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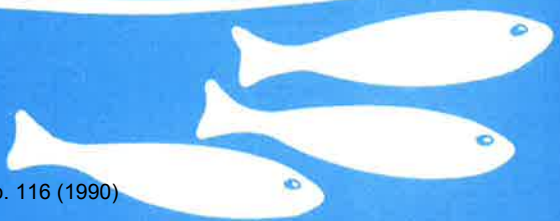
NEW ZEALAND FRESHWATER FISHERIES REPORT No. 116

Conservation of New Zealand's Freshwater Fishes



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New Zealand Freshwater Fisheries Report No. 116

Conservation of New Zealand's Freshwater Fishes

by
R.M. McDowall

Report to: Department of Conservation

Freshwater Fisheries Centre
MAF Fisheries
Christchurch

Servicing freshwater fisheries and aquaculture

July
1990

NEW ZEALAND FRESHWATER FISHERIES REPORTS

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CONTENTS

Page

1. INTRODUCTION 7

1.1 Human Impacts on Fish Populations and Habitats 7

1.2 Introduction of Exotic Fishes 7

1.3 Endangered Exotic Species 7

1.4 Sea Migratory Strategies 8

1.5 The Conservation Status of Indigenous Fish Species 9

2. STATUS REPORTS ON SPECIES 9

2.1 Indigenous Species 10

2.1.1 Family Geotriidae 10
2.1.1.1 *Geotria australis* Gray (lamprey) 10

2.1.2 Family Anguillidae 12
2.1.2.1 *Anguilla dieffenbachii* (longfinned eel) and *Anguilla australis* (shortfinned eel) 12

2.1.3 Family Retropinnidae 15
2.1.3.1 *Retropinna retropinna* (common smelt) 15
2.1.3.2 *Stokellia anisodon* (Stokell's smelt) 16

2.1.4 Family Prototroctidae 17
2.1.4.1 *Prototroctes oxyrhynchus* (grayling) 17

2.1.5 Family Galaxiidae 17
2.1.5.1 *Galaxias argenteus* (giant kokopu) 17
2.1.5.2 *Galaxias fasciatus* (banded kokopu) 19
2.1.5.3 *Galaxias postvectis* (shortjawed kokopu) 19
2.1.5.4 *Galaxias brevipinnis* (koaro) 20
2.1.5.5 *Galaxias vulgaris* (common river galaxias) 23
2.1.5.6 *Galaxias maculatus* (inanga) 23
2.1.5.7 *Galaxias gracilis* (dwarf inanga) 25
2.1.5.8 *Galaxias divergens* (dwarf galaxias) 25
2.1.5.9 *Galaxias paucispondylus* (alpine galaxias) 27
2.1.5.10 *Galaxias prognathus* (longjawed galaxias) 27
2.1.5.11 *Neochanna burrowsius* (Canterbury mudfish) 28
2.1.5.12 *Neochanna apoda* (brown mudfish) 28
2.1.5.13 *Neochanna diversus* (black mudfish) 29

2.1.6 Family Mugiloididae 30
2.1.6.1 *Cheimarrichthys fosteri* (torrentfish) 30

2.1.7 Family Eleotridae 31
2.1.7.1 *Gobiomorphus huttoni* (redfinned bully) 31
2.1.7.2 *Gobiomorphus gobioides* (giant bully) 33
2.1.7.3 *Gobiomorphus cotidianus* (common bully) 34
2.1.7.4 *Gobiomorphus hubbsi* (bluegilled bully) 34
2.1.7.5 *Gobiomorphus breviceps* (upland bully) 34
2.1.7.6 *Gobiomorphus basalis* (Cran's bully) 37

2.1.8 Family Pleuronectidae 39
2.1.8.1 *Rhombosolea retiaria* (black flounder) 39

2.2 Introduced Species 40

2.2.1 Family Salmonidae 40
2.2.1.1 *Salmo trutta* (brown trout) 40
2.2.1.2 *Salmo salar* (Atlantic salmon) 40
2.2.1.3 *Salvelinus fontinalis* (brook char) 42
2.2.1.4 *Salvelinus namaycush* (mackinaw) 43
2.2.1.5 *Oncorhynchus mykiss* (rainbow trout) 43
2.2.1.6 *Oncorhynchus tshawytscha* (quinnat salmon) 43
2.2.1.7 *Oncorhynchus nerka* (sockeye salmon) 46

2.2.2 Family Ictaluridae 46
2.2.2.1 *Ictalurus nebulosus* (catfish) 46

2.2.3 Family Cyprinidae 47
2.2.3.1 *Tinca tinca* (tench) 47
2.2.3.2 *Carassius auratus* (goldfish) 49
2.2.3.3 *Cyprinus carpio* (koi or European carp) 50
2.2.3.4 *Scardinius erythrophthalmus* (rudd) 50
2.2.3.5 *Leuciscus idus* (orfe) 51
2.2.3.6 *Ctenopharyngodon idella* (grass carp) 52
2.2.3.7 *Hypophthalmichthys molitrix* (silver carp) 52

2.2.4 Family Poeciliidae 52
2.2.4.1 *Gambusia affinis* (mosquitofish) 52
2.2.4.2 *Poecilia reticulata* (guppy) 53
2.2.4.3 *Poecilia latipinna* (sailfin molly) 53
2.2.4.4 *Xiphophorus helleri* (swordtail) 54

2.2.5 Family Percidae 54
2.2.5.1 *Perca fluviatilis* (perch) 54

3. SUMMARY OF INFORMATION AND RESEARCH NEEDS 54

4. FURTHER BACKGROUND INFORMATION 56

5. ACKNOWLEDGEMENTS 56

6. LITERATURE CITED 56

TABLE

1. Synopsis of New Zealand's indigenous fish species: their distribution and conservation status 10

FIGURES

1. The three types of diadromy exhibited by the New Zealand freshwater fish fauna 8

2. Distribution of *Geotria australis* (lamprey) based on 252 data entries 11

3. Distribution of *Anguilla dieffenbachii* (longfinned eel) based on 2774 data entries 13

4. Distribution of *Anguilla australis* (shortfinned eel) based on 1097 data entries 14

5. Distribution of *Retropinna retropinna* (common smelt) based on 622 data entries 15

6. Distribution of *Stokellia anisodon* (Stokell's smelt) based on 31 data entries 16

7. Distribution of *Galaxias argenteus* (giant kokopu) based on 313 data entries 18

8. Distribution of *Galaxias fasciatus* (banded kokopu) based on 683 data entries 20

9. Distribution of *Galaxias postvectis* (short-jawed kokopu) based on 153 data entries 21

10. Distribution of *Galaxias brevipinnis* (koaro) based on 899 data entries 22

11. Distribution of *Galaxias vulgaris* (common river galaxias) based on 382 data entries 23

12. Distribution of *Galaxias maculatus* (inanga) based on 909 data entries 24

13. Distribution of *Galaxias gracilis* (dwarf inanga) based on 17 data entries 25

14. Distribution of *Galaxias divergens* (dwarf galaxias) based on 189 data entries 26

15. Distribution of *Galaxias paucispondylus* (alpine galaxias) based on 74 data entries 27

16. Distribution of *Galaxias prognathus* (longjawed galaxias) based on 28 data entries 27

17. Distribution of *Neochanna burrowsius* (Canterbury mudfish) based on 50 data entries 28

18. Distribution of *Neochanna apoda* (brown mudfish) based on 62 data entries 29

19. Distribution of *Neochanna diversus* (black mudfish) based on 75 data entries 30

20. Distribution of *Cheimarrichthys fosteri* (torrentfish) based on 687 data entries 31

21. Distribution of *Gobiomorphus huttoni* (redfinned bully) based on 1118 data entries 32

22. Distribution of *Gobiomorphus gobioides* (giant bully) based on 135 data entries 33

23. Distribution of *Gobiomorphus cotidianus* (common bully) based on 1455 data entries 35

24. Distribution of *Gobiomorphus hubbsi* (bluegilled bully) based on 383 data entries 36

25. Distribution of *Gobiomorphus breviceps* (upland bully) based on 919 data entries 37

26. Distribution of *Gobiomorphus basalis* (Cran's bully) based on 237 data entries 38

27. Distribution of *Rhombosolea retiaria* (black flounder) based on 132 data entries 39

28. Distribution of *Salmo trutta* (brown trout) based on 2664 data entries 41

29. Distribution of *Salmo salar* (Atlantic salmon) based on three data entries 40

30. Distribution of *Salvelinus fontinalis* (brook char) based on 77 data entries 42

31. Distribution of *Oncorhynchus mykiss* (rainbow trout) based on 901 data entries 44

32. Distribution of *Oncorhynchus tshawytscha* (quinnat salmon) based on 333 data entries 45

33. Distribution of *Oncorhynchus nerka* (sockeye salmon) based on eight data entries 46

34. Distribution of *Ictalurus nebulosus* (catfish) based on 87 data entries 47

35. Distribution of *Tinca tinca* (tench) based on 17 data entries 48

36. Distribution of *Carassius auratus* (goldfish) based on 177 data entries 49

37. Distribution of *Cyprinus carpio* (koi carp) based on 46 data entries 50

38. Distribution of *Scardinius erythrophthalmus* (rudd) based on 69 data entries 51

39. Distribution of *Gambusia affinis* (mosquitofish) based on 110 data entries 53

40. Distribution of *Poecilia reticulata* (guppy) based on six data entries 53

41. Distribution of *Perca fluviatilis* (perch) based on 144 data entries 55

1. INTRODUCTION

New Zealand has a small, but distinctive, indigenous freshwater fish fauna comprising only 27 species (McDowall 1990). The fauna and the habitats that the fish occupy have been subjected to diverse and enduring impacts, resulting from occupation of the land by both Maori and European immigrants, and it is known that populations of many, if not most, fish species have declined as a result. (It is theoretically also possible that populations of some fish species have increased, though this has not been either claimed or demonstrated.)

This report was prepared for the Department of Conservation to provide their field managers with a compendium of information to assist with their responsibilities for conservation of the fishes and of their habitats. The purposes of the report include:

1. specifying the conservation status of all fish species in the fauna, including exotic as well as indigenous fish; the reasons for including exotics were that some species (e.g., salmon and trout) are of high importance in New Zealand, and their conservation also is a statutory responsibility of the Department of Conservation, whereas other species are regarded as having habits that may have harmful impacts on other fish species or their habitats, and they are therefore relevant to the question of fish conservation;

2. listing the factors that are believed to have had harmful impacts on the fish fauna and its habitats, and have led to changes in the abundance and distributions of species through historic time;

3. pointing to possible means of protecting the species from further decline in abundance and range.

1.1 Human Impacts on Fish Populations and Habitats

Historical changes in fish distributions and abundances are considered to have had diverse causes, including the impacts of:

(a) exploitation of the fish by humans;

(b) introduction of exotic fishes into the environment;

(c) water management strategies on fish habitats and populations;

(d) land management strategies on water quality and quantity, and thus on fish habitat quality and quantity;

(e) discharging modified waters into waterways.

All of these changes to the characteristics of New Zealand waterways (i.e., lakes, swamps, rivers, streams, etc.) have had identifiable, though normally not quantified, effects on fish populations, both fish abundances and fish distributions (McDowall 1990), by affecting habitat quality and/or quantity.

1.2 Introduction of Exotic Fishes

Virtually since Europeans began to settle in New Zealand about 150 years ago, there has been a steady process of introducing exotic fishes into New Zealand and their establishment in the New Zealand environment. As a result, there are now about 20 exotic species that occupy our waters. Although these remain exotic species, they nevertheless now form an integral part of New Zealand's aquatic ecosystems, some of them being fish of great value to New Zealand society, primarily, though not wholly, for recreational angling. Although in some instances such species pose varied threats to the indigenous biota (McDowall 1987, 1990), these threats need to be weighed against the benefits that the exotic species provide. In developing policy relating to the management of exotic species, there is a need to carry out a balancing exercise between their benefits and threats.

1.3 Endangered Exotic Species

In a few instances (e.g., Atlantic salmon, sockeye salmon, mackinaw), the populations of exotic species are weak and will probably need some protection if they are to survive in New Zealand in the medium to long term. In that sense, some exotic species could be regarded as matters of conservation concern, even though they have been introduced to New Zealand. The value of the populations of these species is largely only to New Zealand, and exists because they constitute relatively disease-free stocks of species already present in this country, which could be of significance should some future uses for them develop (e.g., recreational angling or aquaculture). Should such species disappear from New Zealand

waters, importation of new stocks, without importing the diseases that they carry in their natural habitats, could be both very difficult and expensive.

There are possibly features of the New Zealand stocks of some exotic species that are of wider interest for genetic or other reasons. For example, the natural populations from which our stocks originated may now have disappeared owing to land-use practices and fisheries management strategies there.

1.4 Sea Migratory Strategies

One of the distinctive features of the New Zealand freshwater fish fauna is the extent to which species are diadromous (Fig. 1), i.e., they migrate between fresh water and the sea as a regular, often obligatory, phase of their life cycles. This is true for 17 of the 27 indigenous species (McDowall 1988). Diadromous fishes may be of three types:

1. a few species are **anadromous**, i.e., they migrate from the sea into fresh water to spawn. Typically, the larvae return to sea shortly after hatching (e.g., retropinnid smelts), although there may be a more prolonged freshwater-feeding juvenile phase (e.g., geotriid lamprey);

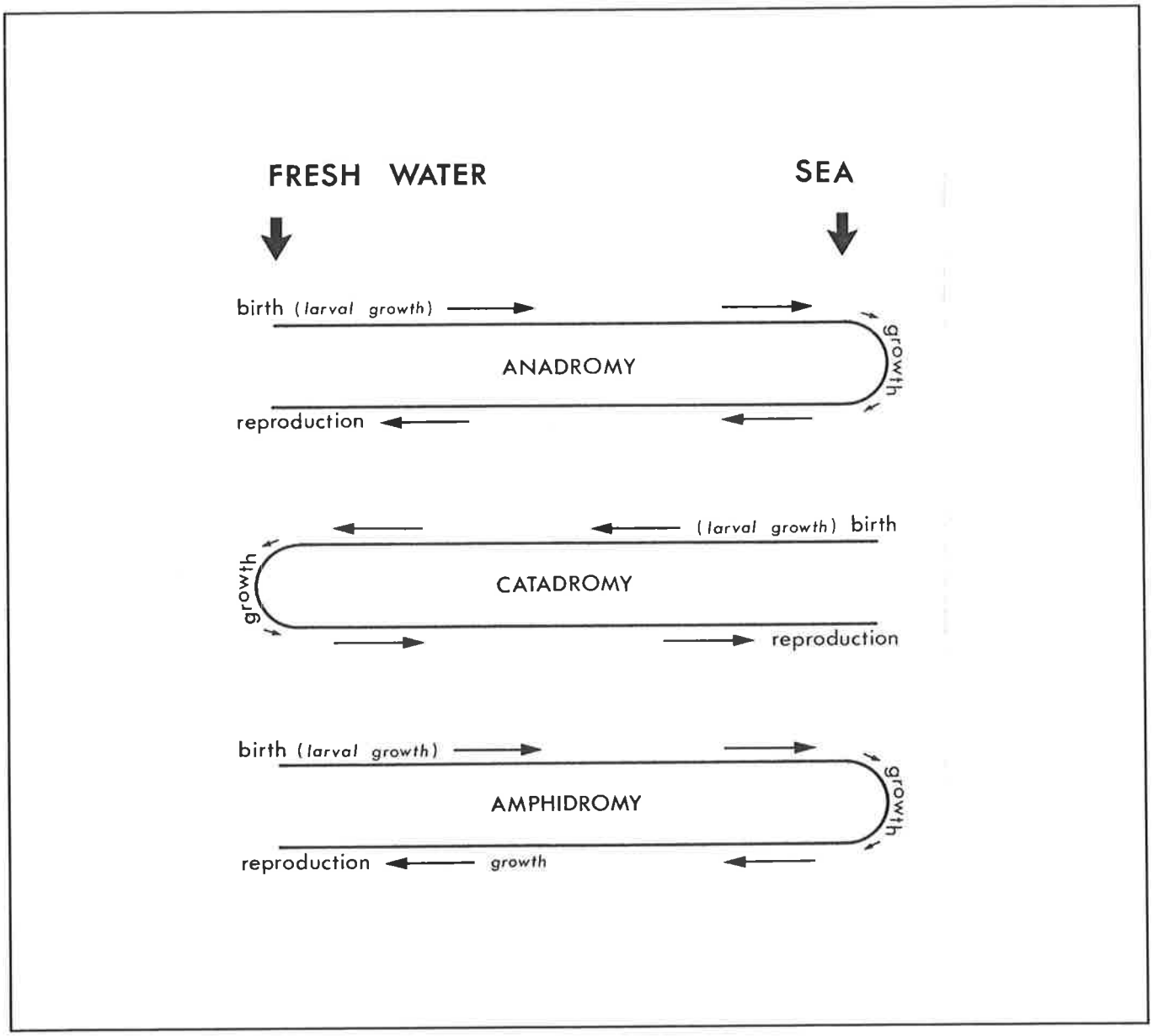

FIGURE 1. The three types of diadromy exhibited by the New Zealand freshwater fish fauna.

