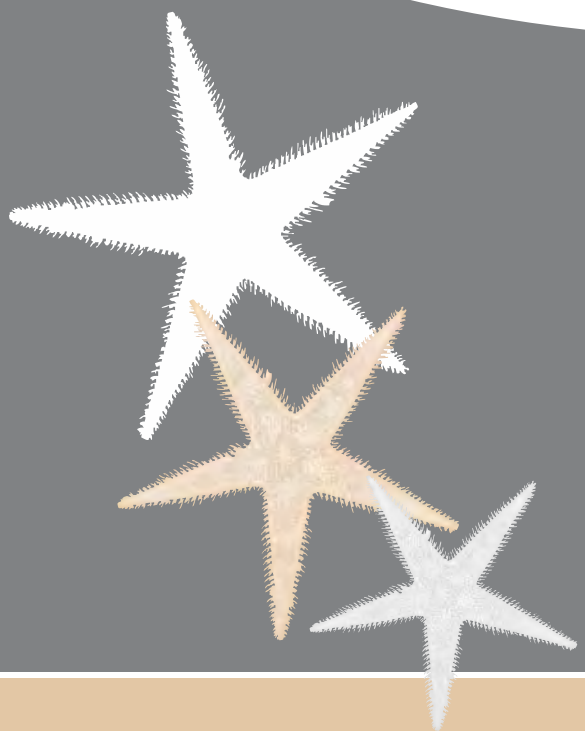


SOUVENIRS FROM THE SEA

AN INVESTIGATION INTO THE CURIO TRADE IN ECHINODERMS FROM MEXICO

K.E. Lunn, M.J. Villanueva Noriega, and A.C.J. Vincent

MARINE CURIOSITIES are collected from seas around the world, often with little understanding of the ecological impacts of such harvesting. As Latin America's top destination for foreign tourists, Mexico was chosen for the first case study of the curio trade in echinoderms (any of a variety of invertebrate marine animals belonging to the phylum Echinodermata, which include sea stars, sea urchins and sea cucumbers). Interviews were conducted with fishers, distributors and retailers in Mexico's capital city and along its Pacific and Caribbean coasts, to document the organization, scale, value, and management of the curio trade in echinoderms. The surveys, undertaken in February and March 2004, were designed to supply baseline information for Mexican resource managers and to raise public awareness about the potential conservation implications of the marine curio trade. Mexican curio traders were found to be selling, collectively, specimens of at least 22 echinoderm species, although most retailers focused on Ochre Sea Star Pisaster ochraceus, *Cushion Sea Star* Oreaster reticulatus, *and Purple Sea Urchin* Echinometra vanbrunti. *Extrapolations from interviews suggested that, together, Mexican fishers hand-collected an estimated 880 000 sea stars and 48 000 sea urchins each year, destined for domestic retail shops and export to the USA and elsewhere. While permits can now be obtained for the commercial exploitation of* Pisaster ochraceus, *the large-scale commercial collection and sale of* Oreaster reticulatus *and* Echinometra vanbrunti *are officially prohibited in Mexico.* >

INTRODUCTION

The curio trade in marine species is a large and global industry, involving molluscs, corals, echinoderms, crustaceans, fishes, and marine turtles collected from seas around the world. Specimens in the dried curio trade are marketed individually or combined with specimens of other species to make elaborate craftwork. More than 5000 species of ornamental shells (Wood and Wells, 1995), 40 corals (Wood and Wells, 1988), and 32 marine fishes (Grey *et al.*, 2005) are known to be traded on the international curio market. From their point of collection, curios are either sold directly on the domestic market or exported from the source country, usually through a chain of distributors (Wood and Wells, 1988). In the mid-1980s, a study of the global shell trade revealed that thousands of tonnes of ornamental shells were being traded every year (Wood and Wells, 1988). United States Fish and Wildlife Service (USFWS) records indicate that most dried marine fish and shells arriving in the USA—thought to be among the world's largest importers of marine curio products—come from the Philippines and Taiwan (Wood and Wells, 1995; Grey *et al.*, 2005). Although recent data on global trade volumes are sparse, a review of US import records revealed that roughly one million marine fish and 360 000 kg of fish parts were imported as curios each year between 1997 and 2001 (Grey *et al.*, 2005).

Limited information about the magnitude of the global curio trade has resulted in a poor understanding of its conservation implications. "Large, sedentary, and easily accessible species with comparatively restricted ranges" are considered most at risk from the curio trade (Wells, 1989: 447). Shallow-dwelling echinoids and asteroids are, for example, easy targets for even the smallest-scale fishers because they have relatively low mobility and some species aggregate for feeding and/or spawning (e.g. *Oreaster reticulatus*, Scheibling, 1980c, 1982). Local depletions have already been observed in many ornamental shell species (e.g. Maui Cowry *Cypraea mauiensis*), although none has apparently been threatened with global extinction as a result (see reviews in Wood and Wells, 1988; Wood and Wells, 1995). Half of the 32 marine fish species known to be traded as curiosities in the USA are included on the *2003 IUCN Red List of Threatened Species* as Near Threatened, Vulnerable, or Endangered (Grey *et al.*, 2005). Assessing the conservation impacts of the curio trade will require further information about the number of animals being collected and the status of exploited populations.

Management of the trade in marine curios tends to vary among nations and among taxa. Trade documentation is required for species protected under the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). Several marine taxa sold as curios are regulated under CITES; all six marine turtle species Cheloniidae are listed in Appendix I[1], while nine giant clam Tridacnidae species, Queen Conch *Strombus gigas*, Great White Shark *Carcharodon carcharias*, all seahorse *Hippocampus* species, and all hard corals are monitored under Appendix II[2] (CITES, 2004b). While CITES requires the collation of export data for listed species (CITES, 2004a), the Convention is not designed to document domestic consumption, which makes it impossible to gauge total exploitation from CITES records alone. National Customs offices can serve as useful sources of information on the exploitation of marine species, provided that data are gathered at a scale that is appropriate to the enquiry—for instance, at the species or genus level for investigations into the

[1]Appendix I of CITES includes species threatened with extinction. Trade is permitted only in exceptional circumstances. [2]Appendix II includes species not necessarily threatened with extinction, but in which trade must be controlled in order to avoid utilization not compatible with their survival (CITES, 2004a).

Figure 1. Map of Mexico showing the directions of trade routes for *Pisaster ochraceus* (dark arrow), *Oreaster reticulatus* (clear arrow), and *Echinometra vanbrunti* (hatched arrow) in the Mexican curio trade, based on interviews with fishers and retailers.

