fishing gears in the Philippines. Dugan, C.E.; Bernarte, A.L., Jr.; Vera, C.A.C., Jr. 2003. Quezon City, Philippines: SIKAT. v, [328 p.] CD-ROM version available. 971-92765-0-9. SH307 P5D83.

19787 - Fisheries management by communities: a manual on promoting the management of subsistence fisheries by Pacific Island communities. King, M.; Lambeth, L. 2000. New Caledonia: Secretariat of the Pacific Community. 87 p. 982-203-713-9. SH319 A2K56.

19788 - Effects of growth hormone transgenesis on metabolic rate, exercise performance and hypoxia tolerance in tilapia hybrids. McKenzie, D.J.; Martinez, R.; Morales, A.; Acosta, J.; Morales, R.; Taylor, E.W.; Steffensen, J.F.; Estrada, M.P. 2003. J. Fish Biol.

63((2): 398-409. CREMA L'Houmeau, Place du Seminaire, B.P. 5, 17137 L'Houmeau, France (E-mail: david.mckenzie@ifremer.fr).

19789 - Dietary essentiality of ascorbic acid in rohu larvae: quantification with ascorbic acid enriched zooplankton. Mitra, G.; Mukhopadhyay, P.K. 2003. Aquacult. Int. 11(1-2): 81-93. Nutrition & Biochemistry Division, Central Institute of Freshwater Aquaculture, Kausalyaganga, Bhubaneswar-751 002, India (E-mail: gopamitra@yahoo.com).

19790 - Evaluation of marine reserves as basis to develop alternative livelihoods in coastal areas of the Philippines. Kuhlmann, K.J. 2002. Aquacult. Int. 10(6):527-549. German Development Service (DED) Philippines, Guiuan Development Foundation Inc., 6809 Guiuan, Eastern Samar, Philippines (E-mail: kuhlmann.kp@eudoramail.com).

19791 - Macro policies to promote sustainable commercial aquaculture. Hishamunda, N.; Ridler, N.B. 2002. Aquacult. Int. 10(6): 491-505. Write to N. B. Ridler, Centre for Coastal Studies and Aquaculture, University of New Brunswick, P.O. Box 5050, Saint John, New Brunswick, Canada E2L 4L5 (E-mail: Ridler@unbsj.ca).

19792 - Traditional milkfish aquaculture in Nauru. Spennemann, D.H.R. 2002. Aquacult. Int. 10(6): 551-562. The Johnstone Centre, Charles Sturt University, Australia (E-mail: dspennemann@csu.edu.au).

19793 - Food habits of brackish water tilapia *Sarotherodon melanotheron* in riverine and lacustrine environments of a West African coastal basin. Kone, T.; Teugels, G.G. 2003. Hydrobiologia 490: 75-85. Write to G. G. Teugels, Universite de Cocody Abidjan, UFR Biosciences, Laboratoire d' Hydrobiologie 22 BP 582 Abidjan 22, Cote d' Ivoire (E-mail: teugels@africamuseum.be.).

19794 - Inhibition of protease activities in discus *Symphysodon* spp. by three plant meals. Chong, A.; Roshada Hashim; Ahyaudin Ali. 2002. Aquacult. Int. 10(5): 433-441. School of Biological Sciences, Inversiti Sains Malaysia, Minden, 11800, Penang, Malaysia (E-mail: alex@usm.my).

19795 - Wetlands management in Vietnam's Mekong Delta: an overview of the pressures and responses. Torell, M.; Salamanca, A.M. 2003. Penang, Malaysia: WorldFish Center. Wetlands management in Vietnam: issues and perspectives. p. 1- 19. Write to: WorldFish Center, P.O. Box 500, GPO, 10670 Penanag, Malaysia (E-mail: worldfishcenter@cgiar.org) SH207 TR4 #61.

19796 - Wetlands protection and management in Vietnam. Doan Nang. 2003. Penang, Malaysia: Worldfish Center. Wetlands management in Vietnam: issues and perspectives. p. 21- 24. Legislation Department, Ministry of Science, Technology and Environment, 37 Tran Hung Dao, Hanoi, Vietnam. SH207 TR4 #61.

19797 - Status of the Mekong Delta: agricultural development, environmental pollution and farmer differentiation. Ni, D.V.; Maltby, E.; Stafford, R.; Tuong, T.P.; Xuan, V.T. 2003. Penang, Malaysia: WorldFish Center. Wetlands management in Vietnam: issues and perspectives. p. 25-29. Farming Systems R&D Institute, Can Tho University, Can Tho, Vietnam. SH207 TR4 #61.

19798 - Managing and classifying wetlands in the Mekong River Delta. Pham, T.T. 2003. Penang, Malaysia: WorldFish Center. Wetlands management in Vietnam: issues and perspectives. p. 31-43. Science Section, Sub-FIPI, Secretary of Vietnam Wetland Team, 245/5 Banh Van tran Tan, Tan Binh District, Ho Chi Minh City, Vietnam. SH207 TR4 #61.

19799 - Institutional and policy issues of wetlands management in Ben Tre Province, Vietnam. Trinh, V.Y. 2003. Penang, Malaysia: WorldFish Center. Wetlands management in Vietnam: issues and perspectives. p. 45-47. SH207 TR4 #61.

19800 - Lecithin: a breakthrough in drug delivery for shrimp. Rao, P.D.; Hertrampf, J.W.; Krishna, P. 2003. INFOFISH Int. (5): 13-17. Quality Control Laboratory, The Waterbase Ltd, Nellore, India.

19801 - Ornamental fish trade runs into billions. Tarlochan Singh; Dey, V.K. 2003. INFOFISH Int. (5): 55-60. INFOFISH, PO Box 10899, 50728 Kuala Lumpur, Malaysia (E-mail: infish@tm.net.my).

19802 - Rubber wood: can it replace hard wood in boat building? Edwin, L.; Thomas, S.N.; Meenakumari, B. 2003. INFOFISH Int. (5): 65-68. Fishing Technology Division, Central Institute of Fisheries Technology, Cochin, India.

19803 - Taking tilapia to the top. Tarlochan Singh. 2003. INFOFISH Int. (5): 20-24. INFOFISH, PO Box 10899, 50728 Kuala Lumpur, Malaysia (E-mail: infish@tm.net.my).

19804 - How to produce 100 tonnes of sandfish. Pitt, R.; Duy, N.D.Q. 2003. SPC Beche-de-mer Info. Bull. (18): 15-17. Write to: WorldFish Center, PO Box 500, GPO, 10670 Penang, Malaysia. (E-mail: worldfishcenter@cgiar.org).

19805 - Larval development and juvenile growth of the Galapagos sea cucumber *Isostichopus fuscus*. Hamel, J.F.; Hidalgo, R.Y.; Mercier, A. 2003. SPC Beche-de-mer Info. Bull. (18): 3-8. Society for the Exploration and Valuing of the Environment (SEVE), 655 rue de la Riviere, Katevale, Canada JOB 1WO (E-mail: seve@sympatico.ca).

19806 - Papua New Guinea sea cucumber and beche-de-mer identification cards. Desurmont, A. 2003. SPC Beche-de-mer Info. Bull. (18): 8-14. SPC, BP D5, 98848 Noumea Cedex, New Caledonia (E-mail: aymericd@spc.int).

19807 - Overview of sea cucumber farming and sea ranching practices in China. Chen, J. 2003. SPC Beche-de-mer Info. Bull. (18): 18-23. Yellow Sea Fisheries Research Institute, Qingdao, China 266071 (E-mail: chenjxin@qd-public.sd.cninfo.net).

19808 - Conservation strategies for sea cucumbers: can a CITES Appendix II listing promote sustainable international trade? Bruckner, A.W.; Johnson, K.A.; Field, J.D. 2003. SPC Beche-de-mer Info. Bull. (18): 24-33. NOAA Fisheries, Office of Protected Resources, 1315 East West Highway, Silver Spring, MD 20910, USA (E-mail: andy.bruckner@noaa.gov).

19809 - Sexual reproduction in a fissiparous holothurian species, *Holothuria leucospilota Clark* 1920 (Echinodermata: Holothuroidea) Purwati, P.; Thinh, L.J. 2003. SPC Beche-de-mer Info. Bull. (18): 33-38. Research Centre for Oceanography - LIPI. Jl. Pasir Putih 1, Ancol Timur, Jakarta Utara, Indonesia (E-mail: pradina@indo.net.id).

19810 - Clinging to the wreckage: unexpected persistence of freshwater biodiversity in a degraded tropical landscape. Dudgeon, D. 2003. Aquat. Conserv: Mar. Freshwat. Ecosyst. 13: 93-97. Department of Ecology & Biodiversity, The University of Hong Kong, Hong Kong SAR, China (E-mail: ddudgeon@hkucc.hku.hk). R 2003-35.

