Ohio Biological Survey

Special Publication

ISBN-13: 978-0-86727-152-3
ISBN-10: 0-86727-152-3
Library of Congress Number: 2004115835

Literature Citation

Smith, M., D. Warmolts, D. Thoney, and R. Hueter (editors). 2004. The Elasmobranch Husbandry Manual: Captive Care of Sharks, Rays and their Relatives. Special Publication of the Ohio Biological Survey. xv + 589 p.

Cover and Title Page
Illustration by Rolf Williams, The National Marine Aquarium, Rope Walk, Coxside, Plymouth, PL4 0LF United Kingdom

Distributor
Ohio Biological Survey, P.O. Box 21370, Columbus, Ohio 43221-0370 U.S.A.

Layout and Design: Brian J. Armitage, Ohio Biological Survey
Printing: The Ohio State University, Printing Services, Columbus, Ohio

Ohio Biological Survey
P.O. Box 21370
Columbus, OH 43221-0370
<ohiobiosurvey@sbcglobal.net>
www.ohiobiologicalsurvey.org

11-2004—1.5M

The Elasmobranch Husbandry Manual: Captive Care of Sharks, Rays and their Relatives, pages 89-103.

Chapter 7
Elasmobranch Capture Techniques and Equipment

ALLAN MARSHALL

Pittsburgh Zoo and PPG Aquarium
One Wild Place,
Pittsburgh, PA 15206, USA.
E-mail: allanm@zoo.pgh.pa.us

Abstract: Captive elasmobranchs are often collected using techniques modified from commercial fishing practices. However, elasmobranch species fill diverse niches within the marine environment and additional specialized fishing techniques have been developed. In general, there are four basic methods suitable for live capture: netting, trapping, hooking, and targeting. Hand-drawn nets are more forgiving than mechanically trawled nets, and when carefully deployed little physical injury will result. Small, baited traps are effective for catching sedentary elasmobranchs, but are not recommended for pelagic species. Larger, non-baited oceanic traps cause little or no injury to open water animals, as specimens are contained without restricting their swimming patterns. Angling with rod and reel allows an animal to be landed immediately, reducing capture-induced stress. Hooking with long-line can be effective if soak times are limited to less than two hours. Targeting may be employed if netting, trapping, and angling are not sufficiently discriminating to catch the desired elasmobranch. Targeting techniques include, among others, dip netting, SCUBA divers with catch bags, treble hooks cast over and snagging specific specimens, set hooking, and hooping.

Acquiring healthy elasmobranch specimens for aquariums and live research can be a labor-intensive operation. Contrary to popular belief, most elasmobranchs are extremely delicate and when removed from their natural habitat may suffer lethal physiological stress responses (Rasmussen and Rasmussen, 1967; Piiper and Baumgarten, 1969; Piiper et al., 1972; Mazeaud et al., 1977; Gruber, 1980; Holeton and Heisler, 1983; Wood et al., 1983; Cliff and Thurman, 1984; Meroz, 1990; Murru, 1990; Wood, 1991; Smith, 1992; Stevens, 1994). It is generally not practical to rely on by-catch specimens from commercial or recreational fisheries, as survival rates can be unacceptably low. Thus, it is usually necessary to conduct fishing operations using equipment and techniques specific to the species intended for capture. In some cases it may be possible to establish mutually beneficial relationships between aquariums and commercial fishing operations, taking advantage of both commercial fishing equipment and specialized animal handling techniques. In all cases, minimal handling and the minimization of injury to specimens will increase the chances of a successful acquisition.

PLANNING

Extensive planning is required to ensure the acquisition of appropriate animals for a given exhibit. Lists of potential species should take into consideration the size and physical limitations of an exhibit, the geographical area represented, species compatibility, species availability, and budgetary constraints (refer to Chapter 2 of this manual for more information about species selection). It is essential to understand the permitting processes as they pertain to the species selected (refer to chapter 3 of this manual for more information about permitting). Once a species list has been determined, further research into the requirements and habitat of each individual species should be undertaken. This research should yield information about possible commercial collectors, suitable fishing techniques, effective bait, specific handling and

equipment requirements, and appropriate fishing locations.

COMMERCIAL COLLECTORS

There are many professional commercial collectors of marine animals. Unfortunately, a few unscrupulous individuals mar the work of many excellent suppliers, so it is important to get references. The selected commercial collector must have the knowledge and skills to capture and, if required, transport elasmobranchs correctly. Where possible, their facilities should be inspected and the commercial collectors queried about their specific collection and transportation techniques. This information will provide a better understanding of their infrastructure and knowledge limitations. Having an experienced staff member accompany the commercial collector throughout the process will help ensure that best practices are used and provide reliable intelligence about how specimens were caught and subsequently treated (i.e., feeding techniques employed, medications given, etc.). It is imperative that the commercial collector has all the required permits prior to the commencement of fishing operations on behalf of the aquarium. All agreements should be in writing to avoid misunderstandings.

LOCATING SUITABLE SPECIMENS

Each elasmobranch species has specific habitat requirements. In addition, specific parameters (e.g., depth ranges, habitat preferences, and geographic locations) may vary seasonally (Gruber, 1980; Rupp, 1984; Burgess, 1985; Wisner, 1987; Boggs, 1992; Martin and Zorzi, 1993; Di Giacomo et al., 1994; Nakano et al, 1997; Fahy, pers. com.; Human, pers. com.). Understanding these parameters and how they relate to local conditions will increase the chances of successfully locating and capturing required specimens. For example, it is understood that sand tiger sharks (*Carcharias taurus*) undertake annual migrations within their home range and that these migrations usually correlate with seasonal changes in water temperature. The following migration routes are known for this species: Massachusetts to Northern Florida in the USA; Southern New South Wales to Southern Queensland in Australia; and Cape Town, South Africa to Southern Mozambique. Fishermen in the USA have noted that sand tigers will rarely take baited hooks at temperatures below 17°C (Barnhart, pers. com.). In Australia, the sand tiger shark prefers rocky reefs and in particular gutters or channels at depths of ~18 m.

COLLECTION TECHNIQUES

There are four distinct techniques used to capture live elasmobranchs: netting, trapping, hooking, and targeting. Table 7.1 summarizes the methods used to successfully collect different elasmobranch species for aquariums and live research. Quoted techniques are not a guarantee of survival. Capture technique, specimen size, handling time, transport regime, and water quality will all impact specimen survivability. Minimizing capture, handling, and transport times should be the ultimate goal of any expedition.

Netting

Nets can be used to capture a wide variety of elasmobranchs. When nets are carefully deployed, little physical injury results. Hand-drawn nets are more forgiving than mechanically operated and hauled nets, such as otter trawls. However, some sedentary species are hardy enough to survive trawled nets and these nets can therefore be an effective method for collecting resilient animals.

Seine netting

Seine nets are regularly used to collect many species of shallow water sharks and rays. A seine net consists of a length of mesh with sufficient dimensions to reach from the surface to the seabed. Lead weights are attached to the lower edge of the net, keeping it in contact with the bottom, while floats hold the upper edge of the net at the surface (Figure 7.1). If the water is clear and potential specimens can be seen, the net may be deployed, usually by a boat, in a circular pattern around the target animal(s). The net is laid in the boat in such a way as to let it progressively peel out, without tangling, as the boat moves forward. Once the animal is fully encircled, the net is slowly drawn in. The area in which the elasmobranch is swimming gradually decreases until it is fully confined and can be transferred to a transport container. In turbid water, the net can be deployed where target animals are suspected to be present and the net drawn in until capture has been verified. With a proficient knowledge of both target

Table 7.1. Elasmobranchs captured for aquariums and live research, showing successful techniques used. Many of the entries for otter trawl and gillnet are the result of by-catch from commercial fishing operations. All references are personal communications unless otherwise indicated by a date of publication.

