new info
beche-de-mer

Advances in Sea Cucumber Aquaculture and Management (ASCAM)

The international workshop, "Advances in Sea Cucumber Aquaculture and Management (ASCAM)", organised by the Fishery Department of the Food and Agriculture Organization (FAO) was held from 14 to 18 October in Dalian, Liaoning Province, China. Fifty experts from around the world, including China, attended the workshop.

The ASCAM workshop focused its presentations and discussions on three main topics:

Session I: Status of sea cucumber fisheries
Session II: Sea cucumber resources management
Session III: Aquaculture advances

The abstracts of presentations are included below. All workshop reports and recommendations made during the discussions following each session, will be published by FAO in early 2004 (Lovatelli, A., Conand C., Purcell S., Uthicke S., Hamel J.-F. and Mercier A. (eds). Advances in sea cucumber aquaculture and management.

Participants to ASCAM Workshop (*Photo J.-F. Hamel*)

*1- ABSTRACTS**

SESSION 1 - STATUS OF RESOURCES AND UTILISATION

Present status of world sea cucumber resources and utilisation: An international overview

Chantal Conand
Laboratoire ECOMAR, Université de La Réunion, 97715 Saint-Denis Messagerie Cedex 9, France.
Email: Chantal.Conand@helios.univ-reunion.fr

In this report the data on traditional and recent worldwide tropical and temperate sea cucumber fisheries for the last fourteen years (1986–2000) are summarised based on FAO statistics, data from various issues of the SPC Beche-de-Mer Bulletin, and other available publications. There has been increasing interest in this benthic resource and an expansion of the fisheries as a whole. Numerous sea cucumber fisheries are witnessing conflicts among the fishermen, processors and the authorities managing the resources. The processed products are generally exported from the producing countries to Hong Kong (China), Singapore and Taiwan, Province of China, all three of which are important Asian markets for sea cucumber as well as ports for re-exporting to other markets such as the one in China. These market trade flow mechanisms, particularly in Singapore and Hong Kong (China), are difficult to quantify and to keep track of as products are re-exported based on regional demand and quality. The different qualitative indices analysed clearly show that overexploitation is becoming apparent on a worldwide basis as the demand for *trepang* increases. In support of a sustainable utilisation of the resource, an efficient management plan of action has become a priority that should take into account all the different levels of the "Holothurian system" described.

This presentation will help provide a general and current picture on the state of affairs within this industry. The need for further action is emphasised, particularly with regards to the development of standardised stock assessment methodologies and the collection of statistical data.

Present status and prospects of sea cucumber industry in China

Chen Jiaxin
Yellow Sea Fisheries Research Institute, 106 Nanjing Road, Qingdao, Shandong Province, China 266071.
Email: cjxin828@public.qd.sd.cn

In China, there are about 20 species of edible sea cucumbers that have been considered as a traditional medicine and tonic food for many years. Nutrient analysis shows that the body wall and intestine of sea cucumbers has a high nutrient value. Protein content of dried sea cucumber is more than 50 per cent for most edible species, while glucosaminoglycan was detected in sea cucumbers and considered as a functional component for its pharmaceutical value. The clinical function of sea cucumbers is reviewed. In order to meet the increasing demand, while protecting the natural resource, the highest priority of fisheries authorities has been given to seed production of sea cucumber (*Apostichopus japonicus*) and development of farming and ranching techniques. Sea cucumber farming and ranching has become a vital fraction of the aquaculture sector in the northern part of China, including Liaoning and Shandong Provinces. The total landing volume from farming reached over 5800 tonnes (wet weight) in 2000, which were either directly sold to restaurants or processed as dry products and healthy food (functional food). Farming methods and ranching techniques are presented in detail. The confusion of the quality processed products has become a main issue in holding back market development, while overexploitation of sea cucumber farming in earthen ponds may result in a similar disaster to that of shrimp viral diseases occurring in the early 1990s. Suggestions dealing with further development involve seed production, farming and ranching models, as well as quality control.

* *Abstracts have been provided by the authors, and have been reproduced as is*

Historical overview on holothurian exploitation, utilisation and trade in Japan

Jun Akamine
Department of Humanities and Social Sciences, Nagoya City University, Yamanohata 1, Mizuho-cho, Mizuho-ku, Nagoya, Aichi, 467-8501, Japan. Email: akamine@hum.nagoya-cu.ac.jp

Although dried holothurian (*iriko*) was a major export commodity of Japan for at least the last 300 years, it is currently a minor one. On the other hand, nearly all of the Japanese holothurian, namako, from the domestic market are consumed raw in slices soaked in a mixture of vinegar and soya sauce. The ovaries are dried (called *konoko*), and the intestines are salt-fermented (called *konowata*). These byproducts are rare and expensive, and are good income sources for holothurian processors. This presentation has two objectives: 1) to provide a historical overview of the export trends (i.e. when the dried holothurian trade began, how holothurians were fished and produced), and 2) to provide current information on holothurian exploitation in Japan. Based on observations in the Hokkaido and Setouchi regions, the speaker will report on fishing methods, several commodities related to holothurians, and resource management programmes. National catch statistics in Japan are also provided.

Status of sea cucumber fisheries and farming in Indonesia

Ambo Tuwo
Marine Ecology Laboratory, Faculty of Marine Science and Fisheries, Hasanuddin University, Makassar, Indonesia. Email: ambotuwo@indosat.net.id

Indonesia is the biggest island state in the world (8.3 million km^2), consisting of 17,508 islands and 81,000 km of coastline. Sustainable annual catch from Indonesia's marine resources is about 6.2 million metric tonnes (t). The coastal and sea area of Indonesia provide favourable habitats for many sea cucumber species. Sea cucumbers have been exploited for decades and Indonesia remains a major exporter of sea cucumber in the world.

Fishermen exploit sea cucumber by using small- and medium-size fishing boats (1–10 GT). Fishermen that exploit sea cucumber generally have low capital, and few skills in handling and post-harvest processing. Poor handling and post-harvest processing results in a low quality product and price (about USD 1.92 at fisherman level). An additional problem affecting the Indonesian sea cucumber industry is overexploitation. Available statistical data show an important fluctuation of volume (2500–3000 t per year) and value (USD 1.44–15.06 per kg). Price reduction is likely due to a decrease in the individual capture size or the low economic value of the exploited species.

Four important geographical regions that have developed sea cucumber farming in Indonesia include: Papua (378 t wet weight per year), Central Sulawesi (200 t), Southeast Sulawesi (3 t), and East Kalimantan (1 t). Part of the sea cucumber volume reported as cultured is in fact not really a product of farming activities; some fishermen rear their catch, generally *Holothuria scabra*, in cages or ponds until large enough to sell or process. The long rearing period and low number of available seeds are the two main problems of sea cucumber farming in Indonesia.

Overfishing will certainly have a negative effect on the sustainability of sea cucumber production in Indonesia. Overexploitation will accelerate the destruction and depletion of sea cucumber populations. Based on internal and external factors that influence Indonesian sea cucumber fishing and farming, some alternative development strategies have been resumed: 1) promote sustainable use/fishing; 2) develop re-stocking and mariculture activities; 3) marketable size regulation; and 4) improve handling and post-harvest processing.

Fisheries, trade and utilisation of sea cucumbers in Malaysia

Choo Poh-Sze and M.J. Williams
WorldFish Center, PO Box 500 GPO, 10670 Penang, Malaysia. Email: p.choo@cgiar.org

Sea cucumber fisheries in Malaysia are exploited in substantial quantities in the coastal waters around the coral reef regions in Sabah in Eastern Malaysia. In Peninsular Malaysia, this resource is minimally exploited because more than 90 per cent of the coral reef islands in both the east and west coasts have been gazetted as marine parks where fishing activities are prohibited in the vicinity. In Sabah, in the 1980s, sea cucumber landings recorded an annual catch of about 400–500 tonnes, while landings in the 1990s fell to an annual catch of around 100 tonnes. Species exploited for food include the sandfish

(*Holothuria scabra*), black teatfish (*H. nobilis*), white teatfish (*H. fuscogilva*), elephant's trunkfish (*H. fuscopunctata*), *H. leucospilota*, orange fish (*Bohadschia graeffei*), brown sandfish (*Bohadschia marmorata*) and prickly redfish (*Thelenota ananas*). The sea cucumbers caught in Sabah, apart from being consumed locally, are exported mainly to Peninsular Malaysia, Sarawak, Singapore, Thailand, Hong Kong, Taiwan and China. They are processed by boiling and evisceration, and are then exported dried or frozen. Sea cucumbers are also imported into Sabah by fishermen from neighbouring Indonesia and the Philippines, and may be re-exported after processing; however since the 1990s, the volume of imports have decreased drastically.

In Peninsular Malaysia, sea cucumbers (locally known as gamat) belonging to the Stichopidae family, mainly curryfish (*Stichopus hermanni* formerly known as *S. variegatus*) and warty sea cucumber (*S. horrens*), are exploited for their medicinal properties. In Pulau Langkawi on the west coast of Peninsular Malaysia in the state of Kedah, the processing industry has depleted the resources of *S. hermanni*, which is now an endangered, if not an extinct, species in the vicinity of the Langkawi islands. *S. horrens*, however, are still found in relative abundance on the reef flats of Pulau Pangkor located on the west coast of Peninsular Malaysia in the state of Perak. The raw products are traditionally processed into gamat oil and gamat water, and recently into medicated balm, toothpaste and soap.

