

Commonwealth Environmental Impact Statement

Chapter 10 – Fish and
invertebrates



Chapter 10 Fish and invertebrates

10.1 Introduction

This chapter summarises the existing conditions related to fish and invertebrates and assesses the impacts and risks associated with the construction, operation and decommissioning of the Star of the South Offshore Wind Farm Project (the project) on fish and invertebrates. The chapter describes how impacts will be avoided, minimised or managed.

Fish and invertebrates include all bony fishes, sharks, rays, skates and invertebrates such as molluscs (like squid) and crustaceans (like rock lobster).

This chapter is based on the impact assessment presented in *Technical Report C – Fish and Invertebrates*.

Other chapters and modelling that relate to or inform the fish and invertebrates assessment include:

Chapter 8 – Coastal Processes and Sediment Transport

Chapter 9 – Benthic Ecology

Chapter 11 – Marine Mammals and Turtles

Chapter 15 – Commercial and Recreational Fisheries

Chapter 17 – Shipping and Navigation

Chapter 21 – Business and Tourism.

Technical report Attachment I – Underwater Noise Modelling Summary

Technical report Attachment II – Oil Spill Modelling Summary

10.2 Assessment scope

The study objective for fish and invertebrates is to assess the potential impacts and risks to fish and invertebrates associated with the project.

All detailed technical methodologies and assessment on fish and invertebrates can be found in *Technical Report C – Fish and Invertebrates*.

10.2.1 Commonwealth matters

The EIS guidelines for the project inform the preparation of the EIS to enable the Commonwealth Minister for the Environment to make an informed decision on whether or not to approve the project under the EPBC Act.

The aspects of the EIS guidelines that are directly relevant to fish and invertebrates are:

- Section 2.6 – Description of protected matters
- Section 2.7 – Relevant impacts

Further information about the EIS guidelines is listed in *Attachment V – EIS Guidelines Checklist*.

10.3 Evaluation framework

10.3.1 Key legislation, policy, guidelines and standards

Table 10-1 lists the key legislation, policy, guidelines and standards relevant to the assessment of fish and invertebrates. For more detail on relevant legislation refer to *Chapter 5 – Commonwealth Legislative Framework* and *Technical Report C – Fish and Invertebrates*.

Table 10-1 Key legislation, policy, guidelines and standards

Type	Applicable legislation, policy, guideline or standard
International conventions/guidance	United Nations Convention on Biological Diversity - 1992
	Convention on the Conservation of Migratory Species of Wild Animals 1979 (Bonn Convention)
	The Convention on Wetlands of International Importance (Ramsar Convention)
Commonwealth Government	Biosecurity Act 2015
	Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)
	<i>Fisheries Management Act 1991</i> (FM Act)
	<i>Offshore Electricity Infrastructure Act 2021</i> (OEI Act)
	AFMA stock rebuilding strategies: Blue Warehouse (<i>Seriolella Brama</i>) Stock Rebuilding Strategy - revised 2014.
	School Shark (<i>Galeorhinus galeus</i>) Stock Rebuilding Strategy – revised 2015.
	Commission for the Conservation of Southern Bluefin Tuna (CCSBT) management target): Recover SBT stock to 30% of its unfished level by 2035.
	National Recovery Plan for the Australian Grayling (<i>Prototroctes maraena</i>)
	Recovery Plan for the White Shark (<i>Carcharodon carcharias</i>).
	Issues Paper for the White Shark (<i>Carcharodon carcharias</i>).
	South-east Commonwealth Marine Reserves Network Management Plan 2013-23
	<i>Navigation Act 2012</i>
	<i>Protection of the Sea (Prevention of Pollution from Ships) Act 1983</i>
	Research Strategy - 2024-2027 (National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA))
	Key environmental factors for offshore windfarm EIA under the <i>Environment Protection and Biodiversity Conservation Act 1999</i> (DCCEEW)
Introducing the Offshore Infrastructure Regulator (OIR)	

10.3.2 Assessment criteria

To assess the project, predicted impacts and risks are compared to criteria that set required environmental performance outcomes (refer *Chapter 6 – Assessment Framework*).

The criteria for fish and invertebrates are derived from legislation and policy, recovery and conservation management plans for threatened species, relevant standards and guidelines, stakeholder feedback and industry best practice.

The assessment criteria relevant to fish and invertebrates are:

- No medium or long-term impacts to a population of conservation important species
- No medium or long-term disruption to white shark migration
- No mortality of individual white sharks
- No medium or long-term impacts to plankton
- No medium or long-term impacts to populations of fish species
- No net loss of fish biodiversity
- No adverse effect on a population of fish such that biologically important life events (such as breeding, feeding or migration) are disrupted.

10.4 Methods

The purpose of the fish and invertebrates impact assessment is to assess the potential impacts and risks of the project on fish and invertebrates.

The assessment evaluates impacts and risks based on their potential to cause behavioural or physical effects on individuals, communities or assemblages, which could lead to disruptions in migration or breeding events that may affect local abundance and biodiversity.

Impacts refer to the consequences of planned project actions, which are given a rating determined by combining the magnitude of the impact and the sensitivity of the receptor.

Risks are an unexpected (accidental) event and are determined by combining the likelihood of an event occurring and the consequences that would result if the event were to occur.

The technical chapters consider **key impacts and risks** with a residual consequence rating of moderate to severe. **Other impacts and risks** are those with a residual consequence rating of negligible to minor.

Refer to *Chapter 6 – Assessment Framework* for more detail on how impact and risk ratings are derived.

The fish and invertebrates impact assessment involved :

- Reviewing relevant national, state and local legislation (see Table 10-2)
- Identifying matters of national environmental significance and other matters protected under the EPBC Act using the EPBC Act protected matters search tool
- Reviewing relevant scientific and grey (non-peer reviewed) literature, and government and non-government reports and websites
- Undertaking field studies (2020-2022) to provide a baseline description of fish species and communities and their seasonal presence:
 - Catch surveys using two local commercial fishing methods (Danish seine and gillnet)
 - Seasonal stereo baited remote underwater video surveys
 - Integrated echosounder-pelagic baited remote underwater videos
 - Passive acoustic telemetry to confirm the presence of white sharks in the area
 - Observations of large fish and schooling fish during aerial surveys

- Consultation with commercial fishers to inform baseline study design and recreational fishers through surveys at boat ramps (January to March 2021 and March 2022) and through meetings, workshops, surveys and drop-in sessions.

Further information on these field studies (marine ecological survey program) can be found in *Technical Report C – Fish and Invertebrates*.

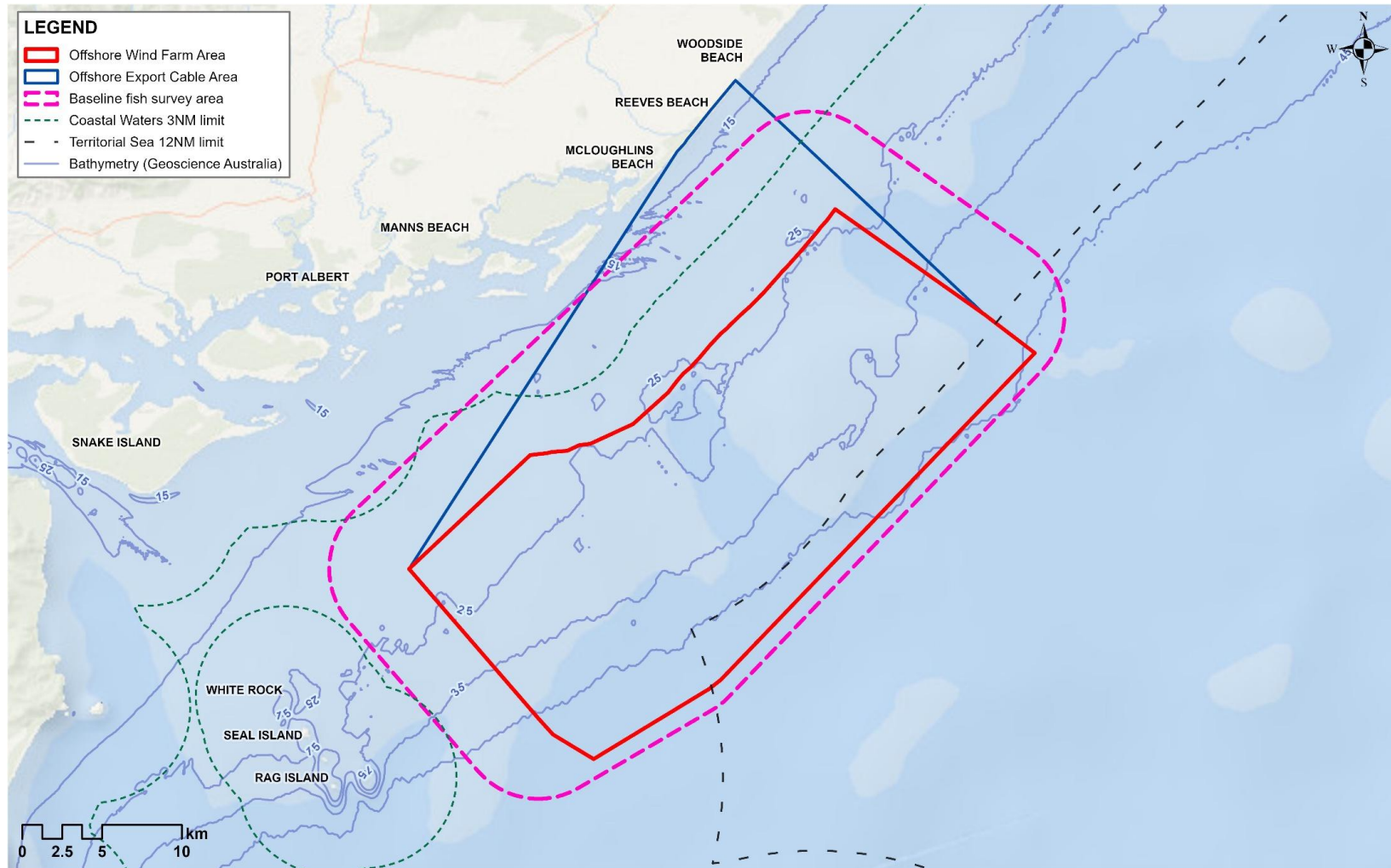
The assessment also draws on information from underwater noise modelling (*Technical report Attachment I – Underwater Noise Modelling Summary Report*) and a simulation of hydrocarbon releases (*Technical report Attachment II – Oil Spill Modelling Summary Report*).

