



Protecting South Australia's Fish, Sharks & Rays

THREATS OVERVIEW

The fish, sharks and rays that inhabit the waters off South Australia face a wide range of threats. The major threats and the actions that can be taken at the national, state, regional, local and individual levels to reduce them are discussed in brief in two other papers in this series. These are: 'Protecting S.A.'s Fish, Sharks and Rays – Through National and State Level Actions' and 'Protecting S.A.'s Fish, Sharks and Rays – Through Regional and Local Level Actions'.

This paper provides more detailed information on a wide variety of threats. The major source for this information is South Australia's first comprehensive study of the conservation status of the fish, sharks and rays that inhabit the waters off SA: Baker, J.L. (2008) Status of Marine Species at Risk in South Australia: Technical Report – Bony and Cartilaginous Fish. Chapters of the Technical Report are being progressively uploaded and can be accessed from <http://www.reefwatch.asn.au/pages/bin/view/Publications/SamsccHome>

A preliminary summary of the findings available at the time the summary was prepared is provided as an Appendix to this paper. A full statistical summary will be available once information on all species is available.

Other sources of information used in this and the other papers in this series are listed in a separate References document.

All of the papers referred to above are available at www.ccsa.asn.au/fsr or by contacting the Conservation Council of SA at fsr@ccsa.asn.au or on (08) 8223 5155.

This threats overview is in three parts: those threats dealt with in the regional and local actions paper; those threats dealt with in the national and state levels actions paper, which relate to improved management of industries and infrastructure that impact on the marine environment; and those threats dealt with in both papers. Clearly all threats can and should be addressed at as many levels as possible, so the distinctions here are somewhat arbitrary, and largely made to simplify the presentation of the information provided.



An Eagle Ray rests on a bed of seagrass
Photo (c) J. Coates

Habitat loss is one of the major threats to the future of SA's fish, shark and ray species. Seagrass, coastal rocky reef and estuarine habitat have been identified by this project as critical habitats for many SA fish species of conservation concern and addressing the many threats to these habitats should be a high priority.

Sunlight plays on bare sand and rocks free from excessive suspended sediment blocking the light, or excessive nutrients leading to algae overgrowth.

Photo (c) J. Coates



Rocky reef and bare sand habitats are important components of the SA fish habitat. Efforts to protect our diverse and unique South Australian marine fish species must take a whole of ecosystem approach addressing threats to species and habitats in the context of the larger marine ecosystem and also links to the terrestrial environment.

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PART ONE: THREATS REQUIRING MAINLY REGIONAL, LOCAL AND INDIVIDUAL LEVEL ACTIONS

POLLUTION

NUTRIENTS

The major source of nutrient inputs into the sea, particularly in highly urbanised areas like the Adelaide coast, is insufficiently treated sewage. Other significant sources are fertilisers, agricultural and industrial waste, and stormwater. On a global scale, it is now estimated that the input of nutrients to the oceans from human sources via rivers is equal to, or greater than, the natural input (Department of the Environment, Water, Heritage and the Arts, 2008).

Fertilisers used in modern broad scale agriculture, animal wastes, industrial wastes and organic rich urban wastewater are washed into the sea via rivers, creeks, drains and stormwater channels, causing an increase in nutrient levels in adjacent coastal waters. Land management practices such as vegetation clearing and wetland reclamation compound the problem by removing natural barriers to erosion and natural 'filters' for nutrients prior to water flowing to the sea.

Excess nutrients can lead to algal and bacterial blooms (sometimes toxic, e.g. 'red tides'), which can in turn lead to oxygen depletion in the water and the 'suffocation' of marine life i.e. eutrophication. The principal nutrients associated with eutrophication are nitrogen and phosphorus but others such as organic carbon, silicon, iron, molybdenum and manganese may play a supplementary role.

Eutrophication has also been implicated in the rapidly increasing number of 'dead zones' in the world's oceans. In 2003, there were 146 of these marine 'deserts' identified, where complex life is virtually non-existent. (UNEP, 2003)

Nutrient overload can also lead to excessive growth of epiphytes i.e. algae growing on marine plants and animals, smothering them and/or cutting off light required for photosynthesis).

SEDIMENT

Water entering the sea from stormwater channels, rivers and creeks carries with it various amounts of sediment i.e. soil and other particles. When the level of sediment is increased above natural levels, primarily as a result of urban developments and land clearing, marine habitats and species can be severely affected.

Sedimentation can smother habitat, increase scouring, clog fish gills and filter feeding organisms, and decrease the amount of available light for marine plants. This is considered to be a significant component in seagrass dieback (Wilkinson, et al., 2005).

In urban areas the majority of sediment enters the sea via stormwater channels. For example, along the Adelaide metropolitan coastline, stormwater contributes around 80% of the 6,700 tonnes of sediment load per year (Wilkinson, et al., 2005). In rural areas, erosion due to land clearing – particularly along river banks – is a major cause of sedimentation.

In addition, dredging for shipping access to ports and coastal developments such as marinas, will stir up sand and other particles on the seabed. This causes the water to become turbid i.e. muddy, which will have similar impacts to those resulting from increased sediment loads.