This paper describes the sea cucumber fisheries in Malaysia — the type of gear used, the abundance, localities where they are caught and ways for stock enhancement. Presently there are no fishing regulations aimed at preventing overexploitation of sea cucumber stocks (except for regulations prohibiting fishing in marine parks). Suggestions for management measures to address overfished stocks are discussed. Sea cucumber trade, pharmaceutical or nutraceutical properties of the Malaysian species are also described.

The status of sea cucumber fisheries and mariculture in the Philippines

Ruth Gamboa[1], Aurelia Luzviminda Gomez[2], Marie Frances Nievales[3], Helen Grace Bangi[4] and Marie Antonette Juinio-Menez[5]

[1] *Department of Biology, College of Science and Mathematics, University of the Philippines in Mindanao, Bago Oshiro, Tugbok, Davao City, Philippines. Email: ruthupmin@yahoo.com*

[2] *School of Management, UP in Mindanao, Anda Street, Davao City, Philippines. Email: twin9512@yahoo.com*

[3] *Division of Biological Sciences, College of Arts and Science, UP in the Visayas, Miag-ao, Iloilo City, Philippines. Email: frances_36@yahoo.com*

[4] *Bolinao Marine Laboratory, Marine Science Institute, UP Diliman, Quezon City, Philippines. Email: hgb@upmsi.ph*

[5] *Marine Science Institute, UP Diliman, Quezon City, Philippines. Email: meneza@upmsi.ph*

There are about a hundred known species of sea cucumbers in the Philippines, 25 of which are harvested commercially. Although, the traditional trade of these resources, which is export, has existed for centuries, statistical monitoring only started in the 1970s. Over the last two decades, export level has been maintained at 1000 metric tonnes (t) annually with the decline in the volume of high value species compensated by the low value species. Hong Kong, as the major export partner, likely serves as a transit point for other countries in the region as well as for the Western Hemisphere, such as Canada. Treated primarily as an export commodity, government statistics on domestic trade and consumption are not available. However, processed products can be found in supermarkets in big cities; for example bêche-de-mer is a common ingredient in Chinese dishes but is largely unknown to local clientele. Between the fishers and the export market are a series of middlemen who have complete control over domestic prices, which in turn are largely influenced by the Chinese market. The fisher or middleman who does the primary processing of drying /chilling the product would first hoard a certain volume before selling to the next middleman in the city. Such practice allows a return of investment period of one week to several months.

Available scientific reports focus mainly on taxonomy and distribution; data on the rate of extraction have been limited to stories of localised depletion as narrated by the fishers during interviews. All those interviewed agreed that their catch per of unit effort has been declining significantly through the years that is, for two or three pieces of >500 g individuals, the fishers have to go to deeper waters for a longer time. Research and development (R&D) on the mariculture of the high value *Holothuria scabra*, began in 2000 with a long-term objective of producing seeds for the enhancement of the wild populations. Studies on an experimental scale were conducted to improve the survival rate of fertilised eggs to juveniles. Likewise, initial investigations on the growth of juveniles in cages in the field have begun. At full scale, the reseeding activity is envisioned to be a partnership between the academe and the stakeholders with the latter taking full charge of the management component. Recently, these R&D efforts suffered a major set back when financial support from the government was suspended.

Status of the sea cucumber fishery in the Red Sea: The Egyptian experience

Andrew J. Lawrence[1], M. Ahmed[1,2], M. Hanafy[2,3,4], H. Gabr[2], and Ashraf Ibrahim[2]
[1] *University of Hull, Department of Biological Sciences, Hull, UK. Email: A.J.Lawrence@hull.ac.uk*
[2] *Suez Canal University, Department of Marine Science, Ismailia, Egypt*
[3] *Egyptian Environmental Affairs Agency, Hurgada, Egypt*
[4] *The Red Sea Governorate, Hurgada, Egypt*

The beche-de-mer fishery in Egypt began in 1998 in the southern part of the country. Initially this was at a low level and primarily performed by trawling boats. By 2000 the fishery had expanded dramatically, leading to fears of overexploitation. As a consequence, The Red Sea Governorate initiated a ban on sea cucumber fishing in 2001 whilst a baseline survey and stock assessment could be performed. This survey began in 2001 and was undertaken jointly by the Egyptian Environmental Affairs Agency and Universities of Hull and Suez Canal through a UK government-sponsored Darwin Initiative project. The initial ban on fishing resulted in the development of a large illegal fishery along the coast of Egypt. In addition, pressure from the Government Fisheries Agency to re-open the fishery, led to the Red Sea Governorate lifting its ban in 2002. However, preliminary data collected by the Darwin project indicates that populations of commercial sea cucumber have undergone a rapid decline, and this has now led all government agencies and departments to realise that the resource needs immediate protection. Consequently, a new ban was decreed in March 2003 to cover the entire coastline. The government will make a new decision on the fishery in 2004 based on the results from the project stock assessment. This paper will review what is known of the current status of the fishery together with preliminary data collected as part of the stock assessment.

Population density and fishery impacts on the sea cucumber (*Stichopus fuscus*) in the Galápagos Islands

M. Verónica Toral-Granda[1] and Priscilla C. Martínez[1,2]
[1] *Marine and Coastal Research Department, Charles Darwin Research Station, Puerto Ayora, Isla Santa Cruz, Galápagos Islands, Ecuador. Email: vtoral@fcdarwin.org.ec*
[2] *Present address: Zoology Department, University of Melbourne, Parkville, Victoria 3052, Australia*

Over the last decade, the sea cucumber *Stichopus fuscus* has been the target of a continuous fishery in the Galapagos Islands. The increasing growth of this activity and its potential impacts prompted the Park authorities to initiate a participatory management programme to assess the status of the resource. From 1999 until date, density surveys of *S. fuscus* have been conducted before and after each fishing season by teams of fishers, naturalist guides, managers and scientists. Using a 100 m^2 sweep circular transect an average of 900 m^2 have been surveyed in specific sites of Fernandina, Isabela, Española, Floreana, Santa Cruz and San Cristóbal. A drastic decrease of density and size structure of *Stichopus fuscus* has been observed after each fishing season, with population densities partly recovered between fishing periods. In Isabela and Fernandina, a single recruitment event was recorded in April 2000, which reached its peak in March/April 2001 and probably helped the ongoing fishery on those islands. No recruitment has been detected on any other island. Nonetheless, current adult and juvenile densities show that *S. fuscus* populations in the Galápagos Islands are severely depleted and unless another recruitment pulse occurs with a complete ban on fishing activities, these populations are in serious risk.

From the sea to the market place: Issues, problems and opportunities of sea cucumber fisheries and trade

Mark Baine
Motupore Island Research Centre, University of Papua New Guinea, PO Box 320, University 134, National Capital District, Papua New Guinea. Email: markbaine@gaelmail.com

Using published information and an exploratory questionnaire, this paper presents the difficulties associated with the collation of official statistics on sea cucumber catch, effort and trade. This paper highlights specific problems associated with the identification of catch origins, illegal landings and trade, trans-boundary effects, taxonomic problems, confusing beche-de-mer categorisation, inadequate monitoring and a lack of internal national prioritisations and funding. It concludes with a clear presentation of the issues that need to be addressed and an analysis of the possible means by which to do so.

World markets and trade flows of sea cucumber

Fatima Ferdouse
INFOFISH, Trade Promotion Unit, 1st Floor Wisma PKNS, Jalan Raja Laut, PO Box 10899, Kuala Lumpur 50728, Malaysia.
Email: infish@po.jaring.my

The international trade structure for sea cucumber differs from the general trends in seafood. While its demand is restricted to Oriental Asians of Chinese origin, the market is also dominated by the same race. Sea cucumber species are mostly exported in dried form but a small quantity of fresh and frozen sea cucumber also enters into the international trade. Nearly 90 per cent of this trade takes place in the Asia Far East where Hong Kong (China) and Singapore dominate the business and China PR remains the main consuming area. The niche markets located outside Asia are strongly linked with trading houses in these two markets.

Regular supply of this seafood continues to remain in question and prices have increased over the years. However, it is interesting to observe the changes in consumption pattern of this highly traditional product outside of China.

Sea cucumber fishery and mariculture in Madagascar: A case study of Toliara, southwest of Madagascar

Richard Rasolofonirina[1,2] and Michel Jangoux[2,3]
[1] Institut Halieutique et des Sciences Marines, Université de Toliara, BP 141, Toliara 601, Madagascar. Email: aqua-lab@malagasy.com
[2] Laboratoire de Biologie Marine CP 160/15, Université Libre de Bruxelles, 50 Av. F. D. Roosevelt, B-1050 Bruxelles, Belgium. Email: rrasolof@ulb.ac.be
[3] Laboratoire de Biologie Marine, Université de Mons-Hainaut, 20 Place du Parc, 7000 Mons, Belgium. Email: mjangoux@ulb.ac.be

Sea cucumber fishing is a permanent activity in coastal regions of Madagascar, especially near coral reefs. Production of Malagasy trepang is based on family or artisanal fisheries, and the resource is entirely exported to Asian countries. The first exportation recorded in Madagascar was in 1920 with about 40 t of trepang from three species. Exportation varied annually from 50 to 140 t. Since 1990, sea cucumber harvesting greatly increased and resulted in the overexploitation of the resource. The maximum intensity of the exportation was recorded in 1994 with 540 t of trepang. The fishery then declined.

