

Abstracts and new publications

First report of the development of microsatellite markers for a tropical sea cucumber (*Stichopus chloronotus*)

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Source: Accepted as technical note in Conservation Genetics Resources (2010).

We isolated new 10 polymorphic microsatellites from the tropical sea cucumber *Stichopus chloronotus*. These loci provide one class of variable genetic marker as the number of alleles ranged from 2 to 6 and the observed and expected heterozygosity ranged from 0.083 to 1.0 and from 0.081 to 0.724, respectively. We consider that these loci are potentially useful for revealing clones (resulting from asexual repro) and then participate in detailing the genetic structure and gene flow among *S. chloronotus* populations.

Managing sea cucumber fisheries with an ecosystem approach.

S.W. Purcell

Source: Edited/compiled by Lovatelli A., Vasconcellos M. and Yimin Y. FAO Fisheries and Aquaculture Technical Paper. No. 520. Rome, FAO. 2010. 157 p. <http://www.fao.org/docrep/012/i1384e/i1384e00.htm>

Sea cucumbers are important resources for coastal livelihoods and ecosystems. At least 60 species are fished from more than 40 countries and most of the harvests are processed then exported to Asian markets. Sea cucumbers generally appear to have slow rates of population turnover and are easily harvested in shallow waters in the tropics. With retail prices of up to USD 300–500 per kg (dried), exploitation has often been indiscriminate and excessive. Overfishing in recent years has led to local extinction of high-value species in some localities and prompted closures of many national fisheries to allow stocks to recover and to allow more sustainable management plans to be established. Apart from a few developed countries, only a small number of sea cucumber fisheries are currently being managed sustainably. Sea cucumber fisheries differ greatly in the scale of the fishing activities, status of stocks and the capacity of the management agency. Consequently, some management measures will be appropriate in some fishery scenarios but not others. This document presents a logical framework to assist fishery managers in choosing an appropriate suite of regulatory measures and management actions and elaborates on the uses, limitations and ways to implement them. This document contains five main sections. The first provides an overview of the biology and ecology of sea cucumbers, the international market for beche de mer market, types of sea cucumber fisheries and their global status (i.e. population abundance). The second section summarizes fisheries management principles and approaches, with an emphasis on the ecosystem approach to fisheries (EAF). The third section provides the “roadmap”, by way of instructions, flow diagrams and tables, to lead fishery managers along the path of choosing management measures appropriate to their fishery. The fourth and fifth sections discuss the application of each regulatory measure and management action – with Examples and lessons learned boxes to illustrate management problems and potential solutions from various fisheries. Improved management of sea cucumber fisheries is an imperative. It will be best achieved by applying an EAF, in which multiple regulatory measures and management actions are applied in full consideration of the sea cucumber stocks, the ecosystems in which they live and the socioeconomic systems that drive exploitation. The commitment of governments, fishery managers and scientists to develop, apply and strictly enforce EAF will be crucial to sustaining sea cucumber populations for current and future generations.

Sea cucumber aquaculture — promising opportunity for sustainable sea cucumber fishery in South-East Asia

D.A.B. Giraspy and G.W. Ivy

Source: Asian-Pacific Aquaculture 2009, Kuala Lumpur, Malaysia

Overexploitation is affecting sea cucumber population worldwide, and aquaculture and restocking programs are needed to bring back the depleted fisheries to sustainable level. The demand for beche de mer is significantly increasing in Asia, making the sea cucumbers more vulnerable for exploitation. The sea cucumbers sandfish (*Holothuria scabra*) and the golden sandfish (*H. lessoni*) are the most valuable tropical species with highest prices on the international market and these species are available in Malaysian waters. Also there are traditionally valuable species such as gamat species (*Stichopus horrens*) that has more value on the Chinese culture. There has been plenty of interest in recent days for the aquaculture of economically valuable tropical sea cucumbers such as *H. scabra* and *H. lessoni* are distributed in throughout Southeast Asia.

