2 Physical setting

2.1 Geomorphology and geology

The Derwent Estuary, illustrated in Figure 1, extends for a distance of 52 kilometres from New Norfolk to the Iron Pot and covers an area of 198.4 km^2. The morphology of the estuary is that of a drowned river valley, which was formed between 6,500 and 13,000 years ago, when sea level rose around 60 metres to near its current level. South of the Tasman Bridge, the lower reaches of the Derwent Estuary are 4-6 km wide, characterised by a relatively straight western shoreline and a single large (>50 km^2) embayment - Ralphs Bay - on the eastern shoreline. The middle part of the estuary - between the Bridgewater Causeway and Bowen Bridge - is 1 to 2 kilometres wide, with a more convoluted shoreline and numerous small embayments. The estuary bends sharply at Dogshear Point, - deflecting the river flow and channel. As indicated in Figure 2, average water depths in the lower and middle estuary are in the order of 10 to 20 metres, with maximum depths (44 m) observed immediately south of the Tasman Bridge. North of the Bowen Bridge, the estuary is characterised by a well-defined channel (3 to 10 m deep) bordered by extensive shallow flats and wetlands. Several deep holes (8 to 17 m) are found in the vicinity of Boyer and just to the east of New Norfolk.

The river and estuary wind through the Derwent Valley, bordered by the high ranges and foothills of Mt Wellington to the east and by the rolling hills of the Meehan Range and by South Arm Peninsula to the east. The regional geology is extremely complex, dominated by Jurassic dolerites and Cambrian basalts, with smaller areas of Triassic and Recent sedimentary deposits (Department of Mines, 1976).

2.2 The Derwent catchment

The Derwent Estuary's catchment covers an area of approximately 8900 km^2 in central and southeastern Tasmania (approximately one-fifth of Tasmania's land mass) and comprises the Derwent River catchment (7764 km^2), the Jordan River catchment (742 km^2) and other areas immediately adjacent to the estuary (375 km^2), as indicated in Figure 3. This is a region of varied relief, ranging from the gently undulating agricultural lands of the Southern Midlands to the high altitude plateaus and peaks of the Central Plateau, Mt. Field and Mt. Wellington. These topographic features are a reflection of the underlying geology, which can be broadly described as post-Carboniferous sediments intruded by igneous dolerites and basalts. Precipitation within the catchment is variable, as indicated in the mean annual rainfall map of Tasmania (Figure 4), ranging from 500 to 600 mm/yr in the vicinity of the estuary, to about 800 mm/yr in the Central Highlands, to over 1200 mm/yr in more mountainous areas.

Land cover type is predominantly woodlands and forests (52%), followed by agriculture (27%) and scrub and heath lands (15%). Water storages account for another 3%, while urban and industrial lands comprise less than 1% of the catchment and are mostly restricted to the Hobart metropolitan region (see Table 1). Agricultural land covers an area of approximately 2500 km^2, and is predominantly located in the catchments of the Jordan, Clyde and Ouse Rivers and along the Derwent River Valley between Ouse and New Norfolk.

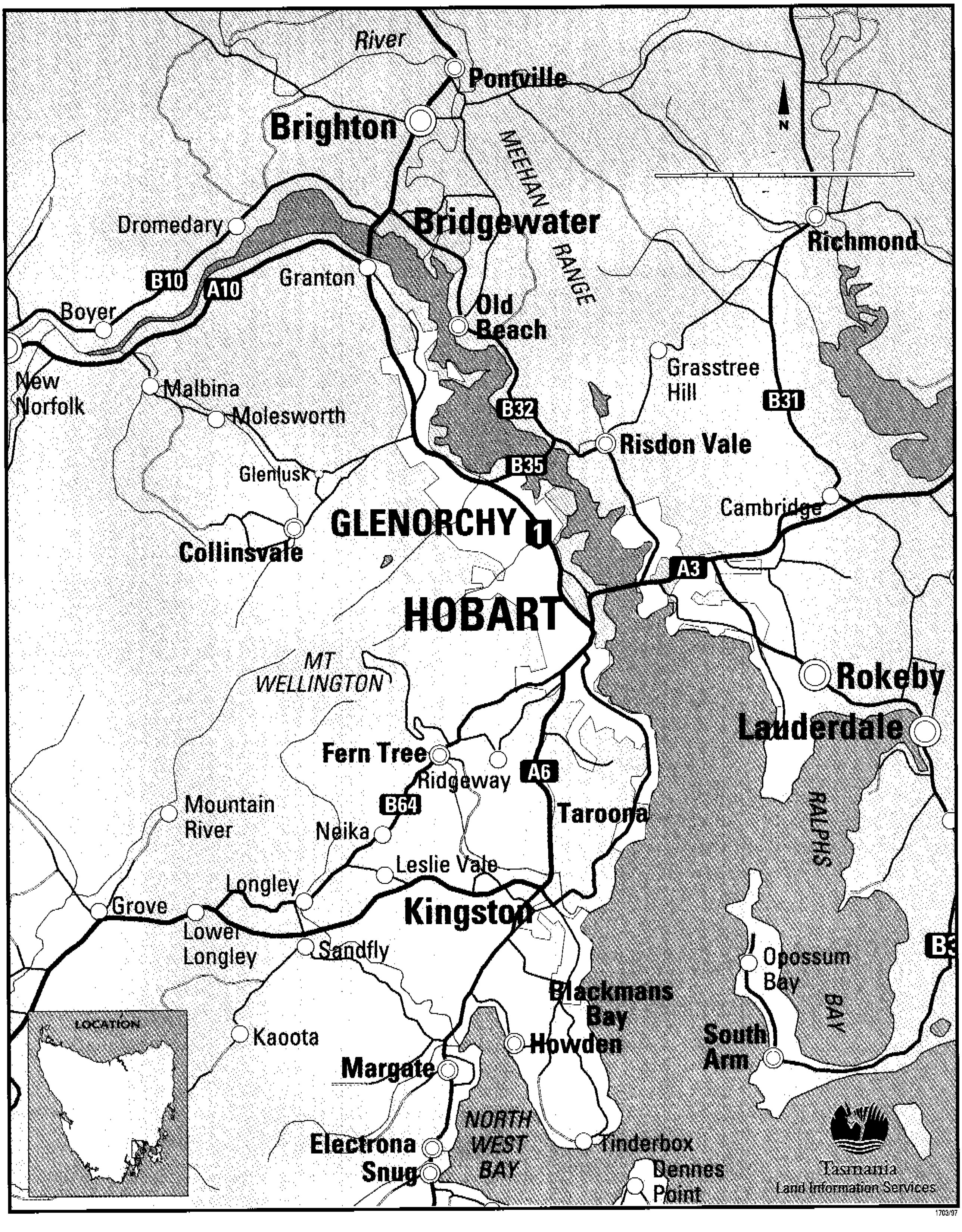
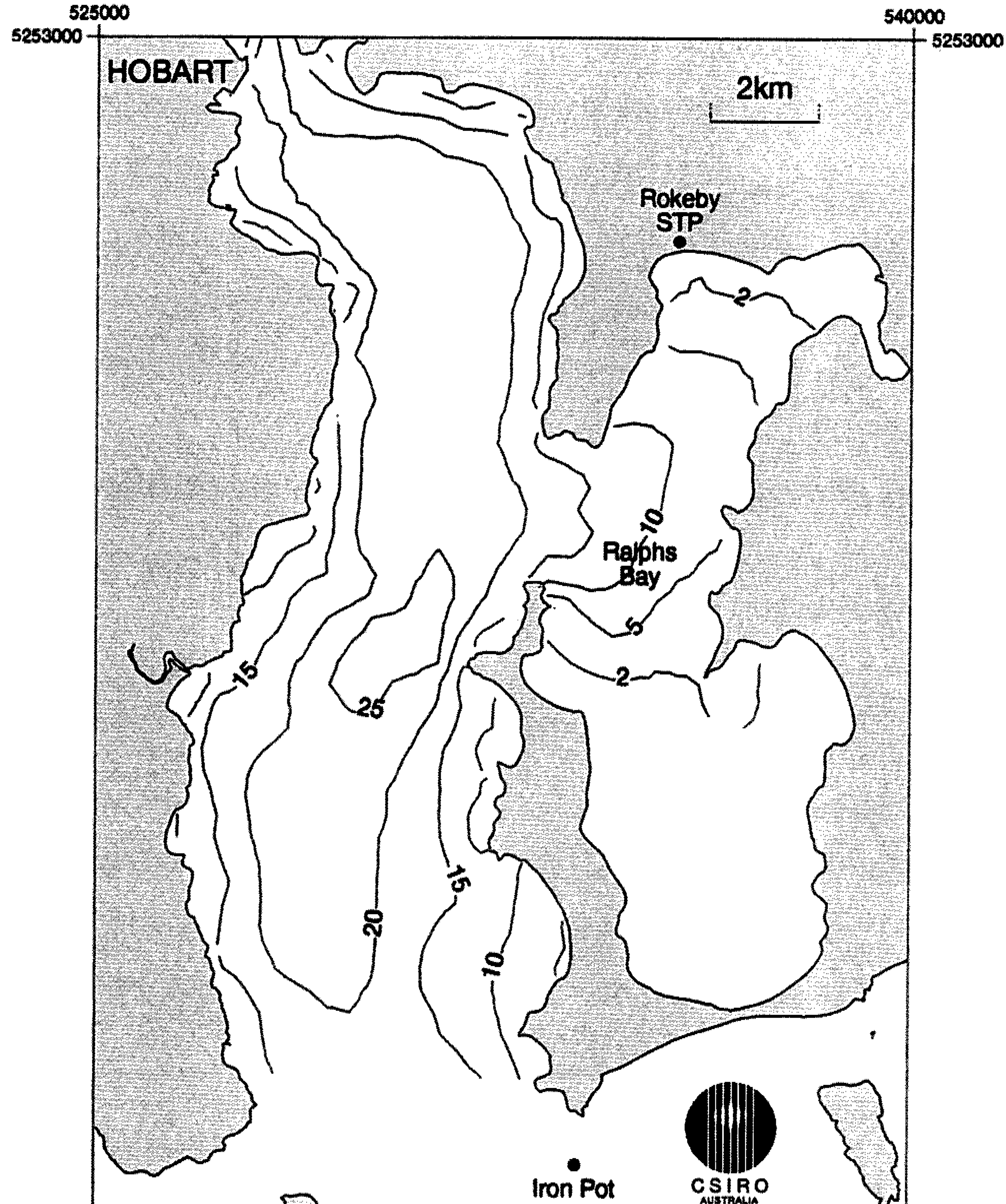


Figure 1 The Derwent Estuary



(CSIRO Coastal Zone Program)

