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NEW ZEALAND FRESHWATER FISHERIES MISCELLANEOUS REPORT NO. 54

CLIMATE WARMING AND FRESHWATER FISHERIES RESEARCH IN NEW ZEALAND

By

D.K Rowe

Submission to: Ministry of Research, Science and Technology

Freshwater Fisheries Centre
MAF Fisheries
PO Box 6016
ROTORUA

Servicing freshwater fisheries and aquaculture

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NEW ZEALAND FRESHWATER FISHERIES MISCELLANEOUS REPORTS

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MAF Fisheries is the fisheries business group of the New Zealand Ministry of Agriculture and Fisheries. The name MAF Fisheries was formalised on 1 November 1989 and replaces MAFFish, which was established on 1 April 1987. It combines the functions of the former Fisheries Research and Fisheries Management Divisions, and the fisheries functions of the former Economics Division of MAF.

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SUBMISSION ON RESEARCH RELATED TO IMPACTS OF CLIMATIC WARMING ON NEW ZEALANDS FRESHWATER FISHERIES RESOURCES

Prepared by Dr D K Rowe
Freshwater Fisheries Centre
PO Box 6016
Rotorua
Ph 073 463 730

1. INTRODUCTION

This submission has been prepared for the Fisheries Research Centres (Christchurch and Rotorua) of MAF Fisheries. Its aim is to identify the main opportunities for new and additional research in relation to interactions between the atmosphere and biosphere. In particular, research related to impacts of climate change is identified.

2. CURRENT SCIENCE ACTIVITIES RELATED TO IMPACTS OF CLIMATE WARMING

o MAF Fisheries and New Zealand's freshwater fisheries

MAF Fisheries staff are involved in research on freshwater fisheries throughout New Zealand. This research is carried out from two centres, one in Christchurch and the other in Rotorua. These centres are the largest laboratories for freshwater fisheries research in the South and North Island respectively. Research based at them covers most species of freshwater fish in New Zealand.

Three factors combine to make these laboratories centres of excellence for the provision of scientific advice on New Zealand's freshwater fisheries resources. Firstly, staff have expert knowledge about various groups of fish (e.g., eels, salmonids, native fish, carps, coarse species). Secondly, staff have the training and experience to deal with the range of problems affecting fisheries resources in New Zealand (e.g., resource assessment, damming, fish passes, water abstraction and pollution, forestry, introduced species, weed control, eutrophication, aquaculture, fishery management). Thirdly, staff have an overview of problem areas and future research needs related to freshwater fisheries resources. This overview is gained from the wide geographic spread of research projects undertaken for a range of clients in rivers and lakes, from

Northland to Fiordland. Continuing liason with other providers, and users, of fisheries research (e.g., Universities, Fish and Game Councils, District Councils, Department of Conservation, Electricorp) ensures that MAF Fisheries research priorities reflect the need for applied, as well as strategic, research requirements.

As a consequence of its overview of New Zealand's freshwater fisheries resource, and preliminary studies already completed, MAF Fisheries has identified a number of potential fishery problems that can be expected with increased environmental temperatures. Many of these were summarized, along with beneficial effects on fisheries, in the MAF Fisheries report to the Impacts Working Group of the New Zealand Climate Change Programme (Glova 1989).

o Trout fisheries in lakes

There is cause for concern over trout fisheries in lakes (Rowe and Scott 1989). Research to identify the effects of water quality deterioration on trout in eutrophic lakes has revealed that rainbow trout rarely forage in waters where temperatures exceed 20°C. During summer months the surface waters of many lakes exceed 20°C. As a consequence, the depth of the 20°C isotherm sets an upper limit to their summer distribution. If increased warming of surface waters increases the depth of this 20°C isotherm, or its duration, trout habitat in lakes will be reduced. Trout growth is already stunted during summer months in some North Island Lakes, and in 1989 Lake Rotorua experienced a longer period of warming during which large numbers of trout congregated in the colder, spring fed tributaries.

o Trout fisheries in rivers

Other research, at the University of Otago, has indicated that eggs of trout are particularly sensitive to increased water temperatures (pers. comm. D. Scott). Mortalities occur at temperatures over 11°C for brown trout which spawn in winter, and at slightly higher temperatures for rainbow trout, which spawn in spring. Incubation temperatures may control the geographic distribution of trout in New Zealand rivers, limiting the northern limit for brown and rainbow trout. If so, increased warming can be expected to result in a decrease in the northern range for both species.

Fish are cold-blooded animals and, compared with birds and mammals, can be expected to be more sensitive to changes in water temperature. Trout are a cold-adapted species and are near the limit to their geographical range in the North Island. They are therefore likely to be more affected by climate warming than other components of the fauna (Mosely 1990).

o Noxious and coarse fish species

There is also cause for concern over potential impacts of noxious and coarse fish species. Just as trout prefer cold waters and will be deleteriously affected by climate warming, the noxious and coarse fish present in the North Island prefer warm water, and can be expected to proliferate.