TOXIC CHEMICALS

The build up of toxins i.e. poisons in the marine environment poses a direct threat to marine and human life. Heavy metals such as lead, copper and zinc, are produced by industrial processes such as mining and refinement, and organic pollutants such as pesticides build up in marine environments and are concentrated up the food chain (bioaccumulation). Toxins are absorbed by small plants and animals, which are in turn consumed by larger predators, and so on. As toxins are not expelled, species at the top of the food chain, such as large fish and marine mammals, can have highly elevated levels of toxins, thus threatening their ongoing survival.

Common toxins introduced to marine

environments at excessive levels by human activities include:

- hydrocarbons from petroleum products (e.g. oil spills);
- heavy metals from urban run off, industrial effluents, byproducts of mining operations and atmospheric fall out;
- organometals from anti-fouling paints (e.g. TBT);
- toxic compounds from industrial or technological processes, e.g. polychlorinated biphenyls (PCBs)
- highly acidic or alkaline substances that cause significant pH change; and
- organochlorines from insecticides (e.g. DDT), herbicides, fungicides and insulating fluids

(Brown, 2001, p35).

In the Adelaide metropolitan region, 'zinc is the metal discharged in the greatest load to the coastal strip with around 14 tonnes per year and around 75% of this comes from stormwater' (Wilkinson, et al., 2005, p.12). Lead is deposited in much smaller amounts at only 1.7 tonnes per year, but with 90% coming from stormwater (Wilkinson, et al., 2005). However, copper is the opposite, with around 70% coming from wastewater treatment plants and is 'presumably due to great extent to erosion of copper pipework' (Wilkinson, et al., 2005, p.13). Even at low concentrations, copper inhibits the reproduction of some phytoplankton species and may influence the seasonal succession of the species (Brand, et al., 1986).

The group of chemicals known as organochlorines (or organochlorides) e.g. DDT, is known for producing 'pseudo-oestrogenic' effects. These chemicals produce an effect the same as if these animals were exposed to high levels of oestrogen. When in contact with high levels of DDT some animals, including some fish, reptiles and birds, experience changes to their sexual organs and/or sexual behaviour. Fortunately most developed countries (including Australia) have now outlawed DDT, but it is still a cheap option for developing and third world countries.

Another group of chemicals of concern are PCBs (polychlorinated biphenyls). While PCB production was banned in 1970, some products containing this chemical are still in use, e.g. in electrical and electronic engineering. PCBs enter the ocean via dumped materials, and via

atmospheric pollution.

PCBs accumulate in fatty tissues such as mammary glands and ovaries in female animals, which affect their reproductive ability, including fish spawning failures at lower doses. PCBs can also accumulate in higher order predators from consuming fish and other species containing PCBs.

MARINE DEBRIS

Marine debris (rubbish) is a significant threat to marine environments and organisms. Carelessly disposed waste from individuals, land-based industry, shipping, fishing or other maritime activities is a serious problem. Entanglement, smothering and poisoning of fish and fish habitats and food sources are all impacts of marine debris. As marine debris breaks up into small pieces, it often appears like prey items to different marine animals, who then mistakenly consume them.

Materials such as plastic bags are a common sight in SA waters and can seriously harm marine creatures. They can subsequently be caught inside the gills and guts of filter feeding organisms such as shellfish, which are then eaten by fish which are unable to digest the plastic.

Discarded or lost fishing tackle from both commercial and recreational fisheries is another major and direct threat to fish species. Lost or discarded nets or lines can remain in the environment for many years continuing to damage and kill marine life. This is known as 'ghost fishing'.

COASTAL DEVELOPMENT

The growth in population and the 'sea change' phenomenon both increase coastal development, and the increasing coastal population is leading to ever increasing pressures on the marine environment.

Processes such as land clearing, engineering / road building and the reclamation of coastal environments are increasing, thereby increasing the dangers of eutrophication, sedimentation, pollution and habitat degradation. Impacts can be direct like the clearing of mangrove, dune or other coastal habitats or indirect such as urban runoff and industrial or domestic



Yorke Peninsula - nearshore rocky reef and bare sand habitat
Photo: (c) J. Coates

The health of SA's beautiful and sensitive coastal ecosystems and the fish that inhabit them is under increasing threat from human impacts as populations increase and the 'seachange' sees more and more people and industry moving to coastal areas.

pollution. Coastal developments such as marinas have the potential to disturb acid sulphate soils - highly toxic soils that lay dormant unless disturbed.

Altered freshwater flows and barriers to connectivity
The reduction of freshwater flows from creeks and rivers is of major environmental concern. The upstream removal of water for agriculture, industry and domestic use, and trapping of fresh water in dams, weirs, etc. reduces the flow of water into estuaries and increases concentrations of nutrients, toxins and sediments entering the sea.

Estuaries are important as 'nursery' areas for many fish species and are critical to the life cycle of many marine creatures. Natural input of freshwater to estuaries is important to the health of these ecosystems and the reduced flows to the Murray mouth/ Coorong areas and other estuaries is having major negative environmental impacts, exacerbated by drought.

