Supplementary Material

The future of fish and fisheries in Australia: prioritisation of research needs through a horizon scanning approach

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Supplementary material
The final list of questions submitted by the Australian Fish and Fisheries community .

What development activities can be provided to support indigenous aquaculture opportunities?

How can links between the health of key habitat and fish stock abundance lead to more effective policy and management decisions at a Federal, State and Local government levels?

How can aquaculture development promote long-term and sustainable increases in food production and food security?

How can resource management be implemented in a way that adapts to extreme climate events (e.g. heat waves)?

How can social attitudes towards research processes and outcomes be improved to increased trust?

How can we better manage resources to meet social objectives?

How do scientists extend research to improve stakeholder acceptance of results and recommendations?

How do we influence public perceptions and understanding to promote greater sustainability outcomes for wild harvest resources?

How can fish and aquatic ecosystems be managed in a way that balances with natural resource requirements of humans (e.g. for water)?

How to value-add to existing catch to increase profitability for fishers within existing harvest limits?

How can we expand shellfish aquaculture opportunities in new and existing areas?

How can we promote the sustainable management of sea country by indigenous people in a way that respects their culture while acknowledging the actions of non-Indigenous people?

How do Australian resource managers prioritise sustainable development over development at all costs?

To what extent are consumers aware of the sustainability profile of the fish products they consume?

What are the opportunities for carbon and nutrient trading as a framework for promoting aquatic, estuarine and marine habitat restoration?

How can management of recreational fishing adapt to issues of population growth and cultural change?

What impact have barriers across inland and coastal waterways had on offshore fish productivity?

What are the primary reasons that policy makers do not use scientific advice?

What are the standardised thresholds for developing marine protected areas?

How can adaptive capacity of existing fisheries be maximised (to better cope with increasing challenges and uncertainty)?

To what extent does habitat loss and degradation affect the productivity of fisheries?

To what extent does the lack of farm irrigation pump screens and fish entrapment have on the recruitment of freshwater fish and biodiversity in Australian river systems?

What is the impact of fish migration barriers on upstream populations of economically important diadromous fish species?

Can we identify freshwater aquaculture species that would be appropriate for development and promotion in Australia?

What are the current and future threats to Australia's aquaculture industry?

How can we improve management and restoration of coastal wetlands to support fisheries production?

What strategies can be used to sustainably harvest species with different life history traits in multi-species fisheries?

Can coral harvesting be sustainability managed at genus level?

How can the importance of seafood as a measure of food security be quantified in Australia?

How can the benefits of marine protected areas to the productivity of fisheries best be quantified?

How can freshwater species and associated ecosystems be better protected from illegal fish imports?

Is the current Australian compliance regime in place adequate to ensure native freshwater species protected from illegal invasive fish?

What changes to community assemblages are occurring in native and invasive biota, and how do we know without baseline data?

What threat do non-native invasive ornamental fish already in Australian households pose to degraded and threatened ecosystems if released?

How do we develop methods to empirically measure the impact of aquatic invasive animals in Australian freshwater ecosystems?

How can we improve the detection of important diseases in shipments of fish, crustaceans or mollusc products imported into Australia?

How can we better understand the integrated impacts a potential release of carp herpes virus within the Murray Darling Basin?

Are we proactively researching, predicting, and implementing management plans that will protect our already threatened native teleosts from invasion threats?

How can we improve the laboratory capacities nationally for detection and verification of diseases in aquaculture and wild fisheries?

What are the density dependent impacts of carp on different native fish species and ecosystems?

How can we prepare to ensure that native freshwater fish populations recover maximally afterwards if the carp herpes virus is released?

Is the regulatory regime controlling the import of fish/aquatic species into Australia adequately managing the risk of invasive aquatic species into aquatic ecosystems?

What is the best way to develop regional solutions by adopting translational ecology principles in aquatic biosecurity?

How do we understand the drivers of incidental and deliberate illegal trade of invasive fish over the internet?

Are compliance and enforcement regimes adequately resourced and utilised to ensure the minimisation of risk of exotic species establishing in our aquatic ecosystems?

Can a database of species likely to migrate south with warming currents be created to determine possible future risks to ecosystems from these expected incursions?

Why are the risk assessments for ornamental fish outdated, and how have previous attempts to list high risk species delayed due to pressure from industry stakeholders?

How can current invasion data from established invasive fish species be used to quantify potential future impacts and management priorities for other species in the future?

What is the function and quality of drought refuge areas for sustaining fish populations in intermittent rivers?

How can regular evaluation and prioritisation of pressures, threats and risks on coastal ecosystems be undertaken?

To what extent does habitat loss and degradation affect ecosystem function?

What level of habitat rehabilitation is necessary to have significant positive impacts on fish populations?