10.5 Existing environment

This section describes the existing environmental conditions within the study area, as they relate to fish and invertebrates. The study area for fish and invertebrates includes the offshore project area, consisting of the offshore export cable area and offshore wind farm area. The study area also includes:

- An ensounded area, defined through the process of modelling of underwater noise emissions to describe the maximum extent of impacts from project activities
- The baseline fish survey area.

Figure 10-1 Fish and invertebrate study area including the offshore project area (offshore export cable area and offshore wind farm area), and the baseline fish survey area.



10.5.1 Physical environment

The physical features of the offshore project area that can influence the biodiversity of fish and invertebrates are summarised below.

Benthic habitat

Benthic habitats mainly consist of soft sediments (89.2 per cent coverage), with sparse patches of rocky reefs (7.9 per cent) and a few areas of soft sediment with seagrass (2.9 per cent). Further detail can be found in *Chapter 9 – Benthic Ecology*.

Water temperature

Water temperature is lower during winter and more variable in shallow water (12.0 to 13.8°C) compared to deeper water (14.0 to 14.4°C). This pattern is reversed in summer with seabed temperature in shallow water becoming considerably warmer (15.5°C – 18.2°C) compared to deeper areas (15.0°C to 16.0°C). Further detail can be found in *Chapter 9 – Benthic Ecology*.

Currents, tides and waves

The eastern Victorian coastline is impacted by the east Australian current, which is a warm, saline current that is strongest in summer, flowing south and often deflecting westward off Gippsland. In winter, the South Australian Current transports dense, salty water eastward from the Great Australian Bight through Bass Strait, aided by prevailing westerly and south-westerly winds. Eastern Bass Strait currents are shaped by tides, winds, and density-driven flows, with tidal phases varying by several hours across the region. Along the Gippsland coast, currents tend to flow parallel to the coast, but strong northeasterly winds can occasionally halt or reverse coastal flow.

Bass Strait is a high-energy environment frequently exposed to storms and significant wave heights, driven mainly by strong west to southwest winds. Storms can occur several times a month, typically producing waves of three to four metres, and occasionally exceeding six metres. The offshore wind farm area is exposed to swell from the southwest through southeast and locally generated wind waves from all directions. Wave disturbance to the seabed is frequent in the shallow, inshore parts of the offshore wind farm area but may only occur during extreme storm conditions in deeper offshore areas.

All details related to currents, tides and waves in the study area can be found in *Chapter 8 – Coastal Processes and Sediment Transport*.

10.5.2 Biological environment

This section outlines the species of fish and invertebrate communities, and their associated habitat-based assemblages, identified during the baseline fish surveys. Overall, seasonality and habitat type were the key variables that influenced species richness and abundance. Species richness of fish and invertebrates combined was highest in rocky reef habitats while abundance was highest in soft habitats, although this latter trend was only present

during summer. A summary of sharks and rays, bony fishes and invertebrates is provided below.

The following terms are used to describe where species tend to live in the water column:

Benthic - primarily live and feed on the seabed.

Benthopelagic - live and feed near the seabed, in the midwaters or near the surface.

Pelagic - live in the open ocean waters, the area close to the seabed through to the surface.

Sharks and Rays

The baseline fish surveys identified 15 shark species and 14 ray species (listed in *Technical Report C – Fish and Invertebrates*), with maximum body sizes ranging from the Greenback Stingaree (*Urolophus viridis*) of 44 centimetres to the White Shark (*Carcharodon carcharias*) of 650 centimetres. The most abundant species are listed in Table 10-2.

The majority (68 per cent) of species observed are benthic, noting that on an individual level there was a high abundance of benthopelagic species. Table 10-2 is a subset of the abundance observations focused on shark and ray species, noting the top two species are benthopelagic. benthic species observed include all stingrays, skates and stingarees (except the Southern Eagle Ray (*Myliobatis tenuicaudatus*)), and 50 per cent of shark species, including Gummy Shark (*Mustelus antarcticus*), Australian Angelshark (*Squatina australis*), Banded Wobbegong (*Orectolobus halei*) and both species of sawshark (*Pristiophorus cirratus* and *Pristiophorus nudipinnis*).

Approximately 26 per cent are benthopelagic, including Port Jackson Shark (*Heterodontus portsjacksoni*) Broadnose Shark (*Notorynchus cepedianus*), Bronze Whaler (*Carcharhinus brachyurus*), School Shark (*Galeorhinus galeus*) and Draughtboard Shark (*Cephaloscyllium laticeps*). Only three species (six per cent) are pelagic (predominantly live and feed in the water column but can be partially associated with the seabed), including the White Shark, Smooth Hammerhead (*Sphyrna zygaena*) and Thresher Shark (*Alopias vulpinus*).

Table 10-2 Top ten most abundant shark and ray species identified in the offshore project area during surveys (SBRUV and gillnet methods only)

Species name	Common name	Location in water column	Season	Fisheries importance*	Abundance		
					Winter	Summer	Total
<i>Heterodontus portusjacksoni</i>	Port Jackson Shark	Benthopelagic	Both	Other	316	574	890
<i>Cephaloscyllium laticeps</i>	Draughtboard shark	Benthopelagic	Both	Other	615	142	757
<i>Mustelus antarcticus</i>	Gummy shark	Benthic	Both	Commercial, recreational	176	578	754
<i>Trygonorrhina dumerilii</i>	Southern fiddler ray	Benthic	Both	Other	39	107	146
<i>Myliobatis tenuicaudatus</i>	Southern eagle ray	Benthopelagic	Both	Minor commercial, minor recreational	4	76	80
<i>Fam. Urolophidae</i>	Stingaree	Benthic	Both	Other	32	48	80
<i>Spiniraja whitleyi</i>	Melbourne skate	Benthic	Both	Minor recreational	26	47	73
<i>Pristiophorus nudipinnis</i>	Southern sawshark	Benthic	Both	Commercial	44	13	57
<i>Urolophus paucimaculatus</i>	Sparsely-spotted stingaree	Benthic	Both	Other	10	30	40
<i>Notorynchus cepedianus</i>	Broadnose shark	Benthopelagic	Both	Commercial	6	34	40

* 'Other' means species is either discarded when caught or not caught by fishing methods

Bony fish

The baseline fish surveys identified 103 bony fish species (listed in *Technical Report C – Fish and Invertebrates*). The principal habitat-based bony fish communities are benthopelagic (58 per cent), followed by benthic (32 per cent) and pelagic (10 per cent). The most abundant species are listed in Table 10-3.

Benthopelagic fish are the most prevalent species in both winter and summer surveys (57 and 64 per cent respectively), including species across a broad size range like Snakeskin Wrasse (*Eupetrichthys angustipes*, 12.4 centimetres) and Snapper (*Chrysophrys auratus*, 130 centimetres). These benthopelagic species display variability in their capacity for broad-scale movement, with the dependence on hard reef habitats rendering some species as site-attached, such as small wrasse, Barber Perch (*Caesioperca razor*) and Bigscale Bullseye (*Pempheris multiradiata*). Primary species identified in this group that are targeted by commercial and/or recreational fisheries include Snapper, Blue-throat Wrasse (*Notolabrus tetricus*), Jackass Morwong (*Nemadactylus macropterus*) and Trevally (*Pseudocaranx species*).

Approximately one-third of bony fish sampled in the winter and summer surveys (35 and 30 per cent, respectively) are benthic, including species of flounder, flathead, gurnard and whiting ranging in maximum length from the southern Gurnard Perch (*Maxillocosta meridianus*, 7.9 centimetres) to the Green Moray (*Gymnothorax prasinus*, 91.5 centimetres) and displayed diverse habitat preferences for soft or hard substrate habitats. While many of these species exhibit a degree of site-attachment in their movement patterns, they are generally broadly distributed throughout temperate Australian waters. Several species were identified as having fisheries importance, including flounder, flathead and whiting species.

Pelagic species represent seven and six per cent of bony fish species sampled during the winter and summer surveys, respectively. These species vary in their maximum size range, from small unidentified foraging baitfish species through to larger predatory species, such as Barracouta (*Thyrsites atun*, 200 centimetres standard length). Pelagic fish are generally highly mobile, occurring throughout the water column, with the species recorded in the baseline surveys associated with continental shelf waters throughout most of their life-history stages. They often aggregate in areas of greater habitat complexity, such as rocky structures, which support higher abundances of vital resources. Pelagic species targeted by commercial and/or recreational fisheries include Blue Mackerel (*Scomber australasicus*), Peruvian Jack Mackerel (*Trachurus murphyi*), Redbait (*Emmelichthys nitidus*), Snook (*Sphyræna novaehollandiae*) and Yellowtail Scad (*Trachurus novaezelandiae*).

Although no Short-finned Eels (*Anguilla australis*) were observed, this species may briefly travel past the offshore wind farm area when migrating to and from the Coral Sea and holds cultural value to the Gunditjmara and Djab Wurrung First Nations peoples.