Species name	Common name	Collection technique	Reference
Aetobatus narinari	Spotted eagle ray	Netting - cast net, otter trawl, seine	Marín-Osorno; Nemeth; Thomas
		Targeting - dip net, snagging, spearing	Christie; Henningsen; Long; Young
Aetomylaeus niehofii		Trapping - hadra	McEwan
Alopias vulpinus	Thintail thresher	Hooking - rod and reel	Thomas
Amblyraja radiata	Thorny skate	Netting - otter trawl	James; Kelleher
		Targeting - grabbing/hand net	Kelleher
Aptychotrema rostrata	Eastern shovelnose ray	Hooking - rod and reel	unpublished results
		Netting - otter trawl	
Asymbolus analis	Australian spotted catshark	Hooking - longline	Kinnunen
		Targeting - grabbing	Kinnunen
Bathyraja aleutica	Aleutian skate	Hooking - rod and reel	Thomas
		Netting - otter trawl	Thomas
Bathyraja interrupta	Sandpaper skate	Hooking - longline	Thomas
Brachaelurus waddi	Blind shark	Hooking - longline, rod and reel	Kinnunen
		Netting - gillnet	Kinnunen
		Targeting - grabbing	Kinnunen
		Trapping - baited trap	Kinnunen
Callorhinchus callorynchus	Cockfish	Netting - otter trawl	Di Giacomo et al., 1994
Carcharhinus acronotus	Blacknose shark	Hooking - longline, rod and reel	Christie; Henningsen; Marín-Osorno; Young
Carcharhinus altimus	Bignose shark	Hooking - longline, rod and reel	Powell; Powell, 2001
Carcharhinus amblyrhynchoides	Graceful shark	Hooking - longline, rod and reel	Stevens, et al., 2001
		Netting - gillnet	Stevens, et al., 2001
Carcharhinus amboinensis	Pigeye shark	Hooking - block line, longline, rod and reel	Ballard, 1989; Stevens, et al., 2001
		Netting - gillnet	Stevens, et al., 2001
Carcharhinus brachyurus	Copper shark	Hooking - longline, rod and reel	Kinnunen; Thomas
Carcharhinus brevipinna	Spinner shark	Hooking - longline, rod and reel	Henningsen; Kinnunen; Marín-Osorno
Carcharhinus dussumieri	Whitecheek shark	Hooking - rod and reel	McEwan
		Netting - otter trawl	McEwan
Carcharhinus falciformis	Silky shark	Hooking - longline, rod and reel	Christie; Marín-Osorno; Thomas; Young
Carcharhinus galapagensis	Galapagos shark	Hooking - rod and reel	Arai, 1997
Carcharhinus leucas	Bull shark	Hooking - block line, longline, rod and reel	Denton, et al., 1987; Ballard, 1989; Henningsen; Marín-Osorno; Thomas; Young
Carcharhinus limbatus	Blacktip shark	Hooking - block line, free float, longline, rod and reel	Christie; Henningsen; Mc Court; Marín-Osorno; Nemeth; Newman; Thomas; Young
		Netting - cast net, gillnet	Henningsen; Nemeth
Carcharhinus longimanus	Oceanic whitetip shark	Hooking - rod and reel	Powell
Carcharhinus macloti	Hardnose shark	Hooking - longline, rod and reel	Stevens, et al., 2001
		Netting - gillnet	Stevens, et al., 2001
Carcharhinus melanopterus	Blacktip reef shark	Hooking - rod and reel	unpublished results
		Netting - otter trawl	McEwan
		Targeting - chasing	Wisner, 1987
		Trapping - hadra	McEwan, 2000
Carcharhinus obscurus	Dusky shark	Hooking - block line, longline, rod and reel	Cliff and Thurman, 1984; Denton, et al., 1987; Ballard, 1989; Henningsen; Kinnunen; Steslow; Thomas

Table 7.1 (continued). Elasmobranchs captured for aquariums and live research, showing successful techniques used. Many of the entries for otter trawl and gillnet are the result of by-catch from commercial fishing operations. All references are personal communications unless otherwise indicated by a date of publication.

Species name	Common name	Collection technique	Reference
Carcharhinus perezi	Caribbean reef shark	Hooking - longline, rod and reel	Christie; Henningsen; Nemeth
		Netting - purse seine	Nemeth
Carcharhinus plumbeus	Sandbar shark	Hooking - block line, longline, rod and reel	Ballard, 1989; Andrews and Jones, 1990; Arai, 1997; Henningsen; Kelleher; Thomas; Young
		Netting - gillnet	Henningsen
Carcharhinus sorrah	Spottail shark	Hooking - longline, rod and reel	Stevens, et al., 2001
		Netting - gillnet	Stevens, et al., 2001; Henningsen
Carcharhinus tilstoni	Australian blacktip shark	Hooking - longline, rod and reel	Stevens, et al., 2001
		Netting - gillnet	Stevens, et al., 2001
Carcharias taurus	Sand tiger shark	Hooking - longline, rod and reel	Visser, 1996; Ellis; Henningsen; Kinnunen; Young
		Netting - gillnet	Kelleher
		Targeting - hooping, feeding hook	Smith, 1992; Menzies
		Trapping - pound net	Ellis
Carcharodon carcharias	Great white shark	Hooking - longline, rod and reel	Kinnunen; Powell; Thomas
		Netting - gillnet, trammel net	Powell; Thomas
Cephaloscyllium laticeps	Australian swellshark	Netting - otter trawl	Kinnunen
Cephaloscyllium ventriosum	Swellshark	Targeting - grabbing, hand collected eggs	Howard; Thomas
Chiloscyllium arabicum	Arabian carpetshark	Hooking - rod and reel	McEwan
		Netting - otter trawl	McEwan
		Trapping - hadra	McEwan, 2002
Chiloscyllium punctatum	Brownbanded bambooshark	Targeting - hand net	unpublished results
Chlamydoselachus anguineus	Frilled shark	Netting - gillnet, otter trawl	Shiobara, et al., 1997
Dasyatis americana	Southern stingray	Hooking - longline, rod and reel	Choe; Henningsen; Marín-Osorno; Nemeth; Thomas; Young
		Netting - cast net, seine	Choe; Christie
		Targeting - drop net, snagging	Christie; Nemeth; Young
Dasyatis brevicaudata	Short-tail stingray	Hooking - longline, rod and reel	Kinnunen
Dasyatis brevis	Whiptail stingray	Hooking - longline	Thomas
Dasyatis centroura	Roughtail stingray	Hooking - longline	Henningsen; Young
		Targeting - grabbing	Henningsen
		Trapping - pound net	Steslow
Dasyatis lata	Brown stingray	Hooking - rod and reel	Wisner
Dasyatis marmorata	Marbled stingray	Netting - seine	Sabalones
Dasyatis sabina	Atllantic stingray	Hooking - longline, rod and reel	Choe
		Netting - cast net	Choe
Dasyatis say	Bluntnose stingray	Hooking - longline, rod and reel	Choe; Henningsen
		Netting - cast net	Choe
Dasyatis violacea	Pelagic stingray	Hooking - rod and reel	Thomas
		Targeting - dip net	Thomas
		Trapping - piscina	unpublished results
Dipturus batis	Blue skate	Hooking - rod and reel	James
Dipturus laevis	Barndoor skate	Netting - otter trawl	Kelleher
Echinorhinus cookei	Prickly shark	Targeting - feeding hook	Powell
Galeocerdo cuvier	Tiger shark	Hooking - block line, longline, rod and reel	Denton, et al., 1987; Ballard, 1989; Christie; Henningsen; Kinnunen; Marín-Osorno; Thomas

Table 7.1 (continued). Elasmobranchs captured for aquariums and live research, showing successful techniques used. Many of the entries for otter trawl and gillnet are the result of by-catch from commercial fishing operations. All references are personal communications unless otherwise indicated by a date of publication.