Figure 2 Bathymetry of the middle and lower estuary

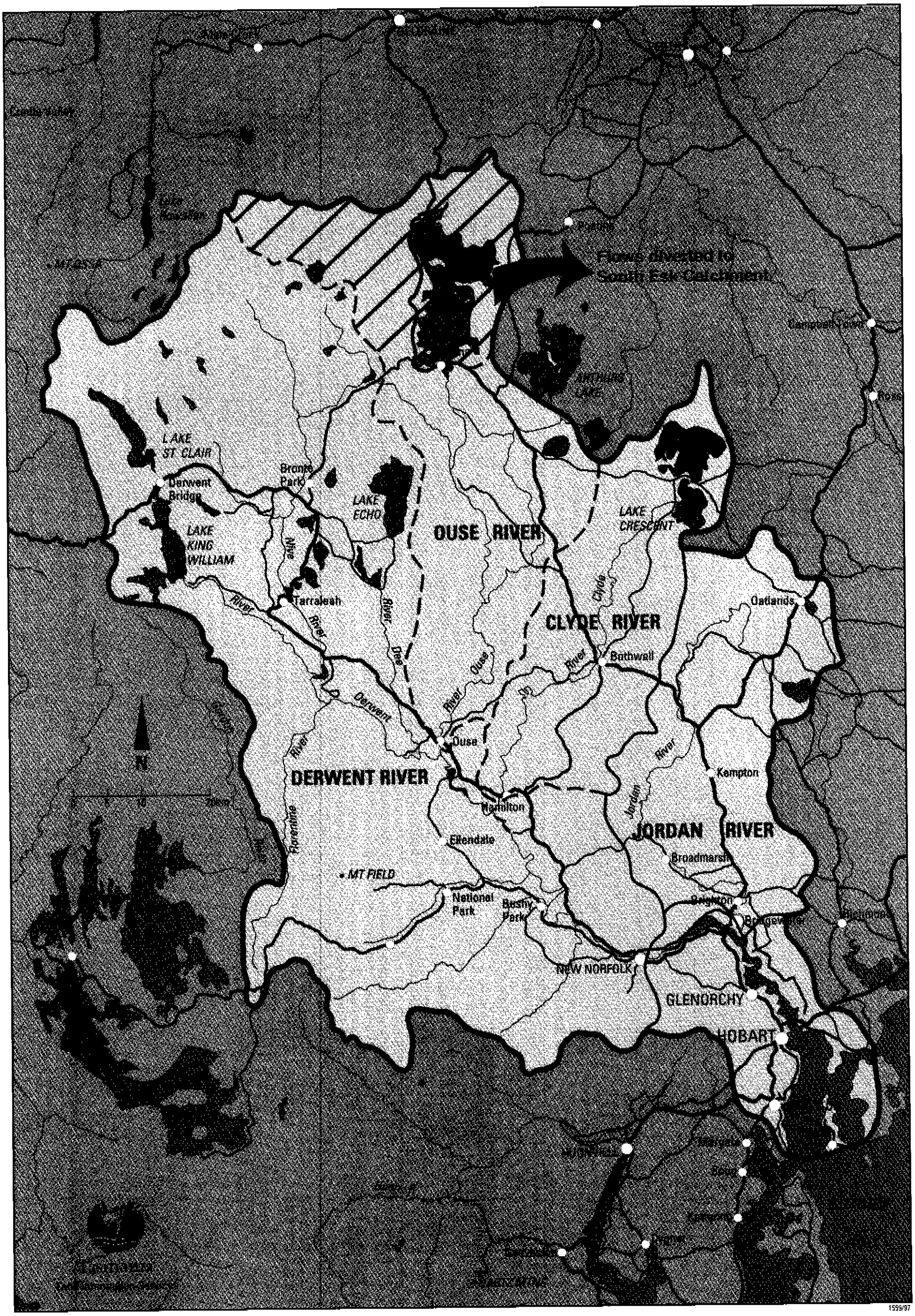


Figure 3 The Derwent Estuary catchment

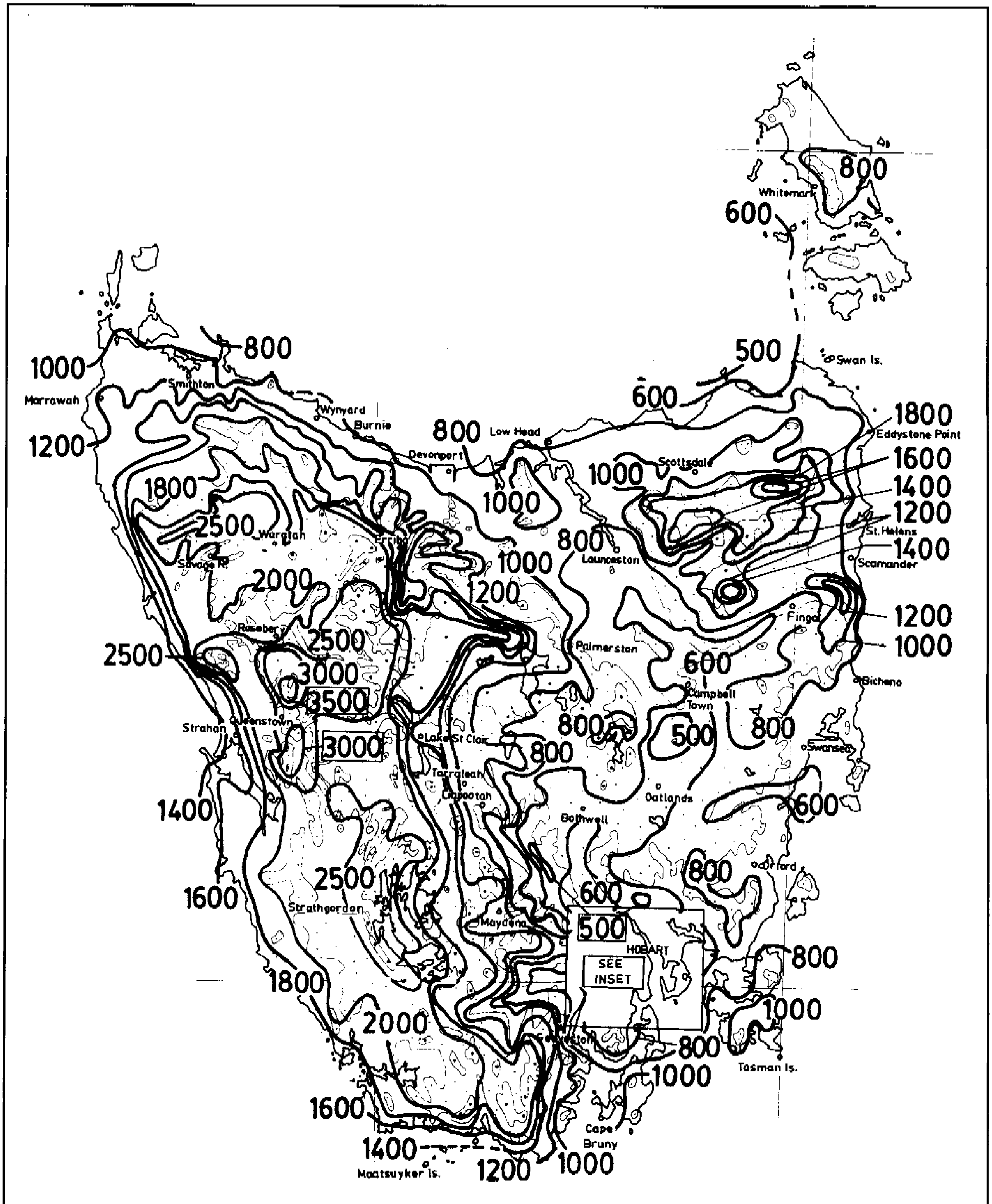


Figure 4 Rainfall map of Tasmania

Sheep and cattle grazing is the main agricultural activity, with smaller areas cultivated for crops such as vegetables, hops, poppies and oil crops. Several large fish hatcheries are situated in the upper catchment (at Wayatinah and Florentine) and along the Tyenna River. Forestry operations are primarily restricted to western and northern areas of the catchment - and include harvesting of native forests and, increasingly, eucalyptus and pine plantations. Conservation areas in the Derwent catchment include portions of Lake St Clair, Mt Field and South West National Parks.

A number of heavy and light industries are situated within the catchment, mostly in the vicinity of Hobart. These include the ANM paper mill, Pasminco Hobart zinc works, Impact Fertilisers, Textile Industries Australia, Cadburys - Schweppes, Cascade Breweries and many smaller operations. Numerous municipal sewage treatment plants and rubbish tips are also situated within the catchment See Chapter 4 for further details.

Table 1 Land use areas within the Derwent catchment

Land Use	% of total catchment
Woodland, forest and rainforest	52
Agriculture	27
Heath and scrub	15
Water Storages	3
Urban	0.5
Other	2.5
Total	*100*

(DELM, 1996)

Approximately 40% of Tasmania's total population - 190,000 people - live within the Derwent catchment, with the majority of the population (90%) concentrated in the Hobart metropolitan area (Clarence, Glenorchy, Hobart, Brighton and Kingborough). Other significant population centres in the catchment include New Norfolk (pop. 10,000), and the towns of the Southern Midlands - Hamilton, Bothwell, Oatlands and Ouse (combined pop. 5000). Tasmania's recent population growth rates are low and have declined from 1.5% in 1990 to 0.21% in 1994 (ABS, 1995).

2.3 Climate and meteorology

The Derwent region experiences a cool temperate climate, with mean monthly air temperatures in Hobart ranging from a maximum of 16.7°C in February to a minimum of 7.9°C in July (BOM, 1989). Wind directions and speeds are highly variable throughout the estuary, varying spatially, diurnally and seasonally. In general, due to topographic influences and the northwest/southeast orientation of the Derwent River Valley, katabatic (downslope) winds prevail, blowing from the northwest. However, during the summer months, southerly sea breezes tend to dominate in the afternoon. Typical wind roses are provided in Figure 5 (see Pendlebury (1987) for more information on winds).

