

A List of Reef Fishes and their Reproductive Ecology in the Coastal Waters of the Sydney Area Based on Underwater Photographs and Movies

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Abstract Fishes of the shore reefs were recorded on photographs and movies at three sites in the Sydney area, New South Wales, Australia. A total of 101 species in 52 families were recorded; of these 62.6% were endemic to the temperate region of Australia. Ten species in 7 families showed evidence of reproduction in this area.

Key words: fauna and flora, temperate reefs, endemic species, spawning behavior, parental care.

Fish collections, from which morphologic measurements and molecular analysis are available, are the most basic and important materials for all ichthyological studies. However, the collections themselves cannot provide ecological information such as body color and habitat in the field. In this respect, underwater photographs of fishes are highly valuable data. Furthermore, they can be easily accumulated from every location at anytime by contributions from sports divers, not only from ichthyologists (Furuse *et al.*, 1996). Accumulated data can explain the distribution, water depth of the habitat and the time of appearance of fishes. Thus, underwater photos have begun to be registered and kept in museums and institutes. Furuse *et al.*, (1996) and Senou *et al.* (1997, 1998) reported lists of fishes of Hachijojima Island and the Izu Peninsula, Japan, based on underwater photos registered to the Kanagawa Prefectural Museum of Natural History. As well as photos, underwater movies are also valuable data since they can record behavioral patterns that have actually been going on in the field, such as courtship displays, spawning behavior and parental egg care. Our institute has been registering and preserving such underwater movies shot in the field (Kawase, 2002b, 2005).

I got an opportunity to study the reproductive ecology of leatherjackets (Family Monacanthidae) in the rocky reefs in the Sydney area, New South Wales, Australia, for a total of three months. During the study, I recorded the fish species inhabiting that area and observed their reproductive behavior in basic research to understand the environmental features of

the study site. In this paper, I report a list of reef fishes in the coastal waters of the Sydney area on the basis of underwater photos and movies. Furthermore, I describe the reproductive ecology of several fishes in that area.

Study Sites and Methods

Underwater observations were carried out at three sites in the coastal waters of the Sydney area (Fig. 1) between 20 January and 12 March 2004 and between 2 February and 1 March 2005. Sutherland Point (34° 00' S, 151° 14' E) is situated at the entrance to Botany Bay, Kurnell. Rocky reefs and boulders exist within 100 m of the shore, and the water depth reaches 14 m at the border of the reefs and the sandy bottom. There are strong tidal currents in both the outward and inward directions of the bay when the tide falls and rises, respectively. Fairlight Beach (33° 48' S, 151° 16' E) is located at Manly Cove, in the northern part of Port Jackson. Rocky reefs cover the area within 80 m of the beach, where the water depth is less than 6 m. Shelly Beach (33° 48' S, 151° 18' E) is located at the innermost area of Cabbage Tree Bay, directly facing the Tasman Sea. Narrow rocky reefs and boulders approximately 10 m wide cover the south coast of the bay, and the water depth reaches 2-4 m at the border of the reefs and the sandy bottom.

Underwater photographs and movies were shot using a Sony DSC-PC9 digital camera with Sony Marine Pack housing and a Sony DCR-PC1 digital video camera with Sea & Sea VX-1D housing. The photos and movies were checked on a monitor, and fish