2. a few species are **catadromous**, i.e., the adults migrate downstream and leave fresh water to spawn at sea (e.g., anguillid eels, black flounder, and (marginally) one galaxiid, the inanga, which migrates downstream to spawn in estuaries);

3. the largest group of diadromous species is classified as **amphidromous**, i.e., there are regular movements to and from the sea, but these movements are not related specifically to reproduction. Usually, spawning is in fresh water, the larvae move rapidly to sea, live and feed there for several months, return to fresh water as small juveniles, and feed and grow there to maturity, prior to spawning etc. (These issues are discussed in detail by McDowall 1988.)

Some species are facultative as regards diadromy, and are able to establish landlocked populations, either with or without the development of barriers to migration; other species are obligatorily diadromous, so that when barriers to migration develop, populations upstream of the barrier are eliminated.

An understanding of these patterns of movement is of profound importance to proper management of New Zealand's fish populations and to conservation of the species. Knowing that species migrate is important, because this identifies the need for fish passage upstream and downstream. Knowing at what stage in the life cycle migrations occur, how large the fish are at that time, how well they can swim, climb, or jump, is also very important to enable identification of the structures etc. that are suitable to facilitate migration, or to mitigate against harmful modifications to stream flows and channels.

1.5 The Conservation Status of Indigenous Fish Species

The conservation status of many indigenous fish species is not well understood, and is based largely on semi-anecdotal information on distribution and abundance. The MAF Freshwater Fisheries Centre's freshwater fish database (McDowall and Richardson 1983) provides an extensive historical resource on occurrence of fish species, but distribution alone is a limited indicator of a species' status. Although it does show how widely a species occurs, the "robustness" of the populations at each locality is not revealed solely by distributional data. In addition, although the numbers of entries for which there are listings in the database for each species are given with the distribution maps (see Section 2), it must be remembered that these entries may include several for different areas at a single location, or could be repeat sampling from one area. For diadromous species, such distributional data may be misleading; e.g., the migratory movements may continually re-introduce a species into an area which does not support the species, either in the long term, or in relation to some age/species-specific resource need, e.g., the fish may be able to live, feed, grow, and mature, but not find spawning habitat (this is almost certainly true of some populations of inanga). Nevertheless, distributions are of some value in assessing the conservation status of fish species.

Indigenous fish species in the fauna, and their distribution and conservation status, are summarised in Table 1.

2. STATUS REPORTS ON SPECIES

In the following text, the status of all New Zealand's fish species is reviewed with regard to knowledge of their natural history and habitat requirements, their general abundance, the availability of habitat to meet the various needs of the species (as far as these are known), and the impacts of the various relevant factors (discussed in Section 1.1) on their abundance. Where pertinent, the significance of migration to and from the sea (diadromy) to the abundance and distribution of the species is reviewed.

The text is presented as follows: the fish are grouped in families, with indigenous and exotic fishes listed separately, and the families listed in the usual order, i.e., the more primitive families first, followed by an increasing order of evolutionary advancement. For each species, the following information is provided: world distribution; New Zealand distribution; natural history (a brief review of the state of knowledge, but not a review of that knowledge itself); traditional Maori fisheries; modern fisheries; abundance and status; causes of decline (in distribution and abundance); important conservation issues.

TABLE 1. Synopsis of New Zealand's indigenous fish species: their distribution and conservation status.

Common Name	Scientific name	Natural distribution	Status
Lamprey	*Geotria australis*	NZ wide	Uncertain, probably much reduced.
Longfinned eel	*Anguilla dieffenbachii*	NZ wide	Abundant and widespread
Shortfinned eel	*Anguilla australis*	NZ wide	Abundant and widespread
Common smelt	*Retropinna retropinna*	NZ wide	Abundant and widespread
Stokell's smelt	*Stokellia anisodon*	East coast SI	Abundant within range
Grayling	*Prototroctes oxyrhynchus*	NZ wide	Extinct
Giant kokopu	*Galaxias argenteus*	NZ wide	Locally eliminated, elsewhere much reduced by habitat loss
Banded kokopu	*Galaxias fasciatus*	NZ wide	Generally much reduced owing to deforestation
Shortjawed kokopu	*Galaxias postvectis*	NZ wide	Greatly reduced throughout range owing to deforestation
Koaro	*Galaxias brevipinnis*	NZ wide	Generally much reduced owing to deforestation
Common river galaxias	*Galaxias vulgaris*	Eastern SI	Widespread, but range fragmented
Inanga	*Galaxias maculatus*	NZ wide	Remains widely abundant
Dwarf inanga	*Galaxias gracilis*	Northland	Some populations threatened
Dwarf galaxias	*Galaxias divergens*	Central NZ	Remains widespread, but range possibly fragmented
Alpine galaxias	*Galaxias paucispondylus*	Eastern SI	Remains quite widespread, but local
Longjawed galaxias	*Galaxias prognathus*	Eastern SI	Remains quite widespread, but local
Canterbury mudfish	*Neochanna burrowsius*	Canterbury	Threatened by habitat loss
Brown mudfish	*Neochanna apoda*	Central NZ	Much reduced and fragmented by habitat loss
Black mudfish	*Neochanna diversus*	Northern NZ	Much reduced and fragmented by habitat loss
Torrentfish	*Cheimarrichthys fosteri*	NZ wide	Abundant and widespread
Redfinned bully	*Gobiomorphus huttoni*	NZ wide	Abundant and widespread
Giant bully	*Gobiomorphus gobioides*	NZ wide	Widespread, but local in occurrence
Common bully	*Gobiomorphus cotidianus*	NZ wide	Abundant and widespread
Bluegilled bully	*Gobiomorphus hubbsi*	NZ wide	Widespread and abundant
Upland bully	*Gobiomorphus breviceps*	Central and southern NZ	Widespread and abundant
Cran's bully	*Gobiomorphus basalis*	Northern and central NZ	Widespread and locally abundant
Black flounder	*Rhombosolea retiaria*	NZ wide	Widespread and abundant

2.1 Indigenous Species

2.1.1 Family Geotriidae

2.1.1.1 *Geotria australis* Gray (lamprey)

World distribution: Known outside New Zealand from western and eastern Australia, Tasmania, and Patagonian South America (Chile and Argentina).

New Zealand distribution: Occurs widely in New Zealand (Fig. 2, 252 entries), and old records show its presence also on the Chatham Islands; this has not been confirmed from recent data, although there is no reason to presume any significant change of status in recent decades. Records are sparse north of Taranaki in the west and north of Banks Peninsula in the east. Data are obviously minimal in that little effort has been expended in searching habitats for lamprey, and they may often be missed, being nocturnal in habit and not being distinguishable from eels without careful observation.

Natural history: Natural history of the lamprey in New Zealand is poorly documented, being based on some now rather dated work by Maskell (1929); much more is known about their natural history in Australia, where there have been extensive studies by Potter and co-workers (see Potter *et al.* 1986). Some more recent work in New Zealand by P.R. Todd (MAF Fisheries, unpublished data) examined the ecology of lamprey ammocoetes (small juveniles), and awaits completion. Virtually

nothing is known for New Zealand populations about the reproduction of the species (duration of adult life in fresh water, spawning habits and requirements, incubation and early life of ammocoetes).

Traditional Maori fisheries: Lampreys are a traditional Maori food and some exploitation still occurs using traditional Maori methods, e.g., in the upper Wanganui River (Todd 1979) and elsewhere, but the fisheries are poorly documented.

Modern fisheries: Large runs of adult lampreys are reported from time to time in various parts of New Zealand, most often because they become obvious when their movements are hindered by falls, dams etc. (Tweed 1987). At these locations they are subject to exploitation, and small fisheries exist for

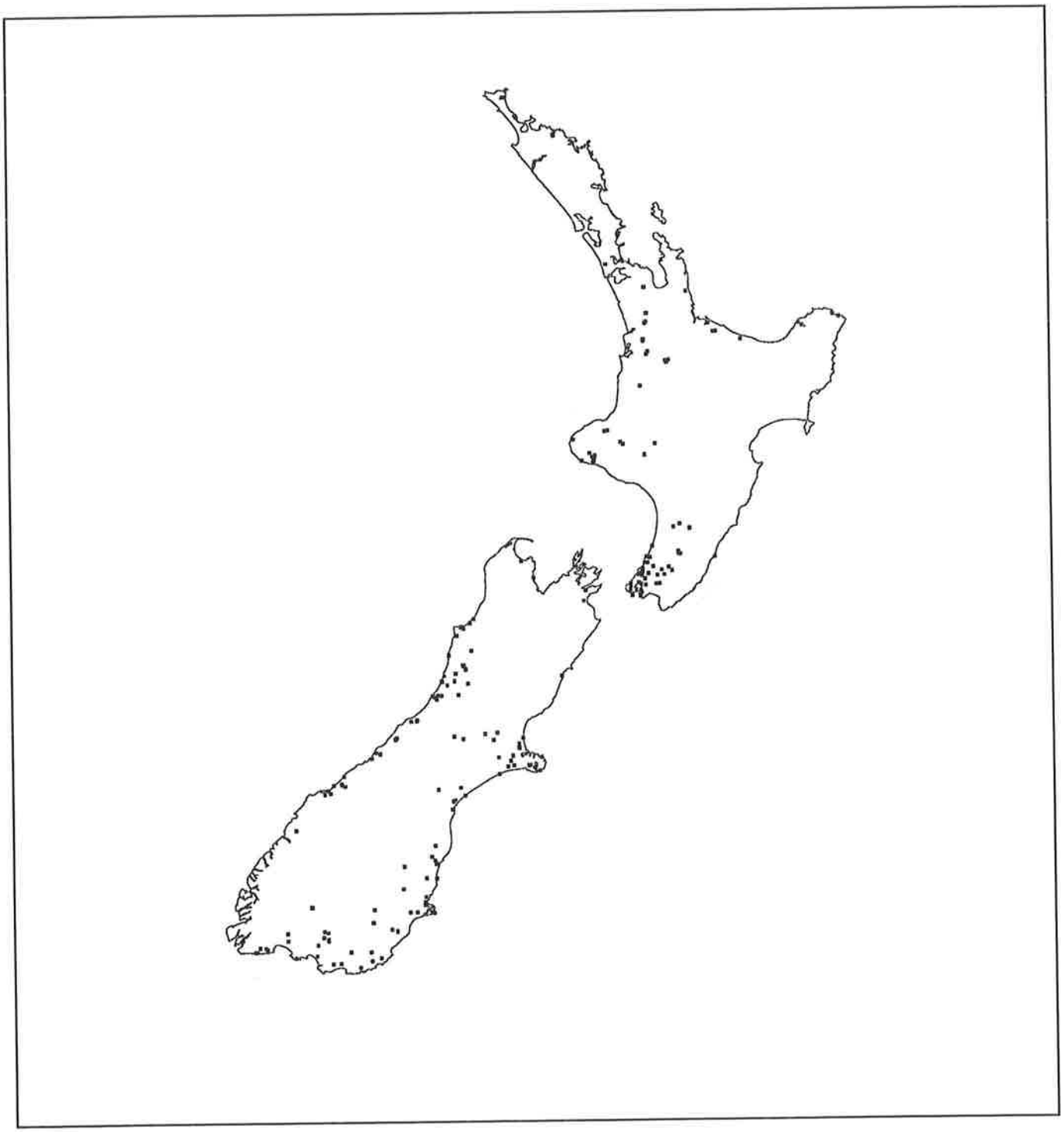

FIGURE 2. Distribution of *Geotria australis* (lamprey) based on 252 data entries.

them in several areas, particularly in Southland rivers, but also in Taranaki and perhaps elsewhere.

Abundance and status: When found, lamprey ammocoetes typically occur in small numbers, though occasionally concentrations are encountered. Adults are seen rarely, probably because their movements tend to be nocturnal, and also because their occurrence in fresh water is seasonal, the adults moving into rivers during spring, and then making their way upstream to find spawning habitats. In spite of seldom being reported in large numbers, adult lampreys are undoubtedly more abundant than reports indicate, since, from time to time, large runs are observed. The lamprey can be described as widespread, intermittent, and locally abundant in New Zealand.

Causes of decline: Abundance of the lamprey in New Zealand has been affected by construction of dams which hinder upstream movement, although adult lampreys are capable of moving upstream past obstructions of surprising magnitude, e.g., Tweed (1987) described migration upstream past the hydro dam on the Arnold River. A general decline in water quality may have affected the distribution and abundance of ammocoetes. The importance of forest cover for this species is unknown.

Important conservation issues: Fish passage is of key importance; water quality and, perhaps, forest cover also may be important, though little is known.

2.1.2 Family Anguillidae

2.1.2.1 *Anguilla dieffenbachii* (longfinned eel) and *Anguilla australis* (shortfinned eel)

New Zealand's two species of freshwater eel have been dealt with together, since many features of their occurrence in New Zealand are in common.

World distribution: The longfinned eel is endemic, but the shortfinned eel occurs also in south-eastern Australia, Tasmania, and several sub-tropical Pacific islands to the north of New Zealand.

New Zealand distribution: Both eel species are very widespread in New Zealand, the longfinned eel being the most widespread and prevalent species in the fauna (Fig. 3, 2774 entries); it has extensive inland penetration of river systems. While the shortfinned eel is less widespread, probably owing to smaller areas of suitable habitat, it is nevertheless very widely distributed; its inland penetration is less intense than that of the longfinned eel (Fig. 4, 1097 entries).

Natural history: The natural history of both eel species is well known as a result of a long series of papers by Burnet (1952, 1963, 1969a,b,c), Jellyman (1977a,b, 1979a), Todd (1980, 1981a,b,c), and Jellyman and Todd (1982).

Traditional Maori fisheries: Eels were, with little doubt, the most important food resource obtained from New Zealand fresh waters by Maori, and were of greatest relative significance to settlements at inland sites, where access to sea-foods was limited or difficult. Traditional Maori fisheries persist in some areas, and retain their importance both as regards mana and food (Best 1929; Todd 1978; Marshall 1987). Explicit knowledge of traditional Maori eel fisheries that persist to the present is deficient.

Modern fisheries: Since the mid 1960s, eels have constituted an important commercial fishery resource, especially in the Waikato and Lake Ellesmere, but also virtually New Zealand-wide. Maximum production was achieved in the mid 1970s, and catch has declined since, but eel fisheries remain as locally significant, and are an important resource (Jellyman and Todd 1982; Town 1986).

Abundance and status: Eels remain abundant, probably the most abundant species in many habitats, and there is no sense in which the species are endangered. Some observers may argue that eels are not as abundant as they used to be, and that there has been a decline in the fishery; nevertheless, eels *per se* remain abundant throughout New Zealand.

One feature of the decline in the eel fishery in New Zealand is that there has almost certainly been a major decline in the abundance of very large eels. Because eels are slow growing and long lived, very big eels (over 10-15 kg) are very old, perhaps 30 or more years (Jellyman and Todd 1982). Once such eels have been cropped from populations, it will take a long time for large fish to return (by growth) to the stocks. The absence of large eels from the populations may have implications for populations of aquatic birds (ducks, dabchicks etc.), upon which it is known, or considered likely, that large eels will prey; it will similarly have impacts on salmonid stocks.

