17 MARINE ENVIRONMENT

Shortly after BHP Billiton's consideration of a desalination plant at Point Lowly began in 2004, the South Australian Government asked BHP Billiton if its planning for the project could include the option of water being available from the plant to supply areas of northern South Australia currently receiving water from the River Murray. The SA Government proposed this because of the need to reduce pressure on environmental flows in the River Murray. As a result, BHP Billiton completed its assessment of a desalination plant based on a maximum daily supply of 280 ML/d, with 80 ML/d to be available for government purposes.

In 2009, after the completion of the Draft EIS, the SA Government advised BHP Billiton that because of its decision to construct a desalination plant in the Adelaide metropolitan area, which would significantly reduce the draw on River Murray supplies, it no longer wanted to be involved in a desalination plant at Point Lowly.

It is noted, however, that BHP Billiton is continuing to assess the impact of the larger 280 ML/d desalination plant (i.e. 370 ML/d peak return water discharge) to maintain consistency with the project referral documentation and the assessments presented in the Draft EIS, and to provide a conservative assessment. The Supplementary EIS also provides comparisons, where appropriate, with the smaller 200 ML/d desalination plant (i.e. 265 ML/d peak return water discharge rate) proposed to supply water to the expanded Olympic Dam operation.

17.1 ECOLOGICAL SURVEYS

17.1.1 HABITAT MAPPING

Issue:

It was suggested that the extent of seagrass clearance should be reviewed using the most up-to-date habitat mapping, and the discrepancies between the Department of Environment and Natural Resources (DENR) maps and those provided in the Draft EIS should be explained.

Submission: 2

Response:

The habitat maps presented in the Draft EIS (refer Figures 16.5 and 16.7) were derived from GIS data (Bryars 2003) from the Department of Primary Industries and Resources of South Australia (PIRSA), a review of aerial photographs and numerous spot dives around Point Lowly. At Point Lowly, divers swam the entire length of the proposed routes for the intake and outfall pipelines to the point where the water depth and currents were too great to sustain seagrass communities (i.e. about 200 m off Point Lowly at a depth of about 10 m). At the site of the proposed landing facility, divers swam five 200 m transects, from the shore to a depth beyond the seagrass communities in the channel.

Bryars (2003) derived PIRSA's Upper Spencer Gulf seagrass maps from aerial photographs, the literature, and existing benthic maps. Bryars noted that the maps should be used cautiously due to some limitations with the data. Similarly, Edyvane (1999) cautioned that her benthic maps were not reliable at a scale greater than 1:100,000. As a consequence, Bryars combined 'seagrass meadow and unvegetated soft bottom' in one mapping category, which was considered to be too general to enable an accurate assessment to be made of impacts for the Draft EIS.

Since the publication of the Draft EIS, more detailed habitat maps of Upper Spencer Gulf have been developed by the Department of Environment and Natural Resources (DENR) for the Eyre Peninsula Natural Resource Management (NRM) Board, using underwater video surveys and aerial photography (Miller et al. 2009). They show a more extensive area of seagrass around Point Lowly than shown in the Draft EIS.

The existing PIRSA habitat maps were refined by the EIS team using data derived from dives at 37 locations along nine 2–3 km transects around Point Lowly. This process enabled the seagrass and soft-bottom communities to be differentiated more accurately (see Draft EIS Figure 16.2). In general, it was found that the long-lived seagrass community (*Posidonia* spp. and to a lesser extent *Amphibolis antarctica*) occupied a narrow band close to shore, and the offshore areas were dominated by unvegetated soft bottom, with an occasional sparse cover of *Heterozostera tasmanica*.

Heterozostera is an opportunistic coloniser that can alternatively die back and flourish in the same area in the space of several years, resulting in rapid changes in seagrass distribution. It is much more dynamic than the *Posidonia australis* and *P. sinuosa* communities.

The discrepancy between the Draft EIS and DENR seagrass distribution appears to have arisen because of the rapid expansion of the *Heterozostera* community south of Point Lowly since the Draft EIS survey in 2006. The community now extends from the 100 m-wide *Posidonia sinuosa* community adjacent to the reefs and sandy beaches to a depth of about 8–10 m (see Plates 17.1 and 17.2). An accurate determination of the seaward boundary of the *Heterozostera* community is difficult as it gradually merges with the silt/sand/shell grit habitat dominated by razorfish and other epibenthic fauna, where a sparse cover of *Heterozostera* (perhaps 5–10% cover) nevertheless still occurs (see Plate 17.3). The presence of *Heterozostera* should be noted in these areas, but should not be mapped as seagrass habitat. The discrepancy may also be a result of a red algal community south of Point Lowly being interpreted as seagrass during analysis of aerial photos.

The NRM map shows seagrass of moderate density off the tip of Point Lowly, which is incorrect. Dives in July 2009 along transects (ranging in depth from 3–18 m) due south of Point Lowly revealed no seagrass, which is consistent with the currents being far too strong. On the northern edge of Point Lowly, where the currents are weaker, there is a 100 m-wide band of *Posidonia sinuosa*, which is far narrower than the band shown in the DENR seagrass map. Although there is very sparse and patchy *Heterozostera* in the deeper water off Point Lowly, the habitat is dominated by epibenthic fauna on a sand/grit seafloor. A revised habitat map, including information from the draft NRM habitat map, is shown in Figure 17.1 of the Supplementary EIS.

BHP Billiton and its specialist ecological consultants are confident that the seagrass clearance areas stated in the Draft EIS are correct as they were based on multiple diving surveys of the preferred intake and outfall pipeline alignments.

Plate 17.1 Narrow band of *Posidonia sinuosa* adjacent to shore at Point Lowly (depth 2 m)

Plate 17.3 Sparse *Heterozostera tasmanica* off Point Lowly, merging with the deep-water invertebrate community (depth 10 m)

Plate 17.2 Dense *Heterozostera tasmanica* off Point Lowly (depth 4 m)

Figure 17.1 Updated Point Lowly marine habitat map incorporating BHP Billiton and DEH survey data

Issue:

It was questioned why statistical extrapolation between data points was not used to derive the overall habitat map at Point Lowly and the landing facility.

Submission: 2

Response:

The use of statistical extrapolation between data points to produce more refined habitat maps would not have improved the impact assessment process or changed the assessment outcomes, and therefore was not required for the Draft EIS.

The habitat maps produced for the Draft EIS were designed to provide sufficient detail to enable potential impacts to be accurately assessed. The maps describe the diversity and relative extent of marine habitats in the area, and the ecological attributes of the benthic communities at each of the 37 surveyed sites. Where more detailed habitat mapping was required (e.g. at the location of the proposed intake and outfall pipelines and the preferred site of the landing facility), site-specific dives were undertaken.

As noted in Appendix U (ID 4) of the Draft EIS, monitoring of benthic communities would be undertaken as a component of the additional baseline surveys to be conducted before construction activities began. This would include statistical comparisons between monitoring sites and mapping of communities.

17.1.2 SUB-TIDAL AND INTER-TIDAL SURVEYS

Issue:

It was suggested that more detailed sub-tidal and inter-tidal surveys be undertaken to provide a more rigorous baseline against which impacts may be compared. Specific requests included collecting inter-tidal survey data and comparing this with 1981 data (over multiple sites and seasons), undertaking more benthic surveys (including seasonal surveys and multiple trophic levels) in the potential impact area and including the results in the Supplementary EIS.

Submission: 2

Response:

Undertaking additional inter-tidal or sub-tidal marine surveys would not improve or change the impact assessment.

The aim of the marine baseline surveys undertaken for the Draft EIS was to characterise marine communities in the vicinity of Point Lowly, and the barge landing facility, to a level that would enable potential impacts to be accurately assessed. The surveys were not intended to provide a detailed quantitative baseline of marine communities against which potential impacts from the ongoing operation of these facilities could be compared.

The survey effort was directed towards communities that were considered to be most susceptible to impact from return water (i.e. sub-tidal benthic communities), filling relevant gaps in existing knowledge (e.g. the distribution of seagrass communities) and compiling broad marine habitat maps of the study area. The main focus of the marine survey was the sub-tidal surveys at 37 locations along nine 2–3 km-long transects around Point Lowly. The benthic survey sites were about 500–1000 m apart and covered an area of about 25 km^2. The additional site-specific surveys were intended to:

- define the extent of the sponge community off Point Lowly
- define the maximum depth of cuttlefish habitat off Point Lowly
- quantify the seagrass area affected by the intake and outfall pipelines and the landing facility.

Should the proposed expansion be approved, BHP Billiton would undertake additional marine baseline surveys that would provide quantitative data against which potential impacts would be monitored. These surveys would be completed before construction began. The additional baseline surveys would aim to accurately characterise the composition and distribution of marine communities and determine their seasonal and yearly variation. Data from previous baseline surveys, including inter-tidal surveys, undertaken at Point Lowly for the Santos oil facility at Port Bonython, would be acquired and compared with existing communities to provide information on the potential long-term natural variation in community structure (i.e. greater than 10 years) that would be relevant to the BHP Billiton monitoring program.

The quantitative baseline surveys would begin only after final design decisions had been made about the precise locations of the intake and outfall pipelines and diffuser. It would be premature to start the detailed surveys before final design as the distribution of control and impact survey locations is dependent on the precise location of the desalination infrastructure.

It is noted that three annual surveys of the Australian Giant Cuttlefish population at Point Lowly and Backy Point have already been undertaken since 2008, continuing the surveys undertaken by SARDI Aquatic Sciences in 1998–2001 and 2005 (refer Appendix O5.5 of the Draft EIS and see Appendix H9.3 of the Supplementary EIS).

It is also noted that the survey methodology and impact assessment approach for marine studies was discussed with, and received in-principle approval from, the South Australian Government before field surveys began.

17.1.3 SPECIES LIST

Issue:

A number of questions were raised about the marine species list for Upper Spencer Gulf provided in the Draft EIS and the number of taxa (groups of organisms) included (167 in the Draft EIS), the structure of the list (suggesting that it was aimed at non-specialists rather than specialist biologists), and the exclusion of species lists prepared by Saunders and SARDI (South Australian Research and Development Institute) Aquatic Sciences.

Submissions: 27, 80 and 86

Response:

The purpose of species lists in the context of an EIS is to provide an indication of the diversity of species inhabiting the study site, and to identify rare or threatened species that potentially may be affected by the proposed development. These species lists are not a definitive list of all species.

The species list included in the Draft EIS is sufficient for the purpose of identifying the most significant and sensitive susceptible species that potentially may be affected by the development. It is also noted that where rare or threatened species were identified from database searches, but not identified during field surveys, the precautionary principle was applied and therefore it was assumed the species would occur in the area for the purposes of the impact and risk assessments.

The marine species list was compiled using the best information available to the ecological consultants acting on behalf of BHP Billiton when the Draft EIS was written. The omission of any species (including fish, polychaetes, plankton etc.) is not an indication that they are considered to be less important than other species. The species list has been updated using data that has become available since the publication of the Draft EIS (e.g. the published species lists of Saunders 2009, Currie et al. 2009 and Sorokin and Currie 2009, and unpublished data from SARDI Aquatic Sciences) (see Appendix H1 of the Supplementary EIS). The list would be further updated with any new data as part of the baseline studies that would be undertaken before construction began.

The information presented in the Draft EIS is directed towards a broad audience that includes specialist biologists, interested members of the public, stakeholders such as the commercial fishing industry, government officers and academics. Consequently, the marine species list is structured in a way that is suitable for use by both specialist biologists and members of the public; it is not meant to be overly technical.

17.2 WATER/SEDIMENT SURVEYS

17.2.1 WATER QUALITY

Issue:

Details were sought on the water sampling that was undertaken, with specific questions about the adequacy of the program and the interpretation of the results.

Submissions: 2, 80 and 84

Response:

A comprehensive program of water sampling was undertaken at Point Lowly to characterise the natural variability in Upper Spencer Gulf and to assist engineering investigations associated with the pilot desalination plant. The interpretation of results from this sampling program simply determined compliance or otherwise with the criteria defined in the South Australian Environment Protection (Water Quality) Policy of 2003 (WQEPP) and the guidelines produced by the Australian and New Zealand Environment and Conservation Council and the Agriculture and Resource Management Council of Australia and New Zealand (ANZECC/ARMCANZ 2000).

As discussed in Appendix O14 of the Draft EIS, the suite of water quality parameters sampled was based on the WQEPP in relation to discharges from a desalination plant (as documented in Appendix H2.1). The assessment undertaken was to determine whether the return water discharge complied with the criteria documented in the WQEPP. The WQEPP criteria are based on the guidelines produced by ANZECC/ARMCANZ, but have trigger values specific to South Australia. The WQEPP guidelines are currently being amended to conform to ANZECC/ARMCANZ guidelines.

Two series of water sampling surveys were undertaken for the Draft EIS (see Appendix H2.1 of the Supplementary EIS):

- six sampling events from December 2006 to April 2007 – three sites were sampled along the Port Bonython jetty at mid-depth and replicate samples were taken on three occasions
- 14 sampling events from September 2007 to November 2008 – duplicate water samples were collected from the surface and 2–3 m from the seabed at two potential locations for the seawater intake (south-west and north of Point Lowly), and from the pilot desalination plant intake located on the Port Bonython jetty.

Samples were sent to three different NATA (National Association of Testing Authorities) accredited laboratories for the initial analysis to identify consistency in sample analysis and promote quality control. The quality checks resulted in the selection of the Australian Water Quality Centre for subsequent analyses.

The suite of parameters was reviewed and refined periodically and included the following:

- Physicochemical parameters:
    - pH
    - Electrical conductivity (EC)
    - Turbidity
    - Temperature (°C)
    - Dissolved Oxygen (DO) (mg/L and % saturation)
    - Oxidation reduction potential (ORP)
    - Total Dissolved Solids (TDS) @ 180°C

  Suspended Solids (SS) (ALS 0.45 µm)
    - UV Absorbance @ 254 nm
    - Total Hardness as $CaCO_3$
- Alkalinity by PC Titrator
    - Hydroxide, Carbonate and Bicarbonate alkalinity as $CaCO_3$
    - Hydroxide, Carbonate, and Bicarbonate alkalinity
    - Total alkalinity as $CaCO_3$

- Dissolved major anions
  - Chloride
  - Sulfate as SO_4^{2-}
  - Bromide, Fluoride
- Dissolved major cations
  - Calcium
  - Magnesium
  - Sodium
  - Potassium
- Ionic balance
  - Total anions
  - Total cations
  - Ionic balance
- Hardness
  - Calcium
  - Magnesium
  - Total hardness as $CaCO_3$
- Metals
  - Dissolved metals in saline water (Aluminium, Iron, Barium, Boron, Manganese, Strontium, Silica (by ICP-AES)
  - Total metals in saline water (Aluminium, Iron, Arsenic, Cadmium, Chromium Total, Copper, Lead, Manganese, Mercury, Molybdenum, Nickel, Tin, Zinc)
- Nutrients
  - Ammonia, Nitrite and Nitrate, Nitrite + Nitrate as N
  - Total Kjeldahl Nitrogen and Total Nitrogen as N
  - Total Phosphorus and Reactive Phosphorus as P
  - Dissolved Organic and total Organic Carbon
  - Biochemical oxygen demand
  - Oil and grease
- Microbiological
  - Chlorophyll 'a'
  - Heterotrophic Plate Count (36°C)
  - Heterotrophic Plate Count (21°C)
  - *Escherichia coli*.

Since the publication of the Draft EIS, further water quality data has become available from a monitoring station and pilot desalination plant on the Port Bonython jetty. The monitoring station was managed by the specialist consultancy, Water Data Services, and the pilot desalination plant was installed and operated by Veolia Water Solutions and Technology. This infrastructure was established to provide additional information on ambient water quality and to complete a series of trials to test different parameters that would influence the design of the full-scale plant.

The following water sampling is relevant:

- continuous sampling of ambient seawater at the water quality monitoring station for parameters such as conductivity, pH, dissolved oxygen (DO) and temperature from May 2007 to February 2010 at depths of four, seven and 10 m above the seafloor
- continuous sampling of the ambient and return seawater by the pilot desalination plant for physical parameters (turbidity, pH, conductivity (EC) and temperature) from May 2007 to February 2010
- chemical analysis of various water streams from the pilot desalination plant – two replicate samples were analysed for a suite of parameters on three occasions in June and August 2008 and April 2010.
- salinity data collected concurrently at five locations over 40 days (April–June 2009) using Greenspan CTD3100 sensors (see Figures 17.5 and 17.19 and Section 17.5.3 for further details).

The analysis and interpretation of the two sampling periods undertaken for the Draft EIS are summarised in Appendix O14 of the Draft EIS, and detailed in Appendix H2.1. Results from the continuous water quality monitoring station are provided in Appendix H2.2. Relevant data from the pilot desalination plant is summarised in Appendix H2.3.

All chemical water quality testing complied with the ANZECC/ARMCANZ (2000) guidelines and the WQEPP. The Draft EIS reported that 30 of the 40 parameters tested complied with the trigger values provided in the WQEPP. The compliance of the remaining 10 parameters was noted as 'uncertain' in the Draft EIS because the values were either below detectable limits or additional sampling was required. The concentration of ions in the discharge water was based on the intake concentration, and it was conservatively assumed that the concentration of ions would double as a result of the desalination process. The comparison with the water quality criteria was also based on the concentrations at the point of immediate discharge, whereas in practice the return water would be rapidly diluted and dispersed. The analysis of the actual return water from the pilot desalination plant has indicated that some water constituents are partially or totally removed during desalination, and that the concentration of ions in the return water is typically less than double the concentration of the intake water (see Appendix H2.3).

Sampling of the intake water for the pilot desalination plant confirmed that the copper concentration was below the water quality criteria. Zinc requires further testing (for further details see Section 17.3.2 of the Supplementary EIS).

Issue:

It was suggested that to enable salinity and dissolved oxygen pre- and post-operation of the desalination plant to be compared, baseline water quality surveys should be undertaken at multiple sites and seasons, and particularly in areas where hypersaline water may pool.

Submission: 2

Response:

The data collected to date (see response above and Appendix H2.1 of the Supplementary EIS and refer Appendices O9 and O14 of the Draft EIS) provides a sound baseline of water quality parameters, including salinity and temperature in Upper Spencer Gulf.

As shown in Figure 24.4 of the Draft EIS, this data would be supplemented with a long-term program to monitor salinity and temperature at Point Lowly. This program would occur for two years before the construction of the proposed desalination plant, during construction, and intensively for the first year from the start of its operation. The pre-operational data obtained in this manner would provide a suitable baseline for comparison with monitoring results obtained when the desalination plant was operating.

As described in the Draft Environmental Management Program (refer EM Program ID 4.1 in Appendix U of the Draft EIS), the Water Quality Monitoring Program would comprise comprehensive seasonal monitoring (including salinity and dissolved oxygen) using data loggers and salinity/temperature meters at several key sites off Point Lowly.

Issue:

The need for precise and accurate salinity measurements was noted.

Submission: 2

Response:

It was recognised early in the assessment of the proposed desalination plant that the correct measurement of salinity is paramount for determining natural variations in salinity and return water dilutions. It was also understood that the measurement of salinity is more challenging in the naturally higher salinity waters of Upper Spencer Gulf, because some instruments may be at the upper limit of their ability to measure salinity accurately. As a consequence, a detailed analysis and comparison of salinity records in Upper Spencer Gulf was undertaken for the Draft EIS (refer Appendix O9 of the Draft EIS). BHP Billiton also appointed oceanographer Dr Rick Nunes-Vaz (an author of some of the definitive papers on Spencer Gulf oceanography) to assist in measuring and assessing salinity associated with the proposed Point Lowly desalination plant.

The results of the comprehensive review undertaken for the Draft EIS showed that a calibrated salinometer provides the most routinely accurate and precise results for Upper Spencer Gulf and indicated that the natural range of salinity at Point Lowly is 40–43 g/L.

Monitoring to date has enabled a future water quality program to be designed to ensure salinity is measured both accurately and precisely in the vicinity of Point Lowly before and during the operation of the desalination plant.

17.2.2 SEDIMENT QUALITY

Issue:

The adequacy of the sediment sampling regime to address the true near-, mid-and far-field characteristics was questioned. Concern was expressed that the sampling targeted sediments that were predominantly composed of shelly grit, which are least likely to reflect accurate contamination levels.

Submission: 84

Response:

The sediment sampling was representative of the sediments in the area, and the chemical analysis was consistent with the Interim Sediment Quality Guidelines for sediment contaminants (ANZECC/ARMCANZ 2000).

The sediment survey conducted for the Draft EIS was based on a random grid covering approximately 15 km^2 off Point Lowly and the landing facility, and it provided a good representation of the sediments that occur in these areas. As described in Appendix O7 of the Draft EIS (refer Figures O7.1 and O7.2) surficial sediment samples were taken at 45 locations to analyse grain size and chemistry.

Since the Draft EIS was published, two additional sediment surveys have been undertaken to determine the physicochemical composition of deeper sediments in the areas proposed for construction of the intake and outfall pipes (see Appendix H2.4 and H2.5 of the Supplementary EIS). Sediment grain size was determined at 16 sites, sediment depth at five sites and sediment chemistry at three sites. Grain size was determined for surface, middle and the deepest core sample depths. Chemical analysis was determined for three composite samples from sediment at 1 m depth.

As discussed in Appendix O7 of the Draft EIS, the surficial sediments consisted largely of silty to clayey fine to coarse sand with shell fragments and debris, with a few sites consisting of finer-grained sediments. Core samples were principally sand, with lesser amounts of fine clay and silt at the outfall site. North and west of Point Lowly, in the deeper sites, the proportion of clays and silts increased to 40–50% (see Appendix H2.4 of the Supplementary EIS and refer Appendix O7 of the Draft EIS).

Although many samples contained a high proportion of coarse material such as shelly grit, as expected in a high-energy environment, numerous samples containing fine sediments were included in the surveys. The inclusion of finer-sediment samples in the chemical analysis ensured that potentially contaminated sediments were assessed.

Broad-scale historical sediment data has been used to provide a context for the near-field results. The sediment sampling methods complied with the National Ocean Disposal Guidelines for Dredged Material (Environment Australia 2002), ensuring an adequate sampling regime suitable for impact assessment.

The Draft Environmental Management Program (refer EM Program ID1.2, Appendix U of the Draft EIS) described the sediment monitoring plan that would be established to provide a baseline of sediment physicochemical characteristics near the outfall in order to assess any changes that resulted from operation of the desalination plant.

Issue:

Concern was expressed that deeper sediments containing fine material, which are more likely to be contaminated with toxins and heavy metals from 100 years of industry, would be exposed during construction.

Submissions: 84 and 86

Response:

Neither the shallow nor the deep sediments off Point Lowly were found to be contaminated by heavy metals or other toxins (refer Appendix O7 of the Draft EIS). The sediment sampling methods undertaken for the Draft EIS complied with the National Ocean Disposal Guidelines for Dredged Material (Environment Australia 2002), and analysis was consistent with the Interim Sediment Quality Guideline for sediment contaminants (ANZECC/ARMCANZ 2000).

The fate of heavy metals is linked to the fate of sediments, as most metals in the sea adsorb onto the surface of particulates. The distribution of heavy metals in marine sediments depends on the proximity to the pollution source, transport via currents, water chemistry and prevailing wave and current energy (Harbison 1984). Heavy metals therefore accumulate in low-energy sediment sinks, rather than environments with strong currents such as at Point Lowly. Heavy metals are also more likely to concentrate in surface sediments (Ferguson, Chambers and Burne 1983; Harbison 1984).

Both sediment surveys off Point Lowly (from surficial and core sampling) returned similar results, showing no contamination above the Interim Sediment Quality Guideline – Low Trigger Values established by ANZECC/ARMCANZ (2000) (see Appendix H2.5 of the Supplementary EIS and refer Appendix O7 of the Draft EIS). Installation of the pipelines would not, therefore, expose heavy metals in concentrations that breach sediment quality guidelines.

Issue:

It was suggested that surveys should have sampled a variety of sediments and included analysis of microscopic biota.

Submission: 84

Response:

Although microbenthos (smaller than 0.1 mm) and meiobenthos (between 0.1 and 1 mm) organisms are important components of sediments as they assist with nutrient cycling and contribute to ecosystem productivity, a study of these organisms was not necessary for the impact assessment presented in the Draft EIS. The sediment sampling methodology was consistent with the Interim Sediment Quality Guideline for sediment contaminants (ANZECC/ARMCANZ 2000), which does not require an assessment of the microbenthos and meiobenthos. The sediment sampling methods complied with the National Ocean Disposal Guidelines for Dredged Material (Environment Australia 2002). The main aim of the surveys was to determine whether the sediment contained contaminants that may be remobilised, and provide information on sediment grain size and potential turbidity effects during construction.

No adverse effects are expected on microbenthos and meiobenthos. The risk to these organisms is associated with the potential deoxygenation of bottom waters, but modelling of sediment oxygen demand and oxygen exchange shows the discharge of return water would have virtually no effect on the level of dissolved oxygen in ambient seawater (see Section 17.12.3 of the Supplementary EIS). This is consistent with the high-energy environment off Point Lowly.

Issue:

Further details were requested on the sediment survey methodology (replication and chemical analysis) and presentation (use of < and > symbols, mean and standard error, sediment/suspension/dissolved association).

Submissions: 80, 84 and 86

Response:

The sampling methods complied with the National Ocean Disposal Guidelines for Dredged Material (Environment Australia 2002), ensuring an adequate sampling regime suitable for impact assessment. The methods and range of parameters tested were provided in Appendix O7 of the Draft EIS and are further detailed in Appendices H2.4 and H2.5 of the Supplementary EIS.

The methods used for the studies of surficial sediments off Point Lowly and the proposed landing facility in Upper Spencer Gulf were appropriate to help assess potential environmental impacts. Different methods are appropriate for establishing a monitoring baseline and, as discussed in the Draft EIS, such monitoring would occur for five years before the proposed desalination plant began operating. When baseline surveys of sediment quality were undertaken, adequate replication of samples would occur.

The presentation of data (including < and > symbols, mean and standard error) is a common scientific practice. The symbols represent less than (<) or greater than (>) a set value, such as the limit of reporting (LoR). The < symbol was used only when data was less than the limit of reporting; in all other cases actual values were reported. In all cases the contaminants were below Environment Australia (2002) screening levels.

Issue:

BHP Billiton's commitment to a more extensive sediment sampling analysis was questioned.

Submission: 84

Response:

BHP Billiton has committed to more extensive sediment monitoring in the Draft Environmental Management Program (refer EM Program ID1.2, Appendix U of the Draft EIS). The program includes sediment sampling at Point Lowly to provide further information on sediment quality, including organic and inorganic pollutants and sediment oxygen demand.

The timeframe for the marine monitoring programs was provided in Figure 24.4 of the Draft EIS. Marine monitoring would occur for two years before construction began, and during construction and operation of the plant.

17.3 RETURN WATER CHARACTERISTICS

17.3.1 COMPOSITION OF THE RETURN WATER DISCHARGE

Issue:

Clarification was sought on the physical nature of the return water discharge, particularly the low dissolved oxygen (DO) content.

Submission: 181

Response:

The physical and chemical characteristics of the intake and return water were listed in Table 16.6 of the Draft EIS. Mixing and aeration before discharge would ensure that the dissolved oxygen content of the return water was generally near saturation levels of 5.5–7 mg/L, which is lower than saturated seawater due to its greater salinity (mean 75 mg/L) and slightly elevated temperature (+1°C). Dissolved oxygen levels in return water may fall to zero for about one hour each day due to the action of sodium metabisulphite used in scavenging chlorine. Historical data shows ambient DO levels at Point Lowly typically range from 7–8.5 mg/L, (refer Section 16.4.1 of the Draft EIS) and exceed 92% saturation (see Appendix H7.2 of the Supplementary EIS). Following mixing and dilution upon discharge, oxygen content of the return water would rapidly approximate ambient conditions.

Modelling of the return water discharge during a neap (dodge) tide period has shown the DO content with and without desalination discharge are virtually identical, indicating the impacts of the slightly lower return water DO content are almost immeasurable (Appendix H7.2). The results of the DO modelling are discussed further in Section 17.12.3 of the Supplementary EIS.

Issue:

The potential impact of the increased acidity (reduced pH) of the return water was questioned, especially in the context of climate change consequences.

Submission: 80

Response:

Testing of return water quality at the pilot desalination plant at Port Bonython returned a slightly lower (mean 0.3 units) pH than ambient seawater, indicating that the addition of acid has only a slight effect (Appendix H2.3). The small reduction in pH results from the high buffering capacity of seawater, whereby the relatively high concentration of carbonate and bicarbonate ions in the return water neutralises the acid. Upon discharge, dilution and further buffering would return pH to ambient levels within metres.

The increased carbon dioxide concentrations in gulf waters associated with climate change are predicted to reduce the pH of gulf waters by 0.2 by 2070 (see Section 17.18.2). The reduction in ambient pH would reduce the amount of chemicals required to reduce scale on membranes. Whereas climate change is predicted to have a measurable effect on the pH of gulf waters, the effects of desalination would not be measurable outside the immediate zone of the diffuser.

Water quality monitoring before commissioning and during operation of the desalination plant would include pH measurements at key locations to confirm there were no changes to the pH outside the mixing zone.

Issue:

Further details were requested on reverse osmosis (RO) chemicals contained in the return water discharge, including the cleaning chemicals.

Submissions: 84, 165, 211 and 219

Response:

As discussed in Section 16.4.1 and listed in Table 16.7 of the Draft EIS, six chemicals are likely to be used in the reverse osmosis process: coagulants and flocculants, a chlorine biocide and its neutraliser, and two anti-scalants. Ferric chloride and cationic polymers would be added to the intake water to help remove particles by flocculation and coagulation. Flocculation and coagulation result in sediments aggregating and forming clumps, making it easier to collect and remove the sediments via filtration or in settling ponds. Sediments would be removed and disposed of in licensed landfill. The intake water would be treated with the biocide chlorine to prevent fouling of the intake pipe and storage tanks. Chorine dosage may be less than the levels indicated in the Draft EIS (i.e. daily for one hour at 8 mg/L) and would depend on water quality and ongoing biocide development and testing (see Section 17.8.4). Chlorine would be neutralised with sodium metabisulphite following coagulation and flocculation processes, as the chlorine is incompatible with the RO membranes. The reaction removes the chlorine and produces traces of halogenated organic by-products (mainly trihalomethanes) and residual chlorine, which would enter the return water stream at low concentrations (see Section 17.8.4). Two anti-scaling agents – sulphuric acid and an organophosphate anti-scalant (probably Nalco PermaTreat® PC-1020T) – would be added before RO processing to prevent scale forming on the RO membranes and in the pipelines. The acid would be rapidly buffered by seawater, resulting in the pH of the return water being very similar to that of the intake water. Anti-scalant use would be optimised to minimise use and discharge of chemicals to the marine environment.

Cleaning chemicals would also be used every three to four months to remove deposits of mineral scale, biological growth and particulates from the RO membranes (refer Section 16.4.1 of the Draft EIS). The cleaning chemicals would be discharged to evaporation ponds and ultimately disposed of in licensed landfill sites. Only trace concentrations of cleaning chemicals would be returned to sea.

The potential impacts of processing chemicals contained in the return water discharge were described in Section 16.4.1 of the Draft EIS and further information is provided in Section 17.8.4 of the Supplementary EIS.

17.3.2 HEAVY METALS

Issue:

The type of sampling to determine the current heavy metal loading in the Point Lowly area was questioned, particularly with respect to the cadmium content of the intake water.

Submissions: 79, 80, 84 and 176

Response:

A monthly water quality sampling program in the vicinity of Point Lowly was undertaken from September 2007 to November 2008 (refer Appendix O14 of the Draft EIS and see Section 17.2.1 above and Appendix H2.1 of the Supplementary EIS for details).

The results showed that the concentration of metals, particularly cadmium, in Point Lowly water would be consistent with that of normal seawater and would conform with the applicable water quality criteria for most heavy metals where data currently exist (refer Table O14.1, Appendix O14 of the Draft EIS).

In total, seawater samples were analysed for 16 metals. Fourteen of these were in the Environment Protection (Water Quality) Policy of 2003 (WQEPP) criteria, the concentration of beryllium and mercury was below the limits of reporting, and copper and zinc required further sampling (refer Appendix O14 of the Draft EIS). The concentration of cadmium was below the limit of reporting (0.0002 mg/L) for all samples, and well within the WQEPP criteria of 0.002 mg/L. Average total copper concentrations ranged between <1 and 11µg/L from six sites, and were below the WQEPP criteria of 0.01 mg/L (10µg/L) for all but one of the samples (see Appendix H2.1 of the Supplementary EIS). Analysis of ambient and return water from the pilot desalination plant has since confirmed copper content to be below the water quality criteria (see Appendix H2.3 of the Supplementary EIS). Average zinc concentrations ranged between 5.9 and 30 µg/L from six sites (averages were below 8.4 µg/L for all but one site) (see Appendix H2.1 of the Supplementary EIS), which are within the WQEPP criteria of 0.05 mg/L (50 µg/L) for marine areas, but exceed the guidelines for aquaculture of 0.005 mg/L (5 µg/L). Subsequent analysis of ambient and return water from the pilot desalination plant has shown that zinc levels (0.13 mg/L) exceed the water quality criteria of 0.05 mg/L. This measurement is questionable, however, and further measurements are required (see Appendix H2.3 of the Supplementary EIS). There are no WQEPP criteria for iron. Iron is largely removed, however, during the flocculation and coagulation processes, and would be disposed of with the filter backwash in a licensed landfill (see Appendix H2.3 of the Supplementary EIS).

An extensive study of surficial sediments at Point Lowly and the proposed landing facility in Upper Spencer Gulf was also undertaken (refer Appendix O7 of the Draft EIS). The results showed that heavy metal concentrations in sediments were below screening levels (Environment Australia 2002) (refer Section 16.3.3 of the Draft EIS).

Issue:

Further details were requested about the concentration of metals entering the marine environment from the return water discharge and the long-term effect of heavy metal accumulation.

Submissions: 80, 84 and 211

Response:

The discharge of return water to Spencer Gulf is not expected to increase heavy metal concentrations in gulf waters. Although heavy metal ions occur in solution in seawater, most adsorb onto particulates at the pH prevailing in seawater. During the pre-filtration, flocculation and coagulation processes, particulates and associated heavy metals would be separated from the seawater and removed via settlement and drying processes before being disposed of in a licensed landfill site (refer Section 16.4.1 of the Draft EIS).

A small proportion of the total metals in the intake water would be in solution, rather than associated with particulates. A negligible amount of heavy metals may also enter the discharge through corrosion of the stainless steel alloy components of the plant. However, as the majority of the plant would use highly corrosion-resistant super duplex stainless steel alloys, and only small amounts of stainless steel alloy would be used for the high-pressure sections, the amount of metal resulting from corrosion would be negligible. The metals in solution would be concentrated by the desalination process and discharged at approximately twice their original concentration, because some freshwater is removed (lower volume of return water), and the metals are more soluble at higher salinity. The resultant metal load in the intake and return water, however, is about the same due to the removal of particulate-bound metals described above. This has been confirmed by analysing the metal concentration of the intake water, filtered backwash, and return (RO reject) water from the pilot desalination plant (see Appendix H2.3 of the Supplementary EIS).

Issue:

In view of heavy metals exhibiting greater toxicity at greater salinity and temperatures, questions have been raised about the impact of the increased toxicity associated with the return water discharge.

Submissions: 80 and 138

Response:

In the marine environment most metals adsorb onto particulates, because positively charged metal ions have a strong affinity for particulate organic matter, iron and manganese oxyhydroxides and clay minerals. When pH and particulate loads are low, metals tend to dissolve and become available to the biota. Increased salinity tends to increase the solubility of metals because cations such as Mg^{2+} and Ca^{2+} can compete with metals for binding sites on organic molecules. Increased salinity, however, usually increases the rate of flocculation of clay-organic particles and as a consequence removes metals from solution.

In comparison to ambient seawater, the elevated salinity, lower turbidity and slightly lower pH of the return water (refer Table 16.6 of the Draft EIS) is likely to result in increased metal solubility. However, due to the rapid dilution of the discharge, trace metals would partition into their insoluble phase and bind to particulates, which would be transported and deposited in low-energy environments some distance from Point Lowly.

It is also noted that the ecotoxicity testing undertaken for the Draft EIS used Whole Effluent Toxicity (WET) tests, which include the potential increased solubility and bioavailability of metals in the return water discharge (refer Section 16.4.2 of the Draft EIS for details).

17.4 ECOTOXICOLOGY

The ecotoxicology studies conducted for the Draft EIS met or exceeded the requirements of the ANZECC/ARMCANZ (2000) Guidelines for Fresh and Marine Water Quality, which provide the accepted standard for such studies. Many of the responses below draw on these guidelines to address a number of submissions that suggested alternative approaches.

It is noted that this section by its very nature is complex. However, the overarching conclusion is that the further analyses presented in this section and the accompanying appendices reinforce the conservatism in the species protection trigger value (SPTV) of 1:85 that was identified in the Draft EIS.

17.4.1 COMPOSITION OF EFFLUENT/DILUENT/TEST SOLUTIONS

Issue:

Concern was expressed that the ecotoxicology tests did not use effluent that is representative of all chemicals likely to be present in the return water.

Submissions: 1, 2, 57 and 209

Response:

The ecotoxicology tests conducted for the Draft EIS used the effluent likely to best represent the return water discharged from the proposed Point Lowly desalination plant (refer Section 16.2.3 of the Draft EIS). The effluent was derived from seawater collected off Point Lowly and passed through a portable reverse osmosis plant, with the addition of the anti-scalant that is used in the Perth desalination plant (i.e. Nalco PermaTreat® PC-1020T), added at a concentration of 3.6 mg/L and concentrated to approximately 7 mg/L.

As discussed in Section 16.4.1 of the Draft EIS, the other five potential chemical additives used in the reverse osmosis desalination process are commonly used in traditional domestic water treatment plants and are discharged with treated wastewater. Furthermore, these chemicals, or their by-products, would only be present in the return water in traces, if at all. Ecotoxicology studies undertaken for the Adelaide desalination plant showed no difference in test outcomes when such pre-treatment chemicals were included in test solutions (Adelaide Aqua D&C Consortium 2009). It was therefore not considered necessary to include these chemicals in the test solutions.

The uncertainty raised in the submissions may also reflect statements made in the Draft EIS that the final composition of the return water discharge would depend on the final design of the pre-treatment processes in the plant and the anti-scalant preferred by the operating contractor. However, the Draft EIS also included a commitment that should other pre-treatment chemicals or anti-scalant be used, the ecotoxicology tests would be repeated before the proposed desalination plant commenced operation, in order to confirm the appropriateness of the species protection trigger value (refer Section 16.4.1 of the Draft EIS and see Section 17.4.9 of the Supplementary EIS for further details). This approach to ecotoxicology testing prior to government approval is considered to exceed standard industry practice.

This approach also provides scope to benefit from improvements in the environmental performance of reverse osmosis chemicals. For example, recent advances in the environmental performance of anti-scalants (and other desalination processing chemicals) have occurred (Patel 2010), and these are likely to result in more benign final effluent than that assessed for the Draft EIS.

Issue:

Concern was expressed that only a limited number of the ecotoxicology tests used diluent water of an appropriate salinity. It was suggested the ecotoxicology tests should be redone using diluent of an appropriate salinity. It was stated that recalculating the test results to account for lower than ambient diluent salinities would be possible, but would reduce the sensitivity of the results with respect to the action of the anti-scalant and any other process chemicals.

Submission: 2

Response:

The diluent used for the ecotoxicology tests and to establish a species protection trigger value (SPTV) in the Draft EIS was entirely appropriate for an environmental impact assessment.

The ecotoxicology tests were conducted for a variety of reasons, including stakeholder requests. Many of the earlier tests required species sourced from oceanic water and used diluent of a corresponding salinity.

