SUMMARY OF POTENTIAL GREENHOUSE EFFECTS ON FISH HABITATS AND FISHERIES RESOURCES IN NEW SOUTH WALES

B.A. Richardson
Division of Fisheries
PO Box K220
Haymarket NSW 2000

D.A. Pollard
Fisheries Research Institute
PO Box 21
Cronulla NSW 2230

INTRODUCTION

The following paper outlines the major potential Greenhouse effects on the fish and fisheries resources of inland, coastal and nearshore waters in New South Wales, based on climatic scenarios derived from the CSIRO predictions. For this exercise NSW has been divided into a number of zones to describe variations within these climatic scenarios. Inland zones constituting the Murray-Darling Basin have been grouped for discussion, as have the coastal river catchments, the estuarine and enclosed coastal waters and the coastal territorial seas. Much of the information summarized in this paper has been collated from those other papers in this volume (plus see references therein) which originated from a seminar held at the Fisheries Research Institute in May 1989 on Greenhouse Impacts on Fisheries in NSW.

SCENARIOS WITHIN ZONES

Murray-Darling Basin - inland freshwater fisheries

Native warmwater fishes such as golden perch (*Macquaria ambigua*), Murray cod (*Maccullochella peeli*), silver perch (*Bidyanus bidyanus*), spangled perch (*Leiopotherapan unicolor*) and introduced European carp (*Cyprinus carpio*) are dominant species in both the commercial and recreational fisheries of the inland. The freshwater yabby (*Cherax destructor*), and to a lesser extent the Murray crayfish (*Euastacus armatus*), are also significant contributors to these fisheries as well as being prime candidates for aquaculture in this area. The inland commercial fishery in this area has been substantially reduced over the past decade.

The above fish species are largely floodplain dependent in that the inundation of floodplains and their associated wetlands provide the rich production of nutrients and plankton which make for their successful reproduction and recruitment (Pollard *et al.* 1980). It is thus predicted that increased rainfall, aligned with increased temperatures in the summer months, may benefit production, reproductive opportunity and rearing success for native species in these waters. However, diffuse source pollutants, such as suspended sediments and pesticides, could well increase with increased runoff. Exotic species present in the Darling-Barwon System, such as carp and redfin (*Perca fluviatilis*), will probably continue to be successful given their wide physiological tolerances and reproductive adaptations (Tilzey 1980). If there was a significant increase in summer rainfall, there would likely be an increase in the amount of floodplain development such as levee construction and large floodplain storages, which would further alienate the floodplain from the fishery. Increased availability of surplus water flows will encourage expansion of primary industries such as cotton growing, which generate further disadvantages for fish due to the acutely toxic pesticides used. On the other hand, surplus flows could be used as environmental allocations and contribute significantly to ecological sustainability for fisheries and other agricultural resources (Burchmore 1990).

Although increases predicted for summer rainfall in this area could be quite beneficial, reductions in winter rainfall may cause additional stresses during low flow periods. If temperatures increase, then the reproductive cues (~20°C) for Murray cod would shift towards earlier spawning, from September back towards winter (Rowland 1983). Less rainfall in these months would reduce the recruitment success of cod spawning earlier in the season.

It is noteworthy that the area between Yarrawonga and Tocumwal supports the last naturally occurring population of the endangered trout cod (*Maccullochella macquariensis*). Shifts in temperature upwards may reduce the viability of this species and speed the process of extinction, given the limited ability for upstream redistribution and the narrow genetic base of this population (Ingram *et al.* 1990). Increases in temperature are also most likely to seriously reduce the riverine trout fisheries of the foothills and tablelands, and to some extent shift the nature of the recreational fisheries so important to local tourism along the Murray River in particular.

Another effect of increased summer rainfall is the possible reduction in irrigation demands, especially along the Murray River in the summer months. This may assist in reversing the current aseasonal hydrographs back towards natural flow patterns and allow for greater instream allocations to wetlands along the floodplain.

Tablelands and Coastal Plains - coastal freshwater fisheries

The southern tablelands support important freshwater fish resources which includes both significant recreational fisheries and fish populations of high conservation value. This area supports the State's most important trout fisheries, including those of the rivers and lakes of the Snowy Mountains and adjacent highlands. These salmonid fisheries are likely to undergo reductions in the distribution of suitable waters (given increases in water temperatures) and reduction in the quality of the remaining fisheries due to decreases in fish growth rates. There is unlikely to be any replacement fishery for

recreational trout anglers in these areas because the cool temperate species native to these waters are either already in serious decline or are of no recreational value. The lower winter rainfalls predicted may also be detrimental to the reproductive success of species such as brown trout (*Salmo trutta*) (Faragher 1990).

Increased summer rainfalls may provide benefits to the reproductive success of coastal species such as the Australian grayling (*Prototrocytes maraena*), which is a seriously threatened native species. This species spawns in late summer, and peak summer flows could flush eggs and larvae out to sea more often rather than allowing their rearing within the brackish or freshwater zone (Ingram *et al.* 1990). Australian bass (*Macquaria novemaculeata*) would be disadvantaged by reductions in winter flows as they require large flows at this time of the year to stimulate their downstream spawning migrations to brackish waters.

