# Field observations of juvenile sea cucumbers

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## Introduction

Recent advances in tropical sea cucumber mariculture have created scope for the rehabilitation of populations affected by overfishing through the production and release of hatchery-raised juveniles. Although the necessary technology required to implement rehabilitation programmes is progressing rapidly (Purcell 2004), there is some speculation as to the viability of such programmes, given major shortfalls in knowledge of important aspects of sea cucumber biology. (For a full review see Bell and Nash 2004.) One area of sea cucumber biology identified as being important to the ultimate success of rehabilitation programmes is a clear understanding of the habitat and ecological requirements of juvenile sea cucumbers (Wiedemeyer 1994; Mercier et al. 1999; Purcell 2004). An understanding of juvenile habitat preferences may help scientists to determine accurately the ultimate carrying capacity of a given sea cucumber habitat (while acknowledging the space occupied by juveniles) and additionally, enable the eventual release of juveniles to appropriate habitats with enhanced probability of survival (Bell and Nash 2004; Purcell 2004).

Much of the existing literature on juvenile holothurian biology has focused on observations or studies of hatchery-raised juveniles, particularly in the context of growth and mortality under laboratory or aquaculture conditions (e.g. Battaglene 1999; Battaglene and Seymore 1998; Battaglene et al. 1999; Engstrom 1980; Hamano et al. 1996; Hamel et al. 2003; Hatanaka 1996; Hatanaka et al. 1994; Ito et al. 1994; James et al. 1994; Kobayashi and Ishida 1984; Mercier et al. 1999, 2000a; Tanaka 2000). However, several authors have also made contributions to the understanding of juvenile biology based on studies of juveniles that were either captured or observed *in situ* (e.g. Cameron and Fankboner 1989; Daud et al. 1993; Hamel and Mercier 1996; Mercier et al. 2000b; Muliani 1993; Purcell 2004; Purcell et al. 2002; Ramofafia et al. 1997; Tiensongrusmee and Pontjoprawiro 1988; Wiedemeyer 1994; Young and Chia 1982). Additionally, observations of juvenile *Holothuria scabra* are reported from a variety of sources (Conand 1997; Gravely 1927; James 1976, 1983; Lokani et al. 1995; Long and Skewes 1997; Shelley 1985).

The relative scarcity of knowledge obtained through direct observation of field based juvenile sea cucumbers is due possibly to two problems. The first, as reported by Wiedemeyer (1994), is that the calcareous spicule arrangement in juveniles could be different to that of adults. Hence, the identification of juveniles based on keys developed for adults may lead to misidentification. Second, and perhaps most importantly, juveniles are very rarely encountered in sufficient numbers for study, if at all. The fact that small juvenile sea cucumbers are rarely encountered in the field (Seeto 1994) may be due to a number of scenarios. Juvenile holothurians have the potential to be misidentified given their potential for morphological differences relative to the adult forms (Wiedemeyer 1994); they occupy habitats different to that of larger specimens (James et al. 1994; Lokani et al. 1996), and finally, they exist in the habitat occupied by the adult form but are obscured from view within sediments or crevices or beneath obscuring objects such as coral (Cameron and Fankboner 1989; Wiedemeyer 1994).

The difficulty in locating juvenile sea cucumbers is perhaps highlighted by the fact that studies relevant to juvenile ecology often result from fortuitous encounters (Conand 1983; Mercier et al. 1999). For example, juvenile *Actinopyga echinites* used in Wiedmeyer's study (1994) were found on the upper reef zone following a strong typhoon. For this reason, and because juvenile sea cucumbers are rarely observed in large numbers, it seemed appropriate and useful to begin consolidating anecdotal observations of juveniles made in the field. This exercise may help to identify differences in habitat preferences between juveniles on the inter-species level and, additionally, between adults and juveniles of the same species. Also, by consolidating these observations, it may be possible to discern future research directions to clarify some of the details of this little known but important life phase.

## Response to the questionnaire included in SPC's *Beche-de-Mer Information Bulletin* #19

Questionnaires on observations of holothurian spawning and fission have been published previously in SPC's *Beche-de-Mer Information Bulletin*. Following the success of these, a new questionnaire

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aimed at consolidatng anecdotal observations of juvenile sea cucumbers in the field, was included in issue #19 (p. 41). Many questionnaire respondents provided observations of juveniles ranging between 0.3 and 21.0 cm in length. Given the inter-species variability in size at first maturity among holothurians, all of the observations were retained in the final results. Twenty-six responses to the questionnaire have been received at the time of writing.