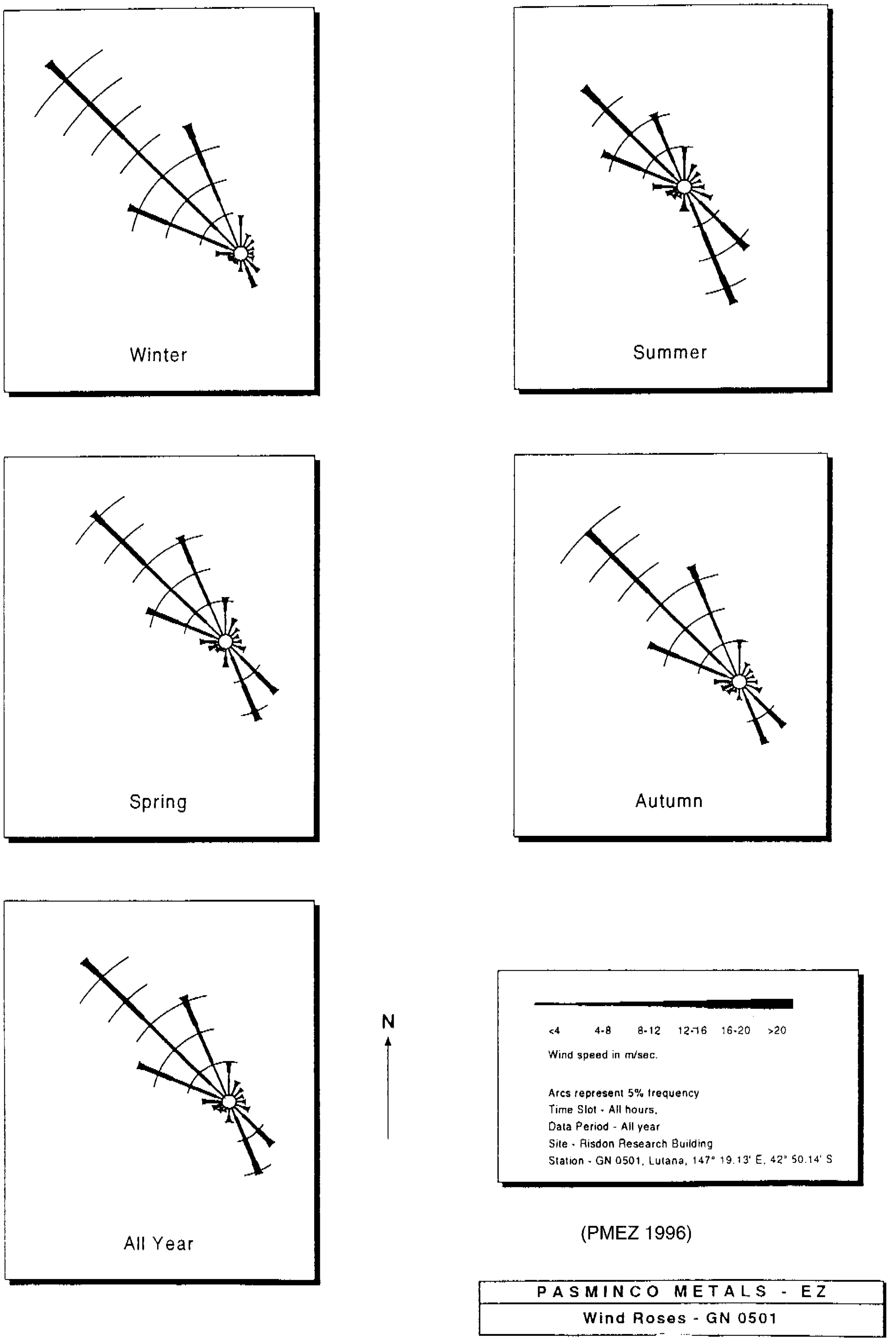


Figure 5 Wind roses

Precipitation is monitored by the Bureau of Meteorology at a number of sites in the vicinity of the Derwent Estuary, including Blackmans Bay, Bellerive, Glenorchy, Hobart (Ellerslie Road and Botanical Gardens), Kingston, Lindisfarne, Rokeby and Taroona. Table 2 summarises long-term rainfall statistics for Hobart (Ellerslie Road site). As indicated in the rainfall map for the Hobart area (Figure 6), the mean annual rainfall over the Derwent is about 600 mm, with slightly higher rainfall on the western side of the estuary than on the eastern side. Rainfall is usually distributed relatively evenly throughout the year, with a mean minimum of 40 mm in February and a mean maximum of 63 mm in October. During 1996, however, precipitation was much higher than average, particularly during the months of January, February and April (see Figure 7 for comparison).

Table 2 Rainfall statistics for Hobart (Ellerslie Road)

Month	Mean 1882-1992 mm	Median 1882-1992 mm	1996 mm
January	48.9	38.4	97.4
February	39.9	32.5	109.4
March	46.0	37.5	52.0
April	52.6	47.6	167.6
May	47.7	38.0	17.8
June	54.5	44.5	32.2
July	53.6	49.2	24.2
August	52.8	44.5	44.2
September	51.9	41.8	73.0
October	62.8	55.6	55.6
November	54.8	49.0	47.6
December	58.0	47.3	28.6
Total	*623.5*	*602.8*	*749.6*

(Hobart Bureau of Meteorology, 1997)

2.4 Major tributaries

The Derwent River is the estuary's main tributary, with a median annual discharge of 120 cumecs (cubic metres/second) (1979 - 1988). Other tributaries include the Jordan River, with a mean discharge of less than 1 cumec, and numerous smaller streams and creeks, which contribute relatively small and often intermittent flows to the estuary.

The Derwent River - the second longest river in Tasmania after the South Esk - originates at Lake St Clair and flows south over a distance of 187 km to New Norfolk at the head of the Derwent Estuary. The Derwent and three of its nine tributaries have been dammed or diverted to over 20 storages for hydroelectricity generation. These include both "run of the river" storages at low altitude and large storages at higher altitude for manipulating winter runoff. Ten hydroelectric power plants are situated on the Derwent or its tributaries and the majority of the catchment's flows are diverted through these power plants, which have a combined average power output of about 300 MW. The Clyde River is also controlled for irrigation purposes. Storage construction commenced in 1916 with the damming of Great Lake and continued until 1968, resulting in a 10% reduction in yield due to diversion to the

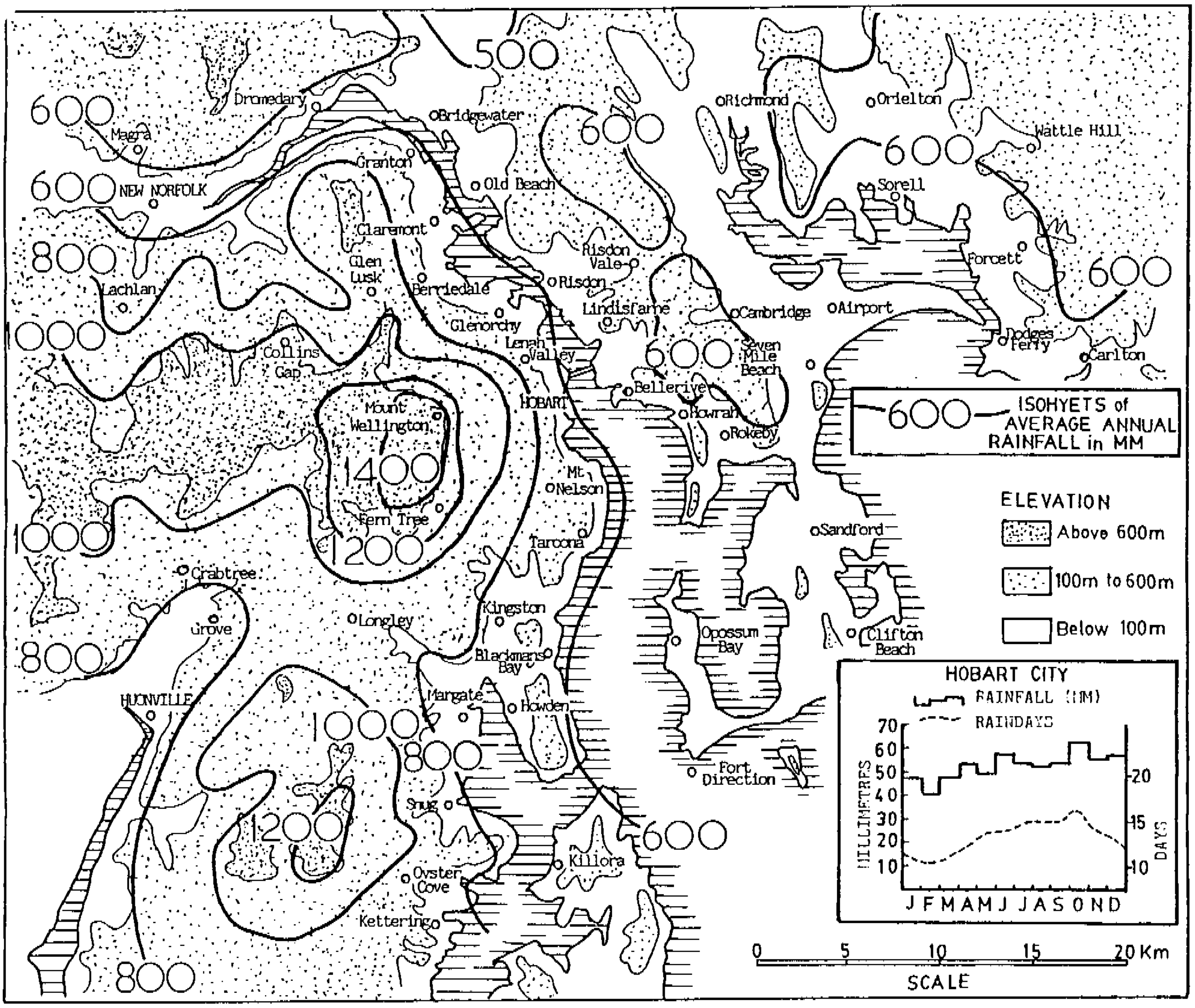


Figure 6 Mean annual rainfall, Hobart area
(Hobart Bureau of Meteorology)

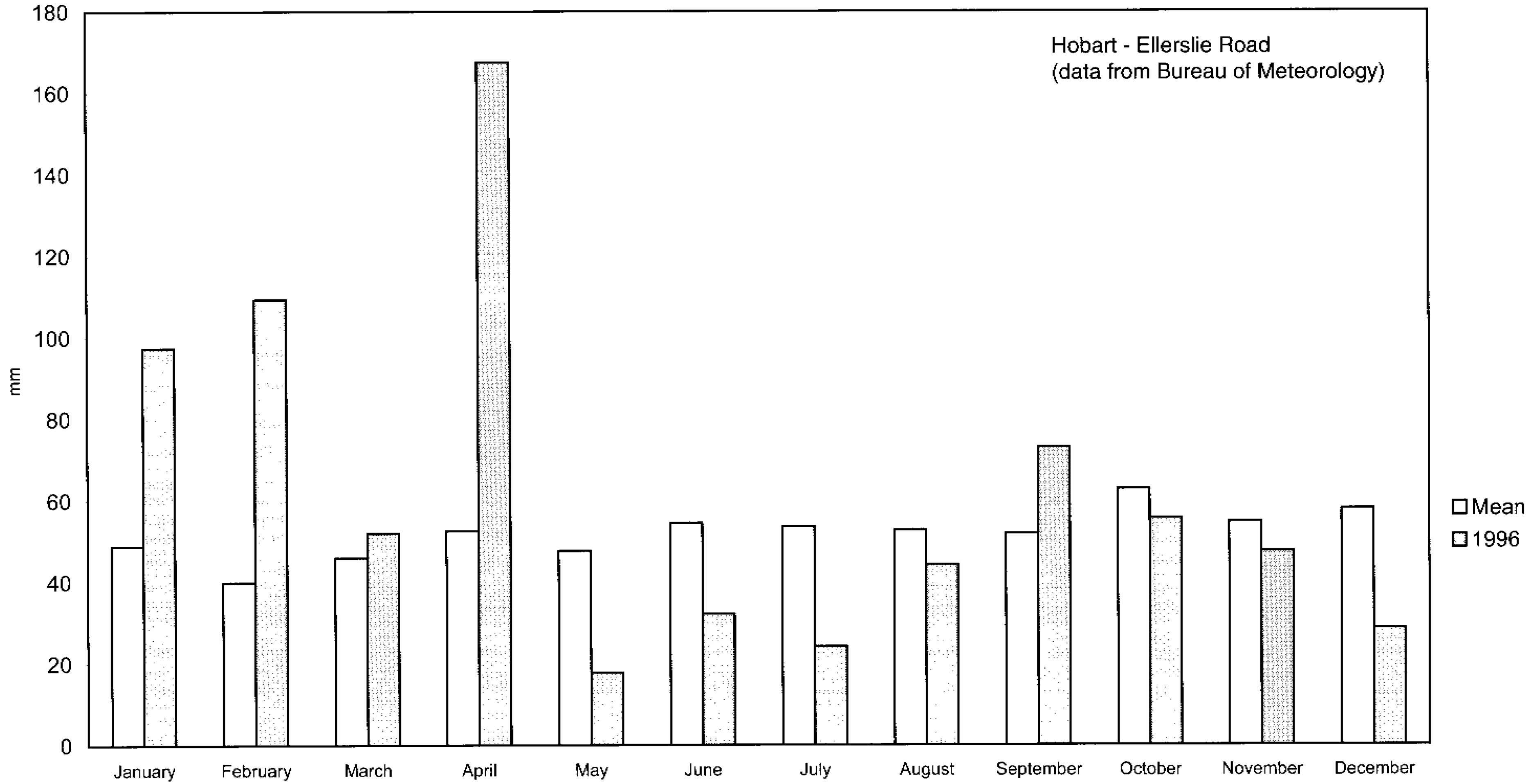


Figure 7 Mean monthly rainfall, Hobart

South Esk catchment in 1964. Overall, the Derwent is characterised by a modified flow regime in which the generation of hydroelectric power and controlled releases for irrigation have been the primary considerations in water management (Davies and Kalish, 1994).