Physical impediments to the movement of marine organisms and tidal flows are another problem faced by marine ecosystems. Coastal developments and infrastructure such as weirs or roads can prevent water from flowing in and out of tidal wetlands and stop the migrations of fish and other species. Many SA fish species rely on access to freshwater environments as part of their life cycle and the health of many coastal environments is dependant on unimpeded flows of water and organisms.

Similarly the connectivity of environments in terms of water or nutrient flow can be important. It is important for ecosystem function that connectivity between marine areas, and between marine and

freshwater systems, is maintained. Barriers might be physical barriers such as a road or weir cutting off access to river or tidal/wetland habitats or may be less obvious such as thermally polluted water.

DREDGING OPERATIONS

Dredging for shipping channels or industrial/residential developments is a significant threatening process for marine ecosystems. Problems include the physical disturbance or removal of benthic (sea bottom) systems and the associated problems of sedimentation, smothering of marine life due to the disturbance of dredging and changed flows due to the cutting of new channels. If thorough prior assessments are not undertaken, it is also possible that toxic sediments may be stirred up by dredging.

TOURISM AND RECREATION

TOURISM

Tourism is big business and the impacts of wildlife based tourism, or 'ecotourism' on marine environments can be significant. Wildlife tourism can influence the behaviour of animals and lead to adverse changes in natural foraging strategies, social interaction and maternal care. This can impact negatively on survival particularly for infants and juveniles as well as sensitive species. In addition, tourism related impacts on the environment such as pollution can cause changes to marine habitats that may also impact on the survival of marine organisms and wildlife.

The charter boat fishing industry is experiencing growth in SA and the increased size and range of boats is extending fishing impacts to areas previously protected by isolation and inaccessibility.

Development associated with

tourism operations is a major outcome of increasing marine tourism, and coast and marine tourism operations need to be well planned to avoid negatively impacting on the environment that sustains them. Ecotourism operators are in a position to lead by example with the development of sustainable infrastructure, and many operators are already going down this path, catering for the demands of their clients who are increasingly conscientious about their impact on the environment.

RECREATIONAL FISHING

Recreational fishing places significant pressure on fish populations, particularly for the inshore and near-shore species, near major population centres. The national survey of recreational fishing conducted in 2000 estimated that over 328,000 (+/- 14,000) or 24.1% of the SA population fished recreationally in the twelve months prior to April 2000, fishing an average of eight days per year (The National Recreational and Indigenous Fishing Survey of Australia, 2000).

Other findings that came from the survey include:

- More than half of the total number of recreational fishing events took place in Gulf St. Vincent and Spencer Gulf, with 33% of the total effort occurring in Gulf St. Vincent. Outside of the gulfs effort was greatest in the River Murray region.
- The species with the highest harvests (biomass) were sharks & rays, King George Whiting and Australian Salmon.
- Approximately 66% of the respondents were aware of King George Whiting regulations, under a half for snapper and about one third for squid.
- In response to whether recreational fishers supported the introduction of a recreational fishing licence, similar to those in NSW and Victoria, 47% supported one, 42% did not support one, and 11% were unsure. The main reasons for the support were for increased funding for research on recreational fishing and additional policing of fishing regulations.

While many recreational fisheries are managed through size and bag limits, this does not limit the total catch in the fishery, potentially resulting in unsustainable catch levels. Less common fishing methods like spear fishing and hand-netting, and collection for the aquarium

industry, add to the pressures on fish stocks.

The SA Department of Environment and Heritage web site identifies the following findings from the 2003 State of the Environment Report as being of particular concern:

- There are concerns regarding the sustainability of Northern Zone rock lobster and snapper in Gulf St Vincent.
- The recreational fishing sector takes a greater proportion of the fish catch for some marine fish species (principally snapper and King George whiting) than the commercial sector, but, while recreational fisheries are subject to bag, boat and size limits, there are not the same levels of control in relation to total annual catch levels.
- The management of fisheries tends to occur at the individual species level, rather than the habitat or ecosystem level.
- There are insufficient resources and funding available for research into marine fish species. This leaves significant gaps in our knowledge and is an impediment to making informed management decisions.

(Source: <http://www.environment.sa.gov.au/reporting/coast/fisheries.html>)

BOATING

Pollution from recreational boating can occur through engine oil leaks, mishandling of equipment at sea, inadequate bilge-retention facilities at boat ramps and the discarding of rubbish at sea. Of local significance, oil pollution is associated with epiphyte blooms (algae and animals growing on seagrass blades), which have been shown to be lethal to seagrass meadows, substantially reducing fish and macroinvertebrate recruitment.

Other impacts on fish, sharks and rays caused by boating activities include collisions and laceration by propellers. Habitat damage can also be caused by propellers and anchors. Boat moorings also stir up sediment in seagrass areas, causing an increase in turbidity, which reduces photosynthesis, thus affecting plant growth.

SHARK CONTROL PROGRAMS

Shark control programs, such as the netting used in the eastern States to protect swimmers from shark attack, have not been implemented on a large scale in South Australian waters. It is important to note the problems associated with such proposals if they are to be considered for SA.