## Results and discussion

The results to date (Table 1) are organised under the following sub-headings: species observed, corresponding observed habitat, date and time of observation, proximity of adults in relation to observed juvenile(s) and the name and affiliation of the observer.

Results presented in Table 1 indicate a broad range of habitat preferences among juvenile holothurians. In most cases, juvenile holothurians were observed within close proximity to adult holothurians of the same species. These observations included representatives of the following genera: *Stichopus* (2 species), *Actinopyga* (3 species), *Isostichopus* (2 species), *Astichopus*, *Thelenota*, *Cucumaria*, *Chiridota*, and *Psolus* (1 species each). Habitat preferences of juvenile *Holothuria* spp. varied, but in most cases, juveniles of this genus were also observed in the presence of adults (e.g. *H. scabra*, *H. leucospilota*, *H. mexicana*, *H. atra* and in some instances, *H. nobilis*). Concurrent occupation of similar habitat between both juvenile and adult *H. scabra* was reported by Mercier et al. (1999, 2000b) who found newly settled and smaller juveniles in the same general area as adults. Both Cameron and Fankboner (1989) and Young and Chia (1982) provide similar evidence, where *Parastichopus californicus* and *Psolus chitonoides* juveniles were also regularly observed within habitats occupied by the adult form. Although it seems common for juveniles and adults to occupy habitats simultaneously, there is evidence that most small juveniles retain some degree of cryptic behaviour that appears to diminish with size. Therefore, it is likely that juveniles may be obscured from view even when present in large numbers within an adult habitat. For example, *Isostichopus fuscus* juveniles (< 6 cm) maintained in aquaculture ponds remain hidden in the rocky substrate during the day, but begin to emerge following nightfall; larger specimens of the same species were otherwise visible throughout the day (Mr Roberto Ycaza, pers. comm.). Similarly, *Cucumaria frondosa* and *Actinopyga echinites* juveniles displayed a progressive tendency to leave protected locations within the substrate as they grew larger (Hamel and Mercier 1996, Wiedemeyer 1994). Smaller specimens of *H. scabra* (> 10–40 mm) are also reported to remain hidden for the majority of daylight hours. Larger *H. scabra* juveniles (> 40–140 mm) emerged from sediments in the middle of the day at around 13:30 hours (Mercier et al. 1999).

Additional results presented in Table 1 indicate a preference for juveniles of selected species to occupy habitats slightly different to those of adults. In these cases, juvenile *Holothuria fuscogilva* and *H. nobilis* were located in shallower water adjacent to the deeper water habitats occupied by adults (Conand 1981). A similar phenomenon was reported in *Cucumaria frondosa* (Hamel and Mercier 1996) that were observed to undergo a process of progressive migration from shallower protected reef areas to deeper more exposed sandy areas as they matured sexually. The reported observation of *H. fuscogilva* juveniles (Table 1) in very shallow water is suggestive of a similar pattern of migration in this species. Evidence for this notion was more recently provided by Ramofafia et al. (2000) who obtained sexually mature individuals of *H. fuscogilva* in water between 25 and 30 m depth. Size related migration from shallow water to deep water has also been reported in *Stichopus variegatus* (now *S. hermanni*) (Conand 1993).

## Conclusions

From the observations provided in Table 1 and the additional evidence provided in the literature, it seems reasonable to conclude that juvenile holothurians display some degree of cryptic behaviour in the earliest stages of their life cycle following settlement. Cryptic behaviour most likely continues until juveniles are large enough to avoid most forms of predation (Cameron and Fankboner 1989). Further migration and hence greater habitat separation between juveniles and adults of some species may then occur as holothurians mature (Hamel and Mercier 1996), but the degree to which this process is common among all holothurians remains unclear.