19811 - Getting into trouble: the diaspora of Thai trawlers, 1965-2002. Butcher, J.G. 2002. Int. J. Maritime Hist. 14(2): 85-121. R 2003-38.

19812 - Isotopic change throughout the life history of a Lake Malawi cichlid fish. Genner, M.J.; Hawkins, S.J.; Turner, G.F. 2003. J. Fish Biol. 62(4): 907-917. Institute for Biodiversity & Ecosystem Dynamics, University of Amsterdam, P.O. Box 94766, 1090 GT Amsterdam, The Netherlands (E-mail: genner@science.uva.nl).

19813 - Field evidence on the influence of seagrass landscapes on fish abundance in Bolinao, northern Philippines. Salita, J.T.; Ekau, W.; Saint-Paul, U. 2003. Mar. Ecol. Prog. Ser. 247: 183-195. Write to: W. Ekau, Zentrum fur Marine Tropenokologie, Fahrenheitstrabe 6, 28359 Bremen, Germany (E-mail: wekau@zmt.uni-bremen.de).

19814 - Larval rearing and spat production of edible oyster *Crassostrea gryphoides* (Schlotheim) Tibile, R.M.; Singh, H. 2003. Aquacult. Res. 34(10): 785-792. Write to: H. Singh, College of Fisheries, Ratnagiri, and Marine Biological Research Station, Ratnagiri, Maharashtra, India (E-mail: rtg.fishcoll@sancharnet.in).

19815 - Shell marking by artificial feeding of the tropical abalone *Haliotis asinina Linne* juveniles for sea ranching and stock enhancement. Gallardo, W.G.; Bautista-Teruel, M.N.; Fermin, A.C.; Marte, C. 2003. Aquacult. Res. 34(10): 839-842. Aquaculture Department, Southeast Asian Fisheries Development Center (SEAFDEC), Tigbauan, Iloilo, Philippines (E-mail: gallardo@aqd.seafdec.org.ph).

19816 - Reproductive performance in induced and spontaneous spawning of the mangrove red snapper, *Lutjanus argentimaculatus*: a potential candidate species for sustainable aquaculture. Emata, A.C. 2003. Aquacult. Res. 34(10): 849-857. Aquaculture Department, Southeast Asian Fisheries Development Center, Tigbauan, Iloilo, Philippines (E-mail: acemata@aqd.seafdec.org.ph).

19817 - Effect of cryoprotectants, extenders and freezing rates on the fertilization rate of frozen striped catfish, *Pangasius hypophthalmus (Sauvage)*, sperm. Kwantong, S.; Bart, A.N. 2003. Aquacult. Res. 34(10): 887-893. Aquaculture and Aquatic Resources Management, Asian Institute of Technology, Klong Luang, Thailand (E-mail: bart@ait.ac.th).

19818 - Age- or length-based methods of growth estimation. What drives the choice? Pilling, G.M.; Halls, A.S. 2003. NAGA 26(2):4-7. CEFAS, Fisheries Laboratory, Pakefield Road, Lowestoft, NR33)HT, United Kingdom (E-mail: g.m.pilling@cefas.co.uk).

19819 - Pawpaw seed as fertility control agent on male Nile tilapia. Ekanemm, S.B.; Okoronkwo, T.E. 2003. NAGA 26(2): 8-10.

Department of Biological Sciences, University of Calabar, P.M.B. 1115, Calabar, Nigeria (E-mail: sbe@unical.anpa.net.ng).

19820 - Fisheries production in Asia: its role in food security and nutrition. Choo, P.S.; Williams, M.J. 2003. NAGA 26(2): 11-16. Write to: WorldFish Center, P.O. Box 500, GPO, 10670 Penang, Malaysia (E-mail: worldfishcenter@cgiar.org).

19821 - Length-weight relationship of some deep-sea fish inhabiting the continental slope beyond 250m depth along the west coast of India. Thomas, J.; Venu, S.; Kurup, B.M. 2003. NAGA 26(2): 17-21. Department of Industrial Fisheries, Cochin University of Science and Technology, Cochin 628 016, Kerala, India.

19822 - Incidence of human pathogenic bacteria in shrimp feeds - a study from India. Raghavan, R.P.. 2003. NAGA 26(2): 22-24. Unit of Aquaculture, PG and Research Department of Zoology, Goverment College-Nandanam, Chennai 600 035, Tamil Nadu, India.

19823 - The cost of action: CRM investment in the Philippines. Salamanca, A.M. 2003. NAGA 26(2): 25-29. Write to: WorldFish Center, P.O. Box 500, GPO, 10670 Penang, Malaysia (E-mail: worldfishcenter@cgiar.org).

19824 - Stock evaluation and development of a breeding program for common carp (*Cyprinus carpio*) in Karnataka, India: progress of a research project. Basavaraju, Y.; Penman, D.J.; Mair, G.C. 2003. NAGA 26(2): 30-32. Fisheries Research Station, UAS, Bangalore-560 089, Karnataka, India.

19825 - Women in fisheries. Singh Kohli, M.P.; Tewari, R. (eds.) 2002. Mumbai, India: Indian Society of Fisheries Professionals. 155 p. 81-901431-0-7. HD6073 F65I52 2001.

19826 - Low-temperature tolerance of Nile tilapia, *Oreochromis niloticus*: effects of environmental and dietary factors. Atwood, H.L.; Tomasso, J.R.; Webb, K.; Gatlin, D.M. III. 2003. Aquacult. Res. 34(3): 241-251. Department of Aquaculture, Fisheries & Wildlife, Clemson University, Clemson, South Crolina 29634, USA (E-mail: hatwood@clemson.edu).

19827 - Investing in Africa: the WorldFish Center's African strategy in summary. Dugan, P. 2003. NAGA 26(3): 4-8. Write to: WorldFish Center, P.O. Box 500, GPO, 10670 Penang, Malaysia (E-mail: worldfishcenter@cgiar.org).

19828 - Potential for the development of aquaculture in Africa. Jamu, D.M.; Ayinla, O.A. 2003. NAGA 26(3): 9-13. Write to: WorldFish Center, P.O. Box 500, GPO, 10670 Penang, Malaysia (E-mail: worldfishcenter@cgiar.org).

19829 - Local solutions to challenges of West Indian Ocean fisheries development. van der Elst, R. 2003. NAGA 26(3):14-17. Oceanographic Research Institute, Durban, South Africa (E-mail: rudyp@xsinet.co.za).

19830 - Valuing Africa's inland fisheries: overview of current methodologies with an emphasis on livelihood analysis. Bene, C.; Neiland, A.E. 2003. NAGA 26(3):18-21. Write to: WorldFish Center, P.O. Box 500, GPO, 10670 Penang, Malaysia (E-mail: worldfishcenter@cgiar.org).

19831 - River fisheries in Africa: their relationship to flow regimes. Welcomme, R.L. 2003. NAGA 26(3):22-26. RRAG, Imperial College, United Kingdom (E-mail: welcomme@dial.pipex.com).

19832 - FishBase species profile: *Clarias gariepinus* (Burchell, 1822) North African catfish. 2003. NAGA 26(3): 27. Write to: WorldFish Center, P.O. Box 500, GPO, 10670 Penang, Malaysia (E-mail: worldfishcenter@cgiar.org).

19833 - Using ReefBase to create customized maps. 2003. NAGA 26(3): 28-30. Write to: WorldFish Center, P.O. Box 500, GPO, 10670 Penang, Malaysia (E-mail: worldfishcenter@cgiar.org).

19834 - Potential genetics for aquaculture development in Africa. Changadeya, W.; Malekano, L.B.; Ambali, A.J.D. 2003. NAGA 26(3): 31-35. Biotechnology-Ecology Research and Outreach Consortium (BioEROC), P.O. Box 403, Zoomba, Malawi (E-mail: aambali@sdnp.org.mv).

19835 - Proposals for a national strategy on sustainable management of wetlands in Vietnam. Le, T.B. 2003. Penang, Malaysia: WorldFish Center. Wetlands management in Vietnam: issues and perspectives. p. 49-53. National Environment Agency, Ministry of Science, Technology and Environment, 67 Nguyen Du, Hanoi, Vietnam. SH207 TR4 #61.

19836 - The national policy to rehabilitate and develop 5 million hectares of forests and other issues on wetlands. Nguyen, N.B. 2003. Penang, Malaysia: WorldFish Center. Wetlands management in Vietnam: issues and perspectives. p. 55-57. Forestry Development Department, Ministry of Agriculture and Rural Development, 2 Ngoc Du, Hanoi, Vietnam. SH207 TR4 #61.