For the species used to calculate the SPTV the salinity of the diluent water was 41.2 (refer Table 16.8 of the Draft EIS), which lies within the annual range of 40–43 g/L at Point Lowly and is above the median value recorded during deployments in Autumn 2009 (see Appendix H5.4 of the Supplementary EIS).

To account for all possible salinities that could be encountered at Point Lowly during the remaining part of the year, the SPTV was increased from 1:45 to 1:85 on the recommendation of Dr Michael Warne, Principal Research Scientist for the Centre for Environmental Contaminants Research, CSIRO, and a contributing author of the ANZECC/ARMCANZ (2000) water quality guidelines (refer Section 16.4.2 and Appendix O10.5 of the Draft EIS).

For completeness, further calculations were undertaken whereby the results obtained from the base diluent of 41.2 g/L were adjusted to reflect outcomes from a base diluent of 43 g/L. This process results in lower threshold concentrations (higher required dilutions) and therefore is conservative with respect to the action of the anti-scalant (see Figure 17.2 of the Supplementary EIS).

The outcome of these calculations was a SPTV of 1:70 (see Appendix H4.3 of the Supplementary EIS). Accordingly, the salinity of the test diluent was appropriate and the use of the SPTV of 1:85 (as an upper limit) to discuss the zone of ecological effect in the Draft EIS was conservative.

ECOTOXICOLOGY TEST (e.g. adult Western King Prawn)

	Return Water	Diluent	→	Mixture	
Per cent of mixture	7.5% (EC_{10})	92.5%		100%	
Salinity (g/L)	78	41.2	→	44	Equivalent salinity threshold
Anti-scalant (mg/L)	0.525	0		0.525	Equivalent anti-scalant threshold

PEAK AMBIENT CONDITIONS AT POINT LOWLY

	Return Water	Diluent	→	Mixture	
Per cent of mixture	7.5% (EC_{10})	92.5%		100%	
Salinity (g/L)	78	43	→	45.6	Exceeds salinity threshold
Anti-scalant (mg/L)	0.525	0		0.525	Meets anti-scalant threshold
Per cent of mixture	2.7% (Adjusted EC_{10})	97.3%		100%	
Salinity (g/L)	78	43	→	44	Meets salinity threshold
Anti-scalant (mg/L)	0.189	0		0.189	Below anti-scalant threshold

Figure 17.2 Adjustment of EC_{10} values to account for increased background (diluent) salinities

Issue:

Concern was expressed that the anti-scalant concentration used in the ecotoxicology tests was inconsistent with the proposed production dose.

Submission: 209

Response:

The anti-scalant dose applied to the ambient seawater used to create effluent for the ecotoxicology testing was 3.6 mg/L, which is indicative of the dose to be used during the operation of the proposed desalination plant (refer Section 16.2.3 of the Draft EIS).

The inconsistency noted in the submission is simply a result of rounding up from 3.6 mg/L to 4 mg/L, as was presented in Table 16.7 of the Draft EIS.

Issue:

Concern was expressed that the ecotoxicology studies used static (rather than dynamic, 'flow-through') tests, which could have been confounded by water quality factors.

Submission: 83

Response:

The use of static tests is standard industry practice in Australia, Europe, the United States of America and Canada (e.g. OECD 2006; US EPA 2002a, 2002b; Van Dam and Chapman 2001; Environment Canada 1992, 2007a). It is also impractical to conduct flow-through toxicity tests for micro-alga and the embryo development tests because organisms would be lost with outflowing water.

It is noted that static-renewal tests were used for copepods, prawns and cuttlefish, with 100%, 20%, and 50% renewal of test water every day, respectively. This is ample replenishment of the test media, particularly considering the organism to volume ratios (e.g. there were thirty 2 g prawns in 100 L of aerated water).

There are several points worth noting about the concerns that water quality factors may have confounded the results:

- any water quality problems would have also affected the controls, but this was not the case, as indicated by the controls meeting their quality assurance and quality control criteria (where they were available)
- it is very unlikely that NH_3 and CO_2 would have built up to levels that would have affected test results because of the renewal of test solutions described above, the ratio of biota to test volume, and the constant aeration of the test solutions
- an increase in CO_2 could lead to a decrease in the pH of the test solutions. However, the high buffering capacity of seawater makes this unlikely over the timeframes of the tests
- NH_3 and pH were routinely monitored during the tests and no build-up of NH_3 or decrease in pH was recorded
- had NH_3 or CO_2 built up during the tests, it would have added an additional stressor to the test organisms, which would have resulted in an over-estimation of the toxicity of the saline effluent.

Issue:

Concern was expressed that the ecotoxicology tests were not conducted using consistent, representative conditions. A specific concern was raised that tests on different fish species were not performed under exactly the same conditions and cannot be relied upon.

Submissions: 83 and 176

Response:

While Table 16.8 and Appendix O10 of the Draft EIS showed the results of numerous tests performed on 14 species across differing conditions, the most internally consistent dataset was used to determine the species protection trigger value (SPTV), as recommended by the ecotoxicology specialist (Dr Michael Warne of the CSIRO). This primary dataset comprised results from chronic (or sub-chronic) tests using test solutions based on the same supply of water sourced from Point Lowly.

The dataset included results for two fish species: Mulloway *Argyrosomus japonicus* and Snapper *Chrysophrys*[6] *auratus*. Both tests were conducted using the same protocol, salinity, temperature, lighting and feed (refer Appendix O10.4 of the Draft EIS).

Issue:

It was suggested that test solutions for one of the tests had a pH that was not representative of marine conditions.

Submission: 83

Response:

All results used to calculate the species protection trigger value were from tests using solutions with a pH similar to that of the ambient seawater at Point Lowly (i.e. 7.6–8.9). Although the return water would have a pH of 6.5–7, it would be rapidly buffered by the ambient seawater, resulting in a pH greater than 7.6 being achieved near the outfall. Rapid buffering of return water has been demonstrated at the pilot desalination plant at Port Bonython (see Section 17.3.1 of the Supplementary EIS for further details).

It is noted that the first Yellowtail Kingfish *Seriola Ialandi* test (described in Appendix O10.2 of the Draft EIS) used test solutions at a pH of 7.4–7.7, which is lower than the pH typically encountered at Point Lowly. However, the results of this test were superseded by later Yellowtail Kingfish tests at a pH of 8.1, typical of Point Lowly (refer Appendices O10.4 and O10.5 of the Draft EIS and Appendix H4.1 of the Supplementary EIS). It is also noted that the tests on Yellowtail Kingfish were not included in the primary dataset used to calculate the SPTV.

Issue:

It was suggested that ecotoxicology tests did not take into account changes to the discharge rate during the development of the Draft EIS.

Submission: 27

Response:

The discharge rate, although relevant to the hydrodynamic modelling studies, is not relevant to ecotoxicology testing. It is the resultant concentration of return water in seawater that affects the toxicity of the return water, not the volume.

Issue:

It was questioned whether adequate testing was done on the toxicity of particular metals (including Sr, Ca, K and Mg) in the return water.

Submission: 138

Response:

The whole effluent toxicity (WET) approach adopted for the Draft EIS was consistent with the ANZECC/ARMCANZ (2000) Guidelines for Fresh and Marine Water Quality.

The toxicity of the return water could be related to a number of substances that interact additively or even synergistically (i.e. the overall toxicity is greater than the added individual toxicities) (ANZECC/ARMCANZ 2000). Single-chemical toxicity tests do not account for such factors, and the extrapolation of the results to environmental impacts carries much uncertainty.

There is a considerable body of literature on the toxicity of individual metals that has been used to derive water quality criteria (e.g. EPASA 2003; ANZECC/ARMCANZ 2000), and conformance with such criteria was considered in Appendix O14 of the Draft EIS and Section 17.3.1 of the Supplementary EIS.

For effluent discharges into areas of high conservation value, however, the ANZECC/ARMCANZ (2000) water quality guidelines recommend that WET be applied. The WET approach provides more realistic outcomes by assessing the overall, integrated toxicity of a mixture of compounds rather than individual components, and therefore more closely resembles the situation in the natural environment (ANZECC/ARMCANZ 2000).

6 Referred to as *Pagrus auratus* in the Draft EIS.

Issue:
It was suggested that the total elemental percentage composition of the test effluent should have been reported.

Submission: 84

Response:

The percentage composition of the test effluent is irrelevant in the context of the whole effluent toxicity testing, as discussed in the previous response. Nevertheless, indicative information on the composition of the test effluent is provided in the Draft and Supplementary EIS.

The test effluent was prepared by passing Point Lowly seawater with the addition of 3.6 mg/L of anti-scalant (Nalco PermaTreat® PC-1020T) through a portable reverse osmosis plant. The resulting return water effluent had a salinity of approximately 78 g/L and the anti-scalant was concentrated to approximately 7 mg/L. Table O14.1 of the Draft EIS listed indicative maximum concentrations of the various pollutants in the test effluent for the intake water and discharge water.

It is noted that the concentrations presented for the discharge water are likely to be overstated because many metals would be adsorbed onto particulates (Elder 1988) and removed during the coagulation and flocculation processes (refer Section 16.4.1 of the Draft EIS and see Section 17.3.2 of the Supplementary EIS). The exception may be iron in the form of ferric chloride. However, the concentration of residual ferric chloride in return water at the pilot desalination plant was found to be over 30 times lower than the lowest concentration found to have effects on marine organisms (see Section 17.8.4 of the Supplementary EIS for details).

Additional information on the composition of ambient seawater near Point Lowly is provided in Appendix H2.1 of the Supplementary EIS.

17.4.2 CHOICE OF SPECIES

Issue:
It was suggested that no research had been undertaken into the salinity tolerance of species.

Submissions: 2 and 88

Response:

The Draft EIS included considerable research into the salinity tolerances of species.

For example, Section 16.4.2 and Appendix O8 of the Draft EIS provided a literature review of previous research into the salinity tolerance of species and Sections 16.2.3, 16.4.2 and Appendix O10 of the Draft EIS documented the results of ecotoxicology studies on numerous species at varying salinity levels.

Consistent with the ANZECC/ARMCANZ (2000) guidelines, the studies undertaken for the Draft EIS adopted a whole effluent toxicity (WET) approach. The test solutions had salinity levels varying from 35 to 78 g/L, which provided considerable insight into the salinity tolerance of species.

Issue:
It was suggested that the suite of species selected for ecotoxicology tests may not represent the entire marine community, and that many species may already be at tolerance limits.

Submissions: 36, 80, 123 and 302

Response:

The ANZECC/AMCANZZ Water Quality Guidelines recognise it is impractical to test all species in an entire marine community and, as a consequence, they specify that at least five species (from at least four taxonomic groups) should be tested to represent all the species in the receiving environment. The studies undertaken for the Draft EIS exceeded this requirement; 15 species from seven taxonomic groups were tested and the primary data set used to determine the SPTV included seven species from six taxonomic groups (the secondary data set, which gave a lower estimate of the dilution required, included 10 species from six taxonomic groups). The number of species tested, and used to calculate the SPTV, exceeded that of the six major desalination plants operating or under construction in Australia (see Appendix H3 of the Supplementary EIS).

The choice of species included in the tests was based on an understanding of the biota present in Spencer Gulf gained from a wide range of sources (e.g. refer Appendix O2 of the Draft EIS). These species represented several trophic levels ranging from microalgae up to carnivorous fish. The salinity tolerance of the species was not used as a selection criterion. The focus was on meeting the requirements of the water quality guidelines, including species of local relevance and importance, and using standard tests where possible. Numerous tests of larval stages were included as these tests are considered to offer a high degree of protection than older life stages (refer Section 16.2.3 of the Draft EIS).

An analysis of the species selected suggests that species near (or past) their tolerance limits in Upper Spencer Gulf were well represented in the primary dataset, as evidenced by their distribution along salinity, temperature and wave exposure gradients up the gulf. For example:

- the macroalga *Ecklonia radiata* does not extend as far north in Spencer Gulf as Point Lowly (Council of Heads of Australasian Herbaria 2010)
- adult Western King Prawn *Melicertus latisulcatus* are less abundant north of Point Lowly (to the point that they are not harvested commercially).

The salinity tolerance of each species may also vary between life stages, with adults generally being more tolerant to higher salinities than larvae. A number of sub-chronic tests were undertaken on larvae that are not known to occur at Point Lowly (even though adults occur naturally and/or as aquaculture species). For example:

- larvae of the introduced aquaculture species Pacific Oyster *Crassostrea gigas* were shown to have impeded growth and/or survival at salinities greater than 35 g/L (Wiltshire et al. 2008; Nell and Holliday 1988), and are not known to occur in Upper Spencer Gulf
- larvae of naturally occurring Mulloway *Argyrosomus japonicus* and Kingfish *Seriola lalandi* (secondary dataset), are not known to have been recorded in Upper Spencer Gulf.

If the absence of larval stages at Point Lowly is influenced by the elevated salinities in Upper Spencer Gulf, they may not be representative of the marine community occurring at Point Lowly. Their inclusion in the list of tests used to derive the species protection trigger value (SPTV) may therefore have produced an overly conservative result. A recalculation of the SPTV, excluding the data for larvae not known from Upper Spencer Gulf, resulted in an SPTV of 1:27 (compared with 1:85). This provides considerable evidence that the suite of species chosen and the tests performed to calculate the SPTV for the Draft EIS included species near or beyond the limit of their salinity tolerance, and as such produced a conservative result.

Issue:

Concern was expressed that because urchins have been affected by other desalination plants, a local urchin species should have been tested. A particular species recommended for testing was the Purple Urchin *Heliocidaris erythrogramma*.

Submissions: 86 and 138

Response:

An SPTV to protect 99–100% of species was derived from the whole effluent toxicity testing program, which met or exceeded the requirements of the ANZECC/ARMCANZ (2000) Guidelines for Fresh and Marine Water Quality.

Local urchins include the Purple Urchin *Heliocidaris erythrogramma* (from the same genus as the tested *H. tuberculata*), *Temnopleurus michaelseni* and *Goniocidaris tubaria* (refer Appendix O2 of the Draft EIS). These species are unlikely to be affected by the desalination plant return water, as they have all been recorded near Red Cliff Point (refer Appendix O2 of the Draft EIS; Johnson 1979), where salinities reach 45 g/L (Johnson 1981), which is considerably higher than the salinities predicted near the desalination plant outfall.

It is also noted that the Purple Urchin habitat near Point Lowly is limited to the inshore reefs that lie outside the zone of ecological effect described in Section 16.6.5 of the Draft EIS. Dilutions achieved in the urchin habitat are typically more than double the SPTV of 1:85.

Issue:

It was suggested that ecotoxicology testing relevant to the sponge community is required.

Submission: 2

Response:

After the Draft EIS was published, BHP Billiton engaged Geotechnical Services Pty Ltd to undertake tests on one of the sponge species recorded in the Point Lowly community (*Aplysina lendenfeldi*). As there is currently no standard test for sponge toxicology, Geotechnical Services developed a new test for this species. The EC_{10} results ranged from 8–15%, corresponding to a dilution of one part return water to seven to 13 parts seawater. As such, the species would be adequately protected by the SPTVs of 1:45 or 1:85 calculated for the Draft EIS.

To put the sensitivity of the sponge into further perspective, a comparison of the EC_{10} values of the sponge and of the seven species used in calculating the SPTV for the Draft EIS shows the sponge to be the fourth or fifth most sensitive species.

Issue:

It was stated that laboratory tests undertaken at Flinders University have revealed low tolerance of a number of additional benthic marine invertebrates.

Submission: 80

Response:

The methodology and species tested at the Flinders University do not allow direct correlation with, or change the impact assessment for, the ecotoxicological studies undertaken for the Draft EIS.

Stewart (2008) conducted acute tests on the osmotic tolerance of Southern Calamary *Sepioteuthis australis* by exposing egg capsules to salinities of 35, 45, 55, 65 and 75 g/L. He found a significant increase in mortality at 45 g/L, and 100% mortality at 55 g/L.

Beattie (2009) conducted tests on three invertebrates, the ascidian *Pyura praeputialis*[7], the brittle star *Ophiactis* sp. and the mussel *Limnoperna pulex*.[8] She found significant increases in mortalities of these three species at 51, 51 and 60 g/L respectively. *L. pulex* also showed reduced feeding capacity at 44 g/L.

Heaven (2010) conducted tests on the response of Port Jackson Shark *Heterodontus portusjacksoni* embryos to changes in salinity. She found that embryos all survived at 45 g/L, but none at 55 g/L.

Southern Calamary, Port Jackson Shark and *P. praeputialis* have been recorded in Upper Spencer Gulf, as far north as Red Cliff Point (refer Appendix O2 of the Draft EIS; Shepherd 1983). Salinities at this location seasonally exceed 45 g/L (Johnson 1981), indicating that the results of the ecotoxicology tests are consistent with field observations.

It was suggested by Stewart (2008) and Beattie (2009) that some of these species may be useful indicator organisms for assessing the impacts of brine discharge because of their sensitivity to changes in salinity. However, these species have not been adopted for ecotoxicology studies on this project for one or more of the following reasons:

- they have not been recorded in Upper Spencer Gulf (*Ophiactis* sp. and *Limnoperna pulex*)
- they represent the same taxonomic group as important species with existing tests: *Sepia australis* and *S. apama* are both cephalopods (cuttlefish), with the latter species being tested for this project
- there are no standard ecotoxicology tests for these species.

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[7] Actually *Pyura stolonifera* ssp. *praeputialis* (listed in Appendix O2 of the Draft EIS as *Pyura stolonifera*).

[8] Note that the brittle star and mussel were stated as being *Ophionereis schayeri* and *Mytilus edulis planulatus*, respectively, but these identifications have been revised (K Beattie, Flinders University, pers. comms., 22 April 2010 and 7 April 2010 respectively).

Issue:

Residue testing on Fitzgerald Bay aquaculture species was requested.

Submission: 2

Response:

The Yellowtail Kingfish *Seriola lalandi* is grown in Fitzgerald Bay aquaculture leases located some 5 km north of the proposed return water diffuser, and was therefore included in the ecotoxicology tests undertaken for the Draft EIS. The tests followed the ANZECC/ARMCANZ (2000) water quality guidelines, which note that bioaccumulation generally increases as water solubility decreases, and provide a threshold based on the octanol-water partition coefficient (K_{ow}); only chemicals for which the log K_{ow} is greater than four need to be considered for further investigation.

As discussed in Section 17.4.1, anti-scalant is considered to be the only significant chemical used in the desalination process and discharged with the return water. The anti-scalant assessed in the Draft EIS (Nalco PermaTreat® PC-1020T) is completely soluble in water (Nalco 2006), and has a log K_{ow} of 0.54 (A Head, Business Manager, Nalco, pers. comm. 24 September 2010). Similarly, other chemicals that may be present in the return water in traces would not bioaccumulate, with log K_{ow} values of -3.7 for sodium metabisulphite (Deltrex 2006) and 0.16 for Ferric Chloride (Royal Society of Chemistry 2010). Trihalomethanes, possible by-products of the chlorination/dechlorination process and which may be present in traces, are also considered unlikely to bioaccumulate (Agency for Toxic Substances and Disease Registry 2005). Chloroform, a representative trihalomethane proposed by Lattemann and Hoepner (2008), has a log K_{ow} of 1.97 (Watts et al. 2004), and bromoform, another suitable representative (Symons 1999), has a log K_{ow} of 2.4 (Andenekan 2009).

Residue testing on Yellowtail Kingfish is therefore not considered to be necessary for the impact assessment, because the likelihood of bioaccumulation of return water constituents is low, with log K_{ow} values below the ANZECC/ARMCANZ (2000) threshold by a considerable margin of safety.

If there was to be any change to the pre-treatment chemicals or anti-scalant to be used, their potential for bioaccumulation would be assessed before the proposed desalination plant commenced operation.

17.4.3 LIFE STAGES TESTED

Issue:

It was suggested that a suite of studies, with consistent life stages and test durations, is required for each species in order to infer protection.

Submission: 83

Response:

The testing undertaken for the Draft EIS complied with national requirements; in many cases the tests exceeded these requirements.

The ANZECC/ARMCANZ (2000) Water Quality Guidelines do not require that all stages of the life cycle be tested. Rather, the aim is to use the most sensitive endpoint for the species, taking into consideration the practicality of conducting the tests. For the Draft EIS, tests were typically undertaken on the most sensitive life stages for each species. This resulted in many of the tests being conducted on larval or juvenile stages, as these stages have been shown for many species to be more sensitive than later life stages (Environment Canada 1997, 1998, 2007b; US EPA 2002b).

Furthermore, the duration of the tests reflects the endpoint that is being considered. For larvae, development is rapid and effects are detectable in days or even hours (US EPA 2002a).

Issue:

It was suggested that toxicity tests on cuttlefish should have lasted longer to include adult reproduction.

Submissions: 27 and 348

Response:

As noted in the response above, larvae or juveniles are typically the most sensitive life stage of species (Environment Canada 1997, 1998, 2007b; US EPA 2002b). Generally, as organisms get older they become more tolerant to toxicants. Therefore, it is unlikely that tests on adults would have resulted in a more conservative cuttlefish result or SPTV.

Furthermore, it is considered that toxicity testing on adult cuttlefish would have been impractical due to the complexity of the testing facilities that would be required and difficulties associated with breeding cuttlefish in captivity (Hall and Fowler 2003).

To reiterate, the assessments undertaken for the Draft EIS were consistent with the requirements of the ANZECC/ARMCANZ (2000) Water Quality Guidelines.

Issue:

Concern was expressed that testing had not included all stages of the life cycle of the Western King Prawn, and therefore it cannot be guaranteed that there would be no impact on stock levels, breeding or spawning rates and therefore future recruitment to the prawn fishery.

Submission: 83

Response:

- As noted in the responses above, the ANZECC/ARMCANZ (2000) Water Quality Guidelines do not require all stages of a species' life cycle to be tested; it is appropriate to test the most sensitive life stage for the species.
- The post-larval stage of the Tiger Prawn *Penaeus monodon* was tested (refer Appendix O10.2 of the Draft EIS). With respect to the Western King Prawn *Melicertus latisulcatus*, larvae are known to occur in nursery areas in high-salinity environments (i.e. up to 55 g/L) in South Australia and Western Australia (Dixon et al. 2009). Therefore the larval stage, in this particular case, was not considered to be the most sensitive.

Both adult and juvenile life stages were tested, with the adult prawn proving to be the most sensitive (refer Table 16.8 and Appendix O10.4 of the Draft EIS). This result is consistent with the reduced abundance of adult prawns north of Point Lowly, to the point that they are not harvested commercially (Dixon et al. 2009).

The testing of adult prawns, in particular, has provided additional certainty that stock levels, breeding or spawning rates and therefore future recruitment to the prawn fishery would not be affected.

17.4.4 ACCLIMATION AND EXPOSURE CHARACTERISTICS

Issue:

Concern was expressed that acclimation issues were not adequately described or addressed, and it was not clear from the consultant reports how long any acclimation period actually was.

Submission: 83

Response:

Appendix O10.5 of the Draft EIS described and discussed acclimation issues.

Acclimation in this sense refers to the control tests and allowing the tested species to 'acclimatise' to the base diluent, which in this case was seawater collected off Point Lowly. As a consequence the salinity level of the base diluent was 41.2 g/L rather than the normal oceanic salinity level of 35–36 g/L.

It was noted in Appendix O10.5 of the Draft EIS that of the species used to calculate the species protection trigger value (SPTV), only the cuttlefish eggs and prawns were collected from Point Lowly, and were therefore acclimated to the control salinity used during tests. Snapper and Mulloway eggs were placed in test solutions to acclimatise for 24 hours prior to hatching. The remaining species were all transferred from normal seawater to the base diluent with a salinity of 41.2 g/L or greater.

The effect therefore to most of the species tested would be the equivalent of organisms moving instantaneously from oceanic water to Point Lowly, and thus an instant increase in salinity of up to 6 g/L. Since organisms would never be exposed to such large or rapid salinity changes, the lack of or limited acclimation in the test species is likely to have resulted in actual toxicity being overestimated. In other words, this approach provided a conservative SPTV, and should all species have been fully acclimated, the target dilution of return water in seawater would probably be lower (and therefore achieved more readily) than that documented in the Draft EIS.

Issue:

Clarification was sought about the method of exposure to the test concentrations (i.e. how rapidly it occurred) and whether it was similar to the exposure that would occur at Point Lowly.

Submission: 83

Response:

Organisms were instantaneously transferred from control seawater to the test solutions during tests (which is distinct from the transfer of organisms from oceanic seawater to the control seawater, discussed above). This instantaneous transfer would probably be similar to the effect of a saline plume causing abrupt salinity changes when tidal flows reversed. The tests would reflect the likely exposure and therefore provide reliable estimates of the toxicity at Point Lowly.

Issue:

It was suggested that the continuous exposure to test solutions was not conservative because organisms would adapt more easily than when repeatedly, but intermittently, subjected to the same stressor.

Submission: 80

Response:

In general, as the duration of exposure increases, the concentration at which toxic effects occur decreases (Newman 2010). Although some organisms can develop tolerance with prolonged exposure, it typically takes generations. Furthermore, the development of tolerance is likely to result in some adverse effects (Calow and Sibly 1990). For example, with elevated salinity, higher energy demands are likely to be placed on the organism, which may result in less energy being available for other functions, such as reproduction. Dassanayake (2008) showed that neither a freshwater alga nor a micro-crustacean developed tolerance to salinity after at least five generations were exposed to elevated salinity.

17.4.5 QUALITY CONTROL ISSUES

Issue:

It was suggested that the Australian Giant Cuttlefish test should be redone due to high mortality in the controls.

Submissions: 2 and 86

Response:

It is not necessary to repeat the cuttlefish test because the impact assessment is underpinned by a test in 2006 which had no mortality in the controls.

Standard tests have associated quality assurance and quality control (QA/QC) procedures, which generally include a validation criteria for survival of the control organisms, based on extensive knowledge of what high-quality procedures can normally achieve (refer Appendix O10.5 of the Draft EIS). This value does vary between species, reflecting their normal sensitivity and ability to adapt to laboratory conditions, but is typically 80–90% (ANZECC/ARMCANZ 2000). As little ecotoxicology research had been conducted on Australian Giant Cuttlefish prior to the Draft EIS investigations, a robust basis for setting this limit was not available. Nevertheless, the Australian Giant Cuttlefish tests were undertaken by experienced professionals from Geotechnical Services Pty Ltd, which operates under the ISO 9002 Quality Assurance System, with many of its routine tests registered by the National Association of Testing Authorities (NATA). The Australian Giant Cuttlefish test was performed according to Geotechnical Services' in-house quality assurance processes.

The lack of formal criteria for control survival did not matter for the 2006 tests, as there was 100% survival of the controls. The most sensitive result from these tests was used to ground-truth and adjust the SPTV used for the impact assessment, and has also been used to assess the impact on the cuttlefish spawning population (refer Appendix O10.5 of the Draft EIS). This has resulted in an assessment based on results that are not only very conservative, due to the high salinity of the diluent used in the tests, but which are also highly reliable (refer Appendix O10.5 of the Draft EIS, and see Appendix H4.3 of the Supplementary EIS).

The 2007 test had a survival rate of 62%, possibly due to a low fertilisation rate (refer Appendix O10.4 of the Draft EIS). Although this survival rate is lower than typically permitted by validation criteria, the 2007 test nevertheless provides useful data (refer Appendix O10.5 of the Draft EIS).

17.4.6 ACUTE VERSUS CHRONIC TESTS

Issue:

It was suggested that ecotoxicology studies should use only chronic or sub-chronic tests, rather than acute tests.

Submission: 2

Response:

This suggestion is consistent with the ANZECC/ARMCANZ (2000) Water Quality Guidelines, where it is considered that chronic or sub-chronic test data will give the most reliable trigger values. It is noted that the primary dataset used to determine the species protection trigger value (SPTV) for the Draft EIS included only results from chronic or sub-chronic tests (refer Table 16.8 of the Draft EIS).

Acute tests were initially conducted for two species, the Tiger Prawn *Penaeus monodon* and the Yellowtail Kingfish *Seriola lalandi*. However, following the review by Dr Michael Warne of the CSIRO, the results for the Tiger Prawn were not included in either the primary or secondary datasets used to determine the SPTV and the acute test for the Yellowtail Kingfish was superseded by a sub-chronic test which was included in the secondary dataset (refer Appendix O10.5 of the Draft EIS). The 28-day reproduction test with two-day pulsed exposure for the copepod *Gladioferens imparipes* is considered to be an acute test (refer Appendix O10.5 of the Draft EIS) but the results were included only in the secondary dataset.

Issue:

It was suggested that sub-lethal effects, including the effects on metabolic processes, immunity and behaviour (e.g. feeding and migration), were not considered.

Submissions: 80 and 86

Response:

All 13 chronic and sub-chronic tests involved sub-lethal endpoints related to growth and reproduction.

The ANZECC/ARMCANZ (2000) Water Quality Guidelines give more weight to endpoints of growth and reproduction because they are directly relevant to ecosystems. The guidelines state that the ecological significance of behavioural and biochemical endpoints is doubtful, and specifically refer to immunotoxicology as a new and relatively poorly understood discipline, that is yet to be considered a suitable endpoint for direct toxicity tests.

17.4.7 CALCULATION AND RELIABILITY OF THE SPTV

To provide context to some of the responses below, and as noted in the Draft EIS, the three ecotoxicology reports prepared by Geotechnical Services and Hydrobiology (refer Appendices O10.2 to O10.4 of the Draft EIS) each included calculations of a species protection trigger value (SPTV) based on their respective test results. However, the final SPTV used in the impact assessment was derived by Dr Michael Warne of CSIRO using the most scientifically appropriate results from all tests (refer Appendix O10.5 of the Draft EIS). This approach not only rigorously applied the ANZECC/ARMCANZ (2000) Water Quality Guidelines but also emphasised local species, used sufficient species to give stability to the results from the BurrliOz routine (Campbell et al. 2000) and avoided the use of acute tests and acute-to-chronic ratios.

Issue:

An alternative method for calculating a 'no effects' concentration was suggested.

Submission: 89

Response:

The submission discussed the limitations associated with using no observable effect concentrations (NOECs) for calculating an SPTV, and proposed an alternative model-based approach for estimating 'no effects' concentrations. Although this alternative model is of considerable interest, it is not included in the ANZECC/ARMCANZ (2000) Water Quality Guidelines and therefore has not been used. The Water Quality Guidelines recommend a phasing in of EC_{10} data to replace NOECs. This approach was adopted for the Draft EIS, with EC_{10} data, where available, being used instead of NOECs to calculate an SPTV for the proposed Point Lowly desalination plant (refer Section 16.4.2 and Appendix O10.5 of the Draft EIS).

Issue:

It was suggested that most test results failed to meet the assumptions of the statistical tests used to calculate EC_{10} values.

Submission: 2

Response:

In response to this submission, the ecotoxicology data from the Draft EIS was re-examined. It was concluded that the calculations of most EC_{10} values are valid, and minor adjustments to the others would not result in a more conservative SPTV.

The submission is disputed for most species for the following reasons (see Appendix H4.3 of the Supplementary EIS for details):

- There were no problems with the data used in the preferred dataset for the unicellular alga *Isochrysis galbana*, the macroalga *Ecklonia radiata*, the Pacific Oyster *Crassostrea gigas* and the Australian Giant Cuttlefish *Sepia apama*.
- The only potential problem for the Western King Prawn *Melicertus latisulcatus*, the Pink Snapper *Chysophrys auratus* and the Mulloway *Argyrosomus japonicus* was that the toxicity reports indicated that there was significant heterogeneity in the variances (refer Appendix O10.4 of the Draft EIS). However, the statistical method (Probit) used to analyse these data does not assume homogeneity of variance.
- For Pink Snapper, the statistical method models the data well, particularly in the region of concern (i.e. the region below the 50% effect level).
- Adjustments for the Western King Prawn and Mulloway to account for poor fits did not result in a more conservative SPTV (see Appendix H4.3 of the Supplementary EIS), and would therefore not change the impact assessment.

Issue:

Concern was expressed about the use of acute-to-chronic ratios (ACRs); one respondent stated it is not completely necessary to use an ACR as high as 10, while another claimed their use is not appropriate.

Submissions: 83 and 89

Response:

The impact assessment in the Draft EIS was based on a species protection trigger value (SPTV) derived from a primary dataset using only chronic and sub-chronic data and therefore did not use ACRs (refer Section 16.4.2 and Appendix O10.5 of the Draft EIS). The calculation of an SPTV using an ACR was done only for an ecotoxicology report prepared by Hydrobiology Pty Ltd based on its specific results (refer Appendix O10.2 of the Draft EIS).

Issue:

Clarification was sought about why SPTVs of 1:45 and 1:85 were adopted when there is data showing that a dilution factor of 1:103 would be required.

Submission: 83

Response:

The calculation of an SPTV of 1:103, based on a suite of Australian Giant Cuttlefish test results rather than data from multiple species, was done only for an ecotoxicology report prepared by Geotechnical Services Pty Ltd (refer Appendix O10.3 of the Draft EIS). This particular ecotoxicology report did not provide an SPTV suitable for impact assessment.

The impact assessment in the Draft EIS was based on SPTVs of 1:45 and 1:85 derived primarily from a dataset comprising test results for seven species, selected by Dr Michael Warne of CSIRO, using a rationale that is consistent with the ANZECC/ARMCANZ (2000) water quality guidelines (refer Section 16.4.2 and Appendix O10.5 of the Draft EIS).

Issue:

It was suggested that the procedure of using the endpoint with the lowest geometric mean should be extended to the suite of studied species, so that the species most intolerant of the tested conditions be considered as the one at which the dilution levels are aimed.

Submission: 83

Response:

This suggestion, depicted in Figure 17.3b of the Supplementary EIS, is inconsistent with the ANZECC/ARMCANZ (2000) water quality guidelines. The approach recommended by the guidelines, and adopted by Dr Michael Warne of CSIRO for the Draft EIS, is to use the BurrliOZ program to generate the SPTV from the sensitivities of multiple species. The geometric mean is used only to resolve multiple results for the same endpoint for the same species (see Figure 17.3 of the Supplementary EIS).

Dr Warne also ground-truthed the SPTV produced using the BurrliOZ method against all relevant toxicity data, and adjusted the final SPTV accordingly (refer Appendix O10.5 of the Draft EIS and see Appendix H4.3 of the Supplementary EIS).

Issue:

Concern was expressed that the calculation of species protection trigger value (SPTV) from only six results is likely to be unstable.

Submission: 89

Response:

The ANZECC/ARMCANZ (2000) water quality guidelines require data from a minimum of five species from four taxonomic groups to derive an SPTV. The impact assessment in the Draft EIS was based on an SPTV derived primarily using seven species from six taxonomic groups selected from all the test results by Dr Michael Warne of CSIRO. A secondary dataset using 10 species from six taxonomic groups produced convergent results, thus increasing its reliability (refer Section 16.4.2 and Appendix O10.5 of the Draft EIS).

The submission refers to an ecotoxicology report prepared by Hydrobiology Pty Ltd, which provided an SPTV based on its results from six species and taxonomic groups (refer Appendix O10.2 of the Draft EIS).

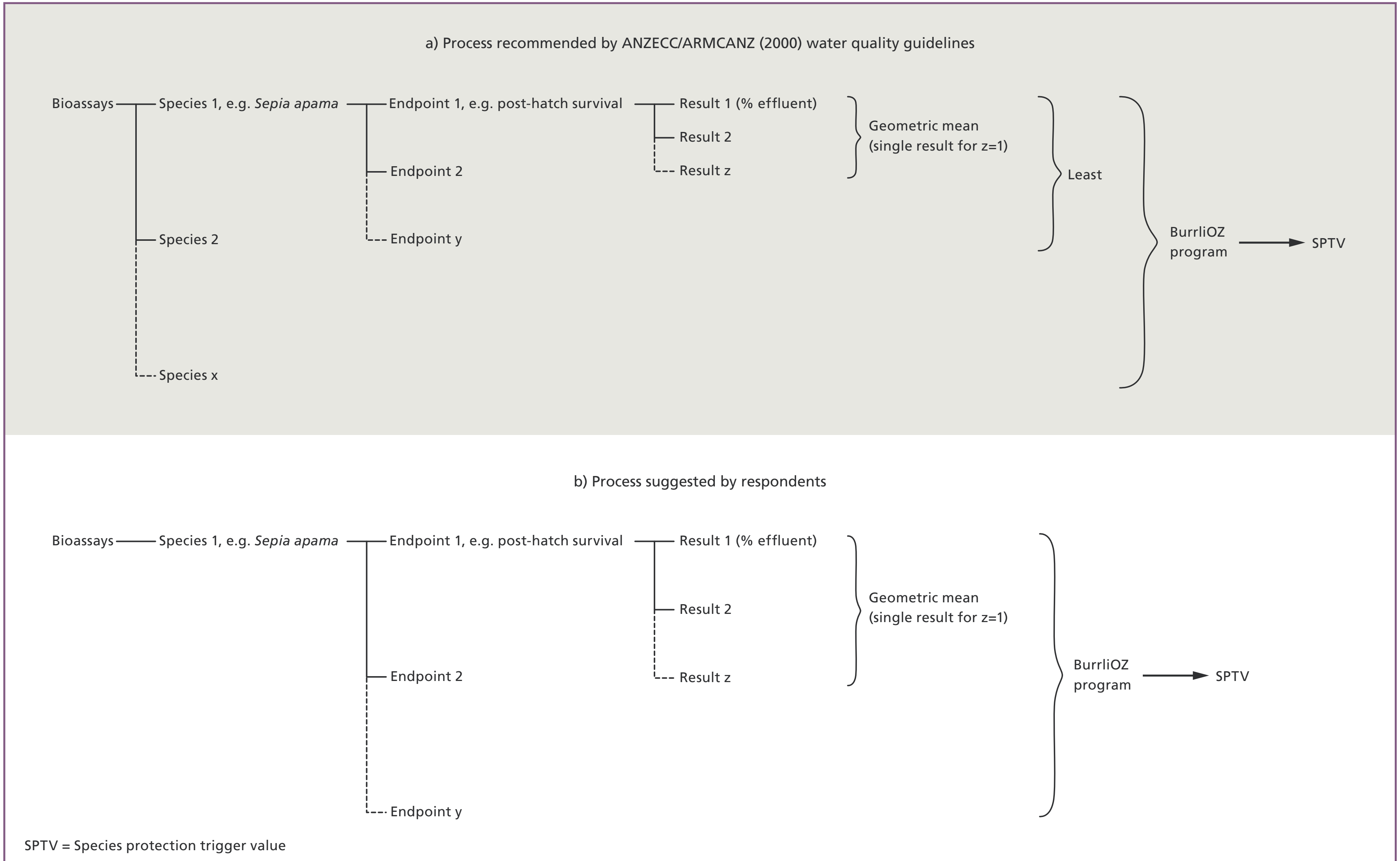


Figure 17.3 Process for calculating SPTV from multiple species, endpoints and results

Issue:
It was suggested that no clear conclusion could be drawn from the whole effluent toxicology (WET) tests.

Submission: 387

Response:

The WET tests enable reliable conclusions to be drawn concerning potential impacts of the return water discharge at Point Lowly on marine biota by providing a species protection trigger value (SPTV), or a safe dilution of return water in ambient seawater required to protect the marine ecosystem. The WET tests provide an assessment of the combined effect of increased salinity and anti-scalant.

Very reliable conclusions can be drawn regarding the overall toxicity of return water. Dr Michael Warne (Principal Research Scientist for the Centre for Environmental Contaminants Research, CSIRO, and contributing author to the ANZECC/ARMCANZ (2000) water quality guideline) reviewed all the toxicity data and concluded that an SPTV of 1:85 would protect 99–100% of species, exceeding the ANZECC/ARMCANZ (2000) requirements for protecting ecosystems of high conservation value (refer Section 16.4.2 of the Draft EIS).