An additional observation is that juvenile and adult sea cucumber habitat preferences consistently appear to differ at some level of scale. For example, although *H. scabra* juveniles and adults have been observed in the same general area, clear differences in habitat preferences at the microhabitat level have been identified (Mercier et al. 2000b). Microhabitat requirements of juvenile holothurians are likely to vary both between stages of development and between species. To further develop viable restocking programmes using hatchery-raised juveniles, it would be desirable to investigate microhabitat requirements in more detail. Specifically, future research direc-

**Table 1.** ***In situ*** **observations of juvenile holothurians.**

| Species observed | Approx. size and number | Location | Habitat | Time | Date | Adults present? | Observers' name(s) and affiliation / Source of further information |
|---|---|---|---|---|---|---|---|
| *Astichopus multifidus* | 8–21 cm | North at Isla de la Juventud | Seagrass | 15:40 | April 2002 | | Irma Alfonso Hernández, María del Pilar Frías; Fishery Research Centre of Cuba |
| *Actinopyga agassizii* | 5–18 cm | North central region of Cuba | Seagrass | 14:30 | May 2001 | Yes | Irma Alfonso Hernández, María del Pilar Frías; Fishery Research Centre of Cuba |
| *A. mauritiana* | 2–3 cm | Unia Reef, New Caledonia | Reef flat | Daytime | 1989 | Yes | Chantal Conand; Université de La Réunion |
| *A. echinites* | 4 cm | Ricaudy Reef, New Caledonia | Coral rubble | Daytime | Sept. 1981 | Yes | Chantal Conand; Université de La Réunion (unpub. photo available) |
| *Chiridota laevis* | 0.3–1 cm | Bic Provincial Park (Quebec), Canada | At low tide below the rocks on sand flat | | Summer 1994 | Yes | J.-F. Hamel & A. Mercier; Society for the Exploration & Valuing of the Environment, Canada |
| *Cucumaria frondosa* | 1–3 cm | Passamaquody Bay, New Brunswick, Canada. | Within tide pools near the lowest tide mark; below rocks and in crevices | | Summer 2000 | Yes | J-F. Hamel & A. Mercier; Society for the Exploration & Valuing of the Environment, Canada |
| *Holothuria mexicana* | 5–18 cm | Pingües Channel, south eastern region of Cuba, Baie des Baraderes, Haití | Sand | 11:20 and 14:25 | May 2000 July 2001 | No | Irma Alfonso Hernández, María del Pilar Frías; Fishery Research Centre of Cuba |
| *H. leucospilota* | 1–5 cm | Guadalcanal, Solomon Islands | At low tide on reef flat; below rocks and in crevices | | 1998 | Yes | J-F. Hamel & A. Mercier; Society for the Exploration & Valuing of the Environment, Canada |
| *H. scabra* | 1–5 cm | Ambandjoa, Madagascar | Muddy intertidal | Daytime | 1997 | Nearby, but in deeper water | Chantal Conand - Photo published in: Conand, C. 1999. Manuel de qualité des holothuries commerciales du Sud-Quest de l' Océan Indien. Commission Océan Indien: 39 p. |
| *H. scabra* | ≈ 8 cm (1 individual) | Crab Island, Moreton Bay, Queensland. | Seagrass / algae Shallow water | Daytime | 2002 | Yes, within 50 m | Grant Leeworthy; Tasmanian Seafoods, Australia |
| *H. scabra* | 10 cm long, 2 cm in diameter | Pouangué, Northern Province, New Caledonia | Seagrass on a muddy inshore reef flat (shallow water) | About 15:00 Low tide, when little water present on reef | Oct. 2002 | Yes, same habitat, but juveniles generally burrowed in mud, adults foraging on surface | Steve Purcell; WorldFish Center, New Caledonia |
| *H. fucogilva* | 1–5 cm | Fiji barrier reef | *Halimeda* field, very shallow water | Daytime | 1979 | Yes, nearby, but deeper on coral reefs | Chantal Conand; Université de La Réunion Photo published in Bull. Mar. Sci. 1981 31(3):523–543 |
| *H. nobilis* | 5 cm, colour different from adults, cream patches on black background | Fiji barrier reef and New Caledonia | Seagrass bed, shallow water | Daytime | 1979 | Yes, nearby, but deeper on coral reefs | Chantal Conand; Université de La Réunion Photo published in Bull. Mar. Sci. 1981 31(3):523–543 |
| *H. nobilis* | 14–21 cm (300–625 g), colour different from adults, 3 specimens | Raine Island, Great Barrier Reef, Queensland, Australia | Seagrass bed, shallow water | Daytime | Dec. 2003 | Yes | Sven Uthicke; AIMS, Townsville Australia |
| *H. nobilis* | 12 cm (estimated), colour different from adults, 3 specimens | Michaelmas Reef, Great Barrier Reef, Queensland, Australia | Shallow water, lagoonal reef area | Daytime | Mar. 2004 | Yes | Sven Uthicke; AIMS, Townsville Australia |
| *H. atra* | 2–3 cm (a few specimens) | Ilôt Maitre reef flat, New Caledonia; Planch' Alizés, La Réunion | Coral rubble | | | Yes | Chantal Conand; Université de La Réunion |
| *H. atra* | 1–4 cm | Likiep Atoll, Marshall Islands | At low tide on reef flat; in crevices | | May 2001 | Yes | J.-F. Hamel & A. Mercier; Society for the Exploration & Valuing of the Environment, Canada |