Also shown are some of the locations where interviews were conducted in February and March 2004.

impacts on individual species. Government records that do exist, however, often aggregate large numbers of species into single categories (Wood, 2001). Domestic retail sales are generally only monitored through time-consuming, expensive field studies that have, as a result, only been conducted for a small portion of species in the curio trade (e.g. syngnathid fishes, Vincent, 1996).

The international curio trade in echinoderms has been relatively little studied when compared with that in corals and shells. Large quantities of echinoderms are, however, sold internationally for both food and non-food purposes. Global echinoderm landings were estimated at 105 876 t in 2001, thus comprising approximately 0.1% of the world's total marine fishery production for that year (FAOSTAT, 2004). Sea cucumbers and sea urchins, both taken for the speciality food market, made up the majority of landings (Sloan, 1984). Sea stars Asteroidea, as well as some sea urchins Echinoidea, are taken for purposes other than human consumption, specifically for poultry feed, scientific study in teaching laboratories, and curios (Sloan, 1984). Data on the curio trade in echinoderms are, however, so sparse that the topic has essentially been ignored in the literature (see Sloan, 1984; Conand and Sloan, 1989; Wells and Wood, 1991). Although the impact of the curio trade on echinoderm populations has gone virtually unstudied (Wells and Wood, 1991), target collection for the food industry has led to observed declines in several species, including *Strongylocentrotus franciscanus* (Pfister and Bradbury, 1996; Carter and Van Blaricom, 2002) and *Isostichopus fuscus* (Bremner and Perez, 2002; Shepherd *et al*., 2004; Terney Pradeep Kumara *et al.*, 2005), potentially influencing the structure of nearshore communities (e.g. urchin extraction leading to increased algal growth, see McClanahan *et al.*, 1996; McClanahan, 1999; Carreiro-Silva and McClanahan, 2001).

Given the lack of species-specific export data for many species in the curio trade, and the dearth of information on retail sales, the authors carried out the first field survey of the Mexican fisheries and trades of echinoderms taken as curios. Mexico was chosen as the focus of this case study because of its prosperous tourism industry and its close trade relationship with the USA, two factors that were expected to create a large market for curios. This paper describes the organization, scale, value, and management of the echinoderm curio trade in Mexico, based on the results of interviews with trade participants throughout the country. This survey, focusing on the collection and retail ends of the trade, was designed to provide baseline information for Mexican resource managers and to raise public awareness about the potential conservation implications of the marine curio trade.

EUROPEAN EDIBLE SEA URCHIN
Echinus esculentus

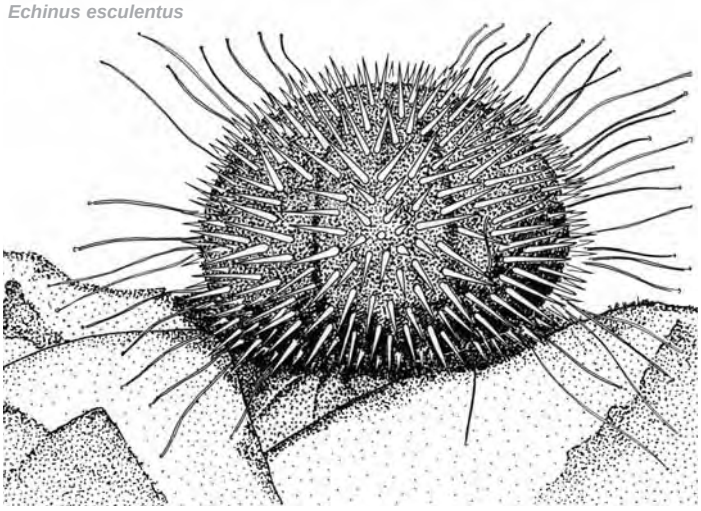


ILLUSTRATION: SARAH ANNE HUGHES

METHODS

Field data were collected during February and March 2004. Interviews were conducted with fishers, distributors, and retailers involved in the curio trade in echinoderms in 16 coastal locations: Acapulco, Cancún, Ensenada, Isla Cozumel, Isla Mujeres, Ixtapa, Manzanillo, Mazatlán, Playa del Carmen, Popotla, Puerto Juarez, Puerto Vallarta, Rosarito, San Quintin, Tijuana, and Zihuatanejo (Figure 1). Interviews followed a semi-structured format based on the methodology used by Vincent (1996). Contacts were identified using the snowball sampling approach, whereby previous interviewees were asked to suggest additional contacts (see description in Miles and Huberman, 1994). When selecting interview respondents, small-, medium-, and large-sized fishing and retail operations were haphazardly sampled in order to deduce average behaviour and involvement in the trade. To gauge the number of participants at each level of the trade, the number of retailers in each trade centre were counted and the numbers of fishers and distributors estimated based on interview responses by other trade participants.

Questions were adjusted to respondents' positions within the trade, varying among fishers, distributors, and retailers. Fishers were asked about:

(i) their fishing equipment (e.g. boat, gear);
(ii) their fishing effort (e.g. length/frequency of trips);
(iii) their catches per unit time;
(iv) seasonal variations in catches and/or effort;
(v) the locations of fishing grounds (e.g. habitat types, depths);
(vi) destinations of catches (e.g. identities of buyers, trade routes);
(vii) sale prices, and
(viii) any changes in these factors over time.

Distributors and retailers were asked questions about:

(i) the size of their business;
(ii) their years of experience;
(iii) the types of products traded;
(iv) the identity of echinoderm species in the curio trade;
(v) the importance of these species to their businesses;
(vi) the popularity of echinoderms compared to other curio products;
(vii) the source of echinoderms (e.g. identities of distributors and/or fishers, locations of fishing grounds);

Location	Retailers interviewed	Retailers observed	Distributors	Fishers	Government officials	NGO staff	Academics
Mexico City					1	3	1
Pacific coast	52	1	4	4	3		2
Caribbean coast	15	6		7	1		
Baja Peninsula	3		3	3	1		1
TOTAL	**70**	**7**	**7**	**14**	**6**	**3**	**4**

Table 1. The roles and locations of interview respondents and the locations of retail shops where echinoderm curios were observed without full interviews being conducted. *A total of 96 people were interviewed during the course of this study, but many had more than one role within the trade; respondents were, as a result, included under all relevant headings.*

(viii) the amounts bought/sold per unit of time;
(ix) the buying and selling prices;
(x) seasonal variations in supply and/or demand;
(xi) the types of retail customers (e.g. age, nationality); and
(xii) any changes in these factors over time.

