

Literature Review

Fish Larval Studies

Water Corporation

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Executive Summary

A desalination plant has been proposed in the southwest region of Western Australia for which environmental investigations are being carried out. Specific studies into the effects of the desalination plants on larvae of fish and other marine organisms have found that an environmental consideration is: entrainment due to the intake pipe.

Based on literature reviews and recent baseline surveys of the southwest region, it is anticipated that a wide variety of habitats occur in the location of the proposed plant, namely: limestone reefs, seagrass beds, the nearshore, the surf zone and detached macrophytes. These habitats are likely to support large populations of fish fauna and other marine organisms, particularly larvae.

Given the likely presence of marine organisms and larvae, entrainment is anticipated to occur; however, impacts on the local fish populations are expected to be minimal.

There is unlikely to be an overall impact upon fish populations and other marine fauna in the region despite the potential localised effects of the desalination plant. This is due to the widespread occurrence of the key habitats identified and similarities in fish populations found throughout the nearshore zone of the southwest. Also, there is no evidence to suggest endemism of larval stages of species at or around the proposed Binningup site. It is therefore anticipated that entrainment will have negligible impacts upon fish fauna and other marine organisms larvae due to the proposed desalination plant, however, further studies will need to be undertaken to confirm this assumption.

1.0 Introduction

Water Corporation has proposed to establish a desalination plant in the southwest of Western Australia (WA) approximately one kilometre north of the township Binningup, and two kilometres south of the Myalup townsite. This will be referred to as the Southern Seawater Desalination Plant (SSDP).

Potential impacts of the plants' operation on the environment are currently being investigated. Maunsell was commissioned to undertake a literature review and provide knowledge on the likely impacts on larval fish populations, resulting from the SSDP. In particular it is the impact due to larvae being drawn into the SSDP that is considered here.

The literature review incorporated ten scientific papers identified by Water Corporation. These include:

- Ayzasian SG, Hyndes GA (1995). Surf-zone fish assemblages in south-western Australia: do adjacent nearshore habitats and the warm Leeuwin Current influence the characteristics of the fish fauna? *Marine Biology* 122: 527-536.
- Ayzasian, S. G., Bastow, T. P., Edmonds, J. S., How, J., Nowara, G. B. (2004). Stock structure of Australian herring (*Arripis georgiana*) in southwestern Australia. *Fisheries Research* 67: 39-53.
- Crawley, K. R., Hyndes, G. A., Ayzasian, S. G. (2006). Influence of different volumes and types of detached macrophytes on fish community structure in surf zones of sandy beaches. *Marine Ecology Progress Series* 307: 233-246.
- Harvey, C. J. (1998). Use of sandy beach habitat by *Fundulus majalis*, a surf-zone fish. *Marine Ecology Progress Series* 164: 307-310.
- Howard, R. K. (1989). The structure of a nearshore fish community of Western Australia: diel patterns and the habitat role of limestone reefs. *Environmental Biology of Fishes* V24, No.2, pp 93 – 104.
- Hyndes, G.A., Platell, M. E., Potter, I. C. & Lenanton, R. C. J. (1998). Age composition, growth, reproductive biology and recruitment of King George whiting, *Sillaginodes punctata*, in southwestern Australia. *Fish Bulletin, U.S.* 96: 258-270.
- Hyndes, G. (2003). Summary Paper: Fish habitat in the nearshore regions of Cockburn Sound, Cockburn Sound Management Council. School of natural Sciences, Edith Cowan University, WA.
- Muhling, B. A. (2006). Larval fish assemblages in coastal, shelf and offshore waters of south-western Australia. PhD Thesis, Murdoch University.
- Valesini, F.J., Clarke, K.R., Eliot, I. & Potter, I.C. (2003). A user-friendly quantitative approach to classifying nearshore marine habitats along a heterogeneous coast. *Estuarine, Coastal and Shelf Science* 56: 1-15.
- Valesini, F.J., Potter, I. C., Platell, M. E., & Hyndes, G. A. (1997). Ichthyofaunas of a temperate estuary and adjacent marine embayment. Implications regarding choice of nursery area and influence of environmental changes. *Marine Biology* 128: 317-328.

Information on baseline surveys relating to the SSDP were provided by Water Corporation and include:

- Centre for Water Research (2007). Horizontal mixing and dispersion at the proposed outfall site for the Southern seawater Desalination Plant, Binningup. Unpublished draft. University of Western Australia, Nedlands.
- Coupland, G., McDonald, J., and Chatfield, B. (2008). Characterising the marine benthic habitats of the proposed southern seawater desalination plant (SSDP) site: Interpretation from underwater towed video and map interpolation. Marine Research Group, University of Western Australia.
- Fugro Survey Pty Ltd (2007). Report on Marine Investigations for the Southern Seawater Desalination Plant, Binningup WA.
- GHD (2007). Southern Seawater Desalination Plant, Marine Investigations Report for Oceanography of Southern Seawater Desalination Plant Seaglider Transects.