Shark control nets are known to kill many species (e.g. marine turtles, whales, protected sharks) and can act as barriers to the natural migration of marine species. Their effectiveness is questionable and many of the sharks that become entangled in these nets are actually caught on the inside of the nets.

PART TWO: THREATS REQUIRING MAINLY NATIONAL AND STATE LEVEL ACTIONS

SHIPPING

OIL POLLUTION

Probably one of the most well known implications of shipping activities is oil spills, which can devastate entire ecosystems. Ironically, these often occur in isolated regions such as islands or iceberg fields, thus impacting areas where species diversity is often high. Crude oil is highly volatile and when exposed to UV radiation forms dense mats on the sea and the adjacent shoreline, smothering aquatic vegetation and benthic fauna and taking many decades to degrade. Oil spills have also been shown to decrease the respiration efficiency of fish gills, especially when dispersants are added.

CHEMICAL POLLUTION

Chemical pollution may arise from:

- accidental release of toxins from onboard materials, such as cleaning agents, paints or mechanical fluids;
- refuelling, when accidental leakages can occur;
- accidental leakages involving the transport of chemical products;
- during the deliberate discharge of effluent from onboard ablutions; and
- bilge/ballast (discussed elsewhere in this report)

One of the most significant issues is the use of tributyltin (TBT) as an anti-fouling paint on ships' hulls. In the UK, it was discovered in the 1980s that TBT was the cause of sex change in some species of marine sea snails. It was causing females to turn into fully functioning males. The UK was one of the first countries to regulate the use of TBT after this discovery. TBT, like many other toxins, bioaccumulates in the food chain, and therefore poses a significant threat to top predators like sharks and marine mammals. There is also a serious threat to humans, through the consumption of shellfish which containing TBT.

Gradual corrosion of ship hulls and the use of copper based anti-fouling paints are also of concern. One study on the effects of copper and cadmium on some species of phytoplankton showed that some species were particularly susceptible to low concentrations of both metals, affecting both reproduction and adult survival (Brand et al., 1986).

ACOUSTIC POLLUTION

Many marine species rely on sound to communicate, to locate and capture prey, and to evaluate physical features of their environment. The most well known of these are whales, dolphins and seals. However, sharks and rays also respond to acoustic vibrations, by means of the macula neglecta organ in the ear, and through the lateral line (which most fish also possess). Researchers suggest that sound may be critical for sharks in detecting prey over longer distances, and may predominate over other senses such as smell, electrosensory or visual.

Acoustic pollution is produced by maritime traffic through direct transmission of engine noise, and by hull vibration from propeller action. Some of the impacts of acoustic interference on sharks and rays include increased stress from over-stimulation of these sensory receptors, resulting in avoidance of areas that may be important for breeding and/or feeding.

ELECTROMAGNETIC RADIATION

Large ships and submarines tend to emit electromagnetic radiation at high intensity due to mechanics and electronics contained within the vessel.

Elasmobranchs (sharks and rays) have highly developed organs in the snout region known as the ampullae of Lorenzini, which can detect electric pulses as low as a few millionths of a volt. It is a short range sense and is used to close in on a prey animal.

The health status of animals changes the electrical signal of its body. Sharks and rays can sense if an animal is not in optimum health and will, therefore, be an easier target. Rays are known to use these unique sensors to detect prey completely hidden in mud or sand. The ampullae, or electroreceptors, are also sensitive to thermal, mechanical and salinity changes, as well as the Earth's magnetic field, and are critical in bodily orientation and prey detection of sharks and rays.

COMMERCIAL FISHING

With the advent of new technologies, fisheries worldwide have experienced a massive increase in catches in the past 50 years (FAO/State of World Fisheries and Aquaculture, 2006a). As a result the potential for over-fishing of commercial species is very real. FAO suggest that 60% of the world's major fisheries resources are either fully exploited or experiencing declining yields. As few countries have effective control over fishing capacity, these resources are in urgent need of management to end overfishing or to restore depleted stocks (FAO/State of World Fisheries and Aquaculture, 2006a).

A recent article in the journal 'Science' entitled 'Impacts of biodiversity loss on ocean ecosystem services' predicted that if this trend continues, populations of all current commercial fish and seafood species will collapse by 2048 (Worm, et al., 2006).

The State Government department responsible for fisheries, Primary Industries and Resources, SA (PIRSA), acknowledges that all of 21 SA fisheries examined are 'fully fished', 'over fished or depleted' or 'environmentally limited' (PIRSA, 2006).

The impacts of commercial fishing extend beyond the direct harvesting of fish. In Australia, some of the most significant impacts are related to bycatch - the accidental catching of other species, such as birds, marine mammals or non-target species of fish and other marine organisms. Other impacts include marine pollution and damage to the seabed, and the species which inhabit it.

A recent paper (Talberth, et al., 2006) examined the ecological 'fish print' of nations. This is a method of describing the sustainability of fisheries similar to terrestrial ecological footprint measures. Essentially the article outlines a method of assessing the impact of fishing and comparing it to the area fished to calculate the fishprint (ecological impact) of a particular country's (or global) fishing. The method uses various formulae to take into account the productivity of the areas fished and the place in the food web (trophic level) of the species targeted.