Table 10-3 Top ten most abundant bony fish species identified in the offshore project area during surveys (SBRUV and gillnet methods only)

Species name	Common name	Location in water column	Season	Fisheries importance	Abundance		
					Winter	Summer	Total
<i>Trachurus novaezelandiae</i>	Yellowtail scad	Pelagic	Both	Minor commercial, minor recreational	1732	2067	3799
<i>Thamnaconus degeni</i>	Degen's leatherjacket	Benthopelagic	Both	Recreational, minor commercial	330	2944	3274
<i>Parequula melbournensis</i>	Silverbelly	Benthopelagic	Both	Other	762	532	1294
<i>Platycephalus bassensis</i>	Southern sand flathead	Benthic	Both	Recreational, minor commercial	606	506	1112
<i>Neosebastes scorpaenoides</i>	Common gurnard perch	Benthic	Both	Minor recreational	454	458	912

Species name	Common name	Location in water column	Season	Fisheries importance	Abundance		
					Winter	Summer	Total
<i>Caesioperca razor</i>	Barber perch	Benthopelagic	Both	Other	185	401	586
<i>Caesioperca lepidoptera</i>	Butterfly perch	Benthopelagic	Both	Other	184	401	585
<i>Chrysophrys auratus</i>	Snapper	Benthopelagic	Both	Commercial, recreational	151	237	388
<i>Platycephalus grandispinis</i>	Longspine flathead	Benthic	Both	Other	159	163	322
<i>Notolabrus tetricus</i>	Blue-throat wrasse	Benthopelagic	Both	Commercial, recreational	65	90	155

* 'Other' means species is either discarded when caught or not caught by fishing methods

Invertebrates

The baseline fish surveys identified 31 invertebrates (listed in *Technical Report C – Fish and Invertebrates*). The most abundant species are listed in Table 10-4.

The invertebrate community consists of several groups occupying diverse habitats, including crustaceans (crabs, hermit crabs, rock lobsters), cephalopods (octopus, squid, cuttlefish), echinoderms (sea stars, brittle stars, feather stars, sea cucumbers, sea-urchins), bivalves (scallops, razor shells) and gastropods (snails). While some of these species are found predominantly in soft sediment-based habitats (such as scallops) or on hard substrates (such as urchins), many exhibit more generalist characteristics and may move regularly between habitats (such as crabs).

Ninety per cent of invertebrates recorded are benthic, two are benthopelagic (Giant Cuttlefish (*Sepia apama*) and Southern Calamari (*Sepioteuthis australis*)), and one pelagic (Gould's Squid (*Nototodarus gouldi*)). Despite being mostly benthic, all recorded invertebrates except for one (Tasmanian Razor Shell (*Atrina tasmanica*)) display a capacity for movement. Seven species of fisheries importance were identified but were sampled in low numbers. The most abundant of these included Southern Calamari (*Sepioteuthis australis*), Gould's Squid and octopus species.

Table 10-4 Top ten most abundant invertebrate species identified in the offshore project area during surveys (SBRUV and gillnet methods only)

Species name	Common name	Location in water column	Season	Fisheries importance	Abundance		
					Winter	Summer	Total
<i>Fam. Diogenidae</i>	Hermit crab	Benthic	Winter	Other	151	0	151
<i>Coscinasterias muricata</i>	Eleven-arm seastar	Benthic	Both	Other	31	34	65
<i>Sepioteuthis australis</i>	Southern calamari	Benthopelagic	Both	Commercial, recreational	4	61	65
<i>Luidia australiae</i>	Southern sand star	Benthic	Summer	Other	0	39	39
<i>Nototodarus gouldi</i>	Gould's squid	Pelagic	Both	Commercial, recreational	0	22	22
<i>Octopus spp.</i>	Octopus	Benthic	Winter	Commercial	10	0	10
<i>Leptomithrax gaimardii</i>	Great spider crab	Benthic	Both	Other	3	6	9
<i>Paguristes frontalis</i>	Common hermit crab	Benthic	Summer	Other	0	7	7
<i>Naxia aurita</i>	Golden decorator crab	Benthic	Both	Other	2	3	5
<i>Macroctopus maorum</i>	Maori octopus	Benthic	Summer	Minor commercial, minor recreational	0	4	4

* 'Other' means the species is either discarded when caught or not caught by fishing methods

Plankton

Plankton are small organisms that drift with ocean currents and form the base of the food web for many fish and invertebrate species. Phytoplankton abundance is indicative of primary productivity and varies with nutrient levels and light, typically declining in summer due to nutrient depletion in warmer waters. Zooplankton abundance and diversity is indicative of secondary productivity and is influenced by environmental factors such as temperature, depth, season, and food availability.

Lower levels of commercial fishing, few sightings of krill and baitfish and low levels of chlorophyll-a (a proxy for phytoplankton detected by satellite imagery) all suggest that the offshore project area has relatively low primary and secondary productivity compared to surrounding regions.

Non-native marine invasive species

Of all fish and invertebrates, the only non-indigenous marine species identified was the New Zealand Screw Shell (*Maoricolpus roseus*). This mollusc was recorded in dense aggregations and is known to form extensive beds on the sandy sea floor in eastern Bass Strait.

10.5.3 Protected species

EPBC Act, FFG Act and International Union for Conservation of Nature (IUCN) red list

Species listed on the EPBC Act, FFG Act or IUCN red list that were either observed in field studies or have a high possibility of occurring in the offshore project area, are shown in Table 10-5. Further details are provided below on EPBC Act-listed species, including Australian Grayling (*Prototroctes maraena*), Blue Warehou (*Seriolella brama*), syngnathid species, School Shark (*Galeorhinus galeus*) and White Shark.

Australian Grayling

The Australian Grayling is only found in south-east Australia and is listed as Vulnerable under the EPBC Act. Adults live in freshwater or brackish environments, but their planktonic larval phase occurs out at sea where individuals are washed out for six to ten months before migrating back into freshwater systems. Key threats to the species include regulation of river flows and degradation of their freshwater habitat.

Due to the proximity of the offshore project area to Corner Inlet, which is fed by several rivers identified as important for the Australian Grayling, it is possible that some larvae may be transported through the offshore project area although none were detected in the field studies.

Blue Warehou

The Blue Warehou is a benthopelagic fish that has been classified as a Conservation Dependent species under the EPBC Act because stocks are below sustainable biomass reference points and require rebuilding. Key threats to the species include overfishing and climate change.

Small sized Blue Warehou were found in the offshore project area at low densities in winter, and none in summer.

Syngnathids (pipefishes, seahorses and sea dragons)

Syngnathids are typically sparsely distributed and site-attached species that are listed as Marine under the EPBC Act and as Protected Aquatic Biota under the Victorian Fisheries Act. Most syngnathid species have low reproductive capacity and exhibit lengthy parental care, with eggs brooded in an abdominal pouch by the male for up to six weeks before giving birth to a few independent young. They are generally not very mobile, and their hidden behaviour means little is known about them. Most species have naturally low population densities and appear to be patchily distributed despite large distribution ranges.

A single syngnathid (a pipefish) was observed during the field studies on rocky reef just outside the offshore wind farm area.

School Shark

The School Shark is a benthopelagic species that is globally distributed across temperate marine waters. It is listed as Conservation Dependent under the EPBC Act as stocks are below sustainable biomass reference points and require rebuilding. Key threats to the species include overfishing.

School Shark were sampled in low numbers in the offshore project area during field studies but are commonly caught by fishers in the area. As such, it is likely that a mix of adults and juveniles may occur within the offshore project area, particularly in nearshore waters during summer.

White Shark

The White Shark is globally distributed in temperate and sub-tropical coastal waters. Key threats to the species in Australia are fishing and shark control programs. There is declining abundance in national and international waters. White Sharks are considered Vulnerable and Migratory under the EPBC Act and are also listed as vulnerable under the FFG Act and the IUCN red list.

While distinguishing exact boundaries of White Shark populations is challenging, the offshore project area lies close to the proposed demarcation between the southwestern and eastern coastal populations of Australia. The offshore project area also overlaps a Biologically Important Area for breeding.

A tagging study detected 136 unique white sharks moving through the offshore project area over two years, of which 81 were detected in 2021 and 74 in 2022. Of the 74 sharks in 2022, only 19 were repeat detections from 2021 which could be driven by factors such as tag loss and mortality, or may reflect a high pass-through rate within the area. The average time white sharks remained in the area was 30 days, with older sharks generally spending less time there than younger sharks. The peak period for White Shark detections was January to March, with no detections from June to August.

Table 10-5 Species listed on the EPBC Act, FFG Act or the IUCN Red List that were observed in the field studies or have a high possibility of occurring in the offshore project area.

Species name	Common name	Habitat assemblage	Conservation status		
			EPBC Act	FFG Act	IUCN Red List
<i>Prototroctes maraena</i>	Australian grayling	Planktonic	Vulnerable	✓	Near threatened
<i>Seriolella brama</i>	Blue warehou	Benthopelagic	Conservation dependent	-	-
<i>Notorynchus cepedianus</i>	Broadnose shark	Benthopelagic	-	-	Least concern
<i>Carcharhinus brachyurus</i>	Bronze whaler	Benthopelagic	-	-	Least concern
<i>Sepia apama</i>	Giant cuttlefish	Benthopelagic	-	-	Near threatened
<i>Urolophus viridis</i>	Greenback stingaree	Benthic	-	-	Data deficient
<i>Dentiraja confusa</i>	Longnose skate	Benthic	-	-	Critically endangered
<i>Spiniraja whitleyi</i>	Melbourne skate	Benthic	-	-	Data deficient
Family Syngnathidae	Pipefish (unidentified)	Benthopelagic	Listed marine	-	Least concern
<i>Urolophus bucculentus</i>	Sandyback stingaree	Benthic	-	-	Data deficient
<i>Galeorhinus galeus</i>	School shark	Benthopelagic	Conservation dependent	-	Critically endangered
<i>Sphyrna zygaena</i>	Smooth hammerhead	Pelagic	-	-	Vulnerable
<i>Thunnus maccoyii</i>	Southern Bluefin Tuna	Pelagic	-	-	Conservation dependent
<i>Mola spp.</i>	Sunfish (unidentified)	Pelagic	-	-	Vulnerable
<i>Alopias vulpinus</i>	Thresher shark	Pelagic	-	-	Least concern
<i>Carcharodon carcharias</i>	White shark	Pelagic	Vulnerable, migratory	✓	Vulnerable
<i>Dentiraja cerva</i>	Whitespotted skate	Benthic	-	-	Near threatened