- Kellogg Brown & Root Pty Ltd (KBR) 2007. Southern Seawater Desalination Plant – Marine Investigations, Preliminary Modelling Report. Prepared for Water Corporation, WA.
- School of Environmental Systems Engineering. (2007). Beach Profile Monitoring at Binningup Beach. Draft report prepared for Water Corporation, WA. University of Western Australia, Nedlands.

Further papers were sought by Maunsell for additional context. These include:

- Alpert, H., Borrowman, C., and B. Haddad, (2007). Evaluating Environmental Impacts of Desalination in California. *Center for Integrated Water Research* 27 July 2007, (accessed 03.01.08). <http://ciwr.ucsc.edu/desalplanning/workshops.html>
- Blidberg, E. (2004). Effects of copper and decreased salinity on survival rates and development of *Tridacna gigas* larvae. *Marine Environmental Research* 58: 793-797.
- Danoun, R. (2007). Desalination Plants: Potential impacts of brine discharge on marine life. The Ocean Technology Group. The University of Sydney, Australia.
- Einav R, Harussi K and Perry D. (2002). The footprint of the desalination process on the environment. *Desalination*. 152: 141-154.
- Gaughan, D. J., Fletcher, W. J., Tregonning, R. J. and Goh, J. (1996). Aspects of the biology and stock assessment of the Whitebait, *Hyperlophus vittatus*, in South Western Australia. Fisheries Research Report No. 108.
- Iso, S., Suizu, S., and Maejima, A. (1994). The lethal effect of hypertonic solutions and avoidance of marine organisms in relation to discharged brine from a desalination plant. *Desalination* 97: 389-399.
- Lenanton, R. C. J., Robertson, A. I. and Hansen, J. A. (1982). Nearshore accumulations of detached macrophytes as nursery areas for fish. *Marine Ecology Progress Series* 9: 51-57.
- Limbourn, A. J. and Westera, M. B. (2006). A review, gap analysis and assessment of current information relating to marine and coastal environments in the southwest region. School of Plant Biology, University of Western Australia, Nedlands.
- The Ecology Lab Pty Ltd. (2005). Planning for Desalination: Marine Ecological Assessment. Preliminary Site Inspection for an Inlet and Outlet and Possible Pipeline Route for Water Distribution. The Ecology Lab Pty Ltd, Brookvale NSW.

The majority of papers supplied by Water Corporation provided information on likely habitats in the area and their associated fish larvae and fish fauna assemblages.

Initial habitat studies specific to the proposed SSDP have identified the associated marine habitat to include limestone reefs, seagrass beds, nearshore and surf zone, and detached macrophytes (Fugro 2007).

Predictions into the likely impacts of the desalination plant need to consider each of these habitats and whether they are likely to support distinct fish fauna assemblages. This paper provides information on the various habitats in the area and their associated fish life in order to determine the magnitude of the potential impact. This can then be used to assess the relative impact caused by entrainment (i.e. larvae being drawn into the plant).

2.0 Proposed Desalination Plant

Entrainment, the in-take of dispersive larvae and juveniles of many different marine species, can potentially lead to a reduction in local fish stocks. For example, as a result of the intake pipe for a particular power plant, up to 1200 tonnes of zooplankton, including fish larvae were entrained and killed annually (The Ecology Lab 2005). Although separate to the SSDP, this example provides an indication of the significance of entrainment and the importance of management. Furthermore, mortality of marine organisms is likely to be absolute (Alpert *et al.* 2007). However, due to an anticipated intake velocity of 10cm/s or less for the SSDP, only larvae and non-mobile organisms are likely to be drawn in.

The proposed SSDP intake pipeline length will be approximately 500 metres, and the proposed diffuser will extend up to 1050 metres offshore (Water Corporation 2007). Water Corporation anticipates that the brine stream will be discharged into the open ocean where the swell of the ocean would enable quick mixing of the salty discharge (Water Corporation 2007).

2.1 Marine Fauna of the Binningup Region

The environmental impacts of entrainment need to be considered with specific reference to the Binningup region. Given nearshore habitats are utilised as nursery areas by fish larvae, and spawning and foraging environments by other fish, any changes to the marine ecosystem may potentially impact on the fish stocks in the region.

Limited information is available on specific fish fauna assemblages of the Binningup region (Limbourn & Westera 2006); however, information is available for the nearby Geographe Bay Region. Similar assemblages of fish species are found throughout most of the southwest of WA, with the Geographe Bay and Cape Leeuwin regions being dominated by warm-temperate species (76%), several subtropical species (19%) and a few tropical species (5%) (Limbourn & Westera 2006). One survey that sampled fish species in the seagrass beds between Capel and Dunsborough found that 52% of all fish fauna caught were whiting species (Limbourn & Westera 2006). Although these fish community compositions do not include the Binningup region, it is likely that similar assemblages occur throughout both regions. Additionally, gastropods, ascidians and crinoids were the dominant classes of invertebrates found throughout the southwest (Limbourn & Westera 2006).