Causes of decline: Eel abundance is certainly reduced in many parts of New Zealand as a result of both habitat degradation and exploitation,

FIGURE 3. Distribution of *Anguilla dieffenbachii* (longfinned eel) based on 2774 data entries.

though the magnitude of such decline has not been quantified. In part, this is because there is little concern about such a decline by some interest groups; eels have long been regarded as `vermin' by those interested in trout fishing and duck hunting.

Important conservation issues: Key aspects of eel conservation include managing the extent of exploitation, maintaining habitat quality, and ensuring that the juveniles migrating upstream have access to lakes and rivers. Although eel populations have been heavily exploited by commercial fishers over the past two decades, and although there has been a significant decline in abundance as a result, viable commercial eel fisheries still exist in most parts of New Zealand, and in no sense are the species involved in this

FIGURE 4. Distribution of *Anguilla australis* (shortfinned eel) based on 1097 data entries.

fishery threatened. Eels are very aggressive upstream migrants and are skilful climbers. They are known to climb both the Karapiro and Arapuni dams on the Waikato River, the Waitaki dam on the Waitaki River, and the Roxburgh dam on the Clutha River. Nevertheless, there is little doubt that dams hinder the upstream migration of elvers, so that the numbers reaching habitats further upstream are greatly reduced. An exception is Arapuni dam, where a fearsome set of rapids and cascades at "Hell's Gate" evidently prevented eels from moving upstream before the dam was built (so that, contrary to popular belief, eels could never reach the Huka Falls, to be excluded from Lake Taupo by them). Even though they are able to climb many obstacles, eels have been excluded from catchments by the construction of dams. The extent to which populations of eels have declined

as a result of exclusion from waters by dams can only be guessed at.

2.1.3 Family Retropinnidae

2.1.3.1 *Retropinna retropinna* (common smelt)

World distribution: Restricted to New Zealand.

New Zealand distribution: Common smelt occur around the whole of New Zealand, including the Chatham Islands, mainly at low elevations and not far upstream from the sea (Fig. 5, 622 entries). Inland penetration may be greater in rivers with low gradients and up which migration is easier (e.g., Waikato, Wanganui, Clutha). Land-locked populations are present in many inland and sub-montane lakes, and also in some lower

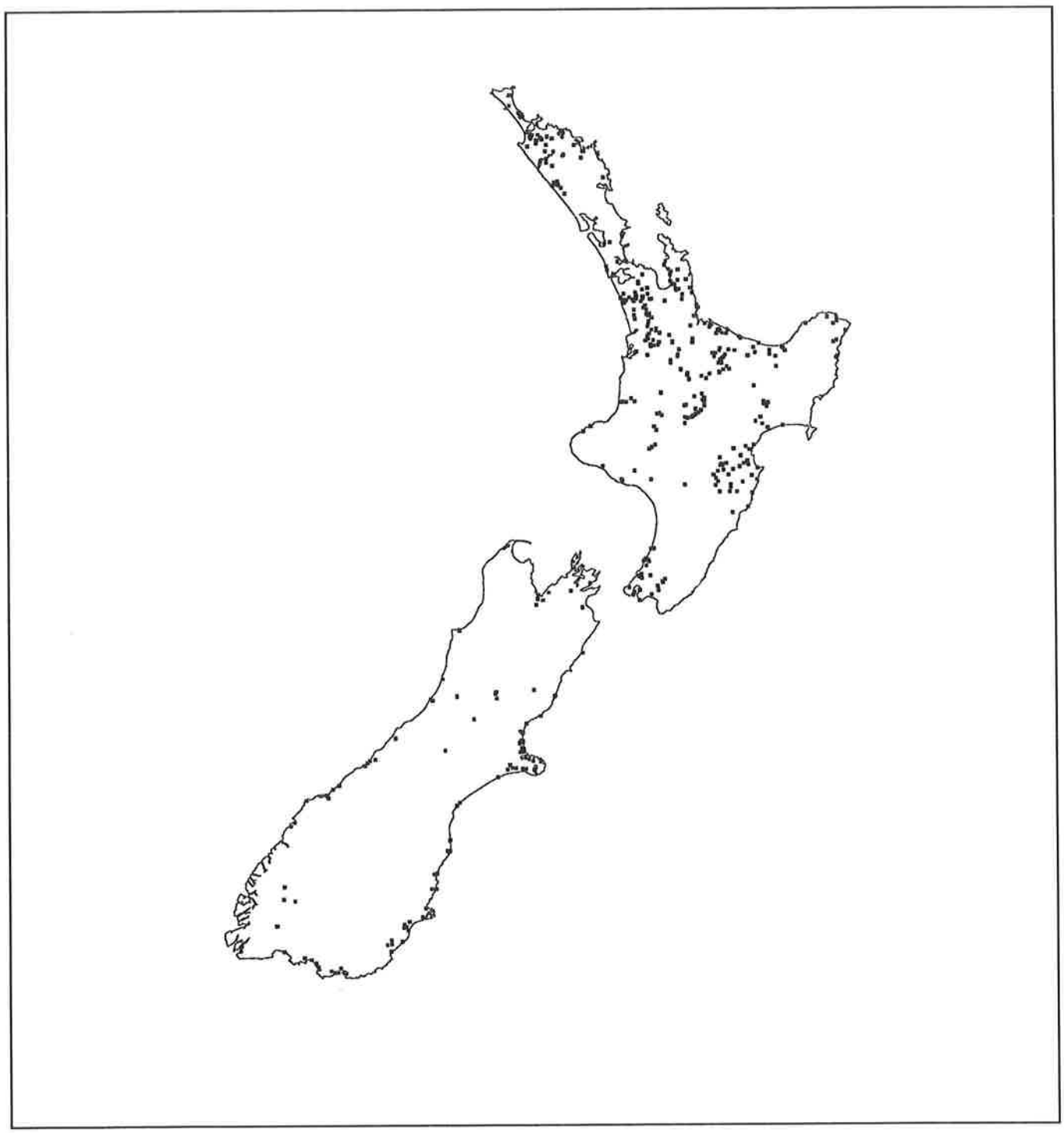

FIGURE 5. Distribution of *Retropinna retropinna* (common smelt) based on 622 data entries.

elevation and coastal/brackish lakes; many of these populations were established from introductions made during the early years of the 20th century (McDowall 1990).

Natural history: The basic life history of the common smelt is understood, but little is recorded about the reproduction of diadromous stocks; considerable attention has been given to the ecology of land-locked stocks in several lakes (Stephens 1983, 1984; Northcote and Ward 1985; Ward *et al.* 1987; Northcote 1989).

Traditional Maori fisheries: A traditional Maori fishery for common smelt persists in the Wanganui River (Hubbard 1979), but otherwise there is no documentation of continued exploitation of this species by the Maori people.

Modern fisheries: Common smelt constitute a significant proportion of the Waikato River "whitebait" fishery (where a considerable proportion of the exploitation is by Maori people, Stancliff *et al.* 1988), and the species forms a minor part of the fishery in some other larger rivers. In addition, the common smelt is the species exploited in the distinctive "whitebait" fishery on the Chatham Islands. For a brief period there was exploitation of land-locked stocks of common smelt in Lake Taupo by Maori, but this was deemed unlawful by the Department of Internal Affairs (in its role as manager of the Central North Island Wildlife Conservancy), and was stopped.

Abundance and status: There is little explicit evidence that numbers of common smelt are changing significantly (in either direction), though there are few historical data against which to measure change.

Causes of decline: There are several circumstances in which changes in abundance of comment smelt can be inferred from known habitat changes. In the Waikato, alterations to the flow patterns and channel conformation are disrupting habitats for fish species, and this may include changes to spawning habitats utilised by common smelt. Degradation in water quality in Lake Waahi has resulted in extirpation of the population of lake-limited common smelt in that lake (Ward *et al.* 1987). In some lower Waikato lakes, and perhaps elsewhere, flow control structures are preventing upstream access to diadromous common smelt moving inland from the sea.

Important conservation issues: Possibly not enough is known to deal effectively with issues relating to conservation of common smelt. Access to some of the lower Waikato lakes is impeded by flow control devices, and water quality in some of these lakes has been harmful to stocks.

2.1.3.2 *Stokellia anisodon* (Stokell's smelt)

World distribution: Restricted to New Zealand.

New Zealand distribution: Stokell's smelt are found along the eastern coast of the South Island from about the Waiau River in North Canterbury to the Waitaki River in North Otago (Fig. 6, 31 entries). (N.B. Some old records of this species from the Waiau River in Southland seem dubious.) Inland penetration is very slight, and, in most rivers, few fish penetrate more than a few kilometres above tidal influence, though small numbers may penetrate as far as 20 km inland.

Natural history: Knowledge of this fish is based on studies by McMillan (1961), augmented by information on Rakaia River populations (Eldon and Greager 1983). Their basic life history is understood, but detailed understanding is lacking.

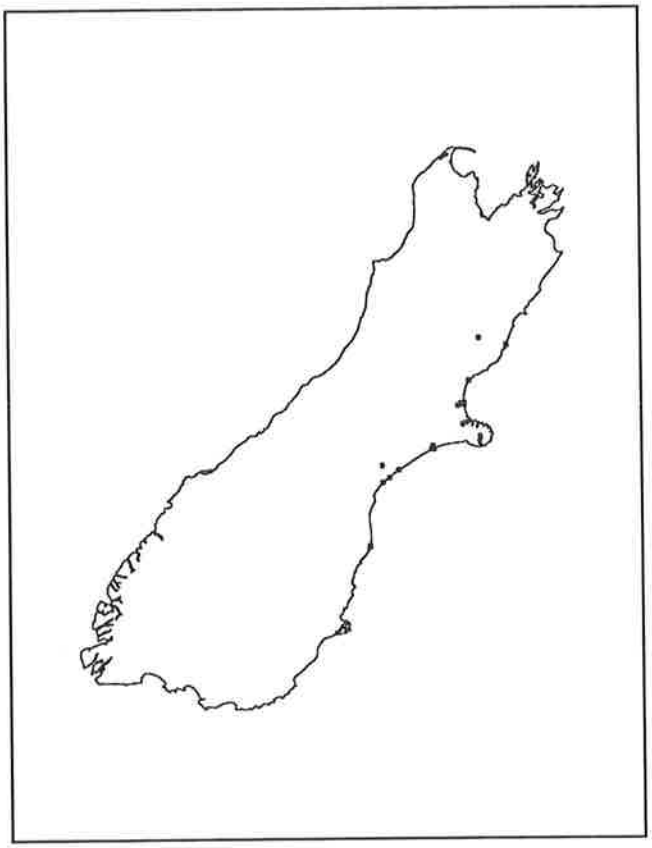

FIGURE 6. Distribution of *Stokellia anisodon* (Stokell's smelt) based on 31 data entries.

Traditional Maori fisheries: There is no evidence that this species was distinguished from the common smelt, nor much evidence that it was a significant target of Maori fishers. Nevertheless, it was probably exploited amongst the varied, small, silvery fishes that migrate through and occupy river estuaries during the spring and summer.

Modern fisheries: A small fishery aimed at commercial exploitation of this resource is developing in some Canterbury rivers (McDowall 1983); the catch at present is only a few thousand kilograms per season, which is unlikely to materially affect the species' abundance.

Abundance and status: These fish are extremely abundant seasonally in rivers like the Rakaia, Ashburton, and Rangitata, though populations are likely to fluctuate naturally in abundance between seasons.

Causes of decline: There is no evidence to indicate decline, though data on abundance are sparse.

Important conservation issues: Abundance of this species could be affected by exploitation if this expands without careful controls. Otherwise, no important conservation issues have been identified.

2.1.4 Family Prototroctidae

2.1.4.1 *Prototroctes oxyrhynchus* (grayling)

World distribution: Restricted to New Zealand.

New Zealand distribution: The grayling was probably once New Zealand-wide at lower elevations and short distances upstream from the sea, except in rivers of low gradient, where inland penetration may have been greater.

Natural history: Little is known, but some inferences can be derived from increasing knowledge of the related Australian species, *P. maraena* (Berra 1982; Berra and Cadwallader 1983).

Traditional Maori fisheries: The grayling was once a species of considerable value to the Maori.

Modern fisheries: The fish was of little consequence to European settlers, although old records show that the fish was sought and caught by anglers, and it did appear on fish markets in some coastal towns (Phillipps and Hodgkinson 1922).

Abundance and status: The grayling has almost certainly been extinct since about the 1920s, although there continue to be occasional claims that grayling have been seen in rivers, particularly rivers in the remoter parts of South Westland. These reports have been followed up, but never authenticated.

Causes of decline: The reasons for extinction are poorly understood, but may relate to a combination of habitat degradation, following deforestation, and the impacts of introduced fish species.

Important conservation issues: With the species already extinct it is too late either to identify these or to put conservation strategies into effect.

2.1.5 Family Galaxiidae

2.1.5.1 *Galaxias argenteus* (giant kokopu)

World distribution: Restricted to New Zealand.

New Zealand distribution: Giant kokopu are distributed widely in locations close to the sea and at low elevations (Fig. 7, 313 entries). Gapsin the known distribution relate in part to incomplete knowledge, but some real distributional gaps exist, particularly in the eastern South Island. There are some land-locked stocks in West Coast and Southland lakes, but the status of these populations is not definitely understood.

Natural history: It is known that this is an amphidromous species (Fig. 1), in which the larvae go to sea on hatching, and the juveniles return from the sea during the spring, when they may be captured in the whitebait fishery. Otherwise, very little is known of the natural history of this species. Published studies comprise a very small amount of information on food (Jellyman 1979b; Main and Lyon 1989).

Traditional Maori fisheries: This species was certainly of some importance to the Maori, but no current interest in this species by Maori is documented.

Modern fisheries: As noted above, the juveniles of this species are taken in the whitebait fishery, although the species' numerical contribution to the catch is extremely small (probably < 1%) (McDowall and Eldon 1980; McDowall 1984b); this is due partly to their later migratory season (when whitebaiting has usually ceased), and to the low numbers present in the whitebait shoals at any time of the season.

Abundance and status: While quantification of a change in abundance is not possible, there can be no doubt that this fish has suffered drastic population decline since the middle of last century. It has virtually vanished from the eastern South Island, though it was once abundant enough for some of the early settlers in the Timaru district to mention it as an item of food (Anderson 1916). There were also early reports from the Lake Ellesmere district, but not in recent decades.

The giant kokopu is designated a species of "indeterminate status" in the New Zealand Red Data Book (Williams and Given1981), owing to the decline in its abundance and the paucity of information on its occurrence and natural history. It is properly a matter for some conservation concern.

FIGURE 7. Distribution of *Galaxias argenteus* (giant kokopu) based on 313 data entries.

Causes of decline: The decline in abundance of the giant kokopu relates principally to habitat modification or destruction, often resulting from the combined or separate effects of swamp drainage and deforestation. The fish rarely co-exists with trout, raising the possibility of competitive exclusion of some sort.

Important conservation issues: This question is in need of investigation, to identify important features of the habitats occupied by giant kokopu. Exploitation in the whitebait fishery may be contributing to reduced abundance, although whitebait of this species tend to migrate towards and after the end of the fishing season. Owing to their migratory habits, maintenance of access to upstream habitats is of great importance to conservation of giant kokopu populations.

2.1.5.2 *Galaxias fasciatus* (banded kokopu)

World distribution: Restricted to New Zealand.

New Zealand distribution: Banded kokopu are present around the entire hilly, lowland areas of New Zealand and penetrates considerable distances upstream in some river systems; present on Banks Peninsula, but otherwise not common in eastern New Zealand from East Cape to the vicinity of Dunedin (Fig. 8, 683 entries). The absence of records from some areas, like southern Taranaki - Wanganui - northern Manawatu, may be due to a lack of sampling.

Natural history: This is an amphidromous species in which spawning occurs in fresh water, with the larvae going immediately to sea for early growth. Some aspects of its natural history (age/growth, feeding, and reproduction) (Ots and Eldon 1975; Hopkins 1979a,b; Mitchell and Penlington 1982; Main and Lyon 1989), and habitat (Main in prep.) have been studied, but information remains fragmentary on many aspects of both natural history and habitat requirements. Land-locked stocks occur in a few lakes.