The daily hydrograph for the Derwent River in 1996 is presented in Figure 8, while Figure 9 shows mean monthly discharges for 1996, as compared to the long-term record. 1996 was an unusually wet year and the Derwent experienced relatively high flow conditions, with 5 flood events of > 300 cumecs and 2 additional events exceeding 500 cumecs.

2.5 Estuarine circulation and coastal oceanography

The circulation of the Derwent Estuary has been investigated by a number of scientists, including Thomson and Godfrey (1985), Davies and Kalish (1989;1994), Hunter and Andrewartha (1992), and more recently the CSIRO Coastal Zone Program. Most investigators describe the middle to lower reaches of the estuary as being partially- to well-mixed (dominated by wind-driven and tidal mixing), with relatively large vertical mass movements within the water column. In contrast, the middle- to upper-reaches of the estuary are highly stratified with a distinct salt wedge, the toe of which is normally situated in the vicinity of New Norfolk.

During high river flows (approximately 150 m^3/s), the toe of the salt wedge migrates downstream as far as Bridgewater. During low river flows, the waters of the upper estuary are poorly mixed, predominantly through the action of sluggish tidal exchange. The strong salinity stratification of the upper estuary, combined with its irregular bathymetry (i.e. deep holes) results in the relative isolation of deeper saline waters during low river flows. In these deep saline waters, the combination of poor flushing and a high respiratory demand from organisms living in the organic-rich sediments often results in very low oxygen concentrations and elevated levels of hydrogen sulphide. These conditions are particularly severe during summer months, with potentially adverse effects on fish and benthic fauna. High river discharges after prolonged low flows may cause the rapid mixing of these low oxygen/high sulfide waters into the upper layer, and have resulted in odours, cessation of fish migrations and fish kills (Davies and Kalish, 1994).

The average tidal range of the Derwent is slightly greater than one meter, ranging from a minimum of 0.3 m to a maximum of 1.6 m. Tides in the Derwent are slightly unusual, in that the diurnal (daily) tide has a slightly greater range than the semidiurnal (twice daily) tide. Hence, Hobart occasionally has only daily tides and usually has large variations in the heights of successive tides (GHD, 1996). Tidal currents are relatively weak, typically in the order of 0.1 to 0.2 m/sec (Thomson and Godfrey, 1985; Davies and Kalish, 1994). Recent investigations and modeling conducted by CSIRO indicate that, on average, surface currents flow to the south at velocities of 0.1 to 0.2 m/s, while bottom currents flow northwards at velocities of 0.02 - 0.05 m/sec. A schematic diagram of circulation within the Derwent Estuary is provided in Figure 10 (CSIRO, 1994). More detailed circulation modeling has been done in specific areas of the estuary, such as the area downstream of ANM's outfall (ANM, 1995) and around existing or proposed sewage treatment plant outfalls (e.g. Hunter and. Andrewartha, 1992; Consulting Environmental Engineers, 1994; GHD, 1996).

Beyond the Tasman Bridge, some combination of wind effects and the Coriolis force deflect the main flow of the Derwent River along the estuary's eastern shoreline, such that low

