PINDIMAR ABALONE FARM, PORT STEPHENS

AQUATIC ECOLOGY ASSESSMENT

Report prepared for Reliance Holdings Pty Ltd

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INTRODUCTION

An abalone farm is to be built on the northern shoreline of Port Stephens at Pindimar. BIO-ANALYSIS Pty Ltd was engaged to address issues associated with the aquatic ecology; specifically, to describe the aquatic habitats and associated flora and fauna adjacent to the farm and examine any potential impacts as a result of either its construction or operation. The focus of this report was primarily on mangrove and seagrass habitats as these were likely to be directly disturbed by the proposed farm. Furthermore, where specific disturbances to aquatic components were identified, recommendations were to be made on ways to mitigate or minimise any potential impacts. A monitoring plan for both mangroves and seagrasses was also to be outlined and any threatened aquatic species or populations were to be identified, including fish, endangered marine mammals and marine turtles.

The Port Stephens estuary is approximately 150km north of Sydney, NSW. The estuary has been the focus of increased residential development and is used for a wide range of recreational and commercial activities, including extensive aquaculture (Umwelt, 2000). A full description of the physical, chemical and biological characteristics of the estuary were reported as part of the estuary process study (Manly Hydraulics Laboratory, 1999) and subsequent management study (Umwelt, 2000). The shallow margins of the estuary are habitat for extensive seagrass meadows consisting of *Posidonia australis*, *Zostera capricorni* and *Halophila ovalis* (West et al. 1985). Since the farm will require that inlets and outlet pipes be placed into the estuary, a number of aquatic habitats were identified that may be affected by the proposed farm's construction and/or operation (Fig. 1). The aquatic habitats that needed to be considered as part of this assessment included;

- estuarine water column
- intertidal mangrove habitat
- intertidal sand-flat
- subtidal vegetated seagrass meadow
- subtidal un-vegetated soft sediments

The inlet and outlet pipes from the farm will pass through mangroves (*Avicennia marina*), intertidal sandflats and *Posidonia australis* seagrass meadows (Fig. 1). The outlet pipes will also discharge farm water into the estuary at a depth of around 6m. Details of the quantity and quality of water being discharged from the farm were addressed by Sanderson (2013). The inlet pipes will draw water from the estuary at a depth of around 18m.

DESCRIPTION OF AQUATIC HABITATS

Water Column

The water column within an estuary provides a habitat for a diverse assemblage of flora and fauna which includes plankton, pelagic fishes and invertebrates. Phytoplankton are microscopic algae which are free floating within the water column (Cummins et al., 2004a), whilst zooplankton are comprised of small animals which can be permanent members of the plankton or early larval stages of larger species both pelagic or bottom dwelling (Day et al., 1987). There are also pelagic fish that utilise the water column in the estuary as well as invertebrates such as squid, prawns and jelly fish (Edgar and Shaw, 1995). The outlet pipes will discharge approximately 50 MLd^{-1} of farm water at around 0.1m/s into the water column at a depth of 6m, whilst the inlet pipes will extract the water from a depth of approximately 18m (Sanderson, 2013). At this depth there should be less growth of fouling organisms on the intakes.

Mangroves

Mangroves are salt-tolerant plants that are generally found growing along the shorelines and creeks within estuaries. Mangroves are important in cycling of nutrients in estuaries and are considered to provide important habitats for birds, fish, invertebrates and a range of macro-fauna (Clarke and Hannon, 1969). It has been established that the structural complexity of a marine habitat is important for benthic organisms. Mangrove forests can support higher diversity of benthic organisms compared to less structurally complex habitats such as saltmarshes and non-vegetated areas (Clough, 1982). Furthermore, vegetated habitats such as mangroves can provide greater amounts of organic material as a food resource for benthic organisms. There have been large-scale declines in the extent of mangrove forests within NSW estuaries (Streever, 1999).

There are two species of mangroves found within the Port Stephens estuary; *Avicennia marina* (grey mangrove) and *Aegiceras corniculatum* (river mangrove). There are significant areas of mangrove forests within the estuary and large-scale mapping of their distribution has been done (West et al., 1985). The most recent mapping of mangroves in Port Stephens was done by Creese et al. (2009).

The mangrove habitat at the site consisted of sparsely distributed juvenile and mature *Avicennia marina* mangroves (Figs. 2-6). The mangrove habitat was situated close to the shoreline and sandy beach and ranged in width from 10 to 95m. The pipeline will pass through approximately 70m of sparse mature mangroves and seedlings (see Fig. 1).

Within the mangrove habitat the aerial roots (pneumatophores) of the mangroves were quite dense. Fauna of the mangrove habitat included molluscs such as oysters and gastropods, crustaceans such as crabs and shrimp and at high tide, various fish species such as mullet and bream. The most abundant species were the bivalve mollusc *Glauconome plankta*. Other common taxa included the gastropod *Battilaria australis*, the crabs *Paragrapsus laevis* and *Heloecius cordiformis* and amphipods from the family Talitridae.

Intertidal Sandflat

Estuarine sedimentary habitats are highly productive and intertidal sand and mudflats are permanently or periodically inhabited by a diverse assemblage of benthic organisms (Day et al., 1987). These organisms range in size from minute bacteria and protozoans to larger colonial animals termed macrobenthos. Macrobenthic organisms in estuarine waters are generally diverse (usually > 100 species) and most species are relatively non-mobile (Poore, 1992). They are represented by different types of feeding groups, i.e., epifaunal suspension-feeders, infaunal suspension feeders, surface deposit feeders, grazers, predators and scavengers, with suspension-feeders and deposit-feeders generally dominating the assemblages (Cummins et al., 2004b). Benthic invertebrates can have a profound effect on the sedimentary environment through their feeding, burrowing, and ventilatory activities (Day et al., 1987). In particular, they play a vital role in the storage, transformation and release of nutrients (i.e. nutrient cycling) to the overlying water column (Coull, 1999; Cummins et al., 2004b).

There is an extensive intertidal sandflat adjacent to the farm site composed of fine to medium grained sand and mud (Fig. 1 & Fig. 7). The width of the sandflat varied, however the pipeline will pass through approximately 150m of this habitat type. There appeared to be extensive sand movement at the site due to exposure to waves and tides. The sandflat at the site was once vegetated with the eelgrass *Zostera capricorni*, but these beds have now predominantly disappeared, most likely due to sand burial and wave exposure. The transient nature of *Zostera capricorni* in these types of sandy exposed habitats has been documented in other estuaries, e.g. Botany Bay (Roberts et al., 2006).

The intertidal sand and mudflats provide habitat for a range of invertebrates, and during high tide many fish also utilise these habitats for feeding. Common invertebrate species identified on the flats included molluscs, polychaetes and crustaceans whilst fish included mullet, whiting, flathead and bream. At the outer edge of the intertidal zone some sparse small patches of *Zostera capricorni* were found as well as paddle weed *Halophila ovalis* (Fig. 8).

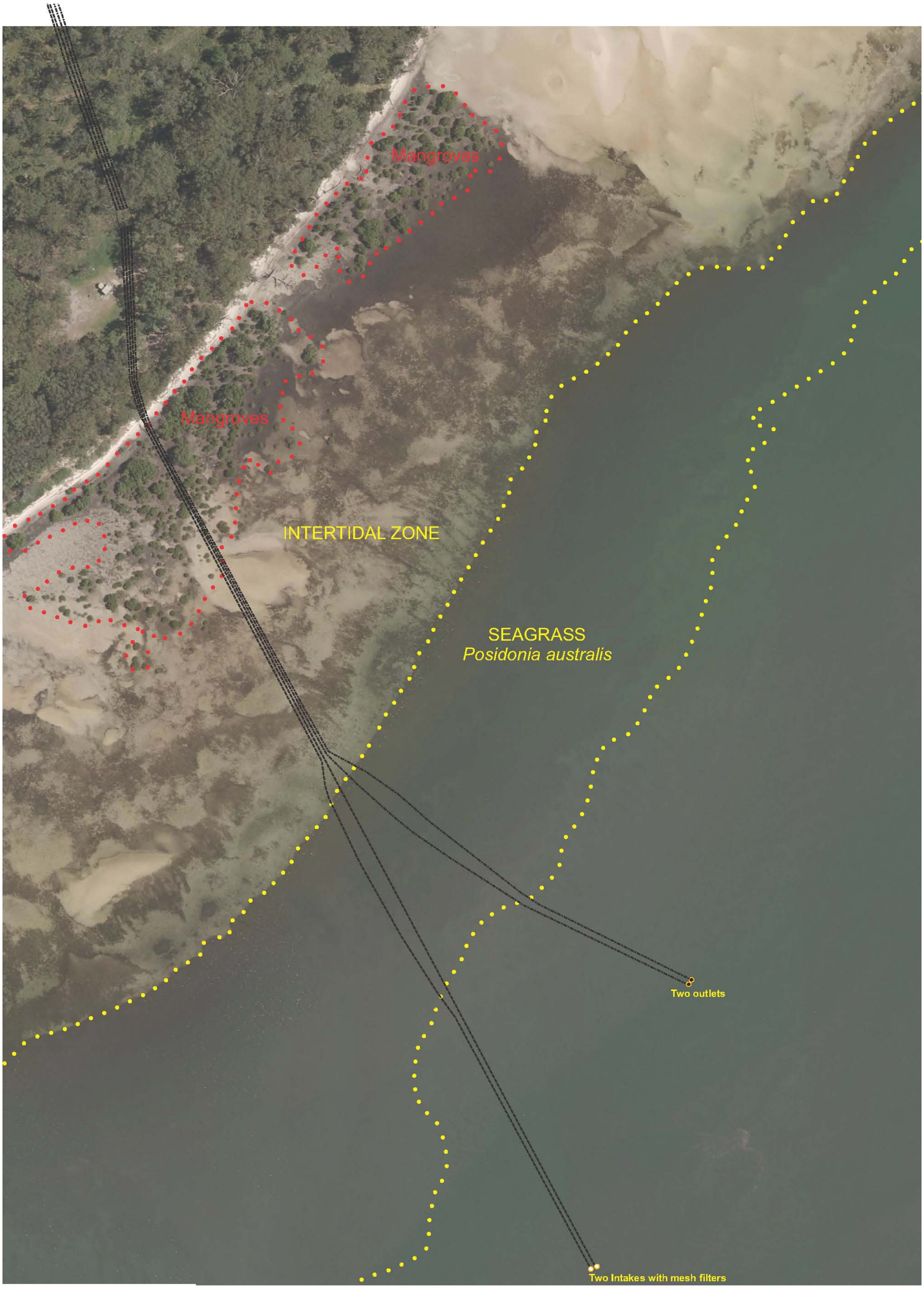

Figure 1. Study location and aquatic habits.

Figure 2. Narrow sandy beach and fringing mangroves.

Figure 3. Facing west with view of intertidal sandflat and mangroves adjacent to the proposed farm.

Figure 4. Mature *Avicennia marina* mangrove at the site.

Figure 5. *Avicennia marina* tree.

Figure 6. Mangrove habitat along the pipeline route with small and juvenile *Avicennia marina* trees and pneumatophores (aerial roots).

Figure 7. Intertidal sandflat habitat adjacent to the site.

Figure 8. The seagrass *Halophila ovalis* and the mollusc *Pyrazus* on the outer edge of the intertidal sandflat.

Seagrass Meadows

Seagrasses are aquatic angiosperms (flowering plants) that are important biological components of estuaries. They provide nursery grounds, food and habitat for a variety of estuarine biota (Edgar, 1990, Heck et al., 2003). Seagrasses also provide a role in stabilising bottom sediments and shorelines and act as a water filter for suspended solids (Boström and Bonsdorff, 2000). There have been large-scale declines of seagrass meadows within NSW estuaries due to anthropogenic disturbance (Butler and Jernakoff, 1999).

Seagrass meadows have been recognised as important habitats for a wide range of estuarine dependent assemblages including invertebrates (Boström and Bonsdorff, 1997; Cummins et al., 2004b) and fish (Edgar & Shaw 1995; Kendrick and Hyndes, 2003; Curtis and Vincent, 2005; Jones and West, 2005). Seagrasses also play a significant role in a number of important physical and chemical processes within estuaries (Roy et al., 2001).

Studies on seagrass meadows in Port Stephens, NSW have generally involved assessments of patterns in their spatial distribution (West et al., 1985; Howitt et al., 1998; Umwelt, 2000; Roberts et al., 2000; Roberts 2002). The most recent mapping of seagrasses in the estuary was done by DPI Fisheries (Creese et al., 2009). There are three common species of seagrass found within the Port Stephens estuary; *Halophila ovalis*, *Zostera capricorni* and *Posidonia australis* (West et al., 1985; Creese et al., 2009). Of these three species, *Posidonia australis* is considered to be the most susceptible to anthropogenic disturbance and has been shown to be difficult to rehabilitate following disturbance (West et al., 1990; Ganassin and Gibbs, 2007).

At the interface of the intertidal and subtidal zones, sparse patches of both *Zostera capricorni* and *Halophila ovalis* seagrasses were found (see Fig. 1 & Fig. 9). It is at this point the farm pipes will emerge from the intertidal trench and cross the *Posidonia australis* seagrass meadow. The pipes will be raised approximately 50cm above the seafloor on concrete footings placed and secured within the seagrass meadow.

The seagrass meadow adjacent to the farm site was found to be primarily composed of *Posidonia australis* with sparse *Halophila ovalis* and *Zostera capricorni* mostly found at the shallow intertidal subtidal interface at around 1m depth (see Fig. 1 & Fig. 10). The percentage cover of *Posidonia australis* along the route of the pipeline ranged between 70-85%, whilst leaf-length ranged from 30-50cm (see Figs. 11-18). The *Posidonia australis* becomes sparse at around 3.0 m (Fig. 18) with bare silty/sand sediments from a depth of 3.2m down to 6m.

Clumps of drift, attached and epiphytic forms of algae were found interspersed throughout the seagrass meadow. The most commonly encountered macroalgae species included *Microdictyon, Cladophora*, *Colpomenia*, *Chaetomorpha*, *Enteromorpha* and *Gracilaria* (Howitt et al., 1998). Species attached to hard substrata such as shells included *Sargassum*. Epiphyte growth on leaves of *Posidonia australis* generally consisted of encrusting bryozoans, spirorbid worms and diatoms (Roberts, 2002).