Species name	Common name	Collection technique	Reference
Galeorhinus galeus	Tope shark	Hooking - longline, rod and reel	Howard; James; Thomas; Whitehead
		Netting - otter trawl	Janse
Galeus melastomus	Blackmouth catshark	Netting - otter trawl	Whitehead
Ginglymostoma cirratum	Nurse shark	Hooking - block line, longline, rod and reel	Carrier; Christie; Henningsen; Nemeth; Young
		Netting - cast net, seine	Carrier
		Targeting - feeding hook, grabbing, hand net	Carrier; Nemeth; Young
		Trapping - baited trap	Carrier; Christie; Nemeth
Gymnura altavela	Spiny butterfly ray	Hooking - longline	Henningsen
		Netting - seine	Henningsen
Gymnura marmorata	California butterfly ray	Hooking - longline	Thomas
Gymnura micrura	Smooth butterfly ray	Hooking - longline	Henningsen
		Targeting - hand net	Henningsen; Young
Haploblepharus edwardsii	Puffadder shyshark	Targeting - grabbing	Dainty; Human; Sabalones
Haploblepharus fuscus	Brown shyshark	Targeting - grabbing	Sabalones
Haploblepharus pictus	Dark shyshark	Targeting - grabbing	Dainty; Human; Sabalones
Hemiscyllium ocellatum	Epaulette shark	Targeting - hand net	Squire
Heterodontus francisci	Horn shark	Targeting - grabbing	Thomas
Heterodontus galeatus	Crested bullhead shark	Hooking - longline	Kinnunen
		Netting - gillnet	Kinnunen
		Targeting - grabbing	Kinnunen
Heterodontus portusjacksoni	Port Jackson shark	Hooking - longline	Kinnunen
		Netting - gillnet, otter trawl	Kinnunen
		Targeting - grabbing	Kinnunen
Hexanchus griseus	Bluntnose sixgill shark	Hooking - longline	Thomas
Himantura bleekeri	Bleeker's whipray	Netting - otter trawl	McEwan
		Trapping - hadra	McEwan
Himantura gerrardi	Sharpnose stingray	Netting - otter trawl	McEwan
		Trapping - hadra	McEwan, 2000
Himantura imbricata	Scaly whipray	Netting - seine, otter trawl	McEwan
		Trapping - hadra	McEwan
Himantura schmardae	Chupare stingray	Targeting - hoop net	Christie
Himantura uarnak	Honeycomb stingray	Netting - otter trawl	McEwan
		Trapping - hadra	McEwan, 2000
Hypnos monopterygium	Australian numbfish	Netting - otter trawl	unpublished results
Isurus oxyrinchus	Shortfin mako	Hooking - longline, rod and reel	Kinnunen; Marín-Osorno; Powell; Steslow; Thomas
		Trapping - piscina	unpublished results
Lamna nasus	Porbeagle	Hooking - rod and reel	James; Thomas
Leucoraja erinacea	Little skate	Netting - otter trawl	Kelleher
		Targeting - grabbing/hand net	Kelleher
Leucoraja naevus	Cuckoo ray	Hooking - rod and reel	Whitehead
		Netting - otter trawl	James
Leucoraja ocellata	Winter skate	Hooking - rod and reel	Whitehead
		Netting - otter trawl	Kelleher
		Targeting - grabbing	Kelleher

Table 7.1 (continued). Elasmobranchs captured for aquariums and live research, showing successful techniques used. Many of the entries for otter trawl and gillnet are the result of by-catch from commercial fishing operations. All references are personal communications unless otherwise indicated by a date of publication.

Species name	Common name	Collection technique	Reference
Manta birostris	Giant manta	Hooking - longline	Marín-Osorno
		Netting - seine, purse seine	Christie; Marín-Osorno
Mobula munkiana	Munk's devil ray	Netting - gillnet	Powell
Mustelus antarcticus	Gummy shark	Hooking - rod and reel	Kinnunen
Mustelus asterias	Starry smooth-hound	Hooking - rod and reel	Kelleher; Whitehead
		Netting - otter trawl	James; Janse
Mustelus californicus	Grey smooth-hound	Hooking - longline	Thomas
Mustelus canis	Dusky smooth-hound	Hooking - longline, rod and reel	Ellis; Henningsen
		Trapping - pound net	Ellis
Mustelus henlei	Brown smooth-hound	Hooking - longline, rod and reel	Howard; Thomas
		Netting - otter trawl	Howard
Mustelus mustelus	Smooth-hound	Hooking - rod and reel	Whitehead
		Netting - otter trawl	James; Janse
Myliobatis aquila	Common eagle ray	Netting - seine	unpublished results
Myliobatis australis	Australian bull ray	Hooking - longline, rod and reel	Kinnunen
Myliobatis californica	Bat eagle ray	Hooking - block line, longline, rod and reel	Howard; Powell; Thomas
		Netting - otter trawl	Howard
Myliobatis freminvillii	Bullnose eagle ray	Hooking - longline, rod and reel	Henningsen
Narcine brasiliensis	Brazilian electric ray	Targeting - hand net	Young
Nebrius ferrugineus	Tawny nurse shark	Targeting - hand net	unpublished results
Negaprion brevirostris	Lemon shark	Hooking - block line, longline, rod and reel	Henningsen; Nemeth; Thomas; Young
		Netting - cast net, dip net, gillnet	Gruber, 1980; Henningsen; Nemeth
Notorynchus cepedianus	Broadnose sevengill shark	Hooking - block line, longline, rod and reel	Rupp, 1984; Howard; Kinnunen; Powell; Thomas
		Netting - otter trawl	Howard; Kinnunen
Orectolobus maculatus	Spotted wobbegong	Hooking - longline, rod and reel	Kinnunen
		Netting - otter trawl	unpublished results
		Targeting - grabbing, hand net	Kinnunen
Orectolobus ornatus	Ornate wobbegong	Hooking - longline, rod and reel	Kinnunen
		Netting - otter trawl	unpublished results
		Targeting - grabbing, hand net	Kinnunen
Paragaleus randalli	Slender weasel shark	Netting - otter trawl	McEwan
Pastinachus sephen	Cowtail stingray	Netting - otter trawl	McEwan
		Trapping - hadra	McEwan
Platyrhinoidis triseriata	Thornback guitarfish	Hooking - longline	Thomas
Poroderma africanum	Striped catshark	Targeting - grabbing	Dainty; Human; Sabalones
Poroderma pantherinum	Leopard catshark	Targeting - grabbing	Dainty; Human; Sabalones
Potamotrygon spp.	Freshwater rays	Hooking - longline	Dowd
		Netting - cast net, gillnet, seine	Dowd
		Targeting - dip net, spearing	Dowd
Prionace glauca	Blue shark	Hooking - longline, rod and reel	James; Kinnunen; Powell; Steslow; Thomas
		Targeting - dip net	Howard; Powell
		Trapping - piscina	unpublished results
Pristis pectinata	Smalltooth sawfish	Netting - gillnet, otter trawl	Christie; Henningsen; Young
		Targeting - hand net, spearing	Christie; Young

Table 7.1 (continued). Elasmobranchs captured for aquariums and live research, showing successful techniques used. Many of the entries for otter trawl and gillnet are the result of by-catch from commercial fishing operations. All references are personal communications unless otherwise indicated by a date of publication.