Traditional Maori fisheries: Like the giant kokopu, banded kokopu were of importance to the Maori as a food, primarily as the large adult (Best 1929).

Modern fisheries: Banded kokopu make a small, though significant, contribution to the whitebait fishery in some river systems, particularly those that continue to have well-forested catchments.

Abundance and status: The fish remains locally abundant in many areas of New Zealand, including parts of Northland and Coromandel, areas around Wellington, and along the West Coast of the South Island; it is intermittent in many other areas.

Causes of decline: The banded kokopu has undoubtedly suffered serious population decline in much of New Zealand, and this is believed to be largely the result of deforestation - the species is rare in catchments that have no forest cover, occasional in streams which have upstream forest remnants, and most abundant in streams within forests (Main *et al.* 1985; Taylor and Main 1987).

Important conservation issues: Retention of forest cover is clearly of high significance to the continued survival of populations of banded kokopu, as is ensuring that access to upstream habitats continues to be available to the migratory whitebait.

2.1.5.3 *Galaxias postvectis* (shortjawed kokopu)

World distribution: Restricted to New Zealand.

New Zealand distribution: The shortjawed kokopu is widespread but intermittent in occurrence, and appears to be absent from wide areas of New Zealand; inland penetration is moderate (Fig. 9, 153 entries, mostly from Westland).

Natural history: This species is amphidromous, with spawning occurring in fresh water and the larval life marine. Juveniles return to fresh water amongst the whitebait fishery. Otherwise, their natural history is virtually unknown. When found, this fish almost invariably occurs in forested streams with extensive instream cover.

Abundance and status: Because the habitat of this species requires investigation and better description, it is difficult to assess its abundance, but on the basis of existing knowledge it can properly be described as a rare species. It was classified as a species of "indeterminate status" by the World Red Data Book on Fishes (Miller 1977), and this status was reiterated by Williams and Given(1981) in the New Zealand Red Data Book.

Causes of decline: Deforestation is likely to be a primary cause of decline in the abundance of shortjawed kokopu. In some places, construction of dams and weirs may prevent upstream migration, resulting in the loss of local populations.

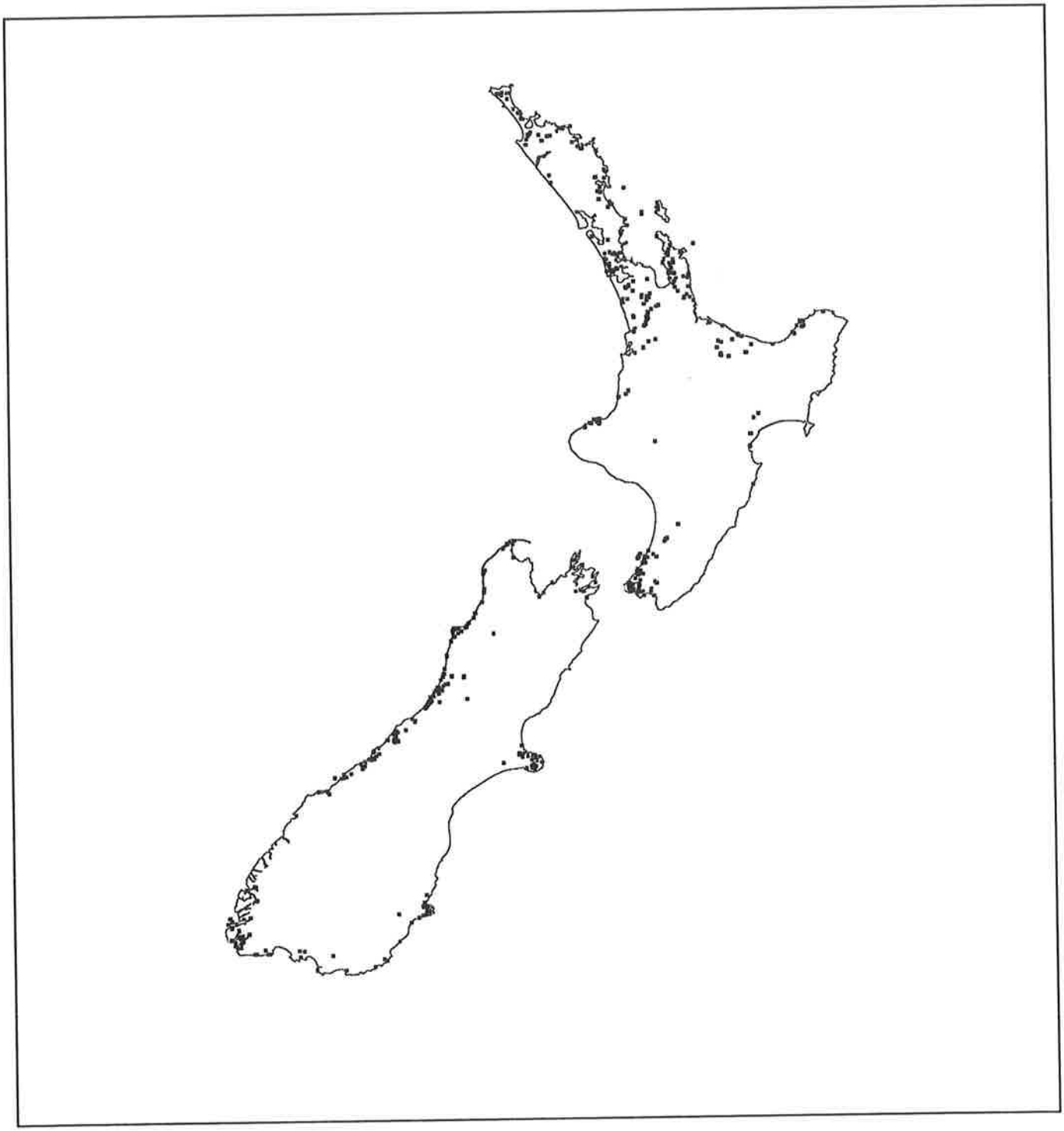

FIGURE 8. Distribution of *Galaxias fasciatus* (banded kokopu) based on 683 data entries.

Important conservation issues: Retention of forest cover is clearly of high significance to the continued survival of populations of shortjawed kokopu, as is ensuring that access to upstream habitats continues to be available to the migratory whitebait.

2.1.5.4 *Galaxias brevipinnis* (koaro)

World distribution: Occurs in south-eastern Australia, Tasmania, and the Auckland and Campbell Islands, in addition to New Zealand.

New Zealand distribution: This species is very widespread, the greatest centres of abundance being along the West Coast (Fig. 10, 899 entries).

FIGURE 9. Distribution of *Galaxias postvectis* (shortjawed kokopu) based on 153 data entries.

This fish penetrates long distances inland, to substantial elevations about 1000 m); it also occupies many inland and high elevation lakes as land-locked populations.

Natural history: This is another amphidromous species, with the juveniles known to return to fresh water amongst the whitebait; otherwise the natural history of this fish has scarcely been studied in any way. Habitats are most often within forest (Main *et al.* 1985; Taylor and Main 1987), but have not been quantified. Nothing is known about reproduction; foods have been examined briefly (Main and Winterbourn 1987; Glova and Sagar 1989).

Traditional Maori fisheries: Koaro was a valued species, especially the shoaling, lake juveniles that

FIGURE 10. Distribution of *Galaxias brevipinnis* (koaro) based on 899 data entries.

were once taken in great abundance by the Maori from lakes of the central North Island (McDowall 1990).

Modern fisheries: This is the second-most abundant species in the whitebait fishery, and in some areas (e.g., West Coast, Bay of Plenty) it makes a significant contribution to the catches from some river systems.

Abundance and status: Koaro remain locally abundant, though populations have obviously declined greatly. However, there is little reliable, long-term information on the abundance of sea-migratory stocks. There have been major declines in lake stocks in the central North Island, such that the fish no longer constitutes a food of any significance to the Maori in that area (McDowall 1987, 1990).

Causes of decline: Deforestation is likely to be a primary cause of decline in abundance of the koaro. In some places, construction of dams and weirs may prevent upstream migration leading to the loss of local populations, although this fish is a very aggressive climber. Declines in inland lakes follow, and can be attributed to the introduction of trout (McDowall 1987, 1990).

Important conservation issues: Retention of forest cover is clearly of high significance to the continued survival of populations of koaro, as is ensuring that access to upstream habitats continues to be available to the migratory whitebait. Where there are lakes that still do not have trout in them, it is important that trout remain excluded. Lakes Rotopounamu, Chalice, and Christabel, all designated Faunistic Reserves, are trout-free lakes of importance to koaro.

2.1.5.5 *Galaxias vulgaris* (common river galaxias)

World distribution: Restricted to New Zealand.

New Zealand distribution: This fish occurs almost exclusively along the eastern South Island from Nelson-Marlborough to Canterbury (Fig. 11, 382 entries); it was found recently on Stewart Island (W.L. Chadderton, pers. comm.) where its status is uncertain.

Natural history: A non-diadromous species, the natural history of the common river galaxias has been studied extensively and is well understood (Benzie 1968d; Cadwallader 1975, 1976a,b, 1978).

Traditional Maori fisheries: There has been no known exploitation by Maori, although the fish was probably not distinguished from the koaro.

Modern fisheries: No exploitation.

Abundance and status: Although this fish remains widespread and abundant within its known range, there is strong circumstantial evidence that its distribution and abundance have declined. Possibly, the current widespread occurrence of this species has obscured the extent to which populations have declined in historic times; the issue needs study.

Causes of decline: Possibly, the widespread invasion of common river galaxias habitats by trout has caused a reduction in numbers and range, but this hypothesis requires investigation.

Important conservation issues: As already noted, study of its present range and interactions with trout are probably the primary issues of concern for the conservation of common river galaxias.

FIGURE 11. Distribution of *Galaxias vulgaris* (common river galaxias) based on 382 data entries

2.1.5.6 *Galaxias maculatus* (inanga)

World distribution: Occurs in western and eastern Australia, Tasmania, Lord Howe Island, Patagonian Chile and Argentina, and the Falkland Islands, in addition to New Zealand.

New Zealand distribution: This fish is universally present around New Zealand in low elevation and low gradient rivers, streams, lakes, and lagoons; inland penetration is slight (Fig. 12, 909 entries).

Natural history: Inanga is a catadromous species in which the adults migrate to estuaries to spawn, and the larvae move to the sea for their early life and growth before returning to fresh water. It has been studied extensively over a long period owing to its importance to the whitebait fishery (Benzie 1968a,b,c; McDowall 1968, 1984a; McDowall and Eldon 1980), and is probably the best known of the

FIGURE 12. Distribution of *Galaxias maculatus* (inanga) based on 909 data entries.

indigenous fishes; nevertheless, gaps in our knowledge inevitably remain and are substantial.

Traditional Maori fisheries: Inanga was of high importance to the Maori, both as the juvenile returning from the sea, but especially the ripe adults moving downstream into river estuaries to spawn (Best 1929; McDowall 1990)

Modern fisheries: Inanga is the basis for the modern whitebait fishery, being the sole species in some rivers, and the predominant species in almost all rivers (McDowall 1968, 1984a; McDowall and Eldon 1980).

Abundance and status: Inanga remain common and widespread in all parts of New Zealand. Although a decline cannot be quantified, there is

nevertheless no doubt that the abundance of the species is substantially less than it was 100 years ago. The species itself is not a matter for concern, but the fishery has declined in most parts of New Zealand.

Causes of decline: The reduction in abundance of inanga is almost certainly a result of habitat degradation; this is especially applicable to the deterioration and loss of estuarine spawning grounds, as well as a reduction in the areas of, quality of, and access to lowland swamps and lakes. Exploitation is often cited as a cause for decline, but is unproven; in view of the fluctuations in abundance, it is unlikely to be a prime cause.

Important conservation issues: Three primary concerns apply to the conservation of inanga, and relate directly to the causes of decline:

(i) maintenance or improvement of estuarine spawning grounds is of fundamental importance;

(ii) adequate lowland habitat must be maintained;

(iii) access to such habitats must be assured.

2.1.5.7 *Galaxias gracilis* (dwarf inanga)

World distribution: Restricted to New Zealand.

New Zealand distribution: Dwarf inanga are found only in a few lakes in Northland (Fig. 13, 17 entries).

Natural history: Unstudied.

Traditional Maori fisheries: None known.

Modern fisheries: None; some agencies have suggested that this species might usefully be introduced into small lakes as trout forage. In view of the failure of the species to withstand trout predation in lakes where it already co-occurs with trout, this suggestion seems to have little sense.

Abundance and status: Stocks have suffered major declines in several lakes (e.g., Kai Iwi Lakes, Lake Waingata, near Dargaville), and the future of this species is a matter for considerable concern.

Causes of decline: The reduction in abundance of this fish seems to be directly related to the introduction of rainbow trout into their habitats.

Important conservation issues: Conservation seems to depend on excluding trout from dwarf inanga habitats, and it is important that at least some of the lakes in Northland where this fish occurs be retained free from trout and other exotic fishes.

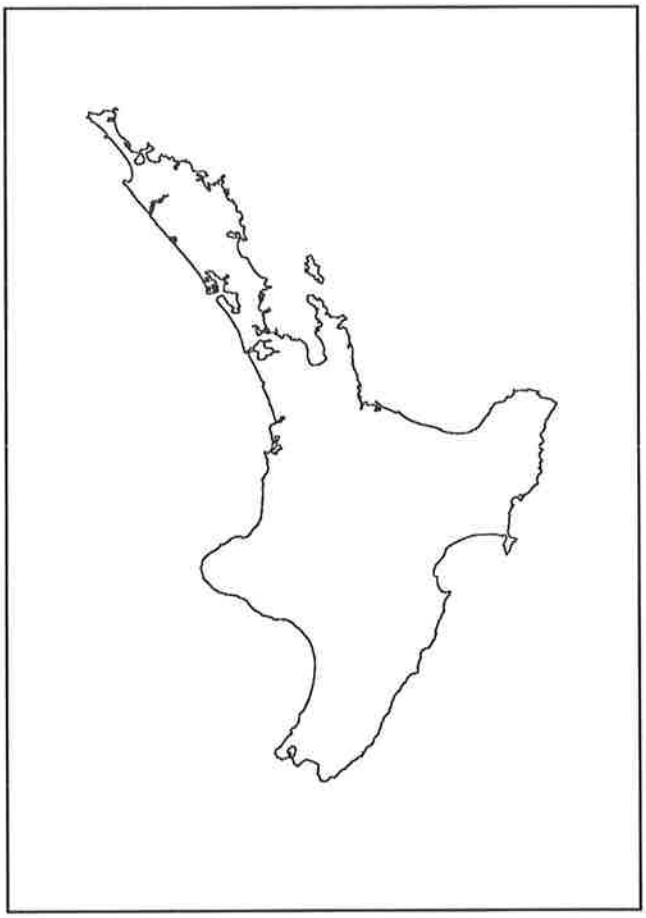

FIGURE 13. Distribution of *Galaxias gracilis* (dwarf inanga) based on 17 data entries.

2.1.5.8 *Galaxias divergens* (dwarf galaxias)

World distribution: Restricted to New Zealand.

New Zealand distribution: This fish occurs widely in the eastern and southern North Island, and northern and north-western South Island. Distribution is intermittent, especially in the North Island (Fig. 14, 189 entries).

Natural history: The dwarf galaxias is a non-migratory species which never enters the sea. Its natural history has been studied (Hopkins 1971), so that essential features of the life cycle are understood, but spawning has not been described.

Traditional Maori fisheries: None known.

FIGURE 14. Distribution of *Galaxias divergens* (dwarf galaxias) based on 189 data entries.

Modern fisheries: None.

Abundance and status: There is little to indicate that this species has declined in abundance. Its distribution is fragmented, perhaps suggesting areas of extirpation, but nevertheless it is locally abundant and widespread.

Causes of decline: It seems inevitable that this fish will have suffered from water resource and catchment management. There is considerable circumstantial evidence that populations in some areas have been diminished by the presence and influence of brown trout.

Important conservation issues: The primary concern is probably to determine the impact of introduced trout on populations of this fish.

2.1.5.9 *Galaxias paucispondylus* (alpine galaxias)

World distribution: Restricted to New Zealand.