The fauna found within the seagrass meadows included epifauna (living on the sediments) and infauna (beneath the sediments). Epifauna included gastropods, worms and small crustaceans as well as those living attached to seagrass leaves (epiphytes). Epibenthic sessile invertebrates that were also commonly found within the seagrass habitats included sponges such as *Niphates* sp. and *Desmapsamma* sp and ascidians *Styela* sp. and *Eudostoma* sp., all of which have been documented with seagrass habitats in local estuaries (Barnes et al., 2006).

The seagrasses within the estuary also provide habitat for recreationally and commercially important species of fish, crabs and prawns (Howitt et al., 1998). Fishes that have been observed within the seagrass meadows at the site included bream, flathead, leatherjackets, trumpeters, porcupine fish, banjo rays, wobbegong shark, garfish, luderick and mullet. Invertebrates such as shrimps, prawns and crabs were also very common.

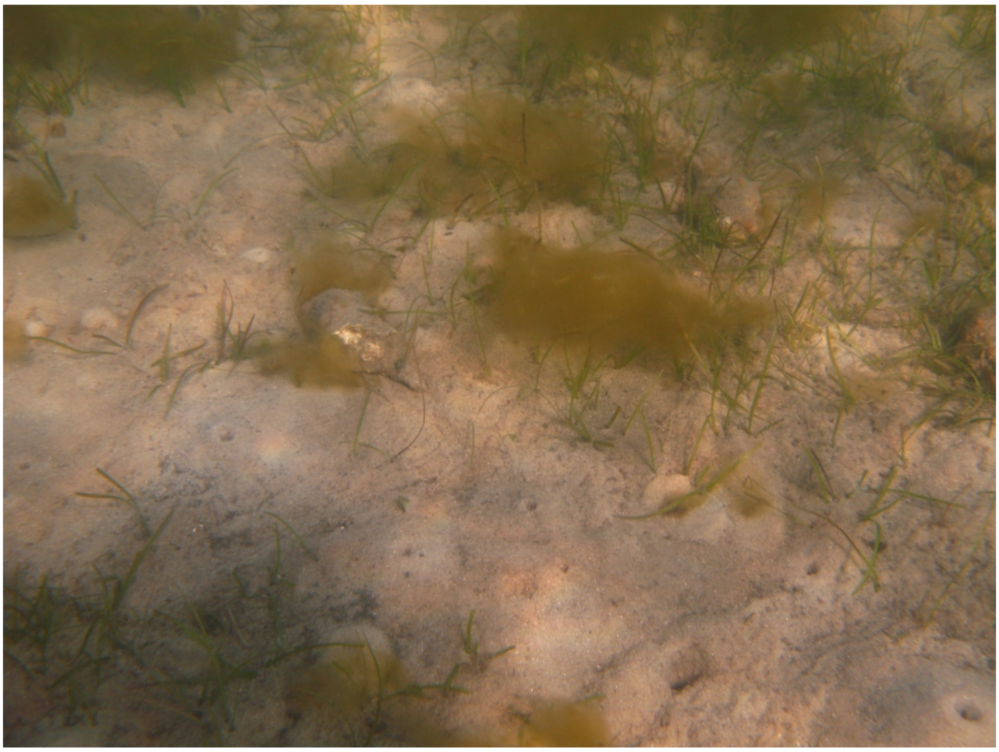

Figure 9. Sparse *Zostera capricorni* in the subtidal zone adjacent to the *Posidonia australis* seagrass meadow.

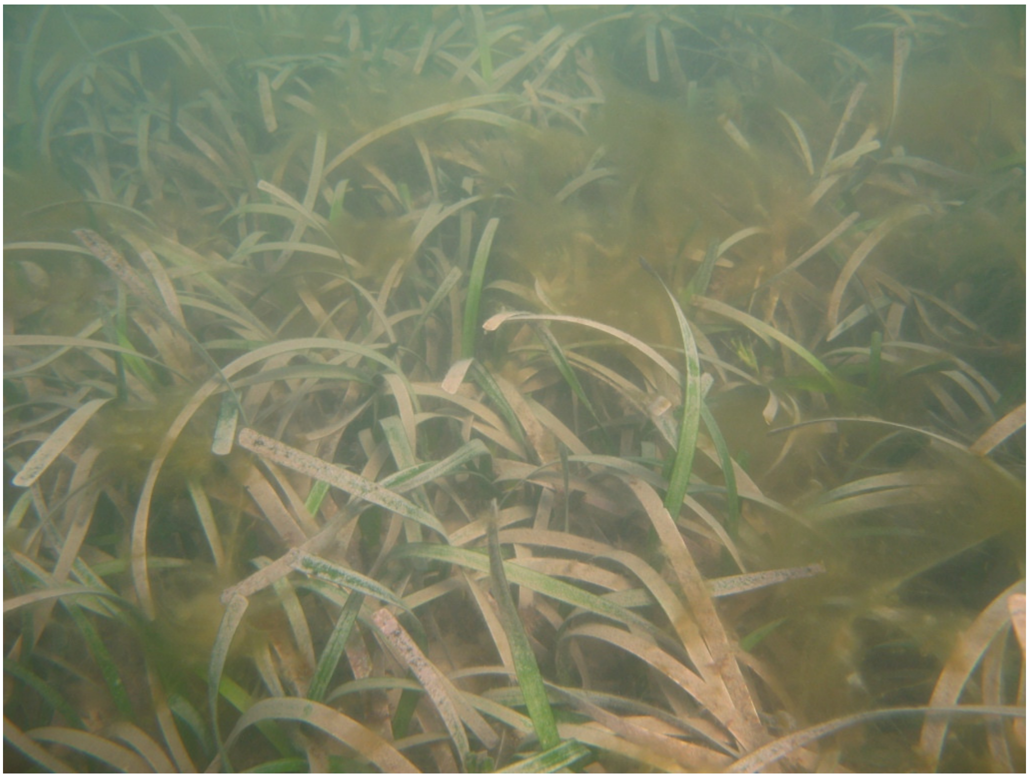

Figure 10. ***Posidonia australis*** **seagrass at approximately 1m depth.**

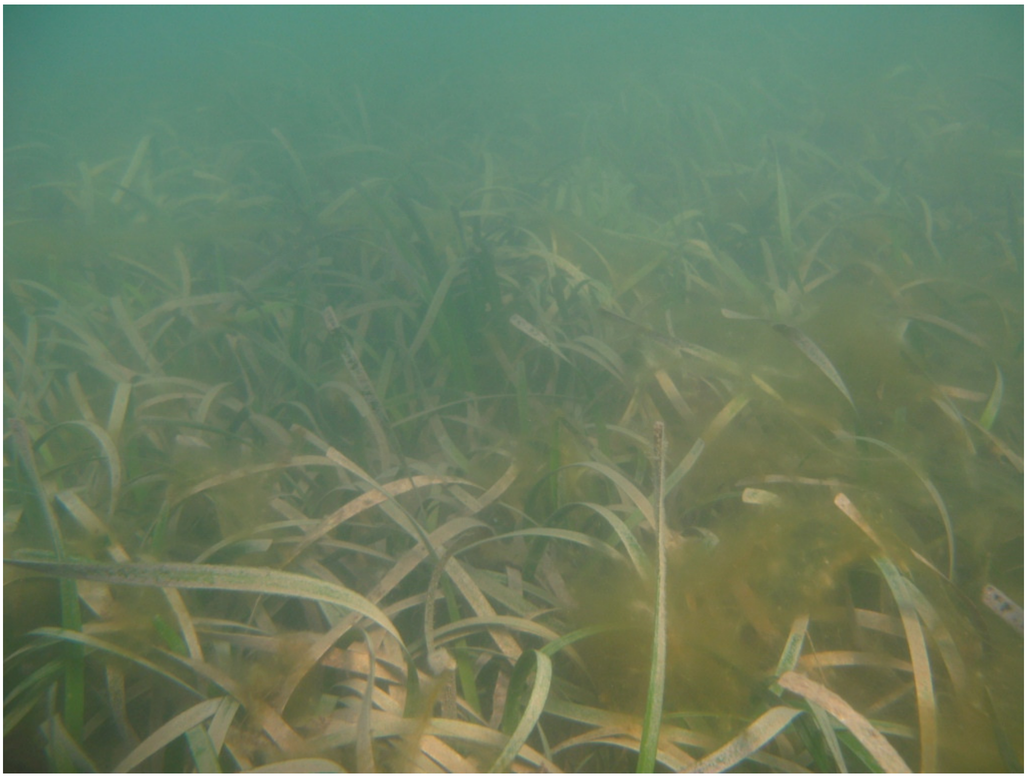

Figure 11. ***Posidonia australis*** **seagrass at approximately 1.5m depth.**

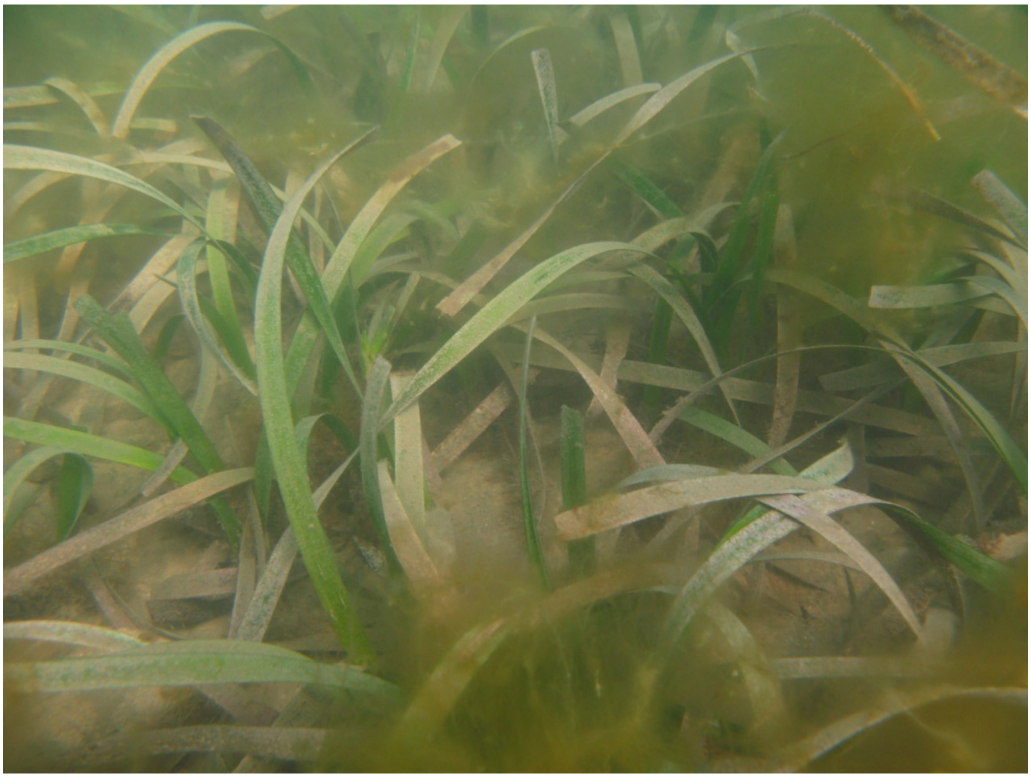

Figure 12. ***Posidonia australis*** **seagrass at approximately 2m.**

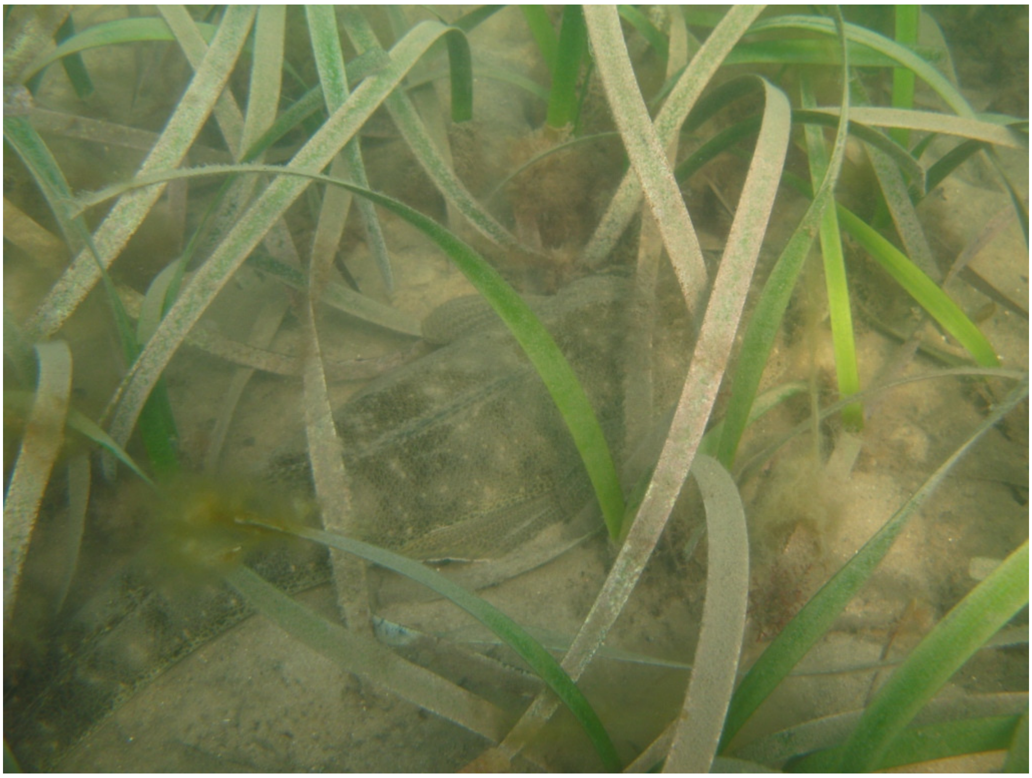

Figure 13. ***Posidonia australis*** **seagrass and a flathead at approximately 2.0m depth.**