Relatively warm water temperature, wide availability of these species, high water quality, suitable coastal environments and potential sea-based sites for grow out in these regions and the availability of commercial technology makes sea cucumbers in aquaculture look very promising. The typical commercial sea cucumber aquaculture operation includes; a. Broodstock collection and management, b. Spawning stimulation and Fertilisation, c. Larval rearing and Feeding, d. Larval development and settlement, e. Nursery rearing of juvenile, f. juvenile pre grow-out and g. Sea ranching or pond grow-out. The Asian demand for human food and medicinal products from sea cucumbers remains strong and on the increasing trend, promising a ready market for output from commercial sea cucumber culture operations. With long standing experience in sea cucumber aquaculture development, Sea cucumber Consultancy has developed the hatchery technology for mass production of two commercially most important tropical sea cucumbers. Using the state of the art technology, millions of *H. scabra* (sandfish) and *H. lessoni* (golden sandfish) juveniles can be produced routinely in the specialized hatchery. These juveniles can be used for restocking depleted wild fishery or grow them in ponds or lagoons to meet the growing market demands. The hatchery production of indigenous gamat species is also possible with the available technology and that would support local gamat industry. Sea cucumber culture could contribute to the restoration of depleted wild populations and allow sustainable fishery.

Diel burying by the tropical sea cucumber *Holothuria scabra*

S.W. Purcell

Source: Marine Biology 157:663–671 (2010)

Understanding concealment behaviour of marine animals is vital for population surveys and captive-release programmes. The commercially valuable sea cucumber *Holothuria scabra* Jaeger 1833 (Holothuroidea) can display a diel burying cycle, but is it widely predictable. Circadian burying of captive *H. scabra* juveniles, and both juveniles and adults in the wild, was examined in New Caledonia. Groups of ten cultured juveniles in mesh chambers in a tank were monitored for 24 h. Small juveniles (1–5 g) displayed an expected diel cycle of epibenthic foraging in the afternoon and night then burial in sediments in the morning. Burial was related significantly to both light and temperature in combination. Similar groups of juveniles were handled once or three times a day for one week then frequency of emergence during another week was compared to unhandled controls. Handling stress, whether occasional or frequent, significantly suppressed the frequency of their afternoon emergence from sediments for 4 days. In a coastal seagrass bed, burial and emergence of *H. scabra* were monitored during days of opposing tidal cycles in three seasons. Adults seldom buried during the day except in the cool season. At that site, most small hatchery-produced *H. scabra* juveniles were buried during most of the day, while larger juveniles showed little diurnal burying. This study underscores that the circadian behaviours of marine animals can exhibit substantial spatial variation, may be absent at certain sites or seasons, and can be mediated by a complexity of factors that vary over short timescales.

Genetic barcoding of commercial bêche-de-mer species (Echinodermata: Holothuroidea)

S. Uthicke, M. Byrne and C. Conand

Source: Molecular Ecology Resources 10:634–646 (2009)

There are more than 47 species of holothurians used for bêche-de-mer production, many of which are locally overfished. With three exceptions, all bêche-de-mer species are Aspidochirotrida and species identification of many of these is difficult. We analysed available genetic information and newly generated sequences to determine if genetic barcoding with the mitochondrial COI gene can be used to identify bêche-de-mer species. Although genetic data were available for $\pm 50\%$ of bêche-de-mer species, sufficient information and within-species replication were only available for six species. We generated 96 new COI sequences extending the existing database to cover most common species. COI unambiguously identified most bêche-de-mer species providing a genetic barcode for the identification of known species. In addition, conspecific (1.3%) variation and congeneric (16.9%) divergence were well separated ('barcoding-gap') albeit with a small overlap, which may lead to some error if genetic sampling alone was applied for species discovery. In addition to identification of adults, COI sequences were useful to identify juveniles that are often morphologically different. Sequence data showed that large (deep) and small (shallow) morphotypes of *Holothuria atra* are the same species, but suggested potential cryptic species within this taxon. For bêche-de-mer, the COI barcode proved useful in species clarification and discovery, but further genetic and taxonomic work is essential for several species. Some bêche-de-mer clades were problematic with morphologically disparate specimens sharing the same barcode. Our study indicated the presence of undescribed species (*Bohadschia* sp.) and species that constitute separate species in the Indian and Pacific Ocean (e.g. *Holothuria fuscogilva*).