19837 - Special use forest management in Vietnam with emphasis on wetlands. Nguyen, T.P. 2003. Penang, Malaysia: WorldFish Center. Wetlands management in Vietnam: issues and perspectives. p. 59-61. Agriculture Department, Goverment Office, 1A Hoang Hoa Tham, Hanoi, Vietnam. SH207 TR4 #61.

19838 - Situation analysis and training needs assessment of natural resource management stakeholders in the Mekong Delta. Hoang, H.C. 2003. Penang, Malaysia: WorldFish Center. Wetlands management in Vietnam: issues and perspectives. p. 63-69. University of Agriculture & Forestry, HCMC, Thu Duc District, Ho Chi Minh City, Vietnam. SH207 TR4 #61.

19839 - Tolerance of seahorse *Hippocampus kuda (Bleeker)* juveniles to various salinities. Hilomen-Garcia, G.V.; Reyes, R.D.; Garcia, C.M.H. 2003. J. Appl. Ichthyol. 19(2): 94-98. Southeast Asian Fisheries Development Center, Aquaculture Department, Iloilo, Philippines.

19840 - Can corals be harvested sustainably? Harriott, V.J. 2003. Ambio 32(2): 130-133. School of Environmental Science & Management, Southern Cross University, P.O. Box 157, Lismore, 2480, Australia (E-mail: vharriot@scu.edu.au).

19841 - Marine protected areas in the eastern African region: how successful are they? Francis, J.; Nilsson, A.; Waruinge, D. 2002. Ambio 31(7-8): 503-511. WIOMSA, P.O. Box 3298 Zanzibar, Tanzania (E-mail: julius@wiomsa.org).

19842 - Coastal resources and management systems influenced by conflict and migration: Mecufi, Mozambique. Bryceson, I.; Massinga, A. 2002. Ambio 31(7-8):512-517. Centre for International Environment & Development Studies, Noragric, Agricultural University of Norway, Box 5001, N-1432 As, Norway (E-mail: ian.bryceson@noragric.nlh.no).

19843 - Marine fisheries in Tanzania. Jiddawi, N.S.; Ohman, M.C. 2002. Ambio 31(7-8):518-527. Institute of Marine Sciences, University of Dar-es-Salaam, P.O. Box 668, Zanzibar (E-mail: jiddawi@ims.udsm.ac.tz).

19844 - The artisanal fishery for *Octopus cyanea Gray* in Tanzania. Guard, M.; Mgaya, Y.D. 2002. Ambio 31(7-8):528-536. Zoology Department, University of Aberdeen, Tillydrone Road, Aberdeen AB24 2TZ, Scotland, UK (E-mail: martin.guard@lycos.com).

19845 - Coastal aquaculture development in Eastern Africa and the Western Indian Ocean: prospects and problems for food security and local economies. Ronnback, P.; Bryceson, I.; Kautsky, N. 2002. Ambio 31(7-8):537-542. Department of Systems Ecology, Stockholm University, SE-106 91 Stockholm, Sweden (E-mail: pat@system.ecology.su.se).

19846 - Wetlands study: lessons learned and future challenges. Trinh, T.G.; Cai, H.H.; Thong, L.Q. 2003. Penang, Malaysia: WorldFish Center. Wetlands management in Vietnam: issues and perspectives. p. 71-73. University of Agriculture and Forestry, HCMC, Thu Duc District, Ho Chi Minh City, Vietnam. SH207 TR4 #61.

19847 - Socio-economic situation, management, rational utilization and development potentials of Tram Chim, a wetlands ecosystem conservation national park. Nguyen, C.T. 2003. Penang, Malaysia: WorldFish Center. Wetlands management in Vietnam: issues and perspectives. p. 75-84. National Coordinator of VN Wetland team, Forest Inventory & Planning (Sub-FIPI), Tan Binh District, 245/5 Banh Van Tran St., Ho Chi Minh City, Vietnam (E-mail: nguyenchi@sg.fpt.vn) SH207 TR4 #61.

19848 - Seagrass ecosystems in the western Indian Ocean. Gullstrom M.; de la Torre Castro, M.; Bandeira, S.O.; Bjork, M.; Dahberg, M.; Kautsky, N.; Ronnback, P.; Ohman, M.C. 2002. Ambio 31(7-8):588-596. Kristineberg Marine Research Station, SE-450 34 Fiskebackskill, Sweden (E-mail: martin.gullstrom@kmf.gu.se).

19849 - Support to marine research for sustainable management of marine and coastal resources in the western Indian Ocean. Berg, H.; Francis, J.; Souter, P. 2002. Ambio 31(7-8):597-601. SIDA, SE-105 25 Stockholm, Sweden (E-mail: hakan.berg@sida.se).

19850 - Sustainable commercial aquaculture: a survey of administrative procedures and legal framework. Hishamunda, N.; Ridler, N.B. 2003. Aquacult. Econ. Manage. 7(3-4):167-178. Write to: N. Ridler, Centre for Coastal Studies and Aquaculture, University of New Brunswick, P. O. Box 5050, Saint John, New Brunswick, Canada E2L 4L5 (E-mail: Ridler@unbsj.ca).

19851 - Managing the commons: an economic approach to pearl industry regulation. Poirine, B. 2003. Aquacult. Econ.

Manage. 7(3-4): 179-193. Universite de la Polynesie Francaise, BP 6570 FAAA, Tahiti, Polynesie Francaise (E-mail: bernard.poirine@upf.pf).

19852 - Profitability and technical efficiency of aquaculture systems in Pampanga, Philippines. Xavier, I.; McKenzie, V. 2003. Aquacult. Econs. & Manage. 7(3-4): 195-211. University of Reading, Department of Agriculture and Food Economics, PO Box 237, Reading, RG6 6AR, UK (E-mail: x.t.irz@reading.ac.uk).

19853 - Comparative cost of production of Nile tilapia (*Oreochromis niloticus L.*) fry in recirculating and flow-through systems in Kuwait. Cruz, E.M.; Ridha, M.T. 2003. Aquacult. Econ. & Manage. 7(3-4): 213-230. Aquaculture, Fisheries, and Marine Environmental Department, Kuwait Institute for Scientific Research, P.O. Box 1638, 22017 Salmiyah, Kuwait (E-mail: ecruz@kisr.edu.kw).

19854 - Potential restaurant markets for farm-raised tilapia in Nicaragua. Neira, I.; Engle, C.R.; Quagrainie. 2003. Aquacult. Econ. & Manage. 7(3-4):231-247. Write to: C. Engle, Aquaculture/Fisheries Center, University of Arkansa at Pine Bluff, Mail Stop 4912, 1200 N. University Drive, Pine Bluff, Arkansas, 71601, USA (E-mail: cengle@uaex.edu).

19855 - Shellfish aquaculture in Thailand. Chalermwat, K.; Szuster, B.W.; Flaherty, M. 2003. Aquacult. Econ. & Manage. 7(3-4): 249-261. Department of Aquatic Science, Burapha University, Bang Saen, Chonburi 20131 Thailand (E-mail: kashane@bucc4.buu.ac.th).

19856 - Fishing gear and methods in Southeast Asia: IV. Vietnam. Long, N.; Nguyen, V.K.; Vu, D.H.; Chokesanguan, B. 2002. Samut Prakan, Thailand: SEAFDEC. x, 279 p. 974-9509-01-3. SH344 F573 Vol. 4.

19857 - Fishing gear and methods in Southeast Asia: III. Philippines, part 1. Dickson, J.O.; Alba, E.B.; Munprasit, A.; Chokesanguan, B.; Siriraksophon, S. 2003. Samutprakan, Thailand: SEAFDEC. iv, 210 p. 974-9509-33-1. SH344 F573 Vol. 3. Pt. 1.

19858 - Coral reefs of India: state-of-the art report. 2001. Tamil Nadu, India: Environmental Information System Centre. 104 p. "Sponsored by Ministry of Environment & Forests, Goverment of India, New Delhi"--Cover. QH183 C67 2001.

19859 - Estuaries of India: state-of-the-art report. 2002. Tamil Nadu, India: Environmental Information System Centre. 195 p. "Sponsored by Ministry of Environment & Forests, Goverment of India, New Delhi"--Cover. GC721 E87 2002.

19860 - Lagoons of India: state-of-the-art report. 2001. Tamil Nadu, India: Environmental Information System Centre. 100 p. "Sponsored by Ministry of Environment & Forests, Goverment of India, New Delhi"--Cover. QH183 L33 2001.

19861 - Mangroves of India: state-of-the-art report. 2002. Tamil Nadu, India: Environmental Information System Centre. 140 p. "Sponsored by Ministry of Environment & Forests, Goverment of India, New Delhi"--Cover. SD397 M25M36 2002.