The number of species collected shifted from 8 in 1990 to 28 in 1996. At the present time, more than 25 species are exploited. The actual harvested species, however, vary according to the market price, the international demand and availability. *Holothuria scabra*, *H. nobilis*, *H. fuscogilva*, *Thelenota ananas* are the main species collected.

Declining export and strong competition between collectors indicates overexploitation of the resources, which affects the local economy and the environment. The situation of some fishermen's villages in the Toliara Province (southwest of Madagascar) is presented. A survey of the production of the main harvested species over one year was made and changes in sea cucumber processing techniques during the seven last years are presented.

Aquaculture is considered to be a solution for solving the problem of sea cucumber overexploitation. A hatchery has been built up in Toliara in 1999/2000 thanks to funds from the Belgian "Coopération Universitaire au Développement". The larval development and metamorphosis of the species *Holothuria scabra* are now under control. An additional project is now considered; it aims to master the growth process of post metamorphic sea cucumbers.

Current status of the sea cucumber fishery in the southeastern region of Cuba

Irma Alfonso, Ma. del Pilar Frías, L. Aleaga and C.R. Alonso
Fishery Research Centre, 5ta. Avenida #248. Barlovento, Santa Fé Playa, Ciudad de la Habana, Cuba. Email: irma@cip.telemar.cu

The analysis of the sea cucumber (*Isostichopus badionotus*) fishery, during August 1999 to June 2003 in the southeastern region of Cuba is synthesised. During the first two years of the fishery (1999–2000) more than three million individuals were captured. In that period, all fishing effort was conducted by one fishing enterprise with 12 boats, in the southeastern region. In 2001, the former enterprise was split into three fishing units, so the effort was then divided into three boats in order to arrange a better

management system. During the first two years, CPUE was around 1153 ± 630 sea cucumbers/boat/day. The capture and CPUE curves decreased throughout the year, until values reached lower than 500,000 individuals for the fishery season and almost 350 sea cucumber/boat/day, respectively. Currently, CPUE values are 1200 ± 200 sea cucumbers/boat/day. This general situation of declining CPUE does not constitute an index of a biomass decrease, as this index fluctuated between 4500 ± 4100 to 7610 ± 3600 ind./ha. The above statements are justified due to the logistical support failures (fuel, etc.) for a prime fishery during 2001–2002.

At present, efforts are being made to re-establish the normal fishery conditions. A total of 1438 t of wet weight have been extracted in the southeastern region, 920 t of this belonging to the two first years of the fishery. A capture of 200 t of wet weight for this region was planned during 2003, which is below the capture quota of 611 t. CPUE has been recommended for each fishery season and locality of no more than 1200–1500 sea cucumbers/boat/day, depending on the locality abundance. At present, around 68.9 t dry weight have been processed and sold in a Hong Kong (China) market and prices have increased from USD 13.5 (1999–2001), to USD 18.0 (2001–2002), and to USD 22.0 (2002–up to date) per kg of dry product, according to the product class and quality.

SESSION 2 - RESOURCES MANAGEMENT

Overfishing of holothurians: Lessons from the Great Barrier Reef

Sven Uthicke
Marine Ecology and Genetic Consulting, c/o AIMS, PMB No. 3, Townsville, Queensland 4810, Australia. Email: svenu@gbrmpa.gov.au

Holothurian fishing has a long tradition in Australia, and provided the first cultural contact of aboriginal and islander communities with non-Australians. These were Macassan fisherman and traders who visited centuries before European settlement. The trepang fishery continued in a typical "boom and bust" fashion. The last cycle commenced in the mid–1980s, and signs of overfishing are now evident. The main target species was the black teatfish (*Holothuria nobilis*). Initiated by a request by the fishing industry and supported by data obtained through studies presented here, the fishery on this species was subsequently closed in 1998. Surveys conducted in 1998/99 on over 60 reefs along the entire Great Barrier Reef (GBR) indicated that stocks of this species were generally lower in the southern half of the GBR. Probably for that reason, nearly the entire fishing effort was concentrated north of Townsville (ca. 12°S to 19°S). The design of the Great Barrier Reef Marine Park allowed a comparison between reefs fished and reefs protected from fishing (Green Reefs, or No Take Zones). This comparison showed that the fishery reduced the densities on fished reefs by about 75 per cent. GIS-based calculations indicate that an initial ("virgin") biomass of about 5500 t was reduced by 2500 to 3000 t. This figure corresponds well to the total reported catch since opening of the fishery.

These model calculations have three major implications for future management of *H. nobilis*, and potentially other species, on the GBR and elsewhere. 1) No take zones can provide an effective means for stock protection of these species. However, whether the area protected was sufficient as a source of recruits for the whole area is currently unknown. 2) The agreement between reported catch and total reduction of numbers indicates that recruitment is very low and fishing has simply reduced stocks over more than a decade without appreciable replenishment. Repeated surveys of 23 reefs one and two years after the closure of the fishery could not detect any recovery of the stocks, providing further evidence for little recruitment. 3) Annual catches of (on average) less than five per cent of virgin biomass severely reduced stocks of *H. nobilis*. This is in sharp contrast to notions that 20 to 40 per cent of virgin stock size might be taken annually. These data suggest an extremely cautious approach in the management of beche-de-mer fisheries.

When should restocking and stock enhancement be used to manage sea cucumber fisheries?

Johann Bell[1] and Warwick Nash[2]
[1] WorldFish Center, GPO Box 500, 10670 Penang, Malaysia. Email: j.bell@cgiar.org
[2] WorldFish Center, c/o Secretariat of the Pacific Community, BP D5, 98848 Noumea Cedex, New Caledonia. Email: w.nash@cgiar.org

Access to technology for producing and releasing juveniles is not a sufficient rationale to proceed with restocking (restoring stocks to the point where they can sustain regular harvests) or stock enhancement (increasing yields by overcoming recruitment limitation) of sea cucumber populations. Rather, careful decisions need to be made about whether these interventions are likely to be cost-effective ways of improving productivity. Although restocking is designed to restore severely depleted stocks, it will be essential to determine whether the release of cultured juveniles will significantly reduce the time needed for replenishment compared to other forms of management, e.g., artificially aggregating and protecting some of the wild adults to promote egg fertilisation rates, or a total moratorium on fishing. This will require an evaluation of population recovery rates under various restocking scenarios, and other interventions, using both theoretical (life table analysis and population modelling) and empirical approaches. The information needed for such comparisons includes: remnant stock size and density, population age/size composition, generation time, fecundity, annual variation in the recruitment rate, natural mortality at different life stages, and behaviour of the species that may affect spawning success or survival at low population density. Investments in hatchery production for restocking should only proceed when the modelling described above demonstrates that releases of cultured animals will "fast-track" replenishment considerably.

Stock enhancement can be considered once sea cucumber fisheries have been rebuilt to the desired level of spawning biomass, although it can only be expected to be of benefit where the supply of juveniles regularly falls well short of the desired levels of recruitment. To assess whether stock enhancement is likely to be effective, managers need sound information on: the carrying capacity of the habitat for sea cucumbers, the abundance and age structure of the stock, the natural supply of juveniles each year, the cost of cultured "seed" and post-release survival rates. Even where the supply of juveniles falls short of the desired level, stock enhancement will not be appropriate if the cost of producing the juveniles exceeds the value of the additional harvests expected to result from the releases.

Another important point is that stock delineation is central to the success of restocking and stock enhancement programmes. The assessments described above need to be made at the level of self-replenishing population units within the stock.

Criteria for release strategies and evaluating the restocking of sea cucumbers

Steven W. Purcell
WorldFish Center, c/o Secretariat of the Pacific Community, BP D5, 98848 Noumea Cedex, New Caledonia. Email: s.purcell@cgiar.org

Careful management should be the key to sustainable sea cucumber fisheries, and the release of hatchery-produced juveniles could speed the recovery of depleted stocks. Advances in methods for culturing sea cucumbers have allowed juveniles to be produced in high numbers for restocking. However, the lack of research on release methods and assessment of stock recovery jeopardises the success of restocking programmes. In order to gain credibility as a wise investment for resource management, programmes should rigorously demonstrate that releases of hatchery-produced juveniles contribute substantially to the replenishment of stocks.

A key criterion before releasing juveniles should be genetic similarity of stocks at release sites and sites of broodstock collection. Research is then needed on release methods, including the optimal mode of transportation, habitat, times of the day and season, and the most cost-effective size for release. Acclimation of juveniles to improve survival may include behavioural conditioning at the hatchery or temporary protection from predators upon release. Field experiments using replicate pen enclosures in New Caledonia have shown high initial survival and growth of hatchery produced *Holothuria scabra* juveniles in certain habitat types. The results also indicate that care is needed for the pen design and the method for extracting juveniles from sediments when conducting experiments. Spatial variability at small scales suggests that high replication is needed for experiments and that multiple release sites are essential for large-scale restocking.