Royal cucumber (*Stichopus regalis*) in the northwestern Mediterranean: Distribution pattern and fishery

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Source: Fisheries Research Fisheries Research 105:21–27 (2010)

Stichopus regalis is a common sea cucumber that is found in a wide depth range in the Mediterranean beyond 50 m depth. Its five longitudinal muscular bands are a culinary delicacy. It is the most expensive seafood product on the Catalan market, and it can reach up to 130 EUR/kg. Despite its ecological and economical importance, information related to this species is very scarce. The population inhabiting the Mallorca and Menorca continental shelf and slope was studied using data from several different surveys conducted from 2001 to 2009. The spatial distribution of the royal cucumber is strongly aggregated. The population showed a multimodal length–frequency distribution, with individuals ranging from 65 to 295 mm in length. Abundance was highest between 100 and 299 m depth and sizes were largest between 50 and 299 m depth. The length–weight relationship indicates a negative allometry, explained by the fact that the thickness of some parts of the body wall appears to be independent of the size of the individual. Although *S. regalis* has a high price, due to its relatively low abundance it is not a particular target species of the multispecies trawl fisheries, and is captured as a by-catch, with a mean catch per unit effort of 1.78 kg per boat and day. The edible part corresponds to 9.81% of the drained weight of the whole animal.

AChE and EROD activities in two echinoderms, *Holothuria leucospilota* and *Holothuria atra* (Holothuroidea), in a coral reef (Reunion Island, South-western Indian Ocean)

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Source: Journal of Environmental Science and Health Part A 45:699–708 (2010)

AChE and EROD activities were investigated in two holothurian species, *Holothuria leucospilota* and *Holothuria atra*, from a tropical coral reef. These organisms were collected from 3 back-reef stations, where temperature and salinity were homogeneous. The activity levels of both AChE and EROD varied significantly between the two species, but were in the range of values determined in other echinoderm species. AChE activity levels were higher in the longitudinal muscle than in the tentacle tegument. Among the several tissues tested, the digestive tract wall exhibited higher EROD activity levels. Sex did not influence AChE and EROD activity levels in both species. Animal biomass and EROD activity levels were only correlated in the tegument tissue of *H. atra*, and we hypothesize a possible influence of age. EROD activity did not show intraspecific variability. A significant relationship was found between AChE activity and Cuvierian tubules time of expulsion in *Holothuria leucospilota*. Individuals collected at the southern site presented both lower AChE activity levels and Cuvierian tubules time of expulsion, indicating possible neural disturbance. More information on holothurians biology and physiology is needed to further assess biomarkers in these key species. This study is the first of its kind performed in the coastal waters of Reunion Island and data obtained represent reference values.

Phylogeny of sea cucumber (Echinodermata: Holothuroidea) as inferred from 16S mitochondrial rRNA gene sequences

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Source: Sains Malaysiana 39(2):209–218 (2010)

This study aimed to determine phylogenetic relationship between and among selected species of sea cucumbers (Echinodermata: Holothuroidea) using 16S mitochondrial ribosomal RNA (rRNA) gene. Phylogenetic analyses of 37 partial sequences of 16S mitochondrial rRNA gene using three main methods namely neighbour joining (NJ), maximum parsimony (MP) and maximum likelihood (ML) showed the presence of five main genera of sea cucumbers: *Molpadia* from order Molpadiida and four genera of order Aspidochirotida namely *Holothuria*, *Stichopus*, *Bohadschia* and *Actinopyga*. All of the 17 species obtained from Malaysia distributed among the main genera except within *Actinopyga*. Interestingly, *Holothuria excellens* was out of *Holothuria* group causing *Holothuria* to be paraphyletic. High bootstrap value and consistent clustering made *Molpadia*, *Stichopus*, *Bohadschia* and *Actinopyga* monophyletic. The relationship of *Actinopyga* with the other genera was un-clarified and *Stichopus* was sister to *Molpadia*. The latter finding caused the resolution at order level unclear. The pairwise genetic distance calculated using Kimura 2-parameter model further supported and verified findings from the phylogenetic trees. Further studies with more samples and different mitochondrial DNA genes need to be done to get a better view and verification on the molecular phylogeny of sea cucumbers.