How can management of freshwater systems be improved to allow integration of terrestrial socio-economic considerations and positive ecological outcomes for native species?

What are the environmental and ecological consequences of fish stocking in freshwater and estuarine ecosystems?

Can recruitment of native freshwater fish species be improved through habitat restoration?

What methods are most effective to promote successful shoreline ecosystem restoration (e.g. mangroves, saltmarshes)?

What are the inter-catchment gene flows between arid zone and semi-arid zone catchments?

Are the revised policies and regulations regarding fish passage and fish-ways improving the fish population dynamics in freshwater ecosystems?

How can spatial connectivity of key fish and invertebrate species be best assessed?

What are the thresholds of riparian restoration necessary to elicit a strong positive change in native freshwater fish assemblages?

Can the development of a research, policy, regulation and compliance system deliver a whole ecosystem management approach to all Australian marine fisheries?

What are the real impacts of freshwater invasive fish species on tropical ecosystems in Australia?

How can we halt the loss of biodiversity in freshwater ecosystems in the face of climate change and associated changes in land use and demand for water?

What are the ecosystem-level impacts of commercial fisheries and associated bycatch on the Great Barrier Reef?

How do migrating elasmobranchs act as a nutrient conveyor belts in marine ecosystems?

What is the best strategy for reintroducing threatened fish species to areas where they are regionally extinct?

How will extreme weather events and sea level rise impact on inter-tidal fish habitats and vegetation?

What is the impact of stocked recreational or commercial species on native biodiversity?

What are the critical functional roles of fisheries target species, and are these functions maintained in the face of fishing and non-fisheries threats?

How can cross-jurisdictional research in the Gulf of Carpentaria be undertaken to effectively monitor the response of large-scale estuarine and marine ecosystems vulnerable to climatic events?

How do we manage the intersecting aspects of flow, habitat and fish life history to best conserve riverine fish populations?

Can genomic capture of environmental samples provide biodiversity profiles for aquatic ecosystems before they are impacted by climate change?

What are the relationships between fisheries and coastal estuarine mangrove habitats?

How can marine protected areas be used to maintain functionally resilient ecosystems?

To increase the effectiveness of marine parks should they be redesigned as a fisheries management tool instead of a tool for protecting biodiversity?

How can we determine whether the deep-water fishes of the Coral Sea form a faunal gyre?

How can resource managers better prioritise species over politics?

Are current access rights robust enough to allow for fisheries development and diversification while still protecting the rights of current licence holders?

How can recreational fisheries be managed for maximum environmental and socio-economic benefits?

Can understanding how policy makers learn about fisheries problems enhance the efficacy and transparency of decision making?

How can we value add to our fisheries, and fisheries products, to innovate and create jobs?

How can fisheries managers, scientists and governments help the fishing industry increase value of their catch?

How can we increase the understanding of recreational fishers' knowledge on fisheries management issues?

How can we more effectively incorporate the effects of environmental variation in fisheries management?

How do we reduce the impacts of industrial coastal development on fisheries?

How can we apply social and economic indicators in management of fisheries?

How do we ensure adequate research funding from State and Commonwealth to maintain sustainable fisheries?

How can fishery managers improve on the considerations of ecosystem based fisheries management, both within and between fisheries?

How can shark control programs be de-politicized so that management can follow the best available science?

Why have fisheries managers been unable to successfully balance the three elements of ecologically sustainable development (biological, social, economic)?

Are size limits an appropriate management tool for species highly susceptible to post release mortality?

How can we improve the management of shared stocks through better collaboration across jurisdictions?

How can State and Federal agencies better adopt ecosystem based fisheries management?

How does uncertainty in fishery stock assessment influence fisheries management in practice?

How do we develop indices of recruitment and abundance to enable sustainable fisheries management in the face of increasing environmental change?

How can we improve management of species of conservation interest in commercial fisheries?

What management strategies can be developed and utilised to reduce instances of shark depredation in recreational and commercial fisheries?

How can we integrate fisheries management and marine spatial planning by considering the strengths and weaknesses of each?

How can external and collaborative research be improved to provide benefits to the management of Australian fisheries?

Can we manage fisheries in a way that provides suitable outcomes for functionally resilient fish communities?

How do we manage fisheries to reduce ecosystem impacts in a changing ocean?

How do we balance the competing needs of fisheries and marine protection?

How can marine protected areas be designed to minimise their impact on fisheries?

How can we reduce bycatch of species of conservation concern while considering the human dimensions of the problem?

How can commercial and recreational fishing practices be improved to reduce the amount of lost and deliberately discarded fishing gear?

How can fisheries management become adaptive under a changing climate?