Koi carp (*Cyprinus carpio*) in particular, may create problems with water quality in lakes. Hanchet (1988) concluded that high densities of this fish were required to cause a deterioration in water quality and impacts on fish. Temperature is the most critical factor affecting spawning of this species, and reproduction is optimal at temperatures between 19-23°C. Climate warming could therefore lead to increased densities of koi carp.

The brown bullhead catfish (*Ictalurus nebulosus*) also prefers temperatures over 19°C for spawning, and its populations may increase in size as water temperatures rise. This fish is already an unwanted bycatch, and therefore a nuisance for commercial eel fishermen in shallow lakes of the Waikato River, near Hamilton. Eel fisheries in these lakes are a significant commercial resource and could be endangered by increases in catfish. Furthermore, this species was recently introduced illegally into Lake Taupo. It has now spread throughout the lake, and the larger fish feed heavily on freshwater crayfish (pers. comm. M. Cryer). Crayfish are a major food source for New Zealand eels in rivers.

Rudd (*Scardinius erythrophthalmus*), tench (*Tinca tinca*) and orfe (*Leuciscus idus*) are also introduced fish, recently spread into waters in the top half of the North Island. They may be affecting native species at present and will benefit from warmer waters due to climate change. At present there are no studies being carried out on the ecology of brown bullhead catfish, rudd, tench, koi carp, orfe, or on their interactions with other fish.

The prospect of warmer waters may increase interest in warmwater aquaculture. The recent venture to introduce channel catfish reflects such interest. However, potential impacts of new fish species, which can breed in New Zealand waters, will need to be carefully considered. These have been shown to be negligible for grass carp (*Ctenopharyngodon idella*) which won't breed in New Zealand, and is now being released for weed control. As it is a highly valued table fish in Asia, where it is extensively cultured, it may prove to be a useful candidate for warm water aquaculture in New Zealand.

o Native species

Studies have been carried out on the thermal tolerances of the migratory stages of several native fish species (e.g., Simons 1986). This work was carried out to predict effects of thermal discharges, from the Huntly Power Station, on the fish and ichthyoplankton in the Waikato River (Boubee et al. 1986). The

resulting water rights and controls over thermal discharges mean that increases in river water temperature due to climate warming could limit power production. In addition, such increases could restrict fish movement upriver. At present the thermal plume affects the true left side of the river. A corridor for fish movement is thus provided on the right bank. This corridor for fish movement could be restricted in both time (season) and size (width and length) by the combined effects of climate warming and the thermal discharge on river water temperatures.

Current research for the Department of Conservation is aimed at identifying spawning sites for whitebait in rivers. These occur at the limit of saltwater penetration into rivers and so will be affected by changes in sea levels. However, remedial river control works to prevent flooding and to enhance drainage can be expected to have a more severe impact on the fishery than rises in sea level (pers. comm. C. Mitchell)

o Salmon fisheries and aquaculture

An increase in seawater temperatures during late winter and spring due to climate warming would increase growth rates of salmon. For farmers this will mean increased numbers of earlier maturing, hence smaller and less valuable salmon. MAF Fisheries has produced an all female stock which will ameliorate this effect (males tend to mature at a younger age more readily than females) (Hopkins 1989).

Warmer water temperatures in rearing streams may also increase growth rates of juveniles. Faster spring growth increases the incidence of precocious maturation in salmon, so reducing smolt production (Rowe and Thorpe 1990). In turn this can be expected to reduce runs of adult salmon. Precocious maturation of quinnat salmon in New Zealand waters is already high compared with North American rivers (Flain 1970). This is not surprising given the milder, warmer climate in New Zealand. Climate warming can be expected to increase this response and reduce smolt numbers. In North America increases in the incidence of precocious maturation for Atlantic salmon have been associated with a decrease in the size of wild salmon, and reductions in the numbers of spawning fish.

Warmer water temperatures may also result in a higher incidence of toxic algal blooms (Edwards 1990), which could become a problem in areas used for sea cage rearing of salmon.

o New Zealand's research in relation to that overseas

Similar scenarios (eg. reductions in salmonid habitat and range, increased spread of warm water species) are being predicted for North American waters (Meisner 1990, Mandrak 1990). However, at present there is no published information on impacts of climate warming to fisheries in the southern hemisphere or Europe.

Proposals for studies on the effects of climate warming on

fisheries in New Zealand have already been sent to the Ministry of Research Science and Technology and the Department of Conservation seeking funding. These were unsuccessful, due principally, we believe, to a shortage of funds and uncertainty as to whether climate warming will in fact occur. There is a now a growing consensus that climate change is occurring. As a consequence problems, and new opportunities, can be expected.