Qualitative and quantitative saponin contents in five sea cucumbers from the Indian Ocean

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Source: Marine Drugs 8:173–189 (2010)

To avoid predation, holothuroids produce feeding-deterrent molecules in their body wall and viscera, the so-called saponins. Five tropical sea cucumber species of the family Holothuriidae were investigated in order to study their saponin content in two different organs, the body wall and the Cuvierian tubules. Mass spectrometry techniques (MALDI- and ESI-MS) were used to detect and analyze saponins. The smallest number of saponins was observed in *Holothuria atra*, which contained a total of four congeners, followed by *Holothuria leucospilota*, *Pearsonothuria graeffei* and *Actinopyga echinites* with six, eight and ten congeners, respectively. *Bohadschia subrubra* revealed the highest saponin diversity (19 congeners). Saponin mixtures also varied between the two body compartments within a given animal. A semi-quantitative approach completed these results and showed that a high diversity of saponins is not particularly correlated to a high saponin concentration. Although the complexity of the saponin mixtures described makes the elucidation of their respective biological roles difficult, the comparisons between species and between body compartments give some clues about how these molecules may act as predator repellents.

The ecological role of *Holothuria scabra* (Echinodermata: Holothuroidea) within subtropical seagrass beds

S.-M. Wolkenhauer, S. Uthicke, C. Burridge, T. Skewes and R. Pitcher

Source: Journal of the Marine Biological Association of the United Kingdom, Cambridge University Press 90:215–223 (2010)

Some sea cucumbers species are heavily exploited as bêche-de-mer for the Asian food industry and the global decline of certain highly sought after species has generated an interest in determining the ecological function of those animals within their ecosystem. This study investigated the ecological role of *Holothuria scabra*, a commercially valuable tropical species closely associated with seagrass beds. Seagrass productivity, seagrass and benthic microalgae (BMA) biomass and organic matter (OM) were measured during two exclusion experiments conducted using *in situ* cages deployed for two months both in 2003 and 2004. Density of *H. scabra* was manipulated in caged exclusions (near-zero density, 'EX'), caged controls (natural densities, 'CC') and uncaged controls (natural density, 'NC'). Seagrass growth was lower when holothurians were excluded (5% in 2003, 12% in 2004). Seagrass biomass decreased in all treatments, but reduction was greater in EX than in controls (18% in 2003, 21% in 2004). Both BMA biomass and OM increased in EX compared to NC/CC (in 2004). From a multivariate perspective, a principal component biplot separated EX from both types of controls in 2004, and multivariate tests based on four attributes supported this separation. These results indicate that seagrass systems may suffer in the absence of holothurians; however, the effect size varied between the two experiments, possibly because experiments were conducted at different times of the year. Nevertheless, our results suggest that holothurian over-fishing could have a negative impact on the productivity of seagrass systems.

Management of sea cucumber stocks: patterns of vulnerability and recovery of sea cucumber stocks impacted by fishing

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Source: Fish and Fisheries. Article first published online: 10 Sep. 2010. DOI: 10.1111/j.1467-2979.2010.00384.x

Identifying rates of change in the abundance of sea cucumbers under differing management regimes is fundamental to estimating commercial yields, identifying ecological interactions and facilitating management. Here, we review the status of sea cucumber stocks from a range of Pacific Island countries (Samoa, Tonga, Palau, Fiji and Papua New Guinea), some of which have had a moratorium on exports for up to a decade. We use a time-series approach to look at variation in sea cucumber presence, coverage and density from survey and re-survey data. Results give an appreciation of variation between 'high' status (less impacted) and depleted stocks. Survey data show marked declines in coverage and abundance as a result of artisanal fishing activity, and although species groups were not lost at a country level, local extirpation and range restriction was noted. Resilience and 'recovery' following cessation of fishing varied greatly, both among locations and among the species targeted. Worryingly, even after extended periods of moratorium, the density of some species was markedly low. In many cases, the densities were too low for commercial fishing, and may be at a level where the effective population size is constrained due to 'Allee' effects. From these results, we suggest that management regimes presently employed are generally not well aligned with the level of response to fishing mortality that can be expected from sea cucumber stocks. New adaptive, precautionary approaches to management are suggested, which would allow more timely interventions to be made, while refined information on stock dynamics is sought.

Torres Strait sea cucumber survey, 2009.