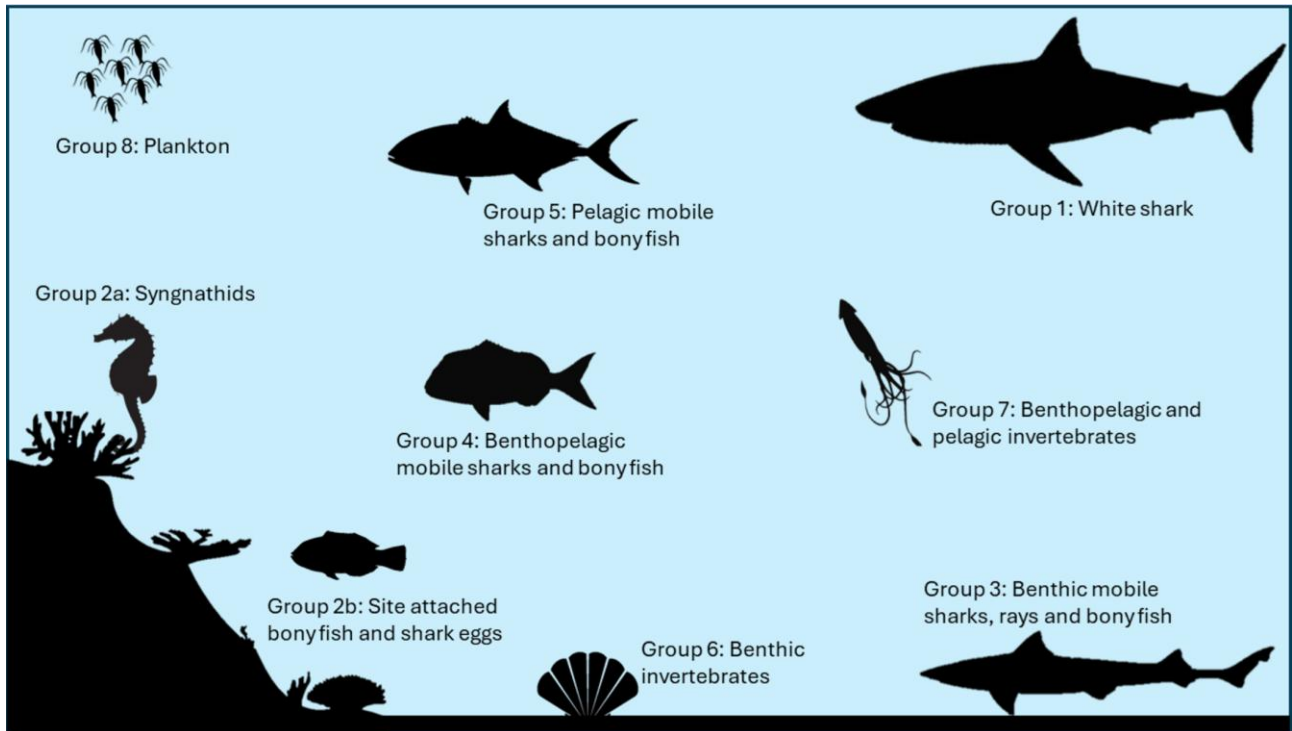
10.5.4 Receptor groups for impact assessment

To allow consistent assessment of impacts across a wide range of species with varying life histories, habitat associations and conservation importance, fish and invertebrates are grouped into nine receptor groups, described and illustrated below (Table 10-6 and Figure 10-2). These receptor groups also consider the mobility and vertical distribution of species in the water column, as such factors are key determinants of susceptibility to impacts like seabed disturbance and underwater noise.

Table 10-6 Fish and invertebrate receptor groups identified for impact and risk assessment

Receptor group	Description
Group 1: White Shark	Standalone species of high social, ecological and conservation importance that is seasonally abundant within the offshore project area.
Group 2a: Syngnathids	These species have the same characteristics as site-attached bony fish but are in a standalone group given their protected status under the EPBC Act.
Group 2b: Site-attached bony fish and shark eggs	Site-attached species, often small and reef-associated, are particularly vulnerable to seabed disturbances, noise emissions, and sediment plumes due to their limited mobility. Includes smaller wrasse and goby species, Barber Perch, Bigscale Bullseye and Rainbow Cale, and larger species such as Green Moray and Common Stargazer.
Group 3: Benthic mobile sharks, rays and bony fish	Can move away from hazards, reducing their vulnerability to physical effects, and their preferred habitat is widespread. However, they may still experience behavioural disruptions to migration, spawning, feeding, or pupping. Includes Longnose Skate, Gummy Shark, sawsharks, flathead and whiting species.
Group 4: Benthopelagic, mobile sharks and bony fish	Can move away from hazards and are less vulnerable to impacts due to their reduced dependency on specific habitats. However, individuals may experience behavioural effects such as disruption to migration, spawning, pupping or feeding activities. Species in this group listed under the EPBC Act are Blue Warehou and School Shark. Also included are eel species such as the Short-finned Eel.
Group 5: Pelagic mobile sharks and bony fish	Fish in this group are all highly mobile, typically migratory and may occur throughout the water column, even if they are often associated with seabed features such as reef. They are therefore less vulnerable to the physical and behavioural impacts that may arise from most project-related hazards. Includes Smooth Hammerhead, Thresher Shark, Yellowtail Kingfish and Sunfish.
Group 6: Benthic invertebrates	Invertebrates in this group are typically small in body size and particularly vulnerable to project-related hazards such as seabed disturbances, noise emissions and sediment plumes because they cannot readily move away from the source or are at increased risk of predation if they do so. Includes several octopus and scallop species.
Group 7: Benthopelagic and pelagic invertebrates	Invertebrates in this group include the Giant Cuttlefish (on the global IUCN red list), Gould's Squid and Southern Calamari.
Group 8: Plankton including fish eggs and larvae	Many fish are broadcast spawners, releasing eggs into the water column which then develop into larvae as part of plankton until they settle as juveniles when suitable habitat occurs. The larval phase of Australian Grayling, Blue Warehou and scallops are included here.

Figure 10-2 Fish and invertebrate receptor groups for the assessment and their general position in the water column.



10.6 Construction impacts

This section discusses the impacts and risks associated with the construction of the project that relate to fish and invertebrates and the respective receptor groups.

10.6.1 Key impacts

The construction impact assessment identified no impacts on fish and invertebrate receptor groups with a residual consequence rating of moderate or higher once mitigation measures are implemented.

10.6.2 Other impacts

Other potential construction impacts with minor to negligible effects on fish and invertebrate receptor groups once mitigation measures are implemented include:

- Underwater noise emissions (FIV-I001)
- Habitat change (FIV-I002)
- Seabed disturbance and sediment plumes (FIV-I003)
- Light emissions and routine vessel discharge (FIV-I004)
- Electromagnetic fields (FIV-I005).

10.6.2.1 Underwater noise emissions (FIV-I001)

Potential impact

Underwater noise generated by construction activities, is defined with an ensonified area (an area that includes levels of underwater generated noise that may cause reversible loss of hearing sensitivity in the most sensitive species ((Temporary Threshold Shift TTS)). This may impact fish differently, depending on the species hearing group and the presence / absence of a swim bladder and if it is used for hearing purposes. The most hearing-sensitive group is bony fish with a swim bladder that is used for hearing. Underwater noise modelling (*Technical report Attachment I – Underwater Noise Modelling Summary Report*) identifies that the most hearing-sensitive group, bony fish with a swim bladder that is used for hearing, could experience recoverable injury within 670 metres and mortality within 230 metres from the maximum noise source (installation of four jacket pin piles) if they remain within those ranges for more than 24 hours. While this is an unlikely scenario as fish are expected to rapidly disperse from a disturbed area, site-attached benthic fish, invertebrate species and plankton (including eggs and larvae), may be most sensitive to impacts from this pathway due to their lower ability to move away from the noise source.

A **swim bladder** is a gas filled organ in bony fish (not found in sharks and rays) that primarily assists with controlling buoyancy but is also used for hearing in some species.

Mitigation

As part of initial mitigation measures, the project has committed to using the best available noise abatement systems (UWN-M03), such as a double big bubble curtain that will reduce noise at the source or reduce the distance the underwater noise travels during construction. Soft start procedures (UWN-M01) that include slowly ramping up piling energy will be used to provide fish and other fauna with a gradual warning of incoming noise, allowing time to avoid the noise source. Underwater noise monitoring (MEMP-M01) will also ensure noise during piling activities does not exceed specified levels.

Residual impact

Considering these mitigations and modelling results, noise impacts will be localised and temporary. Most individual fish will have the capacity and time to temporarily avoid the affected area. Impacts on most receptor groups are assessed as having negligible magnitude and consequence, except for White Sharks and syngnathids for which have higher conservation value and sensitivity (Table 10-7).

Table 10-7 Residual impacts associated with underwater noise emissions

Potential Impact	Receptor	Receptor sensitivity	Magnitude	Initial Consequence	Mitigation Measures	Residual Consequence
Underwater noise emissions	Group 1: White shark	High	Negligible	Minor	UWN-M03 UWN-M01 OFF-M22 VES-M01	Minor
	Group 2a: Syngnathids	High	Negligible	Minor		Minor
	Group 2b: Site-attached bony fish and shark eggs	Medium	Negligible	Negligible		Negligible
	Group 3: Benthic, mobile sharks, rays and bony fish	Low	Negligible	Negligible		Negligible
	Group 4: Benthopelagic, mobile sharks and bony fish	Low	Negligible	Negligible		Negligible
	Group 5: Pelagic mobile sharks and bony fish	Low	Negligible	Negligible		Negligible
	Group 6: Benthic invertebrates	Medium	Negligible	Negligible		Negligible
	Group 7: Benthopelagic and pelagic invertebrates	Low	Negligible	Negligible		Negligible
Group 8: Plankton (including eggs/larvae)	Medium	Negligible	Negligible	Negligible	Negligible	

10.6.2.2 Habitat change (FIV-I002)

Potential impact

The installation of foundations, cables and scour protection may alter habitats by providing hard substrate for organisms to colonise and by causing a loss of existing habitat, most likely soft sediment.