New Zealand distribution: This species occurs almost exclusively in the eastern South Island from Marlborough to Southland, largely in high elevation streams and rivers (Fig. 15, 74 entries).

Natural history: Little is known, but it is currently the subject of exploratory research (Bonnett in prep., Bonnett *et al.* 1989).

Traditional Maori fisheries: None known.

Modern fisheries: None.

Abundance and status: This fish remains locally abundant in largely unmodified and often inaccessible habitats.

Causes of decline: There is no explicit evidence of a decline, although this does not mean that there has not been a reduction in either range or abundance.

Important conservation issues: The primary concern is probably to determine the existing range of the fish, which is still not well defined.

2.1.5.10 *Galaxias prognathus* (longjawed galaxias)

World distribution: Restricted to New Zealand.

New Zealand distribution: This species occurs almost exclusively in the eastern South Island from Marlborough to North Otago, largely in higher elevation, inland rivers and streams (Fig. 16, 28 entries).

Natural history: Little is known, but it is currently the subject of exploratory research (Bonnett in prep., Bonnett *et al.* 1989).

Abundance and status: This species remains locally abundant, but it is not known from many localities. It occurs largely in unmodified and often inaccessible habitats.

Causes of decline: There is no explicit evidence of a decline, although this does not mean that there

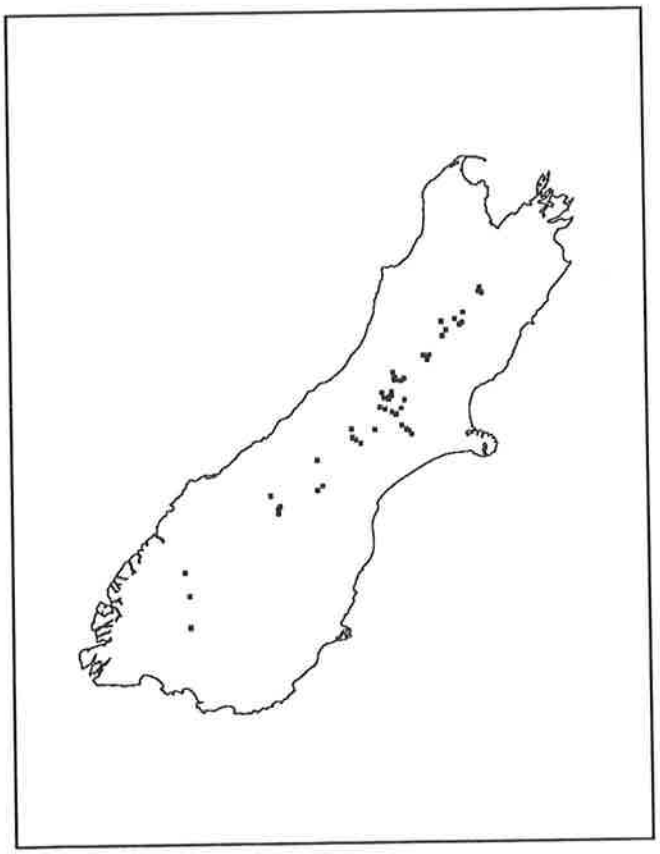

FIGURE 15. Distribution of *Galaxias paucispondylus* (alpine galaxias) based on 74 data entries.

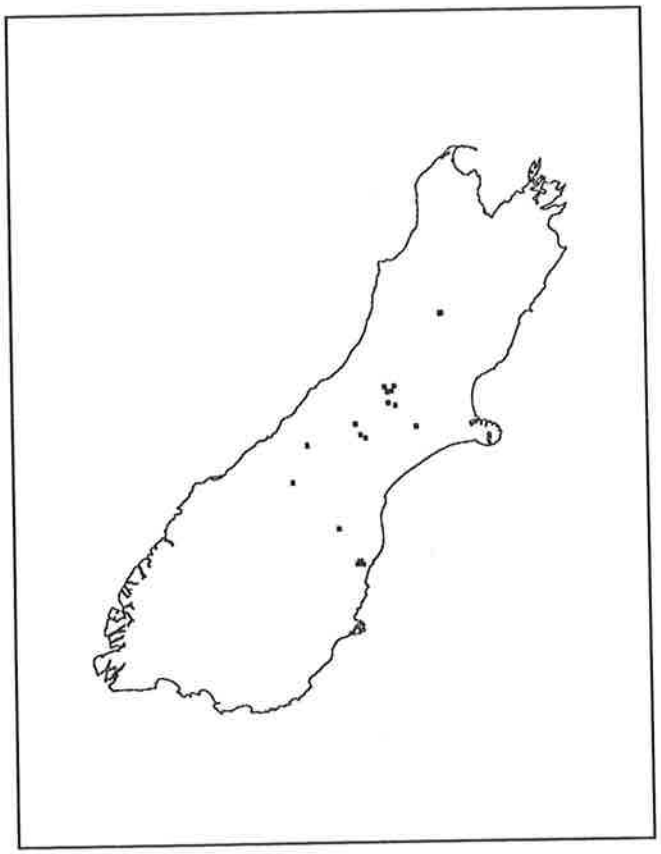

FIGURE 16. Distribution of *Galaxias prognathus* (longjawed galaxias) based on 28 data entries.

has not been a reduction in either range or abundance.

Important conservation issues: The primary concern is probably to determine the existing range of the fish, which is still not well defined.

2.1.5.11 *Neochanna burrowsius* (Canterbury mudfish)

World distribution: Restricted to New Zealand.

New Zealand distribution: This fish is known only from Canterbury and south to the Waitaki River, mostly at lower elevations (Fig. 17, 50 entries).

FIGURE 17. Distribution of *Neochanna burrowsius* (Canterbury mudfish) based on 50 data entries.

Natural history: The Canterbury mudfish is a non-migratory species that spends its entire life in fresh water; its natural history has been well studied (Eldon 1979a,b,c; Eldon *et al.* 1978).

Traditional Maori fisheries: Status uncertain, as "hauhau", which are evidently a form of mudfish, were taken as food by the Maori (Phillipps 1940).

Modern fisheries: None.

Abundance and status: The distribution and abundance of the Canterbury mudfish have declined greatly over the past 50 years, and the species is now only locally present, often in fragile or threatened habitats.

It has been designated a "rare" species in the World Red Data Book on Fishes (Miller 1977), and its status is a matter for concern to conservationists.

Causes of decline: The reduction in its range and abundance can be attributed to habitat modification. Many former habitats have disappeared over the past 50 years, largely owing to swamp drainage.

Important conservation issues: The key to preserving this species is location and protection of the remaining habitats, including the careful management of land surrounding habitats, to prevent lowering of water tables and dehydration of habitats.

2.1.5.12 *Neochanna apoda* (brown mudfish)

World distribution: Restricted to New Zealand.

New Zealand distribution: This species occurs in the southern North Island, from Taranaki (although there have been no records there for many years) and Wairarapa southwards), and on the West Coast of the South Island (once, perhaps, also in Nelson) (Fig. 18, 62 entries).

Natural history: The brown mudfish is a non-migratory species that spends its entire life in fresh water; its natural history has been well reported (Eldon 1978).

Traditional Maori fisheries: Brown mudfish were once favoured by Maori as a food (known as hauhau) (Phillipps 1940).

Modern fisheries: None.

Abundance and status: The species has undoubtedly suffered great reductions in range, available habitats, and abundance. It has been eliminated from some substantial areas, such as the west coast of the North Island from Taranaki to Wellington, where it is now only occasionally recorded - though isolated pockets remain. In many areas, its chief habitats are now road-side and farm drains, which are very vulnerable to destruction or degradation. Nevertheless, the fish

FIGURE 18. Distribution of *Neochanna apoda* (brown mudfish) based on 62 data entries.

remains locally abundant in some areas, especially Wairarapa and the West Coast.

Causes of decline: The reduction in brown mudfish populations is primarily a result of deforestation and swamp drainage.

Important conservation issues: Conservation of this species depends on finding and preserving its remaining habitats, including the careful management of areas surrounding such habitats to prevent reduction of water tables.

2.1.5.13 *Neochanna diversus* (black mudfish)

World distribution: Restricted to New Zealand.

New Zealand distribution: The species occurs in the northern North Island from the King Country and Hauraki Plains to the far north (Fig. 19, 75 entries).

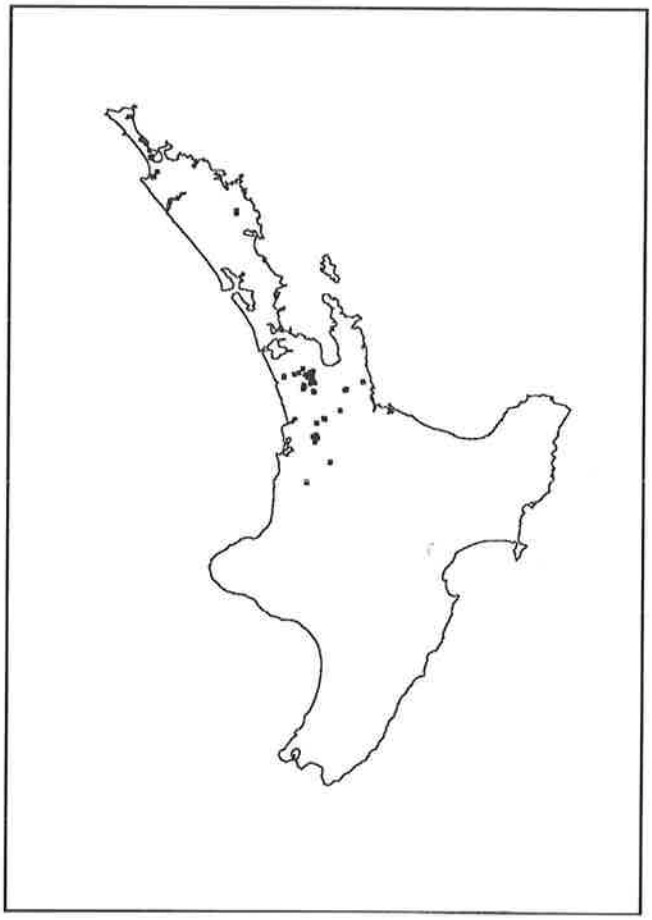

FIGURE 19. Distribution of *Neochanna diversus* (black mudfish) based on 75 data entries.

Natural history: The black mudfish is a non-migratory species which spends its entire life in fresh water. Its natural history is virtually unstudied (see, however, Thompson 1987).

Traditional Maori fisheries: Status uncertain, as "hauhau", which are evidently a form of mudfish, were taken by the Maori as food (Phillipps 1940).

Modern fisheries: None.

Abundance and status: The black mudfish undoubtedly has suffered great reductions in range, available habitats, and abundance. It has been eliminated from some substantial areas, although isolated pockets remain. It remains abundant in some of the lower Waikato swamplands, which is now its chief centre of occurrence.

Causes of decline: The reduction in black mudfish populations is primarily a result of deforestation and swamp drainage.

Important conservation issues: Conservation of this species depends on finding and preserving its remaining habitats, including the careful management of areas surrounding such habitats to prevent reduction of water tables.

2.1.6 Family Mugiloididae

2.1.6.1 *Cheimarrichthys fosteri* (torrentfish)

World distribution: Restricted to New Zealand.

New Zealand distribution: Torrentfish are very widespread and present in most parts of New Zealand; the paucity of records from southern New Zealand may reflect a lack of sampling (Fig. 20, 687 entries).

Natural history: An amphidromous species in which the larvae (? = uncertain) go to sea on hatching; they feed and grow at sea before returning to fresh water as juveniles. The natural history of this species is very little studied, but it seems that sexes segregate within rivers, with females living further upstream than males (Scrimgeour and Eldon 1989; McDowall 1990).

Traditional Maori fisheries: Evidently the torrentfish was once a species of considerable culinary importance, but its precise value to the Maori is little understood.

Modern fisheries: None.

Abundance and status: Remains widespread and abundant.

Causes of decline: There is no evidence that points to a decline in torrentfish populations in historic times.

Important conservation issues: The key to conservation of this species is to increase our understanding of its natural history, especially reproduction, which is virtually unknown, and its migratory behaviour, which appears to be both complex and important to maintaining populations. Dams on river systems will impede movement and disrupt the life cycle.

FIGURE 20. Distribution of *Cheimarrichthys fosteri* (torrentfish) based on 687 data entries.

2.1.7 Family Eleotridae

2.1.7.1 *Gobiomorphus huttoni* (redfinned bully)

World distribution: Restricted to New Zealand.

New Zealand distribution: This species is widely present at lower altitudes, but inland penetration is only moderate (Fig. 21, 1188 entries).

Natural history: The redfinned bully is an amphidromous species which has a moderately well understood life history owing to studies in the 1960s (McDowall 1964, 1965a,b); the larvae go to sea on hatching in early spring, and the juveniles return later in spring.

Traditional Maori fisheries: None known.

FIGURE 21. Distribution of *Gobiomorphus huttoni* (redfinned bully) based on 1118 data entries.

Modern fisheries: Of no importance.

Abundance and status: The redfinned bully remains moderately abundant in many parts of New Zealand, although it is largely absent from the east coast of the South Island; it shows some affinity with forested catchments, but is widespread outside forests.

Causes of decline: No decline in abundance has been demonstrated, though it is likely to have occurred, and would be connected with habitat deterioration, including deforestation.

Important habitat issues: Exclusion of the fish from upstream habitats by construction of facilities which impede upstream migration is the most

likely cause of a reduction in their range and abundance.

2.1.7.2 *Gobiomorphus gobioides* (giant bully)

World distribution: Restricted to New Zealand.

New Zealand distribution: The known distribution indicates this species to be widespread around the whole of New Zealand at very low altitudes, close to the sea, with occurrence being patchy; however, it is probably more general in occurrence than the present data suggest (Fig. 22, 135 entries). Further exploratory sampling is desirable to clarify this.

Natural history: The giant bully is virtually unstudied, and understanding of its biology is largely by transfer of knowledge of the life history of other related species. It is considered to be amphidromous.

FIGURE 22. Distribution of *Gobiomorphus gobioides* (giant bully) based on 135 data entries.

Traditional Maori fisheries: Not known, but possibly it was consumed owing to its relatively large size.

Modern fisheries: None.

Abundance and status: This is difficult to determine, owing to the lack of historical information. It is locally abundant, and is possibly more abundant than the present data indicate.

Causes of decline: Degradation of estuarine habitats may have had a serious impact on this species. However, no decline in abundance has been demonstrated, though this is likely to have occurred.

Important conservation issues: Exclusion of the fish from upstream habitats by the construction of facilities which impede upstream migration is a likely cause of a reduction in the range and abundance. Maintenance of quality habitats in estuaries and the lower reaches of rivers is equally important for maintaining populations of this species.

2.1.7.3 *Gobiomorphus cotidianus* (common bully)

World distribution: Restricted to New Zealand.

New Zealand distribution: Widespread throughout New Zealand, with amphidromous populations at low elevations and land-locked populations in lakes at all elevations (Fig. 23, 1455 entries).

Natural history: Despite being a common species, the common bully has received little research attention. Stephens (1982) studied a lake population. Amphidromous and land-locked populations occur throughout its range; the juveniles of amphidromous stocks return to fresh water over the spring and summer.

Traditional Maori fisheries: None known.

Modern fisheries: None.

Abundance and status: The common bully remains abundant and widespread in most parts of New Zealand, and is not a cause for concern.

Causes of decline: No decline in abundance has been demonstrated, though it is likely, and would be connected with habitat deterioration and perhaps barriers to upstream migration.

Important conservation issues: Exclusion of the fish from upstream habitats by the construction of facilities which impede upstream migration is the most likely cause of a reduction in abundance.

2.1.7.4 *Gobiomorphus hubbsi* (bluegilled bully)

World distribution: Restricted to New Zealand.

New Zealand distribution: This species is widespread at lower and moderate elevations with modest inland penetration; the present data suggest that its occurrence is somewhat patchy, but this may be due to sampling inadequacies (Fig. 24, 383 entries).

Natural history: The bluegilled bully is almost completely unstudied; it is known to be amphidromous, but otherwise knowledge is by implication from knowledge of the redfinned bully.

Traditional Maori fisheries: None known.

Modern fisheries: None.