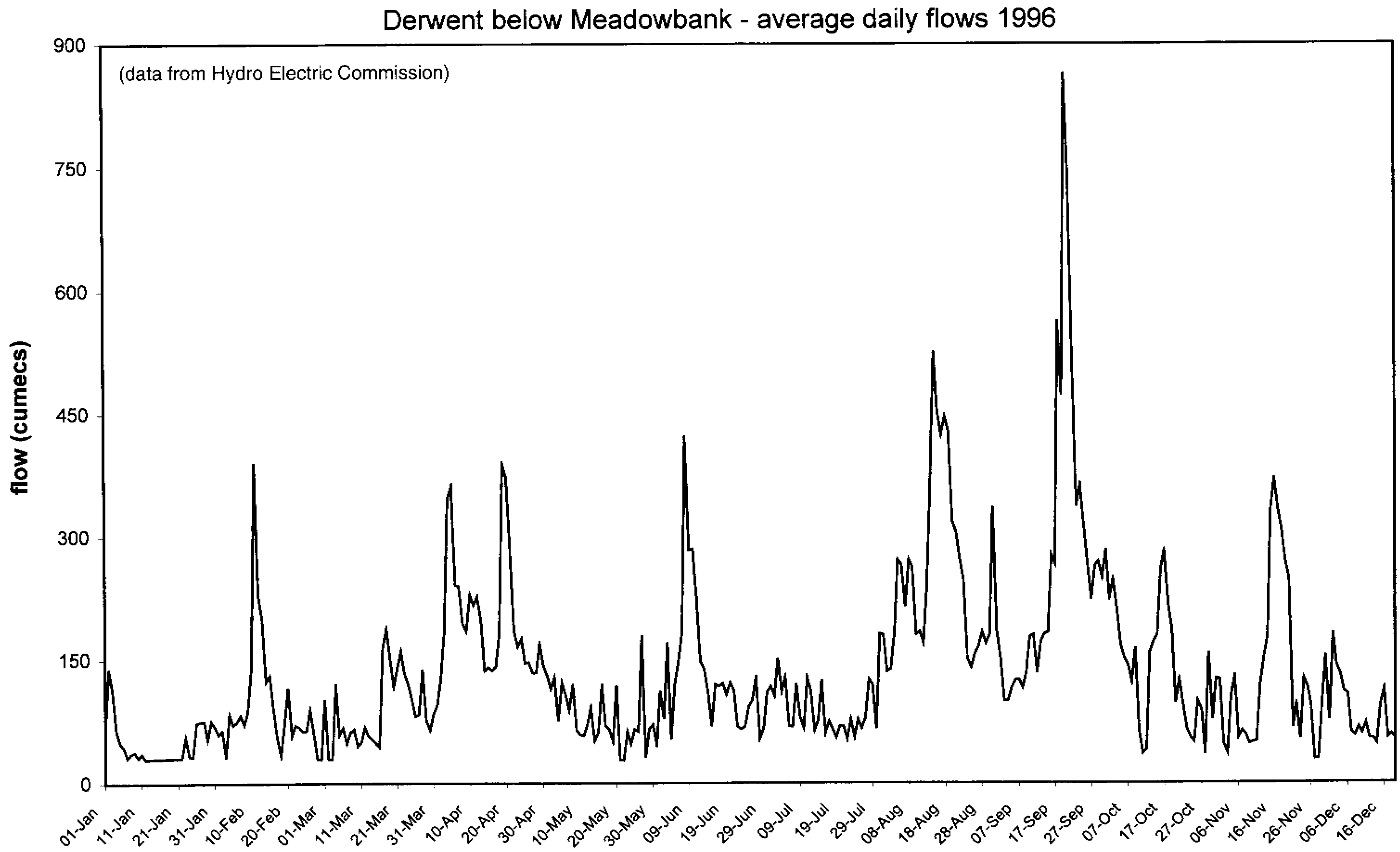


Figure 8 Derwent River at Meadowbank - 1996 hydrograph

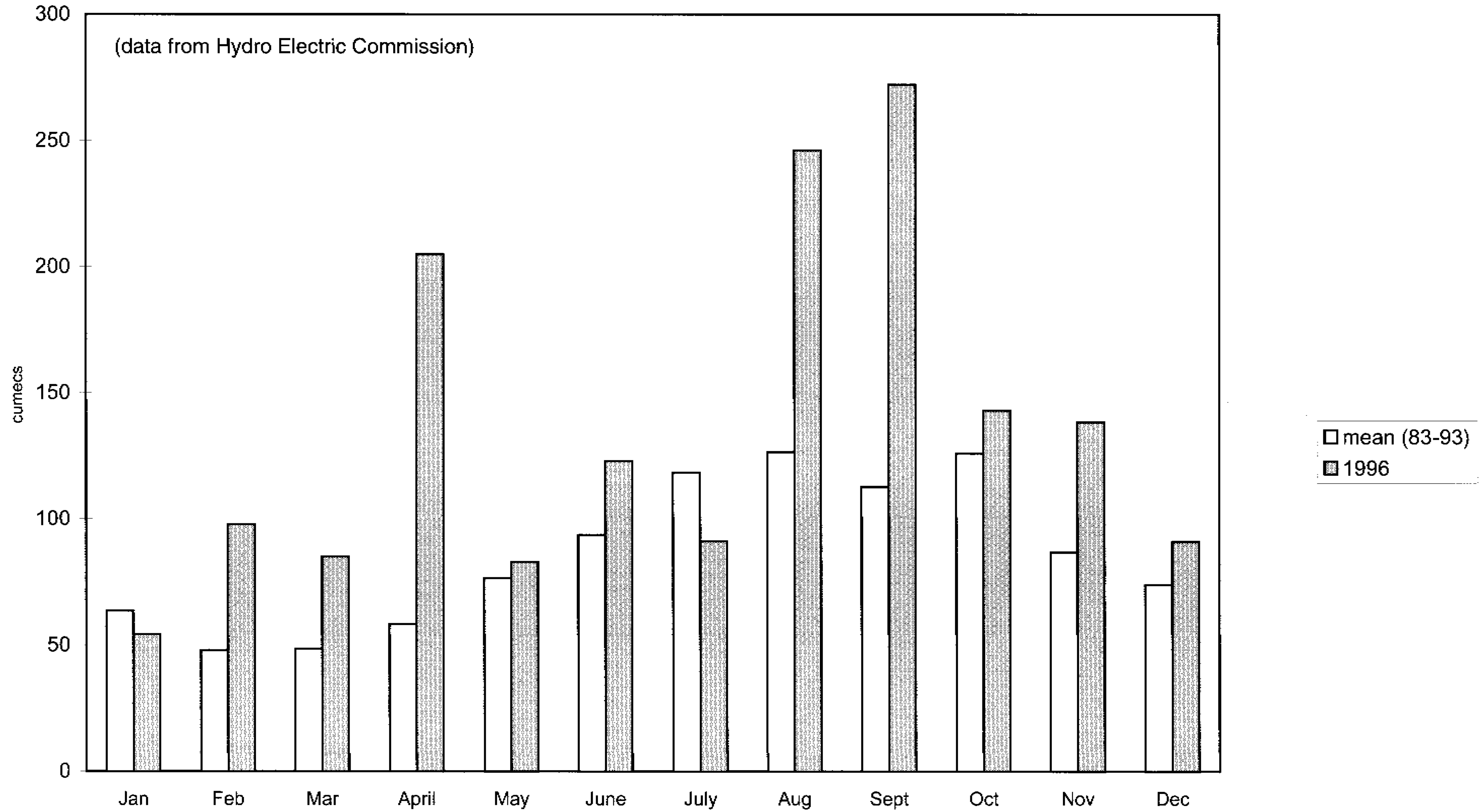


Figure 9 Derwent River at Meadowbank - monthly mean flows

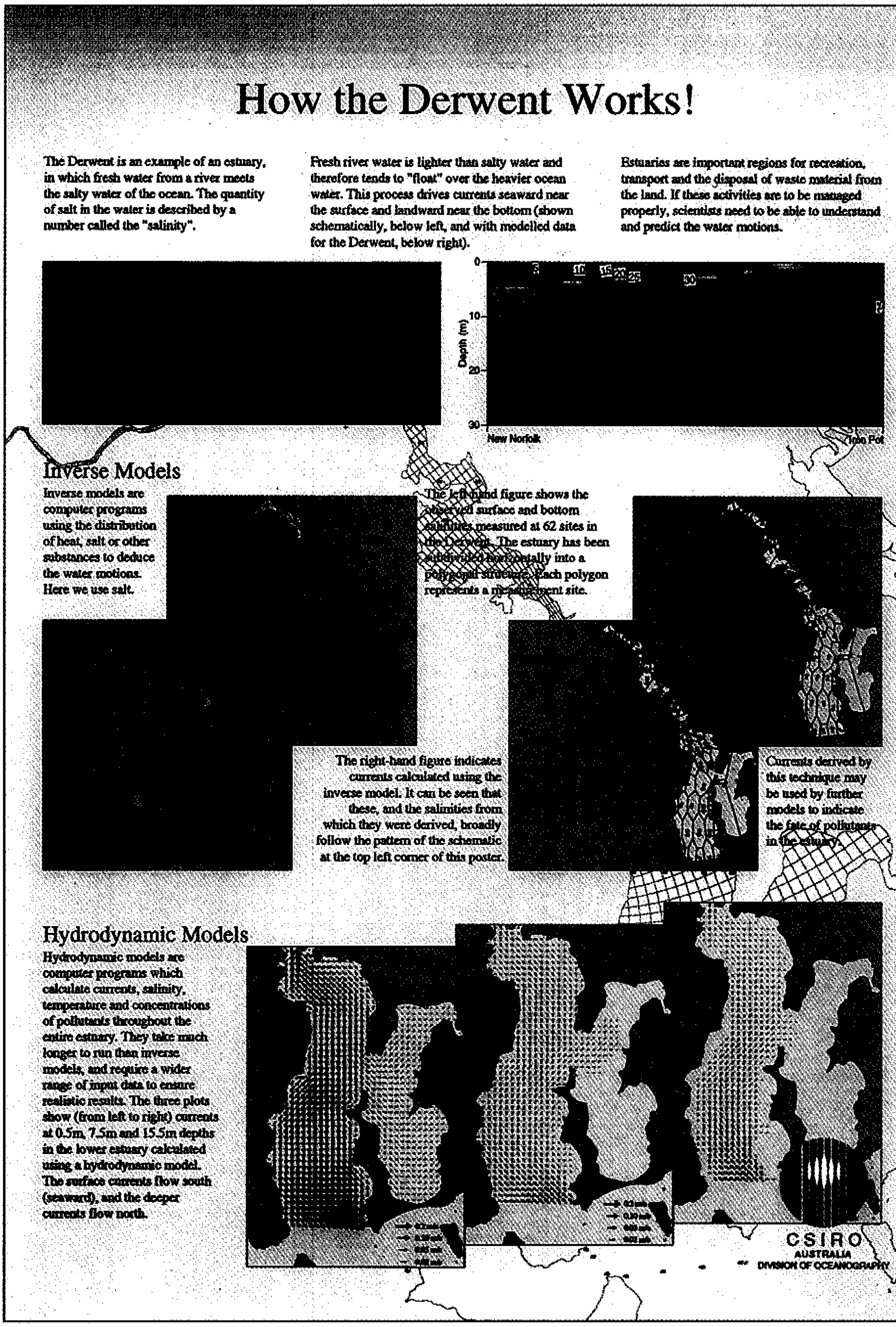


Figure 10 Estuarine circulation
(CSIRO Division of Oceanography)

salinity surface water (and a number of associated contaminants) extends further along the eastern shore than along the western shore. The average flushing period for the estuary is estimated to be 15 days (J. Hunter, pers. comm.), although the relatively isolated deep waters of the upper estuary may be retained for a much longer period (20 to 35 days) during low river flows (Davies and Kalish, 1994).

The marine waters off southeastern Tasmania are known to be an area of convergence between subtropical and subantarctic water masses. The precise location of this convergence varies seasonally and from year to year, depending on climatic and oceanographic factors. During the warmest months (February - March), nutrient-poor, subtropical waters entrained in the East Australian Current may be carried south along the east coast of Tasmania, occasionally extending as far as Storm Bay and entering the mouth of the Derwent. During the cooler months (August - January), nutrient-rich subantarctic waters are carried east/northeast by the West Wind Drift, entering Storm Bay and the Derwent Estuary. (Nyan Taw and Ritz, 1978, 1979; Harris *et al.* 1987). The seasonal interplay between these two fundamentally different water masses strongly influences the nutrient and algal dynamics of southeastern Tasmanian coastal and estuarine waters

2.6 Sediments

There have been few comprehensive sediment surveys of the Derwent Estuary; most surveys have focused on specific areas (e.g. upper Derwent, New Town Bay) or contaminants, including metals (Bloom, 1975), pulp mill sludge (Garland, Horwitz and Holloway, 1990; Garland and Statham, 1992; Garland and Jameson, 1995) and the sewage tracer coprostanol (Leeming and Nichols, pers. comm.). There have been few studies of stratigraphy, sedimentation rates or sediment processes, with the exception of Wood (1988), who investigated sedimentation rates in Lindisfarne Bay.

The most recent sediment study is that of Pirzl (1996), which investigated sediment characteristics (redox, grain size, % loss on ignition (LOI), mineralogy and metal content) in 38 short cores collected throughout the entire estuary. Sandy sediments were found to be largely restricted to the uppermost reaches of the estuary near New Norfolk, the margins and seaward end of the lower estuary and the southern and northern ends of Ralphs Bay. Sediments in most of the upper and middle estuary and in the deeper areas of the lower estuary consist of black, homogeneous muds with a high organic content and a detectable odour of hydrogen sulphide. The distributions of sediment type and % LOI are shown in Figures 11 and 12. Redox values in surface sediments were positive throughout the estuary, giving no evidence of anoxic conditions at the time of sampling (May - July 1996). X-ray diffraction showed that all samples contained a significant quantity of quartz, but surprisingly, few clay minerals. This absence of clay minerals suggests that the fines are poorly crystalline, possibly consisting of iron and manganese oxy-hydroxides. Data on heavy metals in sediments is discussed in Section 6.7.

Industrial discharges from the ANM paper mill situated just downstream of New Norfolk have had a significant impact on sediment characteristics throughout much of the upper and middle reaches of the estuary. Since the plant commenced operations in the 1940s, it is estimated that over 1.5 million tons of wood fibre have been released to the estuary, resulting in the accumulation of extensive deposits of organic-rich sludge in the estuary's surficial sediments (Davies and Kalish, 1994). A number of surveys between 1989 and 1995 have investigated changes in these upper estuary sludge deposits resulting from decreased emissions. These are discussed more fully in Section 6.2.