3.0 Habitats in the Binningup Region of Southwest WA

3.1 Overview

Baseline surveys of the marine substrate in the Binningup region indicated that sand was the dominant substratum (87%) (Fugro 2007), which is likely to be a combination of surf zone and nearshore habitats, and seagrass beds that overlay the sandy substrate. The remainder of the substrate consists of various types of reef (Fugro 2007) (Figure 2).

The proposed SSDP is therefore likely to be located in a marine area that is typified by limestone reefs, seagrass beds both nearshore and offshore, and nearshore and surf zone habitat (Ayvazian & Hyndes 1995; Fugro 2007), these key habitats will be covered in detail.

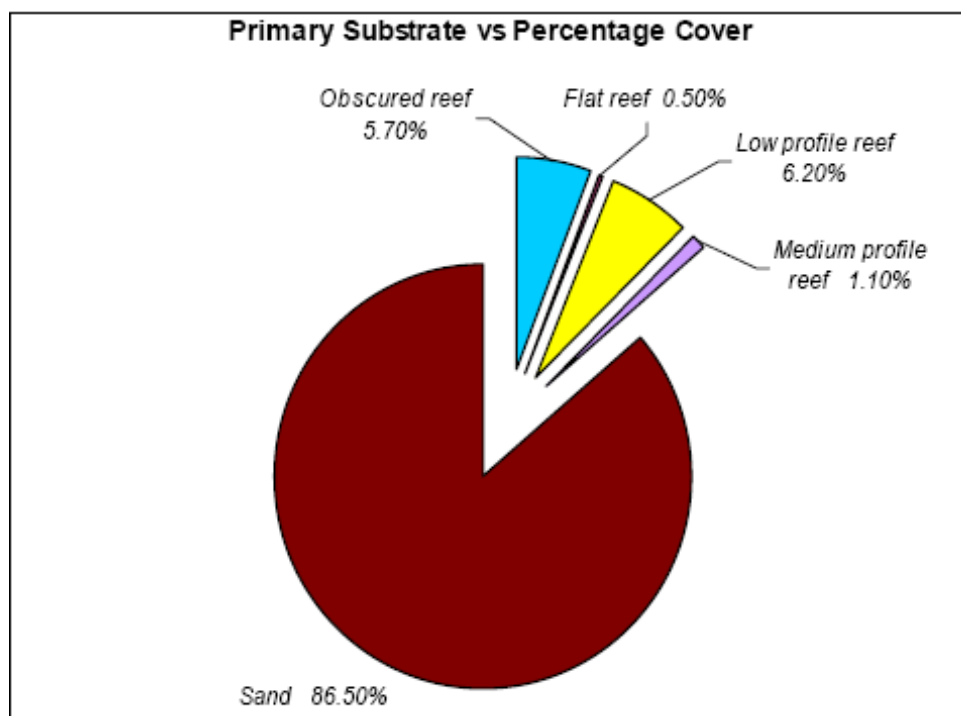


Figure 2 : Primary Substrate vs Percentage Cover for the SSDP marine environment (Fugro 2007)

3.2 Limestone Reefs

The WA coastline from the North West Cape to Cape Naturaliste is typified by a myriad of patch limestone reefs (Ayvazian & Hyndes 1995), covering approximately 1,500 kilometres including the Binningup region. Baseline surveys conducted by Fugro (2007) identified approximately 13% of the Binningup region being covered by reef (Figure 2).

Howard (1989) aimed to address the hypothesis that limestone reefs are primarily used as sheltering habitats and that fish move to surrounding areas to feed. The research results indicated that the structure of coastal fish communities is in fact influenced by the limestone reefs, as it was shown that the species density and biomass is generally higher in the waters surrounding reefs (Howard 1989). The abundance and diversity of fish near the reef system is further influenced by the time of day as fish predominantly forage on or near the limestone reefs (Howard 1989).

The research concluded that the abundance of fish fauna was consistently higher at sites on the reef-edge, or similar to that of the open habitats (Howard 1989). These productive reefs provide essential habitat for juvenile fish and may function as diurnal sheltering sites (Howard 1989). The study also showed that fish densities in limestone reefs in the southwest WA were comparable to densities of fish found in temperate Australian seagrass systems (Howard 1989).

3.3 Seagrass Beds

In terms of biota present on the substrate, seagrass was the most abundant (60.4%), followed by macro-algae (32.1%) (Fugro 2007) (Figure 3). *Posidonia angustifolia* appeared to be the most abundant seagrass species present in the area surveyed, comprising 98.7% of all seagrass species observed (Coupland *et al* 2008).