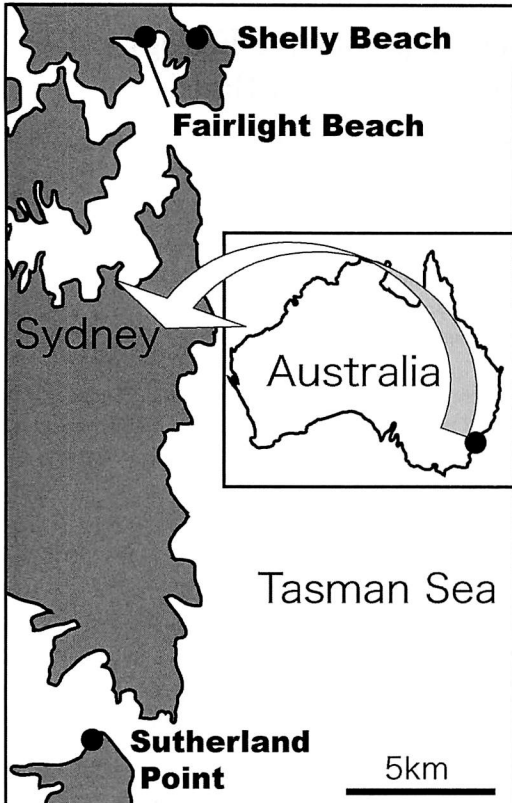


Fig. 1. Location of study sites in the Sydney area, New South Wales, Australia.

species were identified by reference to the photos, illustrations and descriptions of Hutchins and Swainston (1986), Gomon *et al.* (1994), Kuitert (1993, 1996) and Nakabo (2002). Listed fishes were classified into three distributional categories based on the former literature and the web site of the fish database, "FishBase" (<http://www.fishbase.org/home.htm>). The photos and movies have been registered and are kept in the Coastal Branch of Natural History Museum and Institute, Chiba, Japan (CMNH-HP-010001-0100969, MV-0000964-0001100).

Results and Discussion

1. Reef fishes of the Sydney area

Sydney Harbor has a remarkably rich fish fauna, with 571 species recorded in the Australian Museum Ichthyology Database as of August 2005 (M. McGrouther, personal comm.). In this study, a total of 101 species in 52 families were recorded on photographs and movies from three sites in the Sydney area: 55 from Sutherland Point (SP), 48 from Fairlight Beach (FB) and 48 from Shelly Beach (SB) (Table 1). Excluding 10 species that could not be identified on a

species level, 57 (62.6%) were Australian temperate reef endemic species (A), 15 (16.5%) were Australian and New Zealand temperate reef species (AN) and 19 (20.9%) were species widely distributed in temperate and/or tropical regions (W). Southern Australian rocky reefs have a remarkably high degree of diversity and endemism (Gomon *et al.*, 1994; Kingsford, 2000). The reason for this is partially explained by the fact that Australia is a large continental mass and that the marine biota of southern temperate Australia has remained isolated for over 65 million years (Kingsford, 2000). Approximately 600 species of fish have been recorded in this region, and 85% of the fish are endemic (Poore, 1995). The present study showed a high ratio of fish endemism in the shore reefs around Sydney in southeastern Australia.

2. Reproductive ecology

Knowledge of the reproductive ecology of Australian temperate reef fishes is very limited in comparison with that of the Great Barrier Reef (*e.g.*, Tzioumis and Kingsford, 1995; Kawase, 2005). During this study, reproductive behavior, parental egg care and deposited eggs were observed in 10 species in 7 families in shore reefs around Sydney (Table 1).

The crested horn shark *Heterodontus galeatus* commonly occurred on the bottom of rocky reefs around 10 m water deep at Sutherland Point (Fig. 2A). Eggs of *H. galeatus* are shaped like a capsule encircled by a double spiral. Two long tendrils are attached at one end of the egg (Last and Stevens, 1994). The egg was found on a branching sponge anchored by its tendrils to the branch (Fig. 2B).

The weedy seadragon *Phyllopteryx taeniolatus* is a syngnathid endemic to Australian temperate waters and is totally protected in New South Wales. Males incubate the brood on the outside of their body with each egg partly embedded in their skin for two months; the brooding males are present from June to early January (Sanchez-Camara *et al.*, 2005). The fish was observed among the kelp and in the reefs closeby at Sutherland Point. Brooding males were found there at around 10 m deep on 28 January (Fig. 3) and 2 February 2004, but no brooding individuals were found thereafter in the same season.

The Sydney cardinalfish *Apogon limenus* was very common at all three sites around Sydney. The fish aggregated in the shade of ledges, in which mouth-brooding individuals were observed (Fig. 4). Mouth-brooding has been reported for a large number of apogonid species, and males carry out the role in many cases (Thresher, 1984).

Fishes of Shore Reefs around Sydney

Table 1. List of reef fishes at the three sites of the Sydney area based on the underwater photographs and movies. See text for abbreviations.