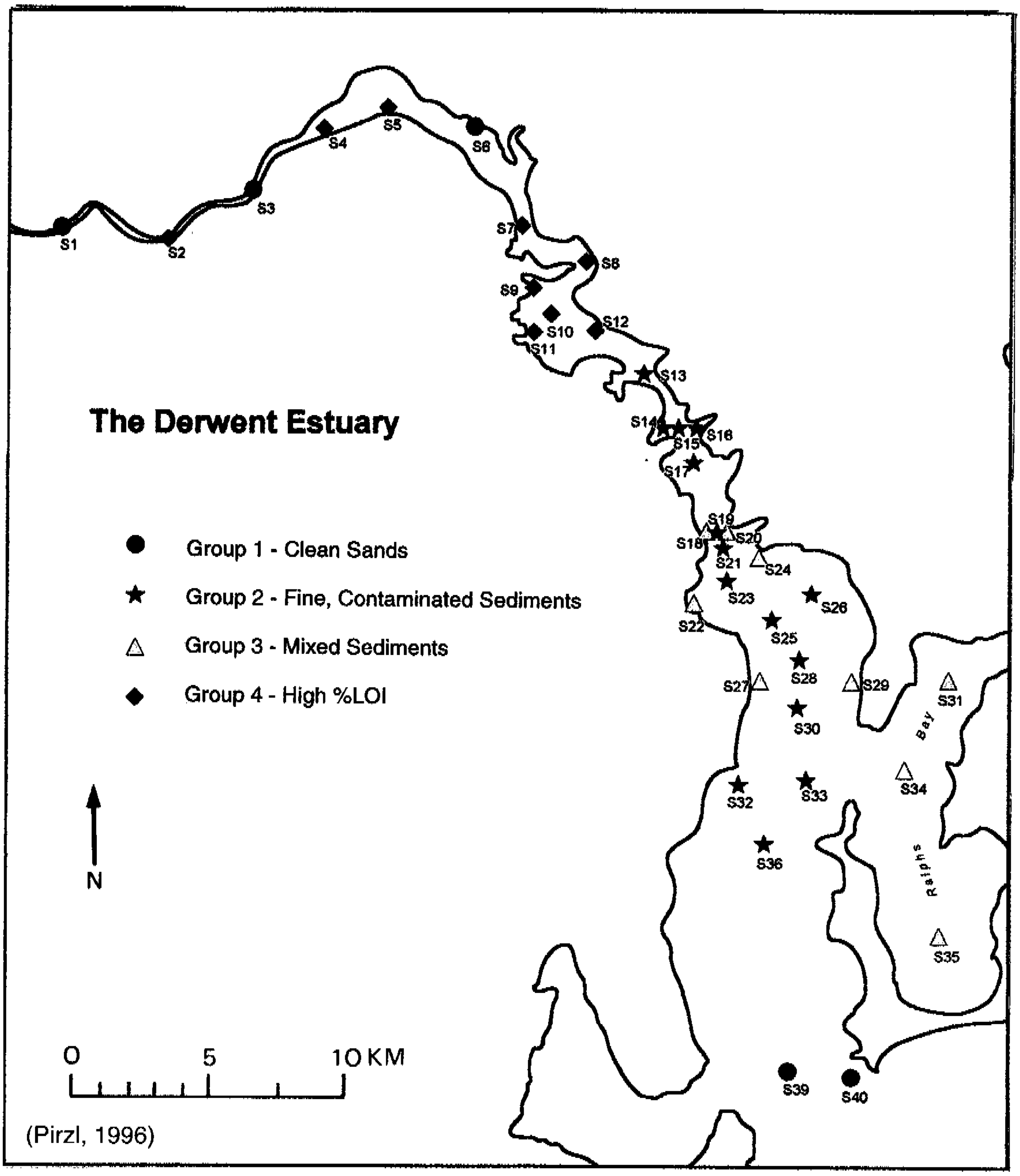


Figure 11 Distribution of the four sediment types in the Derwent Estuary

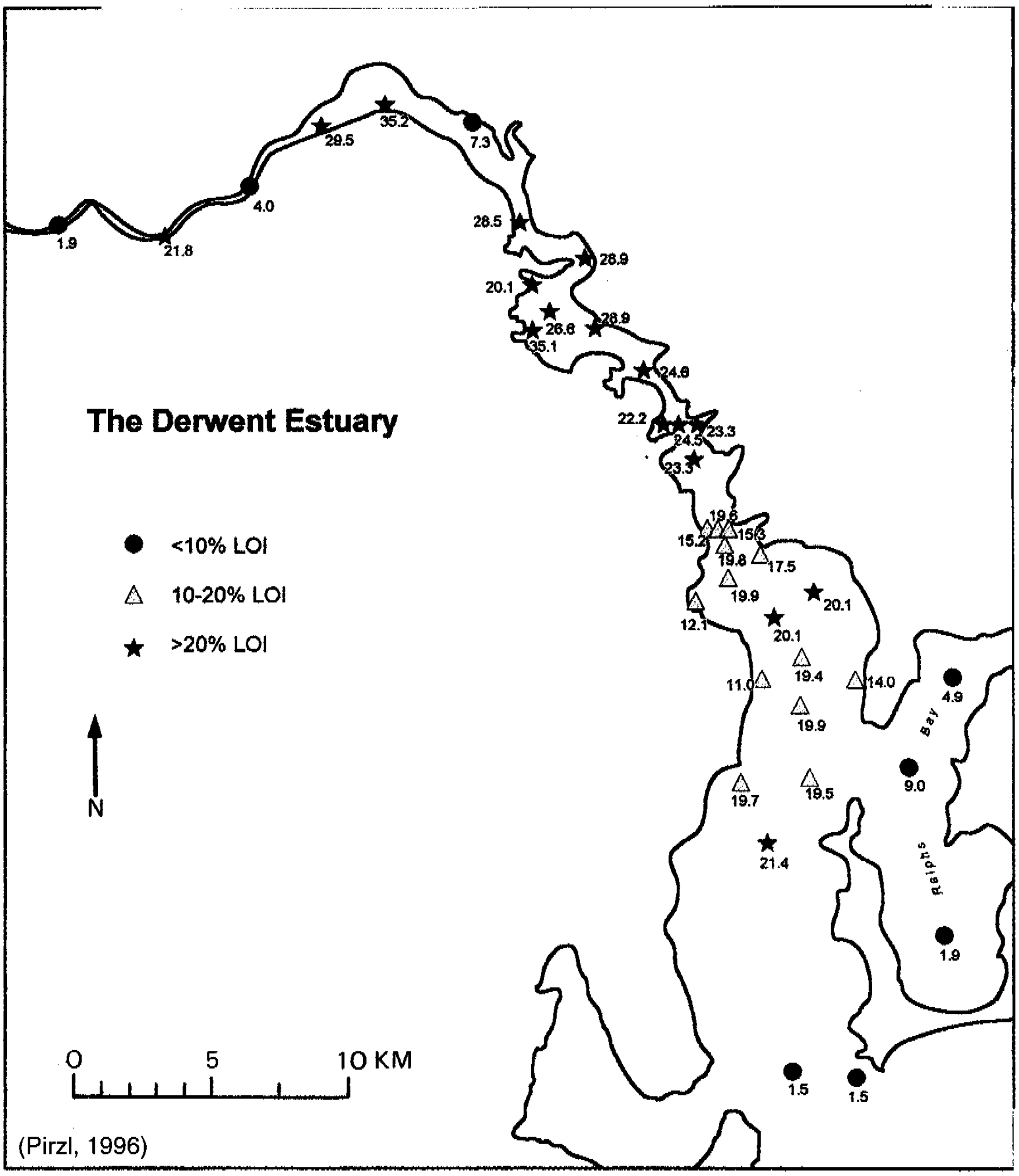


Figure 12 % LOI distribution in Derwent Estuary sediments

2.7 Aquatic vegetation

Phytoplankton are the predominant type of aquatic vegetation in the Derwent Estuary and are described in detail by Hallegraeff and Westwood (1994). The Derwent is characterised by high phytoplankton species diversity (>180 taxa), moderate levels of chlorophyll *a* biomass and no evidence of significant changes in the phytoplankton population since the 1950s. The phytoplankton community in the Derwent comprises approximately 83 species of diatoms, 73 dinoflagellates and 30-40 nanoplankton taxa. Spring diatom blooms - a natural phenomena associated with the annual intrusion of nitrate-rich oceanic water into Storm Bay - are a common feature of the Derwent. The Derwent Estuary is somewhat unusual in that dinoflagellates are abundant throughout most of the year; this also is considered to be largely a natural phenomenon. High concentrations of the toxic dinoflagellate *Gymnodium catenatum* are annually recurrent events during the period January to June, however, the spatial distribution, duration and magnitude of these "blooms" vary significantly from year to year. Significant *Gymnodium catenatum* bloom events have occurred in the Derwent in 1986, 1991 and 1993 (Hallegraeff and Westwood, 1994). Several other studies by Clementson *et al.* (1989) and Harris *et al.* (1987, 1991) have investigated phytoplankton populations and processes in Storm Bay and on a more regional scale.

No systematic surveys of submerged aquatic vegetation have been carried out in the Derwent, however, seagrass is unlikely to be widely distributed in the Derwent in water depths of greater than 3 to 4 meters, due to limited light penetration. In some areas, seagrass beds are locally abundant - particularly in the upper estuary, between Dogshear Point and Bridgewater, at the mouth of the Jordan River and in several mid-estuary embayments (e.g. Cornelian Bay) (A. Jordan, DPIF, pers. comm.). Analysis of historic aerial photographs suggests that seagrass beds were formerly abundant in Ralphs Bay, covering an area of approximately 400 ha in the 1950s, as indicated in Figures 13 and 14. These beds have disappeared over the past 40 years; the cause of their decline is unknown (Rees, 1993).

Extensive bordering marshes and other brackish wetlands are found in the upper estuary between Boyer and Bridgewater, but are poorly developed along most other shorelines of the estuary. Little information is available on wetland areas, vegetation types or habitat values. Although nominally included or associated with the Upper Derwent Wildlife Sanctuary, these upper estuarine wetlands are not effectively managed or protected. Recently, a 60-ha marsh (Murphys Flat) was burned off and trenched, presumably for agricultural uses.

2.8 Marine fauna

Zooplankton

Zooplankton populations and distributions have been investigated in the Derwent by Nyan Taw and Ritz (1978, 1979).

Invertebrates

No comprehensive invertebrate surveys have been carried out for the entire estuary, although a number of investigations have focused on specific areas or specific species. Two surveys have been conducted in the upper estuary to evaluate effects of wood pulp-mill sludge on benthic macrofauna. The 1990 survey looked at 69 sites and found very low species richness

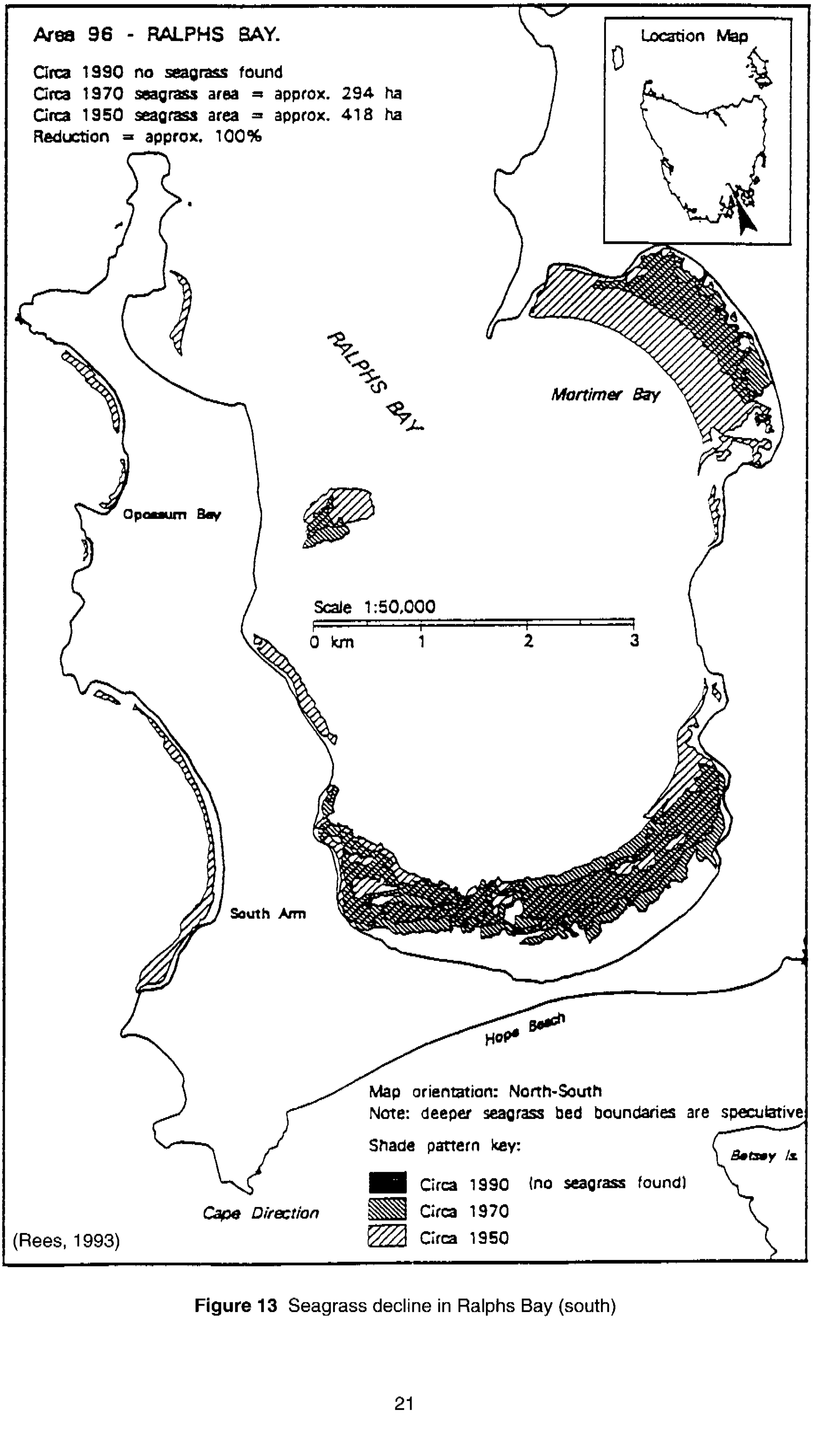


Figure 13 Seagrass decline in Ralphs Bay (south)