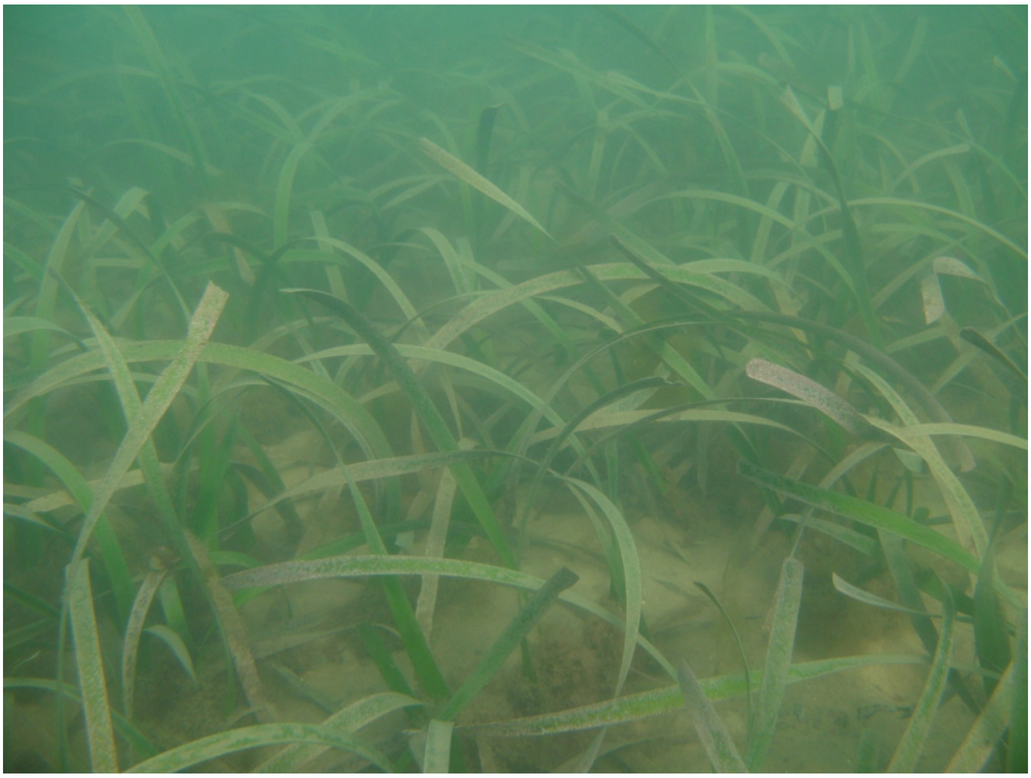

Figure 14. ***Posidonia australis*** **seagrass at approximately 2.5m depth.**

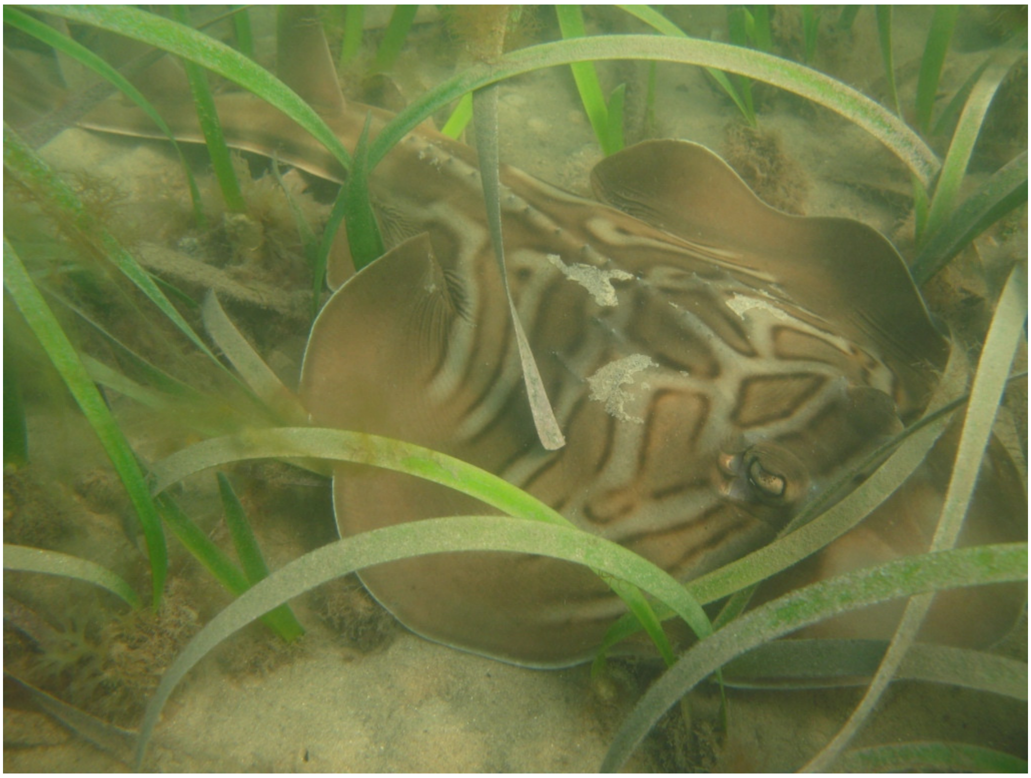

Figure 15. ***Posidonia australis*** **seagrass with banjo ray at approximately 2.5m depth.**

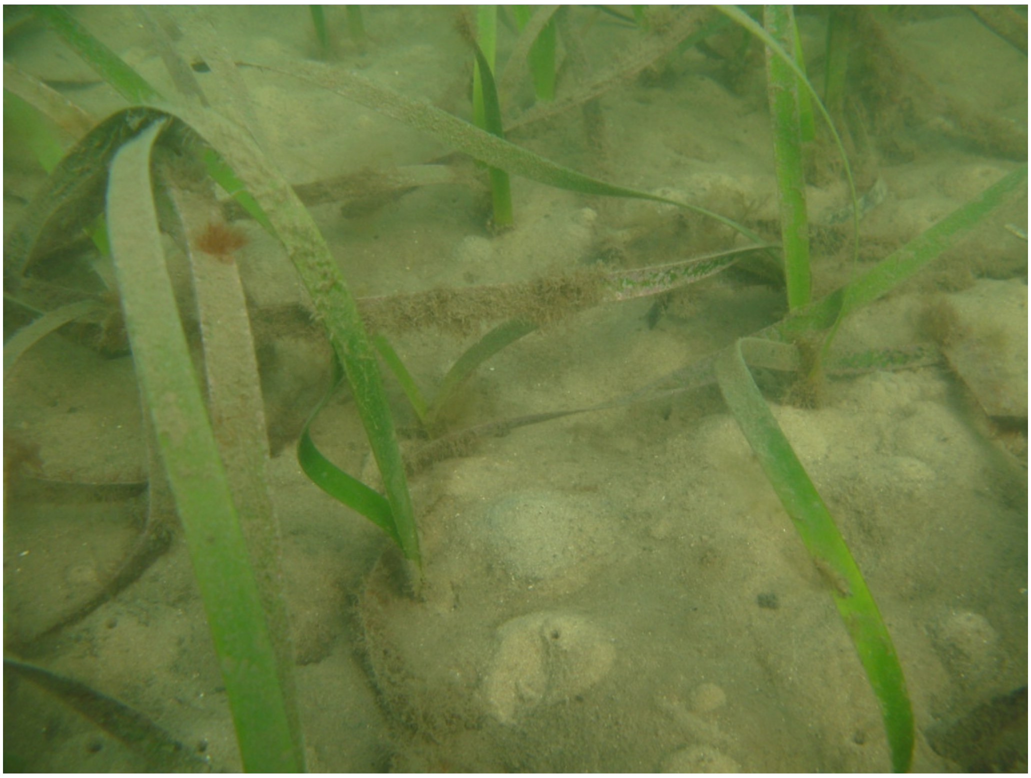

Figure 16. ***Posidonia australis*** **seagrass at approximately 2.8m depth.**

Figure 17. ***Posidonia australis*** **seagrass at approximately 2.9m depth with sea slug.**

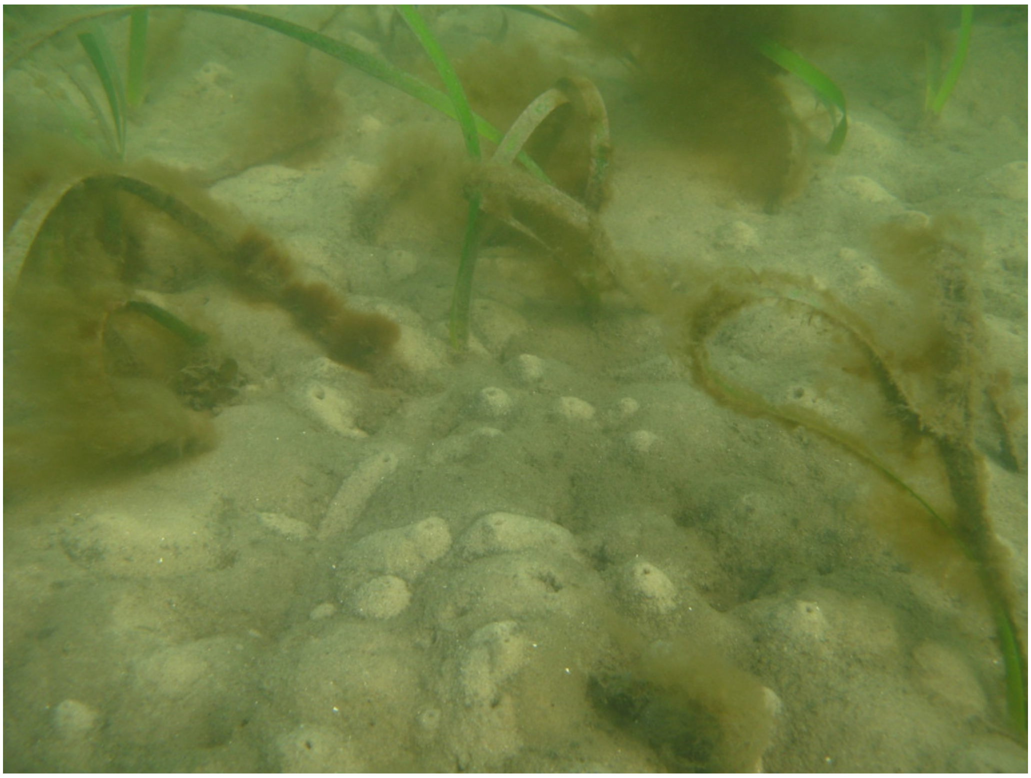

Figure 18. Edge of the *Posidonia australis* meadow at 3.0m depth.

Subtidal Soft Substratum

Once the pipelines leave the seagrass habitat they will cross un-vegetated soft sandy/silty sediments, the outlet pipe will be discharging at approximately 6m depth whilst the inlet pipe will be drawing water from a depth of approximately 18m.

The soft subtidal sedimentary habitat supports a diverse benthic fauna both sessile and mobile, ranging from macrobenthos to meiobenthos (Dye and Barros, 2005). Macrobenthic invertebrates are animals that live on or in the muddy and sandy sediments of an estuary and are considered to be those animals that are retained on a 0.5 mm sieve (Poore, 1992). Macrobenthic organisms in estuarine waters are generally diverse and most species are relatively non-mobile (Day et al., 1987). They are represented by different feeding groups such as suspension and deposit feeders, grazers, predators and scavengers (Day et al., 1987). They play a major role in nutrient cycling processes, and are an important source of food for a variety of organisms (Coull, 1999).

Macrobenthic organisms are also sensitive to anthropogenic disturbance, which can make them an ideal bio-indicator of potential environmental impact (Underwood et al., 2003). Meiobenthic invertebrates range in size from 0.045 to 0.5 mm and are the most abundant and diverse animals inhabiting marine and estuarine sediments. They are recognised as being very important in processes such as nutrient recycling and enhancing bacterial activity and are also important food for higher trophic levels (Dye and Barros, 2005). Meiobenthos are sensitive to anthropogenic disturbance and pollution and their potential as indicators of environmental condition is widely recognised (Dye and Barros, 2005).

There has been very little work done on the macrobenthic organisms living within the sediments of the Port Stephens estuary (Howitt et al., 1998; Umwelt, 2001; O'Connor, 2001; Roberts, 2002). Studies on macrobenthic invertebrates were done as part of habitat assessments prior to removal of derelict oyster leases in the estuary (Umwelt, 2001). The assemblages of macrobenthic invertebrates commonly occurring within the sediments were from several groups of common marine fauna, which included worms, molluscs, echinoderms, crustaceans and ascidians.

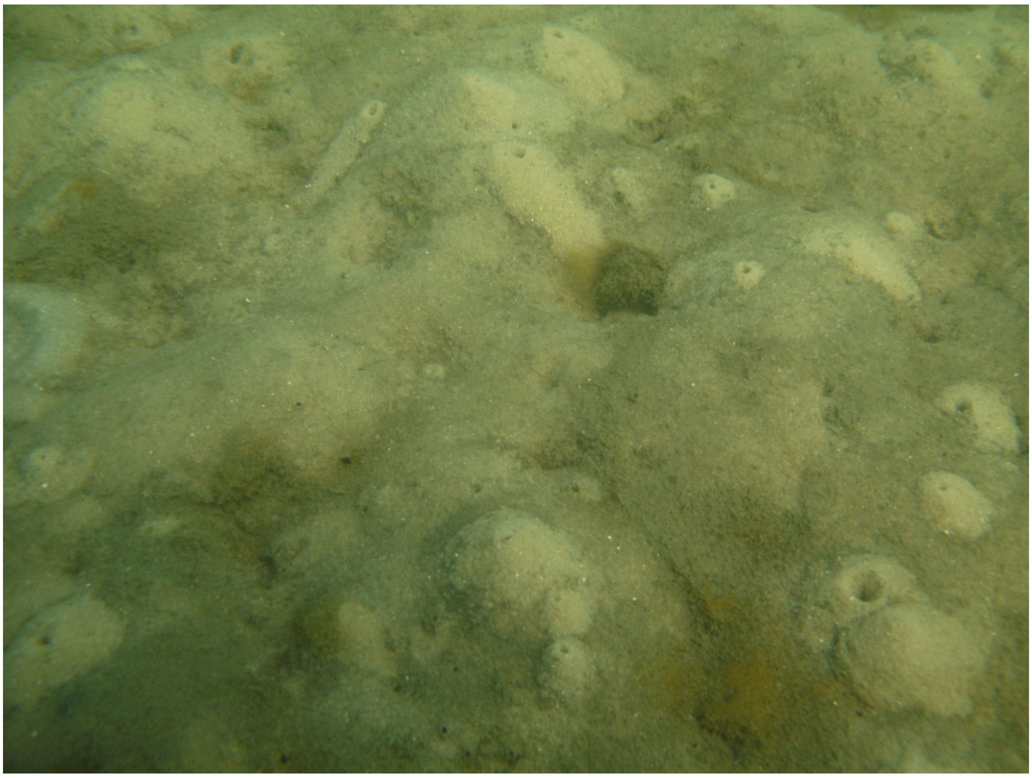

Figure 19. Soft sediment habitat below 3m depth.