17.4.8 COMPARISON WITH INDEPENDENT FINDINGS

Issue:
It was suggested that independent research has shown that cuttlefish eggs are extremely sensitive to changes in salinity.

Submissions: 40, 144, 250 and 319

Response:

The work referred to in these submissions is that of Dupavillon and Gillanders (2009) and this work was considered during the preparation of the Draft EIS. Their findings with respect to the susceptibility of the Australian Giant Cuttlefish to salinity and salinity measurements around Point Lowly were cited as personal communications with Dr Gillanders in Section 16.6.5 and Appendices O8 and O9.2 of the Draft EIS. The results of Dupavillon and Gillanders (2009) are consistent with those of Geotechnical Services Pty Ltd (refer Appendices O10.3 and O10.4 of the Draft EIS) and reinforce the validity of the ecotoxicology work undertaken for the Draft EIS.

Dupavillon and Gillanders (2009) found that survival at 45 g/L (effectively the lowest observable effect concentration (LOEC)) was lower than that at 40 g/L (effectively the no observable effect concentration (NOEC)), and that there was no survival at 50 g/L. However, they used a conductivity meter to measure salinity, and recorded salinities at Point Lowly that were approximately 1 g/L lower than those typically recorded there (refer Appendix O9.1 of the Draft EIS for discussion on salinity measurement). Therefore, it is expected that the true salinity range between the NOEC and LOEC is likely to be 41–46 g/L.

The studies undertaken for the Draft EIS were considerably more complex than the work of Dupavillon and Gillanders (2009). They tested a number of additional endpoints and, importantly, provided greater detail about the response of cuttlefish in the 40–50 g/L salinity range. The bioassays undertaken for the Draft EIS included embryo growth (width, height and weight), hatching success and post-hatch survival, after a number of different exposure durations. The tests were whole effluent toxicity (WET) tests with treatments including a range of effluent concentrations, with corresponding salinities ranging from 41 to 78 g/L. During the first phase of testing (2006), there were five treatments at salinities between 45 and 50 g/L, and three treatments with salinities of 53, 63 and 78 g/L. In the second phase of testing (2008), there were five treatments between 41 and 46 g/L and three with salinities of 50, 60 and 78 g/L.

Nevertheless, the Adelaide University ecotoxicology results are consistent with those presented in the Draft EIS, for which the NOEC, LOEC and EC_{10} were within the upper part of the Adelaide University range (43–46 g/L).

The results summarised in Table 16.8 of the Draft EIS (and presented in detail in Appendices O10.3 and O10.4) showed that the salinity at which there was an effect was 45.6 g/L for the 2006 tests, and 43.6 g/L for the 2008 tests (EC_{10} values for the embryo development endpoint). The NOEC and LOECs were also within the range 43.6–46 g/L. These may understate the tolerance of cuttlefish to salinity, given that the toxicity could be partially due to the anti-scalant.

Therefore, although the results of Dupavillon and Gillanders (2009) are less detailed, it is concluded that they are consistent with those of Geotechnical Services and reinforce the validity of the ecotoxicology work undertaken for the Draft EIS.

17.4.9 FURTHER TOXICITY TESTING

Issue:

Concern was expressed that the toxicity of the return water would not be known until the plant was operating.

Submission: 209

Response:

The most likely composition of the return water from the Point Lowly desalination plant is known and was described in detail in Section 16.4.1 of the Draft EIS. The ecotoxicology testing undertaken for the Draft EIS reflected this composition, consistent with a whole effluent toxicity (WET) testing approach required by the ANZECC/ARMCANZ (2000) water quality guidelines. In particular, test return water was obtained from seawater collected off Point Lowly, with anti-scalant added and passed through a pilot reverse osmosis desalination plant. Therefore the toxicity of the return water, presented in Section 16.4.2 and Appendix O10.5 of the Draft EIS, is known.

For completeness, BHP Billiton noted in the Draft EIS that further testing would occur to confirm the SPTV should the anti-scalant applied to the desalination process be changed from that tested.

Issue:

Additional detail about future ecotoxicology tests was requested. A range of commitments was sought, including repetition of the 30-day post-hatch survival cuttlefish test, before the plant became operational.

Submissions: 1 and 2

Response:

As noted above, future ecotoxicology tests would be done in the event that the anti-scalant selected by the plant operator changed from that assessed in the Draft EIS. The reason for retaining this flexibility rather than dictating the anti-scalant to be used is that it allows for improvements in technology that may reduce the environmental effect of the anti-scalant. Such advances have been recorded by Patel (2010).

In the event that re-testing is required, BHP Billiton would liaise with the Australian and South Australian governments to determine the most appropriate tests to be conducted.

17.5 MODEL VALIDATION AND RELIABILITY

17.5.1 APPLICABILITY OF MODEL TO SPENCER GULF

Issue:

Clarification was sought about the applicability of the hydrodynamic model to the unique environment of Upper Spencer Gulf.

Submissions: 27 and 346

Response:

The Estuary, Lakes and Coastal Ocean Model (ELCOM), developed at the University of Western Australia, provides a modelling framework that can be adapted to a variety of waterbodies. As discussed in Section 16.4.3 of the Draft EIS, it has been successfully applied to 50 waterbodies worldwide, including the Venice Lagoon, the Adriatic Sea, the Caribbean Sea, the Red Sea, the Persian Gulf, the Adelaide coastline and Cockburn Sound in Western Australia, many of which have similarities with Spencer Gulf. The Cockburn Sound model was applied to the Perth desalination plant and has been validated using data collected during operation (Water Corporation and 360 Environmental 2008).

Oceanographic information specific to Spencer Gulf, including bathymetry, weather, tides, salinity and temperature, were used to configure, calibrate and validate the far-field model. Similar information specific to Upper Spencer Gulf was used to configure the mid-field model, in addition to targeted deployments of current meters.

Details of the data used to calibrate and validate the model used in the Draft EIS, and the refined model developed for the Supplementary EIS, are provided in Appendix O11.2 of the Draft EIS and Appendix H5.2 of the Supplementary EIS, respectively.

Issue:

Clarification was sought, in the context of the 2 m vertical resolution of the ELCOM models, about which 2 m section (e.g. surface or bottom) had been modelled.

Submission: 27

Response:

ELCOM is a three-dimensional model and is therefore able to simultaneously model all depths in Spencer Gulf. As discussed in Section 16.2.4 of the Draft EIS, both the mid-and far-field models were set up with a 2 m vertical resolution. This means that, for example, water of 20 m depth would have been considered as 10 separate layers in each 200 m x 200 m mid-field cell (refer Figure 16.3 of the Draft EIS), or 2 km x 2 km far-field cell. These cells and layers can have differing currents, temperatures and salinities that reflect the natural variability found in the gulf. The bottom layer will generally be partially filled to account for the variable bathymetry (refer Figure 16.3e of the Draft EIS). The top layer(s) allows the depth to vary with the tides and allows wetting and drying of coastal areas.

Following the publication of the Draft EIS, additional modelling has been undertaken with a refined ELCOM model to improve the resolution of predictions. The refined model uses 31 vertical layers, including 20 of 1–2 m thickness down to 35 m (i.e. beyond the depth of the diffuser), but increasing to 4–12 m thickness in the deeper (35–70 m) sections of the gulf (see Appendix H5.2 of the Supplementary EIS for details).

17.5.2 CONFIDENCE IN MODEL

Issue:

Concern was expressed that the scientific validity of the modelling had been questioned in submissions to the Parliamentary Committee on Environment, Resources and Development by Associate Professor John Middleton of the South Australian Research and Development Institute (SARDI) and Dr Jochen Kaempf of Flinders University.

Submissions: 26, 27, 86, 124, 131 and 376

Response:

Both Associate Professor Middleton and Dr Kaempf have publicly acknowledged the high quality of the modelling undertaken for the Olympic Dam Expansion Draft EIS. Associate Professor Middleton did, however, note concerns about the quantity of data collected to calibrate and validate the model, which have subsequently been addressed (see Section 17.5.3 of the Supplementary EIS). Although Dr Kaempf expressed various concerns that have also been addressed in the Supplementary EIS, he ultimately concluded that the modelling undertaken for the Draft EIS produced similar results to those of his own work (i.e. Kaempf et al. 2009). The interpretation of these results by Kaempf and others (2009) is discussed in detail elsewhere in this document.

Specifically, Associate Professor Middleton, Oceanography Program Leader at SARDI Aquatic Sciences, told the Environment, Resources and Development Committee's inquiry into desalination that the hydrodynamic ocean current modelling undertaken to predict brine dilution for the Draft EIS was of a very good technical standard in terms of the models, and the sophistication and degree of complexity needed to address the task (ERDC 2009a; Middleton 2009). Professor Middleton did raise some concerns about the amount of data collected to validate the Spencer Gulf model. These concerns are addressed in Section 17.5.3 of the Supplementary EIS.

Similarly, Dr Kaempf described the Spencer Gulf modelling studies as 'good, high quality' (ERDC 2009b). He did not, in general, question the scientific validity of the models, but stated that there were some (unspecified) details with which he disagreed (ERDC 2009b). A subsequent report by Dr Kaempf, included as an attachment to Submission Number 83, raised concerns, addressed elsewhere in the Supplementary EIS, that:

- some instruments used to collect validation data were not sufficiently accurate (see Section 17.5.3)
- the potential for upwelling of the return water plume had been overlooked (see Section 17.7.7)
- predictions of flushing time and salinity distributions shown in the Draft EIS were questionable due to a lack of adequate data for the ocean boundary and exclusion of the oceanic shelf from the model domain (see Sections 17.5.4 and 17.6.1).

Issue:

It was suggested that the model needs to be independently tested, and that an independent model had given (or could give) different outcomes.

Submissions: 81, 83 and 346

Response:

The work undertaken by BMT WBM Pty Ltd for BHP Billiton's Olympic Dam Expansion Draft EIS was independently peer-reviewed by experts from two internationally recognised marine engineering companies: HR Wallingford Ltd in the UK and Cardno (NSW/ACT) Pty Ltd (formerly Cardno Lawson Treloar Pty Ltd). These reviewers provided letters of testimony stating that the modelling was acceptable for its intended use, and to some extent exceeded normal industry practice (refer Appendix O11.1 of the Draft EIS).

This work was also reviewed by oceanographer Dr Rick Nunes-Vaz, an author of some of the definitive papers on Spencer Gulf oceanography. Dr Nunes-Vaz endorsed, in particular, the outcomes of the far-field model, finding that it gave a useful and valid representation of Spencer Gulf hydrodynamics and salt mixing mechanisms (refer Appendix O11.1 of the Draft EIS).

The refined model, developed and calibrated since the Draft EIS was published, has also been reviewed by the same experts who reviewed the original work. They found that the change to a single, integrated three-dimensional model, the increased horizontal resolution near the proposed outfall and improved input data for the model boundaries were significant enhancements, and that the model was again fit for its intended purpose (see Appendix H5.1 of the Supplementary EIS).

It is also noted that Kaempf and others (2009) have provided an independent modelling study of the proposed desalination plant. The results of this model, although in some cases similar to those reported in the Draft EIS, should be interpreted with caution. Furthermore, the conclusions drawn from the model results are disputed. A summary of the modelling approach, results and interpretation of Kaempf and others (2009) compared with those of the Draft and Supplementary EIS is provided by Table 17.1, and a detailed comparison of the models is provided in Appendix H5.3 of the Supplementary EIS.

Table 17.1 Summary of the modelling approach, results and interpretation of Kaempf and others (2009) compared with those of the Draft and Supplementary EIS

	High resolution (mid-field, short-term)	Low resolution (far-field, long-term)
Results from Kaempf et al. 2009	Minimum dilution of approximately 1:10 at 100 m. Salinity changes of 4 g/L and potentially 10 g/L above ambient within 500 m.	Flushing time of 12–24 months and long-term brine concentrations near Point Lowly of 0.3%.
Results from Draft and Supplementary EIS	Minimum dilutions of approximately 1:10 at 100 m for the Draft EIS (corresponding to a salinity 4 g/L above ambient), but 1:43 for the Supplementary EIS, (salinity within 0.7 g/L of ambient at 100 m at all times).	Flushing time of 8–12 months and long-term brine concentrations near Point Lowly of approximately 0.2% (Draft EIS) and 0.4% (Supplementary EIS).
Interpretation of similarity/ difference	An interplay of conservative or questionable assumptions and erroneous parameters by Kaempf et al. (2009) produced coincidentally convergent results to the very conservative approach adopted for the Draft EIS (see Appendix H5.3 of the Supplementary EIS). The results of the Supplementary EIS are based on a modified diffuser design and more accurate (less conservative) modelling, particularly in relation to initial dilutions achieved by the diffuser (see Appendix H7.2 of the Supplementary EIS).	The modelling undertaken for the Draft and Supplementary EIS is considered to be more robust and reliable than that undertaken by Kaempf and others (2009). Nevertheless, flushing times from all three models are generally consistent with oceanographic processes operating on an annual timeframe. Differences in long-term return water concentrations near Point Lowly are difficult to interpret as the discharge rate modelled by Kaempf and others (2009) is less than half that modelled for the Draft EIS, but are of the same order of magnitude.
Ecological conclusions drawn by Kaempf et al. 2009	The relatively slow flushing means that Upper Spencer Gulf is not suited to the discharge of pollutants. The long-term exposure and potential accumulation of pollutants in bed sediment is of ecological concern. Severe and irreversible impacts may arise due to the relatively sheltered marine environment, slow flushing and existing stress (citing seagrass loss 17 years ago near Port Broughton resulting from desiccation during extremely low tides).	
Ecological conclusions drawn by Draft and Supplementary EIS	Impacts near Point Lowly would be restricted to a zone of ecological effect spanning a few hundred metres and may result in a shift in community structure similar to 10–20 km north of Point Lowly.	Annual flushing is adequate to ensure long-term return water concentrations are negligible. The increase in salinity would be comfortably within natural variability and ecological effects would be negligible.

Issue:

It was suggested that the difficulty in modelling fluid dynamics and the inherent complexity of the real world meant hydrodynamic models could not be relied upon.

Submissions: 16, 36, 81, 83, 114, 122, 124, 211, 250, 285 and 368

Response:

A three-dimensional hydrodynamic model, such as ELCOM, is capable of reliably reproducing highly complex hydrodynamics.

Hydrodynamic models have been successfully validated against real data for 50 waterbodies worldwide. In particular, the ELCOM model of the Cockburn Sound desalination plant in Western Australia has been validated using monitoring data collected during operation of the plant (refer Section 16.4.3 of the Draft EIS). The model predictions have also been verified using other assessment tools (e.g. see Appendix H8.1 of the Supplementary EIS).

An important measure of the reliability of hydrodynamic models is their ability to reproduce natural oceanographic phenomena. The ELCOM models developed for Point Lowly have been able to accurately reproduce the following phenomena in Spencer Gulf (refer Section 16.4.3 of the Draft EIS, and see Sections 17.5.3 and 17.5.4 and Appendix H5.2 of the Supplementary EIS):

- the tidal amplification of both diurnal and semi-diurnal constituents, and their phasing, between Port Lincoln and Whyalla
- the very small semi-diurnal component associated with the nodal point near Wallaroo
- the seasonal north-south salinity and temperature gradients throughout Spencer Gulf
- the gulf-scale clockwise circulation pattern in Spencer Gulf, with seasonal removal of salt along the seabed of the eastern shore (refer Figure 16.19 and Section 16.3.2 of the Draft EIS for further detail)
- the clockwise eddy off Point Lowly during an ebbing tide with comparable speeds and directions
- current speeds and directions throughout measured depth profiles
- the occurrence of contra-flows (see response below)
- long-term salinity fluctuations in response to changes in evaporation.

The ELCOM model has also demonstrated why wind-driven upwelling would not occur at Point Lowly (see Section 17.7.7 of the Supplementary EIS for further detail about wind-driven upwelling).

Issue:

It was suggested that Spencer Gulf has many localised conditions that cannot be simulated by a model. A specific example was that, during an ebbing tide, a strong flow was observed running into the gulf at a different level in the water column (i.e. a contra-flow).

Submission: 83

Response:

The ELCOM model is a three-dimensional model and is therefore inherently capable of reproducing such conditions. An example from the refined high-resolution model is provided in Figure 17.4 of the Supplementary EIS.

Further evidence of the model's ability to reproduce water flowing in different directions at different levels in the water column was provided by the comparisons with the boat-mounted Acoustic Doppler Current Profiler (ADCP) transects across the rip off Point Lowly. The model reproduced the transition from southerly to south-westerly flows across the channel in the upper water column and a nearly constant south-westerly flow in the bottom part of the water column (see Appendix H5.2 of the Supplementary EIS).

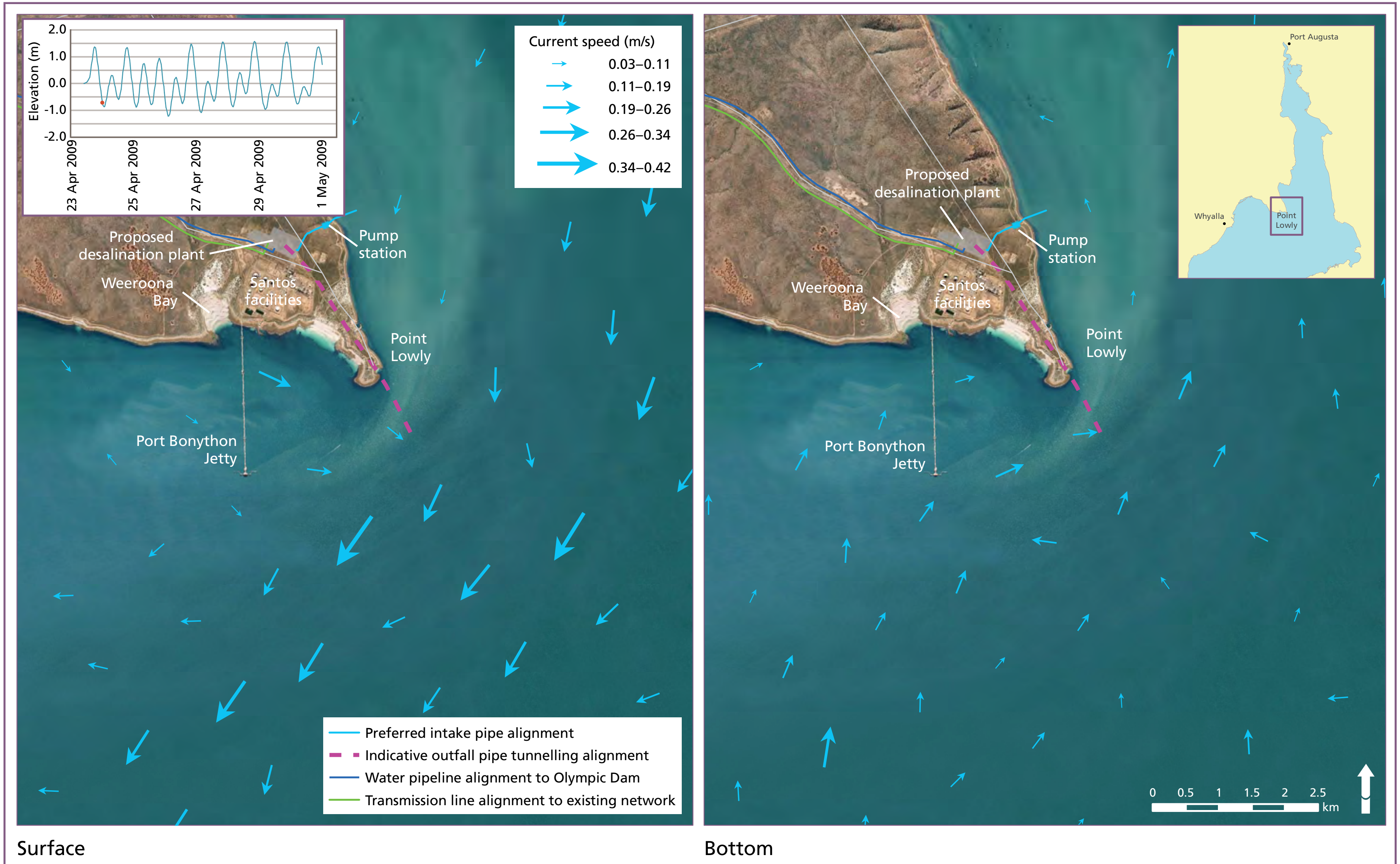


Figure 17.4 Example of contra-flow, with surface and bottom currents travelling in opposite directions

17.5.3 DATA REQUIREMENTS

Issue:

It was suggested that significantly more data should be collected to better calibrate models (especially over extreme dodge tides) and to show that wind- and density-driven currents have been modelled correctly.

Submissions: 2 and 27

Response:

The dataset used to calibrate the hydrodynamic models for the Draft EIS is comparable with best practice (as supported by the peer reviews in Appendix O11.1 of the Draft EIS). The model has been shown to accurately reproduce oceanographic characteristics of Spencer Gulf. Additional data has been collected to increase confidence in the outcomes of the refined model developed for the Supplementary EIS.

In the Draft EIS, far-field model predictions were compared with (refer Appendix O11.2 of the Draft EIS for details):

- data obtained from Flinders Ports for tidal water levels at Port Lincoln, Wallaroo and Whyalla over neap and spring tides (Appendix O11.2, pages 5–13 to 5–14)
- historical salinity and temperature data collected over three years by Dr Rick Nunes-Vaz at four locations, three of which are in Upper Spencer Gulf (Appendix O11.2, pages 5–13 to 5–21)
- additional long-term (5–12 month) historical datasets (day of year comparisons), including water surface elevation and temperature, salinity and density measurements from surface, bottom and mid-depth, at three locations (Appendix O11.2, pages B6 to B14).

Calibration of the mid-field and far-field models was linked to some degree as the mid-field model is nested within the far-field model. Simultaneous predictions of salinity, temperature, tidal elevation and current velocity direction at several sites, including Point Lowly, were found to compare well (refer Appendix O11.2 of the Draft EIS). Note that comparisons of current velocity magnitude were inherently problematic due to the differing grid cell sizes (refer Appendix O11.2 of the Draft EIS).

Further mid-field validation focused on comparisons with (refer Appendix O11.2 of the Draft EIS for details):

- the eddy that forms on the southern side of Point Lowly during an ebbing tide, with current speeds and directions (measured using a boat-mounted Acoustic Doppler Current Profiler (ADCP)) showing that the model was able to accurately reproduce the eddy (Appendix O11.2, pages 5–27 to 5–33)
- current velocity data, collected over a 40-day period in 2006 near Port Bonython jetty (Appendix O11.2, pages 5–34 to 5–39)
- current velocity data collected over a 70-day period in 2007–2008 near Point Lowly (Appendix O11.2, page B-40).

For the calibration and validation of the refined model, additional water elevation, current, salinity and temperature data was collected over a 40-day period in late autumn/early winter (when the most extreme dodge tide periods generally occur), to supplement the data listed above. This data has conclusively demonstrated that wind- and density-driven currents have been properly modelled. The data collected included (see Appendix H5.2 of the Supplementary EIS for details):

- current velocity profiles from the proposed outfall at Point Lowly and three locations approximately 5 km to the west (in cuttlefish habitat), north and south of this point (see locations A-D in Figure 17.5)
- salinity and temperature data from the site of the proposed outfall, the cuttlefish habitat to the west, in channels 5 km and 10 km offshore from Whyalla (in the latter case at two depths), and near Port Augusta (see Figure 17.5)
- meteorological data from an elevated, inland station on Point Lowly peninsula (see label 'MET' in Figure 17.5).

The models developed for the Draft and Supplementary EIS were independently peer-reviewed by experts from two internationally recognised marine engineering companies: HR Wallingford Ltd in the UK and Cardno (NSW/ACT) Pty Ltd (formerly Cardno Lawson Treloar Pty Ltd), and Dr Rick Nunes-Vaz, an author of some of the definitive papers on Spencer Gulf oceanography. Reviewers provided letters of testimony stating that the modelling was acceptable for its intended use, and to some extent exceeded normal industry practice (refer Appendix O11.1 of the Draft EIS and see Appendix H5.1 of the Supplementary EIS).

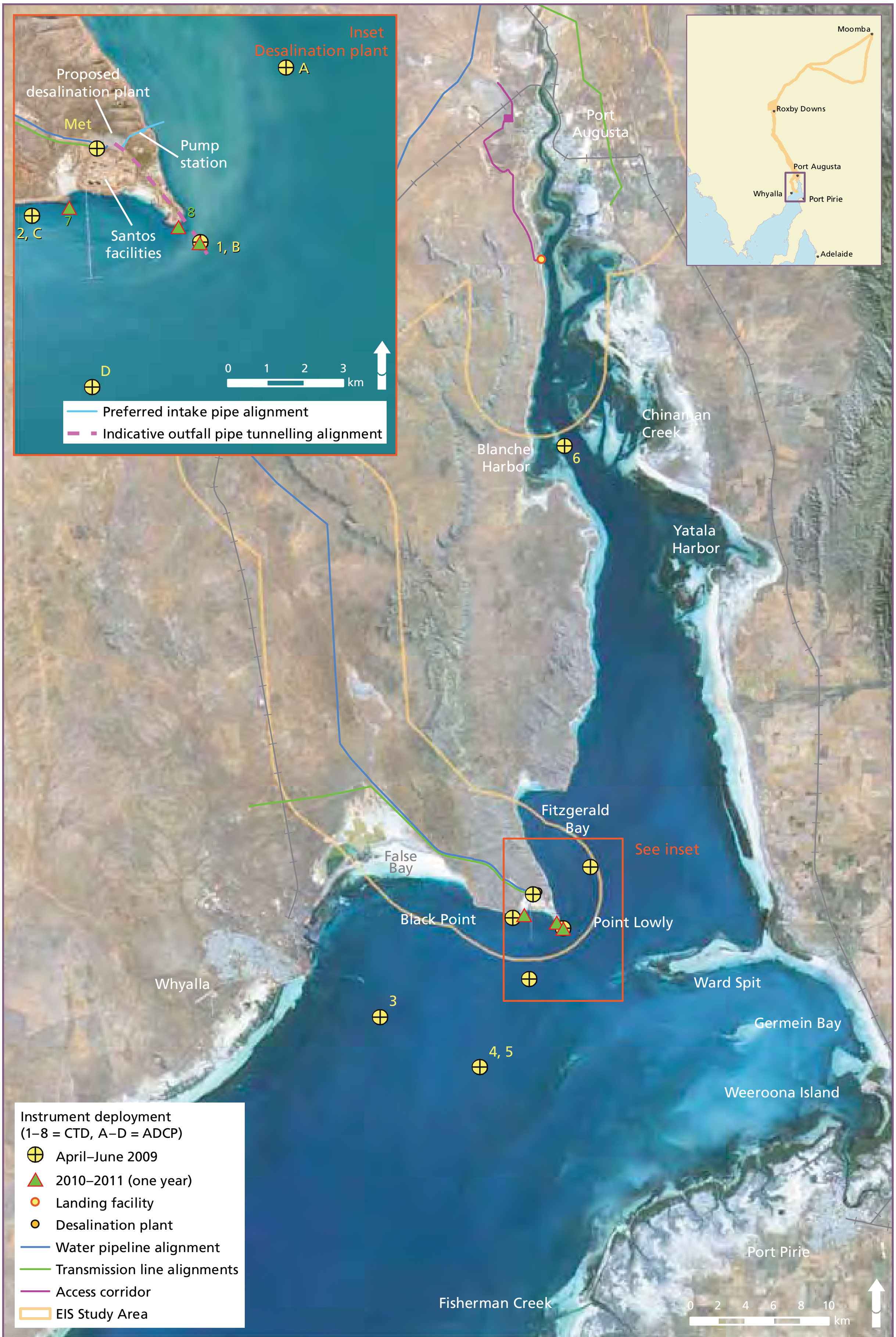


Figure 17.5 Locations of oceanographic and meteorological instruments deployed near Point Lowly from April to June 2009, and March 2010 to March 2011

Issue:

It was suggested that BHP Billiton should commit to continuous collection of water quality and ocean current data before and after the plant commenced operation, and this data should be available 'live', thus facilitating a timely management response where appropriate.

Submission: 2

Response:

BHP Billiton has committed to future monitoring to confirm that model predictions are consistent with measured data both before and during the operation of the desalination plant.

Current speeds would be monitored off Point Lowly using an ADCP (Acoustic Doppler Current profiler) current meter for sufficient time to enable the model predictions to be validated before and during operation of the plant. Current data would be transmitted in real-time to the desalination plant via telemetry on a moored buoy.

Water quality at Point Lowly would be monitored using salinity/temperature data loggers or potentially other means for at least two years prior to construction, during the period of construction before the desalination plant began operating and after the plant became operational (refer Section 16.6.5 of the Draft EIS, and see Section 17.2.1 of the Supplementary EIS).

During operation of the plant, salinity would be monitored continuously at a number of strategic locations, including in the vicinity of the outfall and in the Australian Giant Cuttlefish breeding habitat. The data would be retrieved in real time (using live telemetry) enabling appropriate management responses to be initiated should dilution targets be exceeded.

The proposed monitoring program would need to resolve a number of challenges that are often associated with long-term monitoring of salinity in marine environments, including calibration drift caused by instrument fouling, the ability of adjacent instruments to accurately report small differences in salinity and measuring the broad range of salinities prevailing at Pt Lowly.

The monitoring technology used is likely to be similar to that developed in Western Australia by 360 Environmental, Wave Solutions, Tyco, KBR and Greenspan for the Cockburn Sound Desalination Plant. In Cockburn Sound three monitoring stations continuously record dissolved oxygen, temperature and conductivity via sensors positioned at 1 m intervals through the water column, and transmit the data in real-time to operators at the desalination plant.

At Point Lowly, salinity changes may be monitored by deploying temperature and conductivity sensors upstream and downstream of the outfall and transmitting the data via telemetry on a moored buoy to the desalination plant control room. An alternative approach may be to pump seawater, from locations on the seafloor upstream and downstream of the outfall, to CTD (Conductivity, Temperature and Depth) sensors attached to a moored buoy.

A similar salinity monitoring station would be established in the nearest cuttlefish breeding habitat off Point Lowly, approximately 800 m northwest of the outfall.

It is noted that since the Draft EIS was published, a long-term (minimum 12 months) data collection program has been initiated (in March 2010) using a current meter at the proposed outfall (site B in Figure 17.5 of the Supplementary EIS), and salinity/temperature loggers at the outfall (depth 26 m), at the end of Point Lowly (6 m) (site 8 in Figure 17.5), and near important cuttlefish habitat just off Stony Point (6 m) (site 7 in Figure 17.5). Monitoring would recommence two years before construction of the desalination plant began. Data from the first six months of this program is summarised in Appendix H5.5 of the Supplementary EIS.

Issue:

It was suggested that the model results should be verified with the release of Rhodamine dye tracers.

Submission: 80

Response:

Section 16.6.5 of the Draft EIS stated BHP Billiton's commitment to use Rhodamine dye tests to validate the performance of the diffuser when the plant begins operation.

It is not possible to use Rhodamine dye to verify model predictions of return water dispersion until the return water discharge begins. Rhodamine dye must be introduced into the return water and discharged via the diffuser to enable model predictions to be accurately verified.

Issue:

Additional data was requested to clarify salt accumulation and gulf turnover rates.

Submission: 219

Response:

Considerable effort has been invested to understand the processes that relate to salt balance in Upper Spencer Gulf, through the analysis of long-term monitoring data by an oceanographer and hydrodynamic modelling work. The outcomes of this work were provided in detail in the Draft EIS in Sections 16.4.3 and 16.6.4, Figure 16.20, Appendices O9.4 and O11.4, and in an animation of a model output showing the flushing of Spencer Gulf that was provided with the Draft EIS and was available for viewing on the BHP Billiton website.

The hydrodynamic model predictions showed that the long-term average increases in salinity arising from desalination would be approximately 0.07 g/L near Point Lowly and 0.03 g/L further north in Upper Spencer Gulf. The model predicted that a steady state would be reached after one year and a new salt balance would be maintained from year to year (refer Appendix O11.4 of the Draft EIS). Similarly, the refined model predicts a stable long-term salinity increase of 0.05–0.15 g/L in Upper Spencer Gulf.

Since the Draft EIS was published, a study by Dr Nunes-Vaz has shown a clear relationship between measured evaporation (the dominant cause of water loss), accumulated over the previous six months, and salt loads north of Point Lowly (see Appendix H8.1 of the Supplementary EIS). From this, the impact of desalination (another cause of water loss) on salt loads can be predicted. The outcomes of this study are provided in Section 17.6.1 of the Supplementary EIS and are consistent with the findings of the Draft EIS. The methodology described in this study allows for the validation of hydrodynamic model predictions through monitoring of regional salinity north of Point Lowly (see Section 17.6.3 of the Supplementary EIS).

The gulf turnover rates (i.e. flushing times) were also modelled in order to improve understanding of the oceanography of Spencer Gulf (refer Figure 16.21 and Appendix O11.4 of the Draft EIS). Flushing time is only one factor that influences salt balance in Upper Spencer Gulf, but the finding of an annual flushing cycle is considered to support the conclusion of a steady-state salt balance.

Issue:

Concern was expressed about the accuracy of the YSI Model 650 MDS and Greenspan Model CS304 instruments used to measure salinity.

Submissions: 83, 192 and 376

Response:

Water quality data collected using the YSI Model 650 MDS and Greenspan Model CS304 instruments and presented in Appendix O11.2 of the Draft EIS was not used to calibrate or validate the Draft EIS models. The data in question was used to increase understanding of daily and seasonal variability, and is considered to be adequate for that purpose. The salinity data used to calibrate and validate the hydrodynamic models is considered to be very accurate. The accuracy of the field instruments used to collect this data is ±0.3 g/L, but the data was validated and corrected with a laboratory-based instrument with an accuracy of approximately ±0.02 g/L.

Reliable data sourced from Nunes (1985) was used to calibrate and validate the Draft EIS models. This data was collected using field instruments that had been specially modified to measure the higher salinities of Spencer Gulf. Grab samples taken to validate this data were measured using an Autolab salinometer (Nunes 1985; Nunes and Lennon 1986), with a typical accuracy of 0.02 g/L (R Nunes-Vaz, consultant oceanographer, pers. comm., 17 Jan 2010). A study undertaken for the Draft EIS verified measurements made in 2007 by this same instrument with measurements from the internationally recognised Rosenstiel School of Marine and Atmospheric Science in Florida (refer Appendix O9.1 of the Draft EIS).

For the refined model, however, a heightened emphasis has been placed on the use of recent data for calibration and validation. Salinity data was therefore collected concurrently at five locations over 40 days (April–June 2009) using the more recent Greenspan CTD3100 sensors (see Figure 17.5 and Appendix H5.2 of the Supplementary EIS). A number of strategies (endorsed by Dr Nunes-Vaz) were adopted to ensure the data was accurate (see Appendix H5.2):

- new instruments were used
- extra calibration tests were undertaken at salinities and temperatures expected during deployment near Point Lowly
- instruments were checked and sensor faces cleaned every one to two weeks to minimise calibration drift caused by biofouling

- duplicate grab samples were taken and subsequently analysed using the salinometer, to enable independent cross-checking of the data and *post hoc* correction of calibration drift.

The calibration tests showed that the maximum error in salinity measurements likely from the field instruments would be 0.3 g/L. This is of limited relevance for this study, however, as the grab samples, measured by the highly accurate salinometer, were used to ground-truth and correct the CTD signals. The maximum difference between the field sensor and salinometer measurements was similar to the maximum error predicted from calibration tests (see Appendix H5.2 of the Supplementary EIS).

These measures adopted above have ensured that the data accuracy is excellent, and appropriate for the purpose of modelling saline discharges.

Issue:

The reliability of measurements taken from a boat-mounted Acoustic Doppler Current Profiler (ADCP) was questioned, although no specific concerns were raised.

Submission: 83

Response:

The hydrodynamic models were validated against data collected using both moored ADCPs (to provide detailed temporal information at particular sites) and boat-mounted ADCPs (to provide more detailed information about the spatial variability of currents near Point Lowly).

ADCP measurements from moving vessels are now routinely made over a wide range of hydrological conditions, and have been used to give detailed observations of the spatial patterns of tidal flows (Gartner and Ganju 2007; Larsen 2007; Mirfenderesk and Tomlinson 2007; Vennell and Beatson 2006; Yorke and Oberg 2002; Simpson and Oltmann 1993; see also Appendix H5.2 of the Supplementary EIS).

Staff from BMT WBM Pty Ltd adopted best-practice techniques (e.g. Oberg et al. 2005) during the deployment of the boat-mounted ADCP. This included the use of a differential GPS unit to track boat movement and overcome potential biases that can arise in high current flows, due to downstream bed sediment movement (Gartner and Ganju 2007). It is therefore considered that the data collected using the boat-mounted ADCP is suitable for use for model validation, particularly given that it was applied only qualitatively.

Issue:

Clarification was sought about the apparent lack of measurements of near-bottom currents provided by the Draft EIS. Specific concerns were that: only 40 days of ADCP data had been collected; this data had been inadequately presented; and subsequent field data had not been presented.

Submission: 83

Response:

Details of the most relevant near-bottom current velocity data were provided in the Draft EIS, and have similarly been provided for further relevant data collected for the Supplementary EIS.

As discussed in Appendix O11.2 of the Draft EIS, current velocity data was collected initially over a 40-day period in 2006 near Port Bonython Jetty, but subsequently at Point Lowly over a 70-day period in 2007–2008. The latter dataset is considered to be the most relevant to plume dispersion at the preferred outfall, and was presented as a percentile table in Appendix O11.2 of the Draft EIS and referred to in Section 16.4.3 of the Draft EIS. Percentiles for both datasets are reproduced in Table 17.2 of the Supplementary EIS.

As discussed above, additional current velocity data has been collected to calibrate and validate the refined model. The near-bottom currents measured at Point Lowly have been presented in an appropriate graphical format and accompanied by a percentile table (see Appendix H5.4 of the Supplementary EIS).

Table 17.2 Near-bottom current velocities measured using ADCPs

	Percentile										
Location	**0**	**1**	**5**	**10**	**25**	**50**	**75**	**90**	**95**	**99**	**100**
Port Bonython	0.00	0.02	0.06	0.08	0.13	0.22	0.34	0.50	0.61	0.74	0.86
Point Lowly	0.004	0.048	0.12	0.19	0.38	0.70	1.01	1.26	1.38	1.54	2.11

17.5.4 SPECIFIC MODEL VALIDATION ISSUES

Issue:

It was questioned whether correct tidal flow patterns have been taken into account in the model.

Submission: 346

Response:

Considerable attention has been placed on reproducing tidal currents, particularly during dodge tides, during calibration and validation of hydrodynamic models for the Draft and Supplementary EIS.

As discussed in Section 16.4.3 and Appendix O11.2 of the Draft EIS, the mid-field model accurately reproduced current speeds and directions in the vicinity of Point Lowly, including the clockwise eddy off Point Lowly during an ebbing tide, and currents throughout the depth profile near the end of the Port Bonython jetty.

During development of the Draft EIS, a current meter was deployed at Point Lowly for 40 days (including three dodge tides). The current speeds from near the seafloor were compared with model predictions from the same time of year (see memo entitled Appendix B: Additional Calibration Works, forming part of Appendix O11.2). As discussed in Section 16.4.3 and Appendix O11.2 of the Draft EIS, the model predictions were found to be lower than the ADCP measurements. Consequently, the model provided conservative estimates of dilutions, and therefore recalibration of the model was not considered necessary at that time.