In this paper, Australia is assessed as having 78.0 "global hectares"(gha) of fisheries resources and currently fishes at a level that would require 202.7gha, that's a deficit of -124.7gha meaning that Australia is currently fishing at approximately 260% of our sustainable level. There is potential to apply this kind of formula at State or even regional scales and could potentially be a useful management tool.

AQUACULTURE

There are many examples of aquaculture that meet the requirements for ecologically sustainable development and there is great potential for South Australia to lead the world in aquaculture development within the context of ecologically-based management of the marine environment. Unfortunately not all methods of aquaculture are ecologically sustainable and there are a number of issues associated it.

Increased pressure on wild fish stocks and other marine species for aquaculture feed.

An example of the pressure that aquaculture can put on wild fish stocks is the tuna farming that occurs in South Australia, mainly based in the Port Lincoln region. Wild southern bluefin tuna (*Thunnus maccoyii*) are captured and grown to a larger size in 'sea pens'. This



Photo: (c) Vikki Billings

Pilchards (*Sagax sardinops*) are a critical link in the food chain as they consume plankton and are in turn eaten by a wide variety of larger fish. Their removal in large numbers is therefore a threat to the fish, sharks and rays that rely on them as a food source.

financially valuable industry has expanded quickly in recent years.

With the expansion of the industry has come an expansion of the fishery for small fish to feed the penned tuna. In response, the pilchard (sardine) fishery in SA expanded from a small fishery mainly for the bait market to the largest fishery by landed weight in Australia, in the space of around 10 years. In recent years approximately 10,000 tonnes of pilchards are caught in SA waters every year, with the vast majority going into tuna pens as feed.

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POLLUTION FROM AQUACULTURE

Oceanic and near-shore fish farming can damage the benthic (sea bottom) and surrounding environments through fish excrement and uneaten food sinking below aquaculture pens and increasing nutrient levels. These conditions can lead to artificially increased populations of creatures such as sea lice, which impact negatively on other marine life.

Pollution can also occur in other ways such as discarded or lost gear and spills of contaminants from maintenance or harvesting operations. Similarly the release of untreated wastewater from on-land aquaculture practices can impact nearshore, shallow marine habitats.

DISEASE/ PARASITES

The confined conditions of some aquaculture operations can provide the opportunity for disease to develop, thrive and impact heavily on fish or other cultured species.

Such disease outbreaks can spread to wild populations of the cultured species, or even to other wild species in the vicinity.

Transport of aquaculture species, including brood stock, between operations and regions can also contribute to the spread of disease, as can the transport and import of aquaculture feed between areas.

In 1989 there were only 3 chemical additives being fed to farm-raised salmon. By 2000 this had increased to 26, including herbicides, pesticides, antibiotics and others (World Watch Magazine, 2003). The use of chemicals and drugs to prevent and treat disease is of concern for marine species and human consumers alike. As these drugs are usually administered in pellets and are not all consumed by the farmed fish, a proportion is subsequently released into the sea thereby increasing the concentration of the chemicals they contain.

ESCAPES

Escapes from aquaculture operations are a relatively common occurrence, with over 200,000 fish escaping from fish pens between 1st June 2001 and 30th Oct 2007 (PIRSA, 2008). Escapes can increase pressure on wild species of both prey species and those that are in competition for resources with escapees.

Escapes also have the potential to introduce pest species to the wild in situations where farmed species are not indigenous to the area in which they are cultivated. Escapes can also lead to the spread of disease.

PLANKTON 'STRIPPING'

Intensive aquaculture of filter feeding organisms such as oysters or mussels means that the planktonic feed for these creatures may be locally depleted, upsetting

the ecological balance in bays or estuaries.

DIRECT DAMAGE

Nets or anchors used in aquaculture operations can directly damage the sea floor by dragging or otherwise impacting on the environment. Entanglement of marine animals, such as dolphins and sharks, in nets or other aquaculture equipment is also of concern.

MINING AND EXPLORATION

Both land-based and ocean-based mining pose threats to marine environments and the species that inhabit them. Impacts can be in the form of pollution from both normal operations (some release of oil into the environment is normal practice on offshore oil rigs) and accidental spills. Other impacts include direct disturbance to marine habitats, seismic (sound) pollution and increased localised shipping.

Offshore oil and gas rigs pose a threat of direct pollution of the marine environments in which they are situated. The scale and severity of the impacts of accidents depends on a combination of a number of factors. The most typical causes of accidents are equipment failure, personnel mistakes and extreme natural events (e.g. seismic activity, hurricanes). The main risk from drilling is accidental blowout of oil and gas as a result of encountering zones of excessively high pressure.

The impacts of gas hydrocarbons (e.g. methane) on fish are not well studied but "observations of both fish behavioural responses and fish mortality suggest a relatively low resistance of ichthyofauna [fish] to the presence of natural gas" (Patin, 1999). One potential result is damage to the nervous system.