Family	Scientific name	Japanese name	Reproduction	SP	FB	SB	Distribution
Heterodontidae	<i>Heterodontus galeatus</i>		+	+	+		A
Orectolobidae	<i>Orectolobus maculatus</i>			+		+	A
Triakidae	<i>Mustelus</i> sp.			+			
Torpedinidae	<i>Hypnos monopterygium</i>			+			A
Urolophidae	<i>Urolophus paucimaculatus</i>					+	A
Myliobatididae	<i>Myliobatis australis</i>				+		A
Muraenidae	<i>Gymnothorax prasinus</i>			+	+		AN
Plotosidae	<i>Cnidoglanis macrocephalus</i>					+	A
	<i>Plotosus lineatus</i>	Gonzui		+			W
Aulopodidae	<i>Aulopus purpurissatus</i>			+		+	AN
Moridae	<i>Lotella rhacina</i>			+			A
Batrachoididae	<i>Batrachomoeus dubius</i>			+	+		A
Gobiesocidae	<i>Cochleocephus orientalis</i>			+			A
Hemiramphidae	<i>Hyporhamphus</i> sp.				+		
Atherinidae	Atherinidae sp.				+		
Syngnathidae	<i>Hippocampus whitei</i>			+			A
	<i>Phyllopteryx taeniolatus</i>		+	+			A
	Syngnathidae sp.			+			
Scorpaenidae	<i>Scorpaena cardinalis</i>			+	+	+	AN
Platycephalidae	<i>Thysanophrys cirronasus</i>					+	A
	<i>Platycephalus fuscus</i>					+	A
Serranidae	<i>Hypoplectrodes maccullochi</i>			+			A
Plesiopidae	<i>Trachinops taeniatus</i>			+	+	+	A
	<i>Paraplesiops bleekeri</i>			+			A
Apogonidae	<i>Apogon limenus</i>		+	+	+	+	A
Dinolestidae	<i>Dinolestes lewini</i>			+	+	+	A
Carangidae	<i>Trachurus novaezelandiae</i>			+		+	AN
	<i>Pseudocaranx dentex</i>	Shima-aji		+		+	W
Lutjanidae	<i>Paracaesio xanthurus</i>			+			AN
Gerreidae	<i>Gerres</i> sp.				+		
Lethrinidae	<i>Lethrinus nebulosus</i>	Hama-fuefuki				+	W
	Lethrinidae sp.					+	
Sparidae	<i>Chrysophrys aurata</i>			+		+	AN
	<i>Rhabdosargus sarba</i>				+		A
	<i>Acanthopagrus australis</i>				+		W
Mullidae	<i>Parupeneus signatus</i>			+	+	+	A
	<i>Parupeneus barberinoides</i>	Indo-himeji				+	W
	<i>Upeneichthys lineatus</i>			+			AN
Monodactylidae	<i>Schuettea scalaripinnis</i>			+			A
Pempherididae	<i>Parapriacanthus elongatus</i>				+		A
	<i>Pempheris affinis</i>			+			A
	<i>Pempheris compressa</i>				+		A
Girellidae	<i>Girella tricuspidata</i>				+	+	AN
	<i>Girella elevata</i>			+			AN
Scorpididae	<i>Scorpis lineolata</i>				+		AN
Microcanthidae	<i>Microcanthus strigatus</i>	Kagokakidai			+		W
	<i>Atypichthys strigatus</i>			+			AN
Chaetodontidae	<i>Chelmonops truncatus</i>			+			A
	<i>Chaetodon auriga</i>	Toge-chōchōuo				+	W
	<i>Chaetodon flavirostris</i>					+	W

Table 1. (continued)