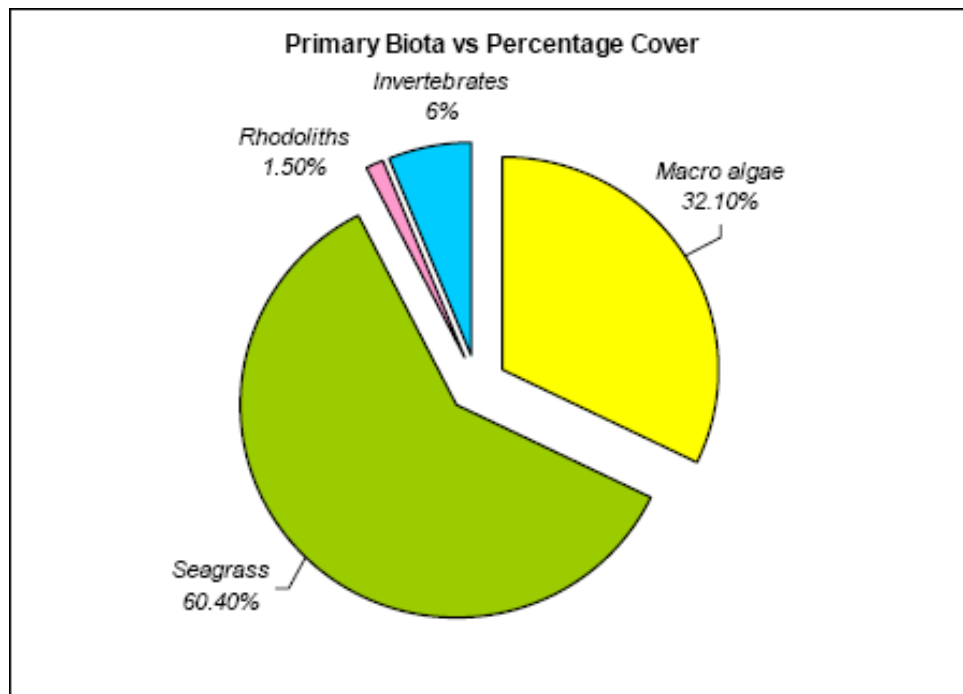


Figure 3 : Primary Biota vs Percentage Cover for the SSDP marine environment (Fugro 2007)

Seagrass beds provide an important habitat for marine organisms and fish fauna in terms of shelter and foraging grounds due to its high productivity (Ayvazian & Hyndes 1995; Howard 1989; Valesini *et al.* 2003). Several studies have been conducted into the importance of seagrass to fish fauna, and the likelihood of species preferentially residing in these habitats.

Howard (1989) demonstrated that the canopy structure of *Amphobolis enterctica* and *A. griffithii* influenced the choice of habitat by fish fauna. Despite the location of the seagrasses, whether in open near reef environments, or on the reef tops, a high abundance of fish was always recorded, which can be attributed to its protective canopy structure (Howard 1989). *Amphobolis* sp were found to represent 40% (Figure 4) of the seagrass species present in the Binningup region (Fugro 2007), which indicates that the area is likely to be a significant habitat for fish fauna.

Ruppia megacarpa is another seagrass species that has been shown to influence the choice of habitat and densities of fish fauna, again due to its sustainable food source and the

protective nature of its canopy (Valesini *et al.* 2003). However, initial surveys did not locate this species.

The presence and abundance of seagrass is important to consider when investigating the impacts of the desalination plant on the local fish fauna and marine organisms. Figure 3 indicates that the area supports extensive seagrass beds, and Figure 4 displays the various species that were located during initial baseline studies. Given the dominance of seagrass beds in the Binningup region, it can be assumed that the area would support a high abundance of fish fauna and other marine organisms. However, the Binningup region is unlikely to support distinct communities of marine fauna as seagrass beds are well represented in the southwest (Limbourn & Westera 2006). In fact, the nearby Geographe Bay region supports the second most extensive seagrass beds in WA after Shark Bay (Limbourn & Westera 2006).