Development of the refined model for the Supplementary EIS has provided an opportunity to recalibrate and refine the modelling of current velocities near the outfall at Point Lowly. Furthermore, four ADCPs have been deployed in the vicinity of Point Lowly, ensuring that modelled currents can be validated across the area likely to be affected by the return water plume (see Section 17.5.3 of the Supplementary EIS), setting a new benchmark for best practice impact assessment. Comparisons between modelled and measured currents clearly show that tidal currents have been accurately modelled (see Section 5 of Appendix H5.2 of the Supplementary EIS). This conclusion has been endorsed by all peer reviewers (see Appendix H5.1 of the Supplementary EIS).

The refined model has predicted better dilutions at 100 m (partly due to diffuser design refinements), and a smaller zone of ecological effect to that presented in the Draft EIS.

Issue:

It was questioned whether the slow rate of exchange has been taken into account in the hydrodynamic model.

Submission: 346

Response:

Modelling has shown the flushing time of Spencer Gulf to be about one year, which is consistent with predicted and observed oceanic processes.

Flushing of the gulf over an approximately annual cycle was confirmed by the model via two distinct measures of flushing: an analysis of salt exchange across the mouth of the gulf, and reproduction of the hypersaline gravity flows along the gulf to the ocean, which is the mechanism by which salt is removed from the gulf (refer Section 16.4.3 and Appendices O11.2 and O11.4 of the Draft EIS).

An annual flushing cycle has been shown to be adequate to prevent significant inter-annual or long-term accumulation of salt or chemicals in Spencer Gulf (refer Section 16.4.3 and Appendix O11.4 of the Draft EIS). Furthermore, the flushing time of the gulf is unrelated to the immediate dispersion of the return water in the vicinity of Point Lowly (see Section 17.7.5 of the Supplementary EIS). Increases in salinity near the diffuser showed a consistent pattern relating to a fortnightly spring-neap tidal cycle rather than an annual flushing cycle (see Appendix H7.2 of the Supplementary EIS).

Issue:

It was questioned whether the modellers from the University of Western Australia had used information provided by BHP Billiton only, or whether they sought local knowledge about Spencer Gulf.

Submission: 165

Response:

The hydrodynamic modelling studies undertaken for the Draft EIS were a partnership between the Centre for Water Research at the University of Western Australia and BMT WBM Pty Ltd (refer Section 16.4.3 of the Draft EIS). The construction, configuration, calibration and validation of the hydrodynamic model were based on data (rather than opinions) from a number of sources, including (refer Appendix O11.2 of the Draft EIS for details):

- a literature review of journals and reports undertaken to identify important background information regarding the study site and hydrodynamic processes occurring in Spencer Gulf
- bathymetry data primarily from local Admiralty and navigation charts
- tidal data from the National Tide Centre (Bureau of Meteorology), Flinders Ports Corporation and Australian Hydrographic Services (Royal Australian Navy)
- meteorological data from the Bureau of Meteorology
- published and unpublished water quality data collected by oceanographer Dr Rick Nunes-Vaz (formerly of Flinders University)
- a data collection program undertaken by BMT WBM Pty Ltd to measure currents, tides, water quality, wind speed and direction.

In addition to the above information, the refined model has used the following information sources (see Appendix H5.2 of the Supplementary EIS for details):

- meteorological, tidal, salinity and temperature data from several global atmospheric models
- high-resolution bathymetry databased on acoustic mapping undertaken for BHP Billiton in the vicinity of Point Lowly
- a second data collection program to measure currents, tidal levels, salinity, temperature and meteorological data (see Section 17.5.3 of the Supplementary EIS).

Both models have been peer-reviewed and endorsed by experts from two internationally recognised marine engineering companies: HR Wallingford Ltd in the UK and Cardno (NSW/ACT) Pty Ltd (formerly Cardno Lawson Treloar Pty Ltd), and Dr Nunes-Vaz, an author of some of the definitive papers on Spencer Gulf oceanography.

Issue:

It was suggested that the scenarios modelled covered only a short period with favourable conditions.

Submission: 83

Response:

As discussed in Section 16.4.3 of the Draft EIS, the mid-field model was run for a 40-day period over summer 2001–2002. This was considered to be an indicative worst-case scenario, when high surface temperatures and thermally induced stratification can restrict mixing, dispersion and dilution. The modelled period included three dodge tides (refer Figure 16.15 of the Draft EIS) and was chosen for the low tidal range during one of these dodge tides. To ensure that true worst-case conditions were simulated over this period, wind forcing was set to zero during the dodge tide, which increased surface temperatures (and thermal stratification) and removed the potential for wind-induced mixing.

Other extreme scenarios were also modelled. A strong south-easterly wind was simulated to determine the net effect of wind-driven currents to increase mixing or, conversely, push the return water towards the cuttlefish habitat. The zero wind scenario resulted in lower dilutions (i.e. less dispersion) at the sensitive receivers than the strong south-easterly wind (refer Appendix O11.4 of the Draft EIS). The zero-wind scenario was therefore used as the basis for the mid-field modelling. In another scenario the tidal amplitude at the model boundary was modified to induce even less water movement than during an indicative extreme dodge tide. The results showed relatively minor changes to the dilutions achieved at sensitive receivers (refer Appendix O11.4 of the Draft EIS).

The refined high-resolution model was run for a 12-month period (see Appendix H7.2 of the Supplementary EIS).

Issue:

It was suggested that dispersion of the oil spill at Port Bonython in 1994 showed localised effects that have not been included in the hydrodynamic model.

Submission: 83

Response:

An insoluble, surface layer of oil will behave in a manner that is completely different from soluble, saline return water released through diffusers. While oil on the surface would be driven by both tidal and wind currents, return water near the seafloor would be driven primarily by tidal currents. For example, westerly winds would tend to push an oil spill from Point Lowly towards the eastern side of the gulf, whereas such conditions would tend to enhance the vertical mixing and dispersion of return water.

Issue:

Concern was expressed that there was inadequate data to force the model at the ocean boundary (with reference to Chapter 5.3.2 of Appendix O11.2 of the Draft EIS), and the model domain should have included portions of the ocean outside the gulf in order to accurately simulate exchanges through the mouth of Spencer Gulf.

Submission: 83

Response:

It is considered that the data used to force the model at the ocean boundary was adequate for the Draft EIS, and has been significantly improved for the Supplementary EIS.

As discussed in Appendix O11.2 of the Draft EIS, in the absence of extensive consecutive datasets for tides near the open boundary of the model, synthetic tide data (based on astronomical predictions) was used to provide a continuous dataset for forcing the far-field model. This dataset was validated against measurements for Port Lincoln and is considered by the peer reviewers to adequately capture the exchanges across the ocean boundary (refer Appendices O11.1 and O11.2 of the Draft EIS).

The refined model provided in the Supplementary EIS used high-resolution tidal boundary forcing data sourced from a global tidal model that has been validated using approximately 5,000 tidal stations and 15 years of satellite altimeter data (see Appendix H5.2 of the Supplementary EIS).

Forcing the model at the mouth of Spencer Gulf boundary is preferable to attempting to model exchanges across this boundary by including oceanic areas in the model. The gulf's oceanography is more strongly influenced by the large gulf-scale gyre (discussed in Section 16.3.2 of the Draft EIS), than interaction with the shelf (Nunes-Vaz et al. 1990). Simulating the outer shelf would not be expected to improve the model performance.

Issue:

It was suggested that the modelling presented in the Draft EIS did not predict the density-driven outflow during winter, or the establishment of a density front across the mouth of Spencer Gulf.

Submission: 83

Response:

The modelling undertaken by BMT WBM Pty Ltd clearly reproduces the seasonal patterns of exchange across the model boundary at the mouth of Spencer Gulf.

As discussed in Section 16.4.3 of the Draft EIS, maintenance of the natural salt balance in the gulf requires the evaporation-induced accumulation of hypersaline water in the gulf to be exchanged with ocean water each winter via the gravity-driven density current. Reproduction of this current was demonstrated in Figure 16.19, Section 16.4.3 (with associated animation), and Appendix O11.2 of the Draft EIS.

The salt balance calculations summarised in Figure 16.22 of the Draft EIS confirmed the seasonal accumulation in summer (while the density front persists across the mouth of the gulf), and the density-driven outflow of the accumulated excess salt in winter (refer Appendix O11.4 of the Draft EIS for details).

The ability of the model to correctly predict exchanges across the mouth of the gulf has been endorsed by Dr Rick Nunes-Vaz, who stated that he has significant confidence, based on his considerable experience and knowledge of the gulf's salt-discharge behaviours, that the far-field model provides a useful and valid representation of Spencer Gulf hydrodynamics (refer Appendix O11.1 of the Draft EIS). He has similarly endorsed the refined model (see Appendix H5.1 of the Supplementary EIS).

17.6 SALT BALANCE IN SPENCER GULF

17.6.1 NATURAL EXCHANGE RATE OF WATER IN SPENCER GULF

Issue:

It was suggested that there was insufficient evidence of adequate water exchange in Spencer Gulf, and that this issue was acknowledged in the Draft EIS, where it stated that water exchange is difficult to model and is therefore only implied.

Submissions: 79, 84, 160, 219, 227 and 325

Response:

The Draft EIS presented considerable evidence of water exchange in Spencer Gulf. Well-documented oceanographic features that maintain the stable natural salinity gradient in the gulf were discussed, and a state-of-the-art tool for assessing hydrodynamic processes, including the rate of water exchange, was applied (refer Sections 16.3.2 and 16.4.3 of the Draft EIS).

Evidence for water exchange in the gulf was provided by three distinct aspects of the gulf's hydrodynamics:

- the gravity currents which provide the mechanism for salt ejection
- the annual salt exchange across the ocean boundary and a boundary near Point Lowly
- measures of gulf flushing time.

As discussed in Section 16.4.3 and Appendix O11.2 of the Draft EIS, the far-field model reproduced the hypersaline density currents during late autumn and early winter, as described in the literature cited in Section 16.3.2 of the Draft EIS (Lennon et al. 1987; Nunes-Vaz et al. 1990). The southern and eastern flow of the hypersaline density current under the influence of gravity and Coriolis force, respectively, is evident in the salinity gradients in the cross-sectional views of the gulf presented in Figure 16.19 of the Draft EIS.

The efficacy and seasonal nature of the salt ejection mechanism was reflected in the salt balance calculations presented in Appendix O11.4 of the Draft EIS. The salt mass (average salinity) of the gulf increases through the summer months, with oceanic seawater containing approximately 0.5 Gt of salt entering the gulf to replace evaporative losses (and a total of 1.09 Gt for the entire year). This excess salt is exported from the gulf during winter via the flow of hypersaline seawater along the seafloor on the eastern side (this exchange was shown graphically in Figure 16.22 of the Draft EIS). Initially, the export of salt occurs rapidly in late autumn to early winter, when the hypersaline bottom currents begin to form and flow towards the ocean, and persists through to November. Salt exchange was also shown to occur across a series of internal boundaries in the gulf (refer Appendix O11.4 of the Draft EIS).

As discussed in Appendices O11.2 and O11.4 of the Draft EIS, the annual (seasonal) timescale of the salt ejection mechanism and the salt balances over the same timescale both imply that Spencer Gulf 'flushes' annually. This hypothesis was tested using two measures of flushing time (i.e. e-folding and water retention). As discussed in Section 16.4.3 and Appendix O11.4 of the Draft EIS, both methods returned a flushing time of less than 12 months, and demonstrated flushing patterns consistent with the salt ejection mechanism discussed above.

Further attention was given in the Draft and Supplementary EIS to water exchange across boundaries near Point Lowly and Whyalla. Without an adequate exchange of seawater between Upper Spencer Gulf and the lower gulf, the salinity of the upper gulf would continue to increase due to the constant replacement of evaporated (fresh) water with inflowing seawater. Calculations presented in Section 16.6.4 of the Draft EIS showed that 78% of the water north of Point Lowly would need to be exchanged annually, with water from south of that boundary, in order to maintain the existing salinity gradients. Another way of expressing the magnitude of this exchange is that the waters north of Point Lowly would need to be mixed with approximately 3.5 times the volume of water of the salinity found at Point Lowly in order to achieve the natural steady state that is found in this area.

It is further noted that the inputs to the calculations presented in the Draft EIS were based on conservative estimates. Recalculation using data provided by Dr Rick Nunes-Vaz (see Appendix H8.1 of the Supplementary EIS) shows that on an annual basis, 90% of the water would be exchanged, or that mixing with more than 10 times the volume would be required. Over a period of two to four months, there would be 66–80% exchange.

As discussed in Section 16.4.3, Section 16.6.4 and Appendix O11.4 of the Draft EIS, model results showed that the flushing time (e-folding) for Upper Spencer Gulf seawater across a boundary near Whyalla is less than four months, compared with up to 12 months for flushing across the ocean boundary. This finding is comparable with the water exchange calculations presented above, based on the e-folding definition that a region is considered flushed if 63.2% of its volume (rather than 100%) has been replaced by ambient water (refer Appendix O11.4 of the Draft EIS).

An animation generated using the refined model illustrates short-term density flows in the upper gulf immediately after each dodge tide, generally along the deep channels, with pulses of saltier water moving south even during flood tides (see Appendix H7.4 of the Supplementary EIS).

On the basis of the above discussion, it is considered that substantial evidence of water exchange in Spencer Gulf has been presented in the Draft EIS and in additional studies undertaken for the Supplementary EIS.

Issue:

Concern was expressed about an apparent contradiction between the stated annual flushing cycle of Spencer Gulf and the statement that 78% of the water north of Point Lowly exchanges from below each year.

Submission: 40

Response:

There is no contradiction between the statements about annual flushing because they do not relate to flushing across the same boundary.

There is an inherent assumption in the submission that the statement that the 'entire gulf flushed' means 100% of the gulf water has been replaced by oceanic water, whereas, as discussed in Appendix O11.4 of the Draft EIS and noted in Submission 83, an accepted industry standard for flushing time is the 'e-folding' time, whereby a water body is considered flushed if 63.2% of its volume has been replaced by ambient water.

Therefore after one year, 63% of the water north of Point Lowly will have been replaced with water from south of the oceanic boundary. The figure of 78% (refer Sections 16.3.2 and 16.6.4 of the Draft EIS) refers to replacement by water from south of Point Lowly. Note that this figure has been revised to 90%, on the basis of additional data (see the above response).

Issue:

It was suggested that an animation provided with the Draft EIS showed that mixing of the waters north and south of Point Lowly occurs for less than four months each year.

Submission: 80

Response:

As discussed above, in parallel with seasonal exchange processes that are largely responsible for overall flushing in Spencer Gulf, there is also regular mixing and exchange of seawater north and south of Point Lowly. The animation provided in conjunction with Section 16.4.3 and Figure 16.21 of the Draft EIS provides the 'trajectory' of a tracer introduced into the model at an arbitrary discrete point in time. It shows the mixing of oceanic water with water in the upper reaches of the gulf.

Although the animation shows a delay of six to eight months before the oceanic water begins to influence the waters near Point Lowly, flushing is a continuous process and the waters north of Point Lowly are constantly mixing with oceanic water that has previously moved up the west coast of Spencer Gulf over that period.

Issue:

Several submissions provided referenced and unreferenced flushing times for Spencer Gulf and noted that these times were inconsistent with the results presented in the Draft EIS. The times presented in the submissions were 20, four, and two years around Whyalla, 15 months around Port Hughes, and six months around Port Stanvac.

Submissions: 83, 211, 319 and 350

Response:

As discussed in Section 16.4.3, Section 16.6.4 and Appendix O11.4 of the Draft EIS, there is compelling evidence that the flushing time of Spencer Gulf is approximately one year. This finding was confirmed using several measures of flushing time. These included the 'e-folding' method and the water ageing method used also by Kaempf and others (2009). An annual flushing time is also consistent with the Spencer Gulf salt/water balance (refer Figure 16.22 of the Draft EIS), salt ejection each year via hypersaline density currents (Lennon et al. 1987; Nunes-Vaz et al. 1990; refer Section 16.3.2 of the Draft EIS), and salt fluxes across the oceanic boundary (see above).

The far-field modelling undertaken by BMT WBM Pty Ltd (and the Centre for Water Research of the University of Western Australia) for the Draft EIS is considered to be significantly more robust and reliable than that undertaken by Kaempf and others (2009) (see Appendix H5.3 of the Supplementary EIS for details). As discussed in Section 17.5.2 of the Supplementary EIS, the modelling undertaken for the Draft EIS was independently reviewed by experts from two internationally recognised marine engineering companies. These reviewers provided letters of testimony stating that the modelling work was acceptable for its intended use, and to some extent exceeded normal industry practice (refer Appendix O11.1 of the Draft EIS). Dr Rick Nunes-Vaz, an author of some of the definitive papers on Spencer Gulf oceanography, also reviewed this modelling. Dr Nunes-Vaz endorsed, in particular, the outcomes of the far-field model, stating that it provided a useful and valid representation of Spencer Gulf hydrodynamics and salt mixing mechanisms (refer Appendix O11.1 of the Draft EIS).

Additional modelling undertaken after the publication of the Draft EIS and presented in the Supplementary EIS (see Appendix H7.2) has undergone similar peer review and has also been strongly endorsed. Reviewers also specifically acknowledged the improved spatial and temporal resolution of the model-forcing data (see Appendix H5.1 of the Supplementary EIS).

The modelling undertaken by Kaempf and others (2009) is considered to be poorly formed and of little use in the upper reaches of the gulf, despite being able to adequately reproduce gross oceanographic processes. The limitations of this model arise from poor spatial and temporal resolution of meteorological forcing data (with no such data used for their finer-scale model), inadequate calibration and several questionable assumptions (see Appendix H5.3 of the Supplementary EIS for details):

- ignoring wetting and drying
- ignoring wet areas within 10 km of Port Augusta
- artificial setting of minimum water depths to 5 m.

It has been suggested (with reference to Chapter 5.3.2 of Appendix O11.2 of the Draft EIS) that the predictions of retention time and salinity distributions in the Draft EIS are questionable as the model developed for the Draft EIS lacks adequate data for the ocean boundary, which controls seawater exchanges between the gulf and the ocean. As discussed in Appendix O11.2 of the Draft EIS, and in a response above, in the absence of extensive consecutive boundary datasets, synthetic tide data was used to provide a continuous dataset for the boundary forcing of the far-field model. This dataset was validated against measurements for Port Lincoln and is considered by the peer reviewers to adequately capture the exchanges across the ocean boundary (refer Appendices O11.1 and O11.2 of the Draft EIS). It is also consistent with salt balance calculations (refer Section 16.4.3, Figure 16.22 and Appendix O11.4 of the Draft EIS).

The refined model has used high-resolution tidal boundary forcing data sourced from a global tidal model validated using approximately 5,000 tidal stations and 15 years of satellite altimeter data (see Appendix H5.2 of the Supplementary EIS). The flushing time of approximately one year was confirmed using the water ageing method (see Appendix H5.2 of the Supplementary EIS).

It is concluded that the flushing times of approximately one year reported in the Draft and Supplementary EIS are consistent with known oceanographic processes in Spencer Gulf and are based on reliable modelling.

Issue:

It was suggested that inverse estuaries are low-flushing, and consequently a desalination plant operating in Spencer Gulf would result in long-term salt build-up (e.g. similar to that of the Dead Sea and the River Murray Lower Lakes).

Submissions: 36, 97, 124, 128, 130, 165, 171, 219, 273, 276, 277, 285, 288, 349, 368 and 376

Response:

As discussed in Section 16.4.3 and Appendix O11.4 of the Draft EIS, hydrodynamic modelling showed that the long-term salt loads in Spencer Gulf would remain in equilibrium despite ongoing evaporation and the relatively minor effect of desalination. The annual flushing of the gulf, the small volume of water loss relative to the volume of the gulf (refer Figure 16.25 of the Draft EIS), and water exchange internal to the gulf, would prevent any localised accumulation of salt.

The hypersaline density currents operating in the gulf mainly during winter (discussed in Section 16.3.2 of the Draft EIS) are able to remove the 1.09 Gt of salt that accumulates in the gulf each year as evaporated (fresh) water is replaced by inflowing seawater (refer Figure 16.22 of the Draft EIS and see Table 17.3 of the Supplementary EIS). The operation of the desalination plant would result in an additional 0.0032 Gt of salt entering Spencer Gulf annually, which is approximately 0.3% of the annual salt increase caused by evaporation.

Table 17.3 Impact of evaporation and desalination on the annual Spencer Gulf salt and water balance

	Water (GL/a)	Salt (Gt/a)
Desalination plant		
Intake	–200	–0.0085
Discharge	+110	+0.0085
Net effect of desalination	–90	0
Seawater drawn into gulf to replace loss	+90	+0.0032
Natural processes		
Evaporation	–36,000	0
Rainfall	+5,000	0
Net evaporation	–31,000	0
Seawater drawn into gulf to replace loss	+31,000	+1.09

In view of the very small contribution of desalination to the annual salt load in Spencer Gulf compared with evaporation (i.e. less than the annual variation), it is considered that the hypersaline density currents would easily adjust to the additional salt load and result in its removal each winter (see Appendix H8.1 of the Supplementary EIS).

Furthermore, calculations based on salinity monitoring spanning three decades have shown that modest net circulation throughout the waters north of Point Lowly is required to maintain the existing salinity gradient; in other words, a natural state of equilibrium exists (see Appendix H8.1 of the Supplementary EIS). It is considered that this equilibrium would remain, as the effects of desalination would be equivalent to only 0.3–15% of the effect of evaporation in Upper Spencer Gulf (see Appendix H8.1 of the Supplementary EIS). The effects of desalination compared with evaporation are provided as a range to reflect the uncertainty about the area of the gulf over which water losses from desalination would affect salinity. The upper bound is based on the assumption that the area of influence is restricted to the waters north of Point Lowly, which is considered to be highly conservative in view of the location of the desalination plant at the southern end of the upper gulf and the gulf-wide circulation discussed below (see Appendix H8.1 of the Supplementary EIS).

The corresponding increase in salinity of the waters north of Point Lowly due to desalination would be 0.003–0.11 g/L. The upper bound represents a rise equivalent to approximately 8% of the mean annual salinity range observed in this area from 1982 to 2009, or 14% of the long-term shift of mean annual salinity during the 10 years from 1997 to 2007 (see Appendix H8.1 of the Supplementary EIS).

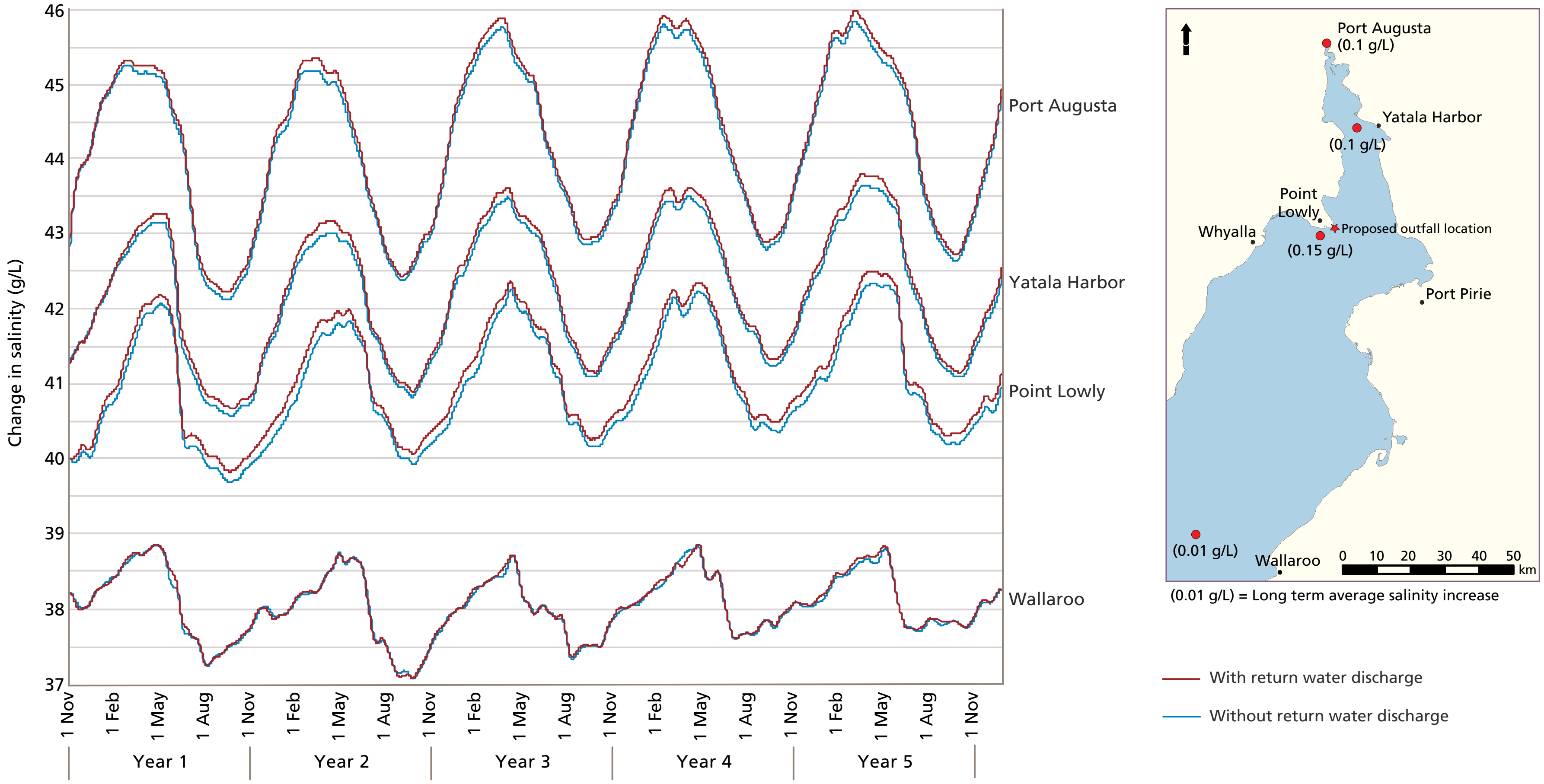


Figure 17.6a Predicted far field changes in salinity near seafloor with and without return water discharge

The hydrodynamic models provide a more precise spatial analysis. As discussed in Section 16.4.3, Section 16.6.4 and Appendix O11.4 of the Draft EIS, the far-field model predicted a long-term average salinity increase in Spencer Gulf of 0.07 g/L in the vicinity of Point Lowly, 0.03 g/L further north in the upper gulf, and 0.01 g/L south of the outfall near Wallaroo. The overall increase in salinity of the gulf was predicted to be 0.01 g/L (refer Table 16.12 of the Draft EIS). The refined model predicted that the area north of Point Lowly would absorb 10–20% of the desalination plant return water, leading to a long-term salinity increase of 0.05–0.15 g/L (see Figure 17.6 and Appendix H7.2 of the Supplementary EIS. These increases are consistent with those predicted from evaporation (see above).

The modelling and monitoring data provide convincing evidence that the annual density-driven ejection of salt and resulting salinity balance in Upper Spencer Gulf would be maintained, and the long-term salinity increase would be negligible.

Issue:

It was suggested that contaminants would not be flushed despite deep, fast currents near Point Lowly, and instead would be returned by daily oscillating tides.

Submissions: 79, 102, 138, 155, 160, 199, 325, 340 and 348

Response:

Contaminants would be flushed from the gulf by the same gulf-wide circulation processes that remove accumulated salt annually. Short-term circulation patterns at Point Lowly that would result in dispersion of contaminants as they are carried north and south with successive tides, are superimposed on a longer-term, gulf-wide circulation pattern driven by gravitational circulation and turbulent diffusion (see Appendix H8.1 of the Supplementary EIS).

Contaminants would be diluted initially by the diffuser and would be further diluted by mixing with ambient water during tidal movements. The gulf-wide flushing processes would also prevent any longer-term accumulation of contaminant, due to oscillating tides.

As discussed in Section 16.3.2 of the Draft EIS, the water continually evaporated from the upper reaches of the gulf is replaced by oceanic water flowing north, along the western side of the gulf, due to Earth's rotation. Periodic stratification of hypersaline water causes 'slugs' of this water to flow south through deep channels or along the eastern side of the gulf to the ocean. Although these flows are subject to semi-diurnal tidal movements, there is a net clockwise circulation that provides the flushing mechanism for the removal of contaminants from the gulf (see the animation in Appendix H7.4 of the Supplementary EIS).

Issue:

It was suggested (as evidence of poor flushing) that the Dow Pty Ltd plant proposed for Red Cliff Point (20 km south of Port Augusta) in the 1980s had been denied approval because an oil spill would have taken a lifetime to exit the gulf.

Submission: 288

Response:

BHP Billiton understands that the Dow plant did not proceed for economic rather than environmental reasons. The dispersion and effect of return water and an oil spill would be completely different and therefore should not be compared. In terms of hydrodynamic dispersion, an insoluble, surface layer of oil would behave in a completely different manner to soluble brine released into the water column through diffusers and dispersed by strong currents.

While the return water would be diluted in the seawater, an oil spill would form as a coherent slick on the sea surface and be transported by tides and wind until it reached land. Oil spills would be cleaned up as part of incident response in accordance with relevant guidelines and protocols. Oil residues would remain in the gulf at the point of landfall until they were eventually removed by weathering, photo-oxidation or biodegradation.

Conversely, the return water would generally be removed from the gulf in about a year as part of the natural flushing process (refer Section 16.4.3 of the Draft EIS and see responses to issues provided above).

Issue:

Clarification was sought about how the regular and historical accumulation of seaweed could be explained if Spencer Gulf undergoes regular flushing.

Submissions: 79 and 160

Response:

In terms of hydrodynamic dispersion, suspensions of dead seagrass would behave in a completely different manner to normal seawater. Seagrass is insoluble and wind-driven currents during storms tend to wash it up onto the shore, where it can remain trapped. Seawater, however, flows back into the ocean and is subjected to the regular circulation patterns that result in flushing.

17.6.2 POTENTIAL SALINITY INCREASE

Issue:

It was suggested that the hydrodynamic model should be run for much longer (up to 50 years) to determine long-term salinity increases.

Submissions: 2 and 172

Response:

As discussed in Section 16.4.3, Section 16.6.4 and Appendix O11.4 of the Draft EIS, the far-field model was run for a simulated period of five years to determine whether the continuous discharge of return water from a desalination plant at Point Lowly would result in the accumulation of salt in Spencer Gulf. The long-term average salinity increases were found to be 0.07 g/L near Point Lowly, and 0.03 g/L at sites further north, including Port Augusta. The model showed that a steady state was reached after one year (i.e. no further salinity increases occurred over the subsequent four years). No increases would therefore occur for any period of simulated modelling beyond the first year.

Nevertheless, to address the issue raised, the refined model developed for the Supplementary EIS was run for a simulated period of 70 years. The long-term salinity increases north of Point Lowly were predicted to be 0.05 to 0.15 g/L (see Figure 17.6 of the Supplementary EIS). Again, the results showed a steady state was achieved after one year, with no detectable salinity increase occurring in the subsequent 69 years (see Appendix H7.2 and Figure 17.6b of the Supplementary EIS).

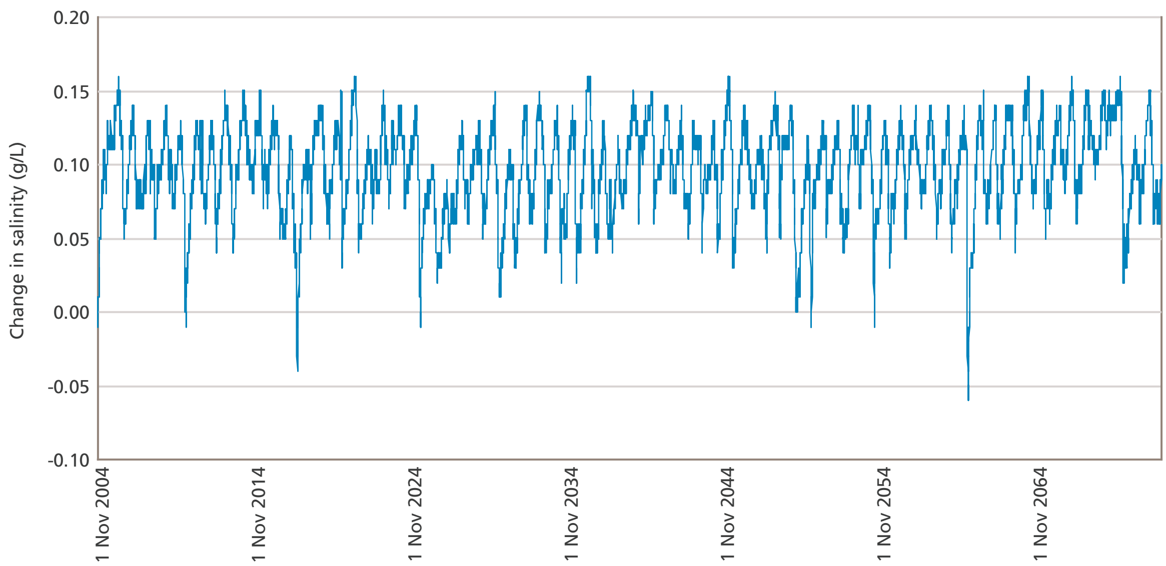


Figure 17.6b Predicted long-term changes in salinity at Point Lowly

17.6.3 SALT REMOVAL MECHANISM

Issue:

Clarification was sought about whether the salt ejection mechanism can cope with additional salt arising from desalination.

Submission: 102

Response:

The operation of the desalination plant would result in an additional 0.0032 Gt of salt entering Spencer Gulf each year as a result of 'fresh' water being removed by desalination and being replaced by seawater flowing into the gulf. This salt increase represents approximately 0.3% of the salt load entering the gulf in seawater replacing water lost through natural evaporation. In view of the very small contribution of desalination to annual salt load entering the gulf compared with evaporation (0.3%), it is considered that the hypersaline density currents would adjust to the additional salt load arising from desalination and result in its removal each winter, in the same way that it adjusts to additional salt arising from annual variations in evaporation (see Appendix H8.1 of the Supplementary EIS). In other words, the natural ejection mechanism of the gulf removes approximately 1.1 Gt of salt every year, which would increase to 1.1032 Gt with operation of the desalination plant. To place this in context, the increased salt load each year resulting from desalination would be equivalent to the effect of evaporative losses during an average day.

Long-term (70-year) simulations have confirmed that a steady state would be reached after one year and a new salt balance would be maintained from year to year (see Figure 17.6b and Appendix H7.2 of the Supplementary EIS).

The question of whether salinity increases arising from desalination (and/or climate change) would be sufficient to disturb the salt removal mechanism to the point where the long-term salt balance was altered is discussed in further detail in Appendix H8.1 of the Supplementary EIS. The study revealed that both the gravitational circulation and the turbulent diffusion and dispersion salt removal mechanisms operating in Spencer Gulf had additional capacity to export salt, and both would adapt smoothly and modestly to salinity increases arising from desalination.

Issue:

Concern was expressed that the relationship between evaporation and salinity presented in the Draft EIS is based on a single data point and is not sufficiently sensitive. It was suggested that long-term continuous monitoring is required to characterise ongoing salinity levels, the salt export mechanisms for Upper Spencer Gulf and the relationship to evaporation.

Submission: 2

Response:

The salinity of Spencer Gulf, north of Point Lowly, was determined from 19 samples in August 2008 and was compared with 12 historical measurements, obtained using the same methodology, from the 1980s (refer Appendix O9.4 of the Draft EIS). The comparison showed that the salt removal mechanisms have proven insensitive to considerable variation in evaporation over the past 30 years, with no substantial change to the salt balance despite an increasing trend in evaporation over the past decade (refer Section 16.6.4 of the Draft EIS).

In response to the concern raised, additional work has been undertaken for the Supplementary EIS.

The relationship between historical measurements of salinity and cumulative net evaporation over previous months was rigorously examined (see Appendix H8.1 of the Supplementary EIS), recognising that the annual salinity cycle in Upper Spencer Gulf is delayed relative to the annual cycle of net evaporation. The mean salinity of the upper gulf (north of Point Lowly) was found to accurately reflect net evaporation during the preceding six months. This relationship was validated with the salinity measurement from August 2008 presented in the Draft EIS, and an additional measurement taken across the upper gulf in May 2009.

This relationship was used to hindcast (retrospectively predict) salinity trends from measured evaporation data, providing a reliable proxy for a times series of salinity levels in the upper gulf over the past three decades (see Figure 17.7 of the Supplementary EIS). These findings can be applied to the long-term monitoring of regional salinity as they provide a basis for separating salinity changes caused by desalination from those arising from variability in evaporation/climate. They also provide a rigorous basis for predicting the effects of desalination on the salinity of the upper gulf (see Section 17.6.3 of the Supplementary EIS for further discussion).

The additional work provides a sufficiently rigorous and sensitive model to support conclusions about changes in salinity arising from evaporation or desalination. Nevertheless, effects of desalination on long-term salinity in Upper Spencer Gulf would be determined by monitoring regional changes in salinity (north of Point Lowly) before and during operation of the desalination plant.

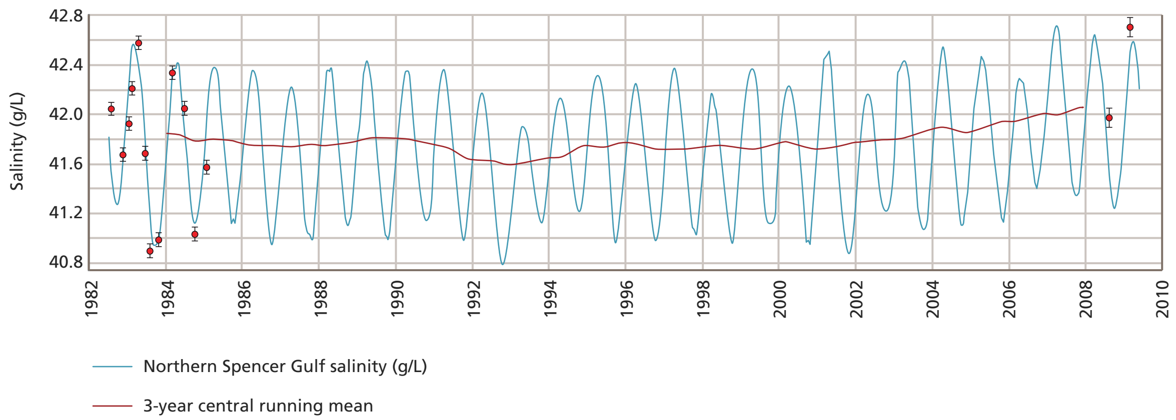


Figure 17.7 Inferred changes in Northern Spencer Gulf salinity during the past 27 years, with a 3-year central running mean

Issue:

Clarification was sought about an apparent contradiction on the water supply fact sheet, which shows currents going one way in a figure but has text stating that 'slugs' of salinity go the other way.

Submission: 102

Response:

The opposing flows presented in the fact sheet are consistent with descriptions of water movement in Spencer Gulf, with the southerly flow representing a short-term tidal flow that is superimposed on a longer-term net clockwise circulation of water through the gulf.

The fact sheet briefly describes the net circulation patterns in the gulf, whereby salt is ejected from the gulf in winter via the southerly flow of pulses or 'slugs' of hypersaline water, and oceanic seawater is drawn into the gulf (mainly in summer) to replace evaporative water losses (refer Section 16.3.2 of the Draft EIS). Earth's rotation causes the inflow of oceanic water to occur along the western side of the gulf.

This northerly flow associated with the gulf-wide circulation pattern is a long-term net flow that occurs concurrently with the daily, fluctuating tidal flows. The flows presented in the fact sheet are correct and consistent with water circulation patterns in Spencer Gulf.

17.6.4 DESALINATION ANALOGIES

Issue:

Concern was expressed that the comparison between desalination and evaporation is misleading as evaporation occurs over the entire gulf, whereas the effect of desalination is localised, resulting in sharper gradients.

Submissions: 80, 165 and 274

Response:

The comparison between desalination and evaporation is reasonable because it has been applied to the long-term salt balance for Spencer Gulf and Upper Spencer Gulf. In this context, both evaporation and desalination can be considered as equivalent water removal processes and the comparison is appropriate when considering the regional effects of desalination.

