

The National Climate Change Action Plan for Fisheries and Aquaculture

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Australian Fisheries Management Forum

(for the)

Natural Resource Management Ministerial Council

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Introduction

The earth's climate is changing^{*}, and further changes are inevitable (IPCC, 2007). As the extent of these changes grows, Australia's fisheries and aquaculture sectors will face increasing challenges, but they may also find opportunities (Handisyde, 2006; Hobday et al., 2008). The *National Climate Change Action Plan for Fisheries and Aquaculture* (Action Plan) identifies strategies and actions to guide management, policy, research and operational decisions in light of climate change.

The scope of the plan includes both the wild catch (commercial, recreational and Indigenous) and aquaculture sectors[†]. The activities described in this Action Plan are designed to inform and guide an effective climate change response that supports the ongoing sustainability, competitiveness and quality of Australian fisheries. The major focus of the plan is on improving the capacity of Australian fisheries sectors to operate under changing climatic conditions (adaptation). The plan also describes a number of actions to minimise greenhouse gas emissions from fishing (mitigation), largely reflecting the energy-intensive nature of some fishing activities.

The Action Plan is relevant to all Australian jurisdictions and fisheries, and was developed in close collaboration with the wild catch fishing and aquaculture sectors, and the Australian, state and Northern Territory governments. It recognises that as our knowledge and understanding of likely climate change impacts evolves, our ability to adapt will improve. Accordingly, the actions in this plan are not prescriptive in detail; rather, they provide fishers, managers and researchers with a broad, principles-based response framework in which to develop responses appropriate to the diverse needs of various fisheries. Implementation of the plan will benefit from a regionally and nationally co-ordinated approach, involving the Australian, state and territory governments, in partnership with the fisheries sectors and their representatives and other relevant groups.

The Action Plan complements a number of related processes, including those that review broader climate change impacts and recommend actions for managing natural resources. It has been developed in recognition of the issues identified through other initiatives including:

- the *National Climate Change Adaptation Framework* (the COAG Framework), endorsed by the Council of Australian Governments in April 2007 (COAG, 2007)
- outputs of the Australian Fisheries Management Forum's National Fisheries and Climate Change Workshop (October 2007)
- the National Agriculture and Climate Change Action Plan 2006-2009 (CoA, 2006)
- the CSIRO reports: *Implications of Climate Change for Australian Fisheries and Aquaculture: A Preliminary Assessment* (Hobday et al., 2008) and *Impacts of Climate Change on Australian Marine Life* (Hobday et al., 2006a, 2006b, 2006c)
- *Climate Change Risk and Vulnerability: Promoting an Efficient Adaptation Response in Australia* (Allen Consulting, 2005)
- *A National Climate Change Research Strategy for Primary Industries* (LWA, 2008)
- the Great Barrier Reef Climate Change Action Plan 2007–2012 (GBRMPA, 2007)
- Intergovernmental Panel on Climate Change Fourth Assessment Report (IPCC, 2007)
- *Climate Change in Australia: Technical Report 2007* (CSIRO & BoM, 2007)
- the Garnaut Climate Change Review Final Report (Garnaut, 2008)

^{*} Climate change, in the context of this Action Plan, refers to global warming and associated effects resulting from the emission of greenhouse gases as a result of human activities.

[†] Throughout this Action Plan, all fishing sectors, including aquaculture, are referred to collectively as 'fisheries' sectors (involving 'fishers' and 'fishing'), except when specifically referring to particular groups.

- A National Approach to Addressing Marine Biodiversity Decline (Marine Biodiversity Decline Working Group, 2008)
- the Carbon Pollution Reduction Scheme White Paper (CoA, 2008)
- the Marine Biodiversity and Resources: National Adaptation Research Plan (Mapstone et al., 2009)
- Commonwealth, state and territory climate change programs and projects that address greenhouse gas emissions, climate variability and the impacts of climate change

Background

The need for an action plan: the national policy context

The need for the Action Plan was first identified in the COAG Framework (COAG, 2007), which was developed to guide government action on adaptation over the five to seven year period from 2007. The framework identifies fisheries as being particularly vulnerable to climate change, and recommends actions to enhance the knowledge base underpinning climate change adaptation for this and other vulnerable sectors.

The COAG Framework recognises that Australian fisheries will be affected by climate change through increasing ocean temperatures; changes to ocean currents, wind and nutrients; changed rainfall patterns; diminished water availability and coastal impacts. To assist the fisheries sectors to adapt to climate change, the COAG Framework recommends that:

- a national climate change and fisheries action plan be developed that
- identifies risks associated with climate change for the sustainable use of Australia's fish stocks
- assesses the impacts and risks of climate change on aquaculture
- determines ways of distinguishing climate change impacts from the impacts of other environmental and management factors
- develops strategies in collaboration with industry and community stakeholders
- research be supported, in association with industry and research providers, to address major knowledge gaps about the impacts of climate change on wild catch fisheries and aquaculture
- a national program be established to understand the impacts of climate change on biodiversity, including marine ecosystems
- the climate change action plan for the Great Barrier Reef be finalised and implemented*.

In addition, the National Climate Change Adaptation Research Facility has been established by the Australian Government, under the COAG Framework. This research facility aims to coordinate and lead the Australian research community to generate the biophysical, social and economic information needed to adapt to climate change. This includes the establishment of a Climate Change Adaptation Research Network for Marine Biodiversity and Resources and the development of the *Marine Biodiversity and Resources: National Adaptation Research Plan* (Marine NARP) (Mapstone et al., 2009). Separate National Adaptation Research Plans for freshwater biodiversity and Indigenous communities are also being developed, and are expected to have relevance to fishing and aquaculture activities.