Information about trade regulations and legislation was collected from the fisheries and natural resource divisions of the federal government. Species' identities were determined by consulting Brusca (1980), Colin and Arneson (1995), and Humann (1992) and were later confirmed by sending photographs to specialists in echinoderm taxonomy.

All interviews were conducted in Spanish. Since the lengths of interviews varied with respondents' willingness to provide information (almost always less than 30 minutes and typically less than half that time), the sample size (presented throughout the text as "n") varied among questions. Rather than writing notes during the interviews, the interviewers recorded their responses and cross-validated their recollections immediately following each interview in order to make the process less formal and to help put respondents at ease. In some cases, certain pieces of information were noted before the start of interviews—for instance, species for sale and display prices in retail shops. Where percentages of respondents are reported, "n" refers to the total sample size of respondents, rather than the number of respondents providing a particular answer. Monetary values given during the interviews were converted from Mexican pesos (MXP) to US dollars (USD) using the average exchange rate 0.091 for the period 1 February to 31 March 2004 (UBC, 2004).

Descriptive statistics, including medians and ranges, are provided to describe the central tendency and variability in the interview data. Median reported values were used as the basis for extrapolating the total volume of echinoderms caught and/or sold in each trade centre. Total trade volumes were only calculated for the collection and retail ends of the trade, as all of the distributors interviewed also operated within one of these trade levels.

Estimated trade volumes were then compared with the USFWS records of dried echinoderm specimens being imported from Mexico between 1997 and 2002, made available under the *Freedom of Information Act*. Relevant Customs codes were species, genera, or class specific, and included: 'PIOH' (*Pisaster ochraceus*), 'PIOC' (*Pilaster ochraceus*) [sic], 'ENCG' (*Encope grandis*), 'ECO?' (*Encope* sp.), 'HNR?' (*Henricia* sp.), MLA?' (*Mellita* sp.), 'OTR?' (*Oreaster* sp.), 'PIR?' (*Pisaster* sp.), 'SGC?' (*Strongylocentrotus* sp.), 'and 'AS00' (Asteroidea). Since some of the echinoderm shipments were recorded as dried weight (in kg), weights were converted to numbers of individuals using various rates. For *Pisaster* sea stars, a conversion rate of 10 individuals/kg—the average weight of an unknown number of medium-sized samples collected in Ensenada (J. Palleiro, Centro Regional de Investigación Pesquera, *in litt.* 2004)—was used to convert dried weights to numbers of individuals. Records for *Encope grandis* were converted using a rate of 34 individuals/kg, based on the average weight of 20 market specimens in Puerto Peñasco (K. Larson, CEDO Intercultural, *in litt.* 2004). USFWS data are presented as mean ± standard deviation.

The authors were told by a government official that Mexican Customs data would not be meaningful for this analysis of the trade in echinoderms, as the codes were too general to allow an estimation of the number or weight of echinoderm species being imported to or exported from Mexico (A. Peralta Delgado, CONAPESCA, *in litt.* 2004).

Results

Ninety-six people were interviewed in Mexico's capital city—Mexico City—and along its Pacific and Caribbean coasts (Table 1). Respondents included echinoderm fishers, marine curio distributors and retailers, staff from international and local non-governmental organizations (NGOs), federal government officials from the Secretaría de Agricultura, Ganadería, Desarrollo Rural, Pesca y Alimentación (SAGARPA) and the Secretaría de Medio Ambiente y Recursos Naturales (SEMARNAT), and professors from three Mexican universities and trade schools. The types and sale prices of echinoderm curios were recorded in an additional seven retail shops (not included in the above total), without conducting full interviews with their owners, and six boat owners were consulted about the catches of their other 20 crew members.

Common Name	Species Name	Range	Habitat Type	Source
SEA STARS				
Ochre Sea Star	*Pisaster ochraceus*	Pacific Northwest (Alaska) to Pacific Eastern Central (Baja California)	rocky shores, low intertidal zones, subtidal on rocks up to 90 m	Paine, R.T. (1980). Food Webs: Linkage, interaction strength and community infrastructure. *The Journal of Animal Ecology* 49(3):666–685.
Cushion Sea Star	*Oreaster reticulatus*	Atlantic Western Central (North Carolina) to Atlantic Eastern Central (Cape Verde Is)	shallow (<5 m) sand bottoms and sparse seagrass beds	Scheibling, R.E. (1980). Abundance, spatial distribution and size structure of populations of *Oreaster reticulatus* (Echinodermata: Asteroidea) in seagrass beds. *Marine Biology* 57:95–105. Hendler, G., Miller, J.E., Pawson, D.L., and Keir, P.M. (1995). *Echinoderms of Florida and the Caribbean. Sea Stars, Sea Urchins, and Allies.* Smithsonian Institution Press, Washington, DC.
—	*Astropecten* sp.	*Astropecten* spp. are generally found in the western Atlantic Ocean, although at least one species is found in the eastern Pacific Ocean. *Astropecten articulatus*, *A. cingulatus*, and *A. duplicatus* are found as far south as northern Brazil and *A. verrilli* is found in the Pacific in the waters of southern California		Clark, A.M. and Downey, M.E. (1992). *Starfishes of the Atlantic*. Chapman and Hall, New York, New York. xxvi+794 pp. Maluf, L.Y. (1988). Composition and distribution of the Central Eastern Pacific Echinoderms. Los Angeles Co. Mus. Technical Report No. 2. 242 pp.
—	*Heliaster* sp.	All species in the genera range from Pacific Eastern Central (Baja California), to Pacific Southwest (Galapagos Is)		Clark, A.M. and Downey, M.E. (1992). *Starfishes of the Atlantic*. Chapman and Hall, New York, New York xxvi+794 pp.
—	*Linckia* sp.	Most *Linckia* spp. are found in the IndoPacific. One species (*L. columbiae*) is found off the coast of California and two other species (*L. guildingii* and *L. bouvieri*) are found in the Atlantic Ocean	coral reefs	Willams, S.T. (2000). Species boundaries in the starfish genus *Linckia*. *Marine Biology* 136:137–148.
Chocolate Chip Sea Star	*Nidorellia armata*	Pacific Eastern Central (Baja California, Panama) to Pacific Southwest (Galapagos Is)	coral reefs	Edgar, G.J., Banks, S., Farina, J.M., Calvopiña, M. and Martínez, C. (2004). Regional biogeography of shallow reef fish and macro-invertebrate communities in the Galapagos archipelago. *Journal of Biogeography* 31:1107–1124. Solís-Marín, F.A., Reyes-Bonilla, H., Herrero-Pérezrul, M.D., Arizpe-Covarrubias, O., and Laguarda-Figueras, A. (1997). Sistemática y distribución de los equinodermos de la Bahía de La Paz. Cienc. *Mars* 23:249–263.