Further to experiments on release methods, cost-benefit analyses at a larger scale will require larger experiments and an accurate evaluation of restocking effects beyond natural recruitment. Until tag-

ging methods for juveniles are developed, such research is likely to utilise experimental designs involving multiple release sites and control sites without released animals. Modelling of the visibility of animals using environmental variables, such as tide, time and temperature, can standardise the data from stock assessments and reduce sampling error. Non-linear mixed effects models offer improved detection of restocking effects, in comparison to ANOVA statistics, when the trends in visibility of animals at sites are temporally repetitive, e.g. seasonal trends. Incorporating these techniques into the analysis of abundance of sea cucumbers is likely to improve the resolution of stock assessments and restocking effects.

Studies on sea cucumbers in Tanzania and the gaps towards resource inventory and management

Twalibu K. Mmbaga and Yunus D. Mgaya
Department of Zoology and Marine Biology, University of Dar-Es-Salaam, PO Box 35064, Dar-Es-Salaam, Tanzania.
Email: Kithakeni@hotmail.com

The story of overexploitation of sea cucumbers in Tanzania has been repeated in many locations throughout the Indian Ocean. Collection methods include i) hand-picking, ii) collection by free-diving, using both ready-made and home-made goggles and iii) SCUBA diving in a few locations. Neither fishery regulations, sea cucumber mariculture, nor resource inventories have been conducted as steps towards management in Tanzania. Data were compiled from various works carried out on the sea cucumber resource in Tanzania and questionnaires were given to sea cucumber dealers and fishery officials. This approach showed several reasons underlying the lack of management of sea cucumber resources: a) the extent to which the stock size of this resource is known to fishermen of Tanzania, b) the lack of proper management framework and stock assessments on sea cucumbers and c) scientific orientation of funding agencies and research findings contrary to dealers' level of education and lack of technological capacity. The appropriate actions to achieve successful management of sea cucumbers should be taken in phases. That is, to raise fishermen's awareness, implementation of regulations, resource assessments, and establishment of pilot small-scale mariculture of the most known species in Tanzania, *Holothuria scabra*.

The Papua New Guinea national beche-de-mer fishery management plan

Philip Polon
Manager, Sedentary Fishery, National Fisheries Authority, PO Box 2016, Port Moresby, Papua New Guinea.
Email: ppolon@fisheries.gov.pg

Papua New Guinea exports more than 400 t of dry beche-de-mer annually, mainly to Hong Kong (China) and Singapore. A total of 21 species are harvested each year. The moving average for the last five years shows a gradual decline in catch rates. This has caused the establishment of the National Beche-de-mer Fishery Management Plan (NBFMP), which aims at sustainably managing the fishery in the country. The objectives are to ensure that the economic benefits, and social and environmental impacts of the fishery are recognised. The stakeholder participation is administered through the establishment of the National and Provincial Management Arrangements as one of the most important parts of the management plan. It ensures that stakeholders are regularly advised on the management of the fishery. The representatives bring perspectives from different provinces so that a large range of issues is considered as management recommendations are agreed upon.

A National Management Advisory Committee was formed and includes stakeholders from across the country. The Committee provides advice on most key management measures and reports to the Managing Director as well as decides when the plan needs revision. The Committee is involved in consultations with the beche-de-mer fishing community. The committees at the provincial level advise the National Advisory Committees on provincial management measures, forming a link with all stakeholders.

Management measures include the type of licenses, licence eligibility, licence requirement, export requirements, prohibitions, closures and reporting requirement. Licensees are closely monitored by the National Fisheries Authority (NFA) to ensure they comply with all management measures. In particular, reporting by exporters becomes even more important, being the only trade information NFA collects. A total allowable catch (TAC) is set for each of

two groups of species because the higher value species are more heavily fished than the lower value ones. Once the TAC of a value group has been reached, NFA closes the fishery, because it is too difficult to monitor the harvest of just one value group.

The trade of undersized and broken beche-de-mer is prohibited in order to protect the young and also to stop people from breaking up undersize beche-de-mer and trading and exporting it — making any undersize product difficult to detect.

A single closed season applies for the whole country during the spawning season from 1 October to 15 January. However, the fishery in each province closes when the TAC of a value group is reached or on the date of the season closure, whichever comes first. If the TAC in one province is reached, other provinces may continue to fish until their TAC is reached or the season is closed. Any customary management practices, which is/are consistent with the plan are recognised by the National Fisheries Authority and will be incorporated into the plan as schedule/s.

Management of trepang in the Northern Territory, Australia, and current research to further improve understanding of the fishery

Colin C. Shelley[1] and Philippe Puig[2]
[1] Darwin Aquaculture Centre, Fisheries Group, DBIRD, Darwin, NT 0801, Australia. Email: Colin.Shelley@nt.gov.au
[2] EWL Sciences, PO Box 39443, Winnellie, NT 0821 Darwin, Australia

Australian federal, state and territory fishery agencies, are committed to the concept of ecologically sustainable fisheries and as a result have in place a plan to demonstrate this for all Australian fisheries. As a result, the trepang fishery in the Northern Territory of Australia is being reviewed and a new research programme has been initiated to further quantify the current fishery, and to develop a suitable monitoring programme to underwrite its sustainability.

Archaeological and historical data from the late 19th and early 20th century demonstrate that current fishing grounds have been consistently harvested for over 300 years, indicating that long-term sustainability of trepang fishing is possible.

ArcView® was used to visualise fishing effort by location in the modern fishery after cleaning the initial dataset from fisheries logbooks. The same software was also used to determine relationships between trepang number and weight.

A fishery-independent survey of the existing trepang fishery and of potential new grounds is proposed for the next two years. This work will combine diver surveys and the use of target specific sampling gear towed by a trawler, utilising a stratified sampling approach to gain information on local habitat preferences. As 12 major fishing grounds account for over 90 per cent of the total catch of the fishery, these will be targeted in the survey, with biological, physical and habitat data being collected on a relatively fine scale.

Beche-de-mer – the West Australian perspective: The fishing history and aspects of the reproductive biology and ecology of the black teatfish, *Holothuria nobilis*

Glenn R. Shiell
School of Animal Biology, The University of Western Australia. Email: cucumber@cyllene.uwa.edu.au

The fishing history and biological aspects of sea cucumbers, namely the abundance, distribution and reproductive activity, are discussed from a Western Australian perspective. There is little information regarding the sea cucumber fishery in Western Australia (WA), and only a limited history of government sanctioned fishing operations. Fisheries in Western Australia currently support six beche-de-mer fishing authorisations. In addition, some fishing is undertaken by a small number of remote aboriginal communities. Management of the WA beche-de-mer fishery will be reviewed post 2007.

The reproductive cycle of the black teatfish, *Holothuria nobilis*, from the Ningaloo Reef, Western Australia, was investigated over the 30-month period, from July 2000 to January 2003. Reproductive activity in *H. nobilis* peaks in late autumn through winter. This pattern follows closely that demonstrated in northeastern Australia and New Caledonia. The timing of spawning and its implications for larval dispersal within WA are discussed.

The abundances of commercial sea cucumber inhabiting Ashmore Reef, Cartier Reef, Ningaloo Reef and Rowley Shoals, NW WA, are described with particular reference to the black teatfish, *H. nobilis*. Observable deleterious fishing pressure has affected both Ashmore and Cartier reefs; abundances of black teatfish are less than 1 individual ha^{-1} in both

cases. Ningaloo Reef and Rowley Shoals, both representing areas closed to beche-de-mer fishing, maintain healthy populations of black teatfish, with abundances ranging between 19 to 27 and 40 to 80 individuals ha^{-1}, respectively. Numbers reported from the latter reefs approximately equal or exceed those reported on reefs that are closed to fishing on the Great Barrier Reef. Hence, it is doubtful Ningaloo Reef or Rowley Shoals have experienced significant fishing pressure in recent times, if at all.

The distribution pattern of adult *H. nobilis*, *H. atra* and *Stichopus chloronotus* was examined on the Ningaloo Reef. Results to date demonstrate distinct distributional patterns between *H. nobilis* and *S. chloronotus*. Relatively, *H. atra* showed little or no pattern of distribution. Studies are underway to determine the relationship between species distribution and physical habitat characteristics.

In contrast to adult sea cucumber, very little to no data exist on habitat preferences of juvenile holothurians. This report highlights the need for in situ research examining the ecology of juveniles and tabulates existing observations of juveniles in their natural habitat. Understanding habitat preferences of juvenile sea cucumbers is crucial to the development of aquaculture-based restocking programs aimed at replenishing areas affected by overfishing.