Species name	Common name	Collection technique	Reference
Pristis spp.	Sawfishes	Netting - gillnet, otter trawl	Squire
Raja binoculata	Big skate	Hooking - longline, rod and reel	Howard; Thomas
		Netting - otter trawl	Howard
Raja brachyura	Blonde ray	Hooking - rod and reel	James; Whitehead
		Netting - otter trawl	James
Raja clavata	Thornback ray	Hooking - rod and reel	Whitehead
		Netting - otter trawl	James
Raja eglanteria	Clearnose skate	Hooking - longline, rod and reel	Henningsen; Young
Raja microocellata	Small-eyed ray	Netting - otter trawl	James
Raja montagui	Spotted ray	Netting - otter trawl	James
Raja rhina	Longnose skate	Hooking - longline	Thomas
Raja stellulata	Starry skate	Hooking - longline, rod and reel	Howard; Thomas
		Netting - otter trawl	Howard
Raja undulata	Undulate ray	Hooking - rod and reel	Whitehead
		Netting - otter trawl	James
Rhina ancylostoma	Bowmouth guitarfish	Netting - otter trawl	McEwan; Squire
		Trapping - hadra	McEwan, 2000
Rhincodon typus	Whale shark	Targeting - Restrained	Kinnunen
Rhinobatos annulatus	Lesser sandshark	Netting - seine	Sabalones
Rhinobatos granulatus	Sharpnose guitarfish	Netting - otter trawl	McEwan
		Trapping - hadra	McEwan, 2000
Rhinobatos lentiginosus	Atlantic guitarfish	Targeting - grabbing, hand net	Henningsen; Young
Rhinobatos productus	Shovelnose guitarfish	Hooking - longline	Thomas
Rhinobatos typus	Giant shovelnose ray	Hooking - rod and reel	unpublished results
		Netting - otter trawl	Kinnunen
		Netting - otter trawl	unpublished results
Rhinoptera bonasus	Cownose ray	Hooking - longline, rod and reel	Marín-Osorno; Thomas
		Netting - seine	Thomas; Young
		Trapping - pound net	Henningsen; Kelleher
Rhizoprionodon acutus	Milk shark	Hooking - longline, rod and reel	Stevens, et al., 2001
		Netting - gillnet	Stevens, et al., 2001
Rhizoprionodon longurio	Pacific sharpnose shark	Hooking - longline, rod and reel	Powell, 2001; Thomas
Rhizoprionodon porosus	Carribean sharpnose shark	Hooking - longline, rod and reel	Henningsen; Nemeth
Rhizoprionodon taylori	Australian sharpnose shark	Hooking - longline, rod and reel	Stevens, et al., 2001
		Netting - gillnet	Stevens, et al., 2001
Rhizoprionodon terraenovae	Atlantic sharpnose shark	Hooking - longline, rod and reel	Christie; Henningsen; Marín-Osorno; Steslow
Rhynchobatus djiddensis	Giant guitarfish	Netting - otter trawl, seine	Kinnunen; McEwan
		Trapping - hadra	McEwan, 2000
Scyliorhinus canicula	Smallspotted catshark	Hooking - rod and reel	Whitehead
		Netting - otter trawl	Janse
		Targeting - grabbing	Whitehead
Scyliorhinus retifer	Chain catshark	Hooking - rod and reel	Nelson
		Netting - otter trawl	Kelleher
		Trapping - baited trap	Ellis; Kelleher

Table 7.1 (continued). Elasmobranchs captured for aquariums and live research, showing successful techniques used. Many of the entries for otter trawl and gillnet are the result of by-catch from commercial fishing operations. All references are personal communications unless otherwise indicated by a date of publication.

Species name	Common name	Collection technique	Reference
Scyliorhinus stellaris	Nursehound	Hooking - rod and reel	Whitehead
		Netting - otter trawl	James
		Targeting - grabbing	Whitehead
Somniosus pacificus	Pacific sleeper shark	Hooking - longline	Thomas
Sphyrna lewini	Scalloped hammerhead	Hooking - longline, rod and reel	Arai, 1997; Henningsen; Newman; Thomas; Young.
Sphyrna mokarran	Great hammerhead	Hooking - longline, rod and reel	Henningsen; Marín-Osorno; Young
		Netting - gillnet	Henningsen
Sphyrna tiburo	Bonnethead	Hooking - longline, rod and reel	Henningsen; Newman; Thomas; Young
		Netting - cast net, gillnet, seine	Henningsen; Powell; Thomas
Sphyrna zygaena	Smooth hammerhead	Hooking - rod and reel	Henningsen; Kinnunen; Thomas
Squalus acanthias	Spiny dogfish	Hooking - longline, rod and reel	Ellis; Howard; Kelleher; Thomas; Whitehead
		Netting - otter trawl	James; Janse; Whitehead
		Trapping - pound net	Ellis
Squatina australis	Australian angelshark	Hooking - longline	Kinnunen
Squatina californica	Pacific angelshark	Targeting - plastic bag	Howard
Squatina dumeril	Sand devil	Netting - otter trawl	Kelleher; Marín-Osorno
Squatina squatina	Angelshark	Netting - otter trawl	James
Stegostoma fasciatum	Zebra shark	Hooking - longline	Kinnunen
		Netting - gillnet, otter trawl	Henningsen; Kinnunen
		Targeting - grabbing, hand net	McEwan
Taeniura lymma	Bluespotted ribbontail ray	Targeting - hand net	McEwan
Torpedo californica	Pacific electric ray	Targeting - hand net	Howard
Torpedo marmorata	Marbled electric ray	Netting - otter trawl	James
Torpedo nobiliana	Electric ray	Netting - otter trawl	James; Kelleher; Whitehead
Torpedo panthera	Panther electric ray	Netting - otter trawl	McEwan
Triaenodon obesus	Whitetip reef shark	Hooking - rod and reel	unpublished results
		Targeting - hand net	McEwan
Triakis megalopterus	Sharptooth houndshark	Hooking - rod and reel	Sabalones
Triakis semifasciata	Leopard shark	Hooking - rod and reel	Howard; Thomas
		Netting - barrier net, otter trawl	Howard; Thomas
Trygonorrhina fasciata	Southern fiddler	Hooking - longline, rod and reel	Kinnunen
		Netting - otter trawl	unpublished results
		Targeting - hand net	Kinnunen
Urolophus halleri	Haller's round ray	Targeting - hand net	Henningsen; Thomas; Young
Urolophus jamaicensis	Yellow stingray	Targeting - hand net	Christie; Fahy; Thomas; Young

Figure 7.1. Seine net used to surround, enclose, and capture potential elasmobranch specimens.

species and fishing areas, this method can be productive.

Multi-strand nylon is an appropriate material for nets, and woven, knotless nets are preferred as they are less likely to injure a struggling animal. Mesh size for seine nets is usually small (~2.5 cm stretched mesh), but can be larger depending on the size of the target species. Oversized mesh is not recommended as an animal can push its head through the net (in a similar fashion to a gill net), become entangled, and ultimately injured.

Purse seine nets are used in a similar fashion to seine nets, however the bottom of the net is drawn together once deployed, when used in deeper water, to prevent animals from escaping.