Table 2. Range and habitat types of echinoderm species seen in the Mexican curio trade.

Common Name	Species Name	Range	Habitat Type	Source
Gulf Star	*Oreaster occidentalis*	USA, Mexico, Panama	coral rubble	Caso, M.E. (1994). *Morphologic, Taxonomic, Ecologic Study and Geographic Distribution of Asterozoa Collected During Cortez 1, 2, and 3 Cruises.* Inst. Cienc. del Mar y Limnol. Univ. Nal. Auton. México, Publ. Esp. (12):1–111. Lessios, H.A. (1990). Adaptation and phylogeny as determinants of egg size in echinoderms from the two sides of the Isthmus of Panama. *The American Naturalist* 135(1):1–13.
Tan Star	*Phataria unifascialis*	Pacific East Central (Gulf of California) to Pacific Southeast (Galapagos Is to Peru)	shallow subtidal, rocky reefs	Maluf, L.Y. (1988). Composition and distribution of the Central Eastern Pacific Echinoderms. Los Angeles Co. Mus. Technical Rept. No. 2. 242 pp.
Giant Spined Sea Star	*Pisaster giganteus*	Pacific Northwest (British Columbia) to Pacific Eastern Central (Baja California)	rocky and sandy bottoms; kelp, low intertidal often shallow but also to 100 m	Hopkins, T.S. and Crozier, G.F. (1966). Observations on the asteroid echinoderm fauna occurring in the shallow water of southern California. *Bulletin of the South California Academy of Science* 65:125–145.
Sunflower Star	*Pycnopodia helianthoides*	Pacific Northwest (Alaska) to Pacific Eastern Central (Baja California)	rock sand or mud in subtidal zone to 435 m (often no deeper than 120 m)	Fisher, W.K. (1928). Asteroidea of the northern Pacific and adjacent waters, Part 2. *Forcipulata Bull.* US Nat. Mus. 76:11–24581.
One unidentified species				
SEA URCHINS				
Purple Sea Urchin	*Echinometra vanbrunti*	Pacific Eastern Central	intertidal; rocky shores	Lessios, H.A., and Cunningham, C.W. (1990). Gametic incompatibility between species of the sea urchin *Echinometra* on the two sides of the Isthmus of Panama. *Evolution* 44(4):933–941.
European Edible Sea Urchin	*Echinus esculentus*	Atlantic Northeast	rocky substrata from sublittoral fringe to 40 m, may be found at depths of 100 m or more	Reid, D.M. (1935). The range of the Sea-Urchin *Echinus esculentus*. *The Journal of Animal Ecology* 4(1):7–16.
Pencil Urchin	*Heterocentrotus mammillatus*	Pacific Eastern Central (Hawaiian Is) to IndoPacific, to Indian Western (Northern Red Sea)	reef fringes with strong water movement	Dotan, A. (1990). Population structure of the echinoid *Heterocentrotus mammillatus* along the littoral zone of south-eastern Sinai. *Coral Reefs* 9:75–80. Ebert, T.A. (1982). Longevity, life history, and relative body wall size in sea urchins. *Ecological Monographs* 52(4):353–394.

Table 2 (ctd). Range and habitat types of echinoderm species seen in the Mexican curio trade.

Common Name	Species Name	Range	Habitat Type	Source
Purple Sea Urchin	*Strongylocentrotus purpuratus*	Pacific Northwest (Alaska) to Pacific Eastern Central (Baja California)	rocky reefs low intertidal to shallow subtidal	Ricketts, E.F. and Calvin, J. (1939). *Between Pacific Tides* (3rd Rev. Ed. 1962 by J.W. Hedgepeth. Stanford University Press xii+516).
White Sea Urchin	*Tripneustes depressus*	Pacific Eastern Central (Panama) and genetically indistinguishable from congener in West Indo-Pacific	seagrass beds, coral rubble, hard substrates, reefs to a depth of 75 m	Lessios, H.A. (1990). Adaptation and phylogeny as determinants of egg size in echinoderms from the two sides of the Isthmus of Panama. *The American Naturalist* 135(1):1–13. Lessios, H.A, Kane, J., Robertson, D.R. (2003). Phylogeography of the pantropical sea urchin *Tripneustes*: contrasting patterns of population structure between oceans. *Evolution* 57(9):2026–2036.
Two unidentified species				
SAND DOLLARS				
Western Sand Dollar	*Dendraster excentricus*	Pacific Northwest (British Columbia) to Pacific Eastern Central (Baja California)	sand; low intertidal to about 90 m	Merrill, R.J. and Hobson, E.S. (1970). Field observations of *Dendraster excentricus*, a sand dollar of western North America. *American Midland Naturalist* 83(2):595–624. Mooi, R. (1997). Sand Dollars of the genus *Dendraster* (Echinoidea: Clypeasteroida): phylogenic systematics, heterochrony, and distribution of extant species. *Bulletin of Marine Science* 61(2):343–375.
—	*Encope grandis*	Pacific West Central (Gulf of California)	lower intertidal and subtidal	Ebert, T.A. and Dexter, D.M. (1975). A natural history study of *Encope grandis* and *Mellita grantii*, two sand dollars in the northern gulf of California, Mexico. *Marine Biology* 32(4):397–407.
Slitted Sand Dollar	*Mellita longifissa*	Atlantic Western Central to Pacific Southeast (Galapagos Islands)	intertidal	Harold, A.S. and Telford, M. (1990). Systematics, phylogeny and biogeography of the genus *Mellita* (Echinoidea: Clypeasteroida). *Journal of Natural History* 24:987–1026.
HEART URCHINS				
Sea Porcupine	*Lovenia cordiformis*	Pacific Western Central (to Panama)	sand; reported depths of 0–201 m but found only at 29 m in Panama	Lessios, H.A. (2005). Echinoids of the Pacific waters of Panama: status of knowledge and new records. *Rev. Biol. Tropical* 53 (sup. 3):147–170.