19862 - Larval duration of the tropical eel *Anguilla celebesensis* from Indonesian and Philippine coasts. Arai, T.; Miller, M.J.; Tsukamoto, K. 2003. Mar. Ecol. Prog. Ser. 251: 255-261. Otsuchi Marine Research Center, Ocean Research Institute, The University of Tokyo, 2-106-1 Akahama, Otsuchi, Iwate 028-1102, Japan (E-mail: arai@wakame.ori.u-tokyo.ac.jp).

19863 - Genetic structure of round scad mackerel *Decapterus macrosoma* (Carangidae) in the Indo-Malay archipelago. Borsa, P. 2003. Mar. Biol. 142(3):575-581. Institut de Recherche pour le Developpement, UR 081 Genome Populations Environnement, BP A5, 98848 Noumea Cedex, New Caledonia (E-mail: Philippe. Borsa@noumea.ird.nc).

19864 - Feeding ecology of the three juvenile phases of the spiny lobster *Panulirus argus* in a tropical reef lagoon. Briones-Fourzan, P.; Castaneda-Fernandez de Lara, V.; Lozano-Alvarez, E. Mar. Biol. 142(5): 855-865. Instituto de Ciencias del Mar y Limnologia, Unidad Academica Puerto Morelos, Universidad Nacional Autonoma de Mexico, P.O. Box 1152, 77500 Cancun, Q.R. Mexico (E-mail: briones@mar.icmyl.unam.mx).

19865 - The future for fisheries. Pauly, D.; Alder, J.; Bennett, E.; Christensen, V.; Tyedmers, P.; Watson, R. 2003. Science 302: 1359-1361. Fisheries Centre, University of British Columbia, Vancouver, BC V6T IZ4, Canada (d.pauly@fisheries.ubc.ca).

19866 - Faecal coliforms in pond water, sediments and hybrid tilapia *Oreochromis niloticus* X *Oreochromis aureus* in Saudi Arabia. Al-Harbi, A. 2003. Aquacult. Res. 34(7):517-524. Fish Culture Project, Natural Resources and Environment Research Institute, King Abdulaziz City for Science and Technology, PO Box 6086, Riyadh 11442, Saudi Arabia.

19867 - Observations on the artisanal stake net fishery for shrimps in the Negombo lagoon, Sri Lanka. Jayawardane, P.A.A.T.; Perera, H.A.R.E. 2003. Fish. Manage. Ecol. 10(1): 41-50. MBRD, NARA, Crow Island, Mattakkuliya, Colombo 15, Sri Lanka (E-mail: paatj@hot mail.com).

19868 - Nitrogen and phosphorus digestibility and excretion of different-sized groups of milkfish (*Chanos chanos Forsskal*) fed formulated and natural food-based diets. Sumagaysay-Chavoso, N.S. 2003. Aquacult. Res. 34(5):407-418. Aquaculture Department, Southeast Asian Fisheries Development Center, Tigbauan, 5021 Iloilo, Philippines (E-mail: nss@aqd.seafdec.org.ph).

19869 - Effect of temperature and phytoplankton concentration on Nile tilapia *Oreochromis niloticus (L.)* filtration rate. Turker, H.; Eversole, A.; Brune, D.E. 2003. Aquacult. Nutri. 34(6):453-459. Write to: A. G. Eversole, Department of Aquaculture, Fisheries and Wildlife, Clemson University, Clemson, SC 29634-0362, USA (E-mail: aevrsl@clemson.edu).

19870 - When fishery rhymes with poverty: a first step beyond the old paradigm on poverty in small-scale fisheries. Bene, C. 2003. World Development 31(6): 949-975. Write to: WorldFish Center, P.O. Box 500, GPO, 10670 Penang, Malaysia (E-mail: worldfishcenter@cgiar.org) R 2003-40.

19871 - The future for fisheries. Pauly, D.; Alder, J.; Bennett, E.; Christensen, V.; Tyedmers, P.; Watson, R. 2003. Science 302:1359-1361. Sea Around Us Project, Fisheries Centre, University of British Columbia, Vancouver, BC V6T 1Z4, Canada (E-mail: d.pauly@fisheries.ubc.ca).

19872 - Marine ecosystem appropriation in the Indo Pacific: a case study of the live reef fish food trade. Warren-Rhodes, K.; Sadovy, Y.; Cesar, H. 2003. Ambio 32(7): 481-488. NASA-Ames Research Center, Mail Stop 245-3, Moffett Field, CA 94035, USA (E-mail: kwarren-rhodes@mail.arc.nasa.gov).

19873 - Fish assemblages and habitat in a Malaysian blackwater peat swamp. Beamish, F.W.H.; Beamish, R.B.; Lim, S.L.H. 2003. Environ. Biol. Fish. 68:1-13. Department of Biology, Faculty of Science, Burapha University, Bang Saen, Chonburi 20131, Thailand (E-mail: billbeamish@hotmail.com).

19874 - Diversity and composition of freshwater fishes in river systems of central western Ghats, India. Bhat, A. 2003. Environ. Biol. Fish. 68(1):25-38. Centre for Ecological Science, Indian Institute of Science, Bangalore 560012, India (E-mail: anuradha@ces.iisc.ernet.in).

19875 - The association of physical and environmental factors with abundance and distribution patterns of groupers around Kolombangara Island, Solomon Islands. Sabetian, A. 2003. Environ. Biol. Fish. 68(1): 93-99. School of Marine Biology & Aquaculture, James Cook University, Townsville, Queensland 4811, Australia (E-mail: armagan_sabetian@jcu.edu.au).

19876 - Effect of calcium and magnesium hardness on acute copper toxicity to Indian major carp, *Labeo rohita (Hamilton)* and catfish, *Channa punctatus*. Adhikari, S. 2003. Aquacult. Res. 34(12): 975-980. Central Institute of Freshwater Aquaculture, Kausalyaganga, Bhubaneswar 751 001, India (E-mail: sadhikari66@indiatimes.com).

19877 - Effect of Nile tilapia, *Oreochromis niloticus (L.)*, size on phytoplankton filtration rate. Turker, H.; Eversole, A.G.; Brune, D.E. 2003. Aquacult. Res. 34(12): 1087-1091. Write to: A.G. Eversole, Department of Aquaculture, Fisheries and Wildlife, Clemson University, Clemson, SC, USA (E-mail: aevrsl@clemson.edu).

19878 - Indian aquaculture. Gopakumar, K. 2003. J. Appl. Aquacult. 13(1-2):1-10. Indian Council of Agricultural Research, Krishi Bhawan, New Delhi - 110 001, India.

19879 - Pond fertilization regimen: state-of-the art. Das, S.K.; Jana, B.B. 2003. J. Appl. Aquacult. 13(1-2):35-66. Department of Aquaculture, West Bengal University of Animal and Fishery Sciences, Mohanpur - 741 252, West Bengal, India.

19880 - Ecological and ethological perspectives in larval fish feeding. Rao, T.R. 2003. J. Appl. Aquacult. 13(1-2):145-178. Department of Zoology, University of Delhi, Delhi-110 007, India.

19881 - Effect of different schedules for broodstock exchange on the seed production of Nile tilapia *Oreochromis niloticus (L.)* in freshwater. Ridha, M.T.; Cruz, E.M. 2003. Aquacult. Int. 11(30: 267-276. Aquaculture, Fisheries and Marine Environmental Department, Kuwait Institute for Scientific Research, Salmiyah, 22017, Kuwait (E-mail: mridha@kisr.edu.kw).

19882 - Terrestrial leaf meals or freshwater

aquatic fern as potential feed ingredients for farmed abalone *Haliotis asinina (Linnaeus 1758)*. Reyes, O.S.; Fermin, A.C. 2003. Aquacult. Res. 34(8):593-599. South-east Asian Fisheries Development Center, Aquaculture Department (SEAFDEC/ AQD), Tigbauan 5120, Iloilo, Philippines (E-mail: Ofer@aqd.seafdec.org.ph).

19883 - Partial replacement of fishmeal with sunflower cake and corn oil in diets for tilapia *Oreochromis niloticus (Linn):* effect on whole body fatty acids. Maina, J.G.; Beames, R.M.; Higgs, D.; Mbugua, P.N.; Iwama, G.; Kisia, S.M. 2003. Aquacult. Res. 34(8):601-608.

19884 - Survival of zebrafish, *Brachydanio rerio* (Hamilton-Buchanan), embryo after immersion in methanol and exposure to ultrasound with implications to cryopreservation. Bart, A.N.; Htin, A.K. 2003. Aquacult. Res. 34(8): 609-615. Aquaculture and Aquatic Resources Management, Asian Institute of Technology, Box 4, Klong Luang, Pathumthani 12120, Thailand (E-mail: bart@ait.ac.th).