Management of the Seychelles sea cucumber fishery: Status and prospects

Riaz Aumeeruddy and Rondolph Payet
Seychelles Fishing Authority, PO Box 449, Victoria, Seychelles. Email: raumeeruddy@sfa.sc

For a long time, the sea cucumber fishery in the Seychelles has been open-access with no management measures in place. The fishery has remained relatively unimportant since the 1950s but has recently seen a rapid development due to the increase in demand for beche-de-mer on the international market. The lack of information on the fishery makes it difficult to ascertain its development, as well as the stocks of sea cucumbers. Six species *Holothuria nobilis*, *H. scabra*, *H. fuscogilva*, *Thelenota ananas*, *Actinopyga mauritiana* and *A. lecanora* are currently exploited, mainly for the export market. The fishery is located on the Mahé Plateau surrounding the main granitic islands of the Seychelles and further south on the Amirantes Plateau. Around 33,000 kg of beche-de-mer were exported in 2002.

Signs of stock reduction have been evident during the past four years, as fishers have to dive deeper, sometimes using scuba. In order to avoid further depletion of stocks, a precautionary approach was taken by the Seychelles Fishing Authority. Some management measures were introduced in 1999 to regulate access to the fishery. A license for fishing and processing sea cucumbers was introduced but the licensees failed to provide adequate and timely catch data. The main constraints in controlling the fishery are the lack of human and financial resources. Fishery dependent data based on catch reports lack accuracy, and catch is often under-reported. This led to more stringent regulations whereby catch and effort reporting became mandatory, and a limit imposed on the number of fishing licenses. Despite these measures, signs of localised overexploitation were evident, and the Seychelles Fishing Authority was charged to conduct a stock assessment and produce a rational management plan for the sea cucumber fishery.

Due to the lack of in-house expertise, the FAO was approached to fund a stock assessment and management programme. The project, which is expected to start in late 2003 will have two major outputs and associated capacity-building. The first output is expected to produce a comprehensive and sustainable programme to assess sea cucumber resources and monitor the development of the fishery. The second output is the development and implementation of a management plan with a revised and improved licensing, reporting and enforcement mechanism; a framework for improved fishers' and stakeholders' participation in the management of the holothurian resource, and a strong link between the scientific assessment of the resources and the regulation of the fishery. The participation of fishers in drafting the management plan will hopefully give them an enhanced sense of responsibility towards the fishery. As a long-term strategy, the project will also look at the potential of sea cucumber culture for restocking purposes.

Holothuria nobilis **(Photo: Aymeric Desurmont)**

The application of the adaptive principle to the management and conservation of *Stichopus fuscus* in the Galápagos Islands, Ecuador

Manfred H. Altamirano and M. Verónica Toral-Granda
Department of Marine Research and Conservation, Charles Darwin Research Station, Galápagos Islands, Ecuador.
Email: vtoral@fcdarwin.org.ec

Beche-de-mer fishing started in the Galápagos Islands in 1999 after commercial depletion of the populations in mainland Ecuador. The management of this fishing activity has evolved from top-down decisions on the little regulations to an adaptive and participatory management scheme. This scheme involves the direct participation of local stakeholders. All decisions approved by a consensus in the local discussion forum (Junta) are then set into law by the government. This strategy is adaptive as it takes into account previous experiences to better the current management of the species.

This paper presents an historical overview of the management regime since the 1990s. We present a conceptual framework, based on which the regulations have been passed in order to support the management of *Stichopus fuscus* on a sustainable level. Changes in the management have been achieved, due mainly to two key factors: 1) the innovative participatory system implemented by the Ecuadorian Government for the management of the Galápagos Marine Reserve (GMR), which enables the equal participation of stakeholders: science and conservation, tourism, fishing and managers. All decisions regarding the GMR, including the management of *S. fuscus* are taken on a consensus with later approval by the Government; and 2) the availability of demographic, biological and ecological information on this species, which acts as a tool on the decisions taken by the stakeholders. Population density information in over 60 sites in all fished islands, reproductive biology, fishery statistics and ecological information has enabled the production of specific regulations aiming to produce a sustainable fishery.

Finally, the document highlights the obstacles such as changes in representatives to the local forum and the social and economic pressure exerted by the fishers and their families, which prompted government decisions in detriment of the species.

Customary marine tenure in Solomon Islands: A shifting paradigm for management of sea cucumbers in artisanal fisheries

Christain Ramofafia, Idris Lane and Cletus Oengpepa
WorldFish Center, PO Box 438, Honiara, Solomon Islands. Email: c.ramofafia@cgiar.org

With limited success of western models to manage fisheries resources, customary marine tenure (CMT) could be a more effective vehicle for forming and imposing sustainable management of sea cucumber resources in Solomon Islands. Analysis of national export data from 1991 to 2001 shows a decreased landing of sea cucumbers from a record level of 622 t (dried) in 1991 to 240 t (dried) in 2001, with > 75 % of the 2001 landings derived from species of medium- and low-commercial value. The resources appear to be overexploited as the falls in landings contrast sharply with the increase in both the exploitation of non-traditional fishing areas and participation of fishers in the fishery in the last 10 years.

The recent years (1998–2000) of civil war and resulting economic hardship in the country have left the sea cucumber resources extremely vulnerable to unsustainable and destructive exploitation. This vulnerability has been complicated by a marked weakness in the government's capacity to formulate and implement the necessary policies to protect these resources. Regulations such as size limits, bag limits, gear restrictions and seasonal closures (which are ad hoc in nature) have failed to achieve the desired aims, due in part to the limited human, financial and technical resources. Given the failure of centralised management of the fishery, the CMT system is likely to be a better tool for managing the sea cucumber resources. Because the CMT system is community-based and the inshore marine resources fall under this jurisdiction, active participation of fishing communities and resource owners in forming and implementing management strategies at the community level is fundamental within this context.

Management of these resources should be transferred to communities and should entail the enforcement of regulations such as bag limits, gear restriction and seasonal closures, species rotation and area restriction. These should be implemented in accordance with the local system of CMT. This shift in the management mode will give a feeling of ownership and control within the communities, providing and empowering them to determine plans, activities and methods of implementation, fitting to local circumstances and needs. In contrast, the national government would undertake a supportive and coordi-

nating role, developing policy and regulatory frameworks. The shift to customary management of sea cucumbers should reduce or halt the current overfishing and reveal an alternative approach for artisanal communities in the Pacific.

Fishing, processing and the resource management of sea cucumber in the archipelagos of Dongsha, Nansha, Xisha, and Zhongsha

Li Xiangmin
Fisheries Research Institute of Hainan Province, 2 Haixiu Dong Lu, Haikou City, Hainan Province, China. Email: yis999@public.hk.hi.cn

Dongsha Islands, Nansha Islands, Xisha Islands and Zhongsha Islands of the South China Sea are situated in the tropics and subtropics and are rich in sea cucumber resources. Generally there are eighteen species of sea cucumbers in the area: *Actinopyga echnites*, *A. lecanora*, *A. mauritiana*, *A. miliaris*, *Bohadschia argus*, *B. marmorata*, *Holothuria arenicola*, *H. atra*, *H. cinerascens*, *H. edulis*, *H. impatiens*, *H. leucospilota*, *H. nobilis*, *H. pervicax*, *H. scabra*, *Stichopus chloronotus*, *S. variegatus*, *Thelenota ananas*. These inhabit the seabed of coral reefs 70 metres deep and feed on organic matter and micro-organisms in the coral sand. For more than 400 years fishers in the eastern Hainan Island have visited Xisha Islands and Nansha Islands to catch sea cucumbers using a specially designed tool named "fork to sea cucumber". Processing of sea cucumbers includes three steps: cleaning out the viscera, cooking and drying. When sea cucumbers are cooked and dehydrated, care is needed in controlling intensity of the fire and the degree of cooking, according to the boiling duration and changes in colour of sea cucumber. Sea cucumbers are rich in ingredients such as protein and amino acids, and are a Chinese traditional medicine as well as a delicious dish. The extended, excessive fishing has caused the resources of sea cucumbers in these four islands to gradually decline. To promote the reasonable utilisation and sustainable fishing of these resources, a plan to protect some regions from fishing should be outlined in the islands where the resources are rich. At the same time, the fishing season and minimum legal size for capturing sea cucumbers should be restricted to preserve adequate breeding populations. Moreover, studies are needed on the artificial reproduction of economically important species of sea cucumber which are also essential to maintain an ecological stability of this resource.

SESSION 3 - AQUACULTURE ADVANCES

Sea cucumber (*Apostichopus japonicus*) pond polyculture in Dalian, Liaoning Province, China

Chang Yaqing[1], Yu Changqing[2] and Song Xin[2]
[1] *College of Life and Technology, Dalian Fisheries University, 52, Heishijiao Street, Dalian, Liaoning Province, 116023 China. Email: yqchang@dlfu.edu.cn*
[2] *Liaoning Province Fisheries Seeds Management Bureau, Dalian, Liaoning Province, China.*

The sea cucumber *Apostichopus japonicus* Liao can be found in Korea, Japan, the eastern shores of Russia, and along the coast of China. It is a favourite seafood in these areas, especially in China. Aquaculture research on this species began in the middle of the 1980s. There were great progresses made in the breeding and larval rearing of *A. japonicus*, which promoted the rapid development of the aquaculture industry in Dalian, Yantai, Weihuai, and Qingdao in northern China. In the early 1990s, numerous coastal ponds, traditionally used for prawn culture, were abandoned due to the emergence of diseases. Hence, many ponds were restored and used for sea cucumber mono-culture or in polyculture with shrimp. Both methods proved to be financially profitable.