How can fishing effort be diversified across under-utilised species and groups?

How should government agencies address gaps in basic biological information for key fish species?

How can we quantify the risk of a harvested population falling below a sustainable threshold?

What defines a fishery as truly ecologically sustainable?

How can a weight of evidence based approach be used to better assess stock status?

How can recreational fishing stakeholders be better engaged in prioritising research?

What can be developed to allow consumers the ability to identify the sex, species and provenance of seafood?

Can a nationally consistent set of performance indicators and reference points be developed for CITES-listed coral species?

How can recreational fishing harvest best be quantified?

How can post release mortality due to the effects of barotrauma in demersal species be measured?

How impact of fishing on bycatch species be reduced?

What is the contribution of stocking in rebuilding depleted fish populations?

Are changes in depredation rates influenced by increases in abundance or behavioural change of predatory species?

In the absence of recreational fishing licenses, what is the optimal methodology to collect a representative sample of recreational fishers?

How do oceanographic hydrodynamics effect larval distribution and recruitment variation of fisheries species with pelagic oceanic larvae?

What river systems contribute the most recruitment to commercial and recreational fisheries?

What are the most cost-effective and scientifically accepted approaches for assessing stock status of low value or data limited fisheries?

What are the environmental, social and economic benefits of catch-and-release recreational fishing compared to harvest for consumption?

How do we cost effectively assess fish stocks where fishery dependent data is no longer a reliable indicator of abundance?

How does the impact of recreational fishing on target species, compare to the impact of commercial fishing?

How can we develop near real-time estimates of recreational fishing harvest?

How does capture stress manifest in the short and long term?

How can the occurrence of illegal, unreported and unregulated fishing be identified and mitigated?

What novel approaches can we use to understand spatial changes in recreational fishing harvest?

How does recreational fishing effect the fish population dynamics (e.g. size and age structure)?

How can we better evaluate the influence of stocking/introductions on native fish species?

How can recreational fishing catch and effort be monitored in remote areas?

How can fisheries reference points be more closely designed around age cohorts of harvested species?

How do freshwater flows influence the productivity of estuarine and inshore marine fisheries?

How can we determine if recreational fishers are travelling further to maintain catch rates?

How can we modify fishing gear to be more selective of target species and reduce bycatch?

Do fish aggregation devices (FADs) and artificial reefs create more profitable charter and commercial fisheries?

How can we estimate the loss of productivity in biomass estimates for revising levels of unfished biomass (i.e. virgin levels)?

How do we demonstrate that local or short-term changes to fish habitats (e.g. hydrological modifications) have a net benefit to local fisheries?

Do net-free zones improve fish stocks in estuarine systems?

Do young mature fish produce the same number and quality of offspring as older fish?

What are the most effective fishery monitoring and validation methods for multi-species and small scale fisheries?

How can we better understand the life-history and population structure/dynamics of endemic deepwater sharks and rays?

What are the physiological and ecological consequences of fisheries capture to non-target species?

How can we better understand the distribution, abundance and impacts of harvesting on CITES listed marine species in tropical Australia?

What is the current scale and composition of illegal, unreported and unregulated shark fishing in Australian waters?

How do oceanographic dynamics and coastal winds influence fisheries production?

Do sharks and rays from different parts of Australia reproduce with each other or are they isolated?

What are the key factors affecting sex ratios in fish populations?

How can we better estimate population number for shark and ray species?

What are the effects of reduced genetic diversity and effective population size on growth rates in wild populations?

How will climate change impact on the movements of marine species?

How can spatial planning best incorporate the responses of fish and fisheries to environmental change?

In a warming climate, will diadromous species have the capacity to disperse via marine connections and move to southerly catchments?

How will new ecological interactions emerge as species change distribution under climate change?

How will climate change impact freshwater fish species survival?

Is it possible to build resilience in native fish species?

How will shifting ranges of fish species associated with climate change be monitored and managed?

Under a changing climate, which species will be vulnerable to extinction and which will species be able to move and establish in new habitat?

How can we incorporate environmental variables into fisheries stock assessments to predict stock productivity and recovery?

Is climate change affecting the spawning habits and yield of our fish stocks?

What are the impacts of climate change on invertebrate fisheries?

What will happen to fish population structures in relation to increased sea surface temperatures and marine heatwaves?

How will the increase in significant weather events (i.e. cyclones) impact on coral reef fin fish communities?

How can fishery managers maximise local fisheries resources for communities in a changing environment?

How are coastal marine and inter-tidal species affected by longer term changes to climate (temperature, rainfall, storm severity) and sea level?

How can identification and prioritisation of vulnerable fishes at risk or extirpation from the effects of a changing climate be undertaken?

How does drought and reduced precipitation affect the spawning and population density of freshwater fishes?

