

**CHECKLIST OF FISHES FROM THE HACKING RIVER CATCHMENT,
INCLUDING THE PORT HACKING ESTUARY,
IN CENTRAL NEW SOUTH WALES**

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Abstract

The fish fauna of the Hacking River catchment has been sampled extensively. The objective of this study was to provide a summary of the fish species recorded during surveys previously conducted in this catchment. The primary output of this study is a tabular checklist of fish species that has been compiled from all available published references and from personal observations by scientific staff at the Cronulla Fisheries Centre. A total of 252 fish species belonging to 97 families are listed. This compilation will be a useful resource for scientists, community groups, amateur naturalists, fishers and divers interested in the local fish fauna. The information also provides a useful baseline for future surveys of fish diversity in the Hacking River catchment.

Introduction

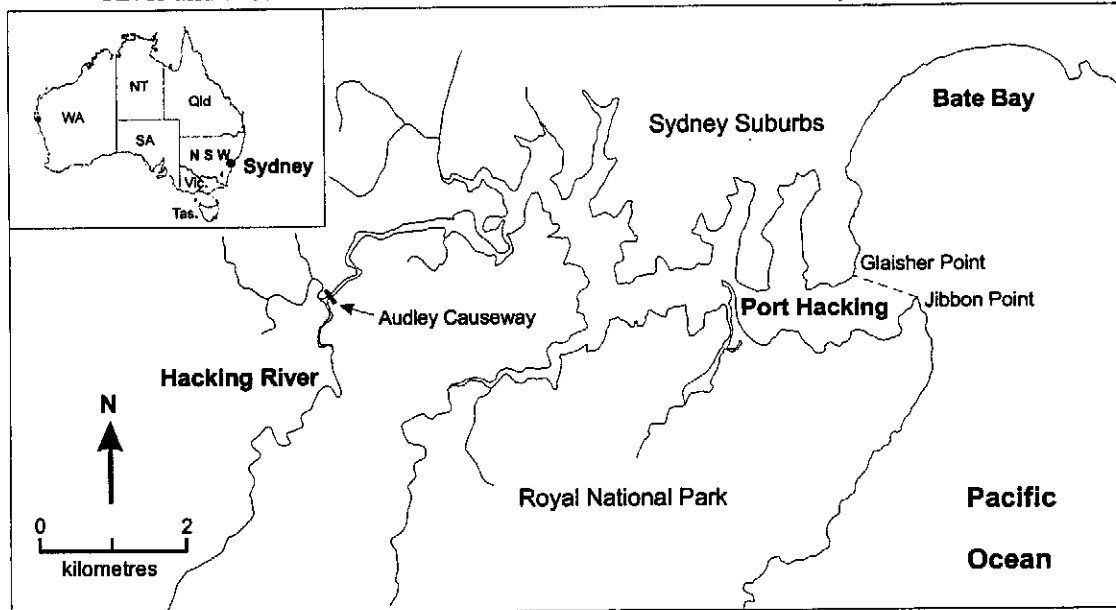
Background

The fish fauna of the Hacking River catchment has been sampled extensively during the 20th century (see footnote to Table 1), due primarily to the location and history of this catchment (Figure 1). For the purposes of this study, the Hacking River catchment is defined as all of the contiguous waters west of a line between Glaisher and Jibbon Points (Figure 1) and includes the Hacking

River, all of its tributaries, as well as the Port Hacking estuary. It forms part of the southern boundary of Sydney, the oldest and largest city in Australia. Most of the catchment is within the Royal National Park, the first national park in Australia. Some of the earliest fisheries research in Australia was conducted in Port Hacking by Harald Dannevig, after his arrival from England in 1902. Fisheries research conducted by the Commonwealth and New South Wales governments has continued at the Cronulla research facility until the present.

Due to concerns about overfishing by commercial fisheries in the Sydney region (Fisheries Inquiry Commission 1880), Port Hacking was closed to commercial fishing in 1886 and has remained closed since that time. Port Hacking has long been a popular area for recreational fishing (Henry *et al.* 1987). In 1982, Shiprock in Port Hacking became the first totally protected (no-take) estuarine aquatic reserve to be established for recreational diving in NSW. Despite its proximity to metropolitan Sydney, but due in part to controls on land use in the national park, the waters of the catchment are considered to be relatively pristine (Hacking River Catchment Management Committee 1997, Environment Protection Authority 1997).

Figure 1. Hacking River catchment including the Port Hacking estuary, Hacking River and tributaries. Dashed line delineates the eastern boundary of the catchment.



In the 21st century, there is much concern about coastal development and its impact on the biodiversity of coastal aquatic habitats. In New South Wales, catchment management committees, and more recently catchment management boards, have been established to monitor the environment within coastal catchments. The authors have compiled the following checklist of fishes from the Hacking catchment as a starting point and continuing reference for catchment management authorities, scientists and interested amateurs conducting future surveys of fish biodiversity in this catchment. It is also intended as a useful reference for recreational fishers and divers.

Site Description

Port Hacking estuary is a drowned river valley formed by the in-filling of a relatively small river channel during the last postglacial sea-level rise about 6,500 years ago (Roy 1984, Roy *et al.* 2001). It

is a marine dominated estuary with full tidal exchange (mean spring tidal range of 1.32 m) through a permanently open entrance. The Hacking River and several small tributaries annually discharge an average of 69 million cubic metres of fresh water into Port Hacking estuary (Bell and Edwards 1980). A causeway at Audley forms a tidal barrier across the Hacking River about 12 km from the mouth of the estuary and is considered to be the boundary between the Hacking River and the Port Hacking estuary. The entire catchment is relatively small, covering an area of only 180 km².

The Hacking catchment is located in the middle of the central estuarine fisheries bioregion described by Pease (1999). This region extends from Wallis Lake in the north to St Georges Basin in the south and encompasses the Hawkesbury Shelf marine and coastal bioregion (ANZECC 1998). Port Hacking is smaller than most of the estuaries in this

region, but with little fluvial input the waters are predominantly marine in character. The zoogeographical affinities of the marine and estuarine fish communities in this bioregion are complex (Pease *et al.* 1981, ANZECC 1998, Pease 1999). The permanent fish fauna of the region is a mixture of warm temperate and sub-tropical species. The East Australian Current (EAC) flows southward from the Coral Sea and typically diverges from the coast at the northern end of the region (Hamon 1965). However, in summer and autumn, the EAC and associated eddies intermittently contact the coast within this region (Cresswell 1987), depositing small juveniles of tropical fish species which generally do not survive through the winter (Hutchins 1991).