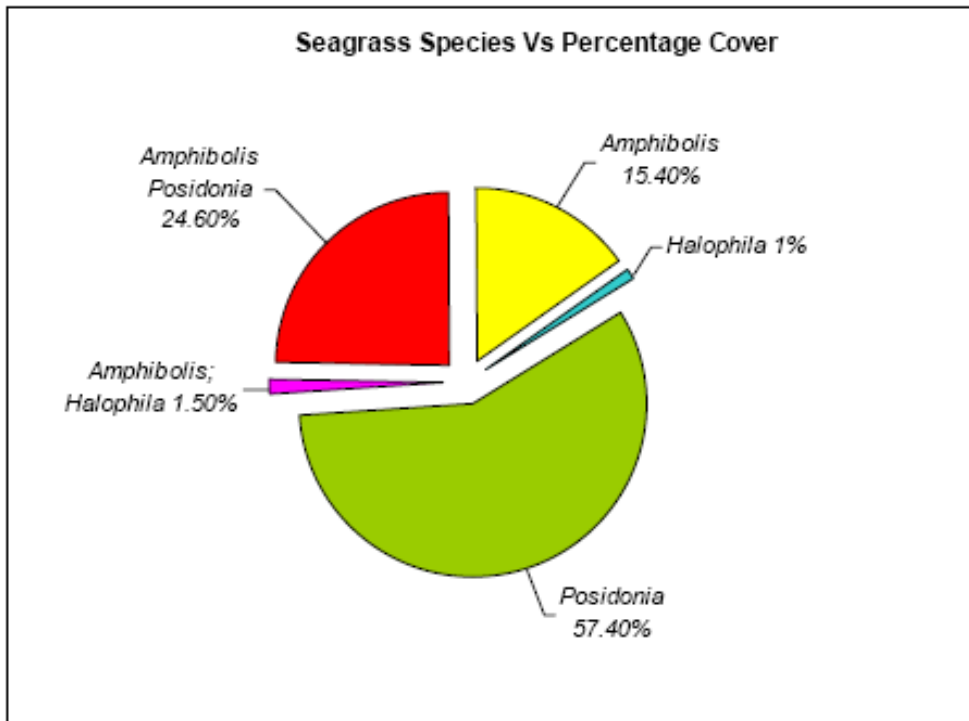


Figure 4 : Seagrass Species vs Percentage Cover for the SSDP marine environment (Fugro 2007)

3.4 Nearshore and Surf Zone

Extensive limestone reefs and seagrass beds cover both the nearshore and offshore regions of the west coast (Ayvazian & Hyndes 1995). It was found that fish assemblages differ between areas that are not sheltered by reefs or islands and those that are more exposed to wind and wave activity. Differences can also be observed between those communities that occupy sheltered nearshore marine habitats and the surf zone (Ayvazian & Hyndes 1995).

Due to the physically dynamic nature of the surf zone environments at sandy beaches, it has long been believed that such environments provide little habitat complexity and minimal shelter for fish fauna (Crawley *et al.* 2006). As a result of this limited structural complexity, surf zone and nearshore areas are generally considered a poor substitute in fish habitats when compared with limestone reefs and seagrass beds (Crawley *et al.* 2006). On the contrary, research has shown that unvegetated surf zone and nearshore environments at times support significant populations of fish, which are primarily comprised of juvenile fish fauna (Ayvazian & Hyndes 1995; Crawley *et al.* 2006; Hyndes *et al.* 1998). Detached

macrophytes have also been shown to be significant in contributing to the abundance of fish in particular habitats (Crawley *et al.* 2006; Lenanton *et al.* 1982).

Baseline studies conducted by Fugro (2007) identified that 87% of the survey area at Binningup was sandy substrate (Figure 2). Figure 5 provides a visual indication of the scattered distribution of the different habitats. The dark areas represent both reef and seagrass beds and the light areas are indicative of nearshore and surf zone environments (sandy areas).

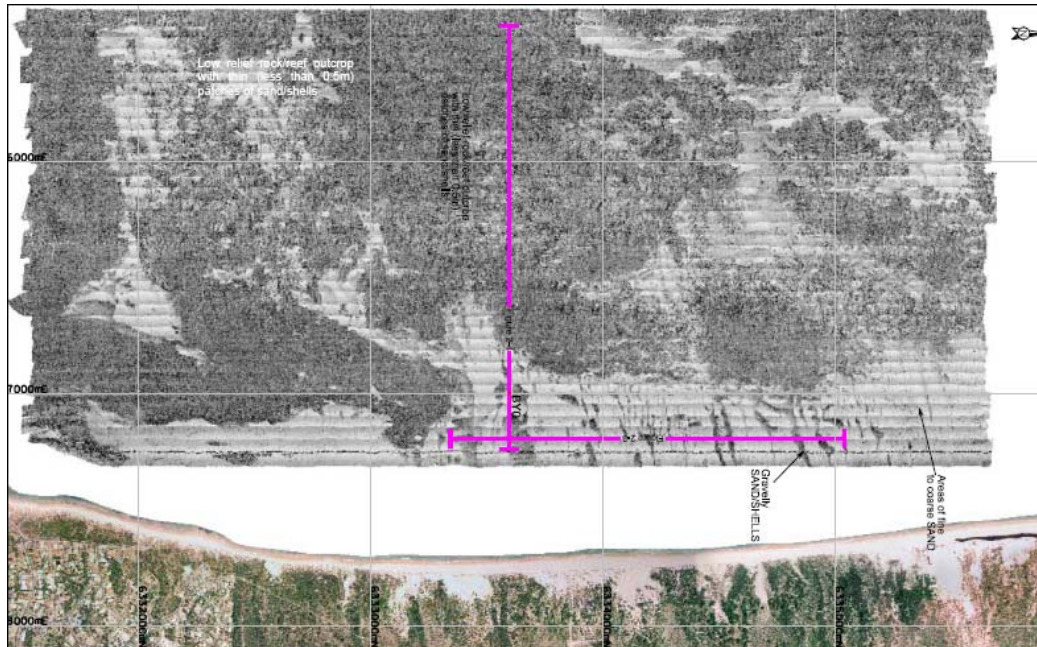


Figure 5 : Backscatter intensity map (Fugro 2007)

Harvey (1998) studied the use of sandy habitats in the surf zone by fish fauna. Although the surf zone environment is considered unproductive and less important for fish fauna due to its instability, research has indicated that fish fauna distribution in the surf zone is influenced by the availability of prey and the limited presence of predators in the region (Crawley *et al.* 2006; Hyndes *et al.* 1998). Fish assemblages predominantly use the surf zone region for functions like spawning, foraging and predator avoidance. In addition, research has shown that many pelagic fish larvae utilise the surf zone as a nursery habitat (Harvey 1998).