Gill netting

Gill nets have a larger mesh size than seine nets. Gill nets are secured in an area, where the presence of a target species has been established, and are left in position for a set period of time. As the name implies, specimens are caught by entangling their heads in close proximity to the gills. Injuries sustained from gill nets are frequently lethal to captured specimens. Many species of elasmobranchs will die if constrained for extended periods, as gas exchange and blood circulation are impaired (Denton et al., 1987; Meroz, 1990; Smith, 1992). Gill nets are therefore not recommended for the live capture of elasmobranchs (Murru, 1990; Stevens, 1994; Shiobara et al., 1997) unless they are constantly monitored (Meroz, 1990; Stevens et al., 2000). If another option for the capture of specimens is available, it should be considered before gill netting is used. In some specific cases, where other options are not available, it is possible to work closely with commercial gillnet fishermen and harvest live specimens recently caught in their nets (Shiobara et al., 1997; Kelleher, pers. com.; Powell, pers. com.).

Sawfishes (Family: Pristidae) are easily ensnared and their numbers have dropped markedly in areas where commercial fishermen use gill nets. If a gill net is constantly monitored, live sawfish specimens may be readily caught, removed, and suffer little injury, as they are usually entangled around their robust saw (Squire, pers. com.; Young, pers. com.).

Cast netting

Cast nets have been employed to capture Atlantic (*Dasyatis sabina*), southern (*Dasyatis americana*), and bluntnose (*Dasyatis say*) stingrays, and other shallow water species of elasmobranch (Gruber, 1980; Murru, 1990; Choe, pers. com.). Cast nets may be thrown from a boat or the shoreline and are most effective when used in water <1 m deep (Figure 7.2). When a cast net has settled over a buried ray, gentle prodding will encourage it to rise out of the sand and move into the net.

Trawling

Otter trawl nets are commonly employed by the commercial fishery to collect crustaceans. Elasmobranchs are a frequent by-catch of the fishery. A conical shaped net is dragged along the sea floor by a boat on the surface. Angled boards are attached to each side of the net, holding the

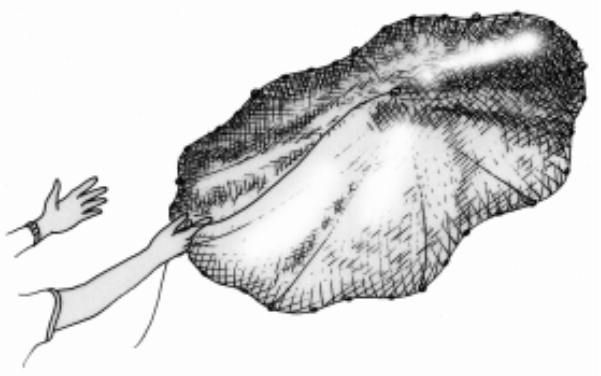

Figure 7.2. A cast net requires practice to be thrown correctly and is most effective in shallow water.

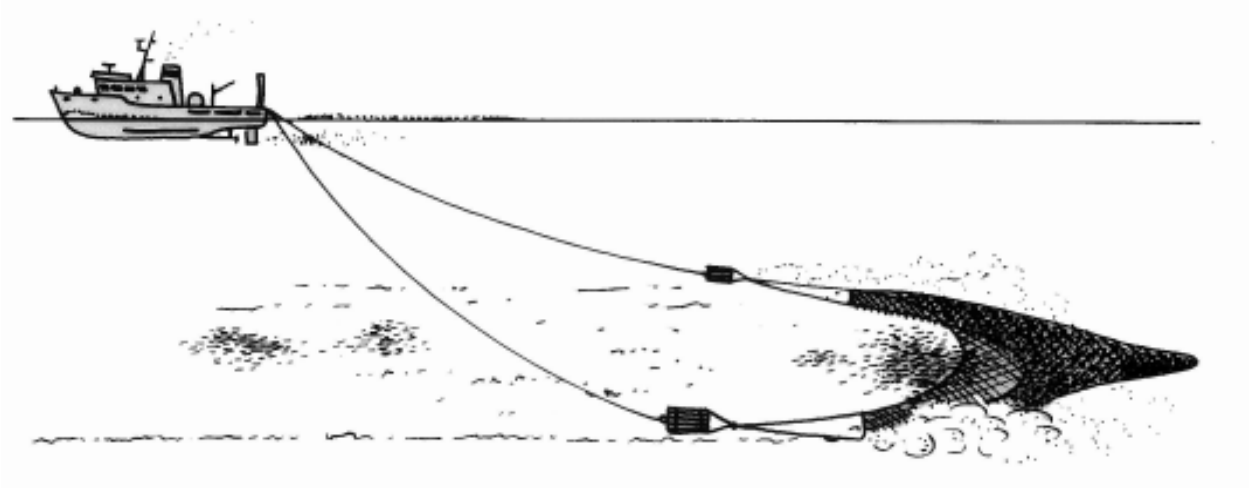

Figure 7.3. An otter trawl showing the otter boards on either side keeping the net open as it is towed.

net open during trawling (Figure 7.3). Animals displaced from the bottom are caught in the net and, following a set period of trawling time, brought to the surface. Although this method of fishing damages most animals, sedentary species of elasmobranchs (e.g., rays and guitarfishes) often fare well, providing an opportunity to acquire healthy specimens. Smaller versions of the otter trawl net have been used by aquariums to collect inshore coastal species for display (Howard, pers. com.). Di Giacomo et al. (1994) collected healthy specimens of the cock fish (*Callorhinchus callorynchus*) using otter trawl nets deployed from research fishing vessels in Patagonia. Towing time was limited to 30 minutes and net retrieval was deliberately slow, reducing possible damage to the animals as they were raised from a depth of 50-100 meters. Because of the risks to captured specimens, other capture techniques should be considered before trawling is employed.

Trapping

Trapping can be an effective technique to collect elasmobranchs, allowing extended fishing periods and minimizing stress on captured specimens. The basic premise of trapping is to confine animals in a small holding area where they can be collected at a later time. Some traps use bait, while others exploit the natural swimming behavior of target animals.

Baited trapping

Several designs of baited traps are used in the fishing industry to collect different species of animal. These traps usually consist of a box-like frame, over which is stretched a mesh of wire or netting, and one or two small, funnel-shaped openings. Animals can easily enter the mouth of the funnel from the exterior, but have difficulty exiting the narrow spout from the interior. Bait is usually placed inside the trap and it is then lowered to the sea floor for a predetermined period of time. Baited traps are effective for catching sedentary species of elasmobranch, but are not recommended for pelagic species.

Non-baited trapping

Larger traps capture animals by exploiting their natural behavior and herding them into a relatively small area. Native fishermen in Kuwait use a trap called a hadra (Figure 7.4) to collect a large variety of fishes (McEwan et al., 2000). The hadra has a design similar to pound nets used by professional fishermen on the East Coast of the USA (Murru, 1990). These traps consist of a long wall of partially submerged netting positioned perpendicular to the coastline. Fishes swimming parallel to the shore encounter the wall and instinctively turn toward deeper water to avoid the obstruction. When they reach the end of the wall, fishes are directed into a corral-shaped net where they continue to swim until removed by the fishermen. Hadras are positioned between the high and low tide marks of a gently sloping shoreline. As the tide recedes, fishes are left with no alternative but to enter a small section of the corral called the ser. In contrast, the corral of pound nets is positioned in deeper water, beyond the low tide mark, and have a floor of netting that can be raised by the fishermen to concentrate the

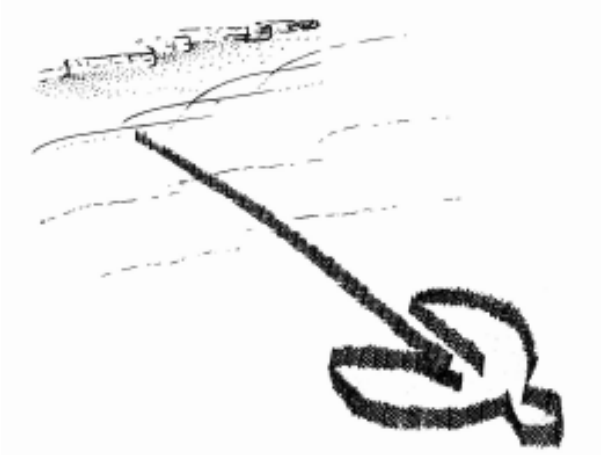

Figure 7.4. The "hadra" trap is positioned perpendicular to the shoreline. As fishes swim along the shoreline, they encounter the fence, head toward deeper water, and become trapped in the "ser".

animals in a smaller area. A larger version of these traps is used in the Mediterranean to capture tuna for the Japanese sushi market. These larger traps frequently collect free-swimming, demersal and pelagic sharks.