The Marine NARP is of particular relevance to the Action Plan, as its scope covers research into climate change impacts and adaptation options for the marine environment and associated natural resources, encompassing the social and economic impacts of climate change on fishing and aquaculture, and biophysical impacts on estuarine and marine ecosystems. Actions to increase the resilience of marine biodiversity to climate change and the adaptive capacity of fisheries sectors can be strengthened by establishing clear linkages between these and other relevant processes.

Dealing effectively with the impacts of climate change on fisheries can be enhanced by engagement with policy-makers and stakeholders outside the traditional fisheries realm. Action Plan outcomes will be improved, for example, where inland, coastal/estuarine and marine impacts are considered in land-use planning processes, given their importance to inshore fish habitat and aquaculture management. Furthermore, many climate change issues, such as adaptive planning and mitigation of greenhouse gas emissions, are common across primary industry sectors. Further information on these matters is available at www.climatechange.gov.au. The fisheries sectors will benefit from understanding broader cross-industry

* The *Great Barrier Reef Climate Change Action Plan 2007–2012* (GBRMPA, 2007) was finalised in 2007 and is now being implemented.

research and policy priorities and from identifying market drivers and how these may affect operating environments.

The fisheries sectors

Fishing is a significant contributor to the Australian economy. It is also a popular recreational pastime and an important activity for many Indigenous Australians. The fisheries sectors contribute substantially, both directly and indirectly, to regional economies and community well-being. Australian commercial fishing (including aquaculture) produced \$2.19 billion (landed value) of seafood and non-edible product in 2007–08 (ABARE, 2009). Of this, wild catch fisheries accounted for \$1.36 billion and aquaculture \$0.82 billion*. The value of seafood exports was \$1.34 billion in 2007–08, mainly from rock lobster, abalone, pearl oysters, tuna and prawns. The commercial seafood industry, including processors and wholesalers, employed approximately 13 000 people in 2007–08. More than 20 per cent of Australian households have at least one person that recreationally fishes at least once a year, and these fishers spend nearly \$2 billion on fishing-related activities and equipment. Fishing is an important activity amongst many Indigenous Australians, with reported participation rates exceeding 90 per cent in northern Australia (Henry & Lyle, 2003).

The fisheries sectors are extremely diverse. Substantial differences exist in relation to gear types, target species, scale of operations and motivations for fishing. Fishing takes place throughout Australia and involves diverse groups, which, in some cases, may have competing interests. Fisheries management tends to have a strong regional focus and can vary across jurisdictional (including international) boundaries, even with respect to common species and stocks. Despite this, there is connectivity between fish stocks and, to some extent, access entitlements across jurisdictions. Accordingly, responses to common risks and large scale impacts will benefit from a national, cooperative approach involving the Australian, state and territory governments, in partnership with the fisheries sectors and others, as appropriate.

Climate change and fisheries

Australia's climate will continue to change over coming decades, irrespective of local and global efforts to reduce greenhouse emissions (IPCC, 2007). Future impacts will reflect past, present and future activities, policies and mitigation strategies. Variables such as winds, currents, rainfall and temperature, which have a strong influence on the distribution and productivity of fish stocks, will be affected by climate change. However, global climate model projections are variable and it is unclear how these effects will translate across smaller scales, particularly as the imprecision associated with such projections is compounded when downscaling to regional or local levels (Garnaut, 2008; Hobday et al., 2006a).

The United Nations Intergovernmental Panel on Climate Change projects average warming of 1.1–6.4°C globally by 2100 (relative to 1980–1999), depending on greenhouse gas emissions levels (IPCC, 2007). Warming of this order will have important ramifications for freshwater and marine ecosystem processes, including sea level rise due to thermal expansion of the ocean and melting of the ice caps. Other likely effects include changes to currents, wind and rainfall patterns; an increase in the frequency and intensity of storm events; more intense tropical cyclones; and altered ocean chemistry (primarily through acidification from elevated atmospheric CO₂). Changes in the characteristics of the El Niño Southern Oscillation (ENSO)[†] cycle may affect the intensity and duration of drought and flood events on land and associated weather patterns over the ocean (CSIRO & BoM, 2007; Garnaut, 2008; Hobday et al., 2006a, 2008).

Estimates for Australia, provided by CSIRO and the Bureau of Meteorology (CSIRO & BoM, 2007), indicate an increase in sea surface temperature of 0.6–0.9°C by 2030 for the southern Tasman Sea and off the north-west shelf of Western Australia, with a 0.3–0.6°C increase projected elsewhere. The East Australian Current is likely to strengthen, resulting in a further southward extension of warmer waters, with potential impacts on marine ecosystems. The greatest increase in ocean acidity in the Australian region is expected to occur in the cooler waters at high-to-mid latitudes. Projections also indicate that there is likely to be an increase in the proportion of more intense tropical cyclones, although there may be a decline in the overall number of cyclones.

* Value of aquaculture production has been adjusted for input of Southern Bluefin Tuna (SBT) to ranches from the wild catch SBT fishery. The apparent difference between the value of total catch and that of the sum of the wild catch and aquaculture components is due to rounding error.

† The ENSO cycle refers to the year-to-year variations in sea-surface temperatures, convective rainfall, surface air pressure, and atmospheric circulation over the equatorial Pacific Ocean.

The fish species most vulnerable to climate change are likely to be those in the most heavily impacted areas, that have barriers to migration (limited habitats or limited mobility), sensitive life-history stages, low thermal tolerance, narrowly defined distributions, that are already occupying the limit of their environment or which are sensitive to changes in the productivity or distribution of species with which they interact (such as predators, competitors and prey). For some species, biological change due to climate change will be gradual and difficult to detect. In some instances, detectable impacts might only be realised when a 'tipping point' or threshold is reached.