3.4.1 Fish Densities in the Nearshore and Surf Zone

Ayvazian & Hyndes (1995) conducted a broad-scale study of the surf zone and nearshore fish fauna densities and composition at 32 sites between Geraldton and Esperance, along the southwest WA coastline. Throughout the 32 sites, 92 species of fish belonging to 47 different families were found (Ayvazian & Hyndes 1995).

Results indicated that fish communities on the west coast of Australia were more diverse than assemblages on the south coast, and that the surf zone and nearshore environments can be considered as important nursery habitats for fish larvae (Ayvazian & Hyndes 1995).

When the species composition of the nearshore was compared with that found in habitats adjacent to the nearshore, 38 and 42% of the species were shared with reefs and seagrass beds, respectively, and 22% were present in all three habitats (Ayvazian & Hyndes 1995).

This indicates that although the habitats do not support as rich diversity as limestone reefs or seagrass beds, they are still fundamental in supporting fish fauna.

One of the 32 sites, site 15 was located in the general vicinity of the proposed SSDP. A total of 21 species of fish were recorded for the site, of which nine were resident species, four were transient species and eight used the area for a nursery (Ayvazian & Hyndes 1995). This implies that the area is important to the maintenance of local fish stocks, providing essential habitats for fish larvae as well as other marine species that may use the area for spawning, shelter or foraging (both transient and/or resident species).

The 21 species recorded for site 15 were:

- *Aldrichetta forsteri*
- *Sillago bassensis*
- *Lesuerina sp*
- *Mugil cephalus*
- *Torquigener pleurogramma*
- *Sillago schomburgkii*
- *Atherinomorus ogilbyi*
- *Hyperlophus vittatus*
- *Scorpis georgianus*
- *Hyporhamphus melanochir*
- *Ammotretis elongatus*
- *Pseudorhombus jenynsii*
- *Aogon rueppellii*
- *Penicipelta vittiger*
- *Gerres subfasciatus*
- *Favonigobius lateralis*
- *Pomatomus saltatrix*
- *Sillago berrus*
- *Arripis georgianus*
- *Sillaginodes punctata*
- *Pseudocaranx dentex*

3.4.2 Whiting in the Nearshore and Surf Zone

The importance of the productivity of the surf zone can further be illustrated by research conducted by Hyndes *et al.* (1998) into the influence of different habitats on attaining sexual maturity in two whiting species (*Sillago berrus* and *S. robusta*), as both species gain sexual maturity once they reach approximately 130mm in length. One of the species, *S. berrus* rapidly reaches sexual maturity (~130mm) by the end of the first year of its life, while the other species does not reach sexual maturity until the second year of its life (Hyndes *et al.* 1998). The main factor that influences the differing growth rates was the environment in which the species predominantly occupied. The first species (*S. berrus*) occupied productive nearshore waters, while the other species (*S. robusta*) was restricted to deeper offshore waters (Hyndes *et al.* 1998). This pattern was observed in other whiting species (Hyndes *et al.* 1998). The difference in growth rates between the whiting species may be attributed to the higher productivity of the nearshore waters, and the lower prevalence of predators than in offshore waters.

Given the dominance of whiting species found in the southwest region, it can be assumed that the surf zone and nearshore areas support large populations of juvenile whiting.

3.4.3 Herring in the Nearshore and Surf Zone

Ayvazian *et al.* (1994) investigated the stock structure of herring in south-western Australia by following the annual summer migration of the species westward along the southern coast of WA, and then the spawning of the species during the summer/autumn months, which occurred predominantly between Perth and Bremer Bay. Following spawning, the larvae and juveniles were transported by the prevailing currents and winds, eastward along the southern coast where the larvae settled in the nursery habitats of nearshore waters between WA and VIC (Ayvazian *et al.* 1994). This suggests that the Binningup region also supports populations of herring larvae in the nearshore and surf zone.

3.4.4 Macrophytes in the Nearshore and Surf Zone

Detached macrophytes, which is commonly referred to as wrack, is transported from offshore environments (seagrass beds) where it accumulates in the surf zone. There is a tendency for wrack to accumulate in greater densities during winter months, given the frequency and intensity of storms during the season. Observations made by the School of Environmental Systems Engineering (2007) in September 2007, confirmed that wrack had accumulated in the nearshore and surf zone waters surrounding Binningup. Wrack is also common in nearshore waters throughout the rest of the southwest (Limbourne & Westera 2006).