Table 2 (ctd). Range and habitat types of echinoderm species seen in the Mexican curio trade. *Regional descriptions follow FAO.*

Species and Products in the Curio Trade

Sea stars and sea urchins dominated the curio trade in echinoderms in Mexico's main tourist centres, while sand dollars and heart urchins were less frequently on sale. A total of 22 echinoderm species, described in Table 2, were seen in the Mexican curio trade, although most participants focused on Ochre Sea Stars *Pisaster ochraceus*, Purple Sea Urchins *Echinometra vanbrunti*, and Cushion Sea Stars *Oreaster reticulatus*. Fifty-nine per cent of retailers interviewed sold *P. ochraceus*, 31% stocked *O. reticulatus*, and 23% carried *E. vanbrunti* (n=75). Seventy-six per cent of surveyed retail shops sold only one or two echinoderm species, while 24% traded more than two species (n=75). Echinoderm species were sold either individually or as part of other shellcrafts in Mexican souvenir shops (e.g. shell mobiles, necklaces, religious icons, and candle holders).

Fishery

Fishers participating in the curio trade either targeted echinoderms and other curio species specifically (n=11), or acted opportunistically when local demand for echinoderms increased, such that echinoderm prices outweighed their usual earnings from other fisheries (e.g. lobster, oyster, octopus) (n=3). Fishers and distributors reported that year-round target fisheries for sea star curios existed only along the northwestern Baja and Caribbean coasts and for sea urchin curios around Manzanillo, Mazatlán, Zihuatanejo, and Acapulco (n=16). Fishing respondents stated that Mexican echinoderms in the curio trade were taken from rocky intertidal, shallow seagrass, and/or sandy-bottom habitats, depending on the species (n=12). Only one respondent—a retailer from Playa del Carmen—reported that some *Oreaster* sea stars in the curio trade were taken as bycatch in shrimp trawl nets, while an American researcher reported "piles of sand dollars five feet high that [shrimp trawlers] dumped on the shore to dry out" (R. Brusca, Arizona-Sonora Desert Museum, *in litt.* 2004).

Trade Structure

After capture, dried echinoderms typically passed through at least one intermediary before reaching their destinations in Mexican and foreign retail shops (Figure 1). Eighty per cent of fishing respondents sold only to domestic buyers and retailers, while the remaining 20% of fishers directly exported a portion of their catches to at least two import companies in the USA and one in Italy (n=14). Mexican retailers said they always purchased at least part of their echinoderm stock from Mexican fishers and/or distributors, although 14% of retail respondents stated that they imported some of their stock from South-east Asia and Africa, either directly or through curio dealers in the USA (n=58).

Retailers were frequently unaware of, or gave incorrect information about, the origins of their curio products. Forty-one per cent of retailers provided plausible source information for the species sold in their shops, while 38% were unable to report the origin of their stock and 21% gave obviously incorrect information about the collection sites of retail species (n=39). For instance, one retailer said that he imported *Pisaster ochraceus* sea stars from South-east Asia, despite the fact that this species has only been recorded in the eastern Pacific (Lambert, 2000). Given that species endemic to European and Indo-Pacific waters (e.g. *Echinus esculentus*, *Heterocentrotus mammillatus*) were observed in Mexican retail shops, some intercontinental trading certainly exists.

Both domestic and international tourists purchased echinoderm curios from Mexican retail shops; 44% of retail respondents reported that domestic tourists purchased the majority of marine curios, 40% said that foreign and domestic tourists bought equal amounts, and only 16% reported that foreign tourists were the main consumers (n=25).

K. LUNN / PROJECT SEAHORSE

CUSHION SEA STARS *OREASTER RETICULATUS* DRYING IN THE OPEN AIR, NEAR CANCUN, MEXICO.

Catch Volumes

Fishers reported catching large quantities of sea stars and sea urchins from Mexico's coastal waters (Table 3). The total annual catch of echinoderm curios, determined for the three main species in the trade, was extrapolated from the median of fishing respondents' reported average catches and the total number of fishers that respondents stated were active (Table 3). Together, these estimates place sea star catches at approximately 880 000 individuals/year and sea urchins at circa 48 000 individuals/year for sale as curios. Ninety per cent of the sea stars thought to be collected for the curio trade were of the genus *Pisaster.* Supply was apparently constant year-round, with 71% of retailers (n=7) and all fishers (n=9) reporting that echinoderms were collected for the curio trade on a consistent, year-round basis. Only two retail shop owners reported seasonal differences in supply, with one claiming that supply peaked in December and January and the other reporting that supply was low between August and November. None of the fishers interviewed collected sand dollars or heart urchins, and thus no information could be gathered about the volumes of these species being caught in Mexico.

Trade Volumes

Mexican retail shops stocking echinoderms were calculated to be selling approximately 40 000 sea stars and 8600 sea urchins per year at the time of the study. This total would account for only five per cent of the sea stars and 18% of the sea urchins apparently being collected from Mexican coastlines. Calculations of trade volumes for domestic souvenirs were based on respondents' estimates of annual retail sales and the total number of shops observed to be selling each class of echinoderm. In counting the number of retail shops, however, the species that each stocked was not recorded, and thus the average sales of different species were combined for each class. Individual retailers reported yearly sales of between 11 and 1500 sea stars per shop (median=200 sea stars/shop; n=36) and 50 and 1067 sea urchin tests (the dried body of the urchin without the spines) per shop (median=288 tests/shop; n=6), with most responses being based on the sales of *Pisaster, Oreaster,* and *Echinometra* spp. (Table 4). Observations of the number of retail shops revealed that at least 201 shops were trading sea stars and 30 selling sea urchins in the cities visited, putting the total sale of echinoderms at an estimated 40 200 sea stars and 8640

Species	Hourly catch #/fisher/hr fisher/day	Daily effort #hours/ #/fisher/day	Daily catch #days/ fisher/year	Annual effort #/fisher/year	Annual catch	Minimum #fishers	Estimated total catch #/year
SEA STARS							
Oreaster spp.							
Median	9	2.5	25	144	3650	24	87 600
Range	6–250	2–4	18–750	12–57	2592–9000		
Sample (n)	11	11	11	11	11		
Pisaster spp.							
Median	53	3.5	244	120	26 400	30	792 000
Range	13–70	2.5–5	33–267	108–144	3943–38 400		
Sample (n)	17	17	17	17	17		
Other sea star species							
Median	22	4.5	75	?	?	8	?
Range	22	4.5	50–100	?	?		
Sample (n)	1	1	2	0	0		
SEA URCHINS							
Echinometra sp.							
Median	507	2.8	778	6	6805	7	47 635
Range	14–1000	1.5–4	55–1500	2–9	110–13 500		
Sample (n)	2	2	2	2	2		
Other urchin species							
Median	?	?	?	?	?	2	?
Sample (n)	0	0	0	0	0		