Methods

Type and voucher specimens of fishes collected from the Hacking catchment since 1902 are held at the Australian Museum in Sydney. In July 1997, data for all fish collected from the catchment were extracted from the Museum's collection database. A literature review was subsequently conducted to obtain information about all fish species sampled during aquatic surveys in the catchment. Finally, some of the scientific staff at the Cronulla Fisheries Centre with extensive scientific collecting, fishing and diving experience in Port Hacking reviewed the list and added additional species that they had identified in the catchment.

The complete list of species is presented as a checklist in the taxonomic order proposed by Paxton *et al.* (1989). The scientific and accepted Australian common names for each family are shown in capital letters. Each species is

listed alphabetically by genus and species under its family heading. The two most widely used Australian common names for each species are also listed. Numeric designators (defined in a footnote) provide references for the sources that originally listed each species. The species name contained in the reference may be a synonym. The following references were used for verifying the most recent taxonomic nomenclature and common names: Allen (1991), Eschmeyer (1995), Kuitert (1996), Allen *et al.* (1998), Grant (1998), Hutchins and Swainston (1999), and Steene (1978). The catalogue by Eschmeyer (1998) was also accessed and searched on the World Wide Web through the FishBase (Froese and Pauly 2000) website (www.fishbase.org/home.htm).

The range of habitats in which members of each family are known to occur are given after the family name, where M = marine, E = estuarine, F = freshwater. Habitat information is presented at the family level because there is a lack of detailed habitat affinity information for many species. The majority of estuarine fish species belong to families that contain primarily marine species. As some members of these families may also be found either occasionally or primarily in estuaries, these families are designated as "M, E". Families that contain species that may be found in estuaries, but may also be found individually or collectively in fresh water, are designated as "E, F". A few families contain members that are only found in freshwater (designated as "F") and a few contain members that are individually or collectively found in all three habitats (designated as "M, E, F").

The residence status of each family group is also listed, where P = permanent resident of the bioregion (Pease 1999) and T = tropical transient. If all members of the family are considered to be permanent residents of the bioregion then the family is designated as "P" and nothing is designated for the individual species. If any of the species within a family are believed to be tropical transients, the family is designated with a "T", as is each relevant species.

Comments on synonyms, distribution, certainty of identification and unusual life history are given for some species. Catadromous fishes are defined as those that migrate from fresh water as adults to spawn at sea. Diadromous fishes are those that migrate between fresh and salt water at a regular life-history phase, in either direction, but not necessarily to spawn (McDowall 1996).

To calculate the number of species found in the Hacking River catchment, checklist entries were only designated as a separate species if they were: 1) identified to the species level, 2) not listed as probably another species in the comments section within the same family, or 3) listed as the only genus within their respective families.

Results

The primary result of this work is the checklist of species presented in Table 1.

A total of 97 families are summarised in the checklist. Of this total, 89 are

designated as "M, E", four as "M, E, F", two as "E, F" and two as "F".

Therefore, most of the families (92%) contain species that are considered to be primarily marine or estuarine. Only 7% of the families contained species which are found in fresh water at some stage in their life history and 2% are only found in fresh water. Of the 97 families listed, 75 were designated as "P", 14 were designated as "P, T" and 8 as "T".

Therefore, most of the families (77%) contain only species that are considered to be permanent residents. A significant proportion of families (23%) contain at least one species that is considered to be a tropical transient which has probably come south with the warm waters of the EAC.

Of the 264 entries listed at the species level, 252 are considered to be distinct fish species. It should be noted that six of these species are listed as "out of known range" and may have been incorrectly identified. Specimens of only 145 of the species (58%) are lodged at the Australian Museum as type or voucher specimens that may be accessed for further identification. Only two of the species are considered to be permanent freshwater residents (*Carassius auratus* and *Gambusia holbrooki*). Both species are not endemic and have been introduced to Australian waters. Of the 252 species, 46 (18%) are considered to be primarily tropical transients that have probably come south with the EAC.

Table 1. Checklist of fish species from the Hacking River catchment.