Family	Scientific name	Japanese name	Reproduction	SP	FB	SB	Distribution
	<i>Chaetodon guentheri</i>	Kokuten-katagi		+			W
	<i>Heniochus</i> sp.	Hatatatedai zoku		+			
Enoplosidae	<i>Enoplosus armatus</i>				+		A
Aplodactylidae	<i>Crinodus lophodon</i>			+	+	+	A
Cheilodactylidae	<i>Cheilodactylus vestitus</i>			+	+		A
	<i>Cheilodactylus fuscus</i>			+	+		A
Cepolidae	<i>Cepola australis</i>			+			A
Pomacentridae	<i>Parma microlepis</i>			+	+	+	A
	<i>Parma unifasciata</i>			+	+	+	A
	<i>Abudefduf bengalensis</i>	Tenjiku-suzumedai			+		W
	<i>Mecaenichthys immaculatus</i>			+	+		A
	<i>Chromis hypsilepis</i>			+		+	AN
	<i>Pomacentrus coelestis</i>	Sora-suzumedai		+	+		W
Labridae	<i>Achoerodus viridis</i>			+	+	+	A
	<i>Notolabrus gymnogenis</i>			+	+	+	A
	<i>Pseudolabrus guentheri</i>				+		A
	<i>Pictilabrus laticlavus</i>		+	+		+	A
	<i>Eupetrichthys angustipes</i>					+	A
	<i>Stethojulis bandanensis</i>	Akaobi-bera				+	W
	<i>Ophthalmolepis lineolata</i>			+		+	A
Odacidae	<i>Odax acroptilus</i>		+	+	+	+	A
	<i>Odax cyanomelas</i>		+	+	+	+	A
Tripterygiidae	<i>Enneapterygius rufopileus</i>				+		AN
Blenniidae	<i>Petroscirtes breviceps</i>	Niji-ginpo			+		W
	<i>Plagiotremus tapeinosoma</i>	Ten-kurosuji-ginpo				+	W
Callionymidae	<i>Eocallionymus</i> sp.					+	
Gobiidae	<i>Istigobius hoesei</i>				+	+	A
Acanthuridae	<i>Prionurus microlepidotus</i>				+		A
	<i>Prionurus maculatus</i>				+	+	AN
	Acanthuridae sp.				+		
Siganidae	<i>Siganus</i> sp.				+		
Sphyracidae	<i>Sphyracna obtusata</i>					+	A
Balistidae	<i>Sufflamen chrysopterus</i>	Tsumaziro-mongara			+		W
Monacanthidae	<i>Eubalichthys mosaicus</i>			+			A
	<i>Eubalichthys bucephalus</i>		+	+	+	+	A
	<i>Meuschenia flavolineata</i>					+	A
	<i>Meuschenia freycineti</i>			+		+	A
	<i>Meuschenia trachylepis</i>				+	+	A
	<i>Cantherhines pardaris</i>	Amime-umadura-hagi				+	W
	<i>Acanthaluteres vittiger</i>					+	A
	<i>Monacanthus chinensis</i>	Morokoshi-hagi			+		W
	<i>Scobinichthys granulatus</i>		+		+	+	A
	<i>Nelusetta ayraudi</i>				+		AN
	<i>Paraluteres prionurus</i>	Nokogiri-hagi		+			W
	<i>Brachaluteres jacksonianus</i>		+	+	+	+	A
Aracnidae	<i>Anoplocapros inermis</i>				+	+	A
Tetraodontidae	<i>Arothron stellatus</i>	Moyō-fugu				+	W
	<i>Tetraodon glaber</i>					+	A
	<i>Torquigener pleurogramma</i>			+			A
	<i>Canthigaster callisterna</i>		+	+			A
Diodontidae	<i>Dicotylichthys punctulatus</i>			+			A