There are more than 2000 hectares of ponds used for polyculture of sea cucumber and shrimp in the Dalian area. The best results are obtained in leak-proof ponds with muddy-sand bottoms. The typical size of a pond is usually between 2 and 6 hectares. Water depth is maintained at 1.5–2.5 m. The seawater is changed by opening and closing the sluice gates with the change of tide. The salinity is 25–35 ppt and the water must be clean and unpolluted. The survival rate varies according to the size of the juveniles. Individuals larger than 2 cm will have a survival rate of 20–30 per cent. The rate of survival will increase if stocking is carried out with larger specimens. The stocking density of sea cucumbers and shrimp is 10,000–15,000 and 1500–3000 per hectare, respectively.

During the culture, the quality of the seawater, and the growth of sea cucumbers and shrimp, should be monitored daily, and the food supply adjusted accordingly. Undesired algae species and harmful organisms should be regularly removed from the ponds. The depth of the water must be maintained throughout summer and winter. After about 1.0–1.5 year, the sea cucumbers can either be collected by divers or taken out after the ponds have been properly drained.

Advances and prospects of sea cucumber (*Apostichopus japonicus*) aquaculture in China

Sui Xilin
Liaoning Marine Fisheries Research Institute, 50 Heishijiao Street, Dalian, Liaoning Province, 116023 China.
Email: dlmel@mail.dlptt.ln.cn

This article summarises the latest progress in the artificial breeding and aquaculture of sea cucumbers *Apostichopus japonicus* Liao along the coast of Dalian, China. The development of specialised techniques will be discussed, emerging problems analysed and future prospects outlined. For the artificial breeding, the broodstock sea cucumbers are maintained under low temperatures (15–16ºC) to maximise the quality, quantity and maturity of the gametes. The density of larvae is kept under 1.0 ind. ml^{-1}. The algae *Dunaliella euchlaia*, *Chaetoceros gracilis*, *Chaetoceros muelleri*, *Nizschia closterium* and *Phaeodactylum tricornutum* can be selected as food for the larvae, whereas *Sargassum* sp. is used to feed the juveniles. The quality of the seawater is a basic requirement for larval and juvenile production.

The grow-out of sea cucumbers is mainly carried out in former shrimp ponds and newly-built ponds in the in-shore regions of Dalian. It has become an important industry after more than ten years of development; the area used for farming is now exceeding 70 hectares. A recently developed model of culture in open sea will be presented in this paper.

Breeding and culture of the sea cucumber *Apostichopus japonicus*

Wang Renbo and Cheng Yuan
Dalian Bang Chuidao Marine Products Co. Ltd, Cheng Zi, Dalian Developing District, Dalian, Liaoning Province, 116045 China. Email: dcdhs_dl@163.net

Apostichopus japonicus Liao is the most important and valuable commercial sea cucumber species in China. The life cycle of *A. japonicus* includes the following stages: auricularia, doliolaria, pentactula, juvenile sea cucumber, young sea cucumber and adult. This paper outlines the several spawning induction methods and artificial rearing techniques. The specific means of cultivation during the different stages of development, the control of chemical and physical factors in the seawater and the prevention and cure of diseases and harmful life-forms will be discussed. The work compares different methods of culture and their respective merits and limitations.

At present, artificial breeding and culture of sea cucumbers is still a work in progress, but the scale of the production is increasing and a number of questions related to the culture techniques are being raised, calling for further studies on the commercial aspects of *A. japonicus* aquaculture.

Studies on hatchery techniques of the sea cucumber *Apostichopus japonicus*

Liu Xiyin[1], Zhu Guanghui[1], Zhao Qiang[1], Wang Liang[1] and Gu Benxue[2]
[1] Yantai Fisheries Research Institute, 162 Nandajie, Yantai, Shandong Province 264000, China. Email: shuichansuo@163.com
[2] Penglai De-run Sea-treasure Hatchery Plant, Penglai, China.

In this paper the authors give an outline of hatchery systems and breeding techniques of the sea cucumber *Apostichopus japonicus* in north China. The selection and maintenance of broodstock, spawning induction method and larval rearing, stimulation of settlement, juvenile growth and management of wintering are presented. The cause of some common diseases observed in the hatchery such as "rotten-stomach" of larva, low success of larva metamorphosis, and mortality of juvenile sea cucumbers are discussed, together with methods used for preventing such problems.

Diseases of cultured sea cucumber (*Apostichopus japonicus*) in China

Wang Yin-Geng[1], Zhang Chun-Yun[2], Rong Xiao-Jun[2], Chen Jie-Jun[2], Shi Cheng-Yin[1], Sun Hui-Ling[1] and Yan Jing-Ping[1]

[1] *Yellow Sea Fisheries Research Institute, Chinese Academy of Fishery Sciences, 266071 Qingdao, China. E-mail: wangyingeng@hotmail.com / wangyg@ysfri.ac.cn*

[2] *Ocean University of China, 266003, Qingdao, China*

Ever since the artificial breeding technique of *Apostichopus japonicus* has been broken through in the 1980s, Chinese researchers have been making efforts to efficiently develop and improve the rearing protocols. In recent years, sea cucumber aquaculture has developed rapidly along the northern coast of China, where more than one billion seeds can be produced and 90,000 t of sea cucumber (fresh weight) can be harvested every year.

The rapid expansion and intensification of sea cucumber farming has led to the occurrence of various diseases, causing serious economic losses and becoming one of the limiting factors in the sustainable development of this industry. Recently, a study was carried out on the diseases of cultured sea cucumber, revealing that several non-reported diseases have been discovered. The epidemiological study showed that the syndromes of rotting edges, ulceration of the stomach in auricularia stages and autolysis of young juveniles were caused by bacterial agents, whereas skin ulceration, erosion of epidermis and body oedema were triggered by various pathogens including bacteria, fungi and parasites during the outdoor cultivation. These pathogens induced high mortality rates, occasionally reaching up to 80 per cent. Upon the isolation of these etiological agents, morphological, physiological, biochemical, molecular and pathological studies have been performed, and a preliminary identification of the isolated agents was conducted in the present study.

Parasites and biotic diseases in field and cultivated sea cucumbers

Igor Eeckhaut[1,2], E. Parmentier[3], P. Becker[1], S. Gomez da Silva[4] and M. Jangoux[1,2,4]

[1] *Université de Mons-Hainaut, 6 ave. du Champ de mars, B-7000 Mons, Belgium. E-mail: Igor.Eeckhaut@umh.ac.be*

[2] *Laboratoire Aqua-Lab, c/o Institut Halieutique et des Sciences Marines (IH.SM), Université de Tulear, 601 Tulear, Madagascar*

[3] *Laboratoire de morphologie fonctionnelle et évolutive, Université de Liège, Institut de Chimie - B6C, Sart Tilman , B-4000 Liège, Belgium*

[4] *Université Libre de Bruxelles (CP160/15), 50 ave. F.D.Roosevelt, B-1050 Bruxelles, Belgium*

Amongst echinoderms, the Holothuroidea represents the class that is the most infested by parasites. Parasites of holothuroids are Bacteria, Protozoa and Metazoa. There are about 150 species of metazoans which parasite holothuroids. Most of them are turbellarians, gastropods, copepods, crabs or fishes. The main body organs suffering from infestation are the digestive system and the coelom. The diseases induced by metazoan parasites are mostly structural: they create galls at the surface of the epidermis, pierce the respiratory tree or dig into the body wall down to the coelom. Most metazoans that live in the digestive system do not induce obvious diseases and their relationship with their hosts is probably close to commensalism. Most Protozoa that parasite holothuroids are sporozoans. They occur mainly in the coelom and/or the haemal system, one species having been reported infesting the gonads. Even in heavily infested hosts, the signs of disease induced by sporozoans are low: at most, host haemal lacuna is occluded by trophozoites or cysts are formed into the coelomic epithelium.

The most frequent pathogen agents reported from cultured sea cucumbers are Bacteria. Cultivated holothuroids may suffer from a bacterial disease affecting their body wall. In particular, juvenile *Holothuria scabra* reared in the Aqua-Lab hatchery of Toliara, Madagascar, suffered from a very contagious disease, which was due to a severe bacterial infection that caused death within three days. The first sign of the infection is a white spot that appears on the integument of individuals, close to the cloacal aperture. The spot extends quickly onto the whole integument leading to the death of individuals. The white spot lesions consist in a zone where the epidermis is totally destroyed and where collagen fibres and ossicles are exposed to the external medium. This zone is surrounded by a borderline where degrading epidermis is mixed with connective tissue. White spot lesions include three bacterial morphotypes: rod-shaped bacteria, rough ovoid bacteria, and smooth ovoid bacteria. Three species of bacteria have also been put in evidence in the white spot lesions thanks to biomolecular analyses (DGGE and sequencing): *Vibrio* sp., *Bacteroides* sp., and an a-Proteobacterium.