POTENTIAL IMPACTS AND MITIGATION

Since the farm will have inlet and outlet pipes that run from the site into the estuary, a number of habitats have the potential to be disturbed during the construction phase. The direct disturbance, its impact, if any, and other potential risks to each habitat is outlined including trimming of mangroves, excavation of mangrove roots during trenching, transplanting of *Zostera capricorni* seagrass if required and impact of pipe footings on *Posidonia australis* seagrass. Indirect disturbances and impacts associated with running the farm are also considered and include discharges to the estuary, shading to seagrass habitat from the pipes, growth of epifauna and fish attraction to the structures, and water quality impacts on the adjacent marine park and oyster farms.

Intertidal Zone

Mangroves

Mangroves are protected under the *Fisheries Management Act 1994* (FMA 1994) and there are adult mangrove trees and small juveniles and some seedlings present at the site. At least two medium sized trees within the footprint of the proposed pipelines for the farm will be directly disturbed by the trenching works through the intertidal zone. The trenching will require some trimming of one medium sized adult mangrove and major trimming (removal of branches) to the other. Both will have disturbance to their lateral and aerial roots (pneumatophores). The extent of damage to the root system of these mangroves may be minimised by carefully excavating the trench at these points. All possible care will need to be taken to avoid damaging lateral roots of all mangroves during the trenching process.

Any small seedlings (< 1m) will need to be transplanted from the "trench footprint" to another location within the existing mangrove habitat using the techniques outlined in the guide to mangrove transplanting (SPCC, 1983). The transplantation of mangrove seedlings is quite simple and success rates are generally high because the root systems are not extensive.

The potential risk that trimming of mangroves could lead to the death of the tree is very small. As discussed above, damage to the root system of one mangrove may not be avoided and there is a high risk that this tree may die. The other risks are that the transplanting of the juvenile mangroves will be unsuccessful, however this risk is considered to be very small. In general, the risk to the mangrove habitat adjacent to the site as a result of any construction or operation of the farm is considered to be low or negligible. Colonisation by mangrove seeds to disturbed sediments should occur quickly.

Invertebrates

Trenching through mangroves and the intertidal sandflat has the potential to also disturb benthic fauna along this section of the pipeline route. Whilst there may be some disturbance to benthic invertebrates, this will be a short term impact and they will recolonise the sandflat very quickly. Studies have shown that benthic invertebrates will colonise disturbed sediments within the timescales of months (Jones, 1986; Underwood et al., 2003; Roberts et al., 2009). Jones (1986) found that some macrobenthic organisms were killed by dredging operations and spoil disposal, however their re-colonisation into the sediments had occurred within a few months once the dredging operation was completed.

Seagrasses

There is no longer any *Zostera capricorni* seagrass found within the intertidal zone at the site, however, prior to any trenching works, an inspection will be done and any *Zostera capricorni* found within the intertidal habitats will be harvested from the footprint of the trench using PVC corers of 15 cm diameter. The corer will be inserted into the substratum to a depth that enables all the rhizomes (roots) of the *Zostera capricorni* to be collected intact within the sediment plug. Each core or plug of seagrass will be placed alongside the trench in plastic tubs full of seawater so that the seagrass does not dry out. Once the pipes are laid and the trench backfilled, each plug of seagrass will be transplanted back into roughly its original position. Excavation and transplanting should be done during the winter months when there are predominantly westerly winds to reduce the likelihood of southerlies interfering with the success of the transplanting programme. Disturbance to *Halophila ovalis* would also be small if it were to colonise areas to be impacted by the pipeline trenching route. This species can and will recolonise any disturbed areas very quickly.

Subtidal Zone

Seagrasses

Seagrasses including *Posidonia australis* are protected under the Fisheries Management Act 1994. *Posidonia australis* within the Port Stephens estuary is not listed as an endangered population (Pronk and Holder, 2012). The impacts associated with laying pipes to the local *Posidonia australis* population are considered to be minimal. There is no evidence to suggest that the current proposal will cause a net loss of seagrasses within the coastal and estuarine waters of NSW. Whilst there may be some initial small-scale damage to marine vegetation during works, the scale of anthropogenic disturbance is very small compared with changes that occur to seagrass habitats as a result of “natural” disturbances.

The pipeline footings will have a direct impact on the *Posidonia australis* seagrass at the site. The pipes (pipeline) would be slowly lowered to the bottom as described in the Environmental Assessment Report (City Plan, 2013). It has been estimated that approximately 40m^2 of seagrass will be directly impacted by these footings. This will result in the leaves of the plants being crushed. SCUBA divers will be in place to ensure that the pipe footings are settled onto the bottom without causing undue damage to *Posidonia australis* leaves outside the footing placements.

Indirect damage to *Posidonia australis* as a result of the effects of shading by the pipes and associated growth of algae and sessile organisms are other potential disturbances that could result from the pipeline placement. Light is a limiting factor in seagrass growth and shading has been shown to impact on seagrasses (Fitzpatrick and

Kirkman, 1995). Studies on abalone farms in South Australia have shown that raising the pipelines over seagrass habitat reduced the impacts of shading and were limited to the footprint of the pipeline (see Fig. 20). The height of the raised pipeline was similar to what is being proposed for the Abalone Farm at Pindimar. Furthermore, the farm proposes to separate the inlet and outlet pipes and this will also help to reduce shading impacts (see Fig. 1)

Other risks to the seagrass as a result of laying the pipes could include scouring and erosion around the base of the footings (Theil et al., 2004), however once the pipes are covered with growth there should be much less risk of any scouring. Once the pipelines are in place, regular inspections will be required by divers to identify any potential scouring (Theil et al., 2004). If scouring was found to be occurring appropriate erosion controls may need to be put in place, e.g. hessian matting.

Fragmentation of *Posidonia* beds as a result of direct or indirect disturbance needs to be monitored. In addition to changes associated with loss of habitat, decreases in patch-size result in a larger ratio of perimeter to area and may facilitate penetration of water, food, recruits (including exotic species) and predators to the interior of patches (Saunders et al., 1991; Turner et al., 1999). Effects may vary according to the size, shape and number of patches of remaining habitat, proximity to other patches and the nature of the surrounding habitat(s) (Saunders et al., 1991; Bell et al., 2001; Goodsell and Connell, 2002; Tanner, 2003). Changes may benefit some taxa (commonly those that live at the edges of patches), be detrimental to others (commonly those that live only in the interior of patches), or have no effect (Bender et al., 1998).

There are documented cases of disturbances including disease, storms, wave-action, feeding activities by animals, cover by macro-algae, dredging, displacement by anchors, propellers and mooring leading to fragmentation of seagrass meadows (Sousa, 1979; den Hartog 1987; Hovel and Lipcius, 2001; Creed and Amado Filho, 1999; Cummins et al., 2004b). *Posidonia australis* has been shown to take many years to recover after disturbance (Butler and Jernakoff, 1999).

Installation of the pipeline is predicted to result in loss and fragmentation of seagrass directly under the pipeline footprint. Given that the pipes will be raised above the seafloor and that regular inspections would be done to determine the need for appropriate erosion controls, it is likely that loss and fragmentation of seagrass and effects on biota that use different resources within the seagrass meadow will be localised. It is recommended that an appropriately designed monitoring programme be implemented to test this prediction.

Figure 20. Example of raised pipeline crossing seagrass habitat from an Abalone Farm in South Australia (photos courtesy of A. Christian).

Benthic Fauna

Some invertebrates living in the footprint of the pipeline footings will be directly impacted. These invertebrates will be either attached to leaves or living in or on the sediments. Infaunal macrobenthic invertebrate assemblages will recover quickly (Underwood et al., 2003), whilst sessile epibenthic invertebrates such as sponges, bryozoans and ascidians will colonise the structures adding to the diversity at the site. Barros et al. (2001) found that reef structures placed within a habitat dominated by soft sediments can influence the surrounding sediments and therefore the structure of the benthic community. The impacts on the benthic fauna next to the footprint of the pipeline will be short-term and very small.

A hierarchical design of sampling was used to examine differences in assemblages and populations of benthic macroinvertebrates among chosen habitats sampled at the proposed location for the Abalone pipeline(P) compared to two reference locations (Reference Location 1: (R1); Reference Location 2 (R2). At each location, two sites were sampled within each of: 1) intertidal mangrove mud (M); 2) intertidal sandflat (SF); 3) subtidal sediments covered by seagrasses (SG); and 4) subtidal bare sediment (B) habitats. The design allowed a test of the null hypothesis that there will be no measurable and important differences in the structure of assemblages of benthic macroinvertebrates at the proposed location for the pipeline compared to the reference locations.

Each habitat was sampled using a PVC corer (10 cm diameter and 10 cm deep). Samples were collected by carefully penetrating the sediment with the corer, which was then capped to create sufficient suction to retain the sample. Samples were sieved through a 0.5 mm mesh, placed into labelled plastic bags and fixed with 7 % buffered formalin/seawater (v/v).

In the laboratory, each sample was rinsed to remove the formalin before sorting under a binocular microscope. Where possible, polychaete worms were identified and enumerated as families whilst bivalves and gastropods were identified to species. Other faunal groups counted included amphipods, Thallassinidea and crabs. Ellis

(1985) described taxonomic sufficiency as the level of identification necessary to meet a study's objectives. In terms of the amount of time and the costs involved, identifying organisms to levels that are finer than required is wasteful of resources that could be redirected into increasing the power of the scales of interest (Chapman, 1998). The family level is adequate for determining the effects of anthropogenic disturbances on macrobenthic assemblages (Chapman, 1998) and has been used successfully in numerous marine studies (Otway et al., 1996; Underwood et al., 2003; Cummins et al., 2004). Specimens were stored in 70% alcohol solution and a voucher collection was prepared for the study. The voucher collection will reside with Bio-Analysis Pty Ltd.

Multivariate statistical techniques were used to test for differences in the composition and structure of assemblages of benthic fauna using the PRIMER+PERMANOVA software (PRIMER-e, Ltd, 2010) software package. Multivariate methods allow comparisons of two (or more) samples based on the degree to which these samples share particular characteristics (e.g. taxa) (Clarke, 1993). Permutational multivariate analyses of variance (PERMANOVA; Anderson et al., 2008) were used to test specific hypotheses about scales of interest (i.e. 'Location' and 'Habitat'). Specifically, analyses were done to test the null hypotheses of no differences (in terms of assemblage structure and composition) among 'Locations' (Pipeline vs References), no differences among 'Habitats' and no interaction between these two factors. Both factors were treated as fixed, while 'Site' was considered as a random factor which was nested within the interaction of Location and Habitat. Statistical null hypotheses for these analyses were constructed using 9999 permutations of residuals (reduced model). When significant interactions were detected, *a-posteriori* comparisons were done to test the null hypotheses of no difference among locations (Pipeline vs References) for each habitat separately. Non-metric multidimensional scaling (nMDS) ordination was used to provide a graphical representation of relationships between samples from two-dimensional ordination plots. Similarity of percentages (SIMPER) was then used to determine those taxa primarily responsible for the observed similarities (or dissimilarities) (Clarke, 1993).

PERMANOVA analyses were also used to test the null hypotheses described above but on the following univariate measures: the total number of taxa, total abundance and abundances of the most important taxonomic groups identified from the samples using SIMPER.

Results

A total of 248 individuals from 39 taxa were identified from samples of sediment from intertidal mangrove (28 individuals), intertidal sand flat (34 individuals), subtidal sediments covered by seagrass (68 individuals) and subtidal bare sediment (118 individuals). In general, four taxa accounted for 70% of the animals that were identified: the bivalve, *Notospisulatrigonella* (Family Mactricidae), the polychaete worm, Capitellidae, and the crustaceans, amphipods and Thallassinidea (Callianassidae).

Multivariate Analyses

Despite the existence of significant variation among sites, a significant interaction was detected for the assemblage of macrobenthic organisms between the factors Location and Habitat (Table 1). *A-posteriori* comparisons showed that assemblages of macrobenthic organisms from samples of subtidal bare sediment habitat collected at Reference Location 1 differed significantly from samples collected at Reference Location 2 and the proposed Pipeline location (Table 2). No differences were detected between the proposed Pipeline location and Reference Location 2 (Table 2). For the other three habitats, no clear differences were found among locations (Table 2). Observed patterns of distribution of assemblages collected from each type of habitat were clearly reflected in the nMDS ordinations (Figures 21a-d).

SIMPER analyses showed that differences detected among locations for the bare sediment habitat were mostly due to abundances of the *Notospisulatrigonella*. This species was abundant in Reference Location 1 but was absent in Reference Location 2 and at the proposed Pipeline location.

Table 1. Summary of permutational multivariate analyses of variance (PERMANOVA) of the assemblage of macrobenthic organisms collected from samples at two sites nested in the factors 'Location' and 'Habitat' (*n* = 3).

Source	**df**	**MS**	**Pseudo-F**	***P***
Location (Lo)	2	4603.20	1.99	0.044
Habitat (Ha)	3	8999.10	3.89	0.001
Lo x Ha	6	4340.20	1.88	0.008
Site(Lo x Ha)	12	2310.80	1.67	<0.001
Residual	48	1382.60		
Total	71			

Table 2. Multiple *a-posteriori* comparisons among Locations for each Habitat, separately (corrected *P*< 0.05).