An advantage of these large traps is that they cause little or no injury to the animals. Specimens are contained without restricting their swimming patterns and stress is presumably limited to the time taken for handling and transport. Many elasmobranch species have successfully been collected using this technique. Most notable are the pelagic blue (*Prionace glauca*) and shortfin mako (*Isurus oxyrinchus*) sharks, notoriously difficult to capture alive using other methods.

Because of the complexity of these large traps and the labor required to keep them operational, it is usually not feasible for an aquarium to own and operate one. Rather, aquarium personnel should build a relationship with trap fishermen so that suitable animals may be acquired for display.

Hooking

The most common method for catching elasmobranchs is to fish them with a baited hook and line (Gruber, 1980; Cliff and Thurman, 1984; Rupp, 1984; Lawlor, 1985; Denton et al., 1987; Ballard, 1989; Jenkins, 1989; Andrews and Jones, 1990; Murru, 1990; Boggs, 1992; Stevens, 1994; Visser, 1996; Arai, 1997; Nakano et al., 1997; Stevens et al., 2000; Martin and Zorzi, 1993; Harrington, pers. com.; Wisner, pers. com.). Elasmobranchs are opportunistic feeders and will readily take bait when offered. Baited hooks may be monitored (e.g., angling) or set and left to fish remotely for a period of time (long-line fishing).

Angling

The advantage of angling with a rod and reel is that an animal can be landed as soon as it has been caught, reducing capture-induced stress (Murru, 1990; Stevens et al., 2000). The movements of live bait are an effective attractant to target elasmobranchs. The size and design of fishing tackle depends on the desired species and size ranges. A long wire trace is essential as the teeth and skin of most elasmobranchs can easily abrade and sever nylon fishing line, freeing the animal. Wire can, however, cause injury to the animal, so plastic-coated traces are recommended (Wisner, pers. com.).

Long-line fishing

Long-line fishing has been used for many years in the commercial fishing industry. Typical long-lines consist of a single line, up to several kilometers long, having hooks attached by short lines (gangions or snoods) at fixed distances along the line. During commercial fishing activities the line, having several thousand gangions, is left to soak for ~24 hours. Many marine animal collectors and aquarium staff have used modified long-line fishing techniques to capture elasmobranchs for display purposes (Rupp, 1984; Jenkins, 1989; Murru, 1990). Minimizing the time between hooking and landing an elasmobranch should be the top priority. This precaution reduces the chances of specimens succumbing to biochemical changes induced by extended capture stress. Thus, for the live capture of elasmobranchs, long-lines are typically reduced to a length of ~300-400 meters and ~50 hooks, and soak times restricted to less than two hours (Murru, 1990). Even fewer hooks can be used if the density of target species is known to be high. Capture stress can be further reduced by attaching the gangions to long leaders, allowing specimens to swim freely once hooked (Denton et al., 1987; Ballard, 1989; Murru, 1990; Boggs, 1992).

Gangions typically consist of a 2 m (x 4 mm diameter) length of nylon rope attached by a large swivel to an additional 1.5 m (x 3 mm diameter) length of heavy, plastic-coated wire. A hook is attached to the end of the wire trace. The heavy line and wire make it easier to haul in captured

specimens quickly. Gangions are usually attached to the long-line with a stainless steel clip. When a specimen is brought to the boat, it can be disconnected from the long-line and lifted into a transport container. The hook is then cut with a pair of bolt cutters, allowing it to be easily removed without further injury to the specimen. If the specimen is too large to be landed, the gangion may be detached from the long-line and the specimen guided to an area where it can be transferred to a transport container or a sea pen (Denton et al., 1987).

A variation of the long-line, whereby individual gangions are attached to individual floats, has been used successfully to collect blacktip sharks (*Carcharhinus limbatus*) in shallow waters (McCourt, pers. com.). This gear, referred to as a free float, is baited with live fish, set within a 300-meter radius of the fishing boat, and closely monitored. When a bait is taken the float is tracked until the boat can get close enough to snare it with a boat hook. The specimen is then landed and placed in a transport container. This technique has proven successful in shallow-water estuaries where it is often impractical to set long- lines. Capture success is high, when using this technique, as animals can run with the bait for a sufficient time to allow the hook to become properly set.

Block-line fishing

Denton et al. (1987) have captured elasmobranchs using a baited hook attached to a 50-meter rope and large, anchored buoy (Figure 7.5). Captured specimens were thus given sufficient freedom to maintain normal swimming patterns and this increased the time that viable specimens could remain on the line. This technique is called block-line fishing in the USA (Henningsen, pers. com.; Young, pers. com.) and drum-line fishing in Australia.

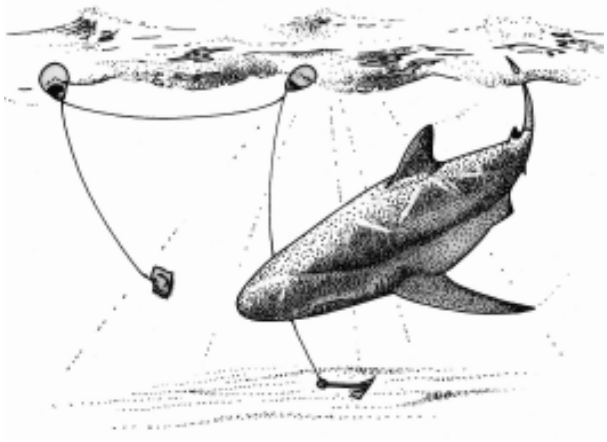

Figure 7.5. Block-line or drum-line fishing allows captured animals freedom to continue normal swimming patterns until retrieved.

Hooks

Any hooking technique has the risk of a specimen swallowing the hook and sustaining internal damage. Using a Mustad circle hook (O. Mustad & Son A. S., Gjøvik, Norway) (Figure 7.6) will reduce this risk as they embed primarily in the lower jaw or jaw hinge (Skomal, 2002; Harrington, pers. com.; Wisner, pers. com.). Wisner (pers. com.) suggests crimping down the barb of circle hooks to further reduce injuries incurred while angling.

Wisner (pers. com.) has used 85-113 gram lead sinkers, attached close to a hook, to prevent brown stingrays (*Dasyatis lata*) swallowing the hook when caught. The sinker is too large to fit into the mouth of the rays and therefore the hook does not get past the buccal cavity. Harrington (pers. com.) has adopted a similar technique, using a stainless steel rod (~30 cm long x 3-4 mm diameter) attached perpendicularly to the trace, to prevent hooks passing beyond the jaws of sand tiger sharks and sandbar sharks (*Carcharhinus plumbeus*) during long-line fishing operations.