Other tools, including hydrodynamic modelling, have been used to assess the potential for shorter-term, localised salinity effects of desalination. These effects are discussed in detail in Section 17.7.5 of the Supplementary EIS.

Issue:

It was suggested that 4 to 5 million tonnes of salt would be pumped back into Spencer Gulf each year, and this would be equivalent to salt dumping.

Submissions: 127 and 219

Response:

Desalination plants do not produce salt; they remove fresh water, which is replaced by the inflow of seawater.

The annual removal of 90 GL of fresh water through desalination would be insignificant in comparison with the annual loss of 36,000 GL through evaporation and the volume of the gulf of 460,000 GL (refer Figure 16.25 of the Draft EIS). Similarly, the salt increase indirectly associated with desalination (0.0032 Gt) represents approximately 0.3% of the salt load of 1.09 Gt entering the gulf as a result of evaporation (see Table 17.3 of the Supplementary EIS), which is subsequently discharged by natural salt ejection processes.

Therefore the amount of water removed by desalination is insignificant compared with the volume of water removed through evaporation and the overall volume of the gulf (with a similar comparison for the salt loads associated with oceanic seawater replacing water lost through desalination and evaporation).

17.6.5 EXTENT OF POTENTIAL EFFECTS

Issue:

It was suggested that all water north of Point Lowly to a depth of 1 m would be affected by desalination within one year.

Submission: 84

Response:

As discussed in Section 16.4.3, 16.6.4 and Appendix O11.4 of the Draft EIS, the long-term average salinity increase near the seafloor in Upper Spencer Gulf resulting from the operation of the desalination plant would range from 0.07 g/L within a few kilometres of the outfall to 0.03 g/L at Yatala Harbor and Port Augusta. For the refined model, the salinity increase was predicted to be 0.05 to 0.15 g/L in Upper Spencer Gulf (see Figure 17.6b and Appendix H7.2 of the Supplementary EIS). These increases are comfortably below the salinity increase of 0.4 g/L corresponding to the species protection trigger value (SPTV) of 1:85 determined from the ecotoxicology tests (refer Section 16.4.2 of the Draft EIS).

As the more saline water discharged from the desalination plant would be heavier than normal seawater, it would remain closer to the seafloor in the deeper channels, and therefore the salinity increases in the more 'elevated', shallower waters would actually be less than the quoted average in the vicinity of Point Lowly. Further away, the small increases in salinity are more evenly spread through the water column (see Appendix H7.2 of the Supplementary EIS).

Issue:

Concern was expressed that flushing would result in pollutant-rich seawater traversing the entire coastline of Spencer Gulf.

Submission: 40

Response:

The flow of return water down the eastern side of Spencer Gulf as part of normal flushing processes would have no effect on the ecology of the gulf.

The return water is not considered to be 'pollutant-rich' as the toxicity of anti-scalants to aquatic life is very low (Lattemann and Hoepner 2008), and all other chemicals that may be present in trace concentrations are commonly used in traditional domestic water treatment plants and discharged with treated wastewater (refer Section 16.4.1 of the Draft EIS).

As discussed in Section 16.4.3 and Appendix O11.4 of the Draft EIS, the return water would be diluted at least 500 times within a few kilometres of Point Lowly (equating to a salinity increase of 0.07 g/L). It would be even further diluted elsewhere in Spencer Gulf. The return water would be at least six times more dilute than the species protection trigger value (SPTV) of 1:85 (refer Section 16.4.2 of the Draft EIS).

17.7 PLUME DISPERSION AT POINT LOWLY

17.7.1 CURRENTS AND CIRCULATION AT POINT LOWLY

Issue:

The assertion in the Draft EIS that tide-driven currents off Point Lowly provide excellent dilution and dispersion of return water was questioned. It was suggested that there is little water movement off Point Lowly except in the rip, and strong currents last only for short periods.

Submissions: 165 and 288

Response:

The tidal currents at the proposed outfall off Point Lowly are among the strongest in South Australia, making the location of the proposed Olympic Dam desalination plant one of the most suitable for rapid dilution and dispersion of the return water.
As discussed in the Draft EIS (refer Section 16.3.2), the combination of the relatively large tidal range in Upper Spencer Gulf (up to 3.9 m) and the narrowing of the gulf between Point Lowly and Ward Spit (to about 8 km) results in a large daily exchange of water and strong currents off Point Lowly. Although the strongest currents occur in the rip off Point Lowly, currents of more than 0.5 m/s are common in the deep channels of Upper Spencer Gulf (see Figure 17.8 of the Supplementary EIS).

Since the publication of the Draft EIS, additional field data on current speeds has been obtained by deploying four Acoustic Doppler Current Profilers (ADCPs) on the seafloor in the vicinity of Point Lowly for a six-week period in May–June 2009. One of these profilers was located in the rip, two about 5 km north-east and 5 km south-west of Point Lowly, and one near Stony Point. The records confirmed that the maximum and median current speeds in the rip were 1.5 m/s and 0.4 m/s respectively (see Appendix H5.2
of the Supplementary EIS). They also confirmed that the strong currents persist beyond the rip, with the maximum and median current speeds 5 km away being 0.75 m/s and 0.2 m/s respectively. To provide context, currents are defined as being 'strong' if they are >0.5 m/s, moderate if they range between 0.2 and 0.5 m/s, and weak at <0.2 m/s.

In terms of durations, current speeds in the rip exceeded 0.2 m/s for 60% of the time, and exceeded 0.1 m/s for 84% of the time (see Figure 17.9 of the Supplementary EIS). It may therefore be concluded that moderate to strong currents (defined as greater than 0.2 m/s) occur for more than 60% of the time at the outfall location.

To place the strength of the currents off Point Lowly in perspective, they are compared with current speeds off Port Stanvac in Gulf St Vincent – where the South Australian Government is building a desalination plant – for all tides and dodge tides in Figure 17.9. The comparison reveals that both the maximum and median current speeds off Point Lowly are about four times greater than the current speeds off Port Stanvac. Even currents during dodge tides off Point Lowly are about 50% greater than currents during all tides off Port Stanvac.

Issue:

It was suggested that heavy wave action and large tides, rather than strong currents, are needed to disperse brine.

Submission: 324

Response:

The mixing energy provided by strong currents has proven to be more effective and reliable than wave action in diluting and dispersing return water. The shape and depth profiles of Spencer Gulf result in tides of up to 3 m at Point Lowly, compared with 2 m at the mouth of the gulf (Noye 1984). The relatively high tidal range in Upper Spencer Gulf, and the narrowing of the gulf between Point Lowly and Ward Spit, results in very strong currents at Point Lowly.

One of the keys to rapid dilution and dispersion of return water is the volume of water passing over the diffuser per second.
As shown in Figure 16.24 of the Draft EIS, large instantaneous dilutions of return water are possible with even moderate current speeds (e.g. with a current speed of 0.3 m/s a dilution of 1:70 would occur within tens of metres of the diffuser). During a single ebb or flood tide lasting four hours, with a current speed of 0.3 m/s, return water would be discharged into a 200 m by 5 m by 4 km volume of seawater, resulting in significant dilution. Although wave action can enhance vertical mixing, it would not match the rate at which return water is dispersed laterally by currents.

Comparing the outcomes of model scenarios with no winds and strong currents, and scenarios with reduced currents (dodge tides) and strong (10 m/s) south-easterly winds (see Figure 17.10 of the Supplementary EIS) provides evidence for this conclusion.
The comparison reveals that tidal currents provide significantly better dilution and dispersion of return water than wind (and waves). ELCOM simulates the effect of wind on mixing by increasing shear in the water column.

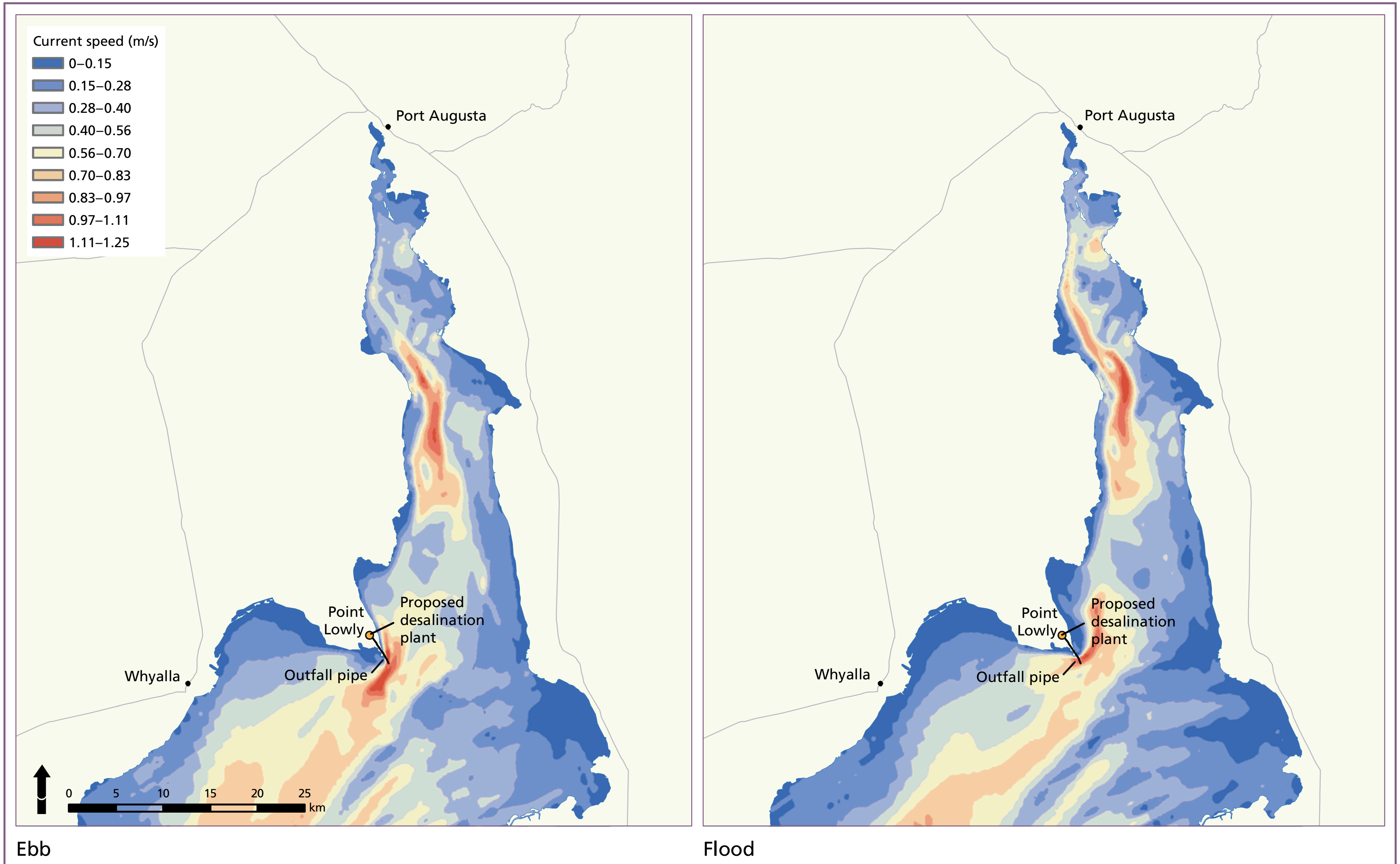


Figure 17.8 Snapshot of typical current speeds in Upper Spencer Gulf during ebb and flood tides

It is also noted that daily tidal currents at Point Lowly are more predictable and regular than oceanic swells off the south coast of Eyre Peninsula. Although there are frequent periods of heavy swell at exposed locations on Eyre Peninsula, there are also regular periods of little or no swell that can last for days or even weeks.

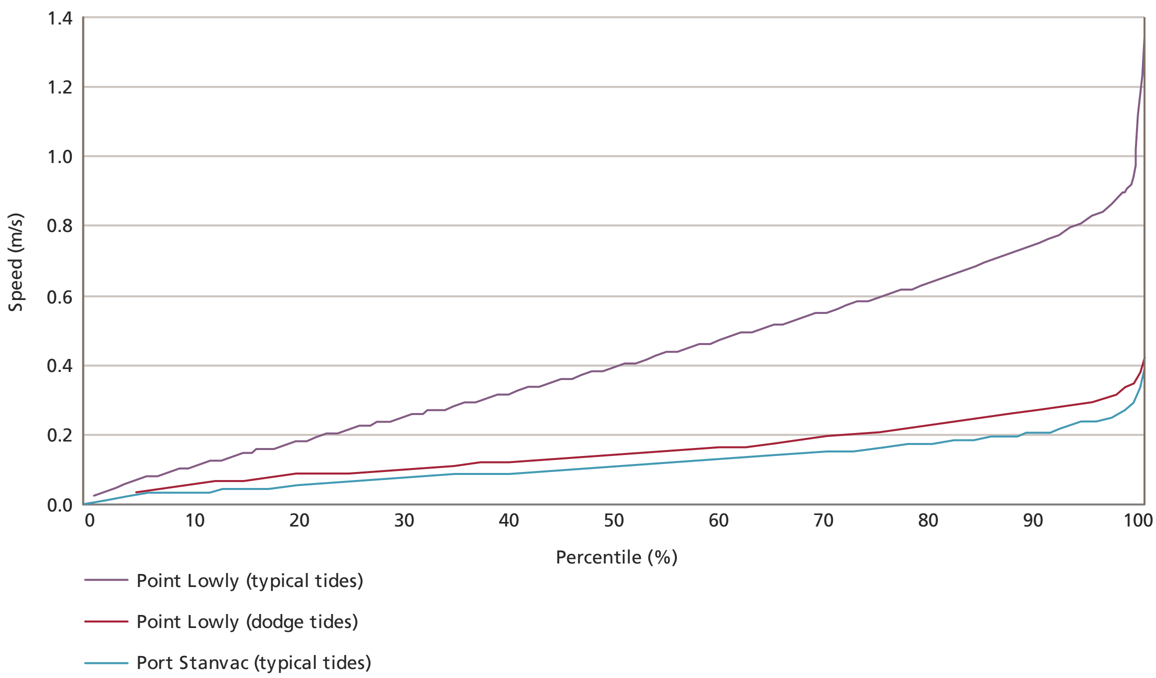
Issue:

It was suggested that tides just wash backwards and forwards, which would result in return water accumulating around Point Lowly rather than dispersing throughout Spencer Gulf.

Submissions: 16, 27, 105, 155, 160, 219 and 358

Response:

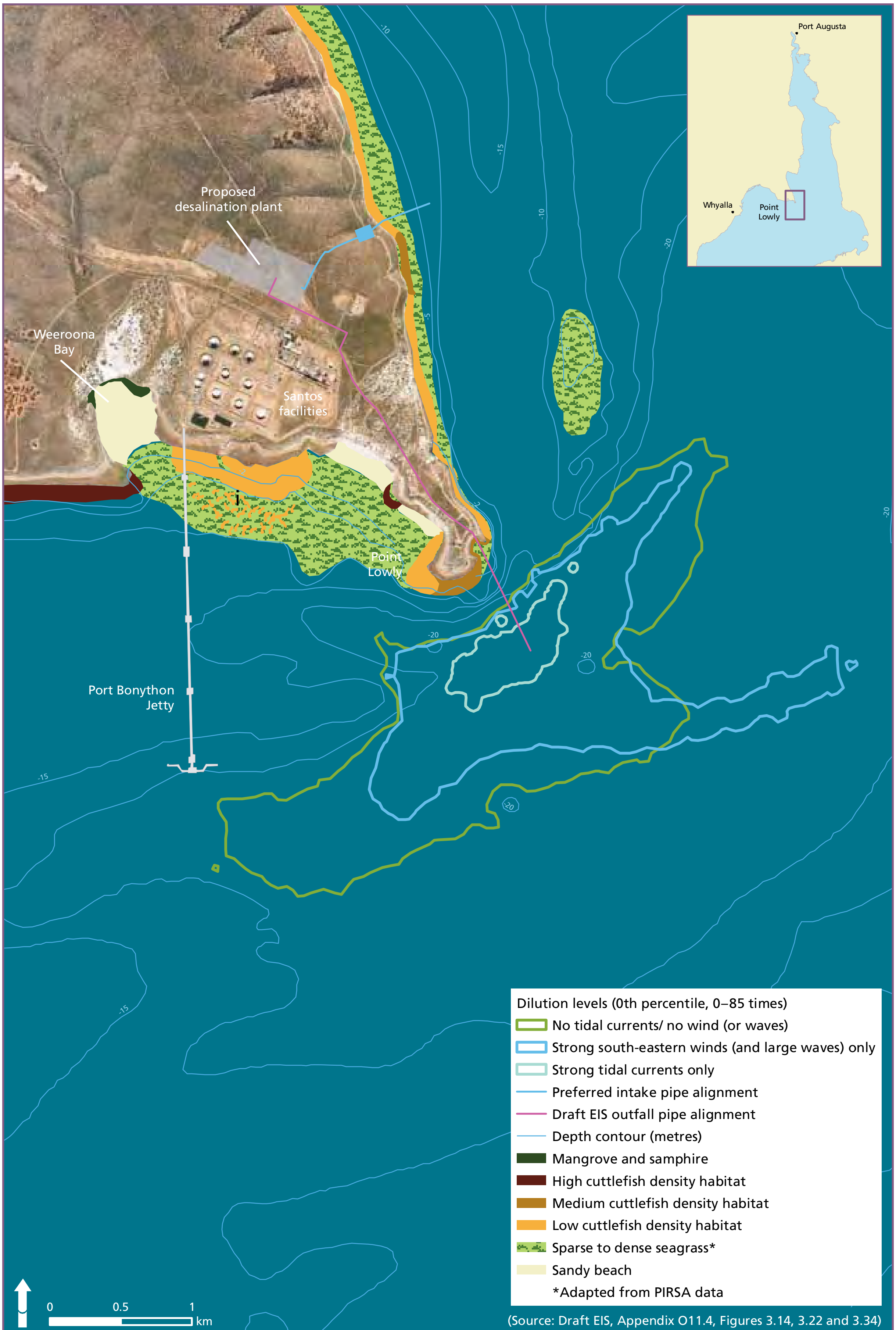
Modelling of successive spring and typical tides over several days has revealed no evidence of significant short-term accumulation of return water around the outfall (refer Draft EIS Appendix O11.4, Figures 3.17 and 3.21). Local shear (both vertical and horizontal) would act to continually increase dilutions of return water as it moved north and south with the tides. In the medium to long term, the slight accumulation of salt in the vicinity of Point Lowly would be removed from the gulf via the natural gulf-wide circulation patterns and gravity currents that remove excess salt each winter (refer Draft EIS Section 16.4.3 and responses to this issue presented in Section 17.6.3 of the Supplementary EIS).



Speed measured between 2.6 and 3.7 metres above the seafloor

Sources: Appendix H5.2 and SA Water 2009

Figure 17.9 Comparison of current speeds off Point Lowly and Port Stanvac



(Source: Draft EIS, Appendix O11.4, Figures 3.14, 3.22 and 3.34)

Figure 17.10 Strong tidal currents result in more rapid dilution and a smaller plume footprint than wind-induced mixing (via waves)

17.7.2 EFFECT OF DODGE TIDES

Issue:

The issue of fortnightly dodge tides resulting in periodic poor dilution and dispersion of return water off Point Lowly has been raised as a significant problem with the proposed development of the desalination plant at Point Lowly. It has been suggested that dodge tides (including 'double dodge' tides) result in no water movement for a day or two.

Submissions: 27, 83, 171, 211, 319 and 320

Response:

The assertion that the fortnightly dodge tides off Point Lowly result in no water movement for up to two days is incorrect.

During dodge tides, the semi-diurnal tidal constituents cancel one another, resulting in reduced tidal amplitude and one rather than two tides per day (this was presented in Section 16.3.2 and Figure 16.6 of the Draft EIS). Although the tidal range is less, a feature of dodge tides is that the tides continue to ebb or flood for approximately 12 rather than six hours. Furthermore, the narrowing of the gulf between Point Lowly and Ward Spit (to about 8 km) tends to enhance the speed of the residual currents that continue to flow during dodge tides.

Data on current speeds during dodge tides was obtained by deploying Acoustic Doppler Current Profilers (ADCP) on the seafloor at several locations around Point Lowly for six weeks in April–May 2009. This period included extreme dodge tides on 3–4 May and 17–19 May. Extreme dodge tides occur every six months, when both the major semi-diurnal and major diurnal tidal constituents cancel one another simultaneously. In Upper Spencer Gulf, this phenomenon occurs in late May and November, and results in tidal ranges of 0.3–0.5 m (R. Nunes-Vaz, consultant oceanographer, pers. comm., 5 May 2008).

Current speeds during the two extreme dodge tides recorded by the ADCPs are given in Figure 17.11. The data indicates that current speeds during the dodge tides attained a maximum of 0.4 m/s, often exceeded 0.2 m/s, and fell below 0.1 m/s for only 16% of the time, with a maximum duration of 4.9 hours (see Table 17.4 of the Supplementary EIS).

As noted in a response above for comparative purposes and context, the median and maximum current speeds off Port Stanvac during typical tides in Gulf St Vincent are 0.1 m/s and 0.4 m/s, respectively (SA Water 2008). These speeds are about the same as the median and maximum currents during extreme dodge tides off Point Lowly – slower than a normal dodge tide off Point Lowly, and significantly slower than average tides off Point Lowly.

Table 17.4 Duration of minimal water movement off Point Lowly over six weeks from April to June 2009

Slow currents (m/s)	Percentage of time current speed is less than slow threshold	Longest duration of slow currents (hours)
<0.01	0.22	0.3
<0.05	4.9	1.3
<0.1	15.6	4.9

Issue:

It was suggested that hypersaline water would pool in the deep channels off Point Lowly, resulting in severe effects on marine life.

Submissions: 285 and 288

Response:

'Hypersaline' return water would not 'pool' in the deep water channel near the outfall during dodge tides. As discussed above, significant residual currents occur off Point Lowly during dodge tides, which would minimise pooling of return water during periods of little tidal movement. In addition, the return water would be no more than 0.8 g/L above ambient levels within 100 m of the diffuser, which would be less than the natural daily variation of around 1.4 g/L, and generally less than the species protection trigger value (see Section 17.4.7 of the Supplementary EIS). Other than in the immediate vicinity of the diffuser (i.e. within 100 m) the effects on marine communities are likely to be immeasurable (see Section 17.7.6 of the Supplementary EIS). Similarly, as discussed in Section 17.12.3, the effects of stratification and deoxygenation of the overlying water column would be negligible.

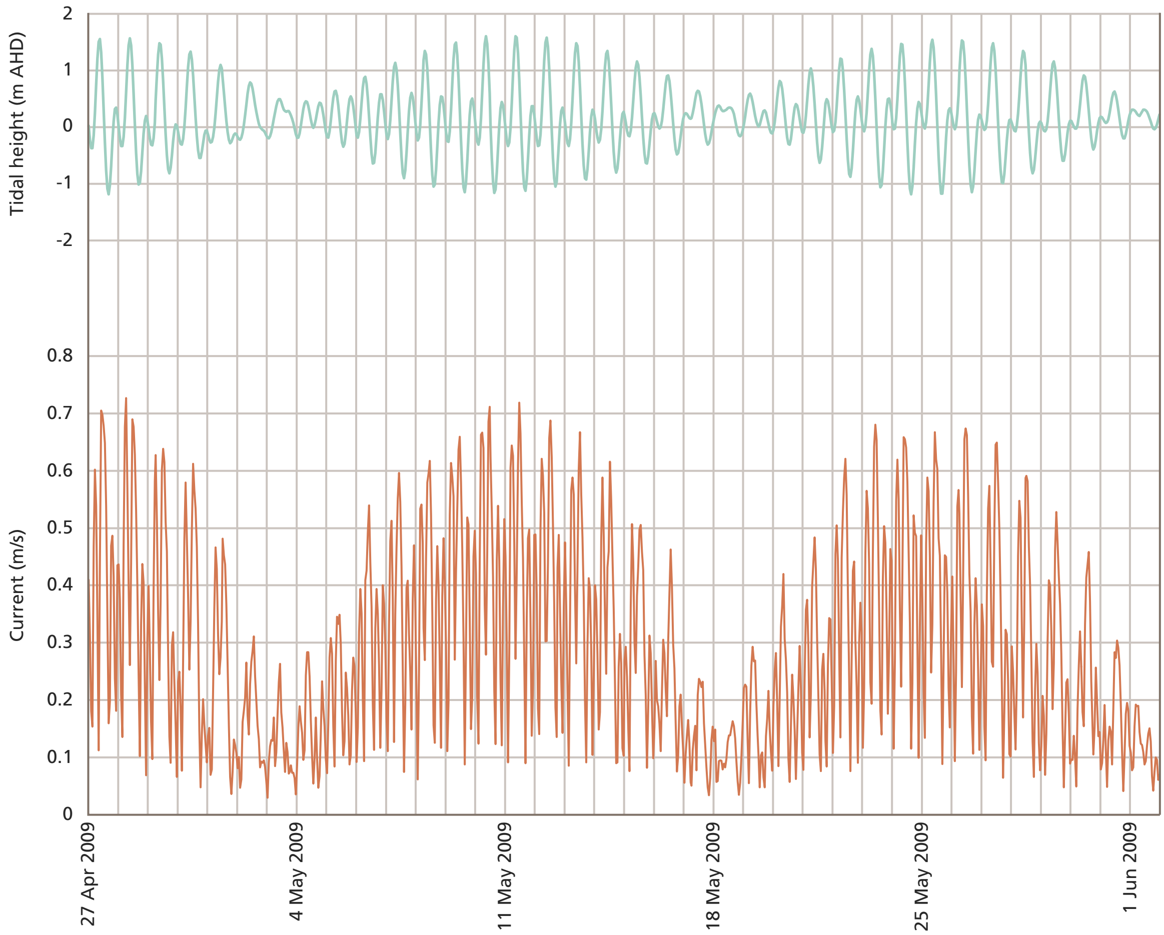


Figure 17.11 Current speeds off Point Lowly during two extreme dodge tides in May 2009

17.7.3 MIXING ZONE TARGETS

Issue:

It was noted in submissions that the near-field mixing zone dilutions for the proposed desalination plant are worse than for any other desalination plant in Australia (four times worse than comparable plants). It was also noted that the 2.5 km mixing zone (i.e. the maximum extent of the area around the diffuser where the species protection trigger value is breached) presented in the Draft EIS breaches the Environment Protection (Water Quality) Policy 2003, which specifies a mixing zone of 100 m.

Submissions: 2, 80, 83, 86, 171, 192, 210, 271, 277, 320, 340, 346 and 376

Response:

The near-field dilution outcomes presented in Section 16.4.3 of the Draft EIS were based on conservative, worst-case assumptions, which was the approach adopted for all aspects of the Draft EIS. This approach provided the upper limits of potential impacts based on preliminary design information (based on a generic diffuser). The upper limit of impacts was then assessed against the impact criteria stated in Section 1.6.2 of the Draft EIS to determine the acceptability of impacts to sensitive receivers. The impact assessment determined that impacts on receivers were negligible to moderate.

The sensitivities around the return water discharge to Upper Spencer Gulf are recognised and, as a consequence, the design of the proposed diffuser to optimise its performance has been improved considerably since the publication of the Draft EIS. The redesigned diffuser would use more of the available operating head at Point Lowly, which would deliver significantly greater exit speeds of return water from the diffuser ports and, in turn, greater near-field dilutions than those presented in the Draft EIS.

As presented in Sections 17.7.4 and 17.7.5 of the Supplementary EIS, the improved diffuser would deliver safe dilutions at the edge of the 100 m mixing zone. Its performance would be consistent with, or exceed, that of any other desalination plant in Australia.

Issue:

It was noted that the Environment Protection (Water Quality) Policy 2003 specifies a mixing zone of <20 m in estuaries. It was further suggested that the mixing zone in Upper Spencer Gulf (an inverse estuary) should therefore be <20 m.

Submissions: 192 and 349

Response:

The reference to estuaries in Environment Protection (Water Quality) Policy 2003 relates to relatively small bodies of water with limited potential for mixing, rather than large, semi-enclosed waterbodies such as Spencer Gulf. Whereas estuaries in South Australia are typically less than several hundred metres wide and relatively shallow, Spencer Gulf near Point Lowly is about 30 km wide and up to 28 m deep.

17.7.4 DIFFUSER OPTIMISATION

Issue:

It was suggested that further diffuser designs, including a range of port sizes, diffuser lengths, low return water flows, and the use of rosettes, should be modelled to optimise the performance of the diffuser.

Submissions: 2, 238 and 271

Response:

As noted in a response above, the assessment in the Draft EIS was based on a conservative approach using the preliminary design of a generic diffuser. Since the Draft EIS was published, the diffuser design has been advanced considerably. A design study has been undertaken to determine the most effective means of optimising the performance of the diffuser in dispersing and diluting return water in the near field (i.e. within about 100 m of the diffuser) (see Appendix H6 of the Supplementary EIS for details). The diffuser design concepts developed during the study included both linear and rosette-style diffusers. BHP Billiton would ultimately be responsible for designing a diffuser capable of achieving near-field dilution targets set in consultation with the EPA. The concept designs therefore represent possible diffuser configurations to demonstrate that appropriate near-field dilution targets can be achieved. These designs would be further refined as detailed design of the project progresses.

The aims of the study undertaken for the Supplementary EIS were to:

- improve the understanding of the critical elements of diffuser design that affect near-field dilutions
- provide an understanding of how the diffuser design may be varied to achieve the desired dilution outcomes
- develop diffuser concept designs that would enable dilution thresholds to be achieved for the anticipated range of discharge rates, and receiving water conditions (e.g. currents).

A basic principle of diffuser design is to maximise the initial dilution by discharging the return water under pressure from numerous ports as high as possible into the water column without interacting with the surface. At Point Lowly the operating pressure would be provided by gravity, using a potential hydraulic head of up to 30 m (i.e. the desalination plant site is about 30 m higher than the diffuser). The high exit speed results in a jet-like flow of return water into the overlying water. As the jet flow quickly dissipates, the momentum of the return water continues to drive the plume high into the water column. During the upward trajectory of the plume, surrounding seawater is rapidly entrained (drawn along) and the return water is diluted. After the limit of the upward trajectory is reached, the dense plume begins to fall towards the seafloor, entraining more seawater and undergoing further dilution. Once the plume reaches the seabed, the influence of the diffuser design on plume dilution ceases, and ambient currents, turbulence and bathymetry become the predominant influences.

The sensitivity of dilution rates to changes in diffuser design parameters was assessed using empirical equations derived from laboratory model tests that were verified in the field. The equations of Roberts and others (1997) and the CORMIX modelling package were used during the analysis. The equations of Roberts and others (1997) are an industry standard, having been used to examine the performance of diffusers and predict near-field outcomes for the Adelaide, Perth, Gold Coast and Sydney desalination plants (see Appendix H3 of the Supplementary EIS). CORMIX is widely used in the United States by the Environmental Protection Agency. Whereas the equations are based on discharge from a single port during zero currents, CORMIX is capable of modelling multi-port diffusers over a range of ambient current speeds. The sensitivity analysis was generally based on zero current speed using the Roberts and others (1997) approach to provide worst-case dilutions.

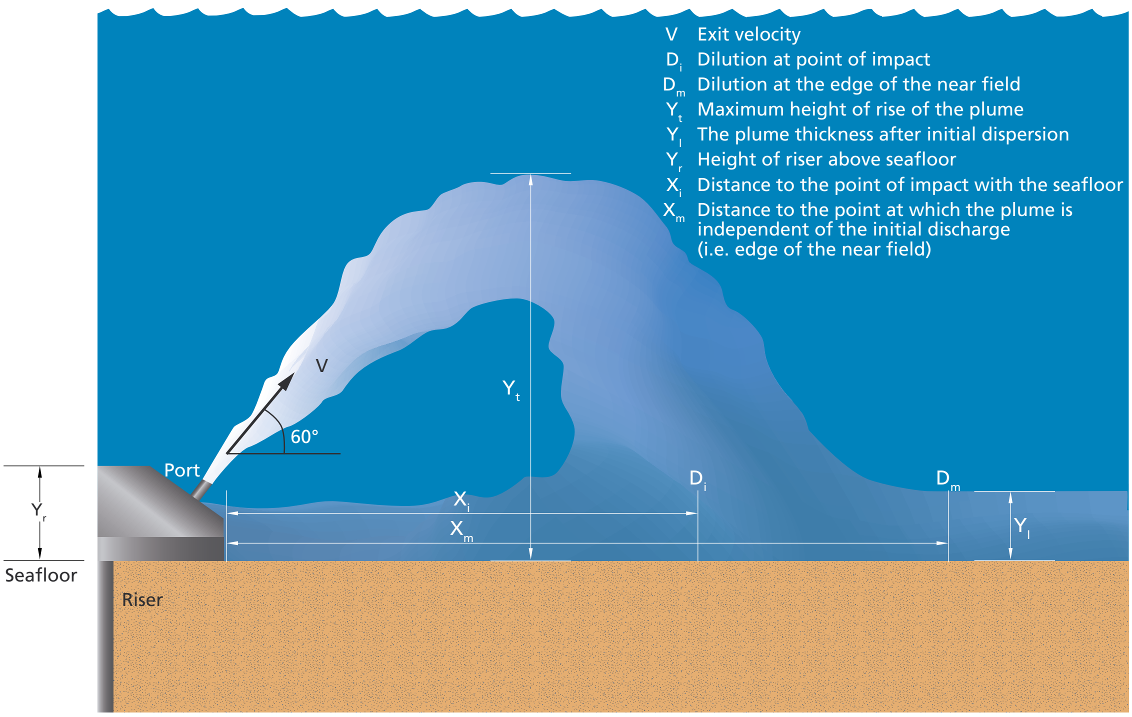
The sensitivity analysis showed that the rate of dilution of the return water was highly dependent on a number of interrelated factors, including the operating head of the gravity-driven discharge, exit velocity of the discharge, the port diameter, and the number and spacing of ports (see Figure 17.12, Table 17.5 and Appendix H6 of the Supplementary EIS). It was evident that one of the key principles of diffuser design is to ensure that the exit speed of the return water is sufficiently great to force the plume as high as possible into the water column to maximise near-field dilutions, but not high enough to result in the plume interacting with the water surface. The maximum height of the plume above the seafloor should therefore be 20 m, which would leave 5–6 m between the top of the plume and the water surface (the depth being 26 m). Examples of a range of conceptual designs for the maximum and minimum discharge rates (4.3 and 2.2 m^3/s respectively) and utilising varying combinations of operating head, port diameter and number of ports are given in Table 17.5 of the Supplementary EIS. A maximum exit velocity of 10 m/s is sometimes recommended to minimise problems associated with cavitation (i.e. the formation of bubbles and pitting of pipes).

The comparisons reveal that high return water flows deliver better near-field dilutions than low flows, which is the opposite of the mid and far fields, where the best dilutions occur during low flows. The reason for this outcome is that higher discharge rates produce higher exit speeds, which propel the plume higher into the water column, where more mixing can occur before the plume reaches the seafloor (see Table 17.5). An important consideration in the concept design is therefore to maintain relatively high exit speeds (and, hence, near-field dilutions) when return water flows are low (i.e. 2.2 m^3/s). There are four methods of maintaining acceptable near-field dilutions during low flows.

- During extended periods of low flow (such as the early years of production when water demand is low), an appropriate number of ports may be capped.
- Duckbill valves made of elasticised rubber compound may be fitted to ports to control the flow of return water. As the discharge rate decreases the duckbill valves contract, which increases the exit speed. Limitations with duckbill valves are that the maximum practicable exit speed is 12 m/s, and they are reported to increase exit speeds to only a limited extent.
- During low discharge rates return water is discharged only intermittently. Return water is allowed to build up in the header tank during low discharge rates, and discharged at the high flow rate until the header tank is empty, when the sequence is repeated.
- The diffuser is configured (without using duckbill valves) to provide acceptable dilutions over the range of expected flow rates.

The sensitivity study revealed that a large number of diffuser configurations would provide acceptable near-field dilutions. Two possible concept designs and performances for the linear and rosette-style diffusers are presented in Table 17.6 of the Supplementary EIS.

The diffuser optimisation study has shown that the optimised diffuser at Point Lowly would be capable of achieving safe dilutions (i.e. at least 1:50) at the edge of the 100 m mixing zone at all times, including dodge tides.



Source: Roberts et al 1997

Figure 17.12 Profile of a return water plume from a single port

Table 17.5 Sensitivity analysis of alternative conceptual diffuser designs (based on Roberts and others 1997 equations) and assuming zero current speeds

Return water flow (m^3/s)	Gravity head (m)	Port diameter (m)	Number of ports	Port exit speed (m/s)	Plume height (m)	Impact point dilution	Location of impact point (m from port)	Near-field edge dilution	Extent of near-field (m from port)
4.3	10	0.10	45	12.2	16.4	119	17.9	194	67.1
4.3	10	0.14	23	12.4	19.7	102	21.5	166	80.6
4.3	10	0.175	14	12.5	22.2	92	24.2	150	90.8
4.3	8	0.10	50	10.9	14.7	107	16	174	60.1
4.3	6.5	0.15	24	10.1	16.7	81	18.2	131	68.2
4.3[1]	5.0	0.175	20	8.9	15.9	66	17.3	107	64.9
3.1	15	0.100	26	15.0	20.2	147	22.0	238	82.4
3.1	15	0.140	13	15.2	24.2	126	26.4	204	99.0
3.1	15	0.175	8	15.3	27.3	113	29.8	184	111.6
3.1	10	0.100	32	12.3	16.5	120	18.0	195	67.6
3.1	10	0.140	16	12.5	19.9	103	21.7	168	81.2
3.1	10	0.175	10	12.6	22.4	93	24.4	151	91.5
3.1	8	0.100	35	11.0	14.8	108	16.2	175	60.7
3.1	8	0.140	18	11.2	17.8	93	19.4	150	72.9
3.1	8	0.175	11	11.3	20.1	83	21.9	136	82.1
2.2	11.5	0.100	26	10.7	14.4	105	15.7	170	58.9
2.2	11	0.140	14	10.5	16.8	87	18.3	142	68.6
2.2	11	0.150	12	10.6	17.4	84	19.0	137	71.3
2.2	10	0.140	11	12.5	19.9	104	21.7	168	81.5
2.2	10	0.175	7	12.6	22.5	93	24.5	152	91.9
2.2	9	0.140	16	9.0	14.3	75	17.7	121	58.7
2.2	8	0.100	25	11.1	14.9	108	16.3	176	61.0
2.2	8	0.100	23	12.3	16.6	121	18.1	196	67.9

[1] Indicative configuration used during subsequent modelling

Table 17.6 Draft EIS and optimised diffuser concept designs and performance

	Draft EIS linear concept	Optimised linear concept	Optimised rosette concept
Length	200 m	200 m	4 rosettes 66 m apart
Pipe diameter	2.1 m	2.1 m	2.1 m
Number of ports	50	20	20 (5 per rosette)
Port diameter	175 mm	175 mm	175 mm
Port spacing	4 m	10 m	3.7 m
Port configuration	60°	60°	60°
Exit speed	3.6 m/s	8.9 m/s	8.9 m/s
Dilution on contact with the seafloor (Roberts et al. 1997)	1:27	1:66	1:66
Dilution at edge of the near-field (~50–100 m) (Roberts et al. 1997)	1:43	1:107	1:107

17.7.5 NEAR-FIELD MODELLING

Issue:

The near-field dilutions reported in the Draft EIS have been questioned. It was suggested that the near-field models be rerun with different diffuser configurations to improve initial dilutions and achieve targets derived from the ecotoxicology studies.