**Table 1 (continued).** ***In situ*** **observations of juvenile holothurians.**

| Species observed | Approx. size and number | Location | Habitat | Time | Date | Adults present? | Observers name and affiliation / Source of further information |
|---|---|---|---|---|---|---|---|
| *Holothuria atra* | 1–4 cm | Likiep Atoll, Marshall Islands | At low tide on reef flat; in crevices | | May 2001 | Yes | J.-F. Hamel and A. Mercier; Society for the Exploration & Valuing of the Environment, Canada |
| *Isostichopus fuscus* | 1–3 cm | Along the coast of mainland Ecuador | Between 5 and 10 m water depth | Autumn 2000. | | Yes | J.-F. Hamel and A. Mercier; Society for the Exploration & Valuing of the Environment, Canada |
| *Isostichopus badionotus* | 5–14 cm | North at Isla de la Juventud, Banes Bay, northern region of Cuba; Pilón Inlet, south eastern region of Cuba; Baie des Baraderes, Haití | Seagrass | Various daylight hours | April to Nov. 2002 | Yes | Irma Alfonso Hernández, María del Pilar Frías; Fishery Research Centre of Cuba |
| *Psolus fabricii* | 0.5–3 cm | Les Escoumins (Quebec), Canada | 3–10 m depth; below rocks and in crevices | | Summer 1991 | Yes | J.-F. Hamel and A. Mercier; Society for the Exploration & Valuing of the Environment, Canada |
| *Stichopus hermanni* | 9 cm | Sainte Marie Bay, New Caledonia | Seagrass | | Sept. 1981 | Yes | Chantal Conand; Université de La Réunion. For more information see: Bull. Mar. Sci. 52(3):970–981 |
| *S. chloronotus* | 3–4 cm (two specimens) | Coral Bay, Ningaloo Reef, Western Australia | Reef flat near crevice | Daytime, afternoon | Aug. 2003 | Yes | Glenn Shiell; University of Western Australia |
| *S. chloronotus* | 2–3 cm (very rare, observed only 3–5 in a 2-year field study at that site) | Great Palm Island, Great Barrier Reef, Queensland, Australia | On *Sargassum* | Daytime | | Yes, dense populations | Sven Uthicke; AIMS, Townsville Australia |
| *S. chloronotus* | 2–3 cm | Several Reunion Island reefs | Rubble and sand | Daytime | | Yes | For more information see: Conand C., Uthicke S. and Hoareau T. 2002 Invert. Reprod. Develop. 41(1–3):235–242 |
| *Thelenota ananas* | 12 cm | Uitoe Pass, New Caledonia | Coral | | 1981 | Yes | Chantal Conand Photo available in: Bull. Mar. Sci. 1981 31(3):523–543 |

tions may investigate the extent to which microhabitat selection at different stages of development are influenced by variables such as settlement, predation and feeding, or at later stages of development, spawning and reproduction.

The observations presented in Table 1 help to consolidate the information relevant to habitat preferences of juvenile holothurians. Based on the observations presented in this review, many juvenile holothurians appear to be present within the same broadly defined habitats as those of the adult form.

However, the significance and extent of this relationship relative to conflicting evidence of size related distribution and migration among certain juvenile holothurian species requires further and more detailed investigation.

## References


Battaglene S.C. 1999. Culture of tropical sea cucumbers for the purposes of stock restoration and enhancement. p. 11–25. In: Baine M. (ed) The conservation of sea cucumbers in Malaysia, their taxonomy, ecology, and trade — Proceedings of an international conference. Heriot-Watt University and the Fisheries Research Institute, Kuala Lumpur, Malaysia.