Early indications are that impacts on marine fisheries are likely to be most severe in the south-east region of Australia, due to the influence of the strengthening East Australian Current. Range expansions of some species from waters off south-eastern mainland Australia into those off eastern Tasmania have already been recorded. Similarly, inland fisheries in south-eastern Australia are likely to be most affected by the cumulative impact of warmer temperatures, changing evaporation rates, reduced rainfall and competition with non-fishing users for increasingly scarce water resources. In the tropics, increasing Sea Surface Temperature (SST) is likely to result in increased occurrences of mass coral bleaching. This, in concert with increasing ocean acidification, more intense tropical cyclones and changing oceanographic currents, may degrade coral reef ecosystems during this century, making some tropical fisheries particularly vulnerable. Increased extreme weather events may also affect fishers' ability to operate. Western fisheries are sensitive to changes in the strength of the Leeuwin Current, although the likely impact of climate change on this current remains unclear (Hobday et al., 2008).

The flow-on effects of climate change on fisheries are likely to result in both opportunities and challenges (Handisyde, 2006; Hobday et al., 2008). Changes may occur to environmental, economic or social characteristics, such as to fish stocks, access to suitable farm sites, profitability, employment opportunities, quality of fishing experience and access to culturally significant or otherwise important species. Climate change may result in the decline of some fish stocks or limit aquaculture operations for certain species but it may promote production in others. Access to some stocks may increase and allow expansion for fisheries operations. Competition between fisheries sectors or groups for particular stocks or sites may grow as a result of climate change, which may increase the importance of formal resource allocation.

Access to fisheries resources may also be affected by changes in the abundance, productivity or distribution of threatened or otherwise protected species. A need to avoid interactions with such species could conceivably limit access to otherwise healthy target fish stocks where the protected and target species' distributions overlap. Where the conservation status of a (target or non-target) species declines, it may be important to distinguish between climate driven changes, and those caused by fishing or other factors, in order to inform decisions that will influence ongoing resource access.

A summary of the potential effects of climate change on fishery resources is provided in Table 1*.

Australian fisheries' contribution to carbon emissions

There is no comprehensive estimate of the volume of greenhouse gas emissions from activities associated with the fisheries sectors. The overwhelming source of emissions associated with fishing operations is generally from energy consumption (diesel, petrol and to a lesser extent, electricity and gas). Claims through the Australian Government's Fuel Tax Credits Scheme[†] in 2008–09 suggest that the commercial fisheries and aquaculture sectors use substantially less petrol and diesel than other eligible sectors including agriculture, mining, manufacturing, construction and road and rail transport (CoA, 2010).

The responsibility for sector specific mitigation strategies, primarily through finding efficiencies in fossil fuel use, will rest largely with the fisheries sectors. In many commercial wild catch fisheries, particularly trawl operations, fuel costs account for a major component of operating expenses (Vieira et al, 2008; Vieira & Perks, 2009). Fuel costs can also be considerable in the other fisheries sectors, including aquaculture where electrical

* A separate analysis of the vulnerability of fishery resources in the Great Barrier Reef is provided in the report *Climate Change and the Great Barrier Reef: A Vulnerability Assessment* (Johnson & Marshall, 2007).

† The Fuel Tax Credit Scheme provides tax credits for fuel (petrol and diesel) used in a range of business activities for industries including agriculture, fishing, forestry, mining and manufacturing.

energy use can also be considerable (Troell et al., 2004). The substantial increase in fuel prices over the last decade, combined with the fuel-intensive nature of some fishing operations, provides an economic incentive for fishers to reduce their greenhouse gas emissions through increasing fuel efficiency.

Table 1. The potential effects of climate change on fishery resources

(Hobday et al., 2006b, 2006c, 2008; Hobday & Poloczanska, 2008)

Environmental variable	Potential effect on fishery resources
Ocean currents, winds and nutrients	<p>Changes to oceanic and inshore productivity (e.g. due to altered upwellings) and food webs.</p> <p>Changes to recruitment patterns of marine organisms, including those affected by fishing.</p> <p>Changes in the abundance of wild catch species and availability and composition of fish meal.</p> <p>Altered flushing rates around sea cages affecting dispersal of waste.</p>
Ocean acidification	<p>Changes in pH could be detrimental to some marine organisms, including:</p> <p>reduced growth of calcifying phytoplankton, corals and molluscs, and effects on the moulting process in crustaceans</p> <p>physiological stress in other marine organisms</p> <p>altered food-web structure</p> <p>possible vulnerability of sensitive life history stages (e.g. larvae).</p>
Rainfall patterns and more frequent, extreme storm events	<p>Altered catchment flows and subsequent changes to estuarine and inshore productivity.</p> <p>Changes to the timing and extent of spawning of estuarine and inshore species.</p> <p>Flooding following storm events may affect fish survival in inshore habitats.</p> <p>Competition for water resources in areas projected to receive less rainfall or reduced downstream flows may impact on inland fisheries and aquaculture.</p> <p>Changes to levels of catchment-sourced pollutants and nutrients entering waterways.</p> <p>Possible infrastructure, stock and property loss associated with storms.</p> <p>Habitat damage, particularly in the tropics, from more frequent storms and cyclones.</p>
Sea-level rise and increased wave activity	<p>Altered inshore habitats and nursery areas for fish, dugongs* and invertebrates.</p> <p>Possible loss of rocky shore macroalgal habitat, and dependent species.</p> <p>Possible changes to the availability of suitable aquaculture sites.</p>

* Dugongs and marine turtles are a traditional Indigenous food resource in some areas.