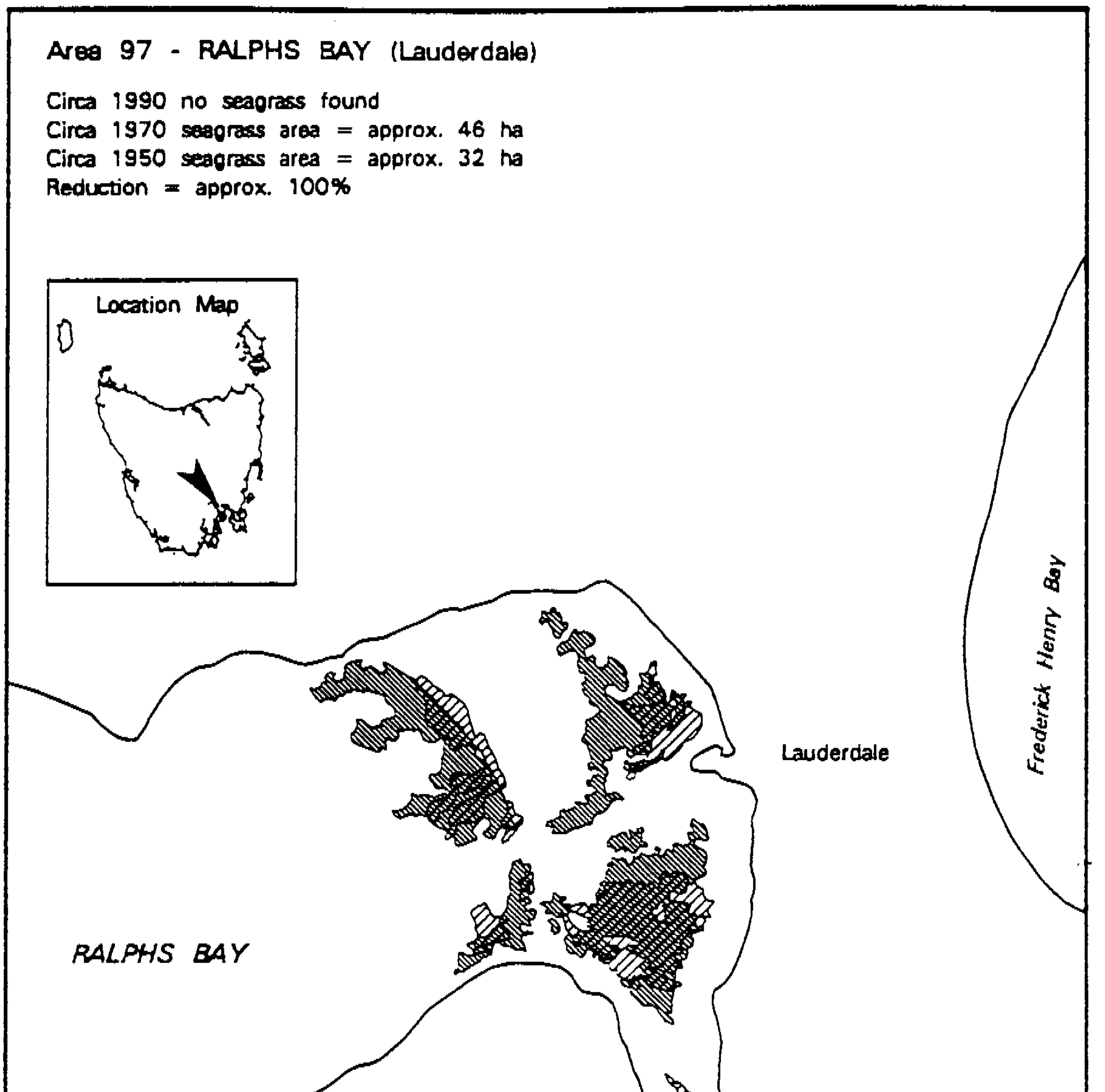


Figure 14 Seagrass decline in Ralphs Bay (north)

(52 spp total) and numbers, particularly in sediments 5 km directly downstream of the ANM outfall, which were essentially lifeless (Garland *et al.*, 1990; Horwitz and Blake, 1992). The 1995 survey revisited 40 of these sites and reported significant improvements in invertebrate species richness and numbers (Moverley and Garland, 1995).

Several localised surveys have also been conducted in the vicinity of existing or proposed sewage outfalls in the lower estuary. These include:

- investigation of meiobenthos around the Sandy Bay sewage outfall off Blinking Billy Point (Moverley and Ritz, 1989);
- survey of epifauna (animals living on the seafloor) along three transects near the Sandy Bay sewage outfall (CEE, 1994);
- survey of benthic invertebrates along 3 cross-estuary transects near the proposed Tranmere Point outfall (Garland *et al.*, 1996). This survey identified a total of 110 taxa and reported low density populations, particularly in deeper water. Overall proportions of the major taxonomic groups were: polychaetes (36%), gastropods (6%), bivalves (7%), crustaceans (36%) and other taxa (14%).

Intertidal macroinvertebrates were recently surveyed by Edgar along 4 intertidal transects in the Derwent: at Cornelian Bay, Claremont, Bridgewater and Browns River. These surveys were part of a statewide investigation; results should be available in 1998 (G. Edgar, pers. comm.). Some data on intertidal macroinvertebrates dating from the 1950s may also be available in papers published by Guiler.

A number of invertebrate surveys in deeper areas of the Derwent were completed in 1993/94 as part of the Northern Pacific Seastar (*Asterias amurensis*) investigations. These included surveys of prey species ingested by the starfish and also a dredging survey of invertebrates from deeper waters. Over 96 species of invertebrates were found in *Asterias amurensis* stomach samples, particularly molluscs and crustaceans. In dredging surveys of deeper waters, two indigenous invertebrates were found in large numbers: the burrowing heart urchin, *Echinocardium cordatum*, and the small brittle star, *Amphiura elandifores*? (pers. comm. L. Turner, Tasmanian Museum).

Fish

Approximately 90 to 100 fin-fish species have been documented in the Derwent Estuary. The distribution of fish species depends on their tolerance to salinity changes, available habitat and other factors. Some species, such as flathead and cod are permanent residents, while others (e.g. Australian salmon, gummy and school shark, eel and snock) are migratory. The Derwent is considered a nursery area for a number of commercially important species, such as gummy and school shark. Commercial netting of these sharks is prohibited within the estuary.

One of the earliest surveys of finfish in the Derwent, carried out by Dix in 1972/73, involved setting of gillnets at 64 stations between Tinderbox and Dogshear Point. A total of 32 species were recorded, the commonest of which were mullet, trumpeter, Australian salmon, morwong and flathead. On the whole, catch rates were not considered to be particularly high. Of the 14 most commonly caught fish, 12-13 were of interest to commercial or amateur fishermen (Dix, 1974). Additional surveys of finfish populations were carried out in the late 1970s by Last (1983); these surveys are currently being replicated by DPIF (A. Jordan, pers.comm.).

Lists for shallow- and deep-water fish species recently recorded by DPIF in the Derwent are provided in Tables 3 and 4. Shallow-water species (< 2 m) were sampled from both seagrass and unvegetated habitats at 6 sites in the Derwent. The dominant species in seagrass were mullet, congolli, soldierfish and gobies, while at unvegetated sites, flounder and eastern Australian salmon dominated. Deep-water species were sampled from the deep channel habitat off Blackmans Bay. The most abundant species groups were leatherjackets and gurnards, while skates and stingarees were dominant in terms of weight (A. Jordan, DPIF, pers. comm.).

Table 3 Derwent Estuary species list - shallow water fish (0-2 m)

Scientific Name	**Common Name**
Anguilla reinhardtii	long-finned eel
Galaxias maculatus	common jollytail
Galaxias truttaceus	spotted mountain galaxias
Atherinosoma microstoma	small-mouthed hardyhead
Leptatherina presbyteroides	silverfish
Hippocampus abdominalis	pot bellied seahorse
Stigmatopora argus	spotted pipefish
Gymnapistes marmoratus	soldierfish
Lepidotrigla papilio	spiny gurnard
Platycephalus bassensis	sand flathead
Arripis trutta	eastern Australian salmon
Acanthopagrus butcheri	black bream
Aldrichetta forsteri	yellow eye mullet
Lesueurina platycephala	common sandfish
Crapatalus munroi	pink sandfish
Pseudaphritis urvilli	congolli
Parablennius tasmanianus	blenny
Heteroclinus perspicillatus	common weedfish
Favonigobius tamarensis	tamar goby
Nesogobius hinisbyi	orange-spotted goby
Pseudogobius olorum	blue-spotted goby
Nesogobius sp.1	girdled goby
Tasmanogobius lasti	lagoon goby
Ammotretis rostratus	long snouted flounder
Rhombosolea tapirina	greenback flounder
Ammotretis liturata	spotted flounder
Taratretis derwentensis	Derwent flounder
Meuschenia freycineti	six-spined leatherjacket
Acanthaluteres spilomelanuru	bridled leatherjacket
Tetractenos glaber	smooth toadfish

(DPIF, 1997)

Table 4 Derwent Estuary species list - deep water fish (10-20 m)

Scientific Name	Common Name
Acanthaluteres vittiger	toothbrush leatherjacket
Allomycterus pilatus	porcupine fish
Ammotretis rostratus	long snouted flounder
Argentina australiae	silverside
Arripis spp.	Australian salmon-eastern/western
Asymbolus sp.d	orange spotted catshark
Callorhynchus milii	elephant fish
Cephaloscylliumlaticeps	draughtboard shark
Chelidonichthys kumu	red gurnard
Contusus richei	barred toadfish
Cyttus australis	silver dory
Cyttus novaezelandiae	New Zealand dory
Dasyatis thetidis	black stingray
Dinolestes lewini	long-finned pike
Diodon nichthemerus	globe fish
Emmelichthys nitidus	redbait
Engraulis australis	Australian anchovy
Eubalichthys gunnii	Gunn's leatherjacket
Eubalichthys mosaicus	mosaic leatherjacket
Galeorhinus galeus	school shark
Gnathagnus innotablis	bulldog stargazer
Gymnapistes marmoratus	soldierfish
Helicolenus percoides	red gurnard perch
Hydrolagus ogilbyi	Ogilby's ghost shark
Kathetostoma canaster	speckled stargazer
Lepidotrigla modesta	grooved gurnard
Lepidotrigla mulhalli	round snouted gurnard
Lepidotrigla papilio	spiny gurnard
Lepidotrigla vanessa	butterfly gurnard
Lophonectes gallus	crested flounder
Meuschenia australis	brown striped leatherjacket
Meuschenia freycineti	six-spined leatherjacket
Mustelus antarcticus	gummy shark
Myliobatis australis	eagle ray
Nemadactylus macropterus	morwong
Neoplatycephalus richardsoni	tiger flathead
Notopogon lilliei	crested bellows fish
Notorhynchus cepedianus	seven gilled shark
Omegophora armilla	ringed toadfish
Parapercis allporti	barred grubfish
Parascyllium ferrugineum	rusty catshark
Parika scaber	velvet leatherjacket