System	**Comparison among Locations**
Intertidal Mangrove	Pipeline = Reference 1 = Reference 2
Intertidal Sand Flat	Pipeline = Reference 1 = Reference 2
Subtidal Seagrass	Pipeline = Reference 1 = Reference 2
Subtidal Bare Sediments	Reference 1 ≠ Pipeline = Reference 2

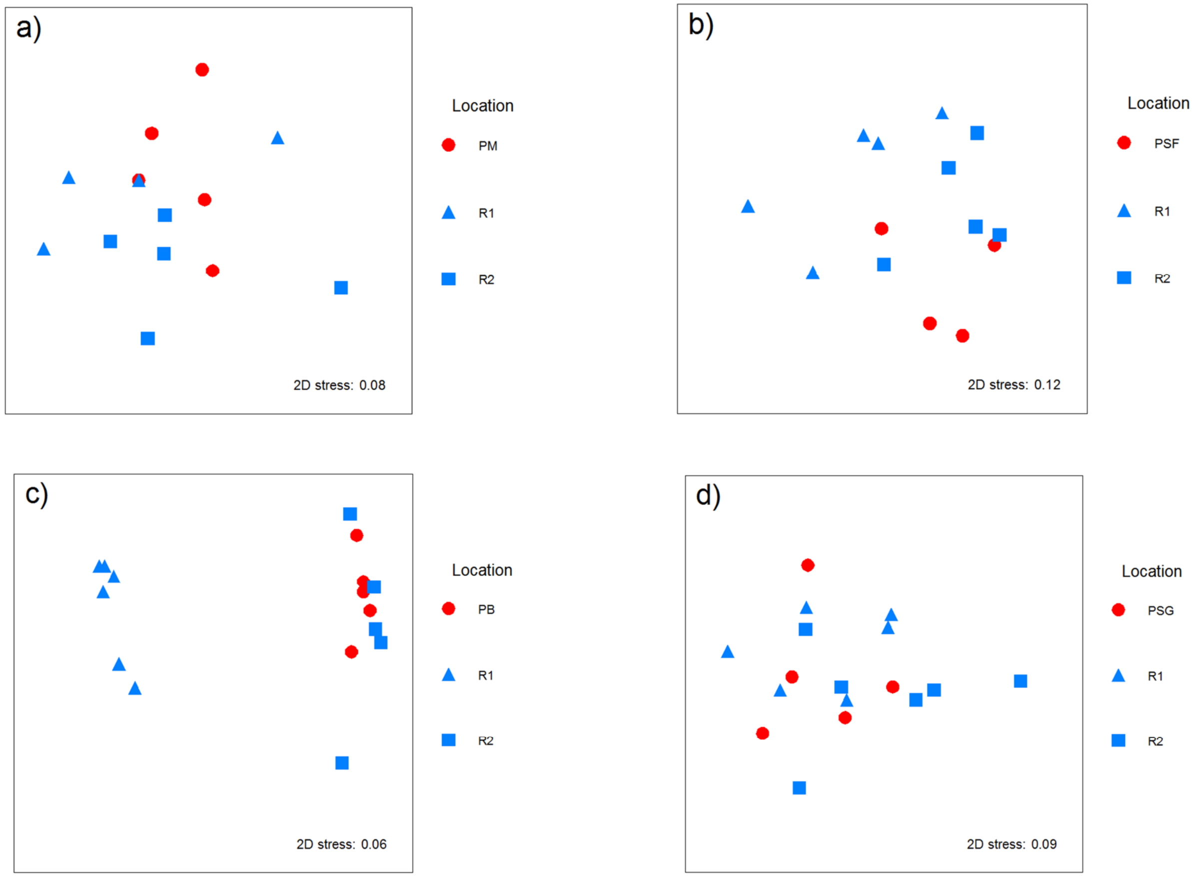

Figure 21. Non metric multidimensional scaling (nMDS) ordinations of macrobenthic assemblages sampled in sediments at three locations (● = Pipeline; ▲= Reference 1; ■ = Reference 2) in a) intertidal mangrove; b) intertidal sandflat; c) subtidal bare sediments and d) subtidal sediments covered by seagrass.

Univariate Analyses

The number of taxa and total abundance of benthic animals (numbers of individual other taxa were too sparse for analysis) were compared among locations (fixed factor), among habitats (fixed factor) and among sites (nested factor) using Permutational multivariate analyses of variance (PERMANOVA). PERMANOVA found no significant differences at the scales examined for the total richness of taxa but total abundances differed significantly among locations and among habitats (Table 3, Figure 22). For total abundance, the difference occurred mostly as a result of relatively large numbers of organisms (the bivalve, *Notospisulatrigonella*) collected in samples of subtidal bare sediment at Reference Location 1 compared to any other Location or Habitat (Table 3b, Figure 22b). Benthic organisms were also relatively abundant in samples collected from subtidal bare sediment and seagrass habitats at Reference Location 2 (Figure 22b). Notably, habitats sampled in the vicinity of the proposed pipeline supported relatively low numbers of species and individuals of benthic organisms (Figures 22a & 22b). Overall, diversity and abundance of benthic organisms was greatest in sediments collected from subtidal bare and seagrass compared to intertidal sand flat and mangrove habitats at each of the reference locations (Figures 22a & 22b).

Table 3. Permutational multivariate analyses of variance (PERMANOVA) on Euclidean distances among samples of a) untransformed total abundances and b) total number of taxa.

a)

Source	**df**	**MS**	**Pseudo-F**	***P***
Location (Lo)	2	84.39	4.38	0.037
Habitat (Ha)	3	94.67	4.91	0.022
Lo x Ha	6	61.50	3.19	0.048
Site(Lo x Ha)	12	19.28	2.30	0.017
Residual	48	8.39		
Total	71			

b)

Source	**df**	**MS**	**Pseudo-F**	***P***
Location (Lo)	2	8.67	2.369	0.105
Habitat (Ha)	3	5.83	1.81	0.195
Lo x Ha	6	1.56	0.48	0.810
Site(Lo x Ha)	12	3.22	1.97	0.048
Residual	48	1.64		
Total	71			

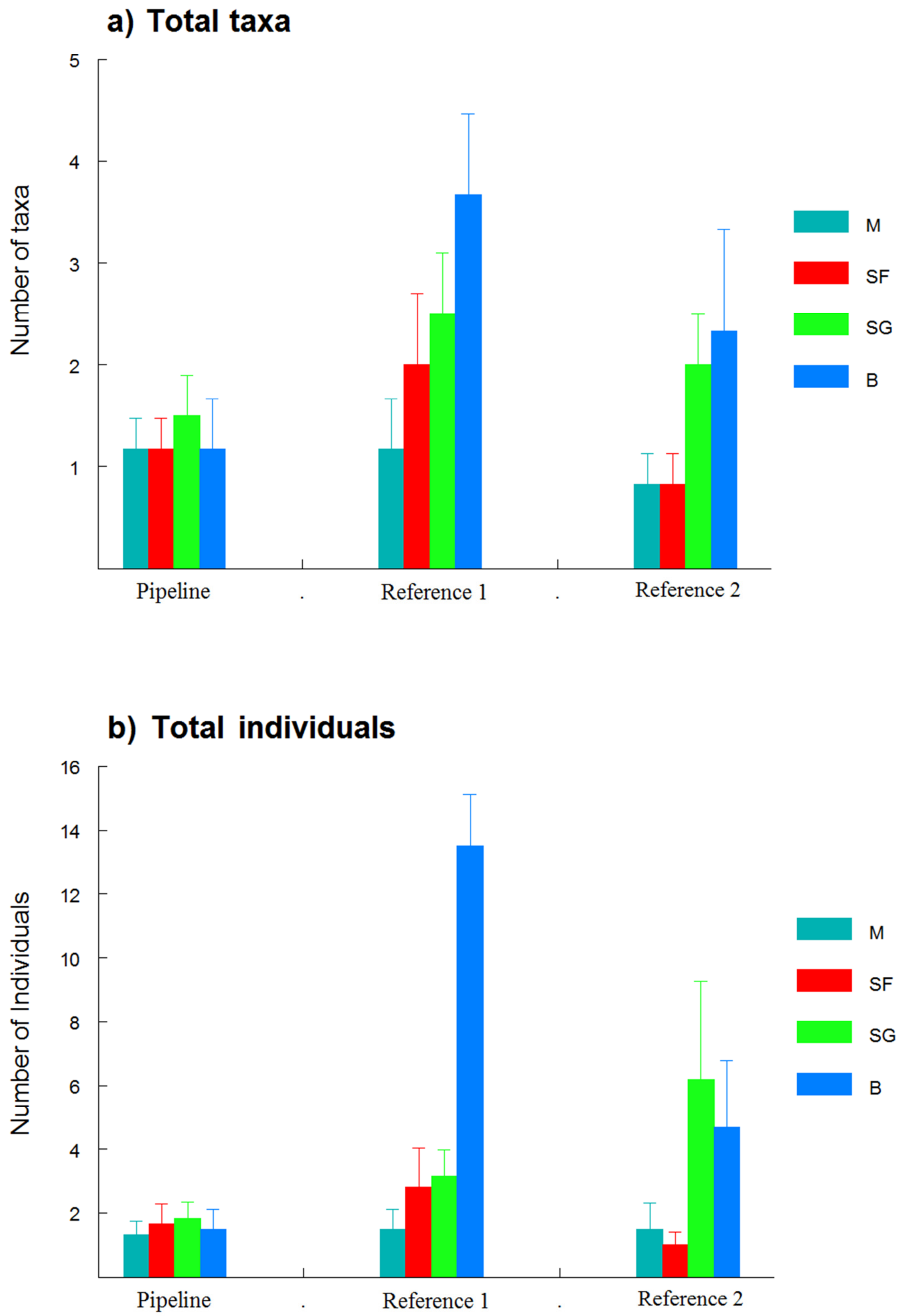

Figure 22. Mean (+SE) number of a) individuals and b) taxa in four habitat types (M = Mangrove sediments; SF = intertidal sand flats; SG = sediments covered with seagrass; and B = subtidal bare sediments) sampled at each location (*n* = 6).

Discussion

Macrobenthic organisms in estuarine waters play a major role in nutrient cycling processes and are an important source of food for a variety of organisms including fish and birds (Coull, 1999). They are also sensitive to anthropogenic disturbance, which can make them an ideal bio-indicator of potential environmental impact (Underwood et al., 2003). For these reasons, information on benthic macroinvertebrates provides an important tool for assessing the risk of various activities to ecosystem and human health.

In this study, the taxa that were consistently most abundant (i.e. polychaete worms and bivalve molluscs) are typical of soft-sediment habitats in estuaries of south-eastern Australia (see Hutchings and Murray, 1984; Jones et al., 1986; Morrisey et al., 1992; Dye, 2006). These taxa included the polychaetes Capitellidae, Nereididae and Oweniidae, the bivalve *Notospisulatrigonella* (Mactridae), amphipods and ghost shrimps (Callianassidae). *N. trigonella*, which is relatively common in many habitats, especially fine mud in estuaries (Robinson and Gibbs, 1982), was relatively abundant in sediments collected from subtidal bare sediment habitat at one of the reference locations.

Diversity and abundance of benthic organisms collected from subtidal bare sediment and seagrass habitats was greater than from the intertidal sand flat and mangrove habitats. Notably, fewer individuals and taxa of benthic macofauna were collected from all of the habitats sampled at the proposed pipeline location compared to nearby reference locations. This study was not designed to identify the processes responsible for determining the observed patterns of distribution of macrobenthic fauna within the habitats and locations sampled but factors such as sediment characteristics, salinity, and temperature, acting singly or in concert, commonly explain the composition and abundance of estuarine assemblages (Dye, 2006).

Temporal variability in macrobenthos has been widely reported (Morrisey et al., 1992; Hewitt et al., 1997) but if the relative paucity of fauna at the Pindimar location is a general pattern and if the abundance of macrobenthic fauna can be considered an indicator of the level of productivity of a location, then it seems reasonable to conclude that the location proposed for deployment of the Abalone Farm pipeline is not very productive.

Conclusions & Recommendations

This study provides baseline data that will form the basis of future assessments to determine whether or not construction of the proposed pipeline has any impact on the structure of assemblages of benthic fauna within the lower Port Stephens estuary. Given the relative paucity of the assemblage and a review of the available literature examining effects of laying pipes across the sea floor, it is expected that there would be no measurable changes to the structure and composition of the existing assemblage of benthic macroinvertebrates at the Pindimar location in relation to the reference locations.

For the future, it is recommended that monitoring of the locations sampled is repeated on at least one more occasion prior to the pipeline being constructed. It is important to note that the same sampling methods should be used to ensure continuity.

Fish

Many species of fish utilise the subtidal seagrass meadows and open water habitats adjacent to the proposed abalone farm. Scanes (et al., 2010) quantified fish amongst estuaries with those within Pindimar Bay close to the site of the proposed abalone farm. They found that all species were typical of NSW estuaries and that the total of 60 species caught over all estuaries and the total number of species caught per estuary was very similar (43 for Pindimar Bay, 42 Wallis Lake, Myall River 40). They also found that there were more species caught within seagrass (*Zostera capricorni*) compared to bare areas. Numbers of individual bream, flathead, luderick, sea mullet, tailor, tarwhine, striped trumpeter and sand whiting were not significantly different between the estuaries sampled. Bream, luderick, tarwhine and striped trumpeter were all more abundant in samples from the seagrass habitats compared with those from the bare areas. Table 1 (after Scanes et al., 2010) lists the types and numbers of fish caught in Pindimar Bay during their surveys.

Table 4. List of fish species and the number caught within Pindimar Bay (after Scanes et al., 2010).