Nutrient requirements and growth of the sea cucumber *Apostichopus japonicus*

Sun Huiling, Liang Mengqing, Yan Jingping and Chen Bijuan
Yellow Sea Fisheries Research Institute, 106 Nanjing Road, Qingdao, Shandong Province, 266071 China.
Email: sunhl@ysfri.ac.cn / sonny@public.qd.sd.cn

The sea cucumber *Apostichopus japonicus* (Echinodermata, Holothuroidea, Aspidochirotida, Stichopodidae) is widely distributed in the waters off China, Japan, Korea and Russia. In China, the species is mainly distributed in the Bohai Sea and the Yellow Sea. Studies on *A. japonicus* started in the 1950s when scientists from China and Japan first tried to develop breeding techniques. During the 1980s, Chinese scientists made a break-through in the larval-rearing of sea cucumbers and made considerable progress in the culture techniques on a commercial scale. Over the last decade, the farming industry of *A. japonicus* has been developing quickly. As of 2003 in the Shandong Province, a total volume of 145,000 m^3 of larval-rearing facilities is being used to produce up to 1.27 billion juveniles. It is estimated that the cultivation areas span on some fifteen thousand hectares and that a harvest of 2250 t can be expected.

Research on sea cucumbers is a relatively recent field of interest. Worldwide, there are only a limited number of reports on the feeding and growth of juveniles. The present paper summarises the latest results on the nutritional requirements of A. japonicus. The feeding experiment was conducted over 70 days by giving artificial feed, mainly composed of fish meal, Sargassum thumbergii and lees, to juvenile sea cucumbers. Using Cr_2O_3 as a marker, we determined that the weight gain rate and digestibility increased with the protein contents of the feed. The optimal protein content was 21.49 per cent. Based on a 40-day growth experiment, during which five different feed formulas were essayed, we found that the increment of weight gain rate was maximal when the food was rich in threonine, valine, leusine, phenylalanine, lysine, histidine and arginine. The highest growth rates were obtained when the ratio between calcium and phosphorus content ranged from 6.78 to 8.80. However, the weight-gain rate decreased when the juveniles were given a fibre-rich feed.

Sandfish breeding and rearing in Vietnam

Rayner Pitt[1] and Nguyen Dinh Quang Duy[2]
[1] WorldFish Center, c/o Research Institute for Aquaculture No. 3, 33 Dang Tat, Nha Trang, Vietnam. Email: worldfish-vietnam@cgiar.org
[2] Research Institute for Aquaculture No. 3, 33 Dang Tat, Nha Trang, Vietnam. Email: haisamduy@yahoo.com

The aims of this project were to develop large-scale breeding and rearing methods for sandfish (*Holothuria scabra*) for commercial culture and/or restocking. The work was carried out in Khanh Hoa Province, Vietnam.

Wild-collected sea cucumbers were initially difficult to spawn. After a period in earthen ponds or seabed pens the broodstock could be induced to spawn year round using temperature changes, emersion, treatment of water with UV light, addition of dry phytoplankton etc. Numerous batches of larvae have been reared to settlement and further, using simple hatchery methods.

Juveniles coming out of the indoor hatchery tanks (mostly below 3 mm in length and about 1 µg in weight) have been grown to a few grams or tens of grams in two or three nursery stages. Trials have been carried out to test these nursery stages. This has been done using different kinds of tanks, in a range of earthen ponds, sometimes using hapas (fine-net bags), larger bag nets and pens inside the ponds, and in the sea using various seabed cages, covers and pens. Nursery has been carried out in monoculture and in polyculture with the shrimp *Penaeus monodon* or the Babylon snail *Babylonia areolata*.

Further growout of nursed juveniles has also been tested in ponds, pens and cages. Big pens (up to 2000 m^2) were built in marine protected areas and stocked with hatchery-produced sandfish, to test their potential as alternative income sources for local fishermen. Growout has often been rapid, in the range of 1–3g day^{-1}. At best, pond growth from 30 g to 300 g has been achieved in only 3 months. Hatchery-produced sandfish from ponds were spawned at less than one year of age, and several batches of their progeny have been produced. Pens have proved cheap and effective for holding broodstock and for ongrowing.

Constraints in sandfish culture include low prices paid by dealers, the large area needed for nursery and growout (growth often slows down or stops when stocking densities exceed about 150–300g m^{-3}), high variability in survival rate at many stages, pre-

dation pressures (including predation by shrimp), the need to guard pens against theft and problems of pond management. Positive factors include the relatively high tolerance of this species to temperature and salinity changes, ease of containment, the fact that sandfish do not need addition of feed in ponds or pens and the idea that they may help to clean the pond floor or seabed of organic matter associated with other aquaculture activities.

Coastal population surveys have not yet been carried out, and only a few small releases of hatchery-produced sea cucumbers made. Natural recovery of overfished sea cucumber populations may be delayed by various factors at different stages in the life cycle. This needs to be better understood in order to design and test possible interventions, including restocking with hatchery-produced juveniles. It is hoped that the information obtained on growth rates and stocking densities, age at maturity and year-round egg production will be of value in this process.

Aquaculture of the Galapagos sea cucumber *Isostichopus fuscus*

Annie Mercier[1], Roberto Ycaza Hidalgo[2] and Jean-François Hamel[1]

[1] *Society for the Exploration and Valuing of the Environment (SEVE), 655 rue de la Rivière, Katevale (Québec) Canada J0B1W0. Email: seve@sympatico.ca*

[2] *Plasfel S.A., 10 de Agosto y Malecon, Piso 9, Oficina 3, Guayaquil, Ecuador. Email: rivex@speed.net.ec*

This paper presents the results of the first attempt to breed the sea cucumber *Isostichopus fuscus* in land-based installations on the coast of Ecuador. This species has been intensively fished along the mainland and around the Galapagos Islands, where efforts at management have always met strong opposition from local communities. Ecuadorian populations of *I. fuscus* have thus been severely depleted over the past decade. The topics presented here include spawning, fertilisation, larval rearing, disease control and juvenile growth. Data pooled from monthly trials conducted over three years indicate that, under optimal conditions, juveniles can be grown to a size of ca. 8 cm in length in 3.5 months. The survival rate is typically between 30 and 50 per cent. Furthermore, preliminary experiments have shown that the growth of young sea cucumbers in old shrimp ponds is a promising option. Overall, this study demonstrates that *I. fuscus* can be reared in captivity, thus providing an alternative to fisheries, or a way to maintain sustainable harvests and eventually contribute to the restoration of the natural populations.

Synchronous gamete maturation and reliable spawning induction method in holothurians

Jean-François Hamel and Annie Mercier

Society for the Exploration and Valuing of the Environment (SEVE), 655 rue de la Rivière, Katevale (Québec) Canada J0B1W0. Email: seve@sympatico.ca

Several years of research on the gametic development and spawning of different species of holothurians have produced results that find applications in aquaculture and fisheries management programs. The first set of data shows that sea cucumbers secrete a biologically active chemical, which allows gamete synthesis synchrony among conspecifics. Laboratory experiments have revealed that the gametic development was significantly less synchronous among individuals that were maintained separately under natural environmental conditions than it was among similarly treated individuals kept in group. Furthermore, the presence of mature individuals was found to induce the gametic development of less mature ones. The active substance is present in the mucus secreted by the body wall, enabling it to travel fair distances, although transmission is often favoured by pairing and aggregative behaviours. These findings indicate that the lunar cycle, photoperiod, food supply and temperature cannot individually account for the onset and synchronisation of reproduction, but rather that environmental cues act synergistically and can be transmitted within and between populations through chemical communication. This has repercussions on both fisheries and aquaculture techniques. Preserving untouched populations while fishing intensively on other grounds should be favoured compared to steadily lessening the biomass, whereas broodstock should be maintained in a way that promotes interactions long before the breeding season. The other aspect of the study propped up from the fact that holothurians are among the most commercially valuable echinoderms for which successful spawning induction is still difficult to obtain on a reliable basis. Recent results show that the transfer of perivisceral coelomic fluid (PCF) can be used as a reliable tool to induce spawning in mature individuals. PCF collected from individuals that had been in the typical spawning posture, without shedding gametes, for about 20 min triggered spawning in 71 to 100 per cent of conspecifics. The individuals responded to the injection of a 2–3-ml aliquot by displaying the spawning posture within 30–62 min, followed by massive gamete broadcast 57–83 min later.

The results varied according to the time of PCF collection with respect to the spawning activity of the donor and the amount of PCF injected. The inductive substance was found not to be sex-specific since positive responses were observed in individuals of the same or opposite sex as the donor. Thus, PCF collected from early spawners, usually males, can be used to spread and maximise the spawning success.