Submissions: 2, 80, 284 and 376

Response:

Additional modelling of near-field dilutions has been undertaken using a rosette-style diffuser. The simulations reported dilutions near the diffuser that were significantly better than those reported from the generic linear diffuser modelled in the Draft EIS.

Since publication of the Draft EIS, and in response to submissions received, BHP Billiton has committed to tunnelling the outfall pipeline. Additional near-field modelling has therefore been undertaken for the Supplementary EIS to assess the performance of a revised diffuser design. The conceptual design of a rosette-style diffuser, used to demonstrate that improved performance can be achieved via a revised diffuser, is shown in Figure 17.13 of the Supplementary EIS.

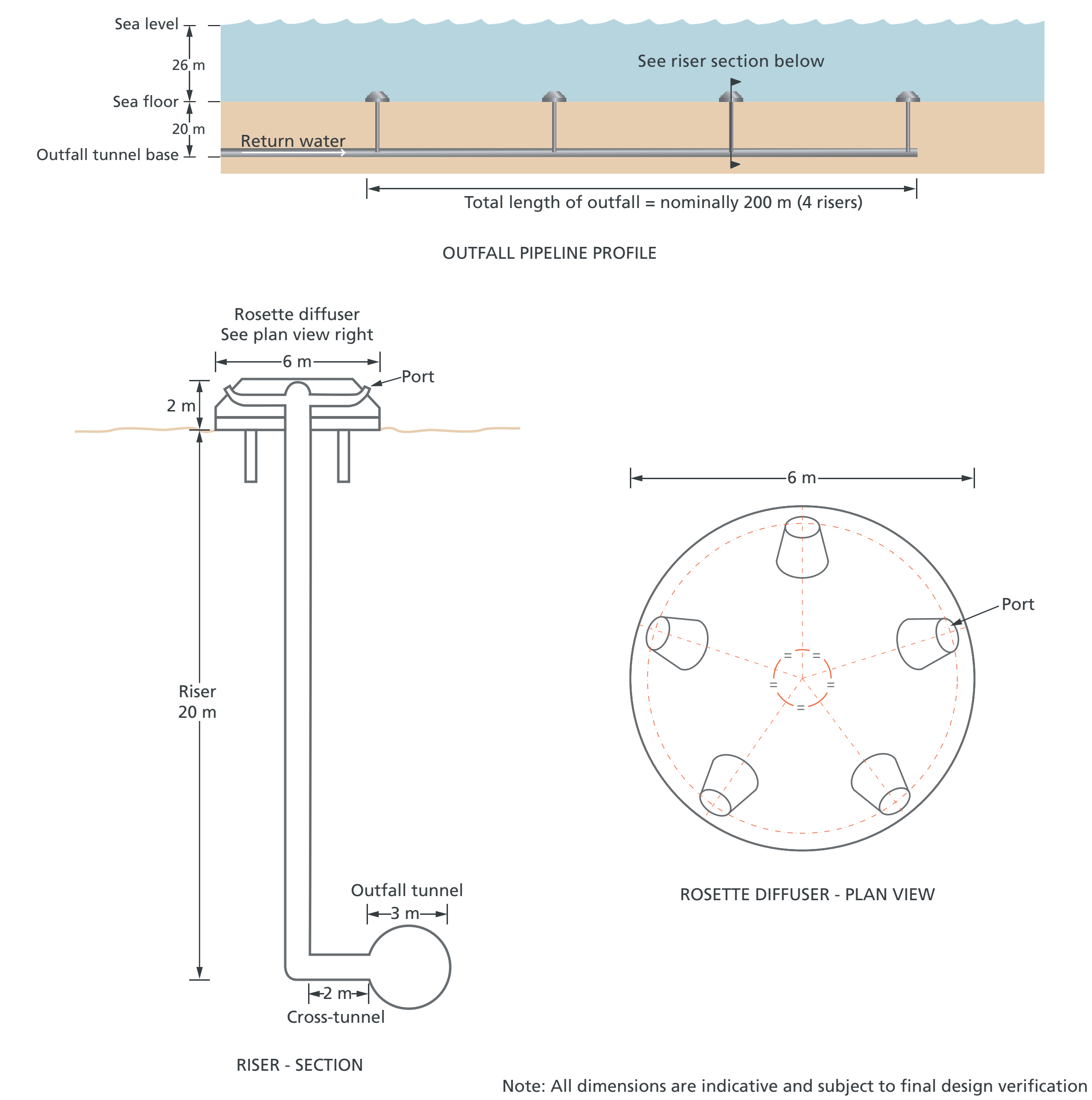


Figure 17.13 Conceptual design of outfall

The approach to the near-field modelling has also been expanded beyond the CORMIX modelling package (the industry standard used in the Draft EIS) to include other widely used modelling techniques and equations.

The empirical equations of Roberts and others (1997) operate at zero current speed and were therefore considered to be more suitable for assessing worst-case dilutions. As with CORMIX, the Roberts dilution equations were derived from laboratory model tests and validated in the field. The Roberts model was used to predict near-field dilutions for the Adelaide, Perth, Sydney and Gold Coast desalination plants. The equations predict dilutions of the plume on first contact with the seafloor and at the edge of the near-field zone (i.e. the point at which the jet-like discharge of return water from the diffuser is fully dissipated). Field-testing of the Roberts equations at Perth’s Cockburn Sound desalination plant showed that they adequately described the dilution of the brine for all but low discharge rates, when dilutions were underestimated (Marti et al. 2011). One limitation of these equations is that they provide outputs for a single-port, rather than a multi-port diffuser, and therefore do not provide information on interactions between separate plumes and re-entrainment.

To overcome the limitations associated with the Roberts and CORMIX models, near-field dilutions were also predicted using Computational Fluid Dynamics (CFD), which is a hydrodynamic model capable of predicting dilutions in three dimensions, and accounting for multiple ports, plume interactions and re-entrainment (see Figure 17.14 of the Supplementary EIS). Although near-field dilutions from the CFD, Roberts and Toms (1987) and CORMIX models were similar, dilutions from the Roberts and others (1997) model were found to be less conservative by a factor of about 20–30% (see Appendix H7.2 of the Supplementary EIS). The more conservative outcomes provided by CFD have therefore been adopted for the assessment of near-field dilutions.

The revised near-field modelling results extracted at first contact with the seafloor and 100 m from the diffuser are presented in Table 17.7 of the Supplementary EIS. The results show the return water would always achieve a dilution of at least 1:45 at the edge of the 100 m mixing zone around the diffuser, even during the most extreme dodge tides. Near-field dilutions over the range of current speeds at Point Lowly are provided in Table 17.8 of the Supplementary EIS.

It is concluded that the species protection trigger value (SPTV) of 1:45 (protecting 95% of species) would be achieved at all times within the near-field mixing zone around the diffuser.

Table 17.7 Minimum near-field dilutions calculated using the Roberts and others (1997) and CFD methods (zero current)

Method	Impact point dilution	100 m dilution
Roberts et al. (1997)	1:66	1:107
CFD	1:43	1:97

Table 17.8 Near-field dilutions over the range of currents occurring off Point Lowly calculated using CFD

Current percentile	Impact point dilution	100 m dilution
Still = 0.0 m/s	43	97
Ebb 10%	53	95
Ebb 30%	64	103
Ebb 50%	136	170
Ebb 70%	187	191
Ebb 90%	314	314
Flood 10%	49	92
Flood 30%	76	112
Flood 50%	126	139
Flood 70%	199	199
Flood 90%	308	309

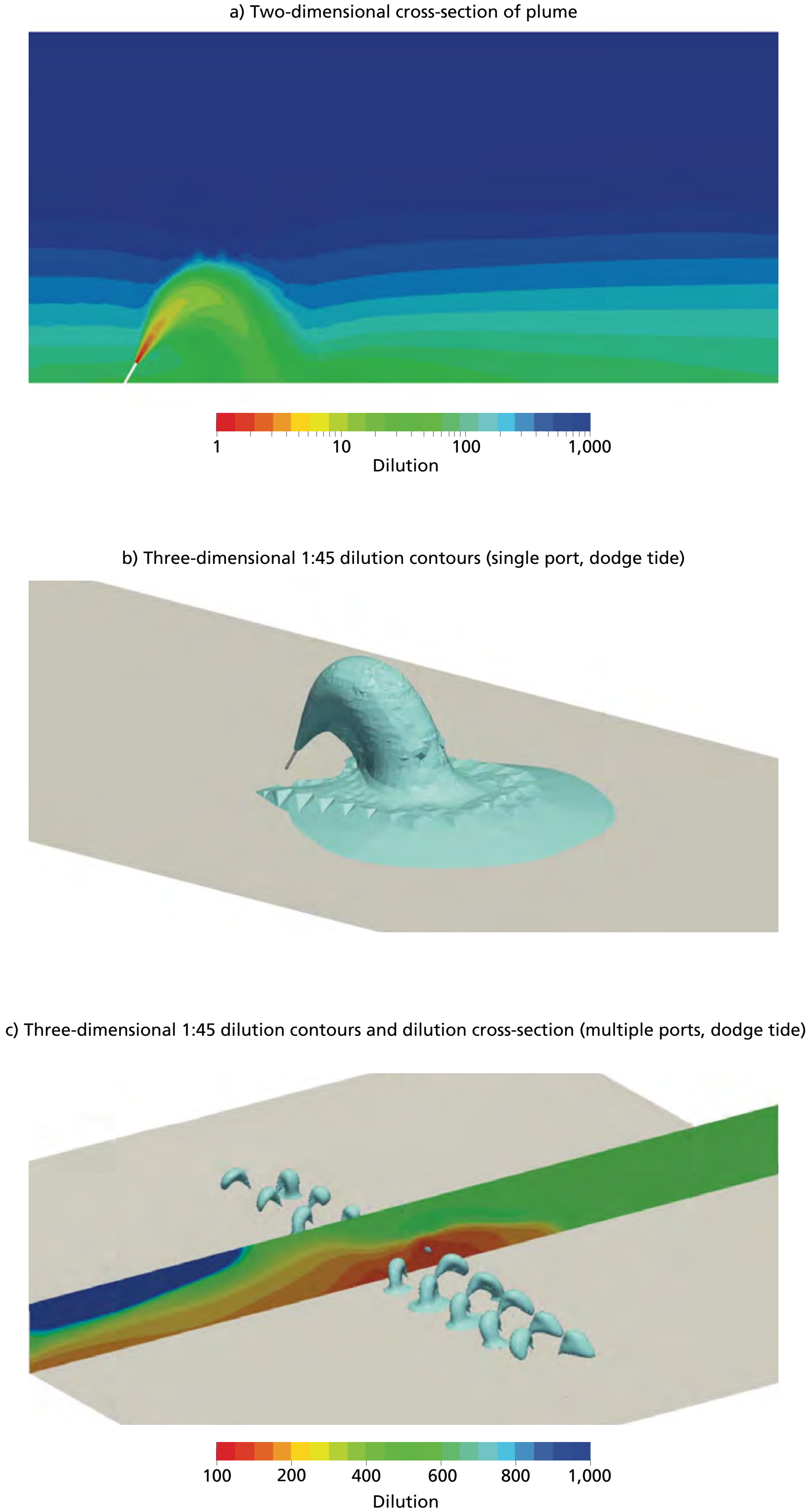


Figure 17.14 Computational Fluid Dynamics (CFD) generated images of the return water plume

17.7.6 MID-FIELD MODELLING

Issue:

It was suggested that the mid-field models be rerun with different diffuser configurations to improve dilutions and achieve targets derived from the ecotoxicology studies.

Submissions: 1 and 2

Response:

The mid-field model simulations have been rerun with near-field dilution inputs from a rosette-style diffuser. The mid-field model (based on ELCOM) has also been upgraded and recalibrated since the Draft EIS, which has resulted in even greater confidence in the model outcomes. The main improvements in the model are:

- a more accurate method of initiating the simulations that takes into account the initial near-field dilution provided by the diffuser
- greater mid-field resolution via the use of 40 m x 40 m x 1 m grid cells (rather than 200 m x 200 m x 2 m cells) in the vicinity of the diffuser
- the ability to run a single mid- and far-field model that incorporates near-field CFD dilutions, which thereby removed the need to combine the results of separate near-, mid- and far-field models
- one-year 'warm-up' periods prior to undertaking simulations to ensure that any long-term effects on salinity were taken into account during model runs
- improved model calibration using field data from Point Lowly and numerous other sites in Upper Spencer Gulf.

For the Draft EIS simulations, return water was introduced to a single bottom cell, which resulted in conservative dilutions in the vicinity of the diffuser. Since ELCOM is only capable of receiving return water into the bottom cells, it does not take into account the action of the jet-like discharge from the diffuser into the overlying water column that delivers rapid near-field dilutions. The mid-field dilutions in the outfall cell therefore reflected the return water injection method, rather than actual near-field outcomes, and were therefore highly conservative. As the return water dispersed into adjacent cells the overly conservative dilutions near the diffuser were corrected to some extent, as secondary mixing processes via currents, waves and turbulence dispersed the return water into the water column. Mid-field dilutions some distance from the diffuser would therefore have been predicted correctly.

The conservatism in the mid-field results near the diffuser has been corrected in the upgraded ELCOM model by distributing the return water discharge into numerous cells around the diffuser at the dilutions provided by the Computational Fluid Dynamics (CFD) model results.

After a model warm-up period of several years to account for the long-term effects of return water discharge, the mid-field simulation was run for a full year, which ensured that all seasonal oceanographic and meteorological conditions were included. The results of the simulation are described in detail in Appendix H7.2 of the Supplementary EIS. Dilutions and salinity increases at key locations around Point Lowly are given in Figure 17.15a and b, and Table 17.9 of the Supplementary EIS. Dilution contours around the outfall are given in Figure 17.16a of the Supplementary EIS. Minimum dilutions along a cross-section of the water column extending 1,200 m from the tip of Point Lowly to beyond the outfall are given in Table 17.10 and Figure 17.16b of the Supplementary EIS.

The following conclusions are derived from the simulation:

- The maximum salinity increase in the immediate vicinity of the outfall would be about 0.8 g/L (i.e. 2% above ambient), which is equivalent to a return water dilution of 1:43.
- The minimum dilution at the edge of the near-field mixing zone (i.e. 100 m from the outfall) would always be better than 1:45 (the dilution threshold required to protect 95% of species at Point Lowly).
- The maximum extent of the 1:70 dilution contour would be about 2 km from the diffuser.
- For 99% of the time the 1:70 dilution contour would extend no more than 400–500 m from the outfall.
- The minimum dilution in the closest section of cuttlefish habitat at the tip of Point Lowly would be 1:107, and would exceed 1:201 for 99% of the time. The safe dilution for cuttlefish (EC10) is 1:16 (see Appendix H4.3 of the Supplementary EIS).
- The safe dilution for cuttlefish would always be attained, even in the immediate vicinity of the outfall.
- The dilution outcomes indicate that measurable chronic and sub-chronic effects are likely to be confined to approximately 5% of species within the near-field mixing zone (i.e. within 100 m of the outfall).

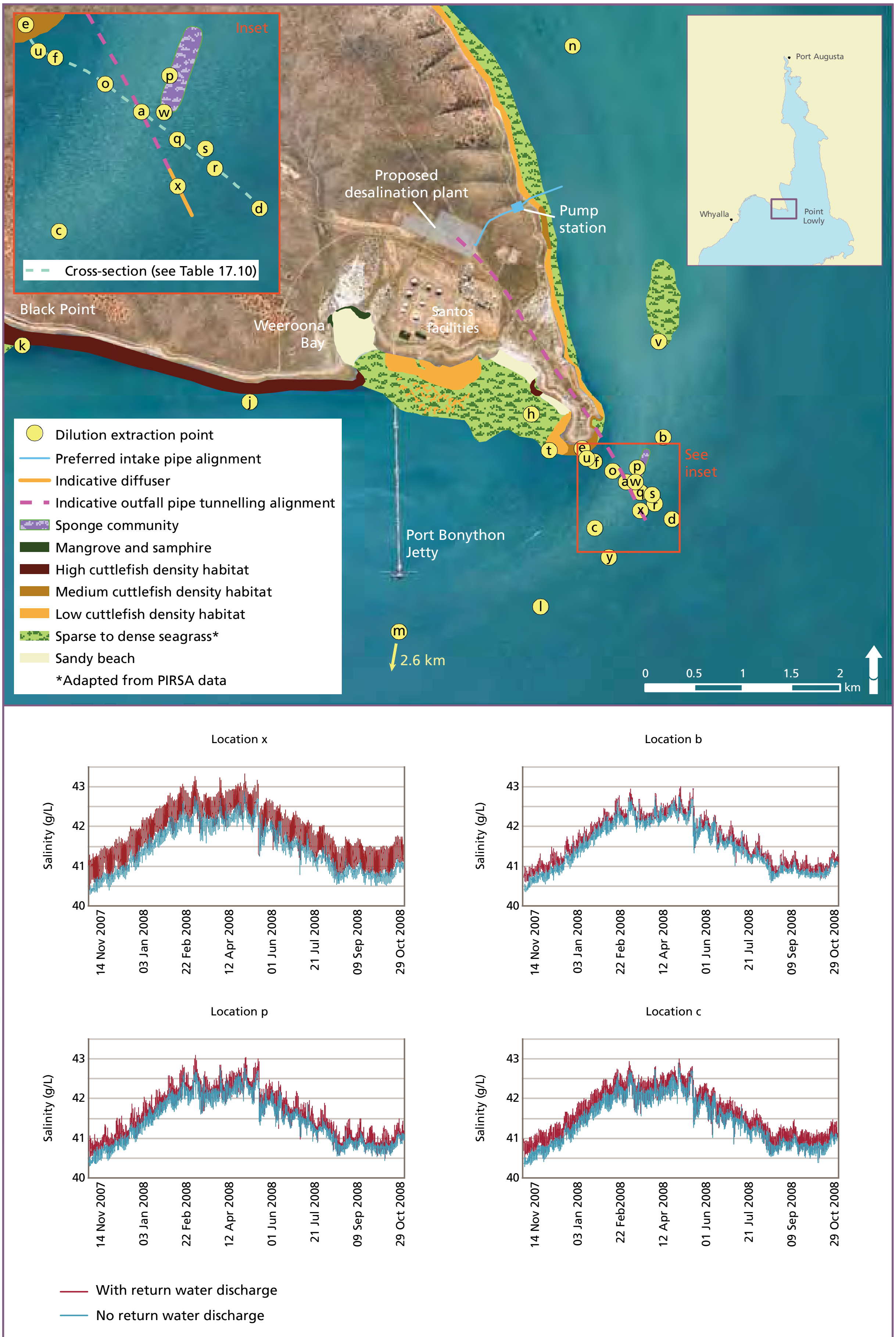


Figure 17.15a Predicted salinity increases at key locations around Point Lowly

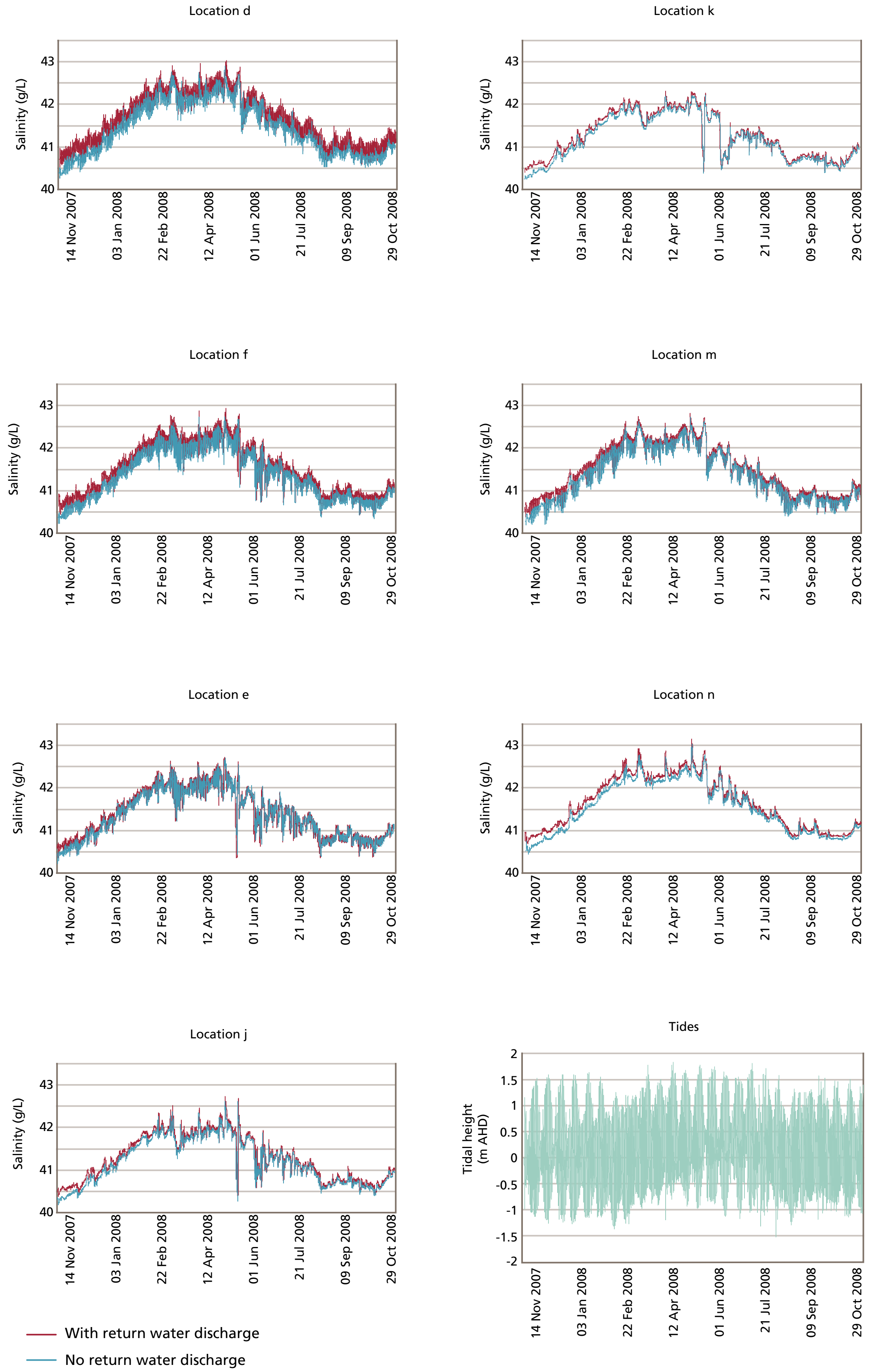


Figure 17.15b Predicted salinity increases at key locations around Point Lowly

Table 17.9 Summary of return water dilutions, salinity increases and breaches of dilution (effects) thresholds at key locations off Point Lowly

Site (Fig. 17.15)	Receptor	Return water dilution					Max. salinity increase (g/L)[1]	Breach of 1:70 dilution		Breach of 1:45 dilution		Conclusion
		Dilution thresholds	0th percentile (minimum)	1st percentile	10th percentile	50th percentile (median)		% of time	Max. time (hrs)	% of time	Max. time (hrs)	
x	Benthic communities near outfall	>1:45–70[2]	1:43[3]	1:46	1:53	1:144	0.8	26	43	0.5	0.75	Possible minor effects on some species
b			1:59	1:84	1:206	1:322	0.6	0.3	5	0	n.a.	Measurable effect unlikely
c			1:59	1:83	1:121	1:288	0.6	0.1	1.5	0	n.a.	Measurable effect unlikely
d			1:56	1:77	1:110	1:314	0.6	0.3	2.5	0	n.a.	Measurable effect unlikely
e	Australian Giant Cuttlefish	>1:16[4]	1:161	1:243	1:311	1:369	0.2	0	n.a.[5]	0	n.a.	No possible effect
u			1:107	1:201	1:286	1:352	0.3	0	n.a.	0	n.a.	No possible effect
h			1:179	1:261	1:334	1:397	0.2	0	n.a.	0	n.a.	No possible effect
j			1:200	1:277	1:352	1:416	0.2	0	n.a.	0	n.a.	No possible effect
k			1:320	1:337	1:374	1:443	0.1	0	n.a.	0	n.a.	No possible effect
l	Prawns	>1:14[4]	1:72	1:126	1:235	1:335	0.5	0	n.a	0	n.a.	No possible effect
m			1:136	1:256	1:303	1:352	0.2	0	n.a.	0	n.a.	No possible effect
n	Kingfish farms	>1:70[4]	1:272	1:287	1:311	1:347	0.1	0	n.a.	0	n.a.	No possible effect
p	Sponge community	>1:45–70[2]	1:52	1:70	1:214	1:324	0.6	1	7.4	0	n.a.	Measurable effect unlikely
w			1:50	1:65	1:176	1:324	0.6	1.9	7.7	0	n.a.	Measurable effect unlikely
t	Seagrass community	>1:45–70[2]	1:102	1:187	1:319	1:384	0.3	0	n.a.	0	n.a.	No possible effect
v			1:164	1:252	1:272	1:329	0.2	0	n.a.	0	n.a.	No possible effect

[1] Based on return water salinity = 75 g/L; ambient salinity = 42 g/L; note salinity at Point Lowly varies seasonally from 40 to 43 g/L, and daily by around 1.5 g/L (see Figure 17.19 and Appendix H5.4);
[2] Species Protection Trigger Values: 1:45 would protect 95% of species at maximum Point Lowly salinity; 1:70 would protect 99% of species at maximum Point Lowly salinity (see Appendix H4.3);
[3] Near-field results (see Appendix H7.2);
[4] Lowest EC_{10} for individual species (refer Table 16.8 of the Draft EIS, and see Appendix H4.3);
[5] n.a. = not applicable.

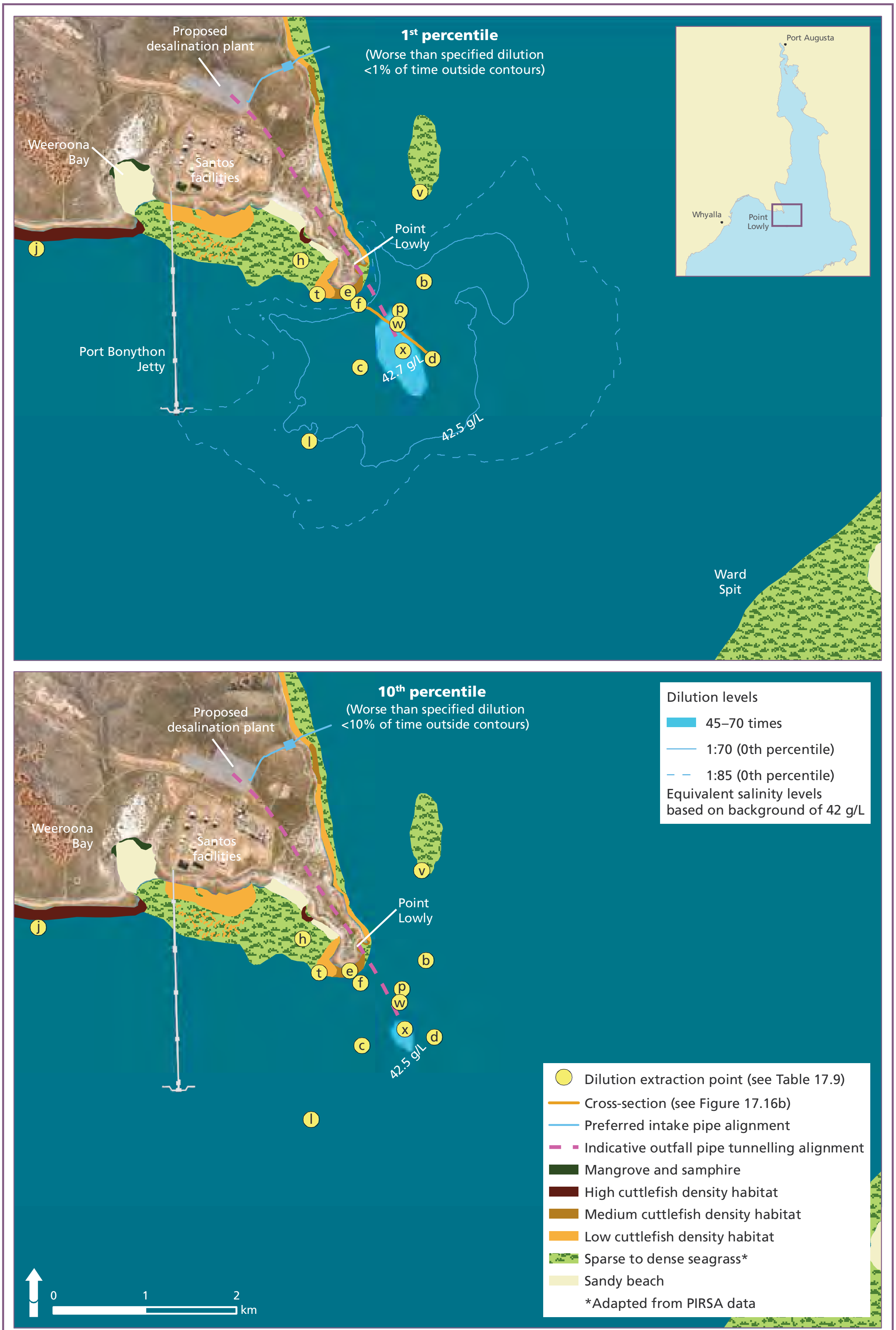


Figure 17.16a Dilution contours showing the return water footprint off Point Lowly

Table 17.10 Minimum dilutions along a 1,200 m cross-section of the water column from the tip of Point Lowly to beyond the outfall (one-year simulation) (bold indicates breaches of the SPTV of 1:70)

Depth (m)	Dilutions through the water column at each site along the cross section[1]							
	e	u	f	o	a	q	r	d
1.0	195	200	192	216	200	213	196	176
1.0	186	163	156	161	169	165	182	163
3.0	183	143	134	163	170	167	181	166
4.9	161	119	112	161	168	172	173	167
6.7		109	107	152	151	119	136	144
8.2		107	107	132	125	78	109	100
9.7			97	128	112	76	96	97
11.0			91	120	91	64	86	101
12.3			89	97	68	64	84	92
13.4			88	87	66	65	81	90
14.5				68	66	65	77	91
15.5				62	65	66	75	90
16.5				62	65	64	76	76
17.5				61	60	64	76	74
18.5				59	58	64	73	73
19.5				58	55	61	71	71
20.5				57	53	60	69	71
21.5				57	50	55	66	65
22.5				56	48	52	62	60
23.5				56	47	51	58	59
24.7				57	46	50	52	56
25.9					46	50	51	56

[1] See Figure 17.15a for site locations.

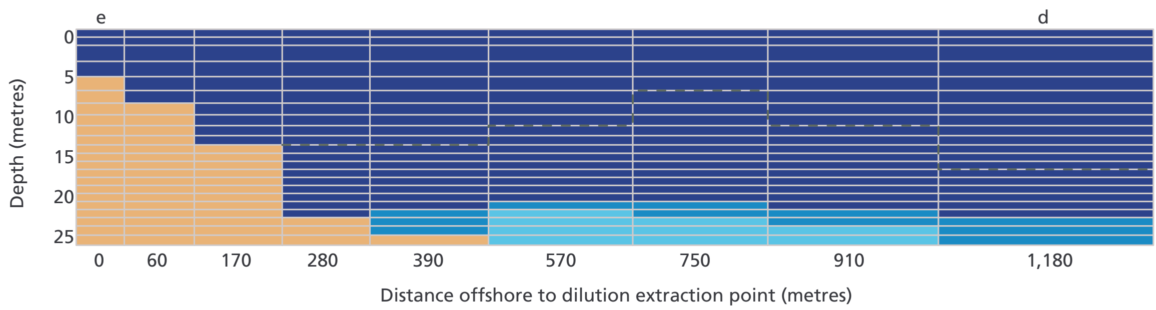


Figure 17.16b Cross-sectional view of the return water dilutions off Point Lowly

Issue:

It was suggested that re-entrainment of return water into the discharge stream should be assessed.

Submission: 2

Response:

Re-entrainment of return water into the discharge stream has been accounted for in the near-field outcomes presented in the Supplementary EIS by using Computational Fluid Dynamics (CFD). CFD is a three-dimensional hydrodynamic model capable of modelling complex aspects of plume behaviour, including plume interactions and re-entrainment. The steady-state CFD outcomes presented in Appendix H7.2 of the Supplementary EIS are considered to resolve re-entrainment and plume interaction issues. The more conservative near-field outcomes provided by CFD, compared with Roberts and others (1997), may be explained to some degree by plume interaction and re-entrainment. Furthermore, before mid-field model simulations began, the ELCOM model was 'warmed-up' for one simulated year to account for long-term salt accumulation near Point Lowly and re-entrainment.

Issue:

It was suggested that there is potentially insufficient safety margin in the hydrodynamic modelling results.

Submission: 238

Response:

The hydrodynamic modelling presented in the Draft EIS had a considerable safety margin as a consequence of numerous conservative assumptions (refer Section 16.6.1 of the Draft EIS). The most important of these were:

- peak discharge rates were used for hydrodynamic modelling (mean discharge is expected to be 16% lower)
- the mid-field model assumed that all return water would be injected into the bottom 1.6 m-high cell (rather than up to 7 m into the water column)
- actual current speeds during dodge tides (measured using a current meter) are significantly stronger than the modelled current speeds used to predict dispersion
- the mid-field model period combined extreme conditions of dodge tides and no wind
- very conservative measures were used to combine the near-, mid- and far-field models, which have led to highly conservative dilution outcomes.

Additional field samples and further, more detailed modelling have confirmed the conservative nature of the assessments undertaken and presented in the Draft EIS (see responses above and Section 17.7.5 of the Supplementary EIS for details).

17.7.7 UPWELLING EFFECTS

Issue:

It was suggested that strong offshore winds during periods of low mixing could induce upwelling of saline return water towards shore, resulting in potentially catastrophic effects on cuttlefish and prawn nurseries. It was noted that certain combinations of tides and winds may induce upwelling.

Submissions: 40, 83, 127, 155, 171, 192, 290, 320 and 324

Response:

Upwelling of return water in the vicinity of Point Lowly is insignificant when the accurate hydrodynamic characteristics of Point Lowly are considered and appropriate model assumptions are used. In reality strong offshore winds induce lateral flows along the deep channels off Point Lowly, away from sensitive receptors rather than upwelling towards the cuttlefish habitat.

Modelling scenarios not reported in the Draft EIS showed that strong offshore winds during dodge tides resulted in higher dilutions (including directly inshore) compared with the zero wind scenario.

A more extensive investigation of the potential for upwelling at Point Lowly has been undertaken for the Supplementary EIS (see Appendix H7.2 for details). Initially the investigation attempted to induce upwelling at Point Lowly by applying artificial confined boundaries similar to those used in the two-dimensional simulations provided in a submission, followed by a series of realistic three-dimensional simulations with open boundaries.

In order to replicate the 'lake-like system' used in the submission by Dr Jochen Kaempf of Flinders University, the upwelling analysis for the Supplementary EIS included a two-dimensional model scenario with artificial weirs spanning Spencer Gulf. When a constant north-westerly wind (15 m/s or 30 knots) was applied to the model, a strong recirculatory flow along the bottom towards the western shore became evident, resulting in some upwelling on the western side of the gulf. When the solid boundaries were removed, however, the recirculatory flow and upwelling ceased. The conclusion is that the upwelling induced in the simulation provided in Dr Kaempf's submission result from the use of incorrect model assumptions, and would not occur to the same extent under natural conditions.

Several realistic simulations were subsequently undertaken using the refined ELCOM model presented in Appendix H7.2 of the Supplementary EIS. Worst-case conditions for upwelling were applied during the simulations, including zero tidal movement and strong westerly, north-westerly and northerly winds. The strong offshore winds induced north-south (rather than east-west) circulatory currents, resulting in lateral flows of return water along the bottom of the deep channels away from the sensitive receptors at Point Lowly (see Figure 17.17 of the Supplementary EIS). Although there was no evidence of upwelling in any of the simulations, a small degree of turbulent mixing was apparent as the return water pool flowed laterally along the seafloor. When natural tidal forcing was applied to the model, the weak lateral flows induced by the offshore winds were overwhelmed by the natural tidal currents (refer Appendix H7.2 of the Supplementary EIS).

It is also noted that the performance of the rosette-style diffuser in returning improved return water dilutions close to the diffuser has reduced the relevance of potential upwelling, as dilution thresholds (at least 1:45 protecting 95% of species) are likely to be attained at all times on the seafloor at the edge of the near-field plume. Safe dilutions would therefore always be achieved in the shallow habitat around Point Lowly.

Issue:

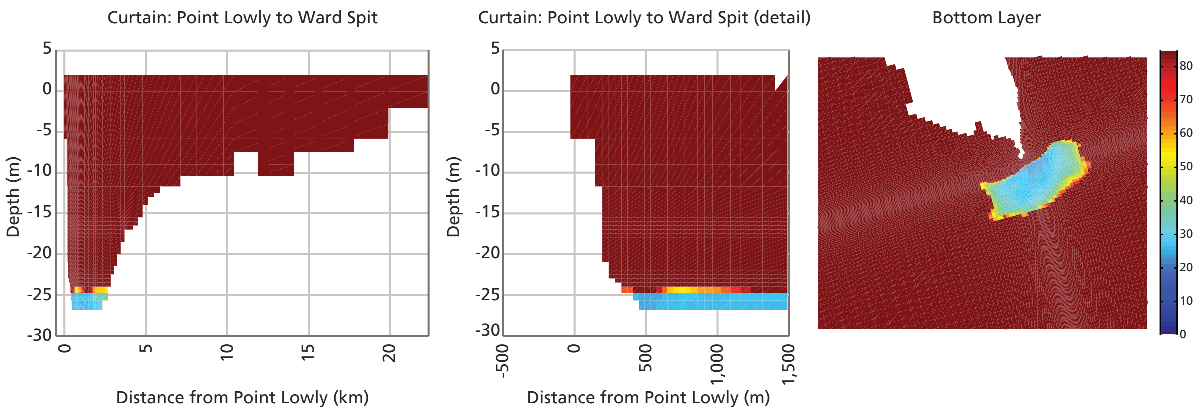
It was suggested that a vertical separation of only 5 m between return water and cuttlefish habitat is small for discharge that would occur 24 hours a day throughout the year.

Submission: 102

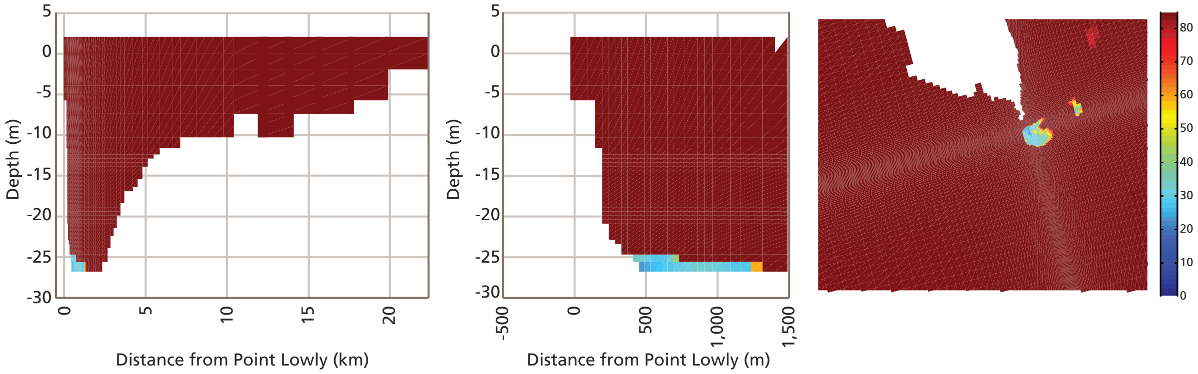
Response:

The 5 m vertical separation between return water and cuttlefish habitat must also be considered in terms of the horizontal separation (i.e. 600 m as per the Draft EIS).