These changes may benefit reef species while impacting those that prefer soft sediments. As most fish and invertebrate species were found around reef habitats during baseline fish surveys, an increase in the availability of this reef habitat may provide significant benefits for numerous fish and invertebrate species. While soft-sediment species could be impacted from a reduction in their preferred habitat type, most of the offshore project area and general region is soft sediment, meaning there is ample alternative habitat available for these species in the event that they need to move elsewhere.

Residual impact

As soft-sediment and reef species are unlikely to be significantly affected, the magnitude of impact from habitat change during construction is negligible and initial and residual consequences for most species are negligible. Impacts to syngnathids are minor, given their high sensitivity rating from their conservation value and dependence on soft sediment (Table 10-8).

Table 10-8 Residual impacts associated with habitat change

Potential Impact	Receptor	Receptor sensitivity	Magnitude	Initial Consequence	Mitigation Measures	Residual Consequence
Loss or alteration of habitat due to installation of project infrastructure	Group 1: White shark	Medium	Negligible	Negligible	-	Negligible
	Group 2a: Syngnathids	High	Negligible	Minor		Minor
	Group 2b: Site-attached bony fish and shark eggs	Medium	Negligible	Negligible		Negligible
	Group 3: Benthic, mobile sharks, rays and bony fish	Medium	Negligible	Negligible		Negligible
	Group 4: Benthopelagic, mobile sharks and bony fish	Medium	Negligible	Negligible		Negligible
	Group 5: Pelagic mobile sharks and bony fish	Medium	Negligible	Negligible		Negligible
	Group 6: Benthic invertebrates	Medium	Negligible	Negligible		Negligible
	Group 7: Benthopelagic and pelagic invertebrates	Medium	Negligible	Negligible		Negligible
Group 8: Plankton (including eggs/larvae)	Medium	Negligible	Negligible	Negligible	Negligible	

10.6.2.3 Seabed disturbance and sediment plumes (FIV-I003)

Potential impact

Seabed preparation, cable installation and associated vessel activities may disturb the seabed and create plumes of suspended sediment in the water column (sediment dispersion) that may then settle on the seafloor (sediment deposition). The species most sensitive to sediment disturbance, dispersion and deposition are those that cannot easily avoid disrupted areas or are static in nature, which includes site-attached fish and benthic invertebrates.

The overall permanent disturbance footprint from installation activities is relatively confined (see *Chapter 9 – Benthic Ecology*) and any loss of individual benthic species that cannot avoid direct disturbance (such as shellfish) would be localised and temporary and have negligible impact on the population or on other fish that prey on them, including conservation and fisheries important species.

Sediment dispersion modelling (see *Chapter 9 – Benthic Ecology*) indicates that sediment plumes resulting from cable installation and other activities would likely remain comparable with or be elevated only temporarily above natural levels before rapidly dispersing over subsequent tidal regimes. Likewise, sediment deposition modelling (see *Chapter 9 – Benthic Ecology*) indicates that a deposition thickness of 6.5 mm, which would cause potential harm to benthic macrofauna, is unlikely to be reached even near drilling operations.

Residual impact

As the spatial extent of such disturbances will be relatively confined and sediment plumes are expected to rapidly disperse over subsequent tidal regimes, impacts are expected to be localised, temporary and at an individual level, and therefore negligible in magnitude. Initial and residual consequences are negligible for most species and minor for syngnathid species due to their conservation value (Table 10-9).

Table 10-9 Residual impacts associated with seabed disturbance and sediment plumes

Potential Impact	Receptor	Receptor sensitivity	Magnitude	Initial Consequence	Mitigation Measures	Residual Consequence
Seabed disturbance and sediment plumes	Group 1: White shark	Medium	Negligible	Negligible	VES-M01	Negligible
	Group 2a: Syngnathids	High	Negligible	Minor		Minor
	Group 2b: Site-attached bony fish and shark eggs	Medium	Negligible	Negligible		Negligible
	Group 3: Benthic, mobile sharks, rays and bony fish	Low	Negligible	Negligible		Negligible
	Group 4: Benthopelagic, mobile sharks and bony fish	Low	Negligible	Negligible		Negligible
	Group 5: Pelagic mobile sharks and bony fish	Low	Negligible	Negligible		Negligible
	Group 6: Benthic invertebrates	Medium	Negligible	Negligible		Negligible
	Group 7: Benthopelagic and pelagic invertebrates	Low	Negligible	Negligible		Negligible
	Group 8: Plankton (including eggs/larvae)	Low	Negligible	Negligible		Negligible

10.6.2.4 Light emissions and routine vessel discharge (FIV-I004)

Potential impact

Construction vessels may emit small volume discharges and light at certain times which may impact pelagic species like squid and plankton due to their position in the water column and their tendency to be attracted to artificial light.

Mitigation

Vessel discharge impacts will be mitigated by the vessel operation framework (VES-M01) which will follow the International Convention for the Prevention of Pollution from Ships (MARPOL) that aims to prevent both accidental pollution and pollution from routine vessel operations. The impacts of light emissions will be minimised by adhering to the National Light Pollution guidelines which includes minimising light sources, light spill and using specific light colours and wavelengths where safe to do so (LIT-M01).

Residual impact

Following these mitigations, the impacts of both light emissions and vessel discharge will be temporary and localised. Therefore, impacts to all receptor groups are negligible (Table 10-10).

Table 10-10 Residual impacts associated with light emissions and vessel discharge

Potential Impact	Receptor	Receptor sensitivity	Magnitude	Initial Consequence	Mitigation Measures	Residual Consequence
Routine operations of project vessels	Group 1: White shark	Medium	Negligible	Negligible	OFF-M22 VES-M01 LIT-M01	Negligible
	Group 2a: Syngnathids	Low	Negligible	Negligible		Negligible
	Group 2b: Site-attached bony fish and shark eggs	Low	Negligible	Negligible		Negligible
	Group 3: Benthic, mobile sharks, rays and bony fish	Low	Negligible	Negligible		Negligible
	Group 4: Benthopelagic, mobile sharks and bony fish	Low	Negligible	Negligible		Negligible
	Group 5: Pelagic mobile sharks and bony fish	Medium	Negligible	Negligible		Negligible
	Group 6: Benthic invertebrates	Low	Negligible	Negligible		Negligible
	Group 7: Benthopelagic and pelagic invertebrates	Medium	Negligible	Negligible		Negligible
	Group 8: Plankton (including eggs/larvae)	Medium	Negligible	Negligible		Negligible

10.6.2.5 Electromagnetic fields (FIV-I005)

Potential impact

Electromagnetic fields are invisible areas of electric and magnetic energy associated with electrical power and other anthropogenic and natural sources, such as the earth's geomagnetic field. During construction, when inter-array cables are first installed and prior to their burial, certain sections of cable may be exposed on the seafloor for a series of electrical and operational tests to ensure their integrity and performance. During this time, electromagnetic fields could impact fish and invertebrates within a five-metre range, depending on the species' electro- or magneto-sensitivity and position in the water column.

Sharks, rays, skates, crustaceans (invertebrates like crabs) are sensitive to electric and magnetic fields, and a few bony fishes (none of which were observed in the offshore project area) are receptive to electric fields. Electromagnetic fields rapidly weaken with distance from the source, therefore, of the above-mentioned fish and invertebrates, it is those restricted to the seabed in proximity to a cable that may be impacted. Considering this, benthic sharks, rays and invertebrates (receptor groups three and six) are likely to be most sensitive to the impacts of electromagnetic fields (Table 10-11).

Mitigation

Upon installation, most cables will be immediately buried thereby mitigating any impact from electromagnetic fields by providing a protective distance the source (cables) and nearby fish. For the sections of cable that are left exposed for testing, testing will be done as soon as possible (within weeks), with an anticipated total timeframe of three to six months for all cables. A cable testing procedure (EMI-M02) will ensure the process is efficient and help minimise the duration of electromagnetic field exposure during this pre-burial testing of inter-array cables.

Residual impact

As cable exposure will be very temporary and localised, impacts from electromagnetic fields during construction are considered minor to negligible for all fish and invertebrate receptor groups (Table 10-11).

Table 10-11 Residual impacts associated with electromagnetic fields during testing of inter-array cables

Potential Impact	Receptor	Receptor sensitivity	Magnitude	Initial Consequence	Mitigation Measures	Residual Consequence
Electromagnetic fields during testing of inter-array cables	Group 1: White shark	Medium	Negligible	Negligible	EMI-M02	Negligible
	Group 2a: Syngnathids	Medium	Negligible	Negligible		Negligible
	Group 2b: Site-attached bony fish and shark eggs	Medium	Negligible	Negligible		Negligible
	Group 3: Benthic, mobile sharks, rays and bony fish	High	Negligible	Minor		Minor
	Group 4: Benthopelagic, mobile sharks and bony fish	Low	Negligible	Negligible		Negligible
	Group 5: Pelagic mobile sharks and bony fish	Low	Negligible	Negligible		Negligible
	Group 6: Benthic invertebrates	High	Negligible	Minor		Minor
	Group 7: Benthopelagic and pelagic invertebrates	Low	Negligible	Negligible		Negligible
	Group 8: Plankton (including eggs/larvae)	Low	Negligible	Negligible		Negligible

10.6.3 Potential risks

Potential risks to fish and invertebrates that could arise from the project's construction have a risk rating of either low or very low. These risks include:

- An oil spill from the collision of a project vessel (FIV-R001)
- The introduction and establishment of invasive marine species (FIV-R002).