Environmental variable	Potential effect on fishery resources
Water temperature	<p>Southward shift in the distribution of many species, particularly off south-eastern mainland Australia.</p> <p>Changes in phenology, such as the timing of spawning, migrations and other life-history events—e.g., a particular species may enter a new area, or be available within its existing range at different times of the year.</p> <p>Altered recruitment and dispersal patterns.</p> <p>Changes to growth and reproductive rates.</p> <p>Altered disease and parasite susceptibility and physiological stress.</p> <p>Possible increased incursions of pest species as a result of ecosystem disturbance.</p> <p>Changes in habitats, communities and mosaics, including poleward shifts in aquatic plants and faunal (e.g. sponge beds) communities.</p> <p>Loss or distribution shift of habitat-forming organisms may alter fish communities and catches.</p> <p>Increased oceanic stratification, limiting the recirculation of nutrients to surface waters.</p> <p>Increased incidence of algal blooms.</p> <p>Decreased oxygen availability as a result of higher water temperatures.</p> <p>Enhanced or suppressed feed-conversion ratios in aquaculture systems.</p> <p>Possible altered sex ratio of marine turtles and range shift in suitable nesting beaches*.</p> <p>Changes in availability of traditional target species, including new opportunities.</p> <p>Increase in the range and/or availability of warm water species (e.g. pelagic gamefish species) for a longer period of the year.</p>

The Action Plan

Industries and activities that directly rely on the management and use of natural resources, such as the fisheries sectors, operate in an environment characterised by varying degrees of uncertainty. Variability in social and economic systems adds to this uncertainty. The fisheries sectors already respond to such change and uncertainty, and adjust their operations accordingly. The effects of climate change represent an additional source of uncertainty with which fishers must contend.

The Action Plan is intended to identify and inform responses to climate change challenges and opportunities, in order to enhance the environmental, economic and social sustainability of the fisheries sectors. Actions within this plan are intended to assist fishers and managers to make operational decisions in the context of 'normal' risk-based business management.

Objective

The scope of the plan extends to all fisheries sectors, including commercial, recreational, aquaculture and Indigenous users. The plan's objective is to guide activities to inform and support adaptation responses to climate change, and to help fishers reduce the intensity of greenhouse gas emissions. This will be achieved by a combination of adaptation and mitigation strategies.

The most effective role for government in assisting the fisheries sectors to adapt to climate change is to continue supporting targeted research and development. This will provide information to make sound decisions on climate change and its impacts, and allow fishers to adapt their operations as they deem necessary. Governments should also aim to ensure that management and legal frameworks are sufficiently flexible to accommodate required changes to fishery operations, such as spatial or species shifts in the fishery and adjusting input restrictions, provided such changes are compatible with other management objectives.

In terms of climate change mitigation, fisheries, as with other sectors of the economy, will need to make their own decisions about how best to reduce greenhouse gas emissions, particularly in relation to fossil fuel use.

Strategies that support socio-economic and biological resilience are identified in the Action Plan. These strategies are grouped within the focus areas of:

1. Improving the adaptive capacity of the fisheries sectors

- Improving the resilience of fishing operations to climate change
- Improving understanding and awareness of climate change impacts on fisheries
- Facilitating ongoing assessment and monitoring of climate change impacts at suitable scales
- Management and policy frameworks that are informed, agile and consistent.

2. Mitigation—reducing emissions intensity

- Fishers understand and reduce greenhouse gas emissions.

Desired outcomes

In achieving the objective outlined above, the Action Plan aims to support the following outcomes:

Fisheries sectors that are:

- ecologically sustainable
- socially and culturally resilient with respect to fishing activities
- profitable and competitive within a changing climate.

Fishers who have the capacity and knowledge to respond to climate change and make educated, risk-based decisions. Fishers who:

- are able to respond to fluctuating operating environments
- look for and capture opportunities that may arise from climate change (for example, commercial operators will benefit from being entrepreneurial and innovative)
- work cooperatively to address climate change challenges.

Flexible and adaptive regulatory and management frameworks that:

- can deal with uncertainty
- accommodate fisher adaptation to climate change
- support long-term biological, economic, social and cultural sustainability
- promote an understanding of appropriate responses to climate change
- involve government and fisheries sector partnerships that provide for ongoing cooperation.

Guiding principles

Responding to climate change will involve action by businesses, communities, individuals, researchers and governments throughout Australia. In general, fishers should manage their own risks from climate change impacts. However, governments also play an important role. For example, governments can remove barriers to adaptation, and provide better public information to build understanding about climate change and inform decision making across both the public and private sectors. The guiding principles that underpin this Action Plan are given in Table 2.

Table 2. The guiding principles of the Action Plan

	PRINCIPLE	RATIONALE
1	Climate change will be an additional consideration for fishers and for fisheries managers carrying out their existing natural resource management responsibilities.	Climate change is only one of many causes of change and uncertainty impacting upon the fisheries sectors. Many of the responses appropriate to climate change are consistent with sound fisheries management practices. Responding to climate change reinforces the importance of these fundamental principles.
2	Fishers will need to manage their own adaptation responses to climate change at scales ranging from operational to sector-wide.	Individuals and businesses are best placed to make operational decisions in response to climate change. Fishers already operate in an uncertain environment and many commercial operators employ a risk management approach, e.g. in response to environmental and market variability. Fishers should, where appropriate, continue to apply such approaches in adapting to climate change.
3	Emissions reduction and other mitigation responses to climate change will primarily be the responsibility of fisheries sectors and individual fishers.	Fishing operations can be energy intensive by their nature. Individuals and businesses will need to consider how best to reduce energy consumption for their particular situation, considering the costs and benefits of various mitigation options.
4	Responses to climate change will be enhanced by targeted research and development, and communication and awareness-raising activities.	Decision making by fishers, managers and policy makers should be supported by access to the best available information.
5	Profitable fisheries and robust fish stocks will, in general, have greater capacity to adapt to climate change.	Robust fish stocks may have greater capacity to absorb climate-driven stresses than those already under strong pressure, and there is a strong link between robust fish stocks and profitability/recreational and subsistence value. Greater fishery profitability translates into greater scope to adjust to adverse changes in productivity of stocks, input costs and catch prices.