Abundance and status: This species remains locally abundant and widespread, though historic changes in distribution and abundance cannot be measured owing to a lack of early data.

Causes of decline: No decline in abundance has been demonstrated, though it is likely, and would be connected with habitat deterioration and barriers to upstream migration.

Important conservation issues: Exclusion of the fish from upstream habitats by the construction of facilities which impede upstream migration is the most likely cause of a reduction in their range and abundance.

2.1.7.5 *Gobiomorphus breviceps* (upland bully)

World distribution: Restricted to New Zealand.

New Zealand distribution: This fish occurs widely in the southern North Island, northern, north-western, and eastern South Island, at all elevations (Fig. 25, 919 entries).

Natural history: The ecology of a lake population is known from a study by Staples (1975a,b,c), but lake populations are unusual. Stream populations are virtually unstudied. It is a non-diadromous species.

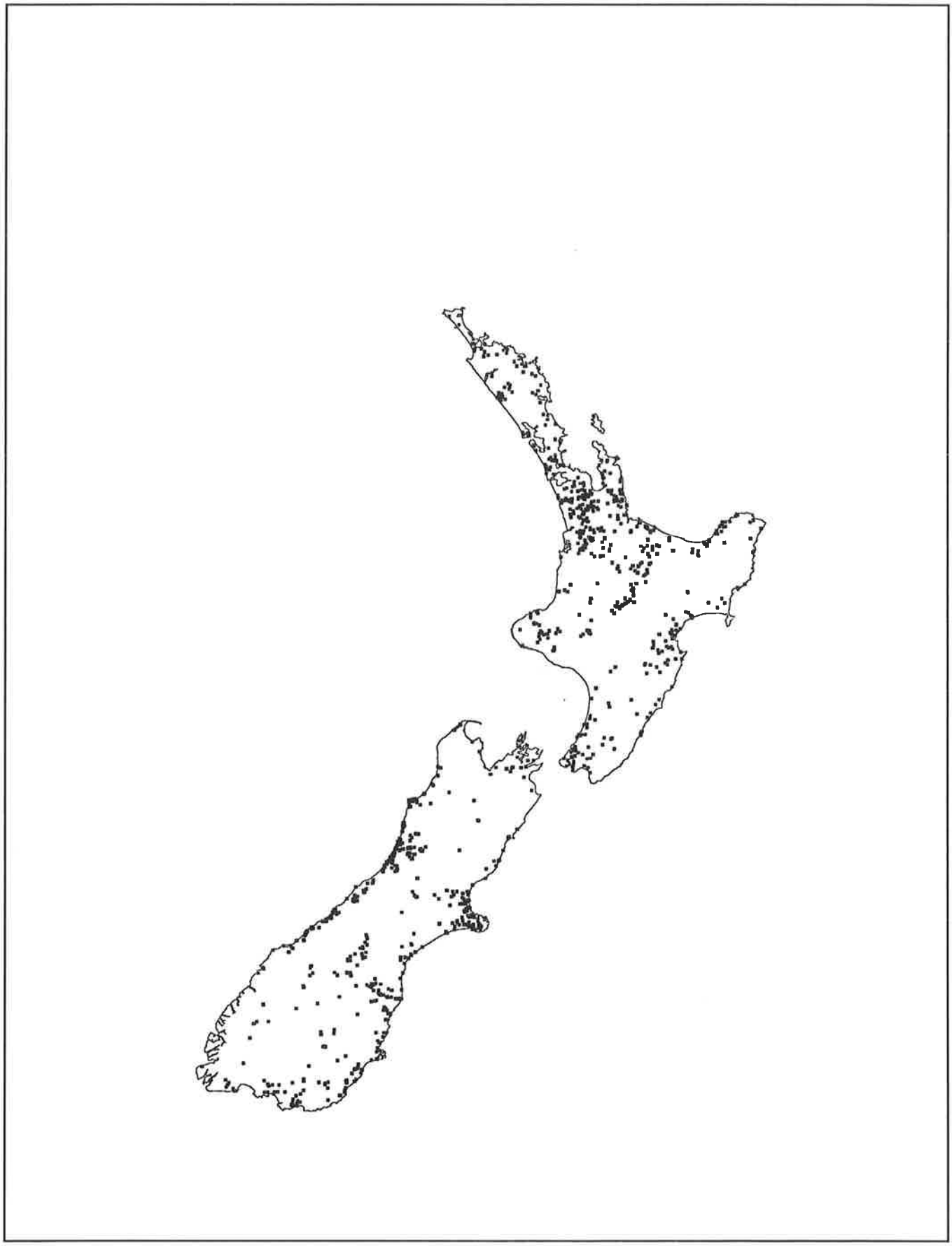

FIGURE 23. Distribution of *Gobiomorphus cotidianus* (common bully) based on 1455 data entries.

FIGURE 24. Distribution of *Gobiomorphus hubbsi* (bluegilled bully) based on 383 data entries.

FIGURE 25. Distribution of *Gobiomorphus breviceps* (upland bully) based on 919 data entries.

Traditional Maori fisheries: None known.

Modern fisheries: None.

Abundance and status: The upland bully appears to be abundant throughout its known range.

Causes of decline: No decline in abundance has been documented.

Important conservation issues: None have been identified.

2.1.7.6 *Gobiomorphus basalis* (Cran's bully)

World distribution: Restricted to New Zealand.

New Zealand distribution: This species occurs widely in the North Island at all elevations; one

enigmatic population occurs in the Marlborough high country (Fig. 26, 237 entries).

Natural history: Virtually unstudied; the species is not diadromous.

Traditional Maori fisheries: None known.

Modern fisheries: None.

Abundance and status: Not well known, but the species certainly remains widespread and is locally abundant, although not enough is known to be clear about this.

Causes of decline: No decline in abundance has been documented.

Important conservation issues: None have been identified.

FIGURE 26. Distribution of *Gobiomorphus basalis* (Cran's bully) based on 237 data entries.

2.1.8 Family Pleuronectidae

2.1.8.1 *Rhombosolea retiaria* (black flounder)

World distribution: Restricted to New Zealand.

New Zealand distribution: This species is present at low elevations around the whole of New Zealand, with some modest inland penetration in some rivers, but its distribution is poorly documented (Fig. 27, 132 entries).

Natural history: Virtually nothing has been reported. It is catadromous, with the adults moving to sea to spawn and the juveniles returning from the sea in spring.

Traditional Maori fisheries: The black flounder was of some significance in coastal locations.

FIGURE 27. Distribution of *Rhombosolea retiaria* (black flounder) based on 132 data entries.

Modern fisheries: It remains a valued species in coastal lakes, river estuaries, and to some extent at sea. It is important to both recreational and commercial fisheries.

Abundance and status: It appears to remain locally common.

Causes of decline: No decline has been identified.

Important conservation issues: Maintenance of upstream access for these migratory fish is the most critical issue.

2.2 Introduced Species

2.2.1 Family Salmonidae

2.2.1.1 *Salmo trutta* (brown trout)

World distribution: Originates from temperate Europe but is now almost world-wide at cooler latitudes.

New Zealand distribution: The brown trout is probably the most widely distributed fish in New Zealand fresh waters, especially south of about the Waikato, but it is also intermittent north of this (Fig. 28, 2664 entries).

Natural history: The brown trout has been studied intensively both in New Zealand and elsewhere (e.g., Hobbs 1937, 1940, 1948); stocks include sea-migratory, or anadromous, "sea trout", particularly in southern latitudes.

Traditional Maori fisheries: None, but it rapidly became important after its establishment in New Zealand in the 1860s and 1870s.

Modern fisheries: Brown trout form the basis of perhaps the most important recreational fishery in New Zealand fresh waters, owing to their widespread occurrence.

Abundance and status: The species remains very abundant and widespread.

Causes of decline: Habitat degradation has had impacts on brown trout populations in recent decades, especially water abstraction and impoundment.

Important conservation issues: Brown trout may pose some threats to indigenous fish species, although the nature of these threats is not understood or quantified. Protection of habitats continues to be a critical issue for this species as a fishery resource.

2.2.1.2 *Salmo salar* (Atlantic salmon)

World distribution: Its natural range comprises lands bordering the northern, cool to cold temperate, Atlantic Ocean (Europe and North America); it has been introduced sparsely elsewhere (e.g., Chile, Australia).

New Zealand distribution: Atlantic salmon are present only in the lakes of the upper Waiau River (Southland) (Fig. 29, three entries).

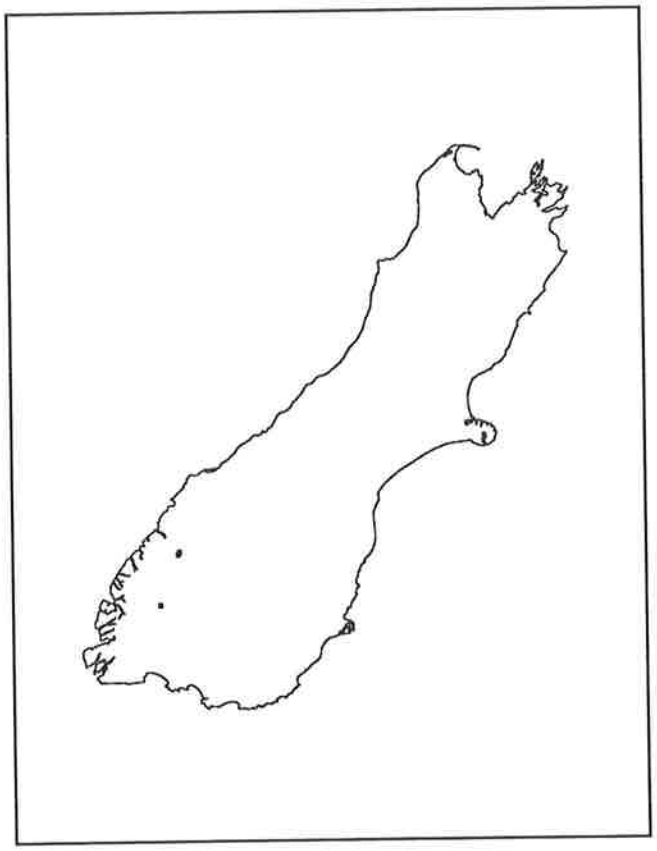

FIGURE 29. Distribution of *Salmo salar* (Atlantic salmon) based on three data entries.

Natural history: This species has been the subject of very many studies in its natural range, but it is little known in New Zealand, and what is known is very dated (Godby1925; Calderwood 1927; Regan 1927; Hefford 1927; Stokell 1934, 1959; Hutchinson 1975; Gibbs 1981). Though it is anadromous in Europe and North America, it is only land-locked in New Zealand.

Traditional Maori fisheries: None.

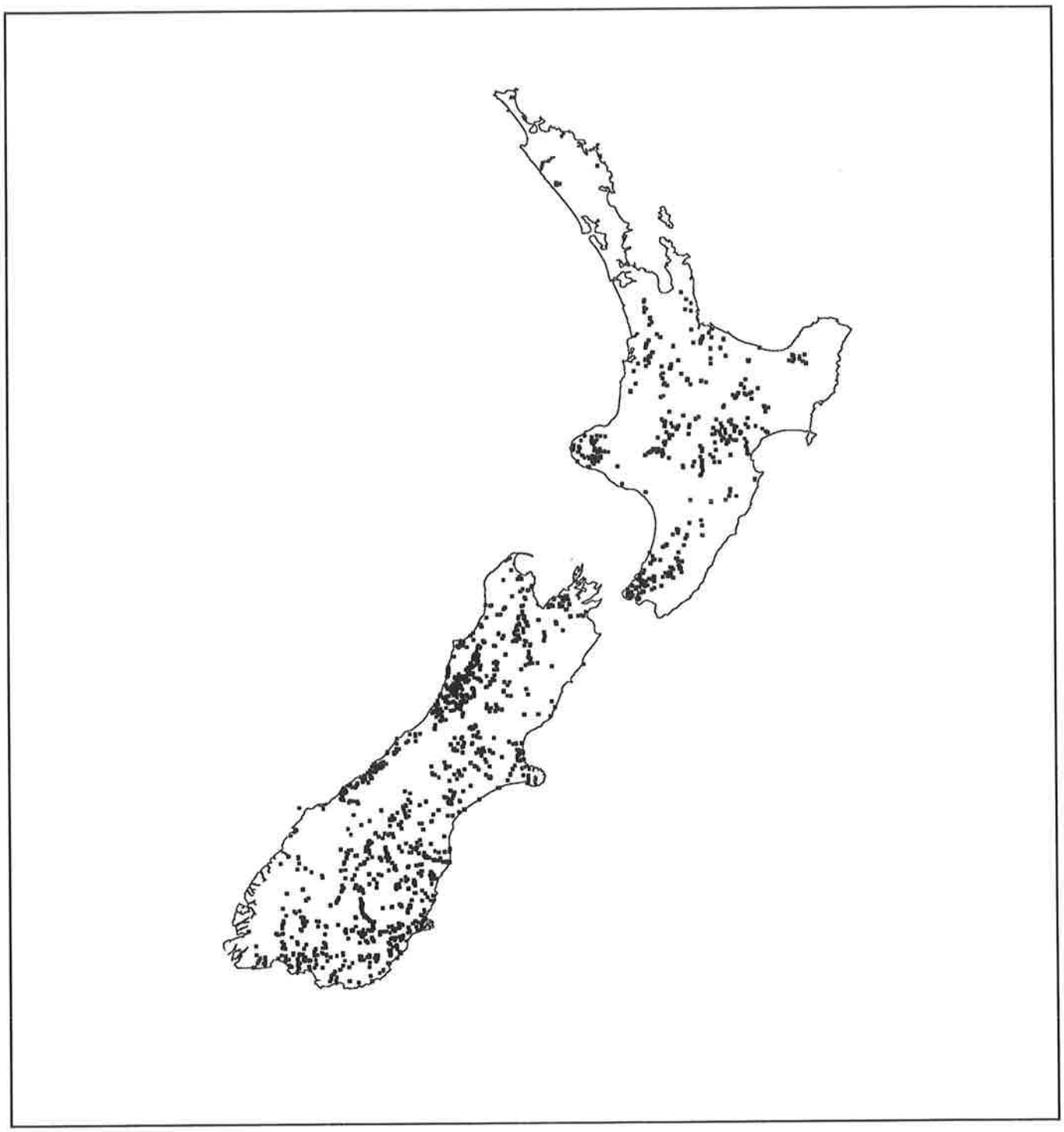

FIGURE 28. Distribution of *Salmo trutta* (brown trout) based on 2664 data entries.

Modern fisheries: Atlantic salmon are caught rarely by recreational anglers.

Status and abundance: The species was once an important aspect of recreational fishing in the lakes of the Waiau (Te Anau, Manapouri), but populations declined during the 1930s and it is now rare and in danger of extirpation in New Zealand. It is a matter for considerable conservation concern if there is any desire or expectation that the species should continue to be present in New Zealand. Hatchery stocks exist.

Causes of decline: This is attributed largely to competition with rainbow trout, which were introduced into the lakes in the 1920s, although sometimes blame is attached to removal of too many ova from the system at that time.

Important conservation issues: Retention of stocks in captivity is the most relevant conservation measure to ensure that this species remains in New Zealand for as long as there might be some value in having it here.

2.2.1.3 *Salvelinus fontinalis* (brook char)

World distribution: This species' natural range is north-eastern North America, but it has been introduced into various other cool-temperate lands in both hemispheres (Chile, Argentina, South Africa, parts of northern Europe), although it is not as widely present as other important salmonids.

New Zealand distribution: It is intermittently present from the Rotorua lakes southwards, and is quite widespread, mostly in small headwater tributaries and occasionally in lakes (Fig. 30, 77 entries).

FIGURE 30. Distribution of *Salvelinus fontinalis* (brook char) based on 77 data entries.

Traditional Maori fisheries: None.

Modern fisheries: The brook char is important for recreational angling in only a few localities.

Abundance and status: Little is known, but it is locally abundant in some locations.

Causes of decline: The brook char's habit of retreating to small headwater streams to avoid competition with other species of salmonid is probably the key to understanding its distribution and abundance.

Important conservation issues: None.