10.6.3.1 Oil spill from the collision of a project vessel (FIV-R001)

Potential risk

A vessel collision resulting in the release of hydrocarbons could risk fish and invertebrates being exposed to concentrations above accepted thresholds. The likelihood of such an event is low. The consequences for fish and invertebrates depends on where and when the spill occurs but is higher for groups that have limited capacity to avoid the spill, such as site-attached species, plankton and benthic invertebrates, as well as groups with higher conservation value.

Oil spill modelling indicates that the spatial extent of a large oil spill event (300 cubic metres of marine gas oil to the sea surface over a six-hour period) in the south-western section of the offshore wind farm area would be localised (see *Technical report Attachment II – Oil Spill Modelling Summary Report*), with potential impacts to species at the individual level and not at the population level. From the modelled scenario, there was a less than two per cent probability of dissolved hydrocarbons, at concentrations that may potentially be toxic, entering Corner Inlet as the movement of hydrocarbons would mainly occur parallel to the coast with the prevailing currents.

Mitigation

This risk will be mitigated by procedures to avoid a vessel collision (VES-M01, VES-M04), including measures such as a marine coordination centre (VES-M03) that will manage simultaneous operations of project vessels. Furthermore, in the rare event that a spill occurs, impacts would be minimised by spill response plans (SPL-M02) which ensure an effective and timely response.

Residual risk

The likelihood of a collision occurring is rare and therefore risk ratings range from very low for mobile fish groups to low for less mobile species (Table 10-12).

Table 10-12 Consequence, likelihood and residual risk ranking associated with a hydrocarbon release from the collision of a project vessel during the construction phase

Risk	Receptor	Receptor sensitivity	Initial Consequence	Initial Likelihood	Initial Risk Rating	Residual Risk Rating
Hydrocarbon release from collision of a project vessel	Group 1: White shark	High	Minor	Rare	Very low	Very low
	Group 2a: Syngnathids	High	Moderate	Rare	Low	Low
	Group 2b: Site-attached bony fish and shark eggs	High	Moderate	Rare	Low	Low
	Group 3: Benthic, mobile sharks, rays and bony fish	Medium	Negligible	Rare	Very low	Very low
	Group 4: Benthopelagic, mobile sharks and bony fish	Medium	Negligible	Rare	Very low	Very low
	Group 5: Pelagic mobile sharks and bony fish	Medium	Negligible	Rare	Very low	Very low
	Group 6: Benthic invertebrates	High	Moderate	Rare	Low	Low
	Group 7: Benthopelagic and pelagic invertebrates	Medium	Negligible	Rare	Very low	Very low
	Group 8: Plankton (including eggs/larvae)	High	Minor	Rare	Very low	Very low

10.6.3.2 Introduction and establishment of invasive marine species (FIV-R002)

Potential risk

Vessel activity in the area during construction presents a risk of introducing non-indigenous marine species into the offshore project area. This may be amplified by the bare substrate that monopile foundations and scour protection provide for any introduced species to colonise and establish.

The majority (76 per cent) of invasive marine species identified in Australia are benthic invertebrates and therefore the most sensitive receptor group to this risk are benthic invertebrates, as they could face increased competition and predation with lower capacity to move. The consequence of this risk is considered moderate for benthic invertebrates and negligible for all other groups.

Mitigation

This risk will be mitigated through vessels complying with relevant biosecurity legislation and guidelines (VES-M05) that manages discharges of ballast water, ensures vessels are confirmed to be a low biosecurity risk before entering Australia or commencing work on the project.

Residual risk

With mitigations in place, the likelihood of an invasive species incursion is rare, and potential risks range from low for benthic invertebrates to very low for all other receptor groups (Table 10-13).

Table 10-13 Consequence, likelihood and residual risk ranking associated with the introduction and establishment of invasive marine species during the construction phase

Risk	Receptor	Receptor sensitivity	Initial Consequence	Initial Likelihood	Initial Risk Rating	Residual Risk Rating
Introduction and establishment of invasive marine species	Group 1: White shark	Low	Negligible	Rare	Very low	Very low
	Group 2a: Syngnathids	Medium	Negligible	Rare	Very low	Very low
	Group 2b: Site-attached bony fish and shark eggs	Low	Negligible	Rare	Very low	Very low
	Group 3: Benthic, mobile sharks, rays and bony fish	Low	Negligible	Rare	Very low	Very low
	Group 4: Benthopelagic, mobile sharks and bony fish	Low	Negligible	Rare	Very low	Very low
	Group 5: Pelagic mobile sharks and bony fish	Low	Negligible	Rare	Very low	Very low
	Group 6: Benthic invertebrates	Medium	Moderate	Rare	Low	Low
	Group 7: Benthopelagic and pelagic invertebrates	Low	Negligible	Rare	Very low	Very low
Group 8: Plankton (including eggs/larvae)	Medium	Negligible	Rare	Very low	Very low	

10.7 Operation impacts

This section discusses the impacts and risks associated with the operation of the project that relate to fish and invertebrates.

10.7.1 Key impacts

The key impact on fish and invertebrates identified for the operation phase of the project is:

- Habitat change (FIV-I002).

10.7.1.1 Habitat change (FIV-I002)

Potential impact

During the operation phase, the long-term presence of artificial surfaces from foundations, scour protection and cable protection could have a 'reef effect'. This can impact fish and invertebrates through changes in habitat type, existing fish assemblages and the broader food web.

The increase in hard substrate is expected to benefit reef species. There is likely to be positive impacts (increased abundance) on benthic invertebrates such as rock lobster and octopus, benthic fish including wrasses and gobies and pelagic fish species such as the recreationally important yellowtail kingfish that are attracted to structure for feeding opportunities.

Species that prefer soft sediment-based habitat may be more vulnerable to this change, dependant on their biological attachment to the specific conditions of the offshore project area, as discussed in the existing environment. For any that are displaced, there is ample environment to move to as the majority of benthic habitat in the offshore project area (89.2 per cent) and the general region comprise soft sandy sediment, along with other similar physical environmental conditions (water depths, wave action) found within the offshore project area, that are important factors in habitat selection for these species (see *Chapter 9 – Benthic Ecology*).

The sensitivity of syngnathids to this change is considered high because of their conservation value and, considering impacts would occur over a longer time frame, the initial consequence for syngnathids is considered moderate (Table 10-14).

Reef effect

The creation of new habitats for marine life, similar to natural reefs, from the introduction of artificial structures in the ocean.

Although the reef effect may lead to various ecological benefits, the specific influence on apex predators, such as through increased prey abundance, remains unclear. Given the long duration of the operational phase and the potential for these impacts to vary between species, along with the White Shark’s presence in the area during summer and their conservation value and corresponding high sensitivity rating, habitat change during the operation phase has a moderate initial consequence for White Sharks (Table 10-14). It is noted that the sensitivity of White Sharks has increased from the construction phase because of the potential increase in fish abundance in the offshore wind farm area. Initial consequence is considered minor for all other receptor groups (Table 10-14).

Mitigation and monitoring

Monitoring is needed to better understand the environmental implications of habitat change to fish within offshore wind farms. Therefore, broadscale monitoring of the fish assemblages and key species, including White Sharks, within and near the project area during operations will be undertaken to assess conclusions made in the impact assessment (MEMP-M07). Further information about this monitoring plan can be found in Section 10.10.2.

Residual impacts

Monitoring measures described above do not alter consequence ratings for each receptor group, and the magnitude of the impact remains low at the population level for all groups except for White Sharks and syngnathids which have a higher sensitivity due to their ecology and conservation status (Table 10-14).

Table 10-14 Residual impacts associated with habitat change from the presence of project infrastructure

Risk	Receptor	Receptor sensitivity	Magnitude	Initial Consequence	Mitigation Measures	Residual Consequence
Alteration of habitat due to installation of project infrastructure	Group 1: White shark	High	Low	Moderate	-	Moderate
	Group 2a: Syngnathids	High	Low	Moderate		Moderate
	Group 2b: Site-attached bony fish and shark eggs	Medium	Low	Minor		Minor
	Group 3: Benthic, mobile sharks, rays and bony fish	Medium	Low	Minor		Minor

Risk	Receptor	Receptor sensitivity	Magnitude	Initial Consequence	Mitigation Measures	Residual Consequence
	Group 4: Benthopelagic, mobile sharks and bony fish	Medium	Low	Minor		Minor
	Group 5: Pelagic mobile sharks and bony fish	Medium	Low	Minor		Minor
	Group 6: Benthic invertebrates	Medium	Low	Minor		Minor
	Group 7: Benthopelagic and pelagic invertebrates	Medium	Low	Minor		Minor
	Group 8: Plankton (including eggs/larvae)	Medium	Low	Minor		Minor

10.7.2 Other impacts

Other impacts from the project's operation phase that were assessed and considered to have a negligible to minor consequence for all fish and invertebrate receptor groups are:

- Underwater noise (FIV-I001)
- Light emissions and routine vessel discharge (FIV-I004)
- Electromagnetic fields (FIV-I005)
- Increased fishing activity (FIC-I006)
- Release of trace metals (FIV-I008).

10.7.2.1 Underwater noise (FIV-I001)

Potential impact

During the operation phase, the predominant sources of underwater noise will be from the rotation of wind turbines and activities of maintenance vessels.

Underwater noise from turbines is typically low in frequency and intensity, and studies from overseas offshore wind farms show that operational noise levels are often indistinguishable from natural background noise at distances beyond a few hundred metres, and not to any extent that will cause significant injury or mortality to fish.

Fewer vessel movements are required during the operation phase, and these vessels are typically less reliant on dynamic positioning that use thrusters to maintain position which generates higher noise. While some maintenance activities may require dynamic positioning, underwater noise modelling indicated that the most hearing-sensitive fish could experience a recoverable injury (a temporary threshold shift) if they are within 20 metres of the vessel.