Table 3. Volumes of echinoderm species being caught for the curio trade in surveyed areas of Mexico, based on interviews with Mexican fishers (n). *The range of responses, sample size, and median values are provided for each of the following columns: hourly catch, daily effort, daily catch, annual effort, and annual catch. Estimated total catch was calculated as the median annual catch x minimum # fishers.*

SPECIES	SALES		
	Range *(#/shop/year)*	Median *(#/shop/year)*	*n*
Astropecten sp.	600		1
Linckia sp.	720		1
Nidorellia sp.	11		1
Oreaster spp.	66–960	332	10
Phataria sp.	182		1
Pisaster spp.	15–1500	132	19
TOTAL SEA STARS	11–1500	200	36
Echinometra sp.	55–1067	430	4
Tripneustes sp.	120–315	218	2
TOTAL SEA URCHINS	55–1067	288	6

Table 4. Range and median of echinoderm sales in Mexican retail shops, based on respondents' accounts (n).

SPECIES	RETAIL PRICES		
	MXP	USD equivalent	n
SEA STARS			
Astropecten sp.	6.0–15.0	0.55–1.37	3
Heliaster sp.	40.0	3.64	1
Linckia sp.	15.0–80.0	1.37–7.28	3
Nidorellia sp.	10.0	0.91	1
Oreaster spp.	20.0–660.0	1.82–60.00	21
Phataria sp.	10.0–35.0	0.91–3.19	3
Pisaster spp.	10.0–95.0	0.91–8.65	53
SEA URCHINS			
Echinometra sp.	4.0–30.0	0.36–2.73	17
Echinus sp.	50.0–180.0	4.55–16.38	2
Heterocentrotus sp.[1]	4.0	0.36	1
Tripneustes sp.	15.0	1.37	2
SAND DOLLARS			
Dendraster sp.	9.5–22.0	0.86–2.00	4
Encope sp.	16.0–36.0	1.46–3.28	3
Mellita sp.	12.5	1.14	1
HEART URCHINS			
Lovenia sp.	7.5–44.0	0.68–4.00	4

Table 5. Range of retail prices for echinoderm species in Mexico. (n = specimens observed). *[1]The price given for this species refers to one individual spine, rather than the urchin test (the urchin shell minus the spines).*

sea urchins per year in the areas surveyed. Retailers reported that echinoderm sales peaked around Easter (n=23), Christmas (n=11), summer holidays (n=10), American schools' spring break (n=2), and other long weekends (n=1), when the numbers of domestic and international tourists were at their highest. Only eight per cent of respondents said that demand was constant year-round (n=26). Respondents were not able to provide information about the number of sand dollars, heart urchins, or pencil urchin spines being sold over any unit of time.

The USA imported large quantities of Mexican sea stars and sand dollars between 1997 and 2002, according to USFWS records. US curio companies showed imports of an estimated 352 302±157 801 dried *Pisaster* sea stars annually from Mexico during this period; approximately 3% were later reportedly re-exported to Australia, Japan, and Spain. Average annual imports of roughly 52 383±24 824 Mexican sand dollars (*Encope grandis*) were documented in US statistics during the same timeframe. The same US data showed only one re-export of *Oreaster* sea stars of Mexican origin during this period, when 200 kg were shipped back to Mexico in 2001, possibly after being processed in the USA. Small numbers of *Henricia* sea stars, *Strongylocentrotus* sea urchins, and *Mellita* sand dollars were also reportedly imported from Mexico between 1997 and 2002; *Echinometra* urchins were, however, not recorded during this time.

Value and Economic Importance of the Fishery and Trade

Echinoderm curio fishers were often involved in additional livelihoods activities. Sixty-four per cent of fishers interviewed participated in inshore fisheries on a full-time basis, while the remaining part-time fishers also worked in retail and marine product distribution (n=14). Only three of the nine full-time fishers surveyed focused solely on echinoderm curios, with all of these respondents working in the Baja region of Mexico. Full-time divers surveyed informally in other areas of the country generally reported that they could earn a better income from food fisheries; one fisher in Puerto Vallarta stated, for example, that he could find 10 oysters in the time it would take to find one sea star and that the former were therefore more lucrative for him.

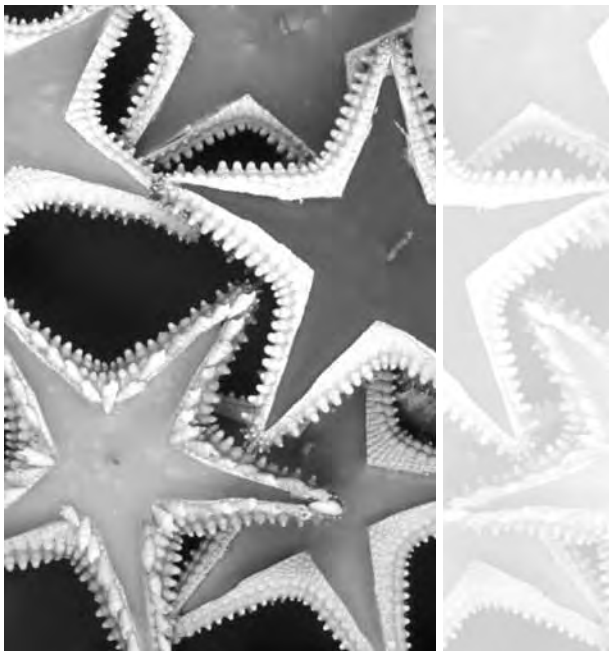
Curio retailers, like fishers, often traded several different types of products, rarely engaging only in the echinoderm trade. Eighteen per cent of retail respondents traded exclusively in marine curios, while only one per cent sold solely echinoderm curios (n=73). Other retailers also sold clothes, jewellery, ceramics, plastic trinkets, leather products, and woven materials; field observations indicated that echinoderm curios usually made up less than five per cent of shops' total stock. Retailers' marine curio selections consisted primarily of gastropod and bivalve shells (e.g. conch, abalone, oyster) and occasionally of dried fish (e.g. porcupinefish, seahorses).