The negative effects of seismic exploration (using high energy sonar to prospect for oil and mineral deposits) on marine mammals is increasingly well documented. The effects on fish species are not as well documented but researchers are finding that the effects can be severe and long term including 'deafening' of fish and disturbance of breeding patterns (Patin, 1999)

Oil rigs are often situated in difficult to access, offshore locations, making them difficult to regulate and enforce compliance

with environmental requirements. In many cases offshore mines actually have legislative exemption from regulations such as the Environment Protection (Sea Dumping) Act (1984). The increase in extreme weather events associated with climate change also increases the risk of major environmental disasters associated with offshore drilling and oil transport.

Exploratory drilling creates piles of 'spoil' brought up from underneath the seafloor and is usually left on the seabed near the drill site, smothering the marine life on top of which they it has been left. The spoil can contain chemicals toxic to the benthic life in the vicinity of the spoil pile.

Another negative side effect of offshore mining is the decommissioning of obsolete installations. There are international obligations (under the United Nations Convention on the Law of the Sea) regarding the size of the installation and the depth of the water in which it is situated, which impact on how much of the installation must be removed. In 90% of cases this involves using explosives (Patin, 1999). Thus the impacts on reproductive success and recruitment into the adult population could be significantly lowered and could seriously impact both commercial and at risk species. Patin (1999) states that "enough evidence exists to enforce strict regulations of explosive activities and to forbid them in areas and in seasons of spawning and fry development" of fish.

Land-based mining can also impact on marine environments as pollution from poorly managed operations can end up in the ocean by being transported downstream in rivers or directly pumped into marine waters.

POWER GENERATION

Power plants use large quantities of seawater for cooling and once used, the water has an elevated temperature. In some locations it is cooled by evaporation in large evaporative cooling towers. However, in coastal locations it is simply pumped back into the water. There are some restrictions on the temperature of the water that is returned to the sea – in Adelaide, it must be a maximum of 2 degrees centegrade higher than the receiving water temperature and it must be released in a way that enables quick dispersion. This kind of situation is

not suited to areas of low mixing, such as enclosed bays or estuaries. Warm water that becomes trapped increases the temperature of the surrounding water, changing the properties of the physical environment, potentially harming native species and encouraging introduced pest species.

DESALINATION PLANTS

Desalination is increasingly being considered and undertaken in Australia to address the freshwater shortage.

The impact of desalination plants on the marine environment takes place mainly in the vicinity of the concentrated brine discharge and uptake pipes. Even though the discharge contains natural marine ingredients, its high salinity (and hence density) causes it to sink to the sea floor without prior mixing. Also contained in this discharge are chemicals administered to the water in the pre-treatment stages of the desalination process and metals from erosion of the pipes, all of which can harm the marine life in the vicinity of the outfall pipe. The actual installation (physical placement) of the discharge pipe can also damage sensitive marine communities.

Another impact of desalination is the loss of tiny planktonic organisms. The seawater pumped through a desalination plant will, despite filters, contain planktonic organisms including the larvae of fish and other marine species, all of which will be killed in the process. The effect of the removal of these planktonic organisms will likely impact negatively on recruitment (successful reproduction) of fish and other species. Planktonic plants (phytoplankton) are the basis of the food chain and a reduction in their availability may have impacts that ripple throughout the food chain.

The environmental impact of a major industrial development in a coastal location is another issue that needs to be considered.

PART THREE: THREATS REQUIRING ACTIONS AT ALL LEVELS

CLIMATE CHANGE

The threat of climate change is global and long term with multiple, significant effects predicted.

The CSIRO predicts Australian atmospheric warming of 0.4-2°C by 2030 and 1-6°C by 2070 compared to 1990 temperatures (warming will not be the same in all places but the climate will change almost everywhere). The Earth has warmed, on average, by about 0.7°C since 1910 with nine of the ten warmest years on record occurring in the past decade. There has been an increase in heatwaves, fewer frosts, and a warming of the lower atmosphere and upper ocean. Australian temperatures have increased by almost 0.9°C over the last 100 years, which is slightly more than the global average (CSIRO, 2008).

South Australia's gulfs already have higher water temperature variations (with warm upper gulf waters and cold Southern Ocean upwellings) and salinity than other state waters and climate change is likely to exacerbate this.

Increases in temperature will affect the oceanographic (sea current) conditions of S.A.'s waters leading to changes in the habitats, distributions and viability of species. Like all life, marine species have evolved to cope with their local conditions, including water temperature. As the oceans warm, the location of the optimum water temperature will shift for many species. Some species will move to new areas, some will adapt to changed conditions and others will not. How well fish and other marine species adapt will depend partly on the robustness of the ecosystem of which they are part.

Recent research has shown that marine species are already responding to changes in water temperatures. During the last decade 34 fish species have 'exhibited major distributional changes: they either become newly established ..., or they show significant range extensions' (Thyer, 2007, p.34). Other marine species are also on the

move – species of barnacles and urchins are moving south to Tasmania, where they were not previously known. Also around Tasmania the composition of phytoplankton blooms is changing, which is of concern, given that phytoplankton are the basis of the food chain. As such, marine species higher up the food chain are likely to be effected.