A study was conducted by Crawley *et al.* (2006) into the influence of the presence of wrack on fish communities in the surf zone. The research compared the abundance of fish fauna with the density and species of wrack. It was found that the total abundance of fish fauna and fish biomass increased as the volume of wrack in the surf zone increased (Crawley *et al.* 2006). Furthermore, the fish fauna that utilised the macrophytes in the surf zone was dominated by juveniles (Crawley *et al.* 2006). Although the research indicated that fish fauna showed a preference for a particular species of macrophytes, it was apparent that the density of the wrack as opposed to the type was more important in providing a habitat for fish larvae assemblages. It is suggested that some species of fish are directly dependant on the wrack for shelter from predators and indirectly dependant by feeding on invertebrates associated with the wrack (Crawley *et al.* 2006).

Based on the scattered distribution of the nearshore and surf zone habitats (Figure 4) in the Binningup region and the significance of the habitats to fish larvae and other marine organisms, it can be assumed that the region supports marine and fish fauna, particularly larvae. However, these types of habitats are well represented throughout the southwest and are unlikely to support unique communities of marine organisms.

4.0 Impact Assessment

4.1 Significance of site specific habitats

There are five main habitats that are important in maintaining the local fish stocks that occur in the region of the SSDP:

- limestone patch reefs,
- seagrass beds,
- nearshore habitats,
- the surf zone, and
- detached macrophytes.

Each of these habitats are common and well represented throughout the southwest of WA (Limbourn & Westera 2006).

Limestone patch reefs generally provided a diurnal sheltering habitat that was predominantly utilised by juvenile fish fauna. Owing to the productivity of the seagrass beds and the shelter provided by the canopy structure, the habitat was found to support a high abundance of fish fauna that utilised that area for foraging and shelter.

Although the nearshore and surf zone environments were originally considered unproductive turbulent environments, it has been shown that the areas are in fact productive and important to fish fauna for predator avoidance. Fish fauna frequent the habitats for spawning events, foraging and predator avoidance, but predominantly fish larvae exploit the areas as nursery grounds.

Detached macrophytes also provide a habitat for both predator avoidance due to its canopy, and foraging grounds given the presence of invertebrates linked with the wrack. Furthermore, a high abundance of juvenile fish fauna was found to be associated with the detached macrophytes.

Based on the habitats present, it is likely that the area supports a variety of fish species in fairly high density. However, local fish populations are unlikely to be unique to the area.

Entrainment of larval fish is also a concern as the intake pipe lies within a combination of the habitats.

4.2 Entrainment

Given the intake pipe is likely to be in close proximity to seagrass beds, limestone reefs and the surf zone, there are likely to be high densities of larvae and juveniles of different marine organisms in the vicinity of the intake pipe. Entrainment of these larval organisms can potentially lead to a reduction in local populations of fish and other marine organisms. The extent of the impact will depend partly on the rate of intake, and the ability of larvae to swim against the inflow. The rate of intake should be modelled on typical current speeds for the region.

5.0 Conclusion

When considering the environmental impacts of entrainment into the intake pipe for the proposed SSDP in the Binningup region, it is important to assess the significance of the habitats that occur in the Binningup region and their relative importance to fish fauna assemblages and fish larvae.

Seagrass beds and limestone patch reefs that are adjacent to sandy surf zone areas on the west coast of WA provide a range of microhabitats for fish fauna. These habitats are generally dominated by juvenile fish fauna, which suggests that these habitats are important alternative nursery habitats to estuaries due to the presence of: zooplankton, a rich source of food; protection from predation due to macrophytes cover and protection due to the turbid nature of the shallow waters. It can therefore be concluded that the habitats surrounding the Binningup region are significant to fish fauna assemblages and support populations of fish larvae.

Given the likely presence of fish larvae in the immediate region of the SSDP, it can be assumed that the intake pipe will impact on fish larvae populations through entrainment.

Although the diverse habitats found in the Binningup region are likely to support large populations of fish fauna and other marine organisms, they are unlikely to be unique assemblages. Given the broad representation of all habitats throughout the southwest and the current similarities of fish assemblages in different regions of the southwest, potential long-term impacts upon fish larvae and other marine organisms due to the proposed SSDP are likely to be minimal.

It can be concluded that the desalination plant is likely to have negligible impacts upon overall populations of fish fauna and other marine organisms; however, further studies would need to be conducted to determine the exact degree of impact on the marine fauna of the Binningup region.