	PRINCIPLE	RATIONALE
6	An integrated ecosystem based approach*, incorporating economic, social and environmental sustainability, should be applied to fisheries management.	This is consistent with the existing whole-of-systems approach to management. Also, see rationale for principle 5.
7	<p>A nationally-coordinated and collaborative approach should be applied where ever possible. Where appropriate, this should involve:</p> <ul style="list-style-type: none"> ▪ fishers, including sector representatives and individuals (commercial, recreational, Indigenous wild catch fishers and aquaculture operators) ▪ fisheries managers ▪ policy makers ▪ climate change and fisheries scientists ▪ communities dependent on fishing for their livelihood ▪ relevant natural resource management and primary industries agencies ▪ others whose activities will impact fisheries (e.g. maritime transport and petroleum exploration). 	Collaborative planning will help fisheries stakeholders better anticipate and more effectively respond to the impacts of climate change on the fisheries sectors. A coordinated response allows synergies to be captured, and information to be shared, when managing the range of issues that may arise from climate change.
8	Governments and fishers should work within the limitations of resources and knowledge of climate change.	Predictions and knowledge of the effects of climate change on the fisheries sectors will always be limited. Climate change will thus add an additional element of uncertainty to decision-making for fishery managers and fishers. However, this should not prevent fishers from using existing knowledge to prepare for the challenges and opportunities from climate change.
9	Addressing the actions in this plan should not lead to a net increase in greenhouse gas emissions intensity†.	Adapting to climate change should be done in a way that does not exacerbate the underlying cause of the change.

Focus areas

The focus areas are divided into the themes of adaptation (Focus Area 1) and mitigation (Focus Area 2), reflecting the two main options for dealing with climate change. They recommend strategies and actions to respond to and mitigate climate change. The actions are not assigned priorities in this document, as their

* Ecosystem based fisheries management refers to the application of the principles of Ecologically Sustainable Development, as described in the *National Strategy for Ecologically Sustainable Development* (ESD Steering Committee, 1992) across fisheries within an ecosystem.

† Emissions *intensity* (emissions produced used per unit of seafood), as opposed to *net emissions*, is an appropriate indicator, as it is not as sensitive to expansion or contraction of the fishery.

urgency and importance will vary across sectors, regions and fisheries over time. In general, coordinated research, development and communication will be important to deliver Action Plan outputs.

References in this section of the document to 'research providers' may refer to universities, publicly funded research agencies or the private sector, while the term 'fishers' may refer to individual fishers, businesses, representative bodies or other groups.

Focus area 1: improving the adaptive capacity of the fisheries sectors

Fishing is inherently subject to variability and uncertainty. This arises from a variety of sources including fluctuations in fish abundance and productivity, weather patterns, operating conditions and markets. Although fishers already deal with and adapt to such variability, climate change will add further complexity to operational and management decision-making, particularly in the medium to long-term. Fishers can be aided by monitoring, assessment, management and operational responses that are resilient to increased uncertainty, irrespective of the cause.

Fishers, and those communities whose livelihoods or subsistence depend on fishing, may be particularly sensitive to the impacts of climate change. Changes in the abundance and productivity of target and non-target species, input costs and market prices will affect the profitability and/or sustainability of fisheries operations. Such changes may arise directly from climate change, or from human responses to it. Preparing for climate change, by considering climate risks in planning processes for example, can help reduce vulnerability to negative effects and improve capacity to capitalise on any opportunities that may arise.

Although species and stocks will differ in their vulnerability to environmental changes, healthy fish stocks managed in an ecologically sustainable manner will generally be better placed to withstand increased environmental stresses. Similarly, efficient and profitable commercial operators in economically healthy fisheries will generally have greater financial scope to adjust to changed conditions.

While adaptation should be driven principally by the fisheries sectors, policy and management frameworks should be flexible, allowing fishers to respond in a timely manner and where appropriate, should identify mechanisms to adapt. These frameworks should allow fishers to capitalise on new opportunities, as well as accommodate the management of stocks that are negatively impacted by climate change. Decision support systems should ideally integrate biophysical, economic and social considerations to underpin sustainable resource use. Management frameworks should address issues such as access and property rights and remove impediments to adaptation without jeopardising long-term sustainability or productivity. Adaptation will also be enhanced by effective communication and collaboration between fishers and governments.

Research and development will need to address environmental, social and economic needs. When properly targeted, communicated and applied this will help provide the tools and knowledge to build resilience in a changing climate. However, although research into fisheries climate change issues is important, investment in this area must be considered in light of other research priorities.

Adaptation to climate change will be assisted by reliable projections of the likely timing, location and magnitude of impacts. Predictive tools can help fishers and managers understand how climate change might affect a particular fishery or associated infrastructure, and contribute to medium to long-term planning and risk management. For example, fishers may use projections to take steps to limit their dependence on stocks that are likely to be threatened by climate change, or to position themselves to take advantage of new opportunities, such as range extensions or movements. Fisheries managers, on the other hand, might adapt spatial management to account for range-shifts.

In the absence of information on the productivity of stocks and the ecosystem impacts of fishing, management should apply an appropriately precautionary approach to establishing new or expanding existing fishing activities. If harvesting of new fishery resources is to be viable over the longer-term, managers must implement appropriate controls to maintain catches of target and non-target species at sustainable levels, ensuring that an ecosystem-based approach is taken.

Many commercial fisheries have extensive historical datasets that are used to guide management decisions based on relationships between fish stocks, harvests and environmental factors. Climate change may disrupt these relationships, limiting the suitability of these data for this purpose, particularly where changes are abrupt (e.g. if a tipping point is reached). Climate driven changes to fisheries productivity or to the validity of reference information, such as the theoretical unfished biomass of stocks, may also have implications for harvest strategies and other management responses that rely on predefined estimates or reference points.

Future management strategies may need to consider an increased reliance on fishery-independent data collection, although in many cases, the costs of collecting such data will be prohibitive. Innovative approaches to collecting data and establishing cost-effective monitoring systems could be beneficial. It will also be important to continue to use fishers' knowledge of the ecosystems in which they work, e.g. to help identify shifting baselines in fisheries and the broader ecosystem.