19885 - Diversity of bacteria in sewage treatment plant used as fish culture pond in southern Ghana. Ampofo, J.A.; Clerk, G.C. 2003. Aquacult. Res. 34(8): 667-675. Water Research Institute, CSIR, Box AH 38, Achimota, Ghana (E-mail: jaampofo@yahoo.com).

19886 - Bacterial flora of fish feeds and organic fertilizers for fish culture ponds in Ghana. Ampofo, J.A.; Clerk, G.C. 2003. Aquacult. Res. 34(8):677-680. Water Research Institute, CSIR, Box AH 38, Achimota, Ghana (E-mail: jaampofo@yahoo.com).

19887 - Replacement of fish meal with a mixture of different plant protein sources in juvenile Nile tilapia, *Oreochromis niloticus (L.)* diets. El-Saidy, D.M.S.D.; Gaber, M.M.A. 2003. Aquacult. Res. 34(13):1119-1127. Write to: M.M.A. Gaber, National Institute of Oceanography & Fisheries, Cairo, Egypt (E-mail: gabermagdy@hotmail.com).

19888 - Comparative nutritional evaluation of raw, methanol extracted residues and methanol extracts of moringa (*Moringa oleifera Lam.*) leaves on growth performance and feed utilization in Nile tilapia (*Oreochromis niloticus L.*) Afuang, W.; Siddhuraju, P.; Becker, K. 2003. Aquacult. Res. 34(13):1147-1159. Write to: K. Becker, Department of Aquaculture Systems and Animal Nutrition, Institute for Animal Production in the Tropics and Subtropics, University of Hohenheim (480b), D-70593 Stuttgart, Germany (E-mail: kbecker@uni-hohenheim.de).

19889 - New biotechnology applications in fish. Gardiner, P.R.; Lim, L.S.; John, G. 2003. Wallingford, Oxon, UK: CABI Publishing. Biotechnology and sustainable development: voices of the south and north. p. 113-124. Write to: WorldFish Center, P.O. Box 500, GPO, 10670 Penang, Malaysia (E-mail: worldfishcenter@cgiar.org) S494.5 B563S47.

19890 - Agricultural biotechnology: country case studies - a decade of development. Persley, G.J.; MacIntyre, L.R. (eds.) 2002. Wallingford, Oxon, UK: CABI Publishing. xix, 228 p. 0-85198-816-4. S494.5 B563P47.

19891 - Role of the private sector in technology transfer and capacity building in sustainable aquaculture. Williams, M.J.; Choo, P.S. 2003. Trondheim, Norway: Norwegian Directorate for Nature Management. Proceedings of the Norway/ UN Conference on Technology Transfer and Capacity Building. p. 161-170. Write to: WorldFish Center, P.O. Box 500, GPO, 10670 Penang, Malaysia (E-mail: worldfishcenter@ cgiar.org) 82-426-1412-1. T174.3 N67 2001.

19892 - Nutrient digestibility studies in *Heteropneustes fossilis (Bloch), Clarias batrachus (Linnaeus)* and *C. gariepinus (Burchell)*. Usmani, N.; Jafri, A.K.; Afzal Khan, M. 2003. Aquacult. Res. 34(14):1247-1253. Fish Nutrition Research Laboratory, Department of Zoology, Aligarh Muslim University, Aligarh 202 002, India (E-mail: usmaninazura@yahoo.com).

19893 - Navigating the institutional landscape: introduction and overview. Torell, M.; Salamanca, A.M. 2002. Penang, Malaysia: WorldFish Center. Institutional issues and perspectives in the management of fisheries and coastal resources in Southeast Asia. p. 1-15. Write to: WorldFish Center, P. O. Box 500, GPO, 10670 Penang, Malaysia (E-mail: worldfishcenter@cgiar.org) 983-2346-07-X. SH207 TR4 #60.

19894 - Institutional and policy issues in the management of fisheries and coastal resources in Cambodia. Vicheth, P.; Carson, T.; Narin, N.; Chhay, S.; Srun, L.S.; Dara, C.; Siphan, O.; Monyneath, V.; Kosal, M.; O' Callaghan, B.; Torell, M. 2002. Penang, Malaysia: WorldFish Center. Institutional issues and perspectives in the management of fisheries and coastal resources in Southeast Asia. p. 16-56. Write to: WorldFish Center, P. O. Box 500, GPO, 10670 Penang, Malaysia (E-mail: worldfishcenter@cgiar.org) 983-2346-15-0. SH207 TR4 #60.

19895 - Institutional issues and perspectives in the management of fisheries and coastal resources in southeast Asia. Torell, M.; Salamanca, A.M. (eds.) 2002. Penang, Malaysia: WorldFish Center. Institutional issues and perspectives in the management of fisheries and coastal resources in Southeast Asia. 212 p. Write to: WorldFish Center, P. O. Box 500, GPO, 10670 Penang, Malaysia (E-mail: worldfishcenter@cgiar.org) 983-2346-15-0. SH207 TR4 #60.

19896 - Coastal resources management in Indonesia: legal and institutional aspects. Purwaka, T.H.; Sunoto. 2002. Penang, Malaysia: WorldFish Center. Institutional issues and perspectives in the management of fisheries and coastal resources in Southeast Asia. p. 60-90. Write to: WorldFish Center, P. O. Box 500, GPO, 10670 Penang, Malaysia (E-mail: worldfishcenter@cgiar.org) 983-2346-15-0. SH207 TR4 #60.

19897 - Community-based approaches to marine and coastal resources management in the Philippines: a policy perspective. La Vina, A.G.M. 2002. Penang, Malaysia: WorldFish Center. Institutional issues and perspectives in the management of fisheries and coastal resources in Southeast Asia. p. 91-142. Write to: WorldFish Center, P. O. Box 500, GPO, 10670 Penang, Malaysia (E-mail: worldfishcenter@cgiar.org) 983-2346-15-0. SH207 TR4 #60.

19898 - Institutional and policy perspectives in the management of fisheries and coastal resources in Thailand. Nissapa, A.; Masae, A.; Boromthanarat, S.; Jungrungrot, V. 2002. Institutional issues and perspectives in the management of fisheries and coastal resources in Southeast Asia. p. 143-182. Write to: WorldFish Center, P. O. Box 500, GPO, 10670 Penang, Malaysia (E-mail: worldfishcenter@cgiar.org) 983-2346-15-0. SH207 TR4 #60.

19899 - Women in fisheries: pointers for development. Williams, M.J. 2002. Penang, Malaysia: ICLARM - The World Fish Center. Global Symposium on Women in Fisheries. 9 p. Write to: WorldFish Center, P. O. Box 500, GPO, 10670 Penang, Malaysia (E-mail: worldfishcenter@cgiar.org) SH207 CP6G56 2001.

19900 - Women in fisheries activities of the Asian Fisheries Society - have they been able to make an impact? Nandeesha, M.C.; Tech, E. 2002. Penang, Malaysia: ICLARM - The World Fish Center. Global Symposium on Women in Fisheries. p. 7-12. Write to: WorldFish Center, P. O. Box 500, GPO, 10670 Penang, Malaysia (E-mail: worldfishcenter @cgiar.org) SH207 CP6G56 2001.

19901 - From women in fisheries to gender and fisheries. Williams, M.J.; Williams, S.B.; Choo, P.S. 2002. Penang, Malaysia: ICLARM - The World Fish Center. Global Symposium on Women in Fisheries. p. 13-18. Write to: WorldFish Center, P. O. Box 500, GPO, 10670 Penang, Malaysia (E-mail: worldfishcenter @cgiar.org) SH207 CP6G51 2001.

19902 - Women in fisheries in Asia. Siason, I.; Tech, E.; Matics, K.I.; Choo, P.S.; Shariff, M.; Heruwati, E.S.; Susilowati, T.; Miki, N.; Shelly, A.B.; Rajabharshi, K.G.; Ranjit, R.; Siriwardena, P.P.G.N.; Nandeesha, M.C.; Sunderarajan, M. 2002. Penang, Malaysia: ICLARM - The World Fish Center. Global Symposium on Women in Fisheries. p. 21-47. Write to: WorldFish Center, P. O. Box 500, GPO, 10670 Penang, Malaysia (E-mail: worldfishcenter@cgiar.org) SH207 CP6G51 2001.

19903 - Responding to globalization trends in fisheries: assets of professional Taiwanese women. Chao, N.H.; Chang, C.F.; Chang, E.Y. 2002. Penang, Malaysia: ICLARM - The World Fish Center. Global Symposium on Women in Fisheries. p. 65-75. Write to: WorldFish Center, P. O. Box 500, GPO, 10670 Penang, Malaysia (E-mail: worldfishcenter @cgiar.org) SH207 CP6G56 2001.