Changes in temperature are already influencing oceanographic patterns on a global and hence localised scale. By 2030, changes to oceanographic conditions are predicted to include:

- A greater separation of layers in the sea, and a shallowing of the mixed layer by about one metre – reducing nutrient inputs from deep waters
- An increase in surface winds of 0-1 metres/second
- A general decline in the strength of surface currents of between 0-1.2 metres/second

(Thyer, 2007, p. 35)

The CSIRO predicts that as a result of global warming Australia will experience more days over 35°C (up to three times as many by 2070), a reduction in the number of frost days and an increase in the frequency and duration of extreme events such as heavy rains, cyclones, floods, and droughts (CSIRO 2008)

Decreased freshwater flows in southern states, and changed weather patterns, will place increased pressure on the marine environment generally, and particularly already stressed sensitive habitats such as mangrove and seagrass areas. Storm events will cause direct damage to habitats and increase erosion. Increases in hot days will have most impact on low wave energy environments such as gulfs, estuaries and bays. This will be particularly so where elevated nutrient levels increase the incidence of algal or bacterial blooms leading to anoxic (low oxygen) conditions i.e. eutrophication. Recent research confirms that rates of sea level rise have been accelerating during the 20th century. The International Panel on Climate Change Fourth Assessment Report (IPCC, 2007) predicts global sea levels to rise between 18 and 59 cm (from 1990s levels) by 2099. Local rates of sea level change depend not only on overall global warming and ice melt, but on regional changes in ocean

and wind circulation patterns. Sea level rise will have strong and direct impacts on low-lying areas through increased coastal flooding and erosion, loss of mangrove and samphire communities, contamination of groundwater supplies, and increased vulnerability to storm surges.

Acidification of the oceans and seas has been confirmed by experiments and modelling based on recent measurements of global levels of carbon dioxide. (Orr et. al. 2005) As increased amounts of carbon dioxide are dissolved in seawater, carbonic acid levels, and hence seawater acidity, increases. As a result calcium carbonate levels in the sea decrease, reducing the capacity of those species which rely on calcium carbonate to produce their shells e.g many form of plankton, oysters and crabs, and structures e.g. red coralline algae

Ocean acidification is a long-term threat to marine species, including commercial shellfish species and marine ecosystems generally – especially in the Southern Ocean as acidification is expected to affect higher latitudes first.

PEST SPECIES AND DISEASE

New marine life can arrive in South Australian waters both by migration and by human introduction.

Common methods of introduction of marine pest species and diseases from human activities are:

- Introduction by shipping through ballast water dumping and/or organisms attached to hulls;
- Transport via the importing of marine organisms and stock transfers for aquaculture or human consumption; and
- Transport of animals and plants for the aquarium trade.

http://www.marine.csiro.au/crimp//Reports/Infosht1_Introvectors_A3S.pdf

“Ballast water from shipping has been responsible for introducing more than 250 species, and possibly as many as 500 species, into Australian waters.” (Beeton et al., 2006)

The number of non-native species is believed to be increasing in marine habitats with

some causing major ecological changes and damage. Introduced pest species such as *Caulerpa taxifolia* (an algal species common in the aquarium trade) can have significant negative effects on marine ecosystems. Also known as 'aquarium Caulerpa', it is an extremely damaging variant of a native Australian species of the same name. This variant has several features that make it potentially devastating:

- It can grow very quickly (up to 4 cm/day);
- It can grow in or over almost any substrate;
- It grows over other organisms, being able to smother entire benthic habitats;
- It is distasteful to fish, who therefore tend not to eat it;
- It has no known natural herbivore to consume it; and
- It is a single-celled organism, meaning that if small pieces are broken off by anchors, flippers, fishing hooks, paddles, etc. these pieces can grow into whole new plants

In South Australia, it was fortunate that the first report of this alga was in West Lakes, a closed system, which made it comparatively easier to deal with. This involved closing the sea entrance of the Lakes and diverting fresh water from the River Torrens into the Lakes system, thereby killing the alga without chemicals. Unfortunately it has now spread into the Port River system and receives ongoing treatment with concentrated doses of salt.

Other introductions to South Australian waters are toxic dinoflagellates, planktonic organisms introduced via the discharge of ballast water. One introduced dinoflagellate, *Alexandrium minutum*, is known to cause Paralytic Shellfish Poisoning (PSP), which contains a neurotoxin that can be lethal to human consumers of shellfish.

Similarly diseases can be imported from distant areas and can have devastating effects on populations not previously exposed to them.

LACK OF KNOWLEDGE

One of the most critical threats facing South Australia's marine environment and fish species is the lack of knowledge of ecological processes and species. Compared with knowledge of terrestrial systems, our understanding of marine ecosystems is very poor, and management decisions are currently made using a very limited knowledge base. Basic survey data regarding distribution and biological parameters for non-commercial fish species are usually not available and new fish species are still being discovered in our waters. For example, the Gulfs Pipefish was recently described after being found off Adelaide's metropolitan coastline.