6.0 References

- Alpert, H., Borrowman, C., and B. Haddad, (2007). Evaluating Environmental Impacts of Desalination in California. *Center for Integrated Water Research* 27 July 2007, (accessed 03.01.08). <http://ciwr.ucsc.edu/desalplanning/workshops.html>
- Ayvazian SG, Hyndes GA (1995). Surf-zone fish assemblages in south-western Australia: do adjacent nearshore habitats and the warm Leeuwin Current influence the characteristics of the fish fauna? *Marine Biology* 122: 527-536.
- Ayvazian, S. G., Bastow, T. P., Edmonds, J. S., How, J., Nowara, G. B. (2004). Stock structure of Australian herring (*Arripis georgiana*) in southwestern Australia. *Fisheries Research* 67: 39-53.
- Blidberg, E. (2004). Effects of copper and decreased salinity on survival rates and development of *Tridacna gigas* larvae. *Marine Environmental Research* 58: 793-797.
- Centre for Water Research (2007). Horizontal mixing and dispersion at the proposed outfall site for the Southern seawater Desalination Plant, Binningup. Unpublished draft. University of Western Australia, Nedlands.
- Coupland, G., McDonald, J., and Chatfield, B. (2008). Characterising the marine benthic habitats of the proposed southern seawater desalination plant (SSDP) site: Interpretation from underwater towed video and map interpolation. Marine Research Group, University of Western Australia.
- Crawley, K. R., Hyndes, G. A., Ayvazian, S. G. (2006). Influence of different volumes and types of detached macrophytes on fish community structure in surf zones of sandy beaches. *Marine Ecology Progress Series* 307: 233-246.
- Danoun, R. (2007). Desalination Plants: Potential impacts of brine discharge on marine life. The Ocean Technology Group. The University of Sydney, Australia.
- Einav R, Harussi K and Perry D. (2002). The footprint of the desalination process on the environment. *Desalination*. 152: 141-154.
- Fugro Survey Pty Ltd (2007). Report on Marine Investigations for the Southern Seawater Desalination Plant, Binningup WA.
- Gaughan, D. J., Fletcher, W. J., Tregonning, R. J. and Goh, J. (1996). Aspects of the biology and stock assessment of the Whitebait, *Hyperlophus vittatus*, in South Western Australia. Fisheries Research Report No. 108.
- GHD (2007). Southern Seawater Desalination Plant, Marine Investigations Report for Oceanography of Southern Seawater Desalination Plant Seaglider Transects.
- Harvey, C. J. (1998). Use of sandy beach habitat by *Fundulus majalis*, a surf-zone fish. *Marine Ecology Progress Series* 164: 307-310.
- Howard, R. K. (1989). The structure of a nearshore fish community of Western Australia: diel patterns and the habitat role of limestone reefs. *Environmental Biology of Fishes* V24, No.2, pp 93 – 104.
- Hyndes, G.A., Platell, M. E., Potter, I. C. & Lenanton, R. C. J. (1998). Age composition, growth, reproductive biology and recruitment of King George whiting, *Sillaginodes punctata*, in southwestern Australia. *Fish Bulletin, U.S.* 96: 258-270.

Hyndes, G. (2003). Summary Paper: Fish habitat in the nearshore regions of Cockburn Sound, Cockburn Sound Management Council. School of natural Sciences, Edith Cowan University, WA.

Iso, S., Suizu, S., and Maejima, A. (1994). The lethal effect of hypertonic solutions and avoidance of marine organisms in relation to discharged brine from a desalination plant. *Desalination* 97: 389-399.

Kellogg Brown & Root Pty Ltd (KBR) 2007. Southern Seawater Desalination Plant – Marine Investigations, Preliminary Modelling Report. Prepared for Water Corporation, WA.

Lenanton, R. C. J., Robertson, A. I. and Hansen, J. A. (1982). Nearshore accumulations of detached macrophytes as nursery areas for fish. *Marine Ecology Progress Series* 9: 51-57.

Limbourn, A. J. and Westera, M. B. (2006). A review, gap analysis and assessment of current information relating to marine and coastal environments in the southwest region. School of Plant Biology, University of Western Australia, Nedlands.

Muhling, B. A. (2006). Larval fish assemblages in coastal, shelf and offshore waters of southwestern Australia. PhD Thesis, Murdoch University.

School of Environmental Systems Engineering. (2007). Beach Profile Monitoring at Binningup Beach. Draft report prepared for Water Corporation, WA. University of Western Australia, Nedlands.

The Ecology Lab Pty Ltd. (2005). Planning for Desalination: Marine Ecological Assessment. Preliminary Site Inspection for an Inlet and Outlet and Possible Pipeline Route for Water Distribution. The Ecology Lab Pty Ltd, Brookvale NSW.

Valesini, F.J., Clarke, K.R., Eliot, I. & Potter, I.C. (2003). A user-friendly quantitative approach to classifying nearshore marine habitats along a heterogeneous coast. *Estuarine, Coastal and Shelf Science* 56: 1-15.

Valesini, F.J., Potter, I. C., Platell, M. E., & Hyndes, G. A. (1997). Ichthyofaunas of a temperate estuary and adjacent marine embayment. Implications regarding choice of nursery area and influence of environmental changes. *Marine Biology* 128: 317-328.

Water Corporation (2007). Supporting information.