19904 - Women in aquaculture: initiatives of Caritas Bangladesh. Shelly, A.B.; Costa, M.D. 2002. Penang, Malaysia: ICLARM - The World Fish Center. Global Symposium on Women in Fisheries. p. 77-87. Write to: WorldFish Center, P. O. Box 500, GPO, 10670 Penang, Malaysia (E-mail: worldfishcenter@cgiar.org) SH207 CP6G56 2001.

19905 - Women-led fisheries management - a case study from Bangladesh. Sultana, P.; Thompson, P.M.; Ahmed, M. 2002. Penang, Malaysia: ICLARM - The World Fish Center. Global Symposium on Women in Fisheries. p. 89-96. Write to: WorldFish Center, P. O. Box 500, GPO, 10670 Penang, Malaysia (E-mail: worldfishcenter@cgiar.org) SH207 CP6G56 2001.

19906 - Alternative livelihoods in a coastal village. Asong, R.H.; Mabunay, Ma. L.; Aure, D.; Seraspe, E.; Braganza, R.; Corda, D.E. 2002.

Penang, Malaysia: ICLARM - The World Fish Center. Global Symposium on Women in Fisheries. p. 97-111. Write to: WorldFish Center, P. O. Box 500, GPO, 10670 Penang, Malaysia (E-mail: worldfishcenter@cgiar.org) SH207 CP6G56 2001.

19907 - Working wives in Philippine coastal fisheries. Banez-Sumagaysay, M. 2002. Penang, Malaysia: ICLARM - The World Fish Center. Global Symposium on Women in Fisheries. p. 113-123. Write to: WorldFish Center, P. O. Box 500, GPO, 10670 Penang, Malaysia (E-mail: worldfishcenter@cgiar.org) SH207 CP6G56 2001.

19908 - An overview of the involvement of women in fisheries activities in Oceania. Lambeth, L.; Hanchard, B.; Aslin, H.; Fay-Sauni, L.; Tuara, P.; Rochers, K.D.; Vunisea, A. 2002. Penang, Malaysia: ICLARM - The World Fish Center. Global Symposium on Women in Fisheries. p. 127-142. Write to: WorldFish Center, P. O. Box 500, GPO, 10670 Penang, Malaysia (E-mail: worldfishcenter@cgiar.org) SH207 CP6G56 2001.

19909 - Making each and every African fisher count: women do fish. Williams, S.B. 2002. Penang, Malaysia: ICLARM - The World Fish Center. Global Symposium on Women in Fisheries. p. 145-154. Write to: WorldFish Center, P. O. Box 500, GPO, 10670 Penang, Malaysia (E-mail: worldfishcenter@cgiar.org) SH207 CP6G56 2001.

19910 - Women and gender participation in the fisheries sector in Lake Victoria. Medard, M.; Sobo, F.; Ngatunga, T.; Chirwa, S. 2002. Penang, Malaysia: ICLARM - The World Fish Center. Global Symposium on Women in Fisheries. p. 155-168. Write to: WorldFish Center, P. O. Box 500, GPO, 10670 Penang, Malaysia (E-mail: worldfishcenter@cgiar.org) SH207 CP6G56 2001.

19911 - Women do fish: a case study on gender and the fishing industry in Sierra Leone. Browne, P.B. 2002. Penang, Malaysia: ICLARM - The World Fish Center. Global Symposium on Women in Fisheries. p. 169-172. Write to: WorldFish Center, P. O. Box 500, GPO, 10670 Penang, Malaysia (E-mail: worldfishcenter@cgiar.org) SH207 CP6G56 2001.

19912 - Women in fisheries in Latin America. Pereira, G. 2002. Penang, Malaysia: ICLARM - The World Fish Center. Global Symposium on Women in Fisheries. p. 175-180. Write to: WorldFish Center, P. O. Box 500, GPO, 10670 Penang, Malaysia (E-mail: worldfishcenter@cgiar.org) SH207 CP6G56 2001.

19913 - Perspectives on women in fisheries in north America. Howell, L.A. 2002. Penang, Malaysia: ICLARM - The World Fish Center. Global Symposium on Women in Fisheries. p. 183-188. Write to: WorldFish Center, P. O. Box 500, GPO, 10670 Penang, Malaysia (E-mail: worldfishcenter@cgiar.org) SH207 CP6G56 2001.

19914 - Women in fisheries in the European Union. Rana, K.; Choo, P.S. 2002. Global Symposium on Women in Fisheries. p. 191-193. Write to: WorldFish Center, P. O. Box 500, GPO, 10670 Penang, Malaysia (E-mail: worldfishcenter@cgiar.org) SH207 CP6G56 2001.

19915 - Replacement of soybean *(Glycine max (L.) Merrill*) meal by lupin (*Lupinus angustifolius*) seed meal in diet for juvenile tilapia (*Oreochromis niloticis* x *O. aureus*) reared indoors. Chien, Y.H.; Chiu, Y.H. 2003. Aquacult. res. 34(14):1261-1268. Department od Aquaculture, National Taiwan Ocean University, Keelung, Taiwan (E-mail: yhchien@mail.ntou.edu.tw).

19916 - Mixed feeding schedules in semi-intensive pond culture of Nile tilapia, *Oreochromis niloticus*, *L.*: is it necessary to have two diets of differing protein contents? Patel, A.B.; Yakupitiyage, A. 2003. Aquacult. Res. 34(14):1343-1352. Environmental Restoration Project, Core Research Laboratory, Shima Branch Office, Ago Cho, Ugata 3098-9, Mie 517-0501, Japan (E-mail: patel@miesc.or.jp).

19917 - Antinutritive effects of galactomannan-rich endosperm of *Sesbania* (*Sesbania aculeata*) seeds on growth and feed utilization in tilapia, *Oreochromis niloticus*. Hossain, M.A.; Focken, U.; Becker, K. 2003. Aquacult. Res. 34(13):1171-1179.

19918 - Aquaculture potential of the black-chiied tilapia, *Sarotherodon melanotheron* (Cichlidae). Comparative study of the effect of stocking density on growth performance of landlocked and natural populations under cage culture conditions in Lake Ayame (Cote d'Ivoire) Ouattara, N.I.; Teugels, G.G.; N'Douba, V. 2003. Aquacult. Res. 34(13): 1223-1229. Write to: V. N'Douba, Universite de Cocody, UFR-Biosciences, Laboratoire. d'Hydrobiologie Abidjan, 22 BP 582 Abidjan 22, Cote d'Ivoire (E-mail: hydrobio@aviso.ci).

19919 - Oceanic survival and movements of wild and captive-reared immature green turtles (*Chelonia mydas*) in the Indian Ocean. Pelletier, D.; Roos, D.; Ciccione, S. 2003. Aquat. Living Resour. 16(1): 35-41. Lab. MAERHA, Institut Francais de Recherche pour l'Exploitation de la Mer, IFREMER, BP 21105, 44311 Nantes cedex 3, France (E-mail: dpellet@ifremer.fr).

19920 - Impact of fishing on fish assemblages in tropical lagoons: the example of the Ebrie lagoon, West Africa. Albaret, J.J.; Lae, R. 2003. Aquat. Living Resour. 16(1): 1-9. Write to: R. Lae, IRD Bel Air, BP 1386, Dakar, Senegal (E-mail: lae@ird.sn).

19921 - Partial and complete replacement of fish meal with gambusia meal in diets for red tilapia "*Oreochromis niloticus* x *O. mossambicus*" Abdelghany, A.E. 2003. Aquacult. Nutr. 9(3):145-154. Central Laboratory of Aquaculture Research, Abbassa, Abohamad, Sharkia, Egypt (E-mail: abdelgh@thewayout.net).

19922 - Utilization of gelatinized carbohydrate in diets of *Labeo rohita* fry. Mohapatra, M.; Sahu, N.P.; Chaudhari, A. 2003. Aquacult. Nutr. 9(3):189-196. Division of Digestive Physiology & Nutrition, Central Institute of Fisheries Education, Versova, Mumbai, India.

19923 - Assessment of soybean meal in diets for discus (*Symphysodon aequifasciata Heckel*) farming through a fishmeal replacement study. Chong, A.; Roshada, A.; Ahyaudin, A. 2003. Aquacult. Res. 34(11):913-922. School of Biological Sciences, Universiti Sains Malaysia, 11800 Minden, Penang, Malaysia (E-mail: alex@usm.my).

19924 - Recent developments and improvements in ornamental fish packaging systems for air transport. Lim, L.C.; Dhert, P.; Sorgeloos, P. 2003. Aquacult. Res. 34(11): 923-935. Freshwater Fisheries Centre, Agri-food & Veterinary Authority of Singapore, Sembawang Research Station, Lorong Chencharu, Singapore 769194 (E-mail: 333@post1.com).