The ability of fisheries to adjust may be affected by the adaptation strategies of other sectors. For example, responses of coastal developments to sea-level rise could affect inshore habitats, such as mangroves and seagrass beds, and the fisheries they support; while any future shift in agricultural production systems to northern Australia may result in changes to river flows, resulting in potential competition between agricultural users and environmental needs (e.g. flows for spawning cues).

Consideration should also be given to addressing non-climate stressors and how these may affect ecosystem function and fish populations. Factors including water quality, impediments to fish movement (particularly in inland waterways) and habitat integrity (including the availability of snags and integrity of nursery grounds such as mangroves and seagrass beds) may all affect populations of aquatic species and their ability to cope with the impacts of climate change.

The following table outlines a series of strategies and actions to guide adaptation to climate change.

STRATEGY		Improving the resilience of fishing operations to climate change
Actions		Lead responsibility
1.1	<p>Incorporate climate change considerations in fisheries sector planning and management processes, and fishing operations. This could include:</p> <ul style="list-style-type: none"> ▪ adapting existing operations, such as through selective breeding of aquaculture species, or changes to gear and fishing practices (where compatible with management arrangements) ▪ investigating and taking advantage of new opportunities as a result of changing climates (e.g. new species) ▪ income and operational diversification ▪ incorporating climate change risk-management strategies into business plans ▪ considering likely changes to trade and market conditions as a result of climate change. 	Fishers and research providers

<p>1.2</p>	<p>Identify and address barriers to adapting fisheries operations to climate change, such as:</p> <ul style="list-style-type: none"> ▪ legislative, policy and management barriers and other fisheries-related factors, including fisher motivations and knowledge of climate change ▪ undertaking cost-benefit analysis of various adaptation options ▪ optimising the efficiency of fishing, e.g. by managing stocks at levels that produce cost-effective catch rates ▪ minimising the negative effects of non-climate stressors. ▪ Addressing such barriers should not inadvertently impact on the sustainability, profitability, competitiveness or recreational/cultural values associated with fishing and fisheries resources. 	<p>Fishers, governments and research providers</p>
<p>STRATEGY Improving understanding and awareness of climate change impacts on fisheries</p>		
<p>Actions</p> <p>1.3</p> <p>Deliver a research, development and extension (RD&E) program that coordinates and targets investment to address fisheries climate change issues, and aims to:</p> <ul style="list-style-type: none"> ▪ encompass physical, biological, economic and social factors as appropriate ▪ capture synergies across fisheries, jurisdictions, regions and beyond, in order to maximise returns and avoid duplication ▪ bring together multiple investors to help identify such synergies and maximise leverage opportunities ▪ encourage end-user input throughout the process, to ensure that RD&E is appropriately targeted, prioritised, communicated and applied ▪ bring together expertise from multiple sources and disciplines ▪ encourage sharing of data, methodologies and results ▪ operationalise and extend results, and encourage uptake to maximise returns. 		<p>Lead responsibility</p> <p>Research providers, fishers and governments</p>
<p>1.4</p>	<p>Identify, prioritise and undertake integrated (environmental, economic and social) vulnerability and opportunity assessments at appropriate scales, which aim to:</p> <ul style="list-style-type: none"> ▪ assess habitats, species and communities within a risk-management framework ▪ inform policy, management and decision making ▪ identify and prioritise data-collection and analysis needs ▪ identify opportunities that deliver greatest returns on investment ▪ build understanding of the implications of climate change on fisheries and dependent communities ▪ improve understanding of how the effects of climate change on terrestrial systems may affect inland waterways, estuarine systems and inshore coastal habitats. 	<p>Research providers, fishers and governments</p>

<p>1.5</p>	<p>Inform management and business decision-making of the likely impacts of climate change through physical and biological predictive modelling. The models should:</p> <ul style="list-style-type: none"> ▪ be delivered at appropriate scales (e.g. regional or fishery) ▪ inform existing fisheries tools/models ▪ describe the probabilities and risks associated with model outputs. 	<p>Research providers and governments</p>
<p>1.6</p>	<p>Provide climate change information for fisheries that is relevant, understandable and easily accessible:</p> <ul style="list-style-type: none"> ▪ ensure that researchers, fisheries managers and policy makers understand fishers' information needs ▪ communicate the outcomes of climate change RD&E to help realise the benefits of research and inform decisions ▪ engage fishers at national, regional and fishery levels as appropriate ▪ raise awareness and attract fisheries stakeholder buy-in and leadership on climate change, e.g. through communicating and showcasing fisher initiatives in response to climate change ▪ ensure information is accessible to stakeholders outside the fisheries realm such as catchment management and landcare groups. 	<p>Fishers, research providers and governments</p>

STRATEGY	Facilitate ongoing assessment and monitoring of climate change impacts at suitable scales	
Actions		Lead responsibility
1.7	<p>Monitor changes in fisheries productivity and indicators of ecosystem structure. This may include:</p> <ul style="list-style-type: none"> ▪ changes in catch rates and composition including, to the extent practicable, non-target species ▪ changes to environmental factors, including benthos and infauna around aquaculture sites ▪ fishers' responses to such changes and interactions, including changes to fishing effort and methods. <p>In doing so:</p> <ul style="list-style-type: none"> ▪ consider governments' and fishers' roles in data collection for fishery and ecosystem monitoring ▪ this includes considering new and cost effective methods for collecting data ▪ capture information from all fishing sectors to the extent practicable. 	Governments, research providers and fishers
1.8	<p>Improve the understanding of how non-climate change stressors interact with climate change, and how they might reduce ecosystem resilience at a local or regional scale:</p> <ul style="list-style-type: none"> ▪ distinguish climate change impacts from the effects of other environmental and management factors, such as natural variability and the effects of fishing, including illegal, unreported and unregulated catch ▪ identify risks from new and existing pests and diseases in changing ecosystems ▪ assess cumulative impacts from a range of sources (e.g. habitat loss through coastal and catchment development). 	Research providers and governments
1.9	<p>Expand data and information frameworks, where practicable, to:</p> <ul style="list-style-type: none"> ▪ take into account data needs, at suitable scales, for the assessment of climate change impacts on fisheries ▪ store relevant physical, biological, economic and social data and metadata for long-term, ongoing assessment of climate change, following established standards (e.g. ISO 19115). 	Governments and research providers