Mariculture of sea cucumber in the Red Sea: The Egyptian experience

Howaida Gabr[1], Ashraf Ibrahim[1], Mahmoud Hanafy[1,2,3], Andrew Lawrence[4] and Mohammed Ismail[1]
[1] Suez Canal University, Department of Marine Science, Ismailia, Egypt. Email: ashrafibrahim2002@yahoo.com
[2] Egyptian Environmental Affairs Agency, Hurgada, Egypt.
[3] The Red Sea Governorate, Hurgada, Egypt.
[4] University of Hull, Department of Biological Sciences, Hull, United Kingdom. Email: A.J.Lawrence@hull.ac.uk

Severe overfishing of sea cucumbers has occurred in most countries of the world. Even though they were abundant on the Red Sea coast of Egypt in the mid 1990s, sea cucumber populations are now significantly reduced and some species have almost disappeared. As a consequence, and as part of a Darwin Initiative project, the release of cultured juveniles is being examined at the Marine Science Department in Suez Canal University, Egypt, as a means of restoring and, eventually, enhancing sea cucumber stocks. One of the most important sea cucumber species occurring along the Red Sea coasts is *Actinopyga mauritiana*. Worldwide, this species is highly valued, in great demand, and harvested in large numbers. This paper summarises the morphological characteristics, anatomy and biology of this species as an introduction, before over-viewing the spawning methods attempted in the Red Sea. The results indicate that outside the spawning season, asexual propagation methods appear the most practical option for increasing the stock of cultured individuals. However, this will only be practicable if the mortality rate of *A. mauritiana* can be reduced during the process. If successful, there is some potential to use this technique in hatcheries with minimum costs.

Captive breeding of the sea cucumber *Holothuria scabra* from India

Daniel B. James
No 37 Sadasiva Metha Street, Metha Nagar, Chennai-600 029, India. Email: baskar_james@yahoo.com

The present report deals with the hatchery and culture techniques of the sea cucumber *Holothuria scabra* from India. Larvae and juveniles were produced for the first time in 1988 at the Research Centre of Central Marine Fisheries Research Institute of Tuticorin on the south eastern coast of India. Large, healthy and uninjured specimens were selected as broodstock. They were stocked in one-tonne tanks in the hatchery. Mud from the natural habitat was collected and put at the bottom of the tanks for the sea cucumbers to bury. The seawater in the tank was changed daily and the bottom mud was changed every fortnight. At Tuticorin, this species was subjected to thermal stimulation during March–May, the major breeding peak and also during November–December, the minor breeding peak. First the males released the sperms within three hours after stimulation, followed by the females, about an hour later. The eggs were washed in fresh seawater and stocked at a density of 0.3 million eggs per 750 litres of seawater. Early the next day, auricularia larvae were developed. These larvae were fed on a microalgal culture of *Isochrysis galbana*. On the tenth day some of the auriculariae transformed into doliolariae. They were smaller than the auriculariae in size, highly motile and non-feeding. After three days some of them transformed into pentactula larvae. They were fed on a mixed culture of *Chaetoceros calcitrans* and *Tetraselmis chuii*. The water in the tanks was changed daily but the bottom was not cleaned to allow the algae to settle. After two months the juveniles reached a length of 20 mm.

These juveniles produced in the hatchery were grown in one-tonne tanks, rectangular cages, velon screen pens and netlon screen pens, concrete rings at Karapad Bay, Valinokkam Bay and inside the harbour area for security. Best growth was noticed when the juveniles were grown in a prawn farm near Tuticorin. It is well known that much of the feed given to the prawns goes to waste, settling at the bottom of the farm pond enriching the farm soil, at the same time polluting the environment. The sea cucumbers are detritus feeders subsisting on the organic matter present in the substrate. The presence of the sea cucumbers at the bottom of the farm pond in no way affects the activities of prawn farming. In fact, the prawns grow faster since the excess of food on the bottom is removed and the environment is kept cleaner by the presence of sea cucumbers. It is an ecofriendly practice that is beneficial both to prawns and sea cucumbers. In recent years the prawn farming industry in India is rocked by disease and legal problems. The culture of sea cucumbers in prawn farms comes as a boon for the prawn farmers.

2- VISIT OF HOLOTHURIAN FARMS AND HATCHERIES
(16 October 2004)

A visit of two large holothurian farms, probably the largest in Asia (or the World) was organised. Visitors were very impressed by the size of the facilities and the quality of the infrastructure. The firms manufacture themselves all the elements necessary to the hatchery and farm (feed, etc. . .). They produce also other marine resource such as abalone, urchins but their principal activity is based on the production of sea cucumbers. A farm can produce several millions of sea cucumbers per year. You will find below some information on and several pictures of the two companies visited by the Workshop participants.

Company Name: Dalian Bang Chuidao Sea Cucumber Development Co. Ltd.
Contact Person: Mr LIU Chun Sheng
Address: Chengzi, Dalian Developing District, Dalian, Liaoning Province, 116045 China
Tel: +86 411 7227888

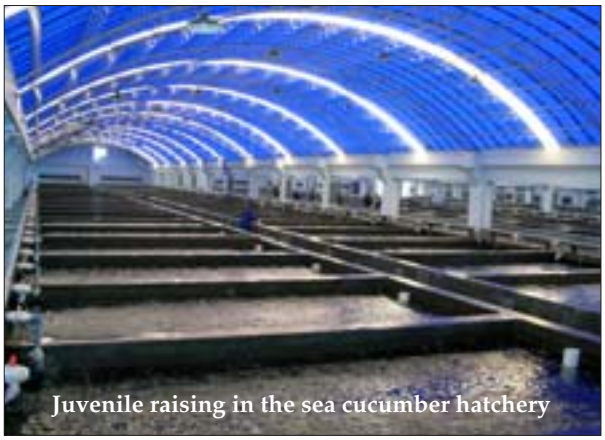
Brief company description:

Dalian Bang Chuidao Sea Cucumber Development Co. Ltd. is located in the Natural Conservation Zone of Chengshantou, Dalian City. The company is a leading Chinese integrated company engaged in mariculture (hatcheries and on-growing facilities), processing and trade of sea products. As a result of its performance over the years, particularly with regards to the production of quality products, the company has been rewarded by the Municipal Government and certified by the National Bureau of Trademarks.

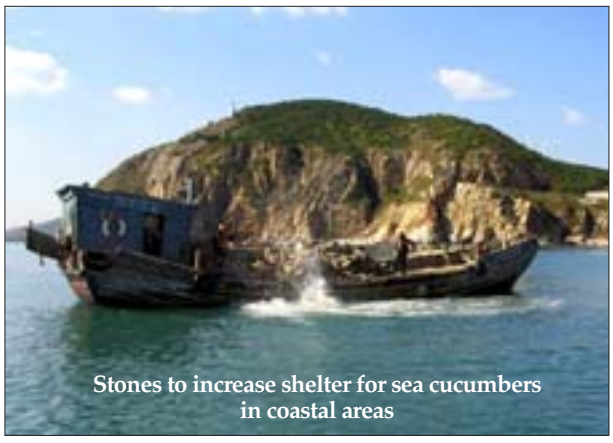
In 2002 the company received approval from by Ministry of Agriculture (MOA) to establish and administer a national sea cucumber project focused on the conservation of endemic species and breeding of commercially important species. In the same year the company established a land-based facility and produced 30 million and 5 million of sea cucumber and sea urchin seed, respectively. All juveniles of both species were stocked in the conservation coastal zone for resource enhancement.

With the completion of the project the company will be in a position to produce annually 60 million sea cucumber seeds. The company plans to produce 3 million sea cucumber annually that will be valued at RM 200 million yuan (@ USD 24 millions with 1 USD = 8.27 RMB ; 1.7.03). In the future the company has plans to invest RMB 38 million yuan (@ USD 4.6 million) in sea cucumber aquaculture. The company's ambition is to become a world leader in sea cucumber aquaculture using its popular "Bang Chuidao" trademark.


Site of the hatchery and sea ranching


Juvenile raising in the sea cucumber hatchery


Juveniles raised on net in the hatchery


Stones to increase shelter for sea cucumbers in coastal areas

(*Photos: C. Conand*)

Company Name: Dalian Youde Marine Biological Garden
Contact Person: Mr JIANG Chun Jia
Address: Chengguan, Pulandian District, Dalian, Liaoning Province, 116222 China
Tel: +86 389 8651188

Brief company description:

The Dalian Youde Marine Biological Garden company is part of a newly established group of companies operating in Dalian. The estimated capital of the group is RMB 130 million (@ USD 15.7 million). The company operates its land-based facilities on a 15 hectares plot and has a sea concession of 4260 hectares.

The company has a large-scale production capacity of a variety of marine species juveniles including sea cucumber, Yeso scallop, geoduck, sea urchin, giant cockle and several finfish species. The company runs its own hatcheries, grow-out facilities (land-based and sea), enhancement programmes and processing facilities. This year the company expects to produce approximately 150 million sea cucumber seeds and 5 billion of scallop seed for their aquaculture programme.

Facilities of the Dalian Youde Marine Biological Garden company (*Photo: C. Conand*)

3- SEA CUCUMBERS IN MARKETS, CHINA

Dalian supermarkets sell different qualities of *Apostichopus japonicus*, Dried, fresh, frozen. In Beijing Hongqiao Market, different tropical species (as well as temperate) sea cucumbers fresh and processed are sold.

Fresh *Apostichopus japonicus* (*Photo: C. Conand*)

Processed *Apostichopus japonicus* (*Photo: C. Conand*)