Targeting

In some cases, the methods described above are not sufficiently discriminating to catch the size class or species of elasmobranch desired. In these cases, a more selective method of collection, e.g., targeting, may be required.

Blue sharks have been attracted to the side of a capture vessel using chum, dip-netted out of the water, and transferred directly into a transport tank on board (Howard, pers. com.).

Pacific angel sharks (*Squatina californica*) have been collected using large, perforated heavy-duty, plastic bags manipulated by a team of three or four SCUBA divers. Once a suitable specimen was located, two of the divers held the bag open near the shark and the other diver(s) maneuvered the shark into the bag (Howard, pers. com.).

Juvenile blacktip reef sharks (*Carcharhinus melanopterus*) have been chased through the reef-flat shallows of Christmas Island and successfully

Figure 7.6. Mustad circle hooks (left) of size 11/0 (top) and 12/0 (bottom), and Mustad number 9174 straight hooks (right) of size 6/0 (top) and 7/0 (bottom). A 1.0 cm scale is provided in the center of the figure. From Skomal et al. (2002).

caught with hoop nets (Wisner, 1987).

Striped catsharks (*Poroderma africanum*), leopard catsharks (*Poroderma pantherinum*), puffadder shysharks (*Haploblepharus edwardsii*), and dark shysharks (*Haploblepharus pictus*) are particularly easy to collect, as they are generally slow-moving and approachable. A mesh dive bag containing bait is tied to the holdfast of some nearby kelp. When the desired species comes in to feed they are simply caught by hand, just behind the head, and placed into a mesh dive bag. This method has been used to capture specimens ranging from 25-100 cm TL (Dainty, pers. com.; Human, pers. com.).

Sedentary tropical coral reef elasmobranchs are often selectively collected by SCUBA divers using hand nets. Once a specimen has been caught, mesh is twisted over the net entrance to prevent the animal from escaping (Squire, pers. com.; Young, pers. com.).

An older method of collecting large rays (e.g., spotted eagle rays, *Aetobatus narinari*) was to spear the selected specimen through the lateral margin of the pectoral fin. The spear was attached to the gun with a long cord, allowing the animal to be dragged to the boat and transferred to a transport container. Injuries to animals were considered relatively minor and wounds healed quickly. Prophylactic antibiotics were frequently given (Long, pers. com.).

A technique used to collect many species of ray is to locate the target specimen, cast a small barb-less treble hook over the animal, and snag the edge of the pectoral fin (Young, pers. com.). The animal is quickly brought to the boat with a rod and reel, as per normal angling. This technique has proven successful, causing minimal injury.

Sand tiger sharks swallow and store air in their stomach to aid buoyancy. If a sand tiger shark is brought to the surface from great depth, gastric emboli may result (Smith, 1992). It is therefore advantageous to burp the air from these animals prior to bringing them to the surface. Two capture methods adopted in Australia have been directed at addressing this issue: set hooking and hooping.

Set hooking uses a standard angling rig with a long steel trace (~3 m) and a toggle positioned close to the end of the line. A SCUBA diver takes the baited hook and feeds it to a selected shark. Once the shark has taken hold of the bait, the diver waits for a few moments before setting the hook by pulling on the toggle. The diver orients the hook so that it imbeds in the lower jaw, causing minimal injury to the specimen. It is important that the surface angler maintains tension on the line, as soon as the hook is set, to prevent the shark from dislodging or swallowing the hook (Menzies, pers. com.).

Hooping employs a rope noose suspended inside a large, rigid hoop. SCUBA divers swim above the shark and lasso the specimen as it swims through the hoop. When the shark is partially through the hoop, as far as the leading edge of its pectoral fins, the noose is pulled taut. The captured shark is thus restrained by the rope around the pectoral girdle. After a brief struggle, the animal is burped, brought to the surface, and transferred to a transport container (Smith, 1992).

CONCLUSIONS

Numerous techniques have been used to acquire live elasmobranchs for display or research purposes. In general, it is essential to understand

the habits and requirements of required species, and to select an appropriate capture method to ensure success. Although little has been published about elasmobranch capture techniques, much information is available from experienced collectors and aquarium personnel. Individuals intending to acquire elasmobranchs would do well to consult these people and heed their advice. Once caught, elasmobranchs need to be handled and transported with great care to avoid excess physical trauma and stress (please refer to Chapter 8 of this manual for more information about the handling and transport of elasmobranchs).

ACKNOWLEDGEMENTS

Aside from the people with whom I have had personal communication, thanks must go to all staff from the institutions cited below. Many of the techniques described in this chapter have arisen from the hard work and inspiration of these individuals.

REFERENCES

Andrews, J. C. and R. T. Jones. 1990. A method for the transport of sharks for captivity. Journal of Aquariculture and Aquatic Sciences 5: 70-72.

Arai, H. 1997. Collecting, transporting and rearing of the scalloped hammerhead. *In:* Proceedings of the Fourth International Aquarium Congress, June 23-27, 1996, Tokyo, p. 87-89. Tokyo, Japan by the Congress Central Office of IAC '96, Tokyo Sea Life Park. 402 pp.

Ballard, J. A. 1989. Some specimen collecting and transport methods. Bulletin de l'Institut Océanographique, Monaco, Nº spécial 5: 63-69.

Boggs, C. H. 1992. Depth, capture time, and hooked longevity of longline-caught pelagic fish: Timing bites of fish with chips. Fishery Bulletin 90(4): 642-658.

Burgess Jr., G. H. 1985. Biology of sharks as related to commercial shark fishing. *In:* Manual on Shark Fishing: a compilation of papers, p. 4-10. W. S. Otwell, (ed.). University of Florida, Sea Grant Extension Program, Gainesville.

Cliff, G. and G. D. Thurman. 1984. Pathological and physiological effects of stress during capture and transport in the juvenile dusky shark, *Carcharhinus obscurus*. Comparative Biochemistry and Physiology 78A: 167-173.

Denton, N. R., G. Cliff, A. P. Bowmaker, and G. D. Thurman, 1987. The capture, transport and maintenance in captivity of large sharks for experimental purposes in the field. Oceanographic Research Institute (Durban). Poster No. 2. Presented at the Sixth National Oceanographic Symposium, University of Stellenbosch, South Africa, July 6-10, 1987. FR 33(4).

Di Giacomo, E. E., A. M. Parma, and J. M. Orensanz. 1994. Food consumption by the cock fish, *Callorhinchus callorhynchus*, (Holocephali: Callorhynchidae), from Patagonia (Argentina). Environmental Biology of Fishes 40: 199-211.

Gruber, S. H. 1980. Keeping sharks in captivity. Journal of Aquariculture and Aquatic Sciences 1: 6-14.

Holeton, G. F. and N. Heisler. 1983. Contribution of net ion transfer mechanisms to acid-base regulation after exhausting activity in the larger spotted dogfish (*Scyliorhinus stellaris*). Journal of Experimental Biology 103: 31-46.

Jenkins, R. L. 1989. The captive biology of elasmobranchs at the National Aquarium in Baltimore. *In:* Annual Conference Proceedings, September 15-19, 1989, Pittsburgh, PA, p. 209-216. American Association of Zoological Parks and Aquariums (American Zoo and Aquarium Association, Silver Spring, Maryland).

Lawlor, F. J. 1985. Shark fishing methods and gear. *In*: Manual on shark fishing: a compilation of papers, p. 11-19. Otwell, W. S. (ed.). University of Florida, Sea Grant Extension Program, Gainesville.

Martin, L., and Zorzi, G. D. 1993. Status and review of the California skate fishery. *In*: Conservation Biology of Elasmobranchs, p. 39-52. S. Branstetter (ed.). US Department of Commerce, NOAA Technical Report, NMFS. Vol. 115.