STRATEGY Management and policy frameworks that are informed, agile and consistent	
<p>Actions</p> <p>1.10 Ensure fisheries management strategies account for climate change. Management strategies should:</p> <ul style="list-style-type: none"> ▪ be collaborative and allow flexibility for adaptation ▪ consider biophysical and socio-economic factors (for fishers and communities), including understanding fisher motivations now, and in response to likely climate-driven changes ▪ incorporate an ecosystem based fisheries management approach ▪ allow for shifting 'baseline' assumptions, appropriate to new climatic conditions ▪ consider the suitability and effectiveness of spatial and other management arrangements, now and in the future. 	<p>Lead responsibility</p> <p>Governments, fishers</p>
<p>1.11 Incorporate climate change into fisheries management scenario modelling and management strategy evaluations, recognising the need to:</p> <ul style="list-style-type: none"> ▪ understand impacts on, and engage regional communities ▪ understand the economic and social, as well as the biological impacts of adaptation options. 	<p>Research providers and governments</p>
<p>1.12 Coordinate fisheries related responses to climate change within and across agencies and governments:</p> <ul style="list-style-type: none"> ▪ align climate change policy objectives across government portfolios ▪ establish and maintain links to parallel climate change initiatives ▪ engage agencies involved in broader planning processes (e.g. local government land-use planning, state planning processes) as appropriate ▪ ensure policy regimes and legislation are flexible and do not unnecessarily impede adaptation. 	<p>Governments and fishers</p>

Focus area 2: mitigation—reducing emissions intensity

Although Australian fisheries operations are not a major source of greenhouse gas emissions, certain fishing activities can be fossil fuel, and hence emissions, intensive (CoA, 2009; FAO, 2009; Hobday & Poloczanska, 2008; Troell et al., 2004; Tyedmers, 2004; Tyedmers et al., 2025; Vieira et al, 2008). Mitigation activities for these fisheries will focus largely on reducing the intensity of fossil fuel use. Given that fuel costs in some commercial wild catch fisheries can account for around 40 per cent of input costs (Troell et al., 2004), reducing fuel consumption can also be a strong economic driver for fishers to reduce emissions intensity.

A range of measures are available for improving fuel efficiency. These include the use of more fuel efficient engines; minimising the drag of trawl gear; the use of fuel flow meters to determine optimal operating speeds; ensuring proper engine and hull maintenance; the use of more efficient hull designs and vessel set-ups; and optimising engine and propulsion systems according to the vessel and its application (FRDC, 2006; Wilson, 1999). Alternative fuels such as liquid petroleum gas and liquid natural gas may be considered. Although suitable for small engines, these may have limitations with respect to storage and use in the heavy-duty engines used by many fishers. Different fishing techniques also vary in their energy requirements, although the flexibility to alter techniques will depend on the species targeted and broader management and sustainability considerations.

Management strategies can influence the capacity of fishers to reduce their greenhouse gas emissions. Government regulators should consider the impact of management strategies on energy efficiency and emissions intensity. For example, well managed fisheries will generally produce higher catch rates, and hence lower fuel consumption per unit of catch, relative to those that are over-capitalised or are targeting depleted stocks. Fisheries and general maritime transport policy and regulations should, where practical (given other objectives), reduce disincentives that impede uptake of more efficient technologies, including gear types, engine and hull designs, and fishing practices. Governments, researchers and fishers should also identify impediments to mitigation and consider strategies to minimise these.

Understanding their greenhouse gas emissions can help fishers reduce climate impacts by adjusting their practices, such as through the application of Environmental Management Systems. Demonstrating environmental credentials in relation to greenhouse gas emissions may also have commercial benefits for some businesses, such as charter operators. Similarly, fishers can indirectly influence emissions by considering the environmental credentials of suppliers when making purchasing decisions.

The following actions are designed to promote climate change mitigation in the fisheries sectors.

STRATEGY Fishers understand and reduce greenhouse gas emissions	
<p>Actions</p> <p>2.1 Reduce greenhouse gas emissions intensity and take advantage of efficiency gains. For example:</p> <ul style="list-style-type: none"> ▪ seek, assess and implement ways to improve the energy-efficiency of operations ▪ investigate the use of lower emissions power such as alternative fuels or energy sources. 	<p>Lead responsibility</p> <p>Fishers and researchers</p>
<p>2.2 Ensure that fishers, managers and policy makers consider/appreciate the implications of management and mitigation strategies for the fisheries sectors.</p> <ul style="list-style-type: none"> ▪ Consider fuel efficiency and other relevant factors when reviewing or implementing legislation and/or regulations (e.g. those relating to fisheries input controls) to avoid imposing unnecessary inefficiencies on fishers. 	<p>Governments and fishers</p>

<p>2.3</p>	<p>Assess greenhouse gas emissions produced by the fisheries sectors for the purposes of understanding emission levels and improving operating practices.</p> <ul style="list-style-type: none"> ▪ Using internationally-agreed methodologies, determine the greenhouse footprint of fishing operations and fisheries sectors as a baseline. 	<p>Fisheries sectors</p>
<p>2.4</p>	<p>Investigate opportunities to reduce greenhouse gas emissions, such as through production of biofuels by the aquaculture sector.</p>	<p>Fisheries sectors</p>

Implementation of the Action Plan

Climate change, coupled with other social and economic factors, is likely to test the way that wild harvest fishing and aquaculture are managed across and within government jurisdictions and fishing sectors in Australia. National and regional coordination involving governments and fisheries sectors will help ensure that the fisheries sectors are prepared for the opportunities and challenges that climate change will bring.