Species	Common name	Number Caught
Acanthopagrus australis	Yellowfin bream	19
Afurcagobius tamarensis	Tamar River Goby	1
Ambassis jacksoniensis	Port Jackson perchlet (Glassfish)	37
Ambassis marianus	Estuary perchlet	2
Arenigobius bifrenatus	Bridled Goby	2
Arenigobius frenatus	Half-bridled goby	303
Atherinomorus vaigiensis	Ogilbys hardyhead	113
Bathygobius krefftii	Kreffts goby	29
Carcharhinus obscurus	Dusky Whaler Shark	1
Centropogon australis	Eastern fortescue	186
Dasyatis spp	Stingray	3
Dicotylichthys punctulatus	Three-bar porcupinefish	1
Dinolestes lewini	Longfin Pike	1
Favonigobius exquisitus	Exquisite Sandgoby	7
Favonigobius lateralis	Southern Longfin Goby	3
Gerres subfasciatus	Silver biddy	40
Girella tricuspidata	Luderick	9
Herklotsichthys castelnaui	Southern Herring	123
Heteroclinus spp	Weedfish	6
Hyperlophus vittatus	Sandy Sprat	9
Hyporhamphus regularis ardelio	Eastern River garfish	88
Leptatherina presbyteroides	Silverfish	5
Liza argentea	Flat-tail mullet	19
Meuschenia trachylepis	Yellowfin Leatherjacket	13
Mugil cephalus	Striped mullet	23
Mullidae spp.	Goatfish	1
Ophisurus serpens	Giant snake eel	1
Pelates sexlineatus	Eastern Striped Trumpeter	130
Platycephalus fuscus	Dusky flathead	3
Pomatomus saltatrix	Tailor	58
Pseudorhombus jenynsii	Small-toothed flounder	13
Repomucenus calcaratus	Spotted stinkfish	2
Rhabdosargus sarba	Tarwhine	31
Sarda australis	Australian Bonito	2
Sillago ciliata	Sand whiting	92
Sillago maculata	Trumpeter whiting	5
Tetractenos glaber	Smooth toadfish	2
Tetractenos hamiltoni	Common toad	2
Torquigener pleurogramma	Weeping toad	1
Trygonoptera testacea	Common Stingaree	1
Trygonorrhina fasciata	Southern fiddler ray	1
Upeneichthys spp.*	Goatfish	2

Vanacampus margaritifer	Mother-of-pearl Pipefish	1
	Total Number Caught	**1391**
	Total number Species	**43**

Alexander (2010) also sampled fish at eight locations (including Pindimar) in Port Stephens that were composed of both bare sand and *Zostera capricorni* seagrass habitats. Seventy four species of fish were recorded and, as with other studies, greater numbers of species and individuals were found within seagrass habitats compared with those in bare habitats. Alexander (2010) found that the assemblages of fish were quite different between habitat types and that the number of species and individuals did not differ significantly between the western and eastern sides of the port. Of the species recorded the Gobiidae, Monoanthiidae, Clinidae and Syngnathidae were the best represented. Four syngnathid species were recorded in seagrass habitats and included *Urocampus carinirostris, Vanacampus margaritifer, Stigmatopora nigra* and *Hippocampus whitei.* Of the 74 fish species recorded, 33 were considered to be of commercial and/or recreational importance with most of these found within the seagrass habitats. The importance of both these studies show that the assemblages of fish found in and around the *Zostera capricorni* seagrass and bare habitats at Pindimar are similar to other locations within Port Stephens.

Whilst most fishes within the seagrass habitat will be able to avoid any impact from the laying of the pipeline footings, one family of fishes, the Syngnathidae, needs to be considered as they are a protected family of fish under the NSW *Fisheries Management Act 1994* (FMA 1994). The family includes the pipefishes and seahorses, which are common within the seagrass habitats of the estuary. Syngnathids are reportedly highly vulnerable to human impacts, due to low rates of reproduction and their sedentary nature (Vincent *et al.*, 2005). There is a risk that pipefish and seahorses may be crushed or injured as the footings are placed onto the bottom.

Any pipefishes and seahorses in the footprint will need to be “ushered” out of the way by divers as the footings are being placed on the bottom. Once the footings are in place these fishes will most likely make use of the structures or nearby seagrass habitat. With that being said, there is also the potential for the structures to act as FADs (Fish Aggregating Devices) for other species of fish. These structures should provide additional habitat for fish and fouling organisms on the pipes and provide additional food resources. It has been well demonstrated that artificial structures can increase diversity and abundance of invertebrates and fish assemblages within estuaries (Connell and Glasby, 1999).

The entrainment/impingement of fish and invertebrates on the intake screens of the pipes is another potential issue that must be considered. The flow into the pipe will be very low (~0.1m/s) and therefore the risk of entrainment/ impingement will also be very low. Slow moving fish such as seahorses and pipefishes will not be present at the depths of the intakes as the habitat will be bare sediments. If they were found near the inlet it is doubtful that they would be damaged by the low currents and entrainment on these screens. Furthermore, Cummins et al. (2011) found that pipefishes survived and were not harmed by entrainment on large screens at the Eraring Energy Power Station (EEPS) water intakes, where the velocity of water passing through the Inlet Canal can be as fast as 2 m/sec.

Notably, burst speeds of fish, which can usually only be maintained for seconds, has been estimated to be about 10 times greater than sustained speed for most species (Weihs, 1973). When Hedger et al. (2010) investigated behaviour of adult Tailor in tidal currents they found that the average speed recorded for tagged fish was 0.464 m/sec.

Measurements of the swimming ability of the jellyfish species, *Catostylus mosaicus* ('Man-of-war'), across a wide range of size classes found that even small medusa (< 80 mm diameter) swim in excess of 0.02 m/sec (Pitt and Kingsford, 2000). While medusa may swim or drift to more favourable waters, the polyp has no such option. Given the very small volume and velocity of water (i.e. ~0.1m/s) drawn into the abalone farm via the inlet pipe and that the intake will be placed over bare sediments rather than seagrass habitat, *the potential for small and/or* slow moving organisms *to be entrained is considered to be low. Notably, the pipe system is a flow return system, so any individuals that are entrained are likely to be returned to the estuary via the* *outlet pipe.* Screens however, will be fitted over the intake but will need to be examined when the vacuum gauges on the intake lines in the pump house show a greater than 10% drop in normal range. Screens will be cleaned regularly to ensure fouling is kept to a minimum.

Marine Park

The proposed abalone farm is to the east of one of the Port Stephens Marine Park sanctuary and habitat protection zones. The pipe outlets from the farm will be at least 415m from the sanctuary zone and water will be discharged at a depth of around 6m. Given the distance from the marine park and the dilutions reported by Sanderson (2013), there will be no impact to the Marine Park or changes to localised ecological processes that could cause any impacts.

Oyster Farms

There are no operational oyster leases in near proximity to the proposed abalone farm and its discharge pipes. Any discharge of water from the farm will result in the fast dilution of any nutrients that could have the potential to impact on oysters within the port (Sanderson, 2013).

Dolphin Watching

The most common species within Port Stephens and just outside the heads is the Indo-Pacific bottlenose dolphin (*Tursiops aduncus*). There is a viable dolphin watching industry within Port Stephens based around the local population of this species of dolphin. Approximately 120 individuals which comprise two mixed-gender social groups live within the port. Although the Indo-Pacific bottlenose dolphin is a relatively common species, populations of this species within Port Stephens are genetically different from other populations of Indo-Pacific bottlenose dolphins found along the NSW coastline, so they are considered a unique group. It is likely that the genetic distinctiveness of the Port Stephens population is caused by the uniqueness of the environment and preferences by females to remain in areas in which they were born.

Dolphins utilise most of the habitat types within the port including seagrass meadows. Dolphins will not be impacted by the proposal as the pipelines are either buried in the intertidal sediments or near the bottom (i.e. the pipe will be elevated 50cm above the seabed) in the seagrass or bare subtidal habitats and there will be no chance of dolphins being injured or snared by the pipes. In addition, Sanderson (2013) predicted that effects on the quality of water pumped through the aquaria and then discharged back into the estuary will be minimal. An assessment of effects on populations of Bottlenose dolphins and dolphins listed under the *EPBC Act 1999* that have the potential to live within the Port Stephens estuary, has been undertaken within the section 'Threatened Species Assessment'.

Pig Station Creek

A wooden boardwalk approximately 2m wide is to be constructed across Pig Station Creek at the end of Cambage Street, Pindimar to allow emergency access from the site. Pig Station Creek enters the estuary to the east of the farm site (Fig. 21). The boardwalk will be raised on pylons and will pass through approximately 20m of previously disturbed saltmarsh (WEC, 2012). Saltmarsh species identified at the location of the crossing included *Baumea juncea, Juncus kraussii, Sporobolus virginicus*, and *Sarcocornia quinqueflora* (Fig. 22). The grey mangrove *Avicennia marina* also lines the edge of the creek where the boardwalk will pass, however no mangroves will need to be disturbed with the exception of minor trimming works (Fig. 22).

The installation and operation of instream structures and other mechanisms that alter natural flow regimes of rivers and streams were listed as a key threatening process under the FMA 1994 (NSW DPI, 2005). Whilst bridges are exempt, the construction of the boardwalk would need to be done without blocking fish passage in the creek. In general, the construction of the boardwalk across the creek will have negligible impacts on aquatic flora and fauna.

Figure 23. Pig Station Creek enters the estuary to the east of the site.

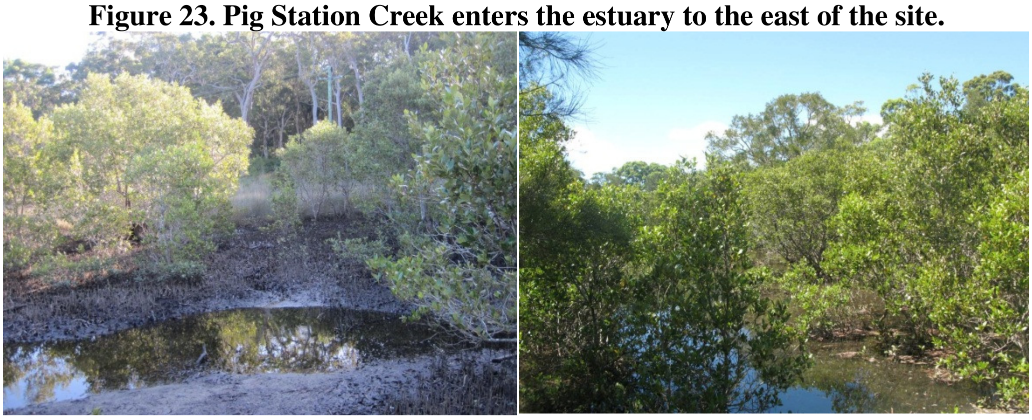

Figure 24. Location of the creek crossing showing mangroves and saltmarsh.

Broodstock

It is proposed that abalone broodstock for the farm will either be purchased from a licensed re-seller or, if not available, that the collection of up to 120 abalone from the natural wild populations be done in the first instance. The restocking of abalone from the wild or purchase by resellers is also proposed to ensure genetic diversity and it has been estimated that up to 24 abalone be purchased or collected annually (Hone et al., 1997; Heasman and Savva, 2007). These numbers are insignificant in terms of what will remain in the natural wild population and there would be no indirect impact on other subtidal marine assemblages. Natural mortality and predation would be far greater in the wild as they are constantly preyed upon by rays and other fishes as well as marine invertebrates such as starfish, lobsters and octopus (Andrew, 1999).

Supervision of Works

Construction works associated with trenching and piping will need to be supervised by an appropriately qualified and experienced marine ecologist with an established record in mangrove and seagrass ecology. They should also be familiar with transplanting and restoration techniques in these types of habitats. The marine ecologist will also require expertise in undertaking and analysing data from monitoring programmes designed to assess the impacts of disturbance on estuarine habitats.

Monitoring Plans

The monitoring plans outlined below list the minimum requirements that will need to be in place to assess the impact on the seagrass and mangrove habitats adjacent to trenching works and pipeline placements. These monitoring plans outline appropriate spatial and temporal scales that may need to be including in assessing impacts. Surveillance monitoring will also need to be in place to assess scouring and erosion around the pipelines as well as potential fouling to intake screens.

Seagrasses

The effects of laying the pipes within the *Posidonia australis* seagrass meadow should be assessed using a "Beyond BACI" experimental design (see Underwood, 1994). As a minimum, the subtidal seagrasses at the disturbed location (seagrass meadow adjacent to the abalone farm site) will be sampled at least two times before and at least two times after the pipes are placed on the seabed. A number of randomly nested sites will be sampled at the disturbed location and at least at two independent reference locations at the same spatial and temporal scales. At each site, the following seagrass variables would be estimated from within 5 replicate $0.25m^2$ quadrats:

- Density of seagrass (number of shoots)
- Percent cover of seagrass
- Leaf-length

Mangroves

A “Beyond BACI” experimental design would be used to assess the impact of trenching and excavation on the mangrove habitat (see Underwood, 1994). The mangroves at the disturbed location (mangrove habitat adjacent to the abalone farm site) will be sampled at least two times before and at least two times after the trimming and trenching works. Appropriate spatial and temporal scales will be used to measure mangrove variables. Two randomly nested sites will be sampled at the disturbed location and at two independent reference locations. Within each site, three 10 m^2 plots will be randomly selected. The number of adult mangrove trees (*Avicennia marina*) will be counted in each plot. An estimate of the height (m) of the forest canopy and its percentage cover (Specht Classification) will also be made from within each plot. Furthermore, within each 10 m^2 plot, five randomly placed 0.25 m^2 quadrats will be used to estimate the number of mangrove seedlings and pneumatophores (aerial roots). Any seedlings transplanted from the disturbed location will be monitored for at least 18 months after their relocation. The exact location of seedlings will be marked and their condition will be recorded on a monthly basis. Seedlings in at least two reference locations will also be monitored. The height of each of the mangrove seedlings will be measured to the nearest cm.

THREATENED SPECIES ASSESSMENT

All known and likely protected threatened species, populations, ecological communities and habitats adjacent to the site were taken into account in assessing aquatic threatened species within the study area. The following information prepared for each species or population assesses both direct and indirect impacts of the proposal on the species or its habitat. The assessment specifically examined threatened species or other protected flora and fauna under the *Fisheries Management Act 1994* and *Threatened Species Conservation Act 1995* that have the potential to be affected by the proposed construction and operation of the Abalone Farm.

Giant Queensland Groper (*Epinephelus lanceolatus*)

a) In the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction.

Protected species (FMA 1994). The giant groper is found in northern NSW coastal waters. The life cycle of this species will not be disrupted as the Abalone Farm is out of its normal range and doesn't include its preferred habitat.

b) In the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.

No known endangered population of giant groper exists within or near the area proposed for the abalone farm.

c) In relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed.

No significant area of known habitat is to be modified or removed.

d) Whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community.

No known habitat will be isolated.

e) Whether a critical habitat will be affected.

No critical habitat for giant groper would be affected by the proposed abalone farm.

f) Whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region.

The species is found in the Great Barrier Reef Marine Park and the Solitary Islands Marine Park.

g) Whether the action proposed is of a class of action that is recognised as a threatening process.

The proposed abalone farm is not recognised as a threatening process.

h) Whether any threatened species or ecological community is at the limit of its known distribution.

The giant groper is not at the limit of its known range at the location of the proposed abalone farm.

Eastern Blue Devil Fish (*Paraplesiops bleekeri*)

a) In the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction.

Protected species (FMA 1994). The blue devil fish inhabits caves and ledges on rocky reefs in 15-20 m along the NSW coastline from Nambucca Heads to Eden. The life cycle of this species will not be disrupted as the Abalone Farm is out of its normal range and doesn't include its preferred habitat.

b) In the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.

No known endangered population of blue devil fish exists within or near the area proposed for the abalone farm.

c) In relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed.

No significant area of known habitat is to be modified or removed.

d) Whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community.

No known habitat will be isolated.

e) Whether a critical habitat will be affected.

No critical habitat for blue devil fish would be affected by the proposed abalone farm.

f) Whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region.