Scientific Name	Common Name	Reference	Habitat	Residence	Comments/Synonyms
DASYATIDAE	STING RAYS		M,E	P	
<i>Dasyatis fluviorum</i>	Brown Stingray	(11)			
UROLOPHIDAE	ROUND STINGRAYS		M,E	P	
<i>Urolophus</i> sp.	Stingray	(10)			Probably <i>Trygonoptera testacea</i>
<i>Trygonoptera testacea</i>	Common Stingaree	(2), (9)			(= <i>Urolophus testaceus</i>)
MYLIOBATIDAE	EAGLE RAYS, COW-NOSED RAYS		M,E	P	
<i>Myliobatis australis</i>	Eagle Ray	(7)			
RHINOBATIDAE	SHOVELNOSE RAYS, FIDDLER RAYS		M,E	P	
<i>Aptychotrema vincentiana</i>	Shovelnose Ray	(8)			Out of known range, probably <i>Aptychotrema rostrata</i>
<i>Trygonorrhina fuscata</i>	Fiddler Ray	(10)			
RAJIDAE	SKATES		M,E	P	
<i>Raja</i> spp.	Skate	(10)			
TORPEDINIDAE	ELECTRIC RAYS		M,E	P	
<i>Hypnos monopterygium</i>	Electric Ray (Numbfish)	(1), (2), (9)			
ORECTOLOBIDAE	WOBBERGONG SHARKS		M,E	P,T	
<i>Orectolobus maculellus</i>	Spotted Wobbegong Shark	(2), (10)			
<i>Stegostoma fasciatum</i>	Leopard Shark	(10)		T	(= <i>Stegostoma tigrinum</i>)
HETERODONTIDAE	PORT JACKSON SHARKS, HORN SHARKS		M,E	P	
<i>Heterodontus portusjacksoni</i>	Port Jackson Shark	(2), (7)			
ELOPIDAE	OXEYE HERRINGS, TARPONS		M,E	T	
<i>Elops hawaiiensis</i>	Giant Herring	(8)			(= <i>Elops australis</i>)
ALBULIDAE	BONEFISHES, LADYFISHES		M,E	T	
<i>Albula vulpes</i>	Bonefish	(6)			
OPHICHTHIDAE	SNAKE EELS, WORM EELS		M,E	P	
<i>Ophisurus serpens</i>	Serpent Eel	(10)			
ANGUILLIDAE	FRESHWATER (RIVER) EELS		M,E,F	P	Catadromous - live in the catchment but spawn in the ocean
<i>Anguilla australis</i>	Short-finned Eel	(5)			
<i>Anguilla reinhardtii</i>	Long-finned Eel	(4)			
MURAENIDAE	MORAY EELS		M,E	P	
<i>Gymnothorax afer</i>	Moray eel	(10)			
<i>Gymnothorax prasinus</i>	Green Moray Eel	(2)			
CONGRIDAE	CONGER EELS, GARDEN EELS		M,E	P	
<i>Conger wilsoni</i>	Eastern (Short-finned) Conger Eel	(2), (10)			(= <i>Conger labiatus</i>)
CLUPEIDAE	SPRATS, PILCARDS, HERRINGS		M,E	P	
<i>Herklotsichthys castelnaui</i>	Southern Herring	(10)			(= <i>Herengula castelnaui</i>)
<i>Hyperlophus</i> sp.	Sprat	(10)			Probably <i>Hyperlophus translucidus</i> or <i>vittatus</i>
<i>Hyperlophus translucidus</i>	Glassy Sprat	(3)			
<i>Hyperlophus vittatus</i>	Sandy Sprat	(9), (10), (11)			
<i>Sardinops sagax</i>	Pilchard	(1), (10)			(= <i>Sardinops neopilchardus</i>)
<i>Spratelloides robustus</i>	Blue Sprat	(9), (10), (11)			
ENGRAULIDAE	ANCHOVIES		M,E	P	
Juvenile engraulid	Anchovy	(8)			Probably <i>Engraulis australis</i>
<i>Engraulis australis</i>	Australian Anchovy (Frogmouth)	(10), (11)			
GALAXIIDAE	JOLLYTAILS, NATIVE TROUTS, GALAXIDS		E,F	P	Diadromous - move between estuary & freshwater
<i>Galaxias maculatus</i>	Common Jollytail	(5)			
CYPRINIDAE	CARPS, GOLDFISHES		F	P	
<i>Carassius auratus</i>	Goldfish	(5)			Introduced
PLOTOSIDAE	EELTAIL CATFISHES		M,E	P	
<i>Ontoogianis macrocephalus</i>	Cobbler (Estuary) Catfish	(2), (4)			
<i>Euristhmus lepturus</i>	Longtalled Catfish	(1)			
<i>Plotosus lineatus</i>	Striped Catfish	(2), (9)			(= <i>Plotosus anguillarlis</i>)
SYNODONTIDAE	LIZARDFISHES		M,E	P	
<i>Trachinocephalus myops</i>	Painted Grinner	(10), (11)			
HARPADONTIDAE	BOMBAY DUCKS, SAURIES		M,E	P	
<i>Saurida gracilis</i>	Slender Saury	(9)			
BATRACHOIDIDAE	FROGFISHES		M,E	P	
<i>Batrachomoeus dubius</i>	Eastern Frogfish (Brown Frogfish)	(1), (2), (10)			
ANTENNARIIDAE	ANGLERFISHES		M,E	P	
<i>Antennarius striatus</i>	Striped Angler	(2), (10)			(= <i>Batrachopus insidiator</i> ; <i>Phrynelox insidiator</i>)
<i>Histrio histrio</i>	Sargassum Fish	(10)			
MORIDAE	CODFISHES, BEARDIES		M,E	P	
<i>Lotella rhacinus</i>	Large-tooth Bearded	(2)			
HEMIRAMPHIDAE	GARFISHES		M,E	P	
<i>Hyporhamphus australis</i>	Sea Garfish	(9)			

Table 1. Continued

Scientific Name	Common Name	Reference	Habitat	Residence	Comments/Synonyms
POECILIIDAE	LIVEBEARERS		F	P	
<i>Gambusia holbrooki</i>	Eastern Gambusia (Mosquitofish)	(5)			Introduced
ATHERINIDAE	HARDYHEADS (SILVERSIDES)		M,E,F	P	
<i>Atherinason hepsetoides</i>	Richardson's Hardyhead	(9), (10)			
<i>Atherinomorus ogilbyi</i>	Common Hardyhead (Ogilby's Hardyhead)	(1), (9), (10), (11)			(= <i>Pranesus ogilbyi</i>)
<i>Atherinosoma microstoma</i>	Smallmouthed Hardyhead	(4), (10)			
<i>Leptatherina presbyteroides</i>	Silverfish (Prettyfish)	(10), (11)			(= <i>Atherinosoma presbyteroides</i>)
<i>Craterocephalus honoriae</i>	Estuarine Hardyhead	(10)			
<i>Craterocephalus marjoriae</i>	Marjorie's Freshwater Hardyhead	(10)			Out of known range
<i>Atherinomorus lacunosus</i>	Hardyhead Silverside	(10)			(= <i>Atherina lacunosus</i>)
MONOCENTRIDAE	PINEAPPLE (PINE-CONE) FISHES		M,E	P	
<i>Cleidopus gloriamaris</i>	Knight Fish (Pineapplefish)	(2), (10)			
TRACHICHTHYIDAE	ROUGHIES		M,E	P	
<i>Trachichthys australis</i>	Roughy	(2)			
ZEIDAE	DORIES		M,E	P	
<i>Zeus faber</i>	John Dory	(2), (7)			
FISTULARIIDAE	FLUTEMOUTHS (CORNETFISHES)		M,E	P	
<i>Fistularia commersonii</i>	Smooth Flutemouth	(10), (11)			
<i>Fistularia petimba</i>	Deepsea (Smooth) Flutemouth	(9), (10)			(= <i>Fistularia villosa</i>)
SOLENOTOMIDAE	GHOST PIPEFISHES		M,E	P	
<i>Solenostomus paradoxus</i>	Ornate Ghost Pipefish	(2), (10)			
SYNGNATHIDAE	PIPEFISHES, SEAHORSES		M,E	P	
<i>Filicampus tigris</i>	Tiger Pipefish	(10)			(= <i>Yozia tigris</i>)
<i>Hippocampus</i> sp.	Seahorse	(10)			Probably <i>Hippocampus abdominalis</i> or <i>whitei</i>
<i>Hippocampus abdominalis</i>	Poibellied Seahorse (Big-belly Seahorse)	(2), (9), (10)			
<i>Hippocampus whitei</i>	White's Seahorse (Common Seahorse)	(1), (2), (8), (9), (10)			
<i>Stigmatopora</i> sp.	Pipefish	(10)			Probably <i>Stigmatopora argus</i> or <i>nigra</i>
<i>Stigmatopora argus</i>	Spotted Pipefish	(1), (4), (9)			
<i>Stigmatopora nigra</i>	Wide-bodied Pipefish	(4), (8), (9), (11)			(= <i>Stigmatopora nigra</i>)
<i>Urocampus carinirostris</i>	Hairy Pipefish	(4), (8), (11)			
<i>Vanacampus margaritifer</i>	Mother-of-pearl Pipefish	(1), (4), (8), (9), (11)			(= <i>Syngnathus margaritifer</i>)
SCORPAENIDAE	SCORPION FISHES		M,E	P,T	
<i>Centropogon australis</i>	Fortesque	(1), (8), (9), (10), (11)			
<i>Dendrochirus zebra</i>	Fire Fish (Zebra Lionfish)	(2), (10)		T	
<i>Gymnapistes marmoratus</i>	Soldierfish	(1), (10)			
<i>Pterois antennata</i>	Spotfin Lionfish	(2), (11)		T	
<i>Pterois volitans</i>	Lion Fish (Butterfly Cod)	(2), (9), (10)		T	
<i>Scorpaena cardinellii</i>	Red Rock-Cod (Red Scorpion-Cod)	(2), (10)			
<i>Scorpaena papillosus</i>	Southern Red Rock-Cod	(4)			(= <i>Scorpaena ergastulorum</i>)
TRIGLIDAE	GURNARDS		M,E	P	
<i>Chelidonichthys kumu</i>	Red Gurnard	(10)			
<i>Lepidotrigla</i> sp.	Gurnard	(10)			
APLOACTINIDAE	VELVETFISHES		M,E	P	
<i>Paraploactis trachyderma</i>	Moseback Velvetfish	(2)			Unlikely, probably <i>Aploactisoma milesii</i>
PLATYCEPHALIDAE	FLATHEADS		M,E	P,T	
<i>Platycephalus arenarius</i>	Northern Sand Flathead (Flagtail Flathead)	(8)			
<i>Platycephalus caeruleopunctatus</i>	Blue-spotted Flathead	(9), (11)			
<i>Platycephalus fuscus</i>	Northern Dusky Flathead	(1), (2), (9), (10), (11), (12)			
<i>Platycephalus indicus</i>	Bartailed Flathead	(10)		T	Out of known range
<i>Platycephalus longispinis</i>	Long-spined Flathead	(7)			
<i>Platycephalus speculator</i>	Southern Blue-spotted (Yank Flathead)	(11)			Out of known range
DACTYLOPTERIDAE	FLYING GURNARDS		M,E	P	
<i>Dactyloptereus orientalis</i>	Flying Gurnard	(10)			
AMBASSIDAE	GLASSFISHES (GLASS PERCHES)		M,E	P	
<i>Ambassis jacksoniensis</i>	Port Jackson Perchlet	(1), (4), (8), (9), (11)			(= <i>Velembassis jacksoniensis</i>)
<i>Ambassis marianus</i>	Glassy Perchlet	(5)			
SERRANIDAE	GROUPERS, SEA BASSES, SEA PERCHES		M,E	P	
<i>Acanthistius ocellatus</i>	Eastern Wirrah (Wirrah Cod)	(10)			(= <i>Plectropoma ocellatum</i>)
<i>Hypoplectrodes maccullochi</i>	Half-banded (Mcculloch's) Seaperch	(10)			(= <i>Ellerkeidia maccullochi</i>)
<i>Epinephelus daemeli</i>	Black Rock Cod	(2)			
PERCICHTHYIDAE	FRESHWATER BASSES & CODS		E,F	P	
<i>Macquaria novemaculeata</i>	Australian Bass	(5)			Diadromous
PLESIOPIDAE	PRETTYFINS (ROUNDHEADS)		M,E	P	
<i>Paraplesiops bleekeri</i>	Eastern Blue Devil (Bleeker's Devilfish)	(10)			(= <i>Plesiops bleekeri</i>)
<i>Trachinops taeniatus</i>	Hula (Eastern Hulafish)	(2), (10)			
TERAPONTIDAE	GRUNTERS		M,E	P	
<i>Pelates quadrilineatus</i>	Trumpeter (Four-lined Trumpeter)	(4), (8), (10)			
<i>Pelates sexlineatus</i>	Six-lined Trumpeter	(1), (9), (10), (11)			
<i>Terapon jarbua</i>	Crescent Perch	(8)			

Table 1. Continued

Scientific Name	Common Name	Reference	Habitat	Residence	Comments/Synonyms
FRIACANTHIDAE	RED BULLSEYES (BIGEYES)		M,E	P	
<i>Priacanthus macracanthus</i>	Spotted Bigeye	(10)			
APOGONIDAE	CARDINALFISHES		M,E	P, T	
<i>Apogon</i> sp.	Soldier Fish	(2), (11)			Probably <i>Apogon limenus</i>
<i>Apogon limenus</i>	Sydney Cardinalfish (Four-banded Soldierfish)	(10)			
<i>Siphamia cephalotes</i>	Wood's Siphonfish	(1), (4), (9), (10)			
<i>Siphamia roseigaster</i>	Pink-breasted Siphonfish	(6), (11)			
<i>Vincentia</i> sp.	Cardinalfish	(10)			Probably <i>Vincentia conspersa</i>
<i>Vincentia chrysur</i>	Northern Cardinalfish	(4)		T	Out of known range, probably <i>Vincentia conspersa</i>
<i>Vincentia conspersa</i>	Southern Cardinalfish (Southern Gobbleguts)	(4)			
DINOLESTIDAE	LONG-FINNED PIKE		M,E	P	
<i>Dinolestes lewini</i>	Longfin Pike	(2)			
SILLAGINIDAE	WHITINGS		M,E	P	
<i>Sillaginodes punctata</i>	King George Whiting (Spotted Whiting)	(10)			(= <i>Sillaginodes punctatus</i>) Out of known range
<i>Sillago ciliata</i>	Sand Whiting	(9), (10), (11), (12)			
<i>Sillago maculata</i>	Trumpeter Whiting (Winter Whiting)	(9), (11)			
POMATOMIDAE	TAILOR (BLUEFISHES)		M,E	P	
<i>Pomatomus saltatrix</i>	Tailor	(9), (11), (12)			
ECHENEIDIDAE	REMORAS (SUCKER FISHES)		M,E	P	
<i>Echeneis naucrates</i>	Slender Suckerfish	(10)			
<i>Remora remora</i>	Remora	(10)			
CARANGIDAE	TREVALLIES (JACKS)		M,E	P, T	
<i>Alectis ciliaris</i>	Pennant Fish	(9)		T	
<i>Elegalis bipinnulatus</i>	Rainbow Runner	(10)		T	
<i>Pseudocaranx dentex</i>	Silver Trevally (White Trevally)	(1), (4), (9), (10), (11)			(= <i>Caranx georgianus</i> ; <i>Usacaranx nobilis</i>)
<i>Seriola lalandi</i>	Yellowtail Kingfish	(2), (6), (10)			(= <i>Regificola grandis</i>)
<i>Seriola rivoliana</i>	Almacco Jack	(7)			
<i>Trachinotus bolta</i>	Common Dart	(9), (10)			Out of known range, probably <i>Trachinotus coppingeri</i>
<i>Trachinotus coppingeri</i>	Swallowtail Dart	(9), (10)			Recorded as the similar <i>Trachinotus bolta</i>
<i>Trachurus declivis</i>	Jack Mackerel	(10)			
<i>Trachurus novaezelandiae</i>	Yellowtail	(2), (10)			(= <i>Trachurus maccullochi</i>)
CORYPHAENIDAE	DOLPHIN FISHES		M,E	T	
<i>Coryphaena hippurus</i>	Common Dolphinfish	(10)			
RACHYCENTRIDAE	COBIAS		M,E	T	
<i>Rachycentron canadum</i>	Cobia (Black Kingfish)	(6)			(= <i>Rachycentra canadus</i>)
ARRIPIDAE	AUSTRALIAN SALMONS		M,E	P	
<i>Arripis trutta</i>	Eastern Australian Salmon	(9)			
LUTJANIDAE	CORAL SNAPPERS (EMPERORS)		M,E	T	
<i>Lutjanus russelli</i>	Moses Perch (Russell's Snapper)	(4), (10)			
GERREIDAE	SILVER BIDDIES		M,E	P	
<i>Gerres subfasciatus</i>	Common Silverbelly (Roach)	(1), (2), (4), (8), (9), (10), (11)			(= <i>Gerres ovatus</i>)
LETHRINIDAE	EMPERORS, SWEETLIPS		M,E	T	
<i>Lethrinus</i> sp.	Emperor	(1), (4)			
<i>Lethrinus nebulosus</i>	Yellow Sweetlip (Spangled Emperor)	(10)			
<i>Lethrinus genivittatus</i>	Longpine Emperor	(11)			
SPARIDAE	SNAPPER, BREAM, TARWHINE		M,E	P	
<i>Acanthopagrus australis</i>	Yellowfin Bream (Silver Bream)	(1), (4), (8), (9), (10), (11), (12)			(= <i>Chrysophrys australis</i> ; <i>Roughleyale australis</i>)
<i>Pagrus auratus</i>	Snapper	(2), (4), (9), (10), (12)			(= <i>Chrysophrys auratus</i> ; <i>C. unicolor</i> ; <i>C. gutturalis</i>)
<i>Rhabdosargus sarba</i>	Tarwhine	(4), (8), (9), (11), (12)			
SCIAENIDAE	JEWFISHES, MULLOWAYS		M,E	P	
<i>Argyrosomus japonicus</i>	Mulloway	(2), (7), (12)			(= <i>Argyrosomus hololepidotus</i>)
MULLIDAE	GOATFISHES, RED MULLET		M,E	P	
<i>Parupeneus porosus</i>	Black-spot Goatfish (Black-saddle Goatfish)	(4), (9), (10)			(= <i>Parupeneus signalus</i>)
<i>Upeneichthys lineatus</i>	Blue-striped Goatfish	(2), (4)			(= <i>Upeneichthys porosus</i>)
<i>Upeneus tregule</i>	Bar-tailed Goatfish	(4), (9), (10), (11)			
MONODACTYLIDAE	BUTTERFISHES (SILVER BATFISHES)		M,E	P	
<i>Monodactylus argenteus</i>	Butter Bream (Diamond-Fish)	(4), (11)			
PEMPHERIDAE	BULLSEYES		M,E	P	
<i>Pempheris compressus</i>	Small-scaled Bullseye	(2)			(= <i>Pempheris compressa</i>)
KYPHOSIDAE	DRUMMERS		M,E	P	
<i>Kyphosus sydneyanus</i>	Silver Drummer	(10)			(= <i>Segutilium sydneyanum</i>)
GIRELLIDAE	BLACKFISHES		M,E	P	
<i>Girella elevata</i>	Eastern Rock Blackfish (Black Drummer)	(6), (7)			
<i>Girella tricuspidata</i>	Luderick (Blackfish)	(1), (2), (8), (9), (10), (11), (12)			
<i>Girella zebra</i>	Zebra Fish	(7)			
SCORPIDIDAE	SWEEPS		M,E	P	
<i>Atypichthys strigatus</i>	Mado	(2), (10)			(= <i>Atypus strigatus</i>)
<i>Microcanthus strigatus</i>	Stripey	(2), (4), (8), (10), (11)			(= <i>Microcanthus joycaae</i>)
<i>Scorpius lineolatus</i>	Silver Sweep	(2), (4), (10), (12)			

Table 1. Continued

Scientific Name	Common Name	Reference	Habitat	Residence	Comments/Synonyms
CHAEODONTIDAE	BUTTERFLYFISHES		M,E	P,T	
<i>Cheetodon</i> sp.	Butterflyfish	(10)		T	
<i>Cheetodon auriga</i>	Threadfin Butterflyfish	(2), (5)		T	
<i>Cheetodon flavirostris</i>	Yellow-faced (Dusky) Butterflyfish	(2), (10)		T	
<i>Cheetodon guentheri</i>	Gunther's Butterflyfish	(2)		T	
<i>Cheetodon lunula</i>	Raccoon Butterflyfish	(2), (5)		T	
<i>Cheetodon melanotus</i>	Black-backed Butterflyfish	(5)		T	
<i>Cheetodon vagabundus</i>	Vagabond Butterflyfish	(2)		T	
<i>Chelmonops truncatus</i>	Eastern Talma (Truncate Coralfish)	(2), (10)			(= <i>Chelmon truncatus</i>)
<i>Heniochus acuminatus</i>	Long-fin Bannerfish	(2), (5)		T	
<i>Heniochus diphreutes</i>	Schooling Bannerfish	(2), (10)		T	
POMACANTHIDAE	ANGELFISHES		M,E	T	
<i>Centropyge tibicen</i>	Keyhole Angelfish	(5)			
ENOPLIOSIDAE	OLD WIVES		M,E	P	
<i>Enoplosus armatus</i>	Old Wife	(2), (4), (9), (11)			
POMACENTRIDAE	DAMSELFISHES		M,E	P,T	
<i>Abudefduf bengalensis</i>	Narrow-banded Sergeant Major	(5)		T	
<i>Abudefduf saxatilis</i>	Five-banded Sergeant Major	(10)		T	
<i>Abudefduf sordidus</i>	Black-spot Sergeant Major	(10)		T	
<i>Abudefduf vaigiensis</i>	Sergeant Major	(2)		T	
<i>Chromis nitida</i>	Yellow-back Puller (Shining Puller)	(2), (5)		T	
<i>Dascyllus trimaculatus</i>	Three-spot Humbug	(5)		T	
<i>Parma microlepis</i>	White Ear	(2), (5)			
<i>Parma polytypis</i>	Banded Scalyfin (Banded Parma)	(2)			
<i>Pomacentrus coelestis</i>	Neon Damsel (Blue Damsel)	(5)		T	
CIRRHITIDAE	HAWKFISHES		M,E	P	
<i>Cirrhitichthys aprinus</i>	Hawk Fish (Blotched Hawkfish)	(2), (10)			
CHEILODACTYLIDAE	MORWONGS		M,E	P	
<i>Cheilodactylus fuscus</i>	Red Morwong (Five-Fingers)	(2),(10)			
<i>Cheilodactylus spectabilis</i>	Banded Morwong	(4), (10)			
<i>Cheilodactylus vestitus</i>	Magpie Morwong	(5), (6)			
<i>Nemadactylus douglasii</i>	Blue Morwong	(6)			
LATRIDIDAE	TRUMPETERS		M,E	P	
<i>Latridopsis forsteri</i>	Bastard Trumpeter	(7)			
MUGILIDAE	GREY MULLET		M,E,F	P	
<i>Liza argentea</i>	Flat-tail Mullet (Tiger Mullet)	(9), (10),(11)			
<i>Mugil cephalus</i>	Sea Mullet (Bully Mullet)	(2), (4), (9), (10), (11)			(= <i>Mugil grandis</i> ; <i>M. dobula</i>)
<i>Mugil georgii</i>	Fantail Mullet (Silver Mullet)	(10)			(= <i>Valamugil georgii</i>)
<i>Myxus elongatus</i>	Sand Mullet (Taliegalane)	(2), (9), (10), (11)			
SPHYRAENIDAE	SEAPIKES, BARRACUDAS		M,E	P	
<i>Sphyræna</i> sp.	Seapike	(10)			
<i>Sphyræna obtusata</i>	Striped Seapike (Yellowtail)	(4)			
LABRIDAE	WRASSES		M,E	P,T	
<i>Achoerodus viridis</i>	Eastern Blue Groper (Giant Pigfish)	(2), (4), (8), (9), (10)			Some recorded as western species - <i>Achoerodus gouldii</i>
<i>Ophthalmolepis lineolatus</i>	Maori Wrasse	(10)			Recorded as invalid species - <i>Coris lineolata</i>
<i>Coris picta</i>	Comb Wrasse	(2), (10)			
<i>Labroides dimidiatus</i>	Cleaner Wrasse	(2), (7)		T	
<i>Natalebrus letricus</i>	Blue-throated Wrasse	(10)			
<i>Pseudolabrus guentheri</i>	Gunther's Wrasse (Gunther's Rainbowfish)	(2), (4), (7), (10)			
ODACIDAE	ROCK WHITINGS (WEED WHITINGS)		M,E	P	
<i>Haletta semifasciata</i>	Blue Rock Whiting (Blue Weed Whiting)	(4)			
<i>Neodax balteatus</i>	Little Rock Whiting (Little Weed Whiting)	(1), (4), (6)			
SCARIDAE	PARROT FISHES		M,E	T	
<i>Scarus</i> spp.	Parrot Fish	(11)			probably <i>Scarus ghobban</i>
LEPTOSCOPIIDAE	SANDFISHES		M,E	P	
<i>Lesueurina platycephala</i>	Sandfish	(9), (11)			(= <i>Crapetalus arenarius</i>)
URANOSCOPIIDAE	STARGAZERS		M,E	P	
<i>Ichthyoscopus</i> spp.	Stargazer	(10)			
BLENNIIDAE	BLENNIES		M,E	P	
<i>Omobranchius anolius</i>	Oyster Blenny	(10)			
<i>Petroscirtes lupus</i>	Wolf Blenny (Brown Sabretooth Blenny)	(1), (4), (8), (9), (10), (11)			(4) recorded as <i>Petroscirtes breviceps</i> (WA and NT only)
TRIPLETYRIDAE	TRIPLEFINS		M,E	P	
<i>Lepidoblennius haplodactylus</i>	Eastern Jumping Blenny	(10)			Recorded as invalid species <i>Lepidoblennius geniculatus</i>
<i>Tripterygion annulatum</i>	Triplefin	(6)			(= <i>Enneapterygius annulatus</i>) reported as <i>Vauclusella annulata</i>
CLINIDAE	WEED FISHES (KELPFISHES)		M,E	P	
<i>Cristiceps australis</i>	Southern Crested Weedfish	(1), (4), (8), (9), (11)			Out of known range
<i>Heteroclinus perspicillatus</i>	Common Weedfish	(6)			(= <i>Cristiceps roseus</i>)
<i>Heteroclinus roseus</i>	Rosy Weedfish	(10)			
CALLIONYMIDAE	DRAGONETS, STINKFISHES		M,E	P	
<i>Repomocentrus calcaratus</i>	Spotted Stinkfish	(9)			(= <i>Callionymus calcaratus</i>)
<i>Foelorepus calauropomus</i>	Common Stinkfish	(10)			(= <i>Synchiropus calauropomus</i>)

Table 1. Continued

Scientific Name	Common Name	Reference	Habitat	Residence	Comments/Synonyms
GOBIESOCIDAE	CLINGFISHES		M,E	P	
Gobiesocid sp. 1		(10)			Identified to family level only
Gobiesocid sp. 2		(10)			Identified to family level only but different than sp. 1
GOBIIDAE	GOBIES		M,E,F	P	
<i>Afurcagobius tamarensis</i>	Tamar River Goby	(3), (4), (8), (11)			(= <i>Favonigobius tamarensis</i>)
<i>Arenigobius bifrenatus</i>	Bridled Goby	(1)			(= <i>Amoya bifrenatus</i>)
<i>Arenigobius frenatus</i>	Half-bridled Goby	(1), (4), (8), (10), (11)			(= <i>Amoya frenatus</i> , <i>Gobius semifrenatus</i>)
<i>Baithygobius krefftii</i>	Kreff's Goby	(1), (4), (8), (10), (11)			
<i>Calligobius depressus</i>	Flathead Goby	(1), (10)			
<i>Calligobius mucosus</i>	Sculptured Goby	(4), (10)			
<i>Gobius cristatus</i>	Crested Goby	(1), (10)			(= <i>Cryptocentroides cristatus</i>)
<i>Favonigobius exquisitus</i>	Exquisite Goby	(4), (8), (10), (11)			(= <i>Papillogobius exquisitus</i>)
<i>Favonigobius lateralis</i>	Long-finned Goby	(4), (8), (9), (10), (11)			
<i>Gobiogobius semivestitus</i>	Translucent Goby	(4), (8), (10)			(= <i>Paraphaya semivestita</i> ; <i>Gobiogobius semivestitus</i>)
<i>Istigobius hoesei</i>	Sloth Goby	(10)			
<i>Mugilogobius paludis</i>	Palud Goby	(10)			(= <i>Waiteopsis paludis</i>)
<i>Nesogobius pulchellus</i>	Sailfin Goby (Castelnau's Goby)	(1), (4), (9), (10)			
<i>Pseudogobius olorum</i>	Swan River Goby (Blue-spot Goby)	(1), (8), (9), (10), (11)			(= <i>Lizagobius olorum</i>), outside known range
<i>Redigobius macrostoma</i>	Large-mouth Goby	(1), (4), (8), (10), (11)			(= <i>Redigobius macrostomus</i>)
<i>Valenciennesia immaculata</i>	Kuiter's Goby	(10)			
<i>Prionospiza nuchifasciata</i>	Orange Reef Goby	(10)			Recorded as invalid species- <i>Zonogobius francoisi</i>
ELEOTRIDAE	GUDGEONS		E,F	P	
<i>Gobiomorphus australis</i>	Striped Gudgeon	(10)			
<i>Gobiomorphus coxii</i>	Cox's Gudgeon (Southern Gudgeon)	(10)			
<i>Philypnodon grandiceps</i>	Flathead Gudgeon	(4), (10), (11)			
<i>Thalasseleotris adela</i>	Tasmanian Gudgeon	(10)			
MICRODESMIIDAE	WORMFISHES (WORM GOBIES)		M,E	P	
<i>Pariglossus marginalis</i>	Worm Goby	(10)			
ACANTHURIDAE	SURGEONFISHES (TANGS)		M,E	P,T	
<i>Acanthurus nigrofasciatus</i>	Dusky Surgeonfish	(5)		T	
<i>Acanthurus olivaceus</i>	Orange-blotch Surgeonfish	(5)		T	
<i>Acanthurus triostegus</i>	Convict Surgeonfish	(5)		T	
<i>Prionurus microlepidotus</i>	Sawtail Surgeonfish	(2), (10)			Probably <i>Prionurus microlepidotus</i>
<i>Prionurus</i> sp.	Surgeonfish	(4)			
<i>Zebrafish veliferum</i>	Sailfin Surgeonfish	(7)		T	
SIGANIDAE	RABBITFISHES, SPINEFOOTS				
<i>Siganus nebulosus</i>	Black Spinefoot (Happy Moments)	(4), (10)			(= <i>Siganus fuscescens</i>)
SCOMBRIDAE	TUNAS, BONITOS, MACKERELS		M,E	P,T	
<i>Cybiosarda elegans</i>	Leaping Bonito	(7)			
<i>Sarda australis</i>	Common Bonito (Australian Bonito)	(7)			
<i>Scomber australis</i>	Slimy Mackerel (Blue Mackerel)	(10)			
<i>Scomberomorus munroi</i>	Spotted Mackerel	(8)		T	
<i>Thunnus albacares</i>	Yellowfin Tuna	(8)			
<i>Thunnus maccoyii</i>	Southern Bluefin Tuna	(10)			
BOTHIDAE	LEFT EYE FLOUNDERS		M,E	P	
<i>Pseudorhombus arsius</i>	Large-toothed Flounder	(9), (11)			
<i>Pseudorhombus jennynsii</i>	Small-toothed Flounder	(9), (10), (11)			
<i>Pseudorhombus tenuirastrum</i>	Flounder	(10)			Recorded as <i>Pseudorhombus tenuirostrum</i>
PLEURONECTIDAE	RIGHT EYE FLOUNDERS		M,E	P	
<i>Ammotretis rostratus</i>	Long-snouted Flounder	(9)			(= <i>Ammotretis rostratus</i>)
SOLEIDAE	SOLES		M,E	P	
<i>Pardachirus hedleyi</i>	Southern Peacock Sole	(9)			(= <i>Achirus hedleyi</i>)
<i>Synaptura nigra</i>	Black Sole	(8)			
CYNOGLOSSIDAE	TONGUE SOLES		M,E	P	
<i>Paraplagusia unicolor</i>	Lemon Tongue Sole	(9)			
MONACANTHIDAE	LEATHERJACKETS & FILEFISHES		M,E	P,T	
<i>Acanthaluteres</i> sp.	Leatherjacket	(10)			Probably <i>Acanthaluteres spilomelanurus</i>
<i>Acanthaluteres spilomelanurus</i>	Bridled Leatherjacket	(4), (11)			(= <i>Balistes spilomelanurus</i>)
<i>Cantherhines dumerilii</i>	Whitespotted Filefish	(10)			
<i>Brachaluteres jacksonianus</i>	Pygmy Leatherjacket	(2), (4), (9), (10), (11)			(= <i>Brachaluteres jacksoniensis</i>)
<i>Eubalichthys mosaicus</i>	Mosaic (Deep-bodied) Leatherjacket	(2), (10), (11)			
<i>Meuschenia freycineti</i>	Six-spined (Reef) Leatherjacket	(1), (4), (9), (10), (11)			(10) recorded as <i>Navodon skottowei</i>
<i>Meuschenia trachylepis</i>	Variable (Yellow-tailed) Leatherjacket	(1), (4), (8), (9), (11)			
<i>Monacanthus chinensis</i>	Fan-belly Leatherjacket	(1), (2), (4), (8), (9), (10), (11)			
<i>Meuschenia hippocrepis</i>	Horseshoe Leatherjacket	(10)			Unlikely, probably a male <i>Meuschenia freycineti</i>
<i>Nelusetta ayraudi</i>	Chinaman Leatherjacket	(1), (2), (4), (10)			(= <i>Navodon ayraudi</i> ; <i>Balistes ayraudi</i>)
<i>Paraluteres prionurus</i>	Mimic Leatherjacket	(7), (10)		T	
<i>Paramonacanthus oisensis</i>	Dusky Leatherjacket	(8)			
<i>Scobinichthys granulatus</i>	Rough Leatherjacket	(1), (4), (9)			

Table 1. Continued

Scientific Name	Common Name	Reference	Habitat	Residence	Comments/Synonyms
OSTRACIIDAE					
BOXFISHES, COWFISHES, TRUNKFISHES					
			M,E	P,T	
<i>Anoplocapros inermis</i>	Eastern Smooth Boxfish	(2)			
<i>Anoplocapros lenticularis</i>	White-barred Boxfish (Humpback Boxfish)	(10)			Out of known range
<i>Anoplocapros robustus</i>	Freckled Boxfish (Robust Boxfish)	(10)			Probably <i>Anoplocapros inermis</i>
<i>Ostracion comuta</i>	Longhorn Cowfish	(2), (9)		T	
<i>Ostracion diaphanus</i>	Roundbelly Cowfish	(10)		T	(= <i>Ostracion diaphanus</i>)
<i>Ostracion fomesini</i>	Thorny-backed Cowfish	(10)		T	
<i>Ostracion cubicus</i>	Yellow Boxfish	(5)		T	
<i>Ostracion concatenatus</i>	Triangular Boxfish (Turretfish)	(9), (11)		T	(9) Recorded as <i>Rhinosomas republicae</i>
TETRAODONTIDAE					
PUFFERFISHES, TOADFISHES					
			M,E	P,T	
<i>Thalassoma hispidus</i>	Stars-and-Stripes Toadfish	(1), (4)		T	
<i>Anthigaster callisterne</i>	Clown Toby	(2)			
<i>Anthigaster valentini</i>	Saddled Puffer	(7)			
<i>Stractenus glaber</i>	Smooth Southern Toadfish	(10), (11)			
<i>Stractenus hamiltoni</i>	Common Toadfish (Hamilton's Toadfish)	(1), (8), (9), (10), (11)			(= <i>Torquigener hamiltoni</i>)
<i>Torquigener pleurogramma</i>	Weeping Toadfish (Banded Toadfish)	(1), (9), (10), (11)			(= <i>Sphaeroides pleurogramma</i>)
<i>Torquigener squamicauda</i>	Toedo (Scaly-tailed Toadfish)	(9), (10), (11)			
IDONTIDAE					
PORCUPINEFISHES					
			M,E	P	
<i>Dicotylichthys punctulatus</i>	Three-bar Porcupinefish	(1), (2), (4), (8), (9), (10), (11)			(= <i>Dicotylichthys myersi</i>)

Footnote

Habitat codes: M = marine, E = estuarine, F = freshwater
Residence codes: P = permanent, T = tropical

References:

- (1)= Burchmore, J.J. *et al.* (1984)
(2)= Lawler, C.J. (1998)
(3)= Ferrell, D.J. and Bell, J.D. (1991)
(4)= Ferrell *et al.* (1993).
(5)= Dr. Bruce Pease, NSW Fisheries, personal observation
(6)= Dr. Aldo Steffe, NSW Fisheries, personal observation
(7)= Dr. John Stewart, NSW Fisheries, personal observation
(8)= Young, P.C. (1981)
(9)= Planning Workshop (1987)
(10)= Australian Museum Records
(11)= R.J. Williams, NSW Fisheries, personal communication in 2001 of unpublished results of fish biodiversity studies funded by the National Heritage Trust
(12)= Henry *et al.* (1987)

Discussion

It is useful to compare the results of this study with the findings of fish surveys conducted in the nearby Georges River/Botany Bay and Parramatta River/Port Jackson catchments. All three catchments have marine dominated, drowned river valley type estuaries (Roy *et al.* 2001) located in close proximity to each other, within the central estuarine and coastal bioregions of New South Wales. Ninety-two families and 229 species of fish were collected from Botany Bay and the

mouth of the Georges River during a fish habitat utilization study conducted by Pease *et al.* (1981), comparing favorably with the 97 families and 252 species on our Hacking River catchment checklist. Samples for the Botany Bay study were collected bimonthly over a two year period in a wide range of estuarine habitats, similar to those in Port Hacking, using a wide range of sampling methods. The greater number of species found in Port Hacking is probably related to the fact that our data set covered a period of almost 100 years.

The similarity of the estimates of species richness from Port Hacking and Botany Bay suggests that one might expect to encounter 220-250 fish species during an intensive, multi-method survey of fish diversity in a marine dominated, drowned river valley estuary within central New South Wales.

Extensive collecting effort in Port Jackson, over approximately 150 years, has resulted in an estimate of at least 500 fish species (John Paxton, pers. comm., 2001) from this estuary. This figure is probably an over-estimate. Some of the early collections from the oceanic and estuarine waters of the central New South Wales region were simply labelled "Sydney" and were later assumed to be from Port Jackson. Rigorous verification of old records will also probably reveal duplication through incorrect identification and use of multiple synonyms. We verified and cross-referenced the Port Hacking records to avoid data artifacts of this type, even though it was a very time consuming process. The result was an accurate consolidation of available information.

The increase in numbers of recorded fish species from Botany Bay, through Port Hacking to Port Jackson sustain the observation by Prendergast *et al.* (1993) that estimates of species diversity are directly related to duration and intensity of collecting effort. Therefore, in order to adequately assess the number of fish species in NSW estuaries, particularly where delivery of tropical species by the EAC is variable, persistent sampling over a long time period is required. Our study suggests that transient tropical species account for approximately 20% of the fish species richness in Port Hacking.

The diverse range of fish species found in the Hacking River catchment is largely a function of its geographic location, sandwiched between subtropical and cooler temperate regions with a variable, annual supply of tropical transients from the EAC (Pease 1999). Another factor is the type of estuary found within this catchment. Roy *et al.* 2001 suggest that drowned river valley estuaries typically support a high diversity of aquatic species because their geomorphology provides relatively open mouths, large areas with marine salinities and a diverse array of habitat types.

We believe that this checklist will provide a useful starting point for researchers conducting future surveys of fish diversity in the Hacking River catchment. All researchers conducting such surveys are encouraged to lodge reference and voucher collections with the Australian Museum so that taxonomic standards are ensured and specimens can be accessed for later verification. We also hope that our study will provide an incentive for researchers to compile checklists for other coastal catchments in southeastern Australia, so that fish diversity can be further compared among differing estuary types and bioregions. These checklists will also provide useful information for assessing the accuracy and adequacy of past surveys, and the need for conducting future surveys of fish diversity in coastal catchments.

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