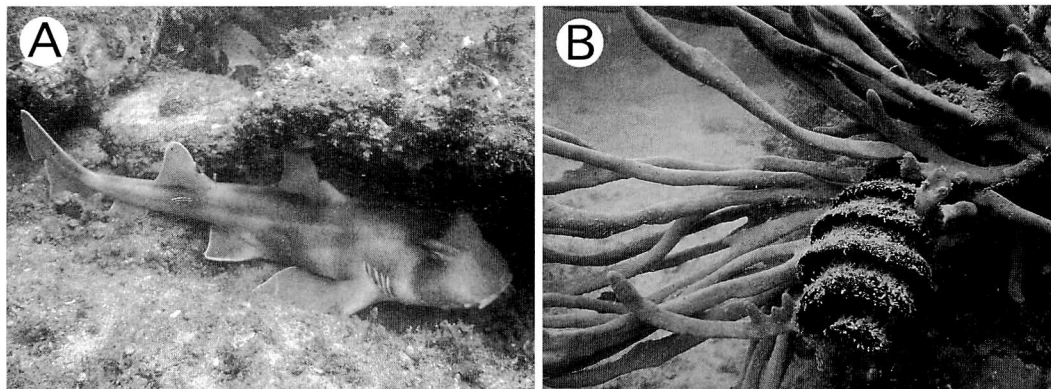


Fig. 2. Underwater photographs of the crested horn shark *Heterodontus galeatus* (CMNH-HP-0100182) (A) and a deposited egg tangling with tendrils in the branch of a sponge (CMNH-HP-0100087) (B).



Fig. 3. A video image of the male weedy seadragon *Phyllopteryx taeniolatus* carrying fertilized eggs externally below his tail (CMNH-MV-0001003).



Fig. 4. Mouthbrooding of the Sydney cardinalfish *Apogon limenus* (CMNH-HP-0100312). Notice the mouth of the individual is swollen with fertilized eggs.

The senetor wrasse *Pictilabrus laticlavius* was very common in shallow reefs with algae at the three sites. Males patrolled the territory and courted females lurking among the algae. Spawning began with a quick rush by the male toward the female with 1-2 m ascents in a water column. The males courted another female after mating and made multiple spawns.

Odadidae is closely related to Labridae (Nelson, 1994). The distribution of odadids is restricted to the temperate reefs of Australia and New Zealand, the rainbow cale *Odax acroptilus* and the herring cale *O. cyanomelas* being endemic to Australia (Gomon *et al.*, 1994). These two odadids were observed in the kelp at the three sites. They released pelagic eggs in a water column.

Among monacanthids, spawning behavior was observed in three species. The pygmy leatherjacket *Brachaluteres jacksonianus* was common in the shallow seagrass beds and rocky reefs, and spawnings were observed at all three sites. The *B. jacksonianus* male exhibits a noticeable display by fully expanding the ventral flap and caudal fin. Females thrust their

snouts into the algae before spawning, and the males and females touch their abdomens on the algae and release gametes quickly in a pair (Kawase, 2005). Spawnings of the black reef leatherjacket *Eubalichthys bucephalus* and the rough leatherjacket *Scobinichthys granulatus* were observed at Sutherland Point for the former, and at Fairlight Beach and Shelly Beach for the latter. They released demersal eggs on the bottoms.

The pre-spawning behavior of the clown toby *Canthigaster callisterna* was observed in the rocky reefs of Sutherland Point. The female thrust her snout into the algae repeatedly, while the male positioned himself behind the female and nuzzled her body (Fig. 5). Similar pre-spawning behavior is reported for the congeneric species *C. valentini* (Gladstone, 1987) and also for the balistoid fishes (Kawase, 2002a).

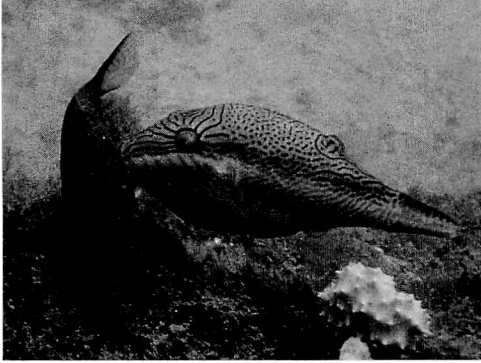


Fig. 5. Pre-spawning behavior of the female (left) and male (right) clown toby *Canthigaster callisterna* (CMNH-HP-0100313).

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References

Furuse, K., H. Senou, S. Kato and T. Kikuchi. 1996. List of the fishes of Hachijo-jima Island, the Izu Islands, on the basis of the underwater photographs registered to KPM-NR. *Nat. Hist. Rep. Kanagawa* 17: 49-62. (In Japanese)

Gladstone, W. 1987. The courtship and spawning behaviors of *Canthigaster valentini*. *Env. Biol. Fish.* 20: 255-261.