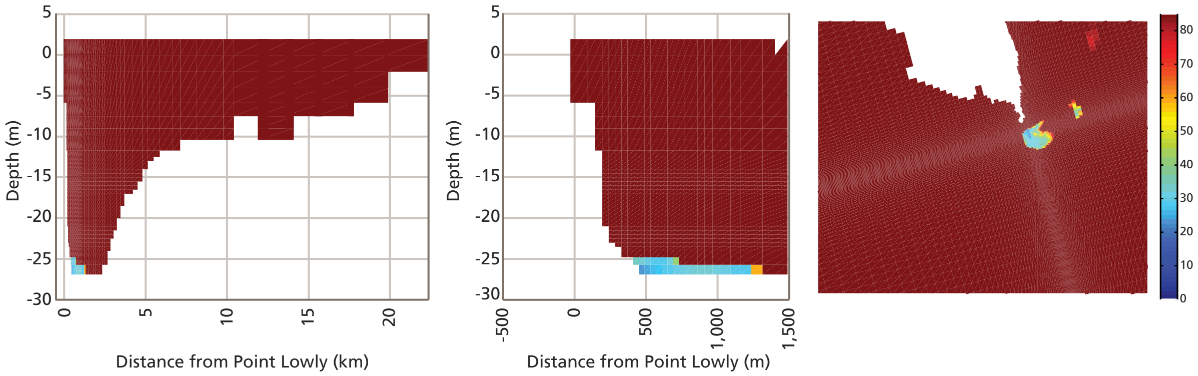
Although the upward momentum of discharge return water may carry it to within 5 m of the surface, the dense plume quickly falls again to the seafloor. The vertical separation between return water and cuttlefish habitat would therefore be maintained.



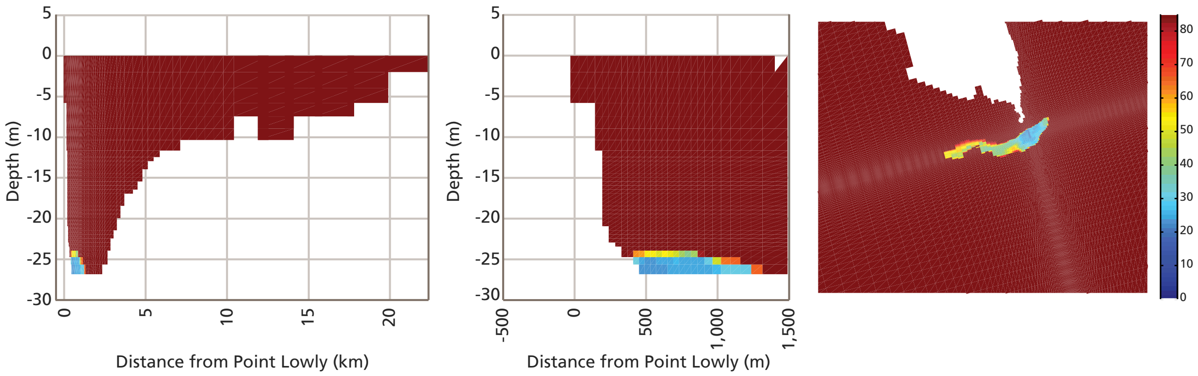
(a) DILUTION AT 0 HOURS FROM WIND COMMENCEMENT



(b) STRONG NORTHERLY WIND – DILUTION AT 24 HOURS FROM WIND COMMENCEMENT



(c) STRONG NORTH WESTERLY WIND – DILUTION AT 24 HOURS FROM WIND COMMENCEMENT



(d) STRONG WESTERLY WIND – DILUTION AT 24 HOURS FROM WIND COMMENCEMENT

Figure 17.17 No evidence of upwelling during a dodge tide with strong offshore winds

17.8 POTENTIAL ECOLOGICAL EFFECTS OF RETURN WATER DISCHARGE

17.8.1 SENSITIVITY OF THE SPENCER GULF ECOSYSTEM TO SALINITY EFFECTS

Issue:

The sensitivity of the Spencer Gulf ecosystem to the effects of increased salinity was questioned in light of the naturally elevated salinity levels in the upper reaches of the gulf. In particular, it has been suggested that the Upper Spencer Gulf ecosystems are fragile, with some species living at their maximum tolerance to salinity and temperature.

Submissions: 2, 59, 80, 216, 328 and 389

Response:

As discussed in Section 16.6.2 of the Draft EIS, Upper Spencer Gulf marine communities would not be particularly sensitive to salinity effects from the proposed desalination plant discharge as the predicted salinity increases in the vicinity of the outfall would be insignificant compared with the natural salinity gradient along the gulf. In late summer, the salinity of the gulf increases by an average of 0.5 g/L every 12 km from south to north (Nunes and Lennon 1986).

The substantial salinity gradient along the length of the gulf contributes to the existence of an ecotone, in which there is a gradual transition in the composition of marine communities from south to north. The marine communities at Point Lowly occupy a zone that is about halfway along the 36–48 g/L salinity gradient in Spencer Gulf (i.e. 40–43 g/L), and they would be tolerant of the minimal long-term salinity increase (of about 0.1 g/L) predicted for the gulf as a result of the proposed desalination plant.

Issue:

It was suggested that the water north of Point Lowly is very finely balanced and a minor error could turn it into a barren dead sea.

Submission: 41

Response:

Rather than being finely balanced, the existing marine communities at Point Lowly are well adapted to the existing environmental conditions, including natural salinity variations in the region. The distribution of marine communities along the salinity gradient in the gulf is determined, in the main, by their tolerance to salinity and temperature, which may vary at different life stages. Similarly, some species probably move along the gulf in response to seasonal salinity and temperature changes. Many species that occur at Point Lowly also occur in the upper reaches of the gulf, indicating that the salinity regime at Point Lowly is well below their maximum tolerance.

The predicted salinity increases in Upper Spencer Gulf are so small that a 'minor error' would not change the assessment outcome, predicting that effects on the marine life would only be detectable in the immediate vicinity of the outfall.

Issue:

It was suggested that long-term salinity increases near the desalination plant and in the upper reaches of the gulf could compound stresses on marine biota, particularly larvae, juveniles and mangroves.

Submissions: 102 and 263

Response:

Computational Fluid Dynamics (CFD) coupled with ELCOM has revealed that benthic communities within 1 km of the desalination plant outfall would be exposed to short, periodic salinity increases of 0.5 to 0.8 g/L, which is the same as the natural ambient salinity about 10 km north of Point Lowly (see Figure 17.18 and the animations in Appendix H7.4 of the Supplementary EIS). Organisms 5–10 km north of Point Lowly would generally be experiencing the same salinity as organisms within about 500 m of the outfall. Similarly, benthic communities within 100 m of the outfall would, at worst, be exposed to salinity increases of up to 0.8 g/L, which is the same as the natural ambient salinity about 10–20 km north of Point Lowly. The salinity increase in the upper reaches of the gulf of 0.1 g/L as a result of the operating desalination plant would be undetectable in terms of natural seasonal and daily salinity variation (3–4 g/L and 1.4 g/L respectively). As discussed in Section 16.6.5 of the Draft EIS, effects on species outside the immediate mixing zone around the diffuser are unlikely to be detectable.

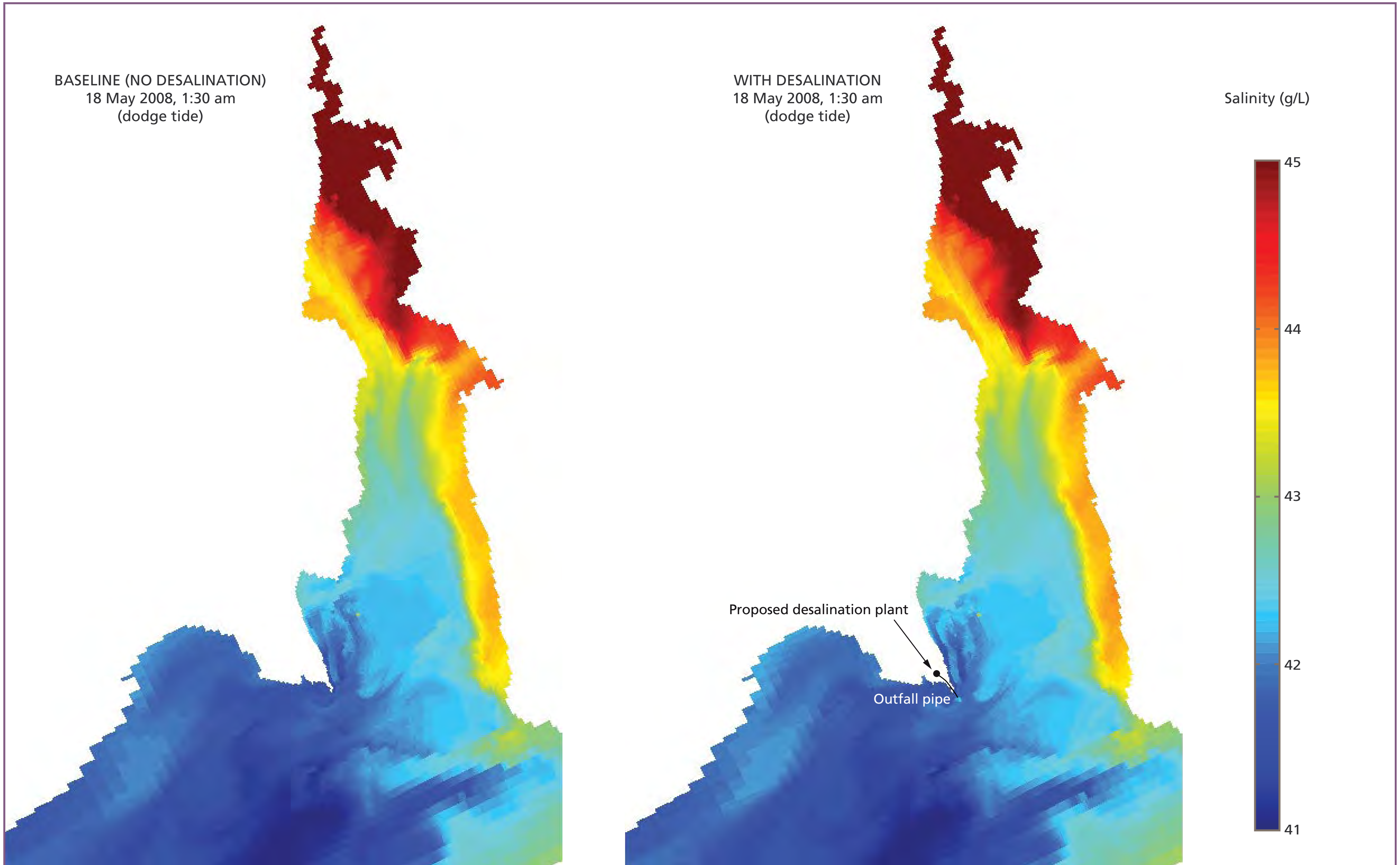


Figure 17.18 Salinity increase near the outfall is insignificant compared with natural saline plumes in Upper Spencer Gulf

Issue:

It was suggested that an unnatural salinity increase of 0.07 g/L is actually quite substantial and could trigger a cascade of detrimental impacts.

Submissions: 80, 350 and 386

Response:

In the context of the 12 g/L salinity gradient along the length of Spencer Gulf, the seasonal variation of 3 g/L at Point Lowly and the daily variation of 1.4 g/L, the predicted far-field salinity increase of 0.07 g/L would be very difficult, if not impossible, to measure and would not trigger a cascade of detrimental impacts. Gulf-wide, seasonal and daily variations in salinity are 170, 43 and 14 times greater, respectively, than the predicted salinity increase of 0.07 g/L from the proposed desalination plant. A salinity increase of 0.07 g/L would be indistinguishable from natural variation in Upper Spencer Gulf, and would have no detectable effect on the ecology of the gulf.

Issue:

It was questioned whether the ecological effects of return water discharges had been investigated for any other desalination plant operating in an inverse estuary.

Submission: 142

Response:

The effects of return water discharge have been investigated at numerous desalination plants operating in the Red Sea, which is a large inverse estuary in the Middle East. Extensive studies of the effects of desalination plants on the ecology of the Red Sea by Lattemann and Hoepner (2008) have resulted in a relatively detailed understanding of the effects of desalination plants on the ecology of an inverse estuary.

Comparisons with Spencer Gulf are only partially relevant, however, as the Red Sea is much deeper than Spencer Gulf and supports a tropical rather than temperate ecosystem. Nevertheless, the work by Lattemann and Hoepner has shown that desalination plants can be successfully operated in an inverse estuary without significant adverse effects on the environment if appropriate environmental safeguards are implemented.

It is noted that Lattemann was used as an internationally recognised specialist to review the studies undertaken to assess the potential ecological effects on Spencer Gulf for the proposed Point Lowly desalination plant and that her review concluded, 'I consider the work to have been undertaken thoroughly and to a high technical level. Adequate methods have been used in the impact assessment and accompanying studies. The work is in line with normal industry practice and it exceeds it to some extent. The conclusions reached are reasonable and the work is acceptable for its intended purpose.' (Letter of Testimony from Sabine Lattemann provided at the start of Appendix O of the Draft EIS).

Another relevant comparison is with the predicted effects of the Adelaide desalination plant at Port Stanvac on the ecology of Gulf St Vincent, which is a similar inverse estuary to Spencer Gulf. Studies conducted as part of the Environmental Impact Statement for the Adelaide plant, and accepted by the South Australian Government, concluded that construction and operation of the desalination plant at Port Stanvac would have localised, short-term impacts on the marine ecosystem, which were deemed to be manageable (SA Water 2009).

17.8.2 ECOLOGICAL IMPLICATIONS OF NATURAL SALINITY VARIATION

Issue:

A comparison has been requested of the relative frequency and scale of natural, short-term salinity variations at Point Lowly and discharge-induced changes. In the context of natural variability in salinity, clarification was also sought on the likely consequences of short-term salinity variation on marine communities at Point Lowly.

Submission: 2

Response:

This comparison was provided in Section 16.6.2 of the Draft EIS, where the natural short-term salinity variation in the Point Lowly region was reported as being of the same order of magnitude as the greatest predicted salinity increase in the vicinity of the outfall caused by return water discharge (i.e. about 1 g/L). As such, salinity increases associated with the operation of the desalination plant would be similar to natural fluctuations.

The information presented in the Draft EIS has been further verified by additional field sampling. Specifically, six Conductivity Temperature Depth (CTD) instruments were deployed at five locations throughout Upper Spencer Gulf from April to June 2009 (see Figure 17.19 of the Supplementary EIS). At one location (Sites 4 and 5 in Figure 17.5) two instruments were deployed: one on the seafloor and one at mid-depth to provide information on vertical salinity differences.

The deployment revealed that salinity is highly variable at the scale of hours, indicating that saline plumes are a common occurrence, and the mixing of higher- and lower-salinity water along the salinity gradient is a common occurrence. The maximum short-term (of the order of hours) salinity variation was about 2 g/L, with the greatest variation being recorded near the Whyalla Approach Channel (Site 3), the Port Bonython jetty (Site 2) and the Flinders Channel (Site 6). At the Port Bonython jetty, salinity variation of about 1 g/L often occurred during each tidal cycle. The difference between bottom salinity and mid-water salinity was up to 1 g/L during the 18–21 May dodge tide.

The results indicate that the marine communities in the vicinity of Point Lowly are not only adapted to seasonal changes in salinity of 3 g/L, but also to natural daily variation of over 1 g/L.

A comparison of the rate of natural and desalination-associated salinity change off Point Lowly is provided in Appendix H7.2 of the Supplementary EIS. The comparison revealed that the rates of salinity change with and without desalination were very similar at sites just outside the near-field mixing zone (i.e. up to 0.8 g/l/hour). At the outfall site the maximum rate of salinity change with desalination was 0.2 g/L/hour greater than for the baseline scenario. In the context of natural variation, however, the difference is considered to be insignificant.

Consistent with the discussion presented in Section 16.6.2 of the Draft EIS, the short-term natural salinity variation is similar to the worst-case short-term increases in salinity of 0.8 g/L in the near-field mixing zone around the outfall, and significantly greater than the predicted maximum short-term salinity increase in the cuttlefish habitat (0.3 g/L).

17.8.3 EXTENT OF POTENTIAL EFFECTS ON MARINE COMMUNITIES

Issue:

It was suggested that the desalination plant discharges may result in significant impacts to marine life, particularly early life stages such as larvae and juvenile fish.

Submissions: 54, 59, 68, 93, 97, 114, 120, 143, 158, 171, 184, 217, 227, 231, 250, 258, 304, 310, 314, 319, 325, 345 and 363

Response:

The ecotoxicology and hydrodynamic modelling studies undertaken for both the Draft and Supplementary EIS have shown that measurable effects on marine communities would be confined to the near-field mixing zone within 100 m of the outfall, where dilutions less than 1:70 (but always greater than 1:43) would occur 10% of the time. The worst dilutions near the outfall are predicted to be close to the thresholds at which effects may occur (i.e. dilutions of 1:45 and 1:70, which are predicted to protect 95% and 99% of species, respectively).

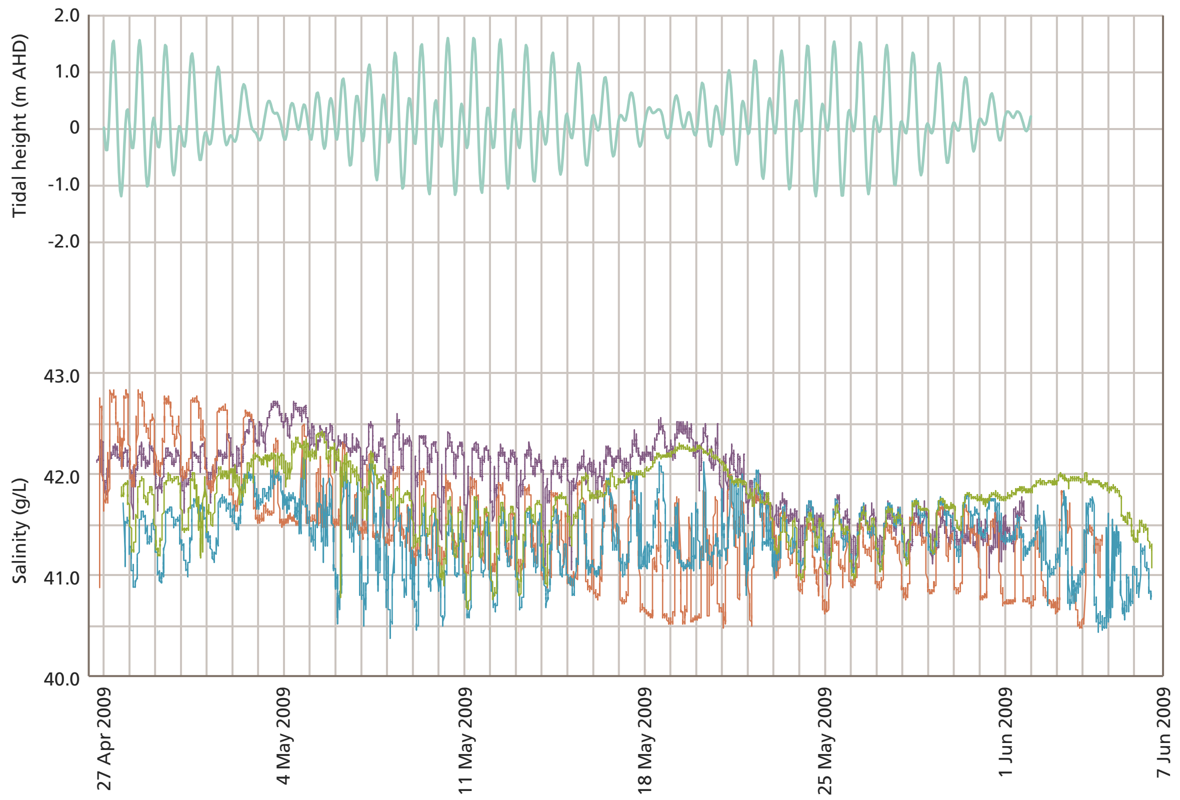


Figure 17.19 Natural short-term salinity variation in Upper Spencer Gulf

Dilutions better than 1:70 are likely to be achieved for 90% of the time at the edge of the near-field mixing zone (see Figure 17.16a of the Supplementary EIS). Although the 1:70 dilution contour is predicted to extend up to 500 m from the outfall for 1% of the time, the conservatism inherent in the species protection trigger values suggest that effects on species would not be measurable beyond the immediate mixing zone (see Figure 17.16 of the Supplementary EIS).

The results indicate that there would be no detectable effects on the nearest reef communities, seagrass communities, sponge community or farmed kingfish. As discussed in more detail in Sections 17.10 and 17.11 and 17.9 of the Supplementary EIS, there would be no detectable effects on the Australian Giant Cuttlefish breeding aggregation, commercial or recreational fisheries, or any listed species.

Issue:

Concerns have been raised about the effect return water discharge would have on marine life, particularly commercial species, in the mixing zone.

Submissions: 2 and 83

Response:

Effects on marine life within 100 m of the diffuser (i.e. the mixing zone) are expected to be minor. As discussed in Section 17.7.5 of the Supplementary EIS, hydrodynamic modelling studies have shown that return water dilutions on the seafloor in the mixing zone would be better than the 1:45 (protecting 95% of species) for more than 99% of the time, and better than 1:70 (protecting 99% of species) for about 90% of the time. Worst-case dilutions (during dodge tides and tide changes) would result in salinity increases on the seafloor of up to 0.8 g/L, which is less than the natural daily variation in salinity off Point Lowly.

Benthic surveys have revealed that the seafloor in the zone where measurable effects may occur consists predominantly of sand and silt, inhabited by a sparse red algal and invertebrate community that occurs throughout most of Upper Spencer Gulf. These communities include the fauna inhabiting the sediment (infauna), and the community of filter-feeding organisms and algae, including soft corals, sea squirts, sponges, polychaete worms and molluscs, that grow prolifically on razorfish and other hard substrates as a result of the strong currents off Point Lowly.

The most diverse and dense community in the vicinity of the outfall is a large community of sponges occurring in a section of the rip, 200–300 m north of the outfall, in response to the prevailing strong currents (refer Figure 16.7 of the Draft EIS). The effects on the sponge community are expected to be minor for several reasons. Ecotoxicology studies revealed that the safe dilution for a typical sponge from the area was 1:7–13 (see Section 17.4.2 and Appendix H4.2 of the Supplementary EIS), which would be significantly exceeded at all times in the sponge community. Other species associated with the sponge community may be adversely affected intermittently as the 1:70 dilution for the protection of 99% of species may be breached for short periods.

The effects on commercial species in the mixing zone were assessed to be negligible, as all commercial species potentially occurring in the vicinity of the outfall would be mobile and therefore able to avoid the immediate area of the saline plume. Snapper, in particular, are likely to occur in the mixing zone as they would be attracted to the diffuser structure because it may resemble an artificial reef. No adverse effects on Snapper are expected to occur. The seven-day larval growth test for Snapper returned a safe dilution (EC_{10}) of 1:5, which would be attained at all times within about 10 m of the diffuser.

Issue:

It was suggested that the prediction of a moderate impact on the Blue Swimmer Crab within 100 m of the outfall needs to be justified.

Submission: 2

Response:

The categorisation of impacts in Section 16.6.8 of the Draft EIS was consistent with the definitions presented in Section 1.6.2, Table 1.3 of the Draft EIS. The moderate impact category was defined as being either a short-term impact on a sensitive or statewide receiver, or a long-term impact on a local or common receiver.

The ecotoxicology and hydrodynamic modelling studies suggest that the species protection trigger value (SPTV) to protect 99% of species (1:70) would be breached approximately 10% of the time within 100 m of the outfall. The effects on common species occurring within 100 m of the outfall (including the Blue Swimmer Crab) are therefore defined as being moderate as the effect would be long-term. In reality, the chronic effect would be very slight, as mobile species such as the Blue Swimmer Crab would be likely to remain in the affected area for only a short time.

Issue:

Concerns have been raised about the effects on species migrating through the saline return water plume or layer.

Submissions: 1, 194 and 346

Response:

The effects of the return water on mobile species such as fish, dolphins, the Australian Giant Cuttlefish, the Blue Swimmer Crab and the Western King Prawn that would inevitably traverse the return water plume within 100–200 m of the outfall are predicted to be negligible as exposure to the plume would occur for only a short time and mobile species would have the ability to avoid it. Furthermore, as discussed in Section 17.8.1 of the Supplementary EIS, exposure to worst-case saline plumes on the seafloor near the diffuser would be similar to that of the natural saline plumes that regularly traverse the area.

Issue:

It was suggested that significant effects could occur during dodge tides, when 'slugs' of higher-salinity water may increase in volume and affect benthic communities.

Submissions: 102, 194, 219 and 290

Response:

As discussed in Section 16.4.3 of the Draft EIS and Section 17.7.2 of the Supplementary EIS, there is no evidence that 'slugs' of saline water would accumulate on the seafloor during dodge tides to the extent that benthic communities would be affected beyond the immediate mixing zone. Computational Fluid Dynamics (CFD) modelling undertaken for the Supplementary EIS has confirmed that even during short periods of zero currents, the diffuser would disperse return water to near-safe dilutions where the plume first contacted the seafloor within 100 m of the diffuser.

Issue:

The issue of the ecological effects associated with the intake and outfall structures acting as artificial reefs was raised.

Submission: 84

Response:

The intake and outfall structures would inevitably act as artificial reefs that would be colonised by a variety of marine organisms. Underwater film of the desalination plant diffuser at Cockburn Sound in Western Australia shows a diversity of sponges and other sessile invertebrates (which appear to be typical of Point Lowly) growing on the diffuser pipes. The community of filter-feeding organisms and algae that would grow on the intake and outfall structures would include soft corals, sea squirts, sponges, polychaete worms, molluscs and mainly red algae (see Butler and Connolly 1999).

The structures are also likely to be colonised by a variety of reef fish, including Snapper.

The reef habitat provided by the intake and outfall structures would be a minor addition to the existing reef habitat in the area provided by the reefs lining the shores of Point Lowly, the Port Bonython jetty, the aquaculture rings in Fitzgerald Bay and various artificial reefs in the area. The ecological consequences of the additional reef habitat would be negligible.

17.8.4 ECOLOGICAL EFFECTS OF SPECIFIC CHEMICALS

Issue:

The potential impacts in general terms of reverse osmosis (RO) chemicals on the marine ecosystem were questioned. Bioaccumulation, in particular, was raised as an issue.

Submissions: 2, 40, 80, 84, 102, 165, 181, 193, 211, 288 and 387

Response:

The proposed diffuser associated with the desalination plant would be designed to ensure that the return water was dispersed and diluted as rapidly as possible. Dilutions greater than 1:45 would occur within 100 m of the diffuser most of the time (see Section 17.7.5 of the Supplementary EIS for details). Consequently, chemicals contained in return water, including anti-scalant, halogenated organic compounds, residual sodium metabisulphite or chlorine, heavy metals and associated by-products, would be rapidly diluted to safe levels within 100 m of the diffuser.

Bioaccumulation would not be an issue as the chemicals would be diluted to very low concentrations in the mixing zone around the diffuser. The concentrations would be similar to heavy metals and other chemicals naturally occurring in seawater off Point Lowly (refer Appendix O14 of the Draft EIS and Section 17.3.1 of the Supplementary EIS for further details). Furthermore, the likelihood of bioaccumulation of chemicals used in the reverse osmosis process (and associated byproducts) is negligible due to their low octanol-water partition coefficients (see Section 17.4.2 of the Supplementary EIS).

It is noted that most of the chemicals used during desalination are commonly used during the treatment of human drinking water supplies and occur in very low concentrations in drinking water.

Issue:

The long-term effect of discharges of heavy metals in return water on the ecology of Upper Spencer Gulf (e.g. invertebrates, migratory and marine bird species and mangroves) was questioned. Issues raised included accumulation of metals (taking into account existing levels), and the higher toxicity of metals at higher salinities and temperatures.

Submissions: 80, 84, 138 and 151

Response:

The long-term discharge of very low concentrations of heavy metals in return water would have negligible effect on the ecology of Upper Spencer Gulf. Pre-filtration and land disposal of the filtrate would in fact result in the net removal of metals from Spencer Gulf.

Although removing fresh water during the desalination process would temporarily concentrate salts (and metals) in the intake water, upon discharge they would rapidly attain their original concentrations through the action of the diffuser in promoting dispersion and turbulent mixing, and prevailing currents. Safe dilutions determined from whole effluent toxicity (WET) testing undertaken for the Draft EIS took heavy metals into account as seawater from Point Lowly was used during the tests. The WET tests also addressed the potential increased solubility and bio-availability of metals in return water in response to high salinity. Consequently, the 1:45 and 1:70 species protection trigger values apply equally to the heavy metals and salts concentrated in return water. As discussed in Section 17.7.5 of the Supplementary EIS, safe dilutions would almost always be attained at the edge of the near-field mixing zone.

It is also noted that operation of the desalination plant would, in fact, result in a net removal of heavy metals from Spencer Gulf. In the marine environment most metals adsorb onto particulates as positively charged metal ions have a strong affinity for particulate organic matter, iron and manganese oxyhydroxides and clay minerals. When seawater was taken into the desalination plant, the particulates and associated heavy metals would be removed during the pre-filtration, flocculation and coagulation processes. The sludge containing the metals would be dried in land-based settling ponds and periodically removed to a licensed landfill site.

Inevitably, a small quantity of metals in the intake water would be in solution and would not therefore be removed during the filtration processes. With the addition of acid (after filtration) to prevent the formation of scale, the solubility of the residual metals would generally increase to some degree. Upon discharge and mixing with seawater, however, the return water would be rapidly buffered to ambient pH levels, resulting in the metals resuming their less soluble and less bio-available state as they reassociated with particulates.

As noted by the CSIRO, the long-term solubility and bioavailability of heavy metals may increase slightly in response to climate change and the predicted decrease in the pH of seawater (CSIRO 2007). Although this would slightly reduce the removal of heavy metals via the filtration process noted above, the net effect of heavy metal removal via the desalination plant would remain.

Issue:

The impact of chlorine biocides and by-products (halogenated organic by-products of chlorine) and sodium metabisulphite on the marine ecosystem was questioned.

Submission: 2

Response:

The discharge of very low concentrations of chlorine biocides and by-products in return water would have negligible effect on the ecology of Upper Spencer Gulf as they would be rapidly diluted and dispersed to trace concentrations through the action of the diffuser, and prevailing currents.

Chlorine would be added to the feedwater to prevent marine growth inside the intake pipe. Chlorine reacts with bromide present in seawater to produce hypobromite and free chlorine.

The chlorinated feed water is passed to the backwash settling lagoons, and any residual chlorine is neutralised using sodium metabisulphite. Sodium metabisulphite reduces hypobromous acid and hypochlorous acid (and their ionised counterparts) to benign sodium salts. Products of this reaction include halogenated organic chlorine by-products and possibly some residual sodium metabisulphite, both of which would be discharged in trace concentrations.

The neutralisation of chlorine biocide with sodium metabisulphite reduces the amount of free and combined chlorine residuals in return water by up to 90%, resulting in estimated concentrations of 20–50 µg/L (Lattemann and Hoepner 2008). The ANZECC/ARMCANZ (2000) Guidelines for Marine Water Quality recommend total chlorine levels in seawater of 7.5 µg/L, which would be attained by a 10 times dilution within metres of the outfall.

The reaction of chlorine with metabisulphite produces trace amounts of halogenated by-products (Abarnou and Miossec 1992). Chlorine in water forms hypochlorous acid, which reacts with bromide ion in seawater to form hypobromous acid, which in turn reacts with natural organic matter to form low concentrations of various trihalomethanes (THMs) (Lattemann and Hoepner 2008). In the absence of toxicological data for the entire range of possible halogenated organic by-products, the criteria for chloroform (i.e. 146 µg/L) is typically used as an indicator of potential toxicities in the European Union (Lattemann and Hoepner 2008). Lattemann and Hoepner conclude that the concentration of chlorine by-products is typically below acceptance criteria, and therefore presents less of an issue than residual chlorine.

Chorine use (and potential for generation of THMs) at the proposed Point Lowly plant may be less than the levels indicated in the Draft EIS (i.e. daily for one hour at 8 mg/L). Villa Sallangos and Kantilaftis (2001), for example, reported adequate anti-fouling outcomes after chlorine dosing was reduced from continuous to twice a month for four hours. Similarly, ongoing biocide development and testing may result in the availability of alternative, less toxic biocides. Preferred biocides would be chosen by the contractors engaged to construct and operate the plant.

Issue:

The impact of organophosphates (anti-scalants) on marine communities, particularly algae and seagrasses, was questioned.

Submission: 102

Response:

The discharge of low concentrations of anti-scalant in return water would have negligible effect on the ecology of Upper Spencer Gulf.

As discussed in Section 16.4.1 of the Draft EIS, anti-scalants are ‘inherently biodegradable’, and their toxicity is generally reported to be low (Lattemann and Hoepner 2003). Anti-scalants consisting of polycarbonic acids and phosphonates (such as Nalco PermaTreat®) are stable and do not break down to provide nutrients for primary producers. Conversely, polyphosphate anti-scalants can cause eutrophication problems as they form orthophosphates (major nutrients) for primary producers. Consequently, the use of polyphosphate anti-scalants is becoming less common.

Anti-scalants may also reduce the availability of essential trace nutrients for use by algae and seagrasses by forming complexes with metals (Lattemann and Hoepner 2008). The effect would be negligible as only a very small proportion of the water in the gulf would be drawn into the desalination plant, and minimal amounts of anti-scalant would be discharged to the gulf.

As discussed in Section 16.4.2 of the Draft EIS, test solutions used during whole effluent toxicity (WET) testing included the anti-scalant Nalco PermaTreat® PC-1020T concentrated to 7 mg/L. Consequently the 1:45 and 1:70 species protection trigger values derived during the ecotoxicology studies apply equally to the anti-scalant and salts concentrated in return water.

Although in most instances it was impossible to separate the effects of salinity and anti-scalant, inferences can be drawn concerning their relative toxicity. The tests revealed that the safe dilutions for the four species of microalga and macroalga tested ranged from 1:2 to 1:8. The results indicated that anti-scalant was not particularly toxic to the algae species tested (refer Draft EIS, Table 16.8). As discussed in Section 17.7.5 of the Supplementary EIS, the safe dilution would always be attained in the near-field mixing zone around the outfall.

Issue:

The impact that ferric chloride (coagulant) could have on the marine ecosystem was questioned.

Submissions: 80 and 211

Response:

The discharge of residual concentrations of ferric chloride in return water would have a negligible effect on the ecology of Upper Spencer Gulf.

As discussed in Section 16.4.1 of the Draft EIS, ferric chloride would be removed from the return water stream by settling in ponds, or filtering centrifugally before disposal off-site on land, resulting in only residual ferric chloride being discharged to sea.

The toxicity of ferric chloride to marine and freshwater organisms (expressed as a NOEC) is reported to range from 0.32 to ▴5 mg/L for the majority (71%) of species tested (refer Appendix O10.2 of the Draft EIS).

Water quality monitoring at the pilot desalination plant at Port Bonython indicated that the total iron concentration in return water was 10 µg/L, which is similar to background levels of 15 µg/L in seawater off Point Lowly (see Appendix H2.1 of the Supplementary EIS). The residual ferric chloride concentration in return water at the pilot desalination plant was over 30 times lower than the lowest concentration at which effects have been reported to be detectable. It is concluded therefore that effects on the marine environments would be negligible.

Issue:

Concerns were raised about potential oil/fuel spills affecting marine communities.

Submissions: 183 and 386

Response:

The risk of oil and/or fuel spills affecting marine communities is considered to be low. Only small volumes of fuel and oil would be stored on-site, and storage and handling of fuel and oil would be consistent with the highest industry standards.

The Draft Environmental Management Program (refer Chapter 24 and Appendix U of the Draft EIS) identified risks and contingencies associated with proposed activities. The 'Storage, Transport and Handling of Hazardous Wastes' Management Program, Section 2.1 Chemical/Hydrocarbon Spillage, includes plans, controls and management actions associated with oil/fuel spills. The existing Management Plans – 'Management of Hazardous Materials' and 'Emergency Response Plan' – would be updated to include the expansion activities, including specific spill management procedures for sensitive areas such as Upper Spencer Gulf. These procedures would ensure that spills were controlled at source, contained on-site and cleaned up according to the requirements of the Materials Safety Data Sheet.

Issue:

The issue of whether vessels using tributyltin (TBT) as an anti-fouling paint would be banned from operating in Upper Spencer Gulf was raised.

Submission: 84

Response:

Australia is a signatory to the International Maritime Organisation (IMO) Anti-fouling System Convention (October 2001). One of the main aims of the convention is to phase out the use of TBT as an anti-fouling paint on ships. The convention recommended a total ban on the use of TBT on hulls by 1 January 2008. Under the convention and the supporting Oceans Policy, Australia has banned the use of TBT on ship hulls in Australian waters. Formal documentation certifying that the anti-fouling system complies with the convention must be kept on board ships.

When chartering vessels, BHP Billiton requires that they comply with all local and international laws covering sea freight.

17.8.5 PRECAUTIONARY PRINCIPLE AND UNCERTAINTY

Issue:

It was suggested that the assessment of potential ecological effects of return water discharge contravened the precautionary principle. The level of confidence in the predictions made in the Draft EIS and the ability to manage impacts were questioned.

Submissions: 80, 83, 208, 258 and 288

Response:

The assessment presented in the Draft EIS was based on numerous conservative assumptions relating to discharge rate, ecotoxicology and hydrodynamic modelling that cumulatively have resulted in a highly conservative assessment, which is consistent with the precautionary principle. The conservative assumptions used during the assessment were listed in Section 16.6.1 of the Draft EIS. The most important of these were:

- peak discharge rates were used for hydrodynamic modelling (mean discharge is expected to be 16% lower)
- the mid-field model assumed that all the return water would be injected into the bottom 1.6 m-high cell at concentrations that did not fully account for the action of the diffuser in providing near-field dilutions
- actual current speeds during dodge tides (measured using a current meter) are significantly stronger than the modelled current speeds used to predict dispersion
- the mid-field model period combined extreme conditions of dodge tides and no wind
- conservative measures were used to combine the near-, mid- and far-field models, which have led to highly conservative dilution outcomes
- the ecotoxicity tests involved continuous exposure to elevated salinity levels over several days or weeks, whereas in reality, biota would be exposed to elevated salinity only intermittently with daily tide changes, and fortnightly for five to six hours
- initially adopting the conservative 99% species protection level normally reserved for pristine environments, rather than the 95% level that has been used for all other desalination plants in Australia (for slightly altered environments)
- finally adopting the even more conservative 100% species protection level to provide an added margin of safety to account for maximum ambient salinity levels at Point Lowly.
- The high level of conservatism and significant margin of safety adopted demonstrate an approach that is consistent with the precautionary principle.

BHP Billiton and its specialist consultants have a high level of confidence in the impact predictions made in the Draft EIS. The marine ecological assessments reported in the Draft EIS were peer-reviewed and endorsed by Dr Sabine Lattemann of the University of Oldenberg in Germany, who is regarded as an international authority on the impact of desalination on the marine environment. Lattemann and Hoepner (2003) undertook a detailed assessment of the environmental effects of numerous desalination plants in the Red Sea, which is an inverse estuary like Spencer Gulf. Of the assessment presented in the Draft EIS, Dr Lattemann stated that the work had been undertaken 'thoroughly and to a high technical standard', 'the work is in line with normal industry practice and exceeds it to some extent' and 'the conclusions reached were reasonable' (refer Appendix O of the Draft EIS).