T. Skewes, N. Murphy, I. McLeod, E. Dovers, C. Burridge and W. Rochester

Source: CSIRO Wealth from Oceans Flagship Final Report. Report available at: <http://www.pzja.gov.au/resources/publications/scientific.htm>

The Torres Strait sea cucumber fishery has been characterised by boom and bust cycles as the result of resource depletion or price fluctuations. Previous research has resulted in the closure of three highly targeted species (*Holothuria scabra* (sandfish), *H. whitmaei* (black teatfish) and *Actinopyga mauritiana* (surf redfish)), and catch limits for two other high value species (*H. fuscogilva* (white teatfish) and *Thelenota ananas* (prickly redfish)). However, the populations had not been assessed since 2005, and given the likely low fishing activity since then; there was a possibility of a recovery for depleted species.

The sea cucumber populations were surveyed at 113 sites in 5 out of 6 zones in east Torres Strait during a 10 day survey in March 2009. The aim of the survey was to assess the current size and status of sea cucumber stocks, especially focussed on the recovery of closed species, *H. whitmaei* and *A. mauritiana*, and to determine the species split for the Actinopyga clade, with particular emphasis on the *A. echinites* – *A. mauritiana* split.

Sixteen commercial species were observed during the survey. The overall average density of commercial holothurians on the reefs was 329.1 per Ha (± 144.9 , 90 % CI), which equated to a total live wet weight of 18,828 t ($\pm 9,014$ t, 90% CI). The overall species composition in 2009 was similar to previous surveys. The most abundant commercial species in the study area was the low value *H. atra* (lollyfish), followed closely by *Stichopus chloronotus* (greenfish) — together these two species make up 79.1% by number and 50.7% by weight of the commercial sea cucumbers in the study area.

The survey found that the density of *H. whitmaei* had increased significantly since 2005, and was the greatest since surveys began in 1995. Their average size was also the largest of any survey carried in Torres Strait. Comparisons with regional density data indicate that the *H. whitmaei* populations in Torres Strait may have recovered to near natural (unfished) densities, and corroborate with islanders reports of a widespread recovery for this species since it was closed in 2003. This is an important example of the recovery of a depleted sea cucumber population, a recovery period of 7 years, and one of the few thus far documented.

Other high value species, *H. fuscogilva* and *Thelenota ananas*, and an important medium value species, *A. echinites*, were either at stable or higher densities than in previous surveys, therefore this represents a healthy fishery with the potential to provide moderate long term income to local Islander communities, provided it is managed carefully. *A. mauritiana* were still uncommon, however, it is now unlikely that this species was ever a large component of the catch. It is more likely that the surf redfish reported in previous catches was made up of *A. echinites* and *A. miliaris*. These two later species were observed at moderate but highly variable densities.

We consider that most other species are still at virgin or near virgin biomass levels, however, some may have a relatively low fishery stock biomass, and the status of *Bohadschia vitiensis* (brown sandfish) is very uncertain due to the burrowing of this species during the day.

We used the density trend and fishery stock estimate data to recommended conservative Torres Strait wide TACs that could be used in conjunction with developing co-management harvest strategies. Re-opening Black teatfish will likely see renewed interest in the fishery. However, the open ended nature of fishing effort (any Torres Strait Islander can theoretically fish the fishery), and the possibility of large pulses in fishing effort due to community interest and momentum partially spurred on by buyer interest, could see at least localised overexploitation of sea cucumber populations.

The introduction of co-management harvest strategies that limit effort pulses, mitigate localised depletion and collect fishery and fishery-independent data should be part of an ongoing harvest strategy. Such strategies could provide the necessary protection to sea cucumber populations.

Additions to the sea cucumber fauna of Namibia and Angola, with descriptions of new taxa (Echinodermata: Holothuroidea)

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Source: Zootaxa 2655:1–24 (2010)

This paper records several species of holothuroid echinoderms dredged from shallow waters of the Angolan-Namibian-coastline by the Leibniz Institute for Baltic Sea Research Warnemünde in Germany. Altogether seven species are dealt-with, including five new species, of which one is referred to a new genus *Lanceophora*. The new species include two in-the cucumariid subfamily Colochirinae (*Ocnus placominutus* and *O. paracorbulus*), two in the cucumariid subfamily Cucumariinae (*Panningia pseudocurvata* and *Lanceophora lanceolata*) and one in the family Rhopalodinidae- (*Rhopalodinaria bocherti*). Other species included are

Pseudocnus thandari Natasen Moodley, 2008 and an indeterminate species of *Cladodactyla* in the subfamily Cucumariinae and *Trachythyone fallax* Cherbonnier, 1958a in the subfamily Colochirinae.