3. MAIN RESEARCH OPPORTUNITIES

o *Rainbow trout fisheries in lakes*

Rainbow trout fisheries in lakes of the Central North Island are a significant economic resource. They earn tourist dollars and sustain local economies and jobs. Research is needed to determine the extent to which they will be affected by climate warming.

Because of their geographic location (i.e., close to the northern limit for this species in New Zealand) they are already affected by warm summer temperatures. They therefore offer a unique opportunity to determine effects of climate warming on trout populations. The range of lakes, and water quality conditions in them, provides a basis for comparative studies. Collectively they could constitute a natural experiment of international significance.

Two factors combine to enhance the research opportunities provided by this natural experiment. Firstly, because of the broader training and emphasis on ecology given to New Zealand science graduates, freshwater fisheries research in New Zealand has generally tended to focus on mechanisms underlying change, rather than on the correlations between change and environmental variables. These approaches towards the development of predictive models are both useful. However, the former is more valuable in that an understanding of the mechanism also provides the groundwork for identifying ameliorative actions.

The second factor is the interest and experience of DSIR (Water Quality) scientists in developing mathematical models to predict the effects of climate warming on lake temperature profiles. The DYRESM model, currently used to determine thermal properties in water supply reservoirs, could be broadened to encompass lakes. A model to predict changes in lake water quality due to climate warming would enable the extrapolation of results on trout to other lakes. It would also be of general use to water managers. Collaborative work focused on trout lakes in the Central North Island would be of practical benefit to New Zealand, and will be relevant to problems that will be experienced in other countries.

o *Trout fisheries in rivers*

Trout fisheries in rivers are also likely to be affected by climate warming. Many New Zealand rivers, such as the Maunganui-a-te-ao and Mohaka in the North Island, contain both rainbow and brown trout. Both species do not usually coexist in rivers overseas. A National Conservation Order has been applied for over the Mohaka River because of the quality of its dual-species trout fishery. Climate warming is likely to restrict the northern distribution of brown trout in New Zealand and river fisheries such as the Mohaka may be affected. There is a need to determine factors influencing the geographical range of the two trout species in New Zealand, and reasons for their coexistence in rivers, as a basis for predicting loss of trout fisheries.

o *Noxious and coarse fish species*

There is growing concern among the public, as well as Fish and Game Councils, the Department of Conservation and the Ministry of Environment about the impact of introduced coarse fish species on trout and the native fish fauna. Recently, such concerns were heightened by the proposed introduction of yet another warm water species, the channel catfish. Warmer waters in northern New Zealand will favour such fish and increase interactions with native species. At present concerns over the impact of warm water species are based mainly on speculation and results of overseas studies. The prospect of warmer waters due to climate change increases the priority for research to determine species interactions. This information is needed as a baseline to predict changes in fish faunas due to climate change.

o *Implications related to thermal power stations*

Water rights for the Huntly Thermal Power Station may need to be reviewed if water temperatures in the river rise due to climate warming. The maintenance of a corridor for fish migration upriver will be a critical condition affecting discharge of thermal wastes. Studies are needed to determine effects of climate change on the river's water temperature profiles below Huntly, and on the upstream migration of native fish in this corridor.

o *Salmon fisheries in rivers and aquaculture*

The main problem affecting salmon is likely to be an increased incidence of precocious parr due to better growth of juveniles in the warmer waters of rearing streams. There is a need to determine the incidence of precocious maturation of wild quinnat salmon in a range of New Zealand rivers. There is also a need to determine whether spring growth influences the maturation decision in this species, as it does in Atlantic salmon, and to explore the relationship between the precocious maturation life history tactic and the size and composition of adult runs.

As with rainbow trout fisheries in lakes of the North Island, the

salmon fisheries of Canterbury rivers are important commercial resources of national significance for tourism.

4. CONCLUSIONS

In general, climate warming, as envisaged under the two scenarios proposed by the Climate Change Working Group, can be expected to have positive and negative effects on New Zealand freshwater fisheries resources. Positive effects are limited to enhanced aquacultural possibilities for some warm water species, particularly grass carp, which are a favoured fish in Asia, and which don't pose an environmental threat to New Zealand. However, most effects will be negative.

In particular, salmon and trout fisheries will be most affected. New Zealand contains a large number of salmon and trout fisheries throughout the country, but rainbow trout in lakes of the Central North Island, and salmon fisheries in Canterbury rivers are of particular significance as tourist assets. Existing knowledge indicates that increased water temperatures could pose threats to these resources.

A number of hypotheses concerning the way in which the trout and salmon populations could be affected have been raised and require testing. Such work is needed, principally to predict impacts, but will also be valuable in identifying possible remedial actions.

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