What are the implications of climate change for upland threatened freshwater fish?

How have reduced flows from river regulation affected fish breeding and productivity in coastal and near-shore environments?

How do we optimise fish habitats under changing estuarine footprints due to sea level rise throughout the transition?

How will the fishing industry adapt to changing target species' abundance and distribution?

If fish species lose habitat required for all or part of their life cycle, what strategies should be pursed to mitigate habitat loss?

How best to integrate environmental and fisheries data to scientifically demonstrate the effects of climate change on fisheries?

How can climate change trend data be incorporated into planning and management to ensure effective long-term measures to protect ecological health?

How will extreme events (e.g. marine heatwaves) impact fish populations?

How will climate change impact harmful algal blooms in Australia?

Are algal blooms increasing in inland waters across Australia and what are the key drivers, impacts and mitigation's?

What is the biological impact of extreme water temperatures on biological processes in freshwater ecosystems in Northern Australia?

What will be the long term, ecological impacts of "tropicalisation" of fish communities on Australia's southern fisheries?

What are threshold levels of habitat modification or recovery in urban catchments to changes in the assemblages of aquatic fauna?

How do we better manage marine pollution (i.e. plastics) in the ocean?

What is the impact of microplastics on plankton and other animals at the bottom of the food chain and what will this impact mean for fisheries and human health?

How will climate change impact the food safety of our seafood?

How can fisheries managers better predict, respond and adapt to a changing climate, in relation to changes to catch composition and target species?

Does water quality affect the potential for increased ciguatera / tropical fish poisoning?

How will climate change impact fisheries production?

How can the fishing industry move to environmentally-neutral practices?

How can fisheries and aquaculture best implement meaningful, large-scale carbon sequestration projects?

How can we design marine protected areas that are robust to climate change?

Can blooms of the cyanobacteria along the east coast of Australia promote ciguatera tropical fish poisoning?

What are the main environmental influences on fish migration between estuarine environments and freshwater nursery habitat?

How can we improve the survivorship of stocked fish through habitat improvement?

What are the main barriers to fish migration between estuarine environments and freshwater nursery habitat?

What habitats are the most important for all life stages in key fish species?

Can blooms of the cyanobacteria *Trichodesmium* spp. lead to plankton community mortality?

Is aquaculture exacerbating algal blooms in Australian coastal waters?

What are the primary anthropogenic impacts on habitat for key fish species?

What are the major environmental drivers of fish recruitment in rivers?

How can we prioritise estuarine fish barrier removal projects to maximise benefits to regional fisheries?

How can eDNA technologies be adopted as standard tools for the detection of endemic or protected species?

How can next-generation sequencing technologies be used to assess fisheries stock structure in a way that better informs fisheries management?

How can block-chain technology be used to improve traceability of shark products (export, import and domestic trade) to better inform end consumers?

How can recirculating aquaculture systems provide a cost-efficient solution for rural aquaculture to enhance water usage (zero-discharge systems)?

What freshwater aquaculture species would be appropriate for development and promotion in Australia?

How can eDNA techniques be developed for use in semi-quantitative population level survey of protected or threatened species?

How can species identification be improved through the use of machine learning and artificial intelligence?

How can scientists improve communication of their research to the general public?

How can eDNA technologies be adopted as standard tools for the detection of dangerous sharks in real time?

How can we utilise emerging technologies for adaptive management?

How can eDNA techniques be improved to better support the surveying of fish biodiversity in turbid rivers?

How can we develop a priority compliance system to match the requirements of fisheries management?

How can we improve the humane and ethical euthanasia of marine and freshwater species?

What kind of cost effective technology could be used to undertake surveys of fish species?

Would desalination plants be a useful approach for freshwater inland aquaculture?

How can renewable energy initiatives be applied in fisheries?

How can new genetic techniques be used to provide updated information of stock boundaries to fisheries managers?

How can genetic stock assessments be applied more widely in Australian fisheries?

How can we utilise technological advancements to enhance data collection in data-poor fisheries?

How can next generation sequencing (NGS) technology become the baseline for future biosecurity screening?

Should regular genetic screening be conducted for early detection and monitoring of biosecurity threats at significant international shipping ports around Australia?

Can eDNA technologies be developed, validated and adopted as standard tools for detection of invasive species?

Can artificial intelligence and robotics be used to design a practical and affordable trap (or other means of control) that identifies and excludes native fish, while collecting noxious fish species?

Can we develop deployment-ready genetic control techniques for invasive freshwater species such as *Gambusia* and European carp?

How can we better promote the development of new gene technology for control/eradication of introduced species?

Can white spot syndrome virus spread be prevented by using smart detection methods like rapid lateral flow devices?