Battaglene S.C. and Seymour J.E. 1998. Detachment and grading of the tropical sea cucumber sandfish, *Holothuria scabra*, juveniles from settlement substratum. Aquaculture 159:263–274.

Battaglene S.C., Seymour J.E. and Ramofafia C. 1999. Survival and growth of cultured juvenile sea cucumbers, *Holothuria scabra*. Aquaculture 178: 293–322.

Bell J. and Nash W. 2004. When should restocking and stock enhancement be used to manage sea cucumber fisheries? In: Lovatelli A., Conand C., Purcell S., Uthicke S., Hamel, J-F. and Mercier A. (eds). Advances in sea cucumber aquaculture and management. FAO, Rome (2004).

Cameron J.L. and Fankboner P.V. 1989. Reproductive biology of the commercial sea cucumber *Parastichopus californicus* (Stimpson) (Echinodermata: Holothuroidea). II. Observations on the ecology of development, recruitment and the juvenile life stage. Journal of Experimental Marine Biology and Ecology. 127:43–67.

Conand C. 1981. Sexual cycle of three commercially important holothurian species (Echinodermata) from the lagoon of New Caledonia. Bulletin of Marine Science 31(3):523–543.

Conand C. 1983. Methods of studying growth in holothurians (beche-de-mer), and preliminary results from a beche-de-mer tagging experiment in New Caledonia. SPC Fisheries Newsletter 26:31–38.

Conand C. 1993. Ecology and reproductive biology of *Stichopus variegatus* an Indo-Pacific coral reef sea cucumber. (Echinodermata: Holothuroidea). Bulletin of Marine Science 52:970–981

Conand C. 1997. Mise en œuvre de la Gestion durable de la Ressource en Holothuries. Rapport de l'intervention GREEN/COL.

Conand C. 1999. Manuel de qualité des holothuries commerciales du sud-ouest de l'océan Indien. Commission Océan Indien. 39 p.

Conand C., Uthicke S. and Hoareau T. 2002. Sexual and asexual reproduction of the holothurian *Stichopus chloronotus* (Echinodermata): A comparison between La Réunion (Indian Ocean) and east Australia (Pacific Ocean). Invertebrate Reproduction and Development 41:235–242.

Daud R., Tangko A.M., Mansyur A. and Sudradjat A. 1993. Polyculture of sea cucumber, *Holothuria scabra* and seaweed, *Eucheuma* sp. In: Sopura Bay, Kolaka Regency, southwest Sulawesi. In: Prosiding Seminar Hasil Penelitian 11:95–98.

Engstrom N.A. 1980. Development and natural history and intestinal habits of the apodous holothurian *Chiridota rotifera* (Pourtales, 1851) (Echinodermata: Holothuroidea). Brenesia 17:85–96.

Gravely F.H. 1927. The littoral fauna of Krusadai Island in the Gulf of Mannar: Echinodermata. Bulletin of Madras Governemnt Museum (Natural History) 1:163–173.

Hamano T., Kondo M., Ohhashi T., Fujimura H. and Sueyoshi. 1996. The whereabouts of edible sea cucumber *Stichopus japonicus* juveniles released in the wild. Suisanzoshoku 44:249–254.

Hamel J-F. and Mercier A. 1996. Early development, settlement, growth and spatial distribution of the sea cucumber *Cucumaria frondosa* (Echinodermata: Holothuroidea). Canadian Journal of Fisheries and Aquatic Sciences 53:253–271.

Hamel J-F., Ycaza Hidalgo R. and Mercier A. 2003. Larval development and juvenile growth of the Galapagos sea cucumber *Isostichopus fuscus*. SPC Beche-de-Mer Information Bulletin 18:3–8.

Hatanaka H. 1996. Laboratory experiments on amount of feeding of the juvenile sea cucumber *Stichopus japonicus*. Saibaigiken 25:11–14.

Hatanaka H., Uwaoku H. and Yasuda T. 1994. Experimental studies on the predation of juvenile sea cucumber, *Stichopus japonicus*, by sea star *Asterina pectinifera*. Suisanzoshoku 42:563–566.

Ito S., Kawahara I. and Hirayama K. 1994. Studies on the technological development of mass production of juvenile sea cucumber *Stichopus japonicus*. Saibaigiken 22:83–91.