2.2.1.4 *Salvelinus namaycush* (mackinaw)

World distribution: This species is native to north-eastern North America in cool and cold locations. Its range has been extended westwards in North America, but, apart from New Zealand, it has not established naturally reproducing populations elsewhere.

New Zealand distribution: Mackinaw are known only from Lake Pearson in inland Canterbury (there are no entries in the freshwater fish database).

Natural history: It is virtually unstudied in New Zealand (Stokell 1951), but is well known in North America.

Traditional Maori fisheries: None.

Modern fisheries: Unimportant, owing to the sparseness of the population, and small size and poor condition of the fish.

Abundance and status: The population seems to have declined in recent decades, and its survival in New Zealand is now a matter for considerable concern. Hatchery stocks exist.

Causes for decline: Its decline probably relates to the habitat being unsuitable, together with possible increased competition from a diversity of other salmonids in Lake Pearson.

Important conservation issues: Maintenance of stocks of this species in New Zealand is possibly important since they are already here and re-introduction, if ever desired, would be difficult and expensive. Survival may depend on the maintenance of hatchery stocks, or the location of more appropriate wild habitats. This is a matter of some urgency.

2.2.1.5 *Oncorhynchus mykiss* (rainbow trout)

World distribution: This species' natural range was land bordering the cool to cold northern Pacific Ocean (North America and Siberia); it has been introduced throughout the world wherever there are cool waters, including alpine catchments in the tropics.

New Zealand distribution: Rainbow trout are widespread, but somewhat intermittent, in New Zealand from the Waikato and Bay of Plenty southwards; they are especially important in lakes in the central North Island, and elsewhere (Fig. 31, 901 entries).

Natural history: The species has been studied extensively in New Zealand and overseas, and its ecology is well understood (Hobbs 1937, 1940, 1948; Smith 1959). New Zealand lacks sea-migratory anadromous populations (known as steelhead).

Traditional Maori fisheries: None, though the fish was rapidly included in Maori fisheries and diets once it became established in New Zealand in the late 19th century.

Modern fisheries: It forms the basis of very important recreational fisheries, and is (arguably) second in importance only to brown trout.

Abundance and status: Rainbow trout are typically abundant in suitable habitats, with no reason for serious conservation concern.

Causes of decline: No significant decline has been documented.

Important conservation issues: The rainbow trout has undoubtedly contributed to major declines in the abundance of lake stocks of koaro in the central North Island, and perhaps elsewhere, as well as to stocks of dwarf inanga in Northland lakes. The protection of habitat continues to be a critical issue for this species as a fishery resource.

2.2.1.6 *Oncorhynchus tshawytscha* (quinnat salmon)

World distribution: This species is naturally present in drainages entering the cool to cold northern Pacific Ocean; attempts to establish the

FIGURE 31. Distribution of *Oncorhynchus mykiss* (rainbow trout) based on 901 data entries.

species elsewhere in the world have been successful only in New Zealand.

New Zealand distribution: Self-sustaining stocks occur along the east coast of the South Island from the Waiau (Marlborough) to the Clutha (Otago); it is also present in some inland South Island lakes (Fig. 32, 333 entries). Occasional strays have been recorded from rivers in the North Island.

Natural history: Quinnat salmon have been studied extensively both in New Zealand and overseas (Hobbs 1937, 1940, 1948; Hopkins 1981; Flain 1982; Unwin 1986; Field-Dodgson 1987, 1988; Hopkins and Unwin. 1987; Davis and Unwin 1989), so are well known. New Zealand has both anadromous and lacustrine stocks, the latter being highly unusual.

FIGURE 32. Distribution of *Oncorhynchus tshawytscha* (quinnat salmon) based on 333 data entries.

Traditional Maori fisheries: None, though the fish is now exploited recreationally by Maori.

Modern fisheries: This fish supports a very important recreational fishery within its range.

Abundance and status: The species remains generally abundant throughout its range.

Causes of decline: Dam construction and irrigation abstraction in Canterbury and Otago rivers have brought about a significant decline in abundance in some river systems. Recent exploitation of marine stocks off the east coast of the South Island has caused a significant decline in abundance. Over-exploitation could become a problem if recreational fishing pressure continues to increase.

Important conservation issues: Control of water abstraction from rivers, and protection of upstream spawning and rearing waters, are important to maintain natural stocks, as is continued control of commercial exploitation at sea. Hatchery enhancement is an alternative, but is costly.

2.2.1.7 *Oncorhynchus nerka* (sockeye salmon)

World distribution: Sockeye salmon are present in rivers draining into the cool and cold northern Pacific Ocean (North America and Siberia).

New Zealand distribution: This species occurs only in some of the lakes of the upper Waitaki catchment, including artificial impoundments developed there (Fig. 33, eight entries).

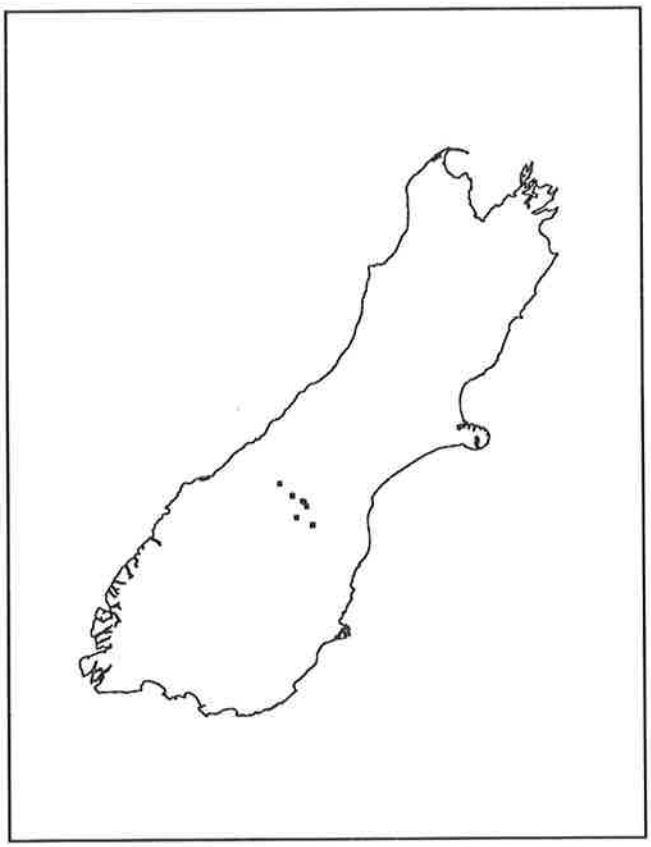

FIGURE 33. Distribution of *Oncorhynchus nerka* (sockeye salmon) based on eight data entries.

Natural history: Sockeye salmon are well-studied within their native range, and recent New Zealand studies have clarified the ecology of New Zealand stocks (Graynoth 1987, Graynoth *et al.* 1986). New Zealand stocks are entirely land-locked, with no anadromous (sea-migratory) fish.

Traditional Maori fisheries: None.

Modern fisheries: This species is insignificant in fisheries of the Waitaki lakes, being caught only occasionally, small, and probably seldom recognised.

Abundance and status: Stocks have declined in abundance in the past decade. Hatchery stocks exist.

Causes of decline: Reductions in the population are due to hydro-electric dams being constructed on the upper Waitaki River. These have interfered with migrations upstream to the spawning grounds, and their continued survival is presently a matter for some conservation concern.

Important conservation issues: Survival of this species in New Zealand may depend on the maintenance of hatchery stocks, as the response of populations to the construction of new dams on the Waitaki River is not yet clear.

2.2.2 Family Ictaluridae

2.2.2.1 *Ictalurus nebulosus* (catfish)

World distribution: The catfish is native to the eastern United States and has been introduced in a few other areas.

New Zealand distribution: Catfish have long been present in the lower Waikato and in Lake Mahinapua (Westland), but have recently become more widespread in Northland and Auckland, Lake Taupo, and elsewhere. Their present range is not well documented (Fig. 34, 87 entries).

Natural history: The catfish is well known in North America but has been little studied in New Zealand (Patchell 1977, 1981).

Traditional Maori fisheries: None.

Modern fisheries: The species is not sought by recreational anglers, though there are small markets for catches; small quantities may be being sold for manufacturing pet foods, but it is not used for human consumption to any extent.

Abundance and status: The catfish appears to be increasing both in range and abundance; it may be a matter for concern amongst eel fishers, but the situation is little understood.

FIGURE 34. Distribution of *Ictalurus nebulosus* (catfish) based on 87 data entries.

Causes for decline: No decline has been identified, nor would any decline in abundance be a matter for concern, owing to the low value of the species to New Zealand.

Important conservation issues: The impacts of catfish on other aquatic biota are not understood and have not been investigated.

2.2.3 Family Cyprinidae

2.2.3.1 *Tinca tinca* (tench)

World distribution: Tench are widely present in the cool waters of Europe, and have been introduced a little more widely than their natural range.

New Zealand distribution: Tench are intermittent but quite widespread, mostly in and north of the Waikato, but also in the eastern central South Island (Fig. 35, 17 entries).

Natural history: Tench are well known in Europe but are totally unstudied in New Zealand.

Traditional Maori fisheries: None.

Modern fisheries: The species is attracting keen interest from a select group of anglers in northern waters.

Abundance and status: Their range has increased substantially in the past 20 years, mostly by deliberate, largely illicit, releases, and they are locally abundant.

FIGURE 35. Distribution of *Tinca tinca* (tench) based on 17 data entries.

Causes of decline: The species is not known to be declining.

Important conservation issues: The impacts of tench on other aquatic biota are not understood.

2.2.3.2 *Carassius auratus* (goldfish)

World distribution: Goldfish probably originated in Eurasia, but are now virtually worldwide.

New Zealand distribution: The species is widespread, intermittent, and locally abundant throughout New Zealand (Fig. 36, 177 entries).

Natural history: This is well known, especially as a result of their importance for keeping in captivity, but they are totally unstudied in the wild in New Zealand.

Traditional Maori fisheries: The species was

FIGURE 36. Distribution of *Carassius auratus* (goldfish) based on 177 data entries.

rapidly adopted as a food fish when it was introduced into New Zealand in the 1870s, but its present level of exploitation is not known.

Modern fisheries: None.

Abundance and status: The species is locally abundant and not of much interest.

Causes of decline: No decline has been identified, nor would it be a matter for concern, owing to the low value of the species in New Zealand waters.

Important conservation issues: The impacts of goldfish on other aquatic biota are not understood; they are believed to be slight, but have not been studied.

2.2.3.3 *Cyprinus carpio* (koi or European carp)

World distribution: The species probably originated somewhere in Eurasia but is now virtually worldwide in tropical and warm climates.

New Zealand distribution: It is not well documented, but is possibly present intermittently in various northern waters, and is widespread in the lower Waikato River (Fig. 37, 46 entries).

Natural history: The species is well known elsewhere, but is unstudied in the New Zealand environment.

Traditional Maori fisheries: None.

Modern fisheries: None at present, although there is some interest amongst coarse fish anglers and in exploitation for pet foods.

Abundance and status: Koi carp are classed as a noxious fish owing to concerns about their impacts on the environment, although these have not been described in New Zealand habitats. A literature review of their potential effects on New Zealand's aquatic ecosystems is about to be published (Hanchet 1990).

Causes of decline: The fish appears to be spreading and increasing in abundance.

Important conservation issues: Koi carp is widely regarded as a troublesome species in aquatic habitats, owing to its feeding behaviour and propensity for uprooting vegetation; the primary concern, therefore, is to limit its spread and to examine its impacts on the aquatic biota where it is already present.

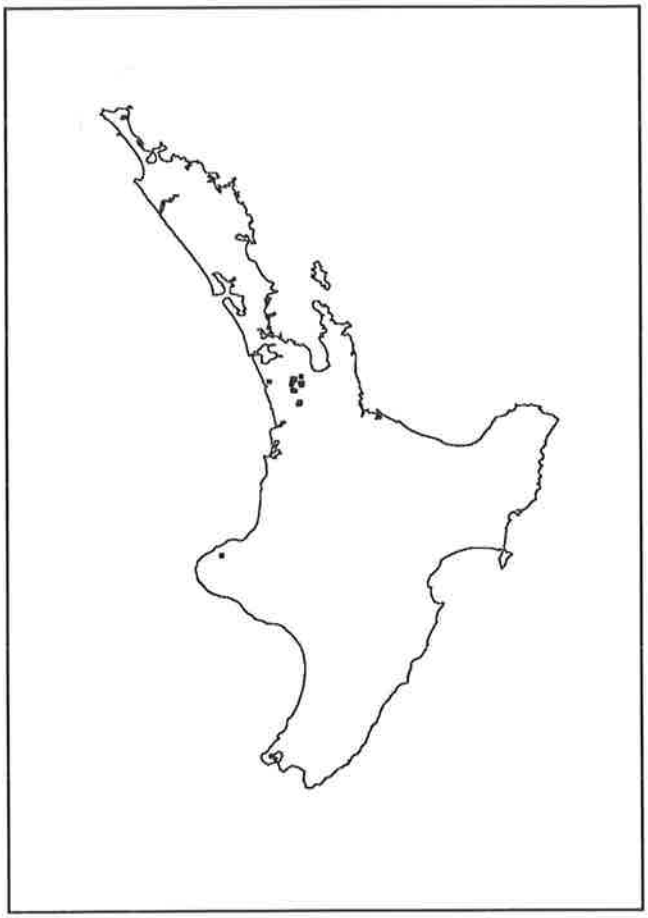

FIGURE 37. Distribution of *Cyprinus carpio* (koi carp) based on 46 data entries.

2.2.3.4 *Scardinius erythrophthalmus* (rudd)

World distribution: This species' natural range is cool areas of Europe, but it is now present in a few other areas.

New Zealand distribution: Rudd are present in and north of the Waikato River, although their distribution is poorly understood (Fig. 38, 69 entries).

Natural history: Their ecology is well understood overseas, with some studies in New Zealand habitats (Cadwallader *et al.* 1977; Lane 1979).

Traditional Maori fisheries: None.

Modern fisheries: Rudd is attracting attention from recreational anglers in northern waters.

Abundance and status: Rudd is classed as a noxious fish in New Zealand, owing to it having been introduced illicitly; it is locally abundant.

FIGURE 38. Distribution of *Scardinius erythrophthalmus* (rudd) based on 69 data entries.

Causes of decline: No decline has been identified, nor would it be a matter for much concern, owing to the present low value of this species in New Zealand waters. Some anglers would view it otherwise.

Important conservation issues: Impacts of rudd on other aquatic biota are not understood; they are believed to be slight but have not been studied.

2.2.3.5 *Leuciscus idus* (orfe)

World distribution: The natural range is the cool waters of Europe; it is now present in a few other areas largely as an ornamental pond fish.

New Zealand distribution: Orfe is present in a few ponds north of Auckland, but its range is not well

defined (there is one entry in the freshwater fish database).

Natural history: Its ecology seems to be only poorly understood in Europe, and it is virtually unstudied in New Zealand (Moore 1988).

Traditional Maori fisheries: None.

Modern fisheries: Orfe has potential for anglers, but this has not yet been realised owing to the recency of its introduction.

Abundance and status: Orfe was brought to New Zealand illegally in recent years and remains little known.

Causes of decline: No decline has been identified, nor would it be a matter for concern, owing to the present low value of this species in New Zealand waters.

Important conservation issues: The impacts of orfe on other aquatic biota are not understood; it is too soon for these to have emerged and stabilised.

2.2.3.6 *Ctenopharyngodon idella* (grass carp)

World distribution: This species' natural range is eastern China/Siberia, but it is now much more widely present for use in aquaculture.

New Zealand distribution: Grass carp occurs in confined waters in a number of North Island locations; some escaped into the lower Waikato, but do not appear to have bred there.

Natural history: This species has been the subject of extensive studies in New Zealand for nearly 20 years (Rowe and Schipper 1985).

Traditional Maori fisheries: None.

Modern fisheries: Grass carp has importance for the control of aquatic macrophytes and also may have value for recreational angling.

Abundance and status: The species is only locally present, in small numbers. It is intended that all uses outside captive brood stock should be of sterile triploid fish, which avoids any dangers of reproduction and proliferation.

Causes of decline: No decline has been identified.