Mazeaud, M. M., F. Mazeaud, and E. M. Donaldson. 1977. Primary and Secondary effects of stress in fish: Some new data, with a general view. Transactions of the American Fisheries Society 106(3): 201-212.

McEwan, T., S. A. F. Bell, and M. J. Dvornak. 2001. The "hadra" fish trap: a technique to acquire fishes for aquaria. *In:* Proceedings: Fifth International Aquarium Congress, November 20-25, 2000, Monaco. p. 205-208. Bulletin de l'Institute oceanographique, Monaco, No. spécial 20, part 1.

Meroz, A. 1990. Innovations in shark fishing. Journal of Aquariculture and Aquatic Sciences 5(4): 118. Abstract.

Murru, F. L. 1990. The care and maintenance of elasmobranchs in controlled environments. *In*: Elasmobranchs as Living Resources: Advances in Biology, Ecology, Systematics, and the Status of Fisheries, p. 203-209. H. R. Pratt, S. H. Gruber, and T. Taniuchi (eds.). US Department of Commerce, NOAA Technical Report. Vol. 90.

Nakano, H., M. Okazaki, and H. Okamoto. 1997. Analysis of catch depth by species for tuna longline fishery based on catch by branch lines. Bulletin - National Research Institute of Far Seas Fisheries (Japan) 34: 43-62.

Piiper, J., and D. Baumgarten. 1969. Blood lactate and acid-base balance in the elasmobranch *Scyliorhinus stellaris* after exhausting activity. Pubblicazioni della Stazione Zoologica 37: 84-94.

Piiper, J., M. Meyer, and F. Drees. 1972. Hydrogen ion balance in the elasmobranch *Scyliorhinus stellaris* after exhausting activity. Respiration Physiology 16: 290-303.

Powell, D. 2001. A Fascination for Fish. Adventures of an Underwater Pioneer. University of California Press/ Monterey Bay Aquarium Series in Marine Conservation, 3, Berkeley. 354 p.

Rasmussen, R. A. and L. E. Rasmussen. 1967. Some observations on the protein and enzyme levels and fractions in normal and stressed elasmobranchs. Transactions of the New York Academy of Science 29: 397-413.

Rupp, J. H. 1984. The Capture and Husbandry of Cowsharks, Family Hexanchidae. *In:* Annual Conference Proceedings, September 9-13, 1984, Miami, FL, p. 325-332. American Association of Zoological Parks and Aquariums (American Zoo and Aquarium Association, Silver Spring, Maryland).

Shiobara, Y., K. Suzuki, and S. Tanaka, 1997. Ecological notes and rearing on the frilled shark from Suruga Bay. *In:* Proceedings of the Fourth International Aquarium Congress, June 23-27, 1996, Tokyo. p. 75-78. Tokyo,

Japan by the Congress Central Office of IAC '96, Tokyo Sea Life Park. 402 pp.

Skomal, G. B., C. C. Bradford, and E. D. Prince. 2002. A comparison of circle hook and straight hook performance in recreational fisheries for juvenile Atlantic bluefin tuna. *In:* Catch and Release in Marine Recreational Fisheries, Symposium 30, p. 57-65. J. A. Lucy and A. L. Studholme (eds.). American Fisheries Society, Bethesda, Maryland.

Smith, M. F. L. 1992. Capture and transportation of elasmobranchs, with emphasis on the grey nurse shark (*Carcharias taurus*). Sharks: Biology and Fisheries 43(1): 325-343.

Stevens, J. E. 1994. The delicate constitution of sharks. Bioscience 44(10): 661-664.

Stevens, J. D., G. J. West, and K. J. McLoughlin. 2000. Movements, recapture patterns, and factors affecting the return rate of carcharhinid and other sharks tagged off northern Australia. Marine and Freshwater Research 51(2): 127-141.

Visser, J. 1996. The capture and transport of large sharks for Lisbon Zoo. International Zoo News 43(3): 147-151.

Wisner, M. 1987. Collecting and transporting blacktip reef sharks. Freshwater and Marine Aquarium 10: 16-17.

Wood, C. M., J. D. Turner, and M. S. Graham. 1983. Why do fish die after severe exercise? Journal of Experimental Biology 22: 189-201.

Wood, C. M. 1991. Acid-base and ion balance, metabolism, and their interactions, after exhaustive exercise in fish. Journal of Experimental Biology 160: 285-308.

PERSONAL COMMUNICATIONS

Barnhart, A. 2001. Dynasty Marine Associates, Inc., Marathon, Florida 33050, USA.

Carrier, J., 2002. Albion College, Albion, Michigan 49224, USA.

Christie, N. 2001. Atlantis Resort, Paradise Island, Bahamas.

Choe, K. 2001. University of Florida, Gainesville, Florida 32611, USA.

Dainty, A. 2001. University of Cape Town, Rondebosch, 7701, South Africa.

Dowd, S. A. 2001. New England Aquarium, Boston, Massachusetts 02110, USA.

Ellis, C. M. 2001. Mystic Aquarium, Mystic, Connecticut 06335, USA.

Fahy, D. P. 2001. Nova Southeastern University - Oceanographic Center, Dania Beach, Florida, 33004, USA.

Harrington, D. 2001. Professional Fisherman, Ocean City, Maryland 21842, USA.

Henningsen, A. 2001. National Aquarium in Baltimore, Baltimore, Maryland 21202, USA.

Howard, M. 2001. Aquarium of the Bay, San Francisco, California 94133, USA.

Human, B. 2001. University of Cape Town Medical School, Observatory, 7925, South Africa.

James, R. 2001. Sea Life Centre, Weymouth DT4 7SX, UK.

Janse, M. 2001. Burger's Zoo, 6816 SH Arnhem, The Netherlands.

Kelleher, M. 2001. New England Aquarium, Boston, Massachusetts 02110, USA.

Kinnunen, N. 2001. Sydney Aquarium, Sydney, New South Wales 2000, Australia.

Long, T. 2001. Sea World Australia, Surfers Paradise, Queensland 4218, Australia.

McCourt, S. 2001. Sea World Australia, Surfers Paradise, Queensland 4218, Australia.

McEwan, T. 2001. The Scientific Centre of Kuwait, Salmiya 22036, Kuwait.

Marín-Osorno, R. 2001. Acuario de Veracruz, Veracruz, 91700, Mexico.

Menzies, S. J. 2001. Shanghai Ocean Aquarium, Pudong New Area, 200120, Shanghai.

Nelson, B. D. 2001. New England Aquarium, Boston, Massachusetts 02110 USA.

Nemeth, D. 2001. Coral World, St. Thomas, 6450, Virgin Islands.

Newman, P. 2001. Sea World, San Antonio, Texas 78251, USA.

Powell, D. 2001. Monterey Bay Aquarium, Monterey, California 93940, USA.

Sabalones, J. 2001. Newport Aquarium, Newport, Kentucky 41071, USA.

Squire, L. 2001. Cairns Marine Aquarium Fish, Cairns, Queensland 4870, Australia.

Steslow, F. 2001 New Jersey State Aquarium, Camden, New Jersey 08103, USA.

Thomas, L. 2001. Squid Inc., Eden Prairie, Minnesota 55346, USA.

Whitehead, J. 2001. New England Aquarium, Boston, Massachusetts 02110, USA.

Wisner, M. 2001. Mauna Lani Bay Hotel, Hawaii 96743, USA.

Young, F. 2001. Dynasty Marine Associates, Inc., Marathon, Florida 33050, USA.