This species is found in the coastal marine extensions of National Parks, Jervis Bay National Park, Shiprock Reserve and other marine reserves located on rocky reefs.

g) Whether the action proposed is of a class of action that is recognised as a threatening process.

The proposed abalone farm is not recognised as a threatening process for the blue devil fish.

h) Whether any threatened species or ecological community is at the limit of its known distribution.

The blue devil fish is not at the limit of its known range at the location of the proposed abalone farm.

Estuary Cod (*Epinephelus coioides*)

a) In the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction.

Protected species (FMA 1994). Estuary cod are commonly found in the lower reaches of estuaries and protected silty reef habitats. Estuary Cod are reef fishes found in northern NSW estuarine waters. Juvenile estuary cod are common in shallow waters of estuaries over sand, seagrass, mud and gravel and among mangroves, and they have also been reported from freshwaters. The life cycle of the species is not likely to be disrupted by the abalone farm or disrupt a viable local population.

b) In the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.

No known endangered population of estuary cod exists within or near the area proposed for the abalone farm.

c) In relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed.

No significant area of known habitat is to be modified or removed.

d) Whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community.

No known habitat will be isolated.

e) Whether a critical habitat will be affected.

No critical habitat for estuary cod fish would be affected by the proposed abalone farm.

f) Whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region.

Estuary cod habitat is located in a number of protected areas in NSW including the Solitary Islands Marine Park, Julian Rocks Aquatic Reserve and Cook Island Aquatic Reserve.

g) Whether the action proposed is of a class of action that is recognised as a threatening process.

The proposed abalone farm is not recognised as a threatening process for the estuary cod.

h) Whether any threatened species or ecological community is at the limit of its known distribution.

The estuary cod is not at the limit of its known range at the location of the proposed abalone farm.

Elegant Wrasse (*Anampses elegans*)

a) In the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction.

Protected species (FMA 1994). Elegant wrasse (*Anampses elegans*) are subtropical, warm temperate species and are widespread but uncommon on reefs habitats at depths from 2-35m. Their range is from southern Queensland to Montague Island on the NSW south coast, particularly around inshore islands. This species life cycle will not be disrupted by the abalone farm, as the site doesn't include its preferred habitat.

b) In the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.

No known endangered population of elegant wrasse exists within or near the area proposed for the abalone farm. No endangered population of elegant wrasse would be negatively affected in terms of its life cycle or viability of the population being significantly compromised.

c) In relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed.

No natural rocky reef occurs at the site and therefore none will be removed or otherwise modified.

d) Whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community.

No known habitat will be isolated.

e) Whether a critical habitat will be affected.

No critical habitat for elegant wrasse would be affected by the proposed abalone farm.

f) Whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region.

Elegant wrasse habitat is located in a number of protected areas in NSW, including Port Stephens – Great Lakes Marine Park, Solitary Islands Marine Park, Julian Rocks Aquatic Reserve, Middleton and Elizabeth Reefs Marine National Nature Reserve and Lord Howe Island Marine Park (DPI Fisheries).

g) Whether the action proposed is of a class of action that is recognised as a threatening process.

The proposed abalone farm is not recognised as a threatening process with respect to elegant wrasse.

h) Whether any threatened species or ecological community is at the limit of its known distribution.

Elegant wrasse occurring in the local area are not at the limit of its known distribution.

Black Rock Cod (*Epinephelus daemelii*)

a) In the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction.

Vulnerable species (FMA 1994). Black cod occur from southern Queensland to South Australia and are found on relatively shallow coastal and estuarine rocky reefs. The life cycle of Black Cod revolves around rocky reefs and possibly rock pools with pelagic dispersal of eggs and larvae.

In Port Stephens, black cod may occur on natural reef at the mouth of the estuary but it is highly doubtful that the life cycle of the species would be disrupted or placed at risk of extinction as a result of the abalone farm.

b) In the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.

No known endangered population of black cod exists within or near the area proposed for the abalone farm. Any disturbance by the farm's construction or operation would occur to soft sediment habitats. No endangered population of black cod would be negatively affected in terms of its life cycle or viability of the population being significantly compromised.

c) In relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed.

No natural rocky reef occurs at the site and therefore none will be removed or otherwise modified.

d) Whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community.

No known habitat will be isolated.

e) Whether a critical habitat will be affected.

No critical habitat for black cod would be affected by the proposed abalone farm.

f) Whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region.

Black cod are protected from fishing in NSW with protected areas for the species, including aquatic reserves at Fly Point and Halifax Park.

g) Whether the action proposed is of a class of action that is recognised as a threatening process.

The proposed abalone farm is not recognised as a threatening process with respect to black cod.

h) Whether any threatened species or ecological community is at the limit of its known distribution.

Port Stephens is in the middle of the Black Cod's geographical range along the NSW coast and therefore not at the limit of its range.

Ballina Angel Fish (*Chaetodontoplus ballinae*)

a) In the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction.

Protected species (FMA 1994). The angel fish occurs in deep water in northern NSW and around Lord Howe Island. No know viable population of the species is to be placed at risk.

b) In the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.

No angel fish exists within or near the area proposed for the abalone farm.

c) In relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed.

No habitat of this fish will be removed or otherwise modified.

d) Whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community.

No known habitat of the angel fish will be isolated as a result of the proposed abalone farm.

e) Whether a critical habitat will be affected.

No critical habitat used by angel fish would be affected by the abalone farm.

f) Whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region.

Angel fish are found in the Solitary Islands Marine Park, Jervis Bay National Park and coastal marine reserves.

g) Whether the action proposed is of a class of action that is recognised as a threatening process.

The proposed abalone farm is not recognised as a threatening process with respect to angel fish.

h) Whether any threatened species or ecological community is at the limit of its known distribution.

The angel fish is not at the limit of its known distribution.

Weedy Seadragon (*Phyllopteryx taeniolatus*)

a) In the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction.

Protected species (FMA 1994). Weedy seadragons (family *Syngnathidae*) are found from Geraldton in Western Australia along the southern Australian coastline to Port Stephens in NSW. They can be found in a variety of habitats including shallow estuaries and deep offshore reefs. They can occur to depths of 50m and are generally found in waters deeper than 10m. Juveniles of the species are often associated with kelp and seagrass habitats (DPI Fisheries). The life cycle of the weedy seadragon is not likely to be disrupted or a local population placed at risk of extinction as a result of the farm.

b) In the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.

No endangered population of weedy seadragon exists within or near the area proposed for the abalone farm and their viability of the population is not likely to be significantly compromised.

c) In relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed.

No habitat that the weedy seadragon utilises occurs at the site and therefore none will be removed or otherwise modified.

d) Whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community.

No known habitat of the weedy seadragon will be isolated as a result of the proposed abalone farm.

e) Whether a critical habitat will be affected.

No critical habitat used by the weedy seadragon would be affected by the abalone farm.

f) Whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region.

Species is represented in conservation reserves and marine protected areas in the region.

g) Whether the action proposed is of a class of action that is recognised as a threatening process.

The proposed abalone farm is not recognised as a threatening process with respect to this species.

h) Whether any threatened species or ecological community is at the limit of its known distribution.

The weedy seadragon are at the limit of its known distribution in the north at Port Stephens (DPI Fisheries Primefact).

Green Sawfish (*Pristis zijsron*)

a) In the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction.

Endangered species (FMA 1994). Green sawfish have been reported from estuarine habitats such as those found in Port Stephens. There is no known local population in Port Stephens. Fisheries Scientific Committee reviewed the conservation status of the species and subsequently determined green sawfish to be a species presumed extinct in NSW (DPI Fisheries).

b) In the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.

No endangered population of green sawfish has been identified in Port Stephens and there is unlikely to be such a population since it is presumed extinct.

c) In relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed.

No known habitat of the green swordfish will be modified or removed.

d) Whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community.

No known habitat of the green swordfish will be become isolated as a result of the abalone farm.

e) Whether a critical habitat will be affected.

No critical habitat would be affected for the green swordfish.

f) Whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region.

The habitat of the green swordfish would be adequately represented in conservation reserves in the region.

g) Whether the action proposed is of a class of action that is recognised as a threatening process.

The proposed abalone farm is not recognised as a threatening process with respect to this species.

h) Whether any threatened species or ecological community is at the limit of its known distribution.

Since it is presumed extinct the range of this species is now not known. The last confirmed sighting of green sawfish in NSW was in 1972 from the Clarence River at Yamba (DPI Fisheries).

Grey Nurse Shark (*Carcharias taurus*)

a) In the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction.

Endangered species (FMA 1994). The Grey nurse shark inhabits deep gutters around rocky outcrops, bomboras and reefs along the NSW coast. They are found in small groups around headlands at the entrance to Port Stephens and along the coastline. Since the life cycle is generally associated with rocky reef it is highly unlikely that the proposed abalone farm would disrupt the life cycle of the shark or any local populations.

b) In the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.

No known endangered population of grey nurse shark exists within or near the area proposed for the abalone farm. Any disturbance by the farm's construction or operation would occur to soft sediment habitats. No endangered population of grey nurse shark would be negatively affected in terms of its life cycle or viability of the population being significantly compromised.

c) In relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed.

No natural rocky reef that the shark utilises occurs at the site and therefore none will be removed or otherwise modified.

d) Whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community.

No known habitat of the grey nurse shark will be isolated as a result of the proposed abalone farm.

e) Whether a critical habitat will be affected.

No critical habitat used by grey nurse sharks would be affected by the abalone farm.

f) Whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region.

Grey nurse sharks are protected and are represented within marine parks in the region.

g) Whether the action proposed is of a class of action that is recognised as a threatening process.

The proposed abalone farm is not recognised as a threatening process with respect to the grey nurse shark.

h) Whether any threatened species or ecological community is at the limit of its known distribution.

Grey nurse sharks can be found in NSW, Queensland and Victoria. They are also found in Western Australia and are not at the limit of their known distribution.

Herbsts Nurse Shark (*Odontaspis ferox*)

a) In the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction.

Protected species (FMA 1994). Herbsts nurse sharks are a rarely encountered species that looks very similar to the grey nurse shark. Herbsts nurse sharks are generally found at depths of 150–600 m off the NSW coast. It is highly unlikely that the proposed abalone farm would disrupt the life cycle of the shark or any local populations.

b) In the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.

No known endangered population of Herbsts nurse shark exists within or near the area proposed for the abalone farm.

c) In relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed.

No habitat that the shark utilises occurs at the site and therefore none will be removed or otherwise modified.

d) Whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community.

No known habitat of the shark will be isolated as a result of the proposed abalone farm.

e) Whether a critical habitat will be affected.

No critical habitat used by these sharks would be affected by the abalone farm.

f) Whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region.

It has not been documented if this species is adequately represented in conservation reserves due to their preference for deep reef.

g) Whether the action proposed is of a class of action that is recognised as a threatening process.

The proposed abalone farm is not recognised as a threatening process with respect to this species of shark.

h) Whether any threatened species or ecological community is at the limit of its known distribution.

The nurse shark can be found off the coast of NSW and are not at the limit of their known distribution.

Great White Shark (*Carcharodon carcharias*)

a) In the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction.

Vulnerable species (FMA 1994). Great white sharks are found throughout the world in temperate and subtropical oceans, with a preference for cooler waters. This distribution includes the coastal waters of NSW. Their life cycles are poorly understood but they are known to enter estuaries like Port Stephens. It is most unlikely that the proposed abalone farm would affect great white sharks.

b) In the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.

It is highly unlikely that the population would be disrupted or compromised by the proposed abalone farm.

c) In relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed.

No known habitat of the great white shark will be modified or removed as a result of the abalone farm.

d) Whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community.

No known habitat of the great white shark will become isolated as a result of the abalone farm.

e) Whether a critical habitat will be affected.

No critical habitat would be affected for the great white shark.

f) Whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region.

The range of the great white shark makes any use of marine protected or conservation areas difficult.

g) Whether the action proposed is of a class of action that is recognised as a threatening process.

The proposed abalone farm is not recognised as a threatening process with respect to this species.

h) Whether any threatened species or ecological community is at the limit of its known distribution.

The range of this species would indicate that it is not at the limit of its known distribution.

Southern Right Whale (*Eubalaena australis*)

a) In the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction.

Vulnerable species (TSC Act 1995). The Southern Right Whale has been frequently observed close to shore, with the majority of sightings occurring from July to September around the southern and central NSW coastlines. It is most unlikely that a local population is to be placed at risk of extinction by the abalone farm.

b) In the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.

It is highly unlikely that an endangered local population would be placed at risk by the proposed abalone farm.

c) In relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified of removed.

No known habitat will be modified or removed for this species of whale.

d) Whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community.

No known habitat will become isolated as a result of the proposed abalone farm.

e) Whether a critical habitat will be affected.

No habitat critical for southern right whales would be affected as a result of the proposed abalone farm.

f) Whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region.

Since these whales have large ranges it is difficult to assign them to conservation areas in the region. They are protected by the Australian Whale Sanctuary Commonwealth waters.

g) Whether the action proposed is of a class of action that is recognised as a threatening process.

The proposed abalone farm is not a recognised threatening process for southern right whales.

h) Whether any threatened species or ecological community is at the limit of its known distribution.

This species is not at the limit of its known distribution.

Humpback Whale (*Megaptera novaeangliae*)

a) In the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction.

Vulnerable species (TSC Act 1995). Humpback whales migrate from summer cold-water feeding grounds in Sub-Antarctic waters to warm-water winter breeding grounds in the central Great Barrier Reef and are regularly observed in NSW waters in June and July, on northward migration and October and November, on southward migration. It is most unlikely that a local population is to be placed at risk of extinction by the abalone farm.

b) In the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.

It is highly unlikely that an endangered local population would be placed at risk by the proposed abalone farm.

c) In relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified of removed.

No known habitat will be modified or removed for this species of whale.

d) Whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community.

No known habitat will become isolated as a result of the proposed abalone farm.

e) Whether a critical habitat will be affected.

No habitat critical for humpback whales would be affected as a result of the proposed abalone farm.

f) Whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region.

Since these whales have large ranges it is difficult to assign them to conservation areas in the region. They are protected by the Australian Whale Sanctuary in commonwealth waters.

g) Whether the action proposed is of a class of action that is recognised as a threatening process.