On the north coast, the eastern freshwater cod (*Maccullochella* sp.), the other endangered freshwater fish species present in NSW, may be disadvantaged by increased flood intensities during summer causing downstream displacement of juveniles. The winter reduction in rainfall may be detrimental for maturation and pairing amongst eastern freshwater cod, and may also reduce spawning success for Australian bass and other winter breeders.

Increases in summer rainfall will also be likely to increase the frequency of fish kills associated with acid sulphate soils due to more summer flooding. This may also reinforce some arguments for more flood mitigation programs, which have been shown to have significant detrimental impacts on estuarine and brackish water fish resources. Sea level rises are also likely to increase waterlogging or inundation of low lying floodplains, which may also create a resurgence in wetland drainage.

Aquaculture ventures in this area such as brackish water prawn, and freshwater yabby and crayfish farms could benefit by increased temperatures increasing these animals' growth rates. However, increased temperatures and reduced winter rainfall will possibly be sufficient to extinguish the few self-reproducing pockets of trout on the tablelands of the New England District.

It is possible that the predicted increases in summer rainfall may reduce the demands for augmentations to water supplies for coastal towns, and therefore the need for further dams and weirs on these coastal streams. Such structures have had serious impacts upon native fishes, which require free passage along rivers for their spawning migrations.

Estuaries and Coastal Embayments - estuarine fisheries

This zone includes estuarine and enclosed waters along the NSW coastline, and the climate change scenario considered presupposes that a 0.2-1.4 m rise in sea level is likely over the next 30-40 years, together with an increased intensity and frequency of storm events and an estimated 2-3°C increase in sea surface temperature.

The first and most obvious change likely to affect our estuaries is the gradual submergence of mangroves, saltmarshes and intertidal seagrasses and the landwards displacement of these estuarine vegetated zones (Bryant 1990). These habitats are already declining due to foreshore encroachment, reclamation and estuarine dredging programs. If sea level rises push these areas inland (due to changes in salinity regimes and depth criteria), there are many areas in estuaries along the entire coastline where prior foreshore settlement and encroachment will prevent replacement wetlands from establishing (Williams 1990). Species contributing some 70% to the total fisheries production in NSW are dependent on a range of estuarine habitats for one or more stages of their life histories (Pollard 1976). Such losses could well be critical to the future of inshore as well as estuarine commercial and recreational fisheries in NSW.

As estuaries become wider and deeper, and increased runoff causes higher sediment loads, the light penetration through these waters may decrease, thus reducing the ability of seagrasses to re-colonise. Increases in storm intensity have been predicted for this coastal zone, which are likely to increase erosion of foreshores, which in turn may encourage the construction of more coastal protection works. Such works as revetment walls can remove important intertidal and shallow inshore habitats, and in some cases alter estuarine hydraulic patterns by reflecting wave patterns onto more distant shorelines.

Aquaculture and oyster farming practices could be disadvantaged by shifts in tidal prism and salinity regimes. Many oyster leases will require relocation to continue farming and this may prove difficult in many estuaries where other uses are already established (Pollard 1990). Similarly, prawn farms and other estuarine aquaculture facilities will face difficulties with site suitability and whether or not they can still secure appropriate growing conditions. In both cases the change in conditions is likely to be gradual over a 30-40 year period and continual site relocation or adjustment is not possible.

Marine submergence of low-lying coastal areas could well inundate farm lands contaminated with persistent agricultural chemicals, or in urban areas inundate toxic waste dumps (e.g. as at Homebush Bay), in addition to increased leaching of buried chemicals due to groundwater percolation.

Coastal Marine Waters - marine fisheries

In the marine environment the effects of climatic changes are likely to be slower, but nonetheless changes to fisheries could be significant. The magnitude of the sea level rise predicted will be relatively small in comparison to historical fluctuations, but will occur over a much shorter time period. In the short term, emphasis should be placed on the more subtle impacts of changing patterns of ocean circulation, the distribution of subtropical and sub-Antarctic waters, and the effects of physical processes on the chemistry and biology of the seas.

The fisheries of these marine waters are particularly sensitive to changes in sea surface temperature and ocean circulation. Many pelagic species, such as jack mackerel (*Trachurus declivus*) in Tasmania, exhibit behavioural changes with a shift in sea surface temperature of as little as 2.5°C, and in 1988-89, when such minor temperature changes occurred, purse seiners could not locate the stocks although they were still thought to be present in Tasmanian waters (Harris *et al.*

1989). This situation could alsao arise in other pelagic and demersal fisheries where catchability is dependent on fish behaviour and the fish following specific ocean currents and surface isotherms. Also, if increased rainfall and river discharge in coastal estuaries stimulates the increased emigrations of king prawns (*Penaeus plebejus*), school prawns (*Metapenaeus macleayi*)and possibly greasyback prawns (*M. bennettae*) to the sea, there is potential for greater aggregations offshore at times of flooding and thus increased catchability (Montgomery 1990). This could, however, be detrimental to the sustainable management of these populations and this should perhaps be considered in any effort analysis for the management plans for these fisheries. If juvenile nursery habitat area were also to be reduced, then actual abundance will be lower and increased catch efficiency would increase the vulnerability of the stocks more dramatically.