Aggregations and temporal changes in the activity and bioturbation contribution of the sea cucumber *Holothuria whitmaei* (Echinodermata: Holothuroidea)

Shiell G.R. and Knott B.

Source: Marine Ecology Progress Series 415:127–139 (2010)

The population density, activity and bioturbation contribution of the sea cucumber *Holothuria whitmaei* was investigated on Ningaloo Reef, Western Australia. Two methods, stratified manta tows and blanket manta tows, recorded population densities between 11.4 and >100 ind. ha⁻¹. Further analysis revealed a heterogeneous pattern of distribution, with individuals tending to aggregate (Moran's I; 0.039; $p < 0.05$) on the outer reef lagoon and particularly in areas of high flow. Densities within aggregations were up to 7.2 times greater than those obtained after blanket manta tows (17.1 ind. ha⁻¹), and 4.5 to 6.3 times greater than those obtained after traditional stratified manta tows (19.3 to 27.1 ind. ha⁻¹). Behavioural studies, including investigations of activity and bioturbation, were conducted over a 2-yr time frame (2002–2003) incorporating 3 monitoring periods within each year: January, April and August. Rates of activity varied diurnally, increasing between morning and afternoon, and seasonally, increasing in April, relative to January and August. Temporal patterns of feeding were more difficult to characterise; although rates of sediment egestion were in many cases higher in the morning, no conclusive diurnal or seasonal patterns could be established. Subsequent regression analysis, however, did find a significant positive correlation between the distance travelled and the volume of sediment egested. The volume of sediment bioturbated by *H. whitmaei* at a population level was found to represent only a small fraction of the sediments available (ca. 2 to 14% per annum), even though the contribution per individual was greater than that of smaller sea cucumber species. However, at maximum densities and typical rates of activity, *H. whitmaei* makes physical contact with approximately 2 times the available coral reef sediments per annum per hectare, simply by crawling. This may represent an important ecological contribution, particularly in light of previously documented links between sea cucumber activity, nutrient recycling and the enhancement of benthic microalgal communities.

The oldest synallactid sea cucumber (Echinodermata: Holothuroidea: Aspidochirotida)

M. Reich

Source: Palaeontol Z. DOI 10.1007/s12542-010-0067-8

Aspidochirote holothurian ossicles were discovered in Upper Ordovician-aged Öjlemyr cherts from Gotland, Sweden. The well-preserved material allows definitive assignment to the family Synallactidae, a deep-sea sea cucumber group that is distributed worldwide today. The new taxon *Tribrachiodemas ordovicicus* gen. et sp. nov. is described, representing the oldest member of the Aspidochirotida. The further fossil record of Synallactidae and evolutionary implications are also discussed.

Diversity of the holothuroid fauna (Echinodermata) in La Réunion (Western Indian Ocean)

Conand C., Michonneau F., Paulay G. and Bruggemann H.

Source: Western Indian Ocean Journal of Marine Science (2010)

Echinoderms are conspicuous components of the tropical fauna and play important roles in the functioning of coral reefs. However their diversity is not as well documented as that of other conspicuous reef organisms, like corals or fishes. We review current knowledge of the diversity of the class Holothuroidea on La Réunion. Several recent initiatives, including the Masma (Conand and Muthiga 2007) and BIOTAS projects, have considerably augmented the number of species known from the island. As a result of these surveys, the recorded holothuroid fauna was doubled. Thirty-six species are now recognized, 17 of which are new records for the island. The order Aspidochirotida, which includes the largest and most conspicuous holothuroids, is the most diverse, with 28 species. Six species of Apodida and two species of Dendrochirotida round out the fauna. These latter groups, especially, may prove more diverse with further investigation. The island's holothuroid fauna is compared with data available from other areas of the Western Indian Ocean and the Indo-west Pacific to evaluate its biogeographic relationships.

The sea cucumber resources and fisheries management in the Western Indian Ocean: Current status and preliminary results from a WIOMSA regional research project.

Conand C. and Muthiga N.

Source: Echinoderms: Durham. Harris et al. (eds) Taylor and Francis, London. 575–581. (2010)