Important conservation issues: An assessment of the impacts of grass carp on other aquatic biota has had some study (Rowe and Schipper 1985), though impacts on wildfowl are little examined.

2.2.3.7 *Hypophthalmichthys molitrix* (silver carp)

World distribution: This species' natural range is eastern China/Siberia, but it is now present much more widely, particularly for use in aquaculture.

New Zealand distribution: Brood stock are present in Lake Omapere (Northland) and Lakes Tutira, Orakai, and Eland (Hawkes Bay).

Natural history: The species is well studied overseas, with some extensive studies of its impacts on a small New Zealand lake (Carruthers 1986).

Traditional Maori fisheries: None.

Modern fisheries: Apart from its value for biological control, silver carp may have value for aquaculture.

Abundance and status: Wild stocks are unlikely to breed, so its abundance depends on continued releases and natural mortalities.

Causes of decline: No decline has been identified.

Important conservation issues: An understanding of the impacts of silver carp on other aquatic biota is not well advanced, although they are unlikely to be severe; this fish is likely to be used only in severely modified habitats.

2.2.4 Family Poeciliidae

2.2.4.1 *Gambusia affinis* (mosquitofish)

World distribution: This species occurs naturally in southern parts of North America, but has been introduced very widely in many parts of the world.

New Zealand distribution: It is widespread in northern New Zealand, south to the Waikato and Bay of Plenty, and seems to be spreading rapidly; it also occurs in Hawkes Bay (Fig. 39, 110 entries).

Natural history: The mosquitofish is well studied overseas, with some recent New Zealand studies (Wakelin 1986).

Traditional Maori fisheries: None.

Modern fisheries: None.

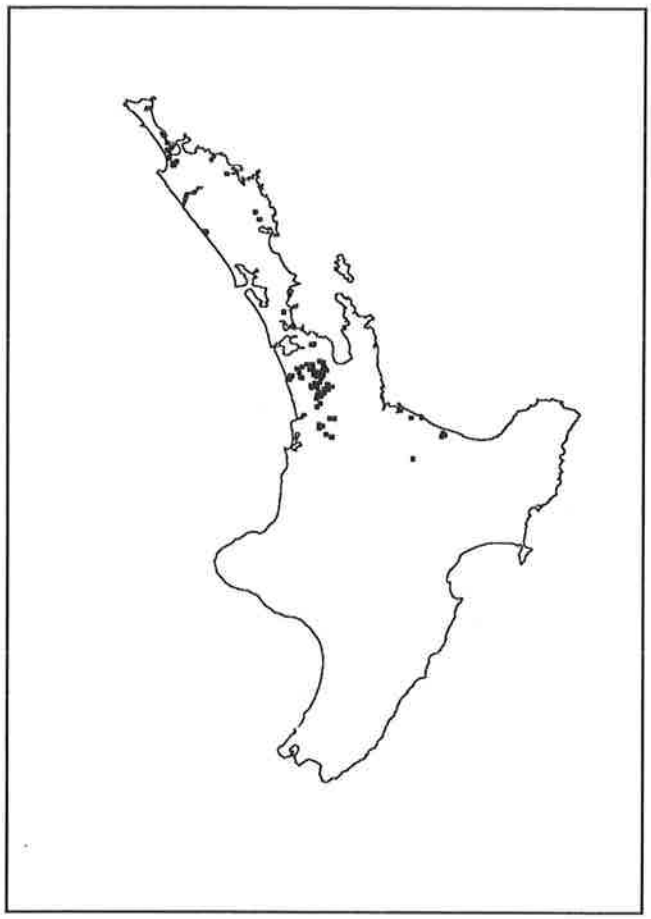

FIGURE 39. Distribution of *Gambusia affinis* (mosquitofish) based on 110 data entries.

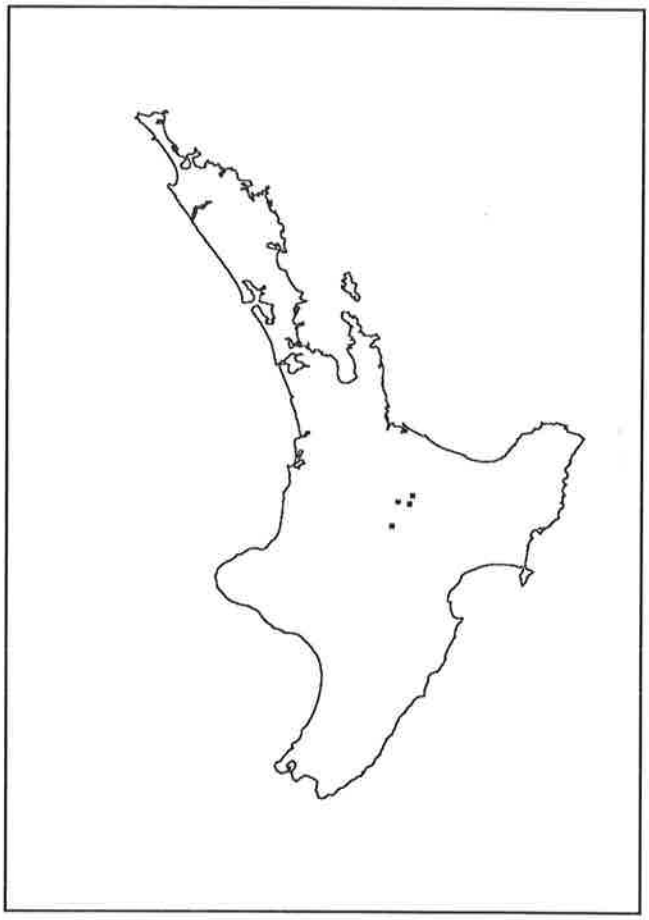

FIGURE 40. Distribution of *Poecilia reticulata* (guppy) based on six data entries.

Abundance and status: The species is becoming increasingly abundant and widespread in northern New Zealand.

Causes of decline: No decline has been identified.

Important conservation issues: An understanding of the impacts of the mosquitofish on other aquatic biota is of prime importance. Its impacts on smaller native fishes could be a matter for concern, but the situation is unstudied.

2.2.4.2 *Poecilia reticulata* (guppy)

World distribution: This species' natural range is central America, but it is now virtually worldwide owing to its use in aquaria.

New Zealand distribution: The guppy is present only in warm geothermal waters in the upper Waikato (Fig. 40, six entries).

Natural history: The guppy's habits are well known, though there have been no studies of wild New Zealand populations.

Traditional Maori fisheries: None.

Modern fisheries: None.

Abundance and status: The guppy is confined to warm waters and is neither of value nor concern.

Causes of decline: No decline has been identified.

Important conservation issues: An understanding of the impacts of the guppy on other aquatic biota would be desirable, although these are likely to be insignificant.

2.2.4.3 *Poecilia latipinna* (sailfin molly)

World distribution: This species' natural range is southern North America, but it has now been introduced to many parts of the world, owing to the interest of aquarists.

New Zealand distribution: Sailfin molly are present only in geothermal swamps at the southern end of Lake Taupo.

Natural history: Its ecology is well known overseas, but it is unstudied in New Zealand.

Traditional Maori fisheries: None.

Modern fisheries: Wild stocks may be of interest to aquarists, owing to the distinctive attributes of wild-grown fish.

Abundance and status: Locally abundant, and is neither of concern nor of any significant value.

Causes of decline: No decline has been identified.

Important conservation issues: An understanding of the impacts of the sailfin molly on other aquatic biota would be desirable, although these are likely to be insignificant.

2.2.4.4 *Xiphophorus helleri* (swordtail)

World distribution: This species is native to Central America, but it is widely distributed owing to interest by aquarists.

New Zealand distribution: The fish occurs only in the geothermally-heated Waipahihi Stream, Lake Taupo.

Natural history: Its ecology is well known overseas but is unstudied in New Zealand.

Traditional Maori fisheries: None.

Modern fisheries: None.

Abundance and status: The swordtail is present locally in small numbers and is neither an asset nor a concern.

Causes of decline: No decline has been identified.

Important conservation issues: An understanding of the impacts of the swordtail on other aquatic biota would be desirable, although these are likely to be insignificant.

2.2.5 Family Percidae

2.2.5.1 *Perca fluviatilis* (perch)

World distribution: Perch is native to the cool waters of eastern Europe, although it has been quite widely introduced elsewhere.

New Zealand distribution: Perch is intermittently present in rivers and small lakes throughout New Zealand, where it may be locally abundant (Fig. 41, 144 entries).

Natural history: Perch have been well studied overseas, with some New Zealand studies (Duncan 1967; Griffiths1975, 1976; Jellyman 1980).

Traditional Maori fisheries: None.

Modern fisheries: Perch is one of the lesser species sought by recreational anglers, but its value is under-rated.

Abundance and status: While perch are locally abundant, little is known nationally; it is a minor recreational fishing asset.

Causes of decline: No decline has been identified.

Important conservation issues: The impacts of perch on the native biota have not been studied and could be significant.

3. SUMMARY OF INFORMATION AND RESEARCH NEEDS

Without indulging in a detailed discussion of information and research needs, the following can be identified:

Indigenous species of concern

(i) The giant kokopu and shortjawed kokopu are clearly in decline and their ecology is poorly understood; their abundance is being affected by habitat degradation and possibly by the whitebait fishery.

(ii) The dwarf inanga is possibly threatened by trout introductions in some lakes and is known from only a few small lakes.

(iii) The three species of mudfish have suffered extensive and prolonged habitat loss; of these, the black mudfish is very little studied.

Exotic species of concern

Atlantic salmon, sockeye salmon, and mackinaw stocks are all fragile and their survival in New

FIGURE 41. Distribution of *Perca fluviatilis* (perch) based on 144 data entries.

Zealand over the long term is unlikely without some active management.

Species whose distributions are poorly known

The principal species in this category are probably the giant bully and black flounder; current studies are clarifying the distribution of Stokell's smelt.

Species likely to have impacts on the New Zealand environment and/or about which little or nothing is known

The prime species in this category would have to be the koi carp, though the recent release of catfish into Lake Taupo is a matter for careful consideration, and the status/potential impacts of

such species as rudd and orfe should not be ignored.

Species in need of research

Obviously, there is a wide range of candidates for this category and all species would benefit from a better knowledge of their natural history. It is a matter of assessing the existing state of knowledge, threats to which the species are exposed, their present state of abundance, their values, and how much and how easily research will contribute to their conservation and/or better management. The following are suggested as candidates, in a very rough order of priority and urgency: black mudfish, shortjawed and giant kokopu, dwarf inanga, giant bully, koaro, bluegilled bully, cran's bully, upland bully, common bully, torrentfish, black flounder.

Interactions between indigenous and exotic species

There is circumstantial evidence that brown trout, in particular, have had, and probably continue to have, harmful effects on indigenous species. Some of these fish, such as the common river galaxias and dwarf galaxias, remain widespread and locally abundant, but have all but disappeared from some catchments where trout prevail in large numbers.

This whole question remains poorly studied and existing views are based on largely anecdotal information. Studies of the explicit interaction of native and exotic species are needed, preferably in paired catchments, one where the species co-exist and the other where only the native species occurs.

4. FURTHER BACKGROUND INFORMATION

This report has provided only skeletal details of the occurrence and natural history of New Zealand's freshwater fishes, but much more comprehensive information is available in supplementary literature on the fauna, should this be desired. The natural history of the New Zealand freshwater fish fauna, both indigenous and introduced, has been reviewed comprehensively and in substantial detail by McDowall (1990). Distributions of freshwater fishes in New Zealand, as of 1986, are illustrated in some detail in McDowall and Richardson (1986), and small distribution maps have been included with the text of this report for each species. The extensive literature on the indigenous fauna is comprehensively listed, and annotated, in Richardson and McDowall (1987), which contains more than 2000 references. The more specific question of the impact of exotic fish species is discussed by McDowall (1987). The general effects of swamp drainage and management on freshwater habitats were explored in *Freshwater Catch* (No. 15, 1982), while the effects of swamp drainage on fish populations were addressed by McDowall (1975). Eldon (1982) discussed the question of wetland use and management, and Davis (1987) identified wetlands of national importance to fisheries. Issues relating specifically to the establishment of reserves for New Zealand freshwater fishes were examined in McDowall (1984a). Teirney *et al.* (1982) made recommendations on the need for preservation or protection of New Zealand waters in a submission when a draft inventory of wild and scenic rivers of national importance to New Zealand was being prepared by the (then) Ministry of Works and Development.

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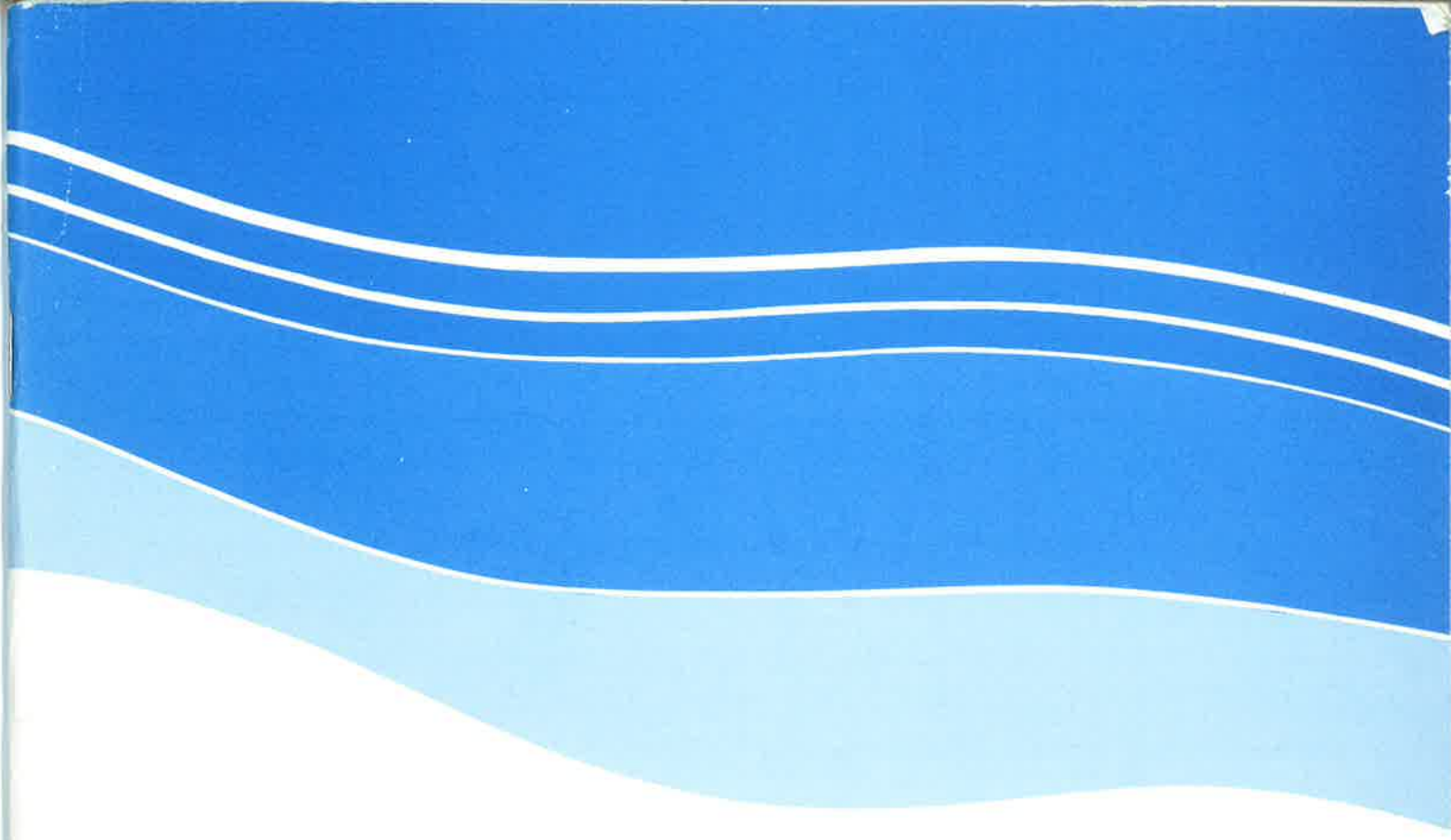

New Zealand freshwater fisheries report no. 116 (1990)