Residual impact

Considering the minor levels and spatial extent of noise emissions by operational wind turbines, and the localised and temporary nature of vessel noise, impacts to all receptor groups are negligible (Table 10-15).

Table 10-15 Residual impacts associated with underwater noise emissions

Risk	Receptor	Receptor sensitivity	Magnitude	Initial Consequence	Mitigation Measures	Residual Consequence
Underwater noise emissions from operational wind turbines and maintenance vessel activities	Group 1: White shark	Medium	Negligible	Negligible	-	Negligible
	Group 2a: Syngnathids	Medium	Negligible	Negligible		Negligible
	Group 2b: Site-attached bony fish and shark eggs	Medium	Negligible	Negligible		Negligible
	Group 3: Benthic, mobile sharks, rays and bony fish	Low	Negligible	Negligible		Negligible
	Group 4: Benthopelagic, mobile sharks and bony fish	Low	Negligible	Negligible		Negligible
	Group 5: Pelagic mobile sharks and bony fish	Low	Negligible	Negligible		Negligible
	Group 6: Benthic invertebrates	Low	Negligible	Negligible		Negligible
	Group 7: Benthopelagic and pelagic invertebrates	Low	Negligible	Negligible		Negligible
	Group 8: Plankton (including eggs/larvae)	Low	Negligible	Negligible		Negligible

10.7.2.2 Light emissions and routine vessel discharge (FIV-I004)

Impacts are the same as those discussed for the construction phase (Section 10.6.2.4) but at a significantly reduced scale because vessels are used less frequently during the operation phase. Impacts to all receptor groups have been assessed as negligible (see Table 10-10).

10.7.2.3 Electromagnetic fields (FIV-I005)

Potential impact

During operation, up to 418 kilometres of inter-array and 286 kilometres of export cables may produce localised electromagnetic fields higher than natural levels. Levels of emitted electromagnetic fields largely depend on the type of current flow and distances from the source, being the cable. All inter-array and export cables will generate alternating current. Alternating current cables generally produce lower electromagnetic fields compared to direct current systems that are already in use by other projects in Bass Strait, such as the Basslink Interconnector.

As discussed for the assessment of electromagnetic fields during construction, benthic sharks, rays and invertebrates (receptor groups three and six) are likely to be most vulnerable to any impacts of electromagnetic fields because of their electromagnetic sensitivity and potential proximity to cables.

Mitigation

Considering that the strength of electromagnetic fields rapidly weakens with distance from the source, impacts will be mitigated by burying inter-array and export cables at a minimum depth of 0.6 metres and 1.0 metre, respectively (EMI-M01), providing a protective distance between the cables and fish. Where burial is not possible, cables will be protected by concrete mattresses or rock armour up to 5.0 meters wide and 1.5 metres high (with a minimum of 0.3 metres for both width and height).

A post-lay cable burial assessment will provide accurate measurement of the cable's 'as-laid' position and depth below the seabed (MEMP-M09), and ongoing monitoring of cables will identify any change that is indicative of altered burial depth. A remedial burial strategy will be implemented if offshore cables are found to be inadequately buried (MEMP-M09).

Residual impact

Following these mitigation measures, impacts from electromagnetic fields during the operation phase is likely to be restricted to individuals, with population level impacts not expected for any fish and invertebrate species. Initial and residual consequences have been assessed as minor for the more sensitive benthic groups and negligible for all other receptor groups (Table 10-16).

Table 10-16 Residual impacts associated with electromagnetic fields (EMFs) from power cables

Potential Impact	Receptor	Receptor sensitivity	Magnitude	Initial Consequence	Mitigation & Monitoring	Residual Consequence
EMF from transmission cables causing behavioural and physical impacts to fish.	Group 1: White shark	Medium	Negligible	Negligible	EMI-M01 MEMP-M07 MEMP-M09	Negligible
	Group 2a: Syngnathids	Medium	Negligible	Negligible		Negligible
	Group 2b: Site-attached bony fish and shark eggs	Medium	Negligible	Negligible		Negligible
	Group 3: Benthic, mobile sharks, rays and bony fish	High	Negligible	Minor		Minor
	Group 4: Benthopelagic, mobile sharks and bony fish	Medium	Negligible	Negligible		Negligible
	Group 5: Pelagic mobile sharks and bony fish	Low	Negligible	Negligible		Negligible
	Group 6: Benthic invertebrates	High	Negligible	Minor		Minor
	Group 7: Benthopelagic and pelagic invertebrates	Medium	Negligible	Negligible		Negligible
	Group 8: Plankton (including eggs/larvae)	Low	Negligible	Negligible		Negligible

10.7.2.4 Increased fishing activity (FIV-I006)

Potential impact

Considering the presence of hard substrate in the open ocean during the operation phase may have a reef effect, this may drive increases in the abundance of certain fisheries species, potentially leading to higher levels of commercial and/or recreational fishing activity in the area. Targeted fisheries species such as Gummy Shark (group 3), Snapper (group 4), Kingfish and Rock Lobster (not identified in surveys but belong to group 5 and 6, respectively), and squid (group 7) are most sensitive to these impacts.

Residual impact

Given these species are broadly distributed in the region with strong connectivity across their geographic range, any decline in their abundance within the offshore project area from increased fishing pressure will have minimal impacts across their population. As such, impacts are considered negligible for all receptor groups (Table 10-17).

Table 10-17 Residual impacts associated with increased fishing activity

Potential Impact	Receptor	Receptor sensitivity	Magnitude	Initial Consequence	Mitigation Measures	Residual Consequence
Increased fishing activity	Group 1: White shark	Medium	Negligible	Negligible	OFF-M22	Negligible
	Group 2a: Syngnathids	Low	Negligible	Negligible		Negligible
	Group 2b: Site-attached bony fish and shark eggs	Low	Negligible	Negligible		Negligible
	Group 3: Benthic, mobile sharks, rays and bony fish	Medium	Negligible	Negligible		Negligible
	Group 4: Benthopelagic, mobile sharks and bony fish	Medium	Negligible	Negligible		Negligible
	Group 5: Pelagic mobile sharks and bony fish	Medium	Negligible	Negligible		Negligible
	Group 6: Benthic invertebrates	Medium	Negligible	Negligible		Negligible

Potential Impact	Receptor	Receptor sensitivity	Magnitude	Initial Consequence	Mitigation Measures	Residual Consequence
	Group 7: Benthopelagic and pelagic invertebrates	Medium	Negligible	Negligible		Negligible
	Group 8: Plankton (including eggs/larvae)	Low	Negligible	Negligible		Negligible

10.7.2.5 Release of trace metals (FIV-I008)

Potential impact

Corrosion protection systems may be used to protect foundations and other offshore infrastructure from corrosion, extending the longevity of infrastructure and reducing maintenance requirements. If trace metals, such as zinc and aluminium, were to leach from these protection systems and exceed certain concentrations, this could impact fish and invertebrates. This is not expected to eventuate, as trace metals have been studied in the vicinity of overseas offshore wind farms and measured concentrations were mostly within the range of known variability for the region.

Residual impact

The potential impacts of trace metals released from protection systems during the project’s operational life will be very limited and is expected to be below water quality guidelines for Australian marine waters. As such, consequences to all receptor groups are assessed as negligible (Table 10-18).

Table 10-18 Residual impacts associated with the release of trace metals from corrosion protection systems

Potential Impact	Receptor	Receptor sensitivity	Magnitude	Initial Consequence	Mitigation Measures	Residual Consequence
Release of trace metals from corrosion protection systems	Group 1: White shark	Low	Negligible	Negligible	-	Negligible
	Group 2a: Syngnathids	Low	Negligible	Negligible		Negligible
	Group 2b: Site-attached bony fish and shark eggs	Low	Negligible	Negligible		Negligible

Potential Impact	Receptor	Receptor sensitivity	Magnitude	Initial Consequence	Mitigation Measures	Residual Consequence
	Group 3: Benthic, mobile sharks, rays and bony fish	Low	Negligible	Negligible		Negligible
	Group 4: Benthopelagic, mobile sharks and bony fish	Low	Negligible	Negligible		Negligible
	Group 5: Pelagic mobile sharks and bony fish	Low	Negligible	Negligible		Negligible
	Group 6: Benthic invertebrates	Medium	Negligible	Negligible		Negligible
	Group 7: Benthopelagic and pelagic invertebrates	Low	Negligible	Negligible		Negligible
	Group 8: Plankton (including eggs/larvae)	Low	Negligible	Negligible		Negligible

10.7.3 Potential risks

All potential risks to fish and invertebrates that could arise from the project’s operation phase have a risk rating of either low or very low. These risks include:

- An oil spill from the collision of a project vessel (FIV-R001)
- The introduction and establishment of invasive marine species (FIV-R002)
- An oil spill during operations on substations (FIV-R003).

10.7.3.1 Oil spill from the collision of a project vessel (FIV-R001)

This risk has been conservatively assessed as the same as during the construction phase but with a significantly lower likelihood of occurrence because of the less frequent, locally sourced and generally smaller vessels used during operations. See section 10.6.3.1 for the assessment.

10.7.3.2 Introduction and establishment of invasive marine species (FIV-R002)

This risk has been conservatively assessed as the same as during the construction phase but with a significantly lower likelihood of occurrence because of the less frequent, locally sourced and generally smaller vessels used during operations. See section 10.6.3.2 for the assessment.

10.7.3.3 Oil spill during operations on substations (FIV-R003)

Potential risk

The offshore substations will collect, transform and export power generated by the wind turbines and provide other power system, control and support functions. They contain transformers which as a worst-case scenario would use naphthenic oil that is manufactured from crude oil, there is a risk of an oil spill from a malfunctioning transformer.

Risks to fish and invertebrates are like those in Section 10.6.3.1, but significantly less considering any substation oil spill would be significantly lower in volume and more contained than that from a vessel collision.