19925 - RAPD fingerprinting of the eel-loaches *Pangio filinaris* and *Pangio piperata*: preliminary evaluation. Ruzainah, A.; Siti Azizah, M.N.; Patimah, I.; Amirrudin, A. 2003. Aquacult. Res. 34(11):959-965. School of Biological Sciences, Universiti Sains Malaysia, Penang, Malaysia (E-mail: sazizah@usm.my)

19926 - Effects of *Yucca shidigera* extract on growth, nitrogen retention, ammonia excretion, and toxicity in channel catfish *Ictalurus punctatus* and hybrid tilapia *Oreochromis mossambicus* x *O. niloticus*. Kelly, A.M.; Kohler, C.C. 2003. J. World Aquacult. Soc. 34(2):156-161. Department of Wildlife and Fisheries, Box 9690, Mississippi State University, Mississippi State, Mississippi 39762 USA.

19927 - Ultrasound enhanced immersion protocols for masculinization of Nile tilapia, *Oreochromis niloticus*. Bart, A.N.; Athauda, A.R.S.B.; Fitzpatrick, M.S.; Contreras-Sanchez, W.M. 2003. J. World Aquacult. Soc. 34(2): 210-216. Aquaculture and Aquatic Resources Management, Asian Institute of Technology, Klong Luang, Pathumthani 12120, Thailand.

19928 - Yield, growth and mortality rate of the Thai river sprat, *Clupeichthys aesarnensis*, in Sirinthorn Reservoir, Thailand. Jutagate, T.; De Silva, S.S. 2002. Fish. Manage. Ecol. 10(4): 221-231. MRC Fisheries Programme Project for the Management of Reservoir Fisheries in the Mekong Basin, Vientiene, Lao PDR.

19929 - The flood pulse and growth of floodplain fish in Bangladesh. De Graaf, G. 2003. Fish. Manage. Ecol. 10(4):241-247. NEFISCO foundation, Amsterdam, the Netherlands.

19930 - Evaluation of full-fat and defatted maggot meals in the feeding of clariid catfish *Clarias gariepinus* fingerlings. Fasakin, E.A.; Balogun, A.M.; Ajayi, O.O. 2003. Aquacult. Res. 34(9): 733-738. Department of Fisheries and Wildlife, Federal University of Technology, PMB 704, Akure, Nigeria.

19931 - Nursing duration and pond fertilization level affect polyculture of Indian major carp (rohu *Labeo rohita* and mrigal *Cirrhina mrigala*) with monosex Nile tilapia *Oreochromis niloticus*. Hossain, M.A.; Little, D.C.; Bhujel, R.C. 2003. Aquacult. Res. 34(9):765-775. Write to: D. C. Little, Institute of Aquaculture, University of Stirling, Stirling FK9 4LA, UK (E-mail: d.c.little@stir.ac.uk).

19932 - Evaluation of partial substitution of live algae with dried Tetraselmis for larval rearing of black-lip pearl oyster, *Pinctada margaritifera (L.).* Doroudi, M.S.; Southgate, P.C.; Robert, J. 2002. Aquacult. Int. 10(4): 265-277. NSW Fisheries, C-Murray Irrigation, Wakool 2710, NSW, Australia (E-mail: doroudim@fisheries.nsw.gov.au).

19933 - Effect of pig dung on water quality and polyculture of carp species during winter and summer. Dhawan, A.; Kaur, S. 2002. Aquacult. Int. 10(4):297-307. Department of Fisheries, Punjab Agricultural University, Ludhiana, 141 004, India (E-mail: dhawan@satyam.net.in).

19934 - Policy options for Cambodia's Ream National Park: a stakeholder and economic analysis. Lopez, T.T. de. 2001. Singapore: Economy and Environment Program for Southeast Asia. 74 p. SB484 C3D56.

19935 - Mekong River Commission: Mekong fish database: a taxonomic fish database for the Mekong Basin. 2003. Phnom Penh, Cambodia: MRC. 1 CD-ROM. Database developed by Theo Visser, Paweena Kullaya and Ekkaphon Udommongkhonkit. QL614.7 M44 2003.

19936 - Fish migrations in the Mekong River Basin. 2003. Phnom Penh, Cambodia: MRC. 1 CD-ROM. SH307 M42F57.

19937 - Medium-term plan. 2003. Penang, Malaysia: WorldFish Center. v.- SH206 A755.

19938 - Strategy for Africa and west Asia: 2002-2006. 2003. Penang, Malaysia: WorldFish Center. 63 p. SH206 A734S77 2003.

19939 - The use of fish by-products in aquaculture: report of the Scientific Committee on Animal Health and Animal Welfare: adopted 26th February 2003. 2003. [Brussels]: European Commission. 93 p. Report extracted from http://europa.eu.int/comm/food/fs/sc/scah/out87_en.pdf.

19940 - Workshop on the impact of development on the coastal fisheries off south-west Penang island. Choo, P.S.; Ismail, I.; Chee, P.E.; Chua, T.T. 2002. Penang, Malaysia: Fisheries Research Institute. x, 112 p. SH307 M3 2001.

19941 - A fishery manager's guidebook: management measures and their application. Cochrane, K.L. (ed.) Fishery management. FAO fisheries technical paper (424): 231 p. SH1 F361 #424.

19942 - A selected bibliography on tilapia (Pisces: Cichlidae): a list of documents available in the WorldFish Center Library. 2003. Penang, Malaysia: WorldFish Center. v, 203 p. SH207 B5 Suppl. 1 #13.

19943 - Development of freshwater fish farming and poverty alleviation: a case study from Bangladesh. de Graaf, G.; Abdul Latif. 2002. Aquacult. Asia 7(2): 5-7. Nefisco Foundation, Amsterdam, the Netherlands (E-mail: deGraaf@nefisco.org).

19944 - Conservation of endangered fish stocks through artificial propagation and larval rearing technique in west Bengal, India. Mijkherjee, M.; Praharaj, A.; Das, S. 2002. Aquacult. Asia 7(2): 8-11. Office of the deputy Director of Fisheries (Microbiology & Parasitology), Captain Bhery, PO. Nawbhanga, E. M. Bypass, Kolkata - 39, West Bengal, India.

19945 - Aquaculture fundamentals: the use of lime, gypsum, alum and potassium permanganate in water quality management. Wilkinson, S. 2002. Aquacult. Asia 7(2):12-14. PO Box 1040, Kasetsart Post Office, Bangkok 10903, Thailand (E-mail: naca@enacva.org).

19946 - The utilizations of heterosis in common carp in China. Dong, Z.J.; Yuan, X.H. 2002. Aquacult. Asia 7(2):14-15. Freshwater Fisheries Research Centre, Chinese Academy of Fisheries Sciences, Wuxi, 214081, China (E-mail: dongzj@bigfoot.com).

19947 - Progress of fish gene technology research in China. Zhang, Y.; Zhu, X. 2002. Aquacult. Asia 7(2):15-16. Pearl River Fisheries Research Institute, Guangzhou, 510380, P. R. China.

19948 - Seed production of Magur (*Clarias batrachus*) using a rural model portable hatchery in Assam, India - a farmer proven technology. Das, S.K. 2002. Aquacult. Asia 7(2):19-21. Assam Agricultural University, College of Fisheries, Raha, Nagaon, Assam, India - 782 103 (E-mail: skdas01@yahoo.com).

19949 - Supply of good quality fish seed for sustainable aquaculture. Mair, G. 2002. Aquacult. Asia 7(2):25-27. Aquaculture and Aquatic Resources Management Group, Asian Institute of Technology, Bangkok, Thailand (E-mail: gcmair@ait.ac.th).

19950 - Sewage fed aquaculture systems of Kolkata: a century-old innovation of farmers. Nandeesha, M.C. 2002. Aquacult. Asia (2):28-32. Department of Aquaculture, College of Fisheries, Central Agricultural University, PO Box No. 120, Agartala 799001, Tripura, India (E-mail: mcnraju@yahoo.com).

19951 - Grouper hatchery production training course, Gondol Research Institute for Mariculture, Bali, Indonesia, 1-21 May, 2002. Sim, S.Y.; Adi, H. 2002. Aquacult. Asia 7(2): 37-39. Network of Aquaculture Centres in Asia-Pacific (NACA), PO Box 1041, Kasetsart Post Office, Bangkok 10903, Thailand (E-mail: sim@enaca.org).

19952 - Fish farming in rice environments of north eastern India. Das, D.N. 2002. Aquacult. Asia 7(2):43-47. Department of Zoology, Arunachal University, Itanagar- 791 112, India.