Gomon, M. F., J. C. M. Glover and R. H. Kuitert. 1994. *The Fishes of Australia's South Coast*. 992 pp. State Print, Adelaide.

Hutchins, B. and R. Swainston. 1986. *Sea Fishes of Southern Australia*. 180 pp. Gary Allen Pty Ltd, Perth.

Kawase, H. 2002a. Simplicity and diversity in the reproductive ecology of triggerfish (Balistidae) and filefish (Monacanthidae). *Proc. Int. Commem. Symp., 70th Anniv. JSFS*: 119-122.

Kawase, H. 2002b. Deep-sea topography and organisms in the Tateyama submarine canyon, Boso Peninsula, Japan: observation with an underwater TV

vehicle. *J. Nat. Hist. & Inst. Chiba* 7: 5-12. (In Japanese with English abstract)

Kawase, H. 2005. Spawning behavior of the pygmy leatherjacket *Brachaluteres jacksonianus* (Monacanthidae) in southeastern Australia. *Ichthyol. Res.* 52: 194-197.

Kingsford, M. 2000. Oceanography and biogeography. In Andrew N. (ed.), *Under Southern Seas: The Ecology of Australia's Rocky Reefs*, pp. 3-7. Krieger Publishing Company, Florida.

Kuitert, R. H. 1993. *Coastal Fishes of South-eastern Australia*. xxxi + 347 pp. Crawford House Press, Bathurst.

Kuitert, R. H. 1996. *Guide to Sea Fishes of Australia*. 434 pp. New Holland Publishers Pty Ltd, Sydney.

Last, P. R. and J. Stevens. 1994. *Sharks and Rays of Australia*. 512 pp. CSIRO, Melbourne.

Nakabo, T. 2002. *Fish of Japan with Pictorial Keys to the Species, English Edition*. 1749 pp. Tokai University Press, Tokyo.

Nelson, J. S. 1994. *Fishes of the World*. 600 pp. John Wiley & Sons, Inc, New York.

Poore, G. C. B. 1995. Biogeography and diversity of Australia's marine biota. In Zann L. and P. Kailola (eds.), *Biogeography and Diversity of Australia's Marine Biota*, pp. 75-84. Great Barrier Reef Marine Park Authority, Canberra.

Sanchez-Camara, J., D. J. Booth and X. Turon. 2005. Reproductive cycle and growth of *Phyllopteryx taeniolatus*. *J. Fish Biol.* 67: 133-148.

Senou, H., A. Mishiku, T. Nomura, K. Sorita and Y. Matsuzawa. 1997. List of the fishes of Osezaki, the western coast of the Izu Peninsula, Suruga Bay, on the basis of the underwater photographs registered to KPM-NR. *Nat. Hist. Rep. Kanagawa* 18: 83-98. (In Japanese)

Senou, H., H. Makiuchi and H. Takeya. 1998. List of the fishes of Atami, the eastern coast of the Izu Peninsula, Sagami Bay, on the basis of the underwater photographs registered to KPM-NR. *Nat. Hist. Rep. Kanagawa* 19: 19-28. (In Japanese with English abstract)

Thresher, R. E. 1984. *Reproduction in Reef Fishes*. 399 pp. T. F. H. Publications, New Jersey.

Tzioumis, V. and M. J. Kingsford. 1995. Reriodicity of spawning of two temperate damselfishes: *Parma microlepis* and *Chromis dispilus*. *Bull. Mar. Sci.* 57: 596-609.

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シドニー周辺の岩礁域で見られる
魚類とその繁殖生態
—水中写真とビデオによる記録—

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2004年と2005年の1月から3月に、オーストラリアのシドニー周辺の3カ所でSCUBA潜水を行い、ここで見られる魚類を水中写真およびビデオに記録した。その結果、合計52科101種が確認され、これらのうち62.6%がオーストラリアの温帯域に固有な魚類で占められていた。また、産卵行動や卵保護行動などにより7科10種の繁殖が確認された。