The prices of echinoderm curios varied with the trade level, location of trade centres, species, size of individuals, and types of products. Although supply chains were short, prices increased dramatically as products moved up trade levels; individual retailers reported average mark-ups of 32–900% (n=12) between their buying and selling prices. Few fishers were, however, willing to provide information on the prices of their catches, unless they were also involved in the retail end of the trade, making it difficult to investigate the changes in price

between collection and retail. The retail location further affected the prices of echinoderm curios; prices were generally higher along the Caribbean coast of Mexico than on the Pacific side. Prices also varied among species, possibly as a function of the location where particular species were most frequently sold. *Oreaster* sea stars, sold almost exclusively along the Caribbean coast, tended to yield the highest retail prices (Table 5). Smaller-sized individuals of each species typically sold for lower prices than larger specimens; for example, "small" *Pisaster* sea stars were priced at an average MXP15.0 (USD1.37) (n=10) in Mexican retail shops, whereas "large" specimens of the same species averaged MXP46.5 (USD4.23) (n=12). Although most of the echinoderm products were sold separately, some were worked into larger pieces and marketed at higher prices. For instance, Pencil Urchin *Heterocentrotus mammillatus* spines were hung from shell mobiles that sold for MXP25–235 (USD2.28–21.39), depending on their size; large mobiles typically incorporated 10 to 15 spines, while small mobiles had only four to five spines. Individual spines sold for only MXP4 (USD0.36) in one Mazatlán shop.

Trade Regulation

The Comisión Nacional de Acuacultura y Pesca (CONAPESCA), a department of SAGARPA, manages Mexico's marine fisheries. Large-scale commercial collection is permitted only for species listed on the Carta Nacional Pesquera (CNP), which has included nine sea star species (*Henricia leviuscula, Leptasterias hexactis, Linckia columbiae, Patiria miniata, Plastasterias latiradiata, Pisaster brevispinus, Pisaster giganteus, Pisaster ochraceus,* and *Pycnopodia helianthoides*) and *Strongylocentrotus* sea urchins since 15 March 2004 and 28 August 2000, respectively. Species on the CNP can be collected and traded commercially, provided that fishers obtain the appropriate permits from CONAPESCA. No specific regulations are in place for the sea stars listed on the CNP. However, *NOM-007-PESC-1993* (Diario Oficial de la Federación, 21 December 1993) specifies permitted fishing gear, minimum size limit, and approved areas for collection of sea urchins *Strongylocentrotus purpuratus* and *S. franciscanus*. In addition, *NOM-009-PESC-1993* (Diario Oficial de la Federación, 4 March 1994) provides prohibited zones and closed fishing seasons for these species. To collect species that are not listed on the CNP, prospective fishers are required to obtain exploratory research (or *fomento*) permits, which allow fishers to take small numbers of these species as long as they report back about their productivity rates. CONAPESCA, in conjunction with the National Fisheries Institute, uses the catch and effort data from the *fomento* permitting system to determine whether or not particular species should be listed on the CNP. All sand dollars and heart urchins remain unlisted, making the large-scale commercial collection of these species illegal and violators officially subject to imprisonment and/or fines.



K. LUNN / PROJECT SEAHORSE

SEA STARS AND SEA URCHINS WERE SEEN TO DOMINATE THE CURIO TRADE IN ECHINODERMS IN MEXICO'S MAIN TOURIST CENTRES DURING THE COURSE OF THE STUDY, WHILE SAND DOLLARS AND HEART URCHINS WERE LESS FREQUENTLY AVAILABLE FOR SALE. OCHRE SEA STARS *PISASTER OCHRACEUS*, PURPLE SEA URCHINS *ECHINOMETRA VANBRUNTI*, AND CUSHION SEA STARS *OREASTER RETICULATUS* WERE THE SPECIES MOST FREQUENTLY COLLECTED. ECHINODERM SPECIES WERE SOLD EITHER INDIVIDUALLY OR AS PART OF OTHER SHELL-CRAFTS IN MEXICAN SOUVENIR STORES (E.G. SHELL MOBILES, NECKLACES, RELIGIOUS ICONS, AND CANDLE HOLDERS (AS ILLUSTRATED)). NINETY PER CENT OF THE SEA STARS THOUGHT TO BE COLLECTED FOR THE CURIO TRADE WERE OF THE GENUS *PISASTER*.

The nation's environmental protection agency, Procuradoría Federal de Protección al Ambiente (PROFEPA), further enforces restrictions that affect the trade in certain Mexican echinoderms. Under the authority of SEMARNAT, PROFEPA is charged with regulating the trade in species included in Mexico's *Red List of Threatened Species* (*NOM-059*) and enforcing fisheries restrictions inside the country's national parks. None of the echinoderm species exploited for the curio trade were included on Mexico's *Red List*; among echinoderms, only one sea urchin *Strongylocentrotus franciscanus* and one sea cucumber *Isostichopus fuscus* have been listed. Retailers in Acapulco, Cancún, Isla Cozumel, Ixtapa, Playa del Carmen, and Zihuatanejo reported that PROFEPA or perhaps other municipal-level officers had confiscated echinoderm curios from their shops, although it was not clear from CONAPESCA whether this was justifiable based on the current legislation. Retailers north of Zihuatanejo never mentioned the existence of trade restrictions for sea stars, despite officially needing *fomento* permits at the time data for this study were being collected in the area. Sea urchin, sand dollar, and heart urchin curios were traded freely in every area visited, in spite of fishing restrictions.

Discussion

Large numbers of echinoderms—mainly sea stars and sea urchins—are collected from Mexico's coastal waters to be sold as curios on the domestic and foreign markets. In this study, carried out in 2004, 22 echinoderm species were found in the Mexican curio trade, although some identified species (e.g. *Echinus esculentus*, *Heterocentrotus mammillatus*) and likely the three unidentified species, were gathered from foreign waters. Mexican echinoderms taken for the curio trade appeared to be collected mainly by hand from nearshore, shallow-water habitats, rather than taken as bycatch by non-selective fishing gear (e.g. shrimp trawls). Trawl nets are unlikely to collect *Echinometra vanbrunti* (see Brusca, 1980; Kerstitch, 1989) and *Pisaster ochraceus* (see Lambert, 2000) as these species are restricted to rocky intertidal areas that would damage the gear. *Oreaster reticulatus*, commonly found in seagrass and sandy bottom areas (Scheibling, 1980a, b; Guzmán and Guevara, 2002), could, however, have been collected incidentally by trawlers operating among these habitat types, as was reported by one retail respondent in Playa del Carmen. Sand dollars and heart urchins were less frequently observed in the Mexican curio trade and respondents provided minimal information about their collection or trade.