19953 - A regional approach to assessing organic waste production by low salinity shrimp farms. Szuster, B.; Flaherty, M. 2002. Aquacult. Asia 7(2):48-52. Thailand Aquaculture Management Program, Department of Aquatic Science, Burapha University, Bang Saen, Chonburi 20131, Thailand (E-mail: bszuster@uvic.ca).

19954 - Aquaculture for poverty alleviation and food security. Edwards, P. 2002. Aquacult. Asia 7(2): 53-56. Asian Institute of Technology, Bangkok, Thailand (E-mail: pedwards@ait.ac.th).

Subject Index

Taxonomic Index

Geographic Index

Selected Websites

AGRIPPA – Peer reviewed electronic journal
http://www.fao.org/agrippa/
AGRIPPA is a new initiative by FAO for the electronic publishing of agricultural literature: reviews, scientific papers, short communications and extension materials.

CGIAR News Releases
http://www.cgiar.org/publications/pub_press.html
A publication of the Consultative Group on International Agricultural Research (CGIAR) Secretariat highlighting important achievements of the CGIAR research centers.

Critical links: food security and the environment in the Greater Horn of Africa
http://www.ilri.cgiar.org/InfoServ/Webpub/Fulldocs/Critical/ToC.htm
Provides a synthesis of major challenges and opportunities in the food security-environmental nexus, highlighting the key linkages, underlying causes of food insecurity and environmental degradation in the Greater Horn of Africa region. The paper concludes with key strategic principles required to reverse the downward spiral of hunger, resources degradation, poverty, and conflict in the region.

Development Gateway
http://www.developmentgateway.org/node/130622/
An independent not-for-profit organization, conceived by World Bank President James Wolfensohn and initially developed in the World Bank. The Foundation aims to help improve people's lives in developing countries by building partnerships and information systems that provide access to knowledge for development.

Fisheries
http://europa.eu.int/comm/fisheries/policy_en.htm
The website of the European Commission's Directorate-General for Fisheries that is responsible for the Common Fisheries Policy (CFP). The CFP covers all fishing activities, the farming of living aquatic resources, and their processing and marketing, on the legal basis of Article 33 (ex 39) of the Treaty establishing the European Community.

Global Facilitation Unit for Underutilized Species
http://www.underutilized-species.org/
It aims to provide an umbrella or portal to all sources of information about underutilized species available.

Global Technology Forum
http://www.gbf2004.cl/newseptember.html
Organized by the United Nations Industrial Development Organization (ONUDI) and the Government of Chile, the forum will be held in Concepcion, Chile on 2-5 March, 2004. It aims to promote biotechnology for sustainable development in the developing world.

Greenpeace: Oceans
http://www.greenpeace.org/international_en/campaigns/intro?campaign_id=3939
This part of the Greenpeace website focuses on their international oceans campaign, which currently focuses on the three major threats to the world's oceans; over fishing, pirate fishing, whaling and intensive shrimp aquaculture. It also contains links to information on marine pollution, latest news releases, multimedia resources and a press centre, and links to documents and reports.

Journal of Landscape Ecology
http://landscape.forest.wisc.edu/landscapeecology/
It provides freely available articles from the journal published from 1987-97.

Large Marine Ecosystems (LMEs)
http://www.edc.uri.edu/lme/
A global effort undertaken by the World Conservation Union (IUCN), the Intergovernmental Oceanographic Commission of UNESCO (IOC), other United Nations agencies, and the US National Oceanic and Atmospheric Administration (NOAA) to improve the long-term sustainability of resources and environments of the world's Large Marine Ecosystems (LMES) and linked watersheds.

Marine Finfish Aquaculture Newsletters
http://www.enaca.org/Grouper/News.htm
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.

Marine Fish Conservation Network.
http://www.conservefish.org/site/
A coalition of over 155 national and regional environmental organizations, commercial and recreational fishing groups, aquariums, and marine science groups dedicated to conserving marine fish and to promoting their long term sustainability. Topics covered include the network's agenda, publications, upcoming events, US fisheries law reforms, US fishing quota (IFQ) programs, news in the media about the network and their press releases, and a list of the member organizations with links to their websites.

NightSea
http://www.nightsea.com/home.htm
NightSea LCC was established to provide equipment that enables scuba divers to see, photograph, and videotape fluorescence. The systems are now finding extensive application in underwater research.

NOAA's National Environmental Satellite, Data and Information Services (NESDIS)
http://www.nesdis.noaa.gov
NESDIS operates NOAA's National Data Centers for Climate, Geophysics, Oceans, and Coasts. Through these data centers and other centers of data, NESDIS provides and ensures timely access to global environmental data from satellites and other sources, provides information services, and develops science products.

Organization for Economic Co-operation and Development (OEDD)
http://www.oecd.org/home/
With 30 member countries and a Secretariat in Paris, OEDD provides governments a setting in which to discuss, develop and perfect economic and social policy. The site gives information on the organization's history, members, its Secretariat, committees and activities, along with the full text of the Convention of the OECD and associated protocols.

Published NAFC Research Papers
http://www.nafc.ac.uk/research.htm
A collection of 17 papers produced by the North Atlantic Fisheries College, covering topics such as stock improvement and enhancement, the effects of oil spills and etc. These papers provide information on specific issues or developments of relevance to Shetland's fisheries industry, including mussel farming and the Atlantic Halibut.

SPC Aquaculture Portal
http://www.spc.org.nc/aquaculture/site/home/index.asp
The purpose of this portal is to be a virtual focal point for aquaculture networking in the Pacific Islands. It serve as an information clearing-house mechanism, highlighting best practices for aquaculture development.

SPC Trochus Information Bulletins
http://www.spc.org.nc/coastfish/News/Trochus/Troc.htm
A bulletin that tries to incorporates news on other molluscs and shellfish.

Species Survival Commission (SSC)
http://www.iucn.org/themes/ssc/aboutssc/whatisssc.htm
A knowledge network of some 7,000 volunteer members working in almost every country of the world. SSC is the largest of the six Commissions of IUCN-The World Conservation Union. It serves as the main source of advice to the Union and its members on the technical aspects of species conservation.

The CFAST Newsletter
http://www.cfast.vt.edu/newsletter/
Published triannually, as a service to the fish and shellfish industries, as well as research and regulatory agencies involved in fisheries, aquaculture, and public health.

The Global Aquaculture Alliance
http://www.gaalliance.org/
An international, nonprofit trade association dedicated to advancing environmentally and socially responsible aquaculture. GAA recognizes that aquaculture; the culture and farming of fish, shellfish and other aquatic organisms, is the only sustainable means of increasing seafood supply to meet growing food needs.

The Strategic Initiative for Ocean and Coastal Management (SIOCAM
http://www.sdnp.undp.org/siocam/
A global framework initiated by the United Nations Development Programme which aims to enhance the capabilities of existing and future ocean and coastal management projects through the systematic identification, documentation and sharing of best practices and lessons learned. The site gives details on the objectives of the framework, along with strategic information and documentation on individual global projects.

Tropical coasts
http://pemsea.org/
A magazine for policymakers, environmental managers, scientists and resource users. It aims to serve as a vehicle to widely disseminate news and information on integrated coastal management, marine pollution prevention and management, and other related topics, relevant to the tropical and subtropical coastal developing countries.

Wealthy countries' trade policies sap the economies of developing nations: new research quantifies harm of agricultural subsidies and protectionism
http://www.ifpri.org/media/trade20030826.htm
An issue brief produced by the International Food Research Institute. The study estimates that protectionism and subsidies by industrialized nations cost developing countries about US$24 billion annually (6.6 billion in Asia) in lost agricultural and agro-industrial income according to a recently released study.

Working Group on Pathology and Diseases of Marine Organisms
http://www.ices.dk/iceswork/wgdetail.asp?wg=WGPDMO
The documents are reports of an expert group under the auspices of the International Council for the Exploration of the Sea.

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Please ensure that the manuscript is clear enough to work on, and adheres to the following:

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- **References (examples)**

Book:

Gupta, M.V. and B.O. Acosta (eds.) 2001. Fish genetics research in member countries and institutions of the International Network on Genetics in Aquaculture. ICLARM Conf. Proc. 64, 170 p.

Longhurst, A. and D. Pauly. 1987. Ecology of tropical oceans. Academic Press, San Diego.

Chapter or part of a book or published conference proceedings:

Christensen, V. and D. Pauly. 1993. On steady-state modeling of ecosystems, p. 14-19. *In* V. Christensen and D. Pauly (eds.) Trophic models of aquatic ecosystems. ICLARM Conf. Proc. 26, 390 p.

Journal article:

Hillman, S. 1994. Environment on trial. NAGA, ICLARM Q. 17(1):8-10.

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