Currently the majority of research into fish, sharks and rays and their habitats is funded by commercial fisheries and therefore focuses on commercial species. Funding for research into non-commercial species is very limited, which has particular implications for the conservation and management of at risk species.

APPENDICES

APPENDIX 1: PRELIMINARY SUMMARY OF 'STATUS OF MARINE SPECIES AT RISK IN SOUTH AUSTRALIA: TECHNICAL REPORT – BONY AND CARTILAGINOUS FISH

As stated in the introduction to this paper, this appendix provides a preliminary summary of the findings of South Australia's first comprehensive study of the conservation status of the fish, sharks and rays that inhabit the waters off SA: Baker, J.L. (2008 in prep.) Status of Marine Species at Risk in South Australia: Technical Report – Bony and Cartilaginous Fish.

The summary is based on data available at the time the summary was prepared. As such it only provides an indication of the major threats faced by S.A.'s fish, sharks and rays, and the habitats most important to their survival. A full statistical summary will be available once information on all species is available.

MAJOR THREATS

The information available to date suggests that the following are the major threats to S.A.'s fish, sharks and rays:

- Fishing bycatch from a range of fishing methods including trawl, gillnet, hook and line, and trap fishing in both the commercial and recreational sector;
- Trawl fishing resulting in habitat damage;
- Recreational fishing, both through the taking of fish and anchor damage;
- Dredging operations which can cause direct mortality, and harm to species and habitat through increased sedimentation/turbidity.
- Site specific impacts such as local point source pollution and intensive tourism, particularly for strongly site associated fish species; and
- Estuarine degradation due to impacts such as reduced or changed freshwater flows from rivers and creeks, increased agricultural runoff and reduced connectivity (i.e. barriers to fish movement, e.g. weirs);

IMPORTANT HABITATS

The information available to date suggests that the following are the most important habitats for S.A.'s fish, sharks and rays

- Reefs and their associated macroalgal habitat.
- Estuaries
- Seagrass
- Bare sand habitats

Note: Reef includes near shore (up to 2 metres deep), coastal (2 to 20 metres) and deep water (over 20 metres) reef habitats. Bare sand includes near shore sandy/muddy bottom, deep water sandy/muddy bottom and mud flat habitats.

APPENDIX 2: CHECKLIST OF ACTIONS FOCUSING ON CONSERVATION OF MARINE BIODIVERSITY

The following checklist has been reproduced from 'Taking NRM Beyond the Shore' which was produced in 2005 by the Marine and Coastal Community Network to provide information and practical advice on how to better incorporate coastal and marine issues into regional NRM plans. It is available at: http://www.mccn.org.au/content/380/mccn_nrm_guide.pdf

INFORMATION GATHERING AND REVIEW

- 1 Have baseline inventories for marine species including seabirds, marine mammals, marine reptiles, fish, invertebrates, algae and marine plants been undertaken in your region?
- 2 Have marine and coastal areas in your region been comprehensively mapped? Is the scale of mapping adequate for management purposes?
- 3 Use the indicator list developed by Jones and Kaly (see page 43). Are there species that might be potentially threatened in your region that require immediate attention?
- 4 What marine species and habitats present in your region are protected by state and/or Australian Government legislation? What species have National Action and Recovery Plans?
- 5 Does your regional NRM plan identify and prioritise local actions as recommended by National Action and Recovery Plans?
- 6 Identify and map locally, regionally, nationally and internationally important wetlands.

RESEARCH AND MONITORING

- 7 Work with organisations involved in species and habitat monitoring to coordinate, develop and implement monitoring programs as needed in your region.
- 8 Support the monitoring of marine and coastal species and habitats by well-trained naturalists.
- 9 Support research on fisheries habitats and effects of fishing, such as bycatch monitoring, seabed disturbance and the effects on the food chain.
- 10 Develop and implement methodologies for regional assessment of selected habitats (e.g. reefs) and assessment for management of impacts and activities.
- 11 Support projects that contribute to processes aiming to identify critical habitats in marine ecosystems.

MANAGEMENT ACTIONS

- 12 Develop and implement local recovery plans for threatened species and ecological communities/populations identified in the region.
- 13 Develop and implement habitat management plans for the critical breeding, feeding and nursery areas of protected species, as well as the ecologically significant habitats, such as seagrasses, mangroves and reefs.

14 Partner with regional fisheries research/management boards to integrate Fisheries Resource and Development Corporation funded projects into a regional ecosystem-based management.

15 Develop management plans for existing MPAs; include performance assessment programs.

16 Encourage projects that investigate and implement management of Nationally Important Wetlands and Ramsar wetlands of international importance.

17 Encourage projects that support the East Asian–Australasian Shorebird Site Network and the Shorebird Action Plan.

CAPACITY BUILDING

18 Undertake community information nights and workshops looking at important coastal and marine species and habitats in the region.

19 Support training in community monitoring techniques including Seagrass Watch, Reef Watch, bird counts and water quality monitoring.

20 Support projects that assist community involvement and support for MPA designations (including community-based monitoring and other assistance with management).

21 Develop local community processes and consultative committees to implement marine conservation initiatives and monitoring.

(MCCN, 2005, p.46)