Pavoraja nitida	peacock skate
Pristiophorus nudipinnis	southern sawshark
Pseudaphritis urvilli	congolli
Pseudophycis bachus	red cod
Pseudophycis barbatus	bearded rock cod
Pterygotrigla polyommata	latchet
Raja cerva	white spotted skate
Raja sp.a	long nosed skate
Raja whitleyi	whitley's skate
Sardinops neopilchardus	pilchard
Seriolella brama	blue warehou
Sillago flindersi	eastern school whiting
Sphyraena novaehollandiae	short-finned seapike
Squalus acanthias	white spotted dogfish
Squalus megalops	piked dogfish
Synchiropus calauropomus	common stinkfish
Tetractenos glaber	smooth toadfish
Thyrsites atun	barracouta
Torpedo macneilli	torpedo ray
Trachurus declivis	jack mackerel
Urolophus cruciatus	banded stingaree

(DPIF, 1997)

Table 5 Finfish of the upper Derwent Estuary

(species of present or potential recreational, commercial and conservation value, which pass through or live in the vicinity of the ANM Newsprint Mill effluent outfall at some time of the year)

Species	Life stage	Reason for migration	Direction	Time of year
1) Sea trout	Juveniles (smolts)	Access to Sea	Downstream	September to October
(Salmo trutta)	Adults	Spawning in fresh water	Upstream	April to May
	Adults	Return to Sea	Downstream	May to June
	Adults	Feeding on whitebait	Upstream and Downstream	August to November
2) Tasmanian Whitebait	Larvae	Access to Sea	Downstream	September to November
(Lovettia sealii)	Adults	Spawning	Upstream	August to November
3) Common Jollytail	Larvae	Access to Sea	Downstream	May to June
(Galaxias cleaveri)	Juveniles	Return to fresh water	Upstream	August to November
	Adults	Spawning in estuary	Downstream	April to June
		General habitat	Local	All year
4) Tasmanian Mudfish	Larvae	Access to Sea	Downstream	June to July
(Galaxias cleaveri)	Juveniles	Return to fresh water	Upstream	August to November
	Adults	General habitat	Local	All year
		(Spawning)		(May to June)
5) Spotted Galaxias	Larvae	Access to Sea	Downstream	May to June
(Galaxias truttaceus)	Juveniles	Return to fresh water	Upstream	August to November
6) Black Bream	Larvae	Access to estuary	Downstream	November to February
(Acanthopagrus butcheri)	Juveniles	Dispersion through estuary	Downstream	All year
	Adults	Spawning in fresh/estuary	Upstream	October to January
	Adults	Return to estuary	Downstream	October to January
7) Yellow Eyed Mullet *(Aldrichetta forsteri)*	Adults	Dispersion through estuary	Local	All year
8) Shortfinned eel	Elvers	Access to fresh water	Upstream	November to January
(Anguilla australis)	Adults	Access to sea	Downstream	November to January
9) Pouched Lamprey	Velasia	Spawning in fresh water	Upstream	September to November
(Geotria australis)	Macroptha lmia	Access to sea	Downstream	September to December
10) Short-headed lamprey	Velasia	Spawning in fresh water	Upstream	November to January
(Mordacia mordax)	Macroptha lmia	Access to sea	Downstream	September to December

(Davies *et al.*, 1988)

The upper Derwent is important for the passage of migratory fish. Sea trout, black bream and yellow eye mullet migrate through the area in significant numbers. The sea trout fishery, in particular, depends on the presence of whitebait populations, as whitebait runs stimulate sea trout migrations in the spring. The whitebait fishery consists of 6 fish species, which migrate into the estuary from Storm Bay each spring. Davies *et al.* (1988) surveyed fish populations in the upper Derwent Estuary between 1986 and 1988, focusing on two groups of migratory fish; large finfish (sampled by gillnets) and whitebait (sampled by traps). The major species recorded are shown in Table 5. Migratory fish cannot pass upstream of Meadowbank Dam on the Derwent, but do enter the Plenty, Tyenna and Styx Rivers.

Birds

The Derwent Estuary and its environs provide habitat, breeding and feeding grounds for a range of water fowl and other birds. Commonly observed species are listed in Table 6. The upper Derwent, in particular, is an important area for waterbirds for a number of reasons. First, it is a large, permanent body of relatively undisturbed brackish water that is shallow and productive. This makes it a useful and reliable feeding area for a wide range of species. Second, it is a Conservation Area, and thus serves as a refuge area for ducks during the annual 3-month hunting season. Its permanence means it is available as a drought refuge for other species as well, during dry periods. Ducks and swans can occur in quite large numbers, particularly in mid-summer, when over 2000 swans and nearly as many ducks are frequently present. Such numbers indicate that the upper Derwent is of regional importance as a summer area, along with the Huon and Pittwater estuaries. In fact, as a single location, it is only exceeded by Moulting Lagoon and the Bass Strait Islands (S. Blackhall, PWS, pers. comm.). A one-day waterbird survey is conducted in February of each year by Parks and Wildlife in the upper estuary (Granton) region. Approximately 10 years of data on numbers and species has been collected, but has not yet been compiled or analysed (S. Blackhall, PWS, pers. Comm.).

Table 6 Birds commonly observed in the Derwent Estuary

pelican
black swan
black duck
chestnut teal
musk duck
Eurasian coot
hoary headed grebe
great cormorant
little pied cormorant
silver gull
Pacific gull
great egret
white-faced heron
white-bellied sea eagle
marsh harrier
brown falcon
masked lapwing
Less commonly seen birds:
little grass bird
Lewins rail
spotless crake
great crested grebe
Australasian shoveler

(Parks and Wildlife Service/DELM, 1997)

Marine mammals

According to H. Wapstra of PWS/DELM, several species of marine mammals occasionally visit the Derwent Estuary, particularly in its lower reaches. These include dolphins, whales (southern right, humpback and orca) and seals. Dolphins are permanent residents of Tasmanian coastal waters and habitually enter bays and estuaries for a variety of reasons, including feeding. Both bottlenosed and common dolphins are being sighted with increasing frequency well into the Derwent, as far up-river as Old Beach and beyond. Southern right whales and humpback whales are migratory, arriving in Tasmanian latitudes on their way from the Southern Ocean starting in late May, with numbers peaking in June and July. These species were hunted close to extinction in the whaling days, but both are showing confirmed signs of steady recovery in numbers. This is reflected in the number of sightings reported over the past 20 years. In 1980, there were only two reports of whale sightings, whereas in 1995 (a peak year) there were 45 reports of southern right whales and 26 humpbacks. Whaling was a significant activity in the Derwent and Storm Bay throughout the first half of the 19th century, and a whaling station known as Tryworks Point was established on Droughty Point in 1805. Whaling continued intermittently until the 1890s.

The southern right whale, in particular, tends to enter bays and estuaries such as the Derwent. At present, PWS normally receives at least one reported sighting/year from the Derwent between North Bruny Island and Taroona or Sandy Bay. Historically, the Derwent was one of the favourite haunts of the southern right whale. In the mid-1800s, the Reverend Knopwood recorded that residents of Taroona complained of being kept awake by the whales' loud snorting noises, and that at times, it was dangerous to cross the estuary in small boats due to the large numbers of whales - sometimes up to 60. The Derwent and other bays and estuaries around southeast Tasmania were once established calving grounds for this species, and recent reports indicate that some southern right whale calves are again being born in the region (e.g. Adventure Bay), though none yet in the Derwent (H. Wapsta, PWS, pers. comm.).

Humpback whales migrate through the region at the same time, but only stay for short periods on their way to tropical waters. They are frequently seen close to the coast and in bays and estuaries, including the Derwent. In 1996, while on their southern migration return, two humpback whales were present in the lower Derwent between South Arm, Dennes Point and Tinderbox during the month of November. These whales were observed to be feeding on large swarms of krill. Orcas or killer whales occasionally enter the Derwent, although they are normally oceanic. There is one account of orcas hunting dolphins at night off Taroona approximately 10 years ago, which led to the stranding of dolphins in Ralphs Bay (H. Wapsta, PWS, pers. comm.).

Seals are also occasionally seen in the Derwent where they haul out on a beach or rocky foreshore. The most frequent visitor is the Australian fur seal but occasionally vagrants of other species are reported, including southern elephant seal, leopard seal and others.

Rare and endangered species

Several rare, endangered or vulnerable species visit or inhabit the Derwent Estuary. These include the humpback and southern right whales (both endangered), possibly the little tern (endangered) and fairy tern (rare), the New Zealand fur seal (rare) and the spotted handfish (endangered) The spotted handfish (*Brachionichthys hisutus*) was once extremely abundant in the Derwent Estuary, but its population collapsed in last decade. The cause of this decline is unknown, but the northern Pacific seastar has been identified as a possible factor.

Introduced species

A number of introduced species have been identified in the Derwent Estuary, some of which have or may potentially have serious impacts on the ecology of the estuary; others may affect human health and public amenity as well. Some of these are listed in Table 7 below:

Table 7 Introduced species in the Derwent Estuary

Common Name	Species Name	Where Found
Northern Pacific Seastar	*Asterias amurensis*	middle and lower reaches
New Zealand seastar	*Patiriella regularis*	middle and lower reaches
New Zealand bivalve	*Venerupis largillierti*	middle and lower reaches
New Zealand screw shell	*Maoricolpus roseus*	middle and lower reaches
Pacific oyster	*Crassostreas gigas*	D'Entrecasteaux Channel
Japanese seaweed	*Undaria pinnatifida*	Tinderbox Marine Reserve
Rice grass	*Spartina angelica*	upper/mid Derwent
Toxic dinoflagellate	*Gynmadium catenatum*	middle and lower reaches

The most serious threat to indigenous vertebrate and invertebrate species in the Derwent Estuary is probably the result of introduced species, particularly the northern Pacific Seastar (*Asterias amurensis*). This species is thought to have been introduced via ballast water in the early 1980s. Surveys of *Asterias amurensis* in southeastern Tasmania in 1993/94, revealed that highest densities were found in the Derwent Estuary, particularly in the vicinity of Macquarie Wharf. In 1997, an estimated 27.7 million northern Pacific Seastars were thought to inhabit the estuary. These predators, which eat essentially anything containing protein and have very high fecundity, have dramatically reduced the numbers and species of benthic fauna in the Derwent (Australian Nature Conservation Organisation, 1996; pers. comm. L. Turner, Tasmanian Museum).

In addition to *Asterias amurensis*, massive numbers of the New Zealand seastar *Patiriella regularis* have colonised the Derwent Estuary, particularly near the Hobart wharves. These were probably introduced with New Zealand oysters early this century, and have almost completely replaced all indigenous *Patiriella* species in the Derwent. A New Zealand bivalve (*Venerupis largillierti*) is also found in large numbers, as is the New Zealand screw shell (*Maoricolpus roseus*), particularly near the mouth of the estuary (pers. comm. L. Turner, Tasmanian Museum).

3 Uses of the Derwent Estuary

3.1 Population centre

The first human occupation of the Derwent area is unknown, but aborigines are thought to have arrived in Tasmania over 35,000 years ago. Two aboriginal tribes inhabited the region surrounding the Derwent Estuary: the Oyster Bay Tribe on the Eastern Shore and the South East Tribe on the Western Shore. Both tribes were hunter-gathers and used the Derwent as a source of food, with shellfish as a major element of their diet (Ryan, 1996).