The proposed abalone farm is not a recognised threatening process for humpback whales.

h) Whether any threatened species or ecological community is at the limit of its known distribution.

This species is not at the limit of its known distribution.

Bryde's Whale (*Balaenoptera edeni*)

a) In the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction.

Migratory species (EPBC Act 1999). Bryde's Whales occur in temperate to tropical waters, both oceanic and inshore and have been recorded from all Australian states except the Northern Territory (Bannister et al., 1996). Insufficient information is available on how Australian Brydes's Whales use their habitat because no specific feeding or breeding grounds have been discovered off Australia. The inshore form of this species appears to be resident in waters containing sufficient prey stocks of pelagic shoaling fishes, while the offshore form appears to extensively migrate between subtropical and tropic waters during winter months (Best, 1977). It is most unlikely that a local population is to be placed at risk of extinction by the abalone farm.

b) In the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.

It is highly unlikely that an endangered local population would be placed at risk by the proposed abalone farm.

c) In relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified of removed.

No known habitat will be modified or removed for this species of whale.

d) Whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community.

No known habitat will become isolated as a result of the proposed abalone farm.

e) Whether a critical habitat will be affected.

No habitat critical for Bryde’s Whales would be affected as a result of the proposed abalone farm.

f) Whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region.

Since these whales have large ranges it is difficult to assign them to conservation areas in the region. They are protected by the Australian Whale Sanctuary in commonwealth waters.

g) Whether the action proposed is of a class of action that is recognised as a threatening process.

The proposed abalone farm is not a recognised threatening process for Bryde’s whales.

h) Whether any threatened species or ecological community is at the limit of its known distribution.

This species is not at the limit of its known distribution.

Pygmy Right Whale (*Caperea marginata*)

a) In the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction.

Migratory species (EPBC Act 1999). Pygmy Right Whales in Australian waters are distributed between 32˚ S and 47˚ S (Kemper 2002). Few or no records are available for NSW (Kemper 2002). It is most unlikely that a local population is to be placed at risk of extinction by the abalone farm.

b) In the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.

It is highly unlikely that an endangered local population would be placed at risk by the proposed abalone farm.

c) In relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified of removed.

No known habitat will be modified or removed for this species of whale.

d) Whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community.

No known habitat will become isolated as a result of the proposed abalone farm.

e) Whether a critical habitat will be affected.

No habitat critical for Pygmy Right Whales would be affected as a result of the proposed abalone farm.

f) Whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region.

Since these whales have large ranges it is difficult to assign them to conservation areas in the region. They are protected by the Australian Whale Sanctuary in commonwealth waters.

g) Whether the action proposed is of a class of action that is recognised as a threatening process.

The proposed abalone farm is not a recognised threatening process for Pygmy Right Whales.

h) Whether any threatened species or ecological community is at the limit of its known distribution.

This species is not at the limit of its known distribution.

Dugong (*Dugong dugon*)

a) In the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction.

Endangered species (TSC Act 1995). Dugong are primarily tropical and subtropical mammals that feed on seagrasses (*Halophila* spp.) and macroalgae. They have been recorded as far south as Jervis Bay NSW. Dugong do not breed in NSW and it is highly unlikely that a local population would be placed at risk of extinction by the abalone farm.

b) In the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.

There are no breeding populations of dugong in the study area and it is highly unlikely that an endangered local population would be placed at risk by the proposed abalone farm.

c) In relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified of removed.

No known habitat will be modified or removed for this species of mammal.

d) Whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community.

No known habitat will become isolated as a result of the proposed abalone farm.

e) Whether a critical habitat will be affected.

No habitat critical for dugongs would be affected as a result of the proposed abalone farm.

f) Whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region.

Seagrass habitats which are critical for this species in the north are protected and adequately represented.

g) Whether the action proposed is of a class of action that is recognised as a threatening process.

The proposed abalone farm is not a recognised threatening process for dugongs.

h) Whether any threatened species or ecological community is at the limit of its known distribution.

This species is not at the limit of its known distribution.

Dolphins

a) In the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction.

Dolphins and porpoises have special protection under the EPBC Act through the Australian Whale Sanctuary. The Sanctuary covers waters within Australia s exclusive economic zone, which is up to 200 nautical miles from the Australian coast, but does not generally include coastal waters within three nautical miles of the coast. It is an offence to kill, injure, take, trade, or interfere with a cetacean within the Australian Whale Sanctuary.

Bottlenose dolphins (*Tursiops aduncus*) live permanently within the Port Stephens estuary. Approximately 120 individuals which comprise two mixed-gender social groups live within the estuary. Although the Indo-Pacific bottlenose dolphin is a relatively common species, populations of this species within Port Stephens are genetically different from other populations of Indo-Pacific bottlenose dolphins found along the NSW coastline, so they are considered a unique group. It is likely that the genetic distinctiveness of the Port Stephens population is caused by the uniqueness of the environment and preferences by females to remain in areas in which they were born.

Individuals and/or habitat for the Dusky Dolphin (Lagenorhynchus obscurus) may also occur within the study area. In Australia, Dusky Dolphins are known from only 13 reports since 1828, with two sightings in the early 1980s (DEW 2007). The area of occupancy of the Dusky Dolphin cannot be calculated due to the sparsity of records for Australia. However, it is likely to be greater than 2000 km² (Peddemors & Harcourt 2006, pers. comm.). Dusky Dolphins are considered to occur in one location, as there are no known fixed pelagic boundaries that would obstruct their movement.

The proposed abalone farm is unlikely to interfere with any local dolphin population.

b) In the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.

No populations of dolphins are likely to be disrupted such that the viability of the population is compromised by the proposed abalone farm.

c) In relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified of removed.

No significant areas of known habitat are to be modified or removed as a result of the abalone farm.

d) Whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community.

No significant areas of known habitat are likely to become isolated as a result of the abalone farm.

e) Whether a critical habitat will be affected.

No dolphin critical habitat will be affected by the proposed abalone farm.

f) Whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region.

Dolphin habitats are adequately represented in numerous marine parks and reserves.

g) Whether the action proposed is of a class of action that is recognised as a threatening process.

The proposed abalone farm is not recognised as a threatening process for dolphins.

h) Whether any threatened species or ecological community is at the limit of its known distribution.

Dolphins within the port are not at the limit of their known distribution.

Killer Whales (*Orcinus orca*)

a) In the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction.

Migratory species (*EPBC Act 1999*). Killer whales are the largest member of the dolphin family. Killer Whales in Australian waters are distributed between 32˚ S and 47˚ S (Kemper, 2002). Few or no records are available for NSW (Kemper, 2002). The preferred habitat of Killer Whales includes oceanic, pelagic and neritic (relatively shallow waters over the continental shelf) regions, in both warm and cold waters. They may be more common in cold, deep waters, but off Australia, Killer Whales are most often seen along the continental slope and on the shelf, particularly near seal colonies. Killer Whales have regularly been observed within the Australian territorial waters along the ice edge in summer (Thiele & Gill, 1999).

The habitat of Killer Whales is difficult to categorise due to the cosmopolitan nature of the species and its ability to inhabit all oceans. Although Killer Whales tend to be found at the ice edge during the Antarctic summer (Gill & Thiele, 1997; Thiele et al., 2000), family groups (including calves) have been seen within the ice during winter (Thiele & Gill, 1999). Subantarctic observations indicate that Killer Whales return to subantarctic Islands, such as Macquarie Island, during the summer. In the north-eastern Pacific, use of different habitats has been linked to behavioural requirements, and the movements of prey (Similae et al., 2002). This may lead to individuals/groups experiencing, and utilising, a large variety of habitats.

Two types of Killer Whales are distinguished in the eastern-north Pacific, from Washington State to Alaska. The two types, referred to as 'residents' and 'transients', each have different ecological preferences (Baird & Dill, 1996). Some studies in other parts of the world suggest that this pattern may be universal (Jefferson et al., 1993). Killer Whales are not part of, nor do they rely on, a listed ecological community. However, they do prey on other listed threatened species, such as Southern Elephant Seals in the subantarctic, plus other cetaceans.

It is possible that Killer whales in Australian waters occur in severely fragmented populations. Complex social structure and little interaction between different Killer whale ‘eco-types’ in the north-east Pacific suggests that there is potential for loss of particular sub-populations and their associated genetic diversity and social culture (Jefferson et al., 1993). Should population fragmentation occur with Killer Whales found in Australian territorial waters, similar extinction of small subpopulations could occur. It is, however, most unlikely that a local population of Killer whales would be placed at risk of extinction by the abalone farm.

b) In the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.

It is highly unlikely that an endangered local population would be placed at risk by the proposed abalone farm.

c) In relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified of removed.

No known habitat will be modified or removed for this species of whale.

d) Whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community.

No known habitat will become isolated as a result of the proposed abalone farm.

e) Whether a critical habitat will be affected.

No habitat critical for Pygmy Right Whales would be affected as a result of the proposed abalone farm.

f) Whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region.

Since these whales have large ranges it is difficult to assign them to conservation areas in the region. They are protected by the Australian Whale Sanctuary in commonwealth waters.

g) Whether the action proposed is of a class of action that is recognised as a threatening process.

The proposed abalone farm is not a recognised threatening process for Pygmy Right Whales.

Marine Turtles

a) In the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction.

Six species of marine turtles that occur in Australian waters are protected under the Australian Government's *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and various State and Northern Territory legislation. The Leatherback (*Dermochelys corlacea*), Loggerhead (*Caretta caretta*) and Olive ridley (*Lepidochelys olivacea*) turtle are listed as endangered under the EPBC Act which means that these species may become extinct if the threats to their survival continue. The green, hawksbill and flatback turtle are each listed as vulnerable which means that they may become endangered if threats continue. Most of the listed marine turtles tend to prefer warmer waters, ranging from tropical to warm temperate seas. The proposed abalone farm is outside the range of most of these turtles and it is unlikely that their life cycle will be disrupted or they will be placed at risk of extinction.

b) In the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.

No endangered populations of marine turtles are likely to be disrupted such that the viability of the population is compromised by the proposed abalone farm.

c) In relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified of removed.

No significant areas of known habitat are to be modified or removed as a result of the abalone farm.

d) Whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community.

No significant areas of known habitat are likely to become isolated as a result of the abalone farm.

e) Whether a critical habitat will be affected.

No marine turtle critical habitat will be affected by the proposed abalone farm.

f) Whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region.

Marine turtle habitats are adequately represented in numerous marine parks and reserves.

g) Whether the action proposed is of a class of action that is recognised as a threatening process.

The proposed abalone farm is not recognised as a threatening process for marine Turtles.

h) Whether any threatened species or ecological community is at the limit of its known distribution.

Marine turtles tend to prefer warmer water but occur around Australia and would not be at the limit of their known distribution.

Whale Shark (*Rhincodon typus*)

a) In the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction.

Vulnerable and Migratory species (EPBC Act 1999). Whale sharks have a broad distribution in tropical and warm temperate seas although sightings have been confirmed on the mid-west coast of Western Australia and Eden (on the NSW south coast). Whale sharks are regarded as highly migratory although their patterns of migration are poorly understood. The proposed abalone farm is outside the common range of this species so it is unlikely that a local population is to be placed at risk of extinction by the abalone farm.

b) In the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.

There are no breeding populations of Whale Shark in the study area. Thus it is highly unlikely that the life cycle of this species would be placed at risk by the proposed abalone farm.

c) In relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified of removed.

No known habitat will be modified or removed for this species.

d) Whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community.

No known habitat will become isolated as a result of the proposed abalone farm.

e) Whether a critical habitat will be affected.

No habitat critical for Whale sharks would be affected as a result of the proposed abalone farm.

f) Whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region.

Habitats which are critical for this species are adequately represented.

g) Whether the action proposed is of a class of action that is recognised as a threatening process.

The proposed abalone farm is not a recognised threatening process for Whale sharks.

h) Whether any threatened species or ecological community is at the limit of its known distribution.

This species is not at the limit of its known distribution.

Porbeagle (*Lamna nasus*)

a) In the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction.

Migratory species (EPBC Act 1999). The Porbeagle shark is a wide-ranging, coastal and oceanic shark. In Australian waters, the Porbeagle is found off southern Australia from southern Queensland to southern Western Australia. On 29 January 2010, the Porbeagle shark was listed under the *EPBC Act 1999* but on 15 July 2010, an amendment was made to the act to allow recreational fishing of this species of shark in Commonwealth waters. It is considered unlikely that the proposed abalone farm would disrupt the life cycle of this species or place it at risk of extinction.

b) In the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.

Thus it is highly unlikely that the life cycle of this species would be placed at risk by the proposed abalone farm.

c) In relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified of removed.

No known habitat will be modified or removed for this species.

d) Whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community.

No known habitat will become isolated as a result of the proposed abalone farm.

e) Whether a critical habitat will be affected.

No habitat critical for Porbeagle sharks would be affected as a result of the proposed abalone farm.

f) Whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region.

Habitats which are critical for this species are adequately represented.

g) Whether the action proposed is of a class of action that is recognised as a threatening process.

The proposed abalone farm is not a recognised threatening process for Porbeagle sharks.

h) Whether any threatened species or ecological community is at the limit of its known distribution.

This species is not at the limit of its known distribution.

CONCLUSIONS

The construction and ongoing operation of the Abalone Farm will result in minimal impacts to aquatic species and habitats adjacent to the site or in the estuary in general. There will be short-term disturbance to mangroves and intertidal sandflats as a result of trenching however these habitats will recover quickly. There will be direct impact to approximately $40m^2$ of *Posidonia australis* seagrass as a result of laying inlet and outlet pipelines into the estuary. This will not have any significant impact on the viability of the local population of *Posidonia australis* within the Port Stephens estuary or result in a net loss of *Posidonia australis* seagrasses within the coastal and estuarine waters of NSW. There will be minimal impacts to aquatic ecology as a result of the construction of an access boardwalk across Pig Station Creek.

A seagrass management plan should be developed to guide and minimise any disturbance as a result of laying pipelines through the seagrass habitat. Quantitative assessment of mangrove and seagrass habitat both before and after construction is recommended as well as ongoing surveillance monitoring of mangrove seedlings and potential erosion around the pipeline structures.

It is highly unlikely that any threatened species or populations will be impacted by the abalone farm. Special attention should be giving to syngnathids (pipefish and seahorses) when constructing the pipeline through the seagrass meadow.

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