Another important impact may be on fish food production, bearing in mind that microscopic algae and plankton are critical foods which determine reproductive success of many fish and prawn species. The distribution of current upwellings and seasonal mixing characteristics affects the availability of nutrients to fuel this primary production, and this in turn may ultimately account for spawning and successful recruitment to these fisheries.

The gradual shifts in temperature and the strength and extent of the inshore East Australian Current could redistribute the inshore trawl fishery, e.g. for flathead (*Neoplatycephalus richardsoni*) and morwong (*Nemadactylus macropterus*), further south into Victoria. This may be accompanied by a southwards extension of the ocean king prawn fishery.

The offshore demersal trawl fishery is predominantly for gemfish (*Rexea solandri*), ling (*Genypterus tigerinus*), ocean perch (*Helicolenus percoides*) and royal red prawns (*Haliporoides sibogae*). Although there are few biological data on many of these species, gemfish are known to migrate northwards to the Tasman Front where spawning aggregations occur in August off Port Macquarie (Rowling, pers. comm.). From what is known of the factors affecting these species' distributions, temperature does not seem to be as critical as current, depth and bottom type. Other important impacts that may be associated with changes in the East Australian Current are the larval transport and settlement patterns of many marine species, and particularly the migration patterns of many inshore species.

For many invertebrates, water temperature is important, and cool temperate species such as abalone (*Haliotis ruber*) may be replaced in NSW by warm temperate species such as turban snails and sea urchins.

Various pelagic fish such as tuna and billfish species provide important recreational gamefisheries, in addition to the important commercial fisheries for tunas. The movement patterns of these species are strongly dependent on changes in sea surface temperatures. Many of them are circumtropical in distribution, with their northern and southern limits of distribution expanding and contracting seasonally. They are thus likely to expand their distributional limits to the south, providing enhanced sportfisheries in NSW (Pepperell 1990).

SUMMARY

Greenhouse related climatic changes are likely to have both positive and negative effects depending on the biology and the environmental requirements of the particular fish and other aquatic species in question. The key issues are summarised below for each of the major types of fisheries:

a) Murray-Darling Basin Fisheries

- any temperature increases will be felt immediately in inland rivers (as opposed, for instance, to oceanic waters, where there will be the greatest lag);
- general increases are likely in opportunities for successful fish reproduction associated with increased summer rainfall, flooding and temperature;
- Greenhouse related climatic changes should favour native species over introduced species such as carp and redfin provided water quality is maintained;
- overall, the fisheries in this area will remain largely dependent on the type of floodplain development, dam and weir construction, use of pesticides and water abstraction practices, which will be the ultimate mechanisms determining the viability of native freshwater fish populations.

b) Tableland and Coastal Plain Fisheries

- many species migrate between freshwaters and estuarine or marine waters for spawning;
- Greenhouse changes will probably favour summer spawning species, such as freshwater mullet (*Myxus petardi*), due to higher summer rainfalls;
- winter spawners (e.g. Australian bass) could be disadvantaged by less frequent winter flood events;
- increased storm intensity may degrade channels and instream habitats;
- increased water temperatures may displace the remaining populations of the threatened Macquarie perch (*Macquaria australasica*), which are confined to small pockets within several headwater systems, as they may also displace native galaxiids from many areas;
- introduced salmonid fisheries are likely to be disadvantaged by temperature increases, with a severe reduction in range;
- growth rates of remaining trout populations could be reduced;
- increased summer mortalities of trout could occur due to heat stress.

c) Estuarine and Coastal Embayment Fisheries

- changes to salinity regimes and tidal limit associated with increased sea level, together with changes to freshwater inflows, are likely to have substantial impacts on many estuarine dependent fisheries;
- important estuarine juvenile fish nursery and feeding habitats such as seagrass meadows, mangroves and saltmarshes are likely to be substantially reduced or lost altogether in many areas;
- oyster farms in many estuaries may require relocation to maintain salinity requirements for oyster growth, as well as there being possible impacts on natural spat production;
- engineering works are likely to be more commonly used to protect and stabilise foreshores, with possible adverse impacts on hydraulic and biological processes in adjacent waterways.

d) Coastal Marine Fisheries

- ocean warming could lag behind mainland temperatures by 10-20 years for surface waters;
- inshore trap and trawl fisheries may move further south due to warmer inshore waters delivered by the East Australian current;
- prawn fisheries are likely to show increased catches associated with increased river discharge, and pawning of prawns may also tend to occur earlier due to water temperature increases;
- many pelagic species have tropical distributions and it could be expected that their distributions would extend southwards with gradual warming of surface waters;
- both pelagic commercial and recreational gamefishing species off the NSW coast are expected to improve in diversity, with a probable increase in overall production;
- demersal fisheries are likely to be less affected, but may shift based on changes in temperature and substrate distributions, and also current patterns, in the longer term.

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