To ensure potential impacts are appropriately managed, BHP Billiton has made a commitment to intensively monitor the ecological effects of the plant upon commissioning, to implement appropriate control measures to mitigate impacts, and to implement contingency measures should the controls prove to be inadequate.

17.9 SIGNIFICANT SPECIES AND COMMUNITIES

17.9.1 GENERAL

Issue:

It was suggested that no significant evidence had been put forward to support the statement that residual impacts on significant species in Upper Spencer Gulf would be negligible.

Submission: 84

Response:

There is significant evidence supporting the conclusion made in the Draft EIS that neither construction nor operation of the desalination plant or landing facility would result in adverse effects on significant marine species, including nationally listed species, in Upper Spencer Gulf.

As discussed in Sections 16.3.5, 16.3.7, 16.6.6 and Appendix O3 of the Draft EIS, significant species potentially occurring in Upper Spencer Gulf were identified from relevant sources. These included 45 species listed under various categories in state or national legislation, and a number of species with no formal status, but nevertheless considered to be significant as they are normally found in the tropics, are endemic to Upper Spencer Gulf or Spencer Gulf, or are uncommon (see Appendix H9.1 of the Supplementary EIS for a list of these species). Impacts on the Australian Giant Cuttlefish were considered in detail in Section 16.6.7 of the Draft EIS.

The potential risk to these species was considered in terms of the following criteria and environmental features (refer Sections 16.6.2 and 16.6.6 of the Draft EIS):

- their occurrence in Upper Spencer Gulf
- their mobility
- the availability of suitable habitat in Upper Spencer Gulf (against recorded distribution)
- the potential for return water from the desalination plant and construction activities to affect their habitat
- the likely sensitivity of these species and their food resources to return water and construction impacts
- the north-south salinity gradient in Spencer Gulf.

Further detail, including information provided in Appendices O2 and O3 of the Draft EIS, has been collated in Appendix H9.1 of the Supplementary EIS. Based on this evidence, it is considered that the impact of the desalination plant on significant species in Upper Spencer Gulf would be negligible as they are highly mobile, have no habitat dependence on Point Lowly, and/or have extensive alternative habitat in Upper Spencer Gulf and elsewhere.

Issue:

It was suggested that information on threatened species (particularly larger, annual migratory species including whales, sharks, turtles, seals and penguins) was very brief in the Draft EIS.

Submission: 122

Response:

Background information on six whale species, four turtle species, the Great White Shark *Carcharodon carcharias*, and the Australian Sea Lion *Neophoca cinerea* and New Zealand Fur Seal *Arctocephalus forsteri* was provided in Table 16.4 (threatened species) and/or Appendix O3 of the Draft EIS. With the exception of the two seal and two whale species, all are listed as migratory under the *Environment Protection and Biodiversity Conservation Act 1999*. Information on penguins was not included in the Draft EIS as the nearest breeding colony (at Lipson Island, 200 km south of Point Lowly) is too far away to be affected.

The information provided is considered to be adequate for assessing the potential impact of the desalination plant and landing facility on these species. Modelling and ecotoxicology work discussed in Section 16.6.5 of the Draft EIS showed that the impacts of the saline discharge would be limited to a relatively small area in the vicinity of the outfall, and that long-term salinity increases elsewhere in Upper Spencer Gulf would be negligible. Silt plume modelling, presented in Section 16.6.11 and Appendix O12.1 of the Draft EIS, showed that effects arising from silt disturbed during construction would be undetectable within a few kilometres of the intake and outfall pipes.

It considered that the impact of the desalination plant on these species would be negligible as they are highly mobile, have no habitat dependence on Point Lowly and have extensive alternative habitat in Upper Spencer Gulf and elsewhere.

17.9.2 SPONGE COMMUNITY

Issue:

Clarification was sought about whether the sponge community at Point Lowly is of regional significance.

Submissions: 2 and 80

Response:

As discussed in Section 16.3.7 of the Draft EIS, a sponge community covering several hectares off Point Lowly was considered to be of regional conservation significance due to the high diversity and density of sponges and associated species.

Subsequent investigations of other sponge communities in Upper Spencer Gulf have been undertaken to further determine the significance of the Point Lowly community. A number of communities had been identified by Shepherd (1983a) near Red Cliff Point but BHP Billiton marine biology consultants tried unsuccessfully to find and collect more than a few isolated sponges. Either the maps of the time were inaccurate (they were produced before the availability of GPS), or the extensive sand movements typical of the area (Shepherd 1983b) have covered these communities.

A sponge community at Two Hummock Point known to the BHP Billiton marine biology consultants was relocated. Inspection by divers revealed that this community was considerably less dense than that at Point Lowly. It was nevertheless considered to be significant.

Sponges are filter feeders that rely on water movement for food supply. The presence of sponge communities at Point Lowly and Two Hummock Point/Red Cliff Point is consistent with the relatively fast current speeds (refer to the animation provided with the electronic version of Section 16.3.2 of the Draft EIS), and exposed rocky substrate at those locations. The lack of rocky substrate in areas of strong currents has probably limited the establishment of extensive sponge communities elsewhere in Upper Spencer Gulf.

Sponges from the communities at Point Lowly were sampled by divers and compared by sponge taxonomists with samples from:

- the Two Hummock Point sponge community
- other locations north of Point Lowly
- 120 sites in Spencer Gulf north to Point Lowly sampled from prawn trawl bycatch (Sorokin and Currie 2009; Currie et al. 2009)
- one of the Sorokin and Currie (2009) sites south of Port Bonython (sampled by divers).

Details of the sponge surveys are provided in Appendix H9.2 of the Supplementary EIS. The following community patterns were evident:

- sponge communities in Upper Spencer Gulf are localised, with limited overlap in species between different sites
- the Point Lowly community has a greater proportion of unique sponges than the other sites investigated, with only four of the 13 taxa found at this site recorded elsewhere in Spencer Gulf.

Therefore the statement of regional significance provided in the Draft EIS remains valid. The diffuser would be designed and/or located to achieve near-field dilutions to ensure that return water would have no effect on the Point Lowly sponge community.

Issue:

Further information about the effect of regular salinity increases on the sponge community was requested.

Submissions: 2 and 80

Response:

The return water discharge would have no adverse effect on the sponge community at Point Lowly. In fact, there is evidence to suggest the installation of outfall structures above the seabed would increase the suitable habitat for this community, with the pipes providing hard substrate on which the sponges may attach in areas of considerable water movement.

While the results of hydrodynamic modelling presented in the Draft EIS showed that the species protection trigger value (SPTV) of 1:85 would be breached 30% of the time at the sponge community (refer Table 16.10 of the Draft EIS), subsequent modelling that included design refinements to the diffuser has demonstrated that dilutions to achieve the SPTVs of 1:45 and 1:70 could be achieved 100% and 98% of the time, respectively, at the sponge community. The 1:70 dilution would be breached for a maximum of 8 hours (see Table 17.9 and Appendix H7.2 of the Supplementary EIS for details).

Additional evidence that suggests there would be no effects on the sponge community includes:

- underwater film of the desalination plant diffuser in Cockburn Sound near Perth, provided on a DVD accompanying the Draft EIS, shows a diversity of sponges and other sessile invertebrates (which appear to be typical of those found at Point Lowly) growing on the diffuser risers
- a bioassay developed since the Draft EIS was published (and in the absence of existing standard sponge ecotoxicology tests) on the sponge *Aplysina* sp. from Point Lowly returned a safe dilution of 1:13 (and possibly 1:7), demonstrating that sponges would tolerate salinity increases (see Appendices H4.2 and H4.3 of the Supplementary EIS).

It is concluded that the return water discharge would have no effect on the sponge community at Point Lowly.

17.9.3 MARINE INVERTEBRATES

Issue:

Concern was expressed about whether adequate consideration was given to marine invertebrates – particularly those in the Point Lowly sponge community – even though they are not listed as protected or threatened species by state or national legislation.

Submission: 80

Response:

Protection of marine invertebrates has been considered through the derivation of a species protection trigger value (SPTV) designed to protect 99–100% of marine species (refer Sections 16.4.2 and 16.6.5 of the Draft EIS for details). Representative marine invertebrates used to calculate the SPTV included the Western King Prawn *Melicertus latisulcatus*, the copepod *Gladioferens imparipes*, the Giant Australian Cuttlefish *Sepia apama*, and the Pacific Oyster *Crassostrea gigas*.

A number of significant invertebrate taxa have received particular attention. Studies have been undertaken to assess the ecological significance of the sponge community off Point Lowly (see Section 17.9.2 of the Supplementary EIS). Invertebrate species that have tropical affinities, are endemic to Upper Spencer Gulf or Spencer Gulf, or are uncommon, were highlighted in Section 16.6.6 of the Draft EIS, and are discussed further in Section 17.9.1 of the Supplementary EIS.

It is considered that marine invertebrate studies have been sufficiently detailed to enable impacts on invertebrate communities to be assessed for the purpose of an EIS.

Issue:

It was suggested that the Black Cowrie should have been included in the list of protected species listed in Appendix O3 of the Draft EIS.

Submission: 80

Response:

The Black Cowrie *Zoila friendii thersites* is not listed as a protected species under the legislation administered by the Department of Primary Industries and Resources of South Australia (PIRSA), nor under any other South Australian or national legislation. It is included, along with species such as Snapper, Whiting and the Blue Swimmer Crab, in a list of species that have a recreational fishing bag limit (see Schedule 6 of the *Fisheries Management (General) Regulations 2007*, which provides classes of fishing activities prescribed for purposes of Section 70 of the *Fisheries Management Act 2007*). As such, it is not appropriate to include the species in the list of threatened species in Appendix O2 or O3 of the Draft EIS.

Issue:

Concern was expressed about potential effects on the gastropod *Dicathais orbita*.

Submission: 80

Response:

The gastropod *Dicathais orbita* typically occurs on reefs to a depth of 10 m (Edgar 2008). It has been recorded in Fitzgerald Bay (DEH, unpublished data, 2009) and near Red Cliff Point (Shepherd 1973, 1983a, cited in Appendix O2 of the Draft EIS as Shepherd 1983b), where salinities reach 45 g/L (Johnson 1981).

As discussed in Section 16.6.5 of the Draft EIS, the zone of potential ecological effect around the outfall does not extend into the reef habitat at Point Lowly. Furthermore, the presence of *D. orbita* at Red Cliff Point, where the ambient salinity is up to 2 g/L higher than at Point Lowly, suggests it would be able to tolerate the maximum salinity increase of 0.3 g/L predicted for the reef/cuttlefish breeding habitat at Point Lowly (as stated in Table 16.10 of the Draft EIS).

17.9.4 DOLPHINS

Issue:

Concern was expressed about potential effects on Common and Bottlenose dolphins.

Submission: 302

Response:

As discussed in Appendix O3 of the Draft EIS, communities of the Common Dolphin *Delphinus delphis* and Indian Pacific Bottlenose Dolphin *Tursiops aduncus* occur off Whyalla, Point Lowly and Fitzgerald Bay. The Spencer Gulf populations of the Indian Pacific Bottlenose Dolphin have been found to be genetically distinct from other populations of *T. aduncus* (Bilgmann et al. 2007). The oceanic species *T. truncatus* does not occur in gulf waters (Kemper 2004).

Both dolphin species are highly mobile and wide-ranging in Spencer Gulf, with the Bottlenose Dolphin being recorded as far north as Port Augusta, and the Common Dolphin in Fitzgerald Bay (refer Appendix O3 of the Draft EIS), where salinity levels would exceed those caused by the desalination plant, except near the diffuser. Similarly, dolphins would experience natural variations in salinity (over distances of 1–2 km, periods of one day, and depth ranges of 10 m) that would exceed the variation caused by the desalination plant discharge near the diffuser (refer Section 16.6.2 of the Draft EIS and see Appendix H5.4 and Section 17.7.6 of the Supplementary EIS).

A number of measures would be adopted to ensure that potential impacts on dolphins were mitigated during the marine construction phase. These are discussed in Sections 17.14 and 17.15 of the Supplementary EIS.

17.9.5 SYNGNATHIDS

Issue:
Concern was expressed about potential effects on the Leafy Seadragon.

Submissions: 288 and 302

Response:

Upper Spencer Gulf is not a significant habitat for Leafy Seadragons, with only isolated records from bycatch surveys and community observations (including one 2007 record from Port Augusta) (Baker, in press). Although more than 1100 sightings of seadragons were reported by divers, snorkellers and beachcombers across South Australia between 1990 and 2005, none were in Upper Spencer Gulf, and only 1% were from Spencer Gulf. Trawl surveys in Spencer Gulf yielded 10 records, all from south of Cowell (see Figure 17.20 of the Supplementary EIS).

The preferred habitat of the Leafy Seadragon is moderately exposed reef and seagrass, 4–30 m in depth (Edgar 2008), which does not occur in the zone of ecological effect of the proposed desalination plant (shown in Figure 16.18 of the Draft EIS).

Issue:
Further information was requested on the distribution of Tiger Pipefish in Spencer Gulf.

Submission: 2

Response:

The preferred habitat of the Tiger Pipefish *Filicampus tigris* is silt/sand. As discussed in Section 16.6.6 of the Draft EIS, impacts on these fish would be negligible as the zone of potential ecological effect would comprise only a very small proportion of their habitat in Upper Spencer Gulf.

Information on the distribution of Tiger Pipefish in Upper Spencer Gulf was based on unpublished SARDI Aquatic Sciences data from seasonal otter trawls between Backy Point and Cowleds Landing during 2002–2010. Additional data has been provided by prawn trawl surveys throughout Spencer Gulf south of Point Lowly in February 2007 (Currie et al. 2009) and unpublished data from beam trawls from Douglas Bank to Wallaroo during 2006 and 2007 (Saunders 2009). Based on these datasets, Tiger Pipefish are widely distributed in Upper Spencer Gulf (see Figure 17.21 of the Supplementary EIS).

17.9.6 TURTLES

Issue:
It was suggested that the Draft EIS contained incorrect information on turtle diets.

Submission: 1

Response:

The submission is correct as the diet summaries of the Green Turtle and Hawksbill Turtle in Table 16.4 (Section 16.3.5) of the Draft EIS were transposed by mistake. This transposition does not change the assessment that the impact of the desalination plant and landing facility on turtles would be negligible.

The Green Turtle should have been described as mainly herbivorous. Adult green turtles feed mostly on seagrass and algae, but will occasionally eat other items, including mangroves, fish-egg cases, jellyfish and sponges. Young turtles tend to be more carnivorous than adults, feeding on plankton during their pelagic phase (DEWHA 2010a, cited as DEWHA 2008c in the Draft EIS).

Similarly, the Hawksbill should be described as omnivorous. Adults eat a variety of animals and plants, including sponges, hydroids, cephalopods, gastropods, cnidarians, seagrass and algae. Young Hawksbill Turtles eat plankton during their pelagic phase (DEWHA 2010b, cited in the Draft EIS as DEWHA 2008e).

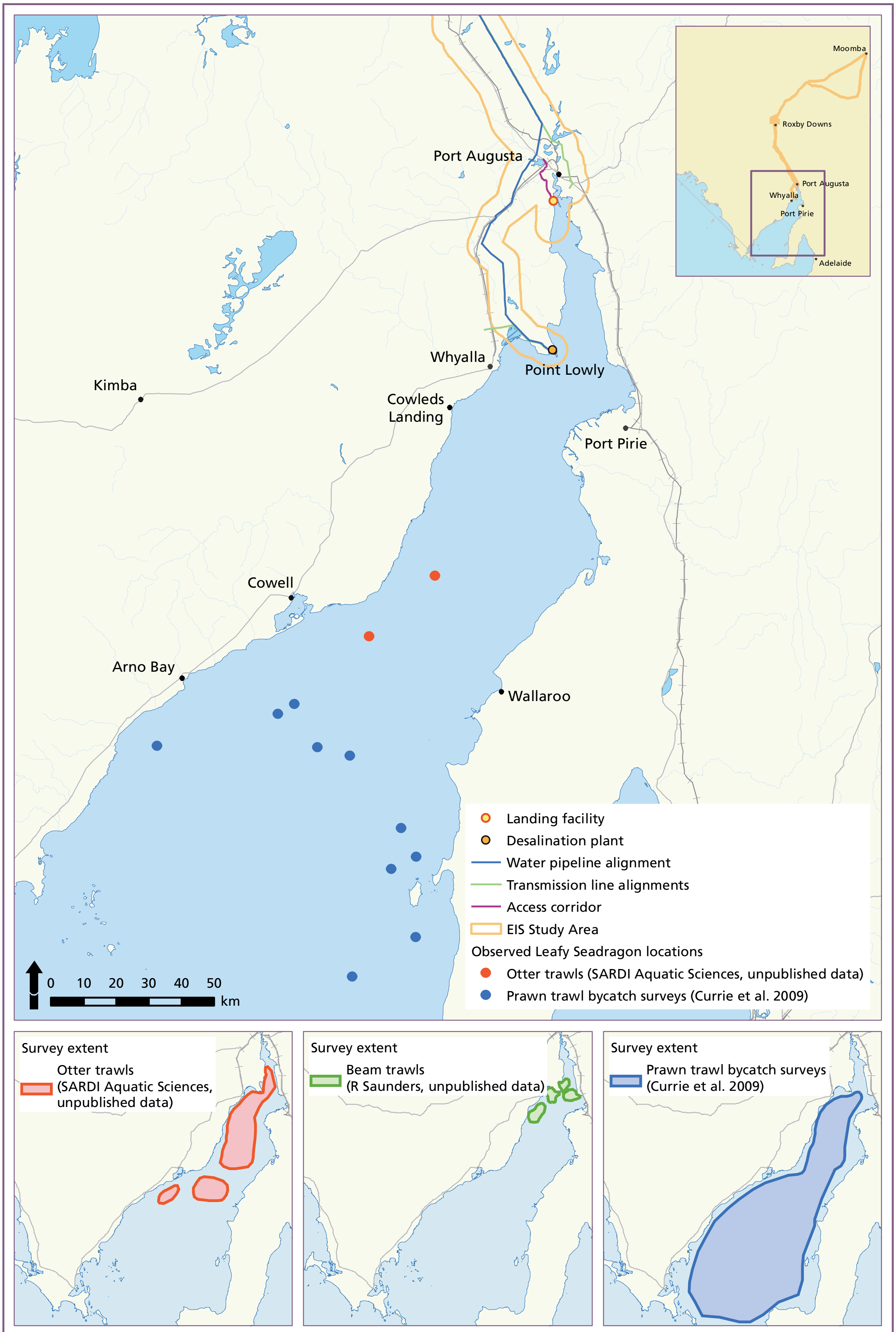


Figure 17.20 Distribution of Leafy Seadragon *Phycodurus eques* from trawl surveys in Spencer Gulf

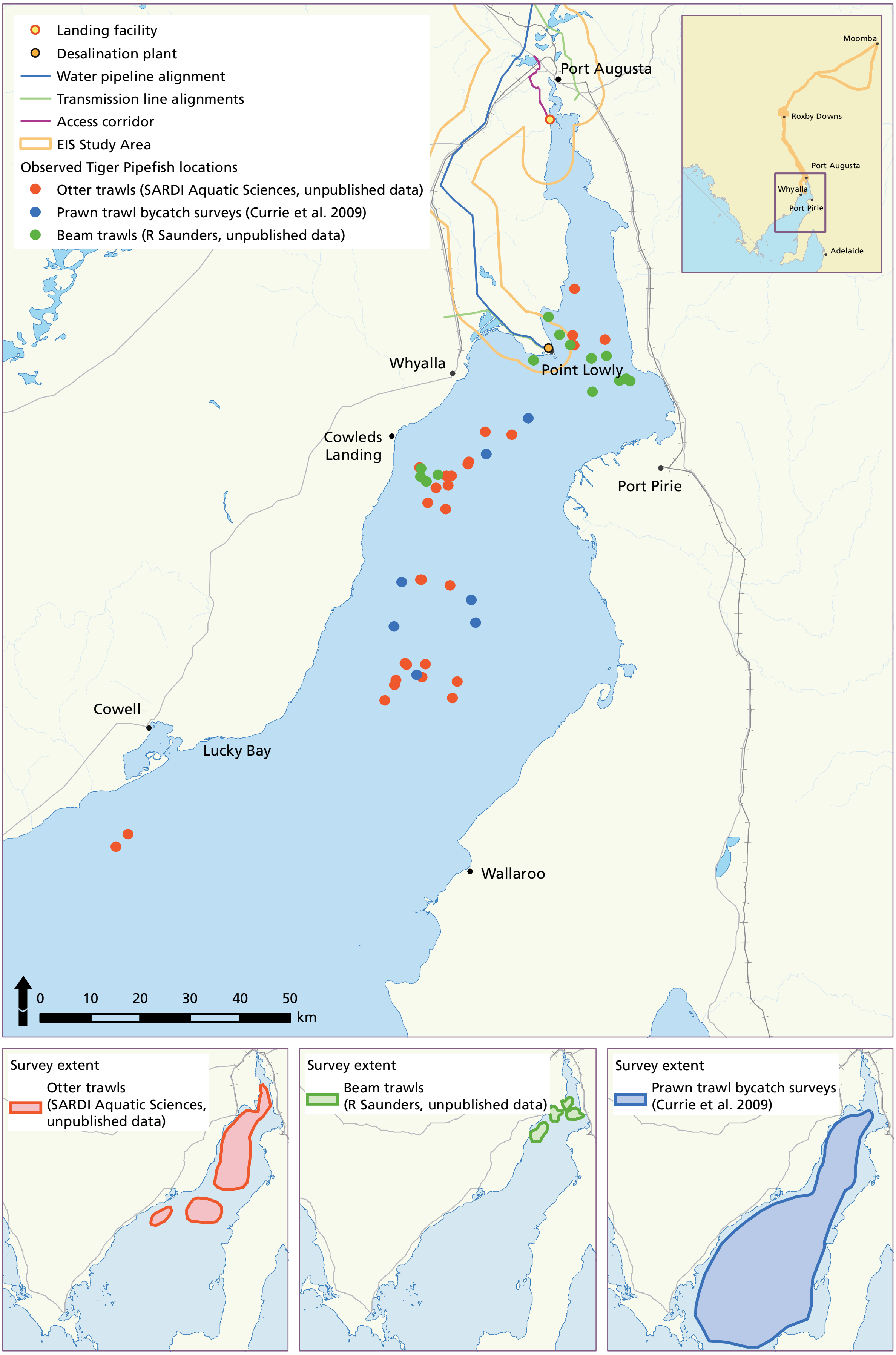


Figure 17.21 Distribution of Tiger Pipefish *Filicampus tigris* from trawl surveys in Spencer Gulf

17.9.7 AQUATIC RESERVES

Issue:

Concern was expressed about potential effects on aquatic reserves.

Submission: 39

Response:

As shown in Figure 16.5 of the Draft EIS, there are three aquatic reserves in Upper Spencer Gulf, namely Cowleds Landing, south of Whyalla, and Blanche Harbor Aquatic Reserve and Yatala Harbor Aquatic Reserve to the north. Each of these aquatic reserves is more than 20 km from Point Lowly.

As shown in Sections 16.4.3, 16.6.4 and 16.6.5 of the Draft EIS, these areas lie comfortably outside the zone of ecological effect extending a few kilometres from the outfall, and there would be negligible residual impact on the long-term salinity of these areas. The long-term average salinity increase was predicted to be 0.03 g/L for the northern aquatic reserves, and 0.07 g/L (using Point Lowly as a proxy) for the southern aquatic reserve (this was presented in Figure 16.20 of the Draft EIS). The refined model has shown these increases would be 0.1 g/L and 0.06 g/L respectively (see Appendix H7.2 of the Supplementary EIS).

It is therefore concluded that the proposed desalination plant would have negligible impact on the three aquatic reserves in Upper Spencer Gulf.

17.10 CUTTLEFISH

Submissions expressed concerns regarding potential effects on the Australian Giant Cuttlefish *Sepia apama*, and highlighted the value and importance of the cuttlefish breeding aggregation and the consequent need for protection. A number of aspects of cuttlefish biology that increase the species' susceptibility to impacts were also emphasised. Extensive investigations undertaken during the Draft EIS and following the publication of the Draft EIS have, however, continued to support the conclusion that impacts on the cuttlefish aggregation resulting from the construction and operation of the desalination plant would be negligible. The specific issues raised and the responses to each of these are provided below.

17.10.1 GENERAL CONCERNS REGARDING EFFECTS ON CUTTLEFISH

Issue:

The appropriateness of the location for the proposed desalination plant given its proximity to the only mass cuttlefish breeding aggregation in the world and its potential impacts on this species has been questioned.

Submissions: 39, 97, 112, 114, 130, 176, 194, 216, 218, 219, 224, 226, 227, 254, 255, 263, 273, 319, 328, 331 and 363

Response:

General conclusions regarding potential impacts on the cuttlefish breeding aggregation are presented below, and more detailed explanations justifying the conclusions are presented in the subsequent sections of the Supplementary EIS.

There is no evidence to suggest that construction and operation of the desalination plant at Point Lowly would have any effect on the cuttlefish breeding aggregation at Point Lowly for the following reasons:

- dilution of the return water by the diffuser and tidal currents would be greater than that which could affect the cuttlefish (see Section 17.10.6 and 17.10.7)
- the greater density of the return water would ensure that it was largely confined to the deep water channels rather than impinging on the cuttlefish breeding habitat in the shallow reef areas (see Section 17.10.5)
- the desalination plant intake and outfall pipe construction would occur outside the cuttlefish breeding season and egg development period (see Section 17.14.5 of the Supplementary EIS)
- the intake structure would be designed to minimise entrainment/entrapment of benthic biota such as cuttlefish (see Section 17.13.4 of the Supplementary EIS)

The use of an efficient diffuser, and the location of the outfall in deep water off Point Lowly, where average current speeds are among the strongest in South Australia, would ensure that return water was diluted to near-background concentrations within several hundred metres of the outfall.

During dodge tides very good dilutions are expected to be maintained as the return water would be discharged from the diffuser up to 15 m into the water column, where it would mix with ambient seawater as it fell to the seafloor (refer Section 17.7.4). The greater density of the return water would ensure that the vertical separation between the return water and cuttlefish habitat in the shallow water would always be maintained.

The significant margin for safety is shown by the safe dilution for cuttlefish being 1:16, and the worst dilution achieved in the cuttlefish habitat being 1:107 (see Section 17.7.6 and Table 17.9 of the Supplementary EIS for details). Salinity increases in the breeding habitat would not be measurable in the context of natural variability.

It is also noted that the Australian Giant Cuttlefish successfully breeds further north in Spencer Gulf at Backy Point, where the salinity at the start of the breeding season would be the same as (and often exceed) the elevated salinity within about 100–200 m of the diffuser. Natural saline plumes that move down the gulf at the start of the breeding season are far more significant than the plumes that would be associated with the desalination plant discharge (see the animations in Appendix H7.4 of the Supplementary EIS). Cuttlefish migrating to and from the breeding habitat would be likely to encounter localised salinity changes associated with the desalination plant plume that were similar to those associated with natural saline plumes.

Construction impacts on cuttlefish would be avoided as BHP Billiton has committed to restricting intake and outfall pipeline construction activities to the period outside the cuttlefish breeding season and egg development period (i.e. from November to the end of April).

It is concluded that the location of the desalination plant at Point Lowly is environmentally acceptable as the cuttlefish breeding aggregation would not be adversely affected.

17.10.2 IMPORTANCE OF THE CUTTLEFISH BREEDING AGGREGATION AT POINT LOWLY

Issue:

Concern was expressed regarding the importance of cuttlefish as a unique natural history phenomenon of international significance (with potential for World Heritage listing) that has promoted tourism and study.

Submissions: 54, 82, 218 and 219

Response:

The importance of the breeding aggregation was acknowledged in the Draft EIS (refer Section 16.3.6 and Appendix O5). In particular, recognition of the high sensitivity of the cuttlefish habitat has resulted in BHP Billiton reporting the 99% species protection level for ecosystems of high conservation value (ANZECC/ARMCANZ 2000), which is the highest level adopted by any proposed or existing desalination plant in Australia. The majority of others have adopted the 95% protection level (see Appendix H3 of the Supplementary EIS).

Increased awareness of the cuttlefish breeding aggregation at Whyalla initially occurred in response to increased fishing pressure in the late 1990s. Subsequent protection and a general increase in awareness of the unique nature of the aggregation have led to the development of a substantial tourism industry which makes a significant contribution to the local and regional economy. It is estimated that about 600 divers visit the breeding aggregation annually, and Australian and international documentary film crews and academics regularly film and study the aggregation.

Extensive investigations undertaken during the EIS determined that impacts on the cuttlefish aggregation resulting from construction and operation of the desalination plant would be negligible. BHP Billiton considers that the attention focused on cuttlefish as a result of the development of the plant would lead to a greater understanding of the species, potentially even greater protection of the breeding aggregation, and increased awareness of its potential as a tourist attraction.

Issue:

The important role of cuttlefish in the food chain was noted, and the potential impacts the desalination plant would have on this aspect have been questioned.

Submission: 54

Response:

The Australian Giant Cuttlefish breeding aggregation forms an important food source for Snapper and Bottlenose Dolphins during winter, when thousands of cuttlefish die after breeding. Similarly, numerous species would feed on juvenile cuttlefish after they hatched and dispersed throughout Upper Spencer Gulf. The importance of the Australian Giant Cuttlefish to food chains in Spencer Gulf is not well understood, and requires future investigations by marine biologists.

Detailed hydrodynamic modelling and ecotoxicology studies have shown that the desalination plant would not affect the Australian Giant Cuttlefish population. Therefore, operation of the desalination plant would not affect the position or role of cuttlefish in the marine food web.

17.10.3 POPULATION AND SPECIES STATUS

Issue:

Further information was requested summarising the relevant cuttlefish research completed to date to substantiate the Draft EIS population estimates of the breeding aggregation, in view of the limited understanding of the distribution, population size and species status of the Australian Giant Cuttlefish in Upper Spencer Gulf.

Submissions: 1, 2 and 138

Response:

Population surveys of the cuttlefish breeding population have been undertaken for the Draft and Supplementary EIS in 2008, 2009 and 2010. The results of these surveys are detailed in Appendix H9.3 of the Supplementary EIS and summarised below.

Studies of the Australian Giant Cuttlefish breeding aggregation (see Plates 17.4, 17.5 and 17.6) near Whyalla and population biology in Upper Spencer Gulf have occurred relatively recently (refer Appendix O5.5 of the Draft EIS; see Appendix H9.3 of the Supplementary EIS; Hall 2002a; Hall 2002b; Hall and Hanlon 2002; Hall and Fowler 2003; Hall et al. 2007; Hanlon et al. 2005; Steer and Hall 2005; Hanlon et al. 2007; Dupavillon and Gillanders 2009; Payne et al. 2011a, 2011b).

In response to concerns about the sustainability of the population posed by the rapid increase in exploitation between 1993 and 1997, the abundance and biomass of cuttlefish in the aggregation area were surveyed by SARDI between 1998 and 2001 (Hall and McGlennon 1998; Hall 1999; Hall 2000; Hall 2002) and again in 2005 (Steer and Hall 2005), using underwater visual strip transects. Since then, three additional surveys, from 2008 to 2010, have been completed for BHP Billiton, using the same methodology (refer Appendix O5.5 of the Draft EIS and see Appendix H9.3 of the Supplementary EIS). The conservative interpretation of the combined results suggests that the estimated abundance and biomass have decreased by 28% from a fluctuating average of over 170,000 and 180 tonnes, respectively, between 1999 and 2001 to approximately 130,000 and 110 tonnes in all years surveyed since 2001 (2005 and 2008–2010). Spatial distribution of cuttlefish was unusual in 2010, with particularly low densities recorded at one site (Stony Point) and the greatest densities ever recorded at two other sites (Backy Point and 3rd Dip) (see Figure 3 of Appendix H9.3). Subsequent dives early in July 2010 at Stony Point and west of the Santos boundary fence (WOSBF) found that cuttlefish densities had considerably increased at Stony Point, suggesting the population had redistributed in the area west of the Santos facility, or the peak density may have been delayed in 2010. In 2010, the majority (82%) of the breeding population aggregated west of the Santos facility while the remaining population was located around Point Lowly (1.5%), Fitzgerald Bay (0.5%) or to the north at Backy Point (16%). This is consistent with the general historical observations of the greatest abundances occurring west of the Santos facility (see Figure 3 of Appendix H9.3). In 2010 cuttlefish biomass decreased by a greater percentage than did abundance, and approached 2008 levels. Size frequency records indicate that there were more smaller animals and fewer larger animals present in the years from 2008 to 2010 compared to preceding years (1999 to 2001).

It is difficult to ascertain whether the recent declines in population size since 2001 represent an unusually delayed response to the intense exploitation of the species between 1993 and 1998, variation in recruitment success, possibly in response to changed environmental conditions, or natural cyclical variability in the population. The particularly small estimates (of only 75,000 and 80 tonnes, respectively) recorded in 2008 were possibly an aberrant response to unfavourable environmental conditions. The biomass in 2010, however, had returned to a similar level to 2008.

Plate 17.4 Male (right) and female cuttlefish

Plate 17.6 A male cuttlefish showing distinctive colour changes

Plate 17.5 Cuttlefish mating during the breeding aggregation

Fisheries records for *Sepia apama* indicate the commercial catch increased 50-fold from approximately 5,000 kg per year before 1994 to 246,000 kg in 1997 (Hall and Fowler 2003). Following closure of the main fishing ground in 1998, the annual catch substantially fell to between 10,100 and 19,300 kg during the period 1999 to 2002 and has fallen by about half again in more recent years, with catches of 3,900 to 8,600 kg between 2004 and 2008 (SARDI Aquatic Sciences, unpublished data), approaching pre-1994 catches. The impacts of commercial and recreational fishing on *Sepia apama* are difficult to ascertain owing to the strong environmental influences on recruitment success of cephalopod populations. However, at least some of the fluctuations in the population estimates of the breeding aggregation are likely to be influenced by this fishing pressure.

While there is limited information on the life history of cuttlefish outside the breeding aggregation, records from juvenile snapper trawling from 1998 to 2010 have indicated *Sepia apama* are distributed as far north as Douglas Bank (see Figure 17.22 of the Supplementary EIS) just before the breeding season (Hall and Fowler 2003; SARDI Aquatic Sciences, unpublished data). Trawl surveys have shown that between February and April, cuttlefish aggregate in the areas to the north, east and south of Point Lowly, in the latter case extending almost to Cowell (Hall and Fowler 2003). However, no detailed location data is available outside these months. Analysis of size, frequency, maturity and sex of animals collected from juvenile snapper trawling and commercial fishing during 1998 and 2001 has occurred (Hall and Fowler 2003), providing evidence for the two life cycle models (see Section 17.10.4). However, further investigations of distribution and composition of *Sepia apama* outside the spawning aggregation are required to help establish the life history outside the breeding aggregation.

Information from trawl bycatch data (Currie et al. 2009) and beam trawls (Saunders 2009), unavailable at the time of publication of the Draft EIS, indicates the presence of a further six species of cephalopod, in addition to the eight species listed in Appendix O2 of the Draft EIS. These species are included in Appendix H1 of the Supplementary EIS.

BHP Billiton has committed to continue financing surveys of abundance and biomass, which will continue to improve the understanding of natural population variability.

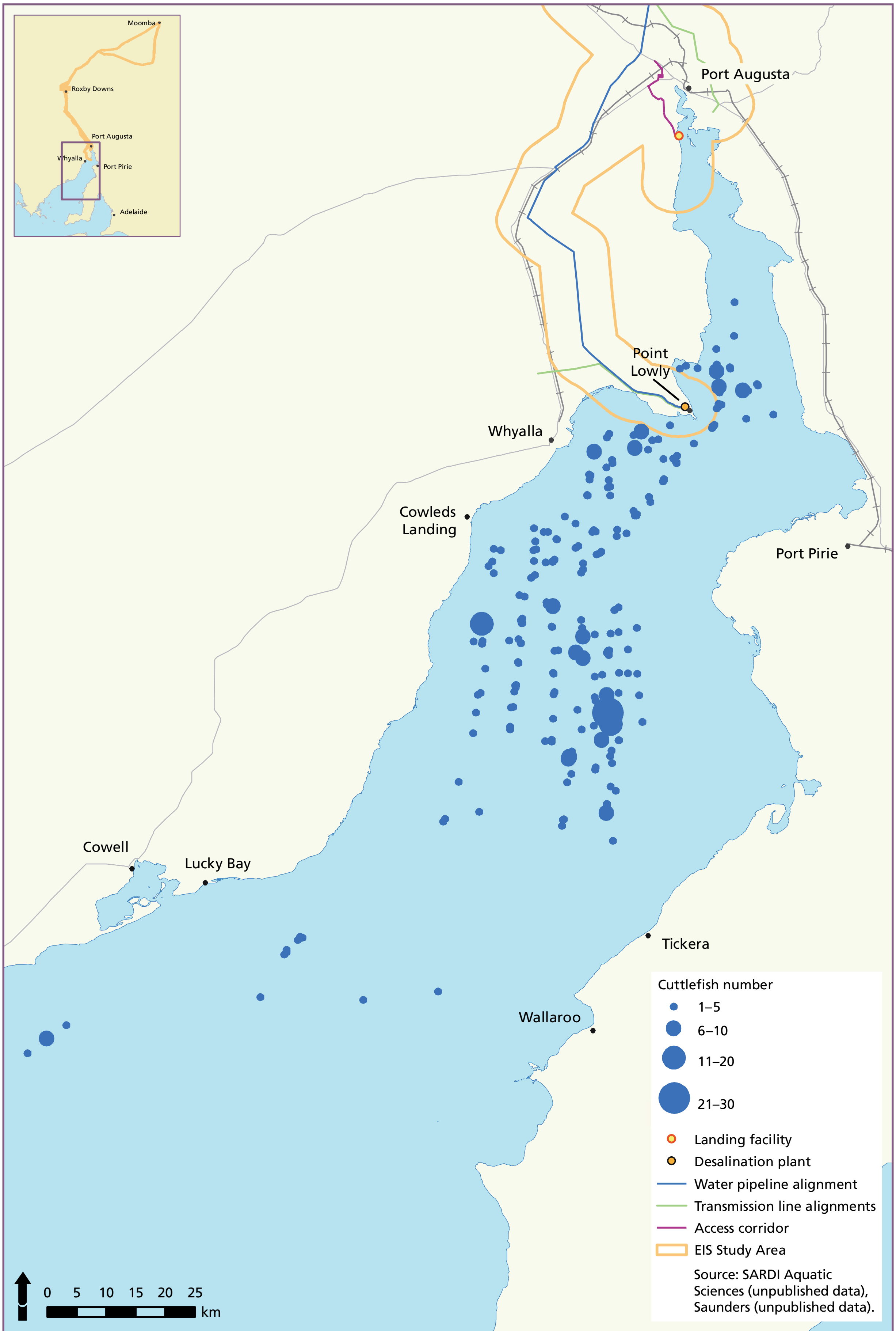


Figure 17.22 Distribution of cuttlefish from trawl surveys in Spencer Gulf

Issue:

The adequacy of the current survey methodology to estimate the abundance and biomass of the cuttlefish population was questioned, and the need for improvements in survey methodology was suggested. Particular concerns related to the residence duration and biennial life cycle of the species, the need to survey the population during its peak, and the need for sufficient statistical replication for inter-site comparisons.

Submissions: 1, 2, 24, 86 and 138

Response:

BHP Billiton has committed to undertaking an annual survey of the Australian Giant Cuttlefish population at Point Lowly to establish a suitable baseline for the cuttlefish population before construction and operation of the desalination plant. Surveys in 2008, 2009 and 2010 as part of the assessments conducted for the EIS added to the data from surveys between 1998 and 2001 (Hall and Fowler 2003) and 2005 (Steer and Hall 2005). The method would continue to follow that developed by research scientist Dr Karina Hall (refer Appendix O5.5 of the Draft