It is envisaged that implementation of the Action Plan will be coordinated through a framework as shown in Figure 1. This framework will provide a mechanism for all Australian governments and fishing sectors to work together to understand, prepare for and respond to future challenges and opportunities.

This framework will influence policy, management and technical capabilities across Australia. Considerable effort will be directed towards providing information to fishers, businesses and communities across the country about the likely changes in our fisheries so that they are best placed to adapt to the impacts and capture the opportunities that arise from future environmental and resource changes.

Importantly, this framework will enable the limited funds across Australia to be coordinated to address common questions in order to drive efficiencies in delivering research and policy outputs throughout and across regions. A well-structured approach to investment and associated governance arrangements will help meet the information and management requirements of governments and fisheries sectors across different jurisdictions in a more effective manner. Accordingly, while framework participants will continue to control their own investment decisions, unstructured and fragmented investment approaches should be avoided.

Fishers and fishery agencies will play a key role in shaping the design of policy, management, science and communication programs developed under the framework to help ensure relevance and final adoption of this work.

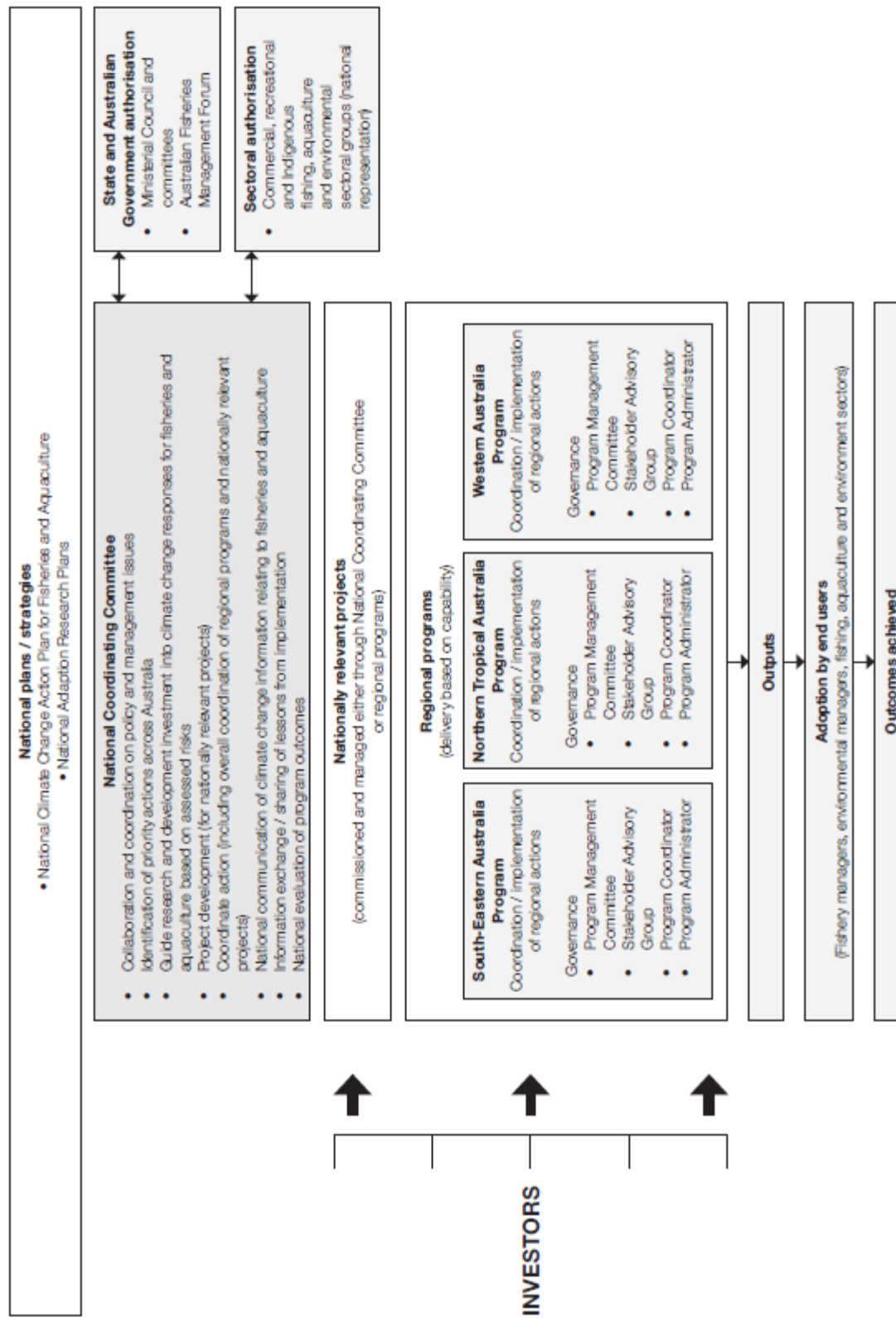
National Coordinating Committee

The National Coordinating Committee will provide oversight on the implementation of the framework. Initial membership may include representatives of the Australian Government, the Australian Fisheries Management Forum, the Fisheries Research and Development Corporation, the various fisheries sectors and other relevant bodies. This Committee will provide a national perspective to the regional programs and may commission nationally relevant projects.

Regional Programs

The regional programs will coordinate, commission and manage projects at a regional and national level. Governance arrangements will be tailored to take account of each regional context.

NATIONAL CLIMATE CHANGE IMPLEMENTATION FRAMEWORK FOR FISHERIES AND AQUACULTURE



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