Fishers' estimates of echinoderm landings were as much as 20 times greater than retailers' estimates of curio trade volumes for echinoderms in the areas surveyed. Together, Mexican fishers are estimated to have collected 880 000 sea stars and 48 000 sea urchins from the country's coastal zones. Retailers in the survey area reported selling approximately 40 000 sea stars and 8600 sea urchins in their shops. These discrepancies between fishers' and retailers' estimates of the magnitude of the trade can likely be attributed to substantial exports, although could also stem (in part) from the limited spatial area covered in this study and/or uncertainty in respondents' estimates of trade volumes. US curio companies' imports of dried Mexican sea stars were estimated at over 350 000 individuals/year between 1997 and 2002. Mexican exports to other countries could also have contributed to the difference between these two estimates, although Customs records were not specific enough to gauge the importance of other such trade routes. Sea star fishers reported selling curios to buyers in 10 Mexican and two foreign cities. During this preliminary study, retailers in only five of the 10 trade nodes described by Mexican fishers were surveyed, so retail sales could have, in fact, been double the volumes estimated in this study. In addition, fishers' and retail respondents' estimates of trade volumes undoubtedly included some degree of error and uncertainty, particularly as it was only possible to estimate the total annual collection and sale from small numbers of interviews.

Assessing the impact of the curio trade will require further investigation into the current size, productivity, resilience, and density dependence of wild populations and the spatial patterns of their exploitation. Although few population assessments of Mexican echinoderms have been published in the primary literature, field studies throughout central America have shown species used as curios living at high densities: (1) *Pisaster ochraceus* sea stars live at average densities of 15–25 individuals/100 m² in the rocky intertidal zones (5–20 m deep) of Mexico's Baja California (E. Sanchez, Centro Regional de Investigación Pesquera, unpublished data); (2) *Oreaster reticulatus* at 0.57–20.00 individuals/100 m² in the Grenadines (Scheibling, 1980a), the US Virgin Islands (Scheibling, 1980b), Panama (Guzmán and Guevara, 2002), and Venezuela (Martin *et al.*, 2001); and (3) *Echinometra vanbrunti* at 25 individuals/100 m² in Bahia de Loreto, Mexico (Quinones *et al.*, 2000). In the absence of detailed habitat maps, these density data are insufficient for estimating the total numbers of these species in Mexican waters. It has, however, been reported that *Oreaster reticulatus* might be under threat from the curio trade in certain parts of the Caribbean; for example, "*Oreaster reticulatus* populations in the Caribbean have been devastated" as a result of curio fisheries (R.E. Scheibling, Dalhousie University, pers. comm. in Sloan, 1984). Trade participants were, unfortunately, unable to clarify the effects of exploitation on source populations, often giving inconsistent information about the changes in echinoderm supply and demand through time.

Sea stars and sea urchins play critical ecological roles within many nearshore communities, so their overexploitation could have negative implications for associated species. In temperate intertidal areas, *Pisaster ochraceus* sea stars are considered keystone predators, influencing the structure of mussel and other prey communities (see Navarrete and Menge, 1996; Palumbi and Freed,

CURIO SHOP IN MANZANILLO. THE TOTAL NUMBER OF SEA STARS AND SEA URCHINS ON SALE PER YEAR IN THE WHOLE SURVEY AREA IN MEXICO WAS ESTIMATED AT SOME 40 000 AND 8600, RESPECTIVELY.

PHOTOGRAPHS: K. LUNN / PROJECT SEAHORSE

SHELLS AND ECHINODERMS FASHIONED INTO ORNAMENTS, CURIO SHOP IN MAZATLÁN (LEFT); SELECTION OF ECHINODERMS AND SHELLS (RIGHT).

2004). Throughout the tropical Caribbean, *Oreaster reticulatus* sea stars function as deposit-feeders, involved in the bioturbation of sandy-bottom, subtidal habitats (Scheibling, 1982). Sea urchins are considered "enormously important" herbivores (Sloan, 1984), with their extraction leading to increases in the growth of coralline turf and, in some cases, macroalgae (e.g. Ayling, 1981; Andrew and Choat, 1982; Leinaas and Christie, 1996; Shears and Babcock, 2002). Unmonitored collection of sea stars and sea urchins for the curio trade could have community- as well as species- and population-level impacts.

Recommendations

At present, the authors see no reason for resource managers to intervene further in the Mexican echinoderm trade. As is so often the case with conservation assessments of resource exploitation, inferences are having to be drawn, and recommendations based, on a single sampling period and with minimal data on effort. In this case study, no concrete evidence has been found for or against a conservation crisis. The trade's apparent lack of economic importance, however, means both that direct pressures will probably remain low and few resources will likely be available for active fisheries or trade control. It therefore serves no great purpose to propose complicated monitoring or management measures at this time. However, CONAPESCA should be encouraged to continue to review the data gathered for species listed on the country's CNP and being monitored through *fomento* permits, and to enforce existing bans against the commercial exploitation of unlisted echinoderm species. Ongoing *de facto* tolerance of illegal trade sends a mixed message to those involved in such fisheries and trades.

This paper is meant to serve as an alert to researchers, resource managers, and stakeholders about the overall scale of exploitation in Mexican echinoderms. Interested and knowledgeable parties are encouraged to contact CONAPESCA with information as it is collected. The authors' intention with such feedback and dialogue is to engage stakeholders as partners in resource monitoring rather than provoking an adversarial response. It would also be useful if the trade were reassessed for comparative purposes in a few years' time, in order to begin developing a temporal map of this exploitation. In the meantime, CONAPESCA and PROFEPA may want to consider what changes in trade dynamics might trigger a more energetic conservation response from management agencies.

Acknowledgements

This paper is a contribution from Project Seahorse. The authors would like to thank the respondents in this study for so generously sharing information with them. They are grateful to their partners at the John G. Shedd Aquarium, especially Jeff Boehm, Nancy Goodman, and Cheryl Mell, for their involvement and support. They also thank Phil Lambert, Katherine Larson, Rodrigo Medellín, Dave Pawson, Adrian Reuter, Enrique Sanchez, Gary Townsend, Peggy Turk Boyer, and especially Rick Brusca and Julio Palleiro for their invaluable advice and assistance throughout the project. Sue Wells and Liz Wood provided helpful comments on an early draft of this manuscript. The support of all Project Seahorse team members is appreciated, particularly that of Sarah Bartnik, Shannon Charney, Sarah Foster, Melissa Grey, James Hrynyshyn, Bob Hunt, Denise McCorry, Angela McCue, Jorma Neuvonen, and Candace Picco. The University of Victoria's Geography Department kindly provided K.E. Lunn with the use of office space.

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