James D.B. 1976. Studies on Indian Echinoderms – 6. Redescription of little known holothurians with a note on an early juvenile of *Holothuria scabra* Jaeger from Indian Sea. Journal of the Marine Biological Association India 18:55–61.

James D.B. 1983. Sea cucumber and sea urchin resources and beche-de-mer industry. Bulletin Central Marine Fisheries Research Institute 34:85–93.

James D.B., Gandhi A.D., Palaniswamy N. and Rodrigo J.X. 1994. Hatchery techniques and culture of the sea cucumber *Holothuria scabra*. CMFRI Bulletin 48:120–126.

Kobayashi M. and Ishida M. 1984. Some experiments concerned with the causes of the decrease of sea cucumber *Stichopus japonicus* juveniles. Saibaigiken 13:41–48.

Lokani P., Polon P. and Lari R. 1995. Fisheries and management of beche-de-mer fisheries in Western Province of Papua New Guinea. p. 267–275. In: Dalzell P. and Adams T.J.H. (eds). SPC Integrated Coastal Fisheries Management Project Technical Document n° 11. SPC, Noumea.

Long B. and Skewes T. 1997. Distribution and abundance of beche-de-mer on Torres Strait reefs. SPC Beche-de-Mer Information Bulletin 9:17–22.

Mercier A., Battaglene S.C., Hamel J-F. 1999. Daily burrowing cycle and feeding activity of juvenile sea cucumbers *Holothuria scabra* in response to environmental factors. Journal of experimental Marine Biology and Ecology 239:125–156.

Mercier A., Battaglene S.C. and Hamel J-F. 2000a. Settlement preferences and early migration of the tropical sea cucumber *Holothuria scabra*. Journal of Experimental Marine Biology and Ecology 249:89–110.

Mercier A., Battaglene S.C. and Hamel J-F. 2000b. Periodic movement, recruitment and size related distribution of sea cucumbers *Holothuria scabra* in the Solomon Islands. Hydrobiologia 440:81–100.

Muliani, 1993. Effect of different supplemental feeds and stocking densities on the growth rate and survival of sea cucumber *Holothuria scabra* in Tallo River mouth, south Sulawesi. Journal Penelitian Budidaya Pantai 9:15–22.

Purcell S.W. 2004. Criteria for release strategies and evaluating the restocking of sea cucumbers. In: Lovatelli A., Conand C., Purcell S., Uthicke S., Hamel J-F., Mercier A. (eds). Advances in sea cucumber aquaculture and management. FAO, Rome (2004).

Purcell S.W., Gardiner D. and Bell J. 2002. Developing optimal strategies for restocking sand fish: a collaborative project in New Caledonia. SPC Beche-de-Mer Information Bulletin 16:2–4.

Ramofafia C., Foyle P.T and Bell J.D. 1997. Growth of juvenile *Actinopyga mauritiana* (Holothuroidea) in captivity. Aquaculture 152:119–128.

Ramofafia C., Battaglene S.C., Bell J.D. and Byrne M. 2000. Reproductive biology of the commercial sea cucumber *Holothuria fuscogilva* in the Solomon Islands. Marine Biology 136:1045–1056.

Seeto J. 1994. The reproductive biology of the sea cucumber *Holothuria atra* Jaeger, 1833 (Echinodermata: Holothuroidea) in Laucala Bay, Fiji, with notes on its population structure and symbiotic associations. MSc Thesis, University of Otago, Dunedin, New Zealand.

Shelley C.C. 1985. Potential for re-introduction of a beche-de-mer fishery in the Torres Strait. Torres Strait Fisheries Seminar, Port Moresby. 11–14 February.

Tanaka M. 2000. Diminution of sea cucumber *Stichopus japonicus* juveniles released on artificial reefs. Bulletin Ishikawa Prefecture Fish Research Centre 2:19–29.

Tiensongrusmee B. and Pontjoprawiro S. 1988. Sea cucumber culture: potential and prospects. United Nations Development Programme, Executing Agency, Food and Agriculture Organization of the United Nations.

Wiedemeyer W.L. 1994. Biology of small juveniles of the tropical holothurian *Actinopyga echinites*: Growth, mortality and habitat preferences. Marine Biology 120:81–93.

Young C.M. and Chia F.S. 1982. Factors controlling spatial distribution of the sea cucumber *Psolus chitinoides*: Settling and post settling behaviour. Marine Biology 69:195–205.