Mitigation

This risk will be mitigated by the bunding of substation transformers and regular maintenance. Together, these mitigations will minimise the likelihood of this risk eventuating (SPL-M03).

Residual risk

With mitigation measures in place, risk ratings are considered very low for all receptor groups (Table 10-19).

Table 10-19 Consequence, likelihood and residual risk ranking associated with a hydrocarbon release during operations on substations

Risk	Receptor	Receptor sensitivity	Magnitude	Initial Consequence	Initial Likelihood	Initial Risk Rating	Residual Risk Rating
Hydrocarbon release during operations on substations	Group 1: White shark	Medium	Negligible	Negligible	Rare	Very low	Very low
	Group 2a: Syngnathids	Medium	Negligible	Negligible	Rare	Very low	Very low
	Group 2b: Site-attached bony fish and shark eggs	Medium	Negligible	Negligible	Rare	Very low	Very low
	Group 3: Benthic, mobile sharks, rays and bony fish	Low	Negligible	Negligible	Rare	Very low	Very low
	Group 4: Benthopelagic, mobile sharks and bony fish	Low	Negligible	Negligible	Rare	Very low	Very low
	Group 5: Pelagic mobile sharks and bony fish	Low	Negligible	Negligible	Rare	Very low	Very low
	Group 6: Benthic invertebrates	Medium	Negligible	Negligible	Rare	Very low	Very low
	Group 7: Benthopelagic and pelagic invertebrates	Low	Negligible	Negligible	Rare	Very low	Very low
	Group 8: Plankton (including eggs/larvae)	Medium	Negligible	Negligible	Rare	Very low	Very low

10.8 Decommissioning impacts

10.8.1 Potential impacts and risks

At the end of the project's life, decommissioning activities will begin. The main objective of decommissioning is to leave a safe, stable and non-polluting environment, and to minimise impacts during the removal of infrastructure.

Decommissioning is expected to involve similar types and numbers of vessels and equipment as the construction phase. Requirements at the time will determine the scope of decommissioning activities and impacts. The anticipated duration is up to three years.

A Marine Decommissioning Management Plan (DEC-M01) will be developed prior to decommissioning to assess the potential impacts from the final agreed methodologies of removing offshore infrastructure.

10.9 Cumulative impacts

This section provides an assessment of the potential for cumulative impacts of the project with other proposed developments in the region. The method to consider cumulative impacts is described in *Chapter 6 – Assessment Framework*.

Potential cumulative impacts arise when the effects of a single project on a receptor are considered alongside the effects of other projects on the same receptor. Projects that are operational are part of the baseline environment, and the cumulative impact assessment focuses on future developments following the tiered assessment methodology.

The projects identified in the cumulative assessment for fish and invertebrates is summarised in Table 10-20.

Table 10-20 Projects assessed for cumulative impacts

Project	Project description	Findings of assessment
Great Eastern Offshore Wind Project (Corio Generation)	This proposed project is located immediately adjacent to the southeast of the offshore wind farm area, 25-40 kilometres from Reeves Beach. The project includes up to 172 fixed foundation wind turbines with a maximum blade tip height of 375 metres, eight offshore substations and associated infrastructure in operation, generating up to 2.5 GW of electricity. Construction is expected to occur from 2028 to 2032, followed by a 30-year operational period.	<p>Habitat change:</p> <p>It is expected that installation of infrastructure for the Great Eastern project will have a similar effect on fish species to that predicted for the Star of the South project, and because both projects will be located adjacent to each other their cumulative effects may be additive. A decrease in fish and invertebrate species richness and abundance is not anticipated, but it is unclear how this may affect apex-predators such as the White Shark. The final consequence for potential cumulative impacts due to habitat change is predicted to remain at minor for all fish receptor groups except White Sharks and syngnathids, for which the final consequence level is predicted to be moderate.</p> <p>Underwater noise during construction:</p> <p>Underwater noise has the potential to result directly in behavioural effects to White Sharks and presents a moderate risk of injury to the larvae of the Australian Grayling within tens of metres of pile driving activities. However, these localised effects are not expected to result in significant impacts to the population of these species. Cumulative impacts are not anticipated for White Sharks because of the short duration of daily pile-driving events (four hours per monopile) and their low sensitivity to changes in sound pressure in the water column, with the implementation of mitigation measures that minimise the spatial extent of noise emissions.</p> <p>The cumulative effects to Australian Grayling larvae and juveniles are unlikely to be significantly more than for each project alone given the broad area across which the planktonic phase of this species are likely to be distributed and the short duration in which they may be present in the area where they are sensitive to noise emissions.</p>

Project	Project description	Findings of assessment
		<p>The cumulative effects on syngnathids and site-attached species are unlikely as the species typically have broad distributions across southern Australia and as such impacts to them from each project separately or cumulatively are unlikely to be significant at the broader population level.</p> <p>Seabed disturbance:</p> <p>Impacts from seabed disturbance and sediment plumes during construction are expected to be confined to individuals of site-attached benthic species, including syngnathid species that rely on soft sediment habitat. Overall, negligible population-level effects are expected.</p> <p>Because the soft-sediment habitat and populations of these species are broadly distributed in the region, it is unlikely that the contribution of additional seabed disturbance and sediment plumes within the Great Eastern offshore wind project area will have a cumulative population-level effect on fish, in particular syngnathids and other site-attached species.</p> <p>Electromagnetic fields:</p> <p>With implementation of management measures, in particular cable burial and monitoring, it is unlikely that the contribution of additional electromagnetic fields from Star of the South and the Great Eastern project (and Marinus Link) will have a cumulative effect at the population level on White Sharks and other fish species, including larvae and juvenile Australian Grayling, as they are unlikely to be in the vicinity of electromagnetic fields from cables during their marine pelagic phase. While cumulative impacts to the movement and ecological processes of individuals of benthic shark, ray and invertebrate species in close vicinity to cables is possible, these impacts are unlikely to extend beyond the project areas of the wind farms and therefore unlikely to have a population-level effect on any species.</p>
Marinus Link	<p>Marinus Link involves the installation of approximately 255 kilometres of (buried) undersea High Voltage Direct Current (HVDC) cable across Bass Strait from Heybridge, Tasmania, to Waratah Bay, Victoria. This will be developed in stages from 2025 through to 2030. Where the cable will make landfall in Victoria is 46 km west of the offshore wind farm area.</p>	<p>Potential cumulative impact pathways include EMFs from HVDC cables causing behavioural disturbance to white sharks.</p> <p>The assessment of impacts described in the Marinus Link Environmental Impact Statement considered electromagnetic field impacts be low for the migration or long-distance movements of EPBC listed sharks, rays or skates (such as White Sharks) and very low for benthic sharks and rays. With implementation of management measures, in particular cable burial and monitoring, it is unlikely that the contribution of additional EMF from Star of the South (and Great Eastern project) will have a cumulative effect at the population level on White Sharks and other fish species.</p>

10.10 Summary of mitigation, monitoring and contingency measures

10.10.1 Mitigation measures

The following section outlines the mitigation measures developed to avoid and minimise impacts on fish and invertebrates within the project area. The focus of these mitigation measures is:

- Avoiding impacts where reasonably practicable
- Developing, preparing and implementing project-specific measures to minimise impacts.

The mitigations below have been developed for the impacts and risks discussed in detail within *Technical Report C – Fish and Invertebrates*. Detailed descriptions of each measure can be found in *Chapter 23 – Commonwealth Environmental Management Framework* and are listed in Table 10-21.

Table 10-21 Summary of mitigation measures relevant to fish and invertebrates

ID	Mitigation measure and description
UWN-M01	Piling soft start procedure
UWN-M03	Noise abatement system (NAS)
OFF-M22	Stakeholder consultation
EMI-M01	Depth of cable burial
EMI-M02	Cable Testing Procedure
LIT-M01	Infrastructure light management
VES-M01	Vessel operations framework
VES-M04	Vessel movement controls
VES-M03	Marine coordination centre
VES-M05	Vessel biosecurity controls
SPL-M02	Spill response plan
SPL-M03	Maintenance of offshore substation transformers
DEC-M01	Marine Decommissioning Management Plan

10.10.2 Monitoring and contingency measures

The monitoring and contingency measures that are proposed to assess potential impacts on fish and invertebrates by the project are described in Table 10-22. Further detailed regarding these monitoring measures can be found in *Chapter 23 – Commonwealth Environmental Management Framework*.

Table 10-22 Monitoring and contingency measures relevant to fish and invertebrates

ID	Monitoring
MEMP-M01	Underwater noise monitoring
MEMP-M07	Monitoring of fish assemblage and key species
MEMP-M09	Cable survey and monitoring

10.11 Conclusion

This chapter identifies the existing conditions related to fish and invertebrates and assesses the associated impacts and risks from the construction, operation and decommissioning.

The offshore project area's fish and invertebrate community comprised 164 species, each with diverse stages of growth and development, ecological traits, and varying levels of conservation concern and fisheries significance. These factors informed nine different receptor groups used for the impact and risk assessment.

The assessment identifies a key impact during the project's operation phase which may have a moderate impact on White Sharks and Syngnathids:

- Habitat change over the course of the project.

Habitat change due to the long duration of the operations phase of the project may cause a change to the existing fish assemblage and broader food web. However, there remains uncertainty about this change and therefore a broadscale monitoring program of fish assemblage and key species will help to inform the environmental implications (positive or negative) of habitat change to fish within the offshore project area while also assessing any conclusions made in the impact assessment and identify associated adaptive management options.

White sharks and syngnathids are considered to have a high sensitivity due to their ecology and conservation status.

All other impacts and risks for fish and invertebrates range from minor to negligible and low to very low. No significant population-level impacts are predicted for any fish or invertebrate species because of the cumulative effects from the project and other projects.

Overall, this assessment finds the impacts and risks are acceptable and meet the pre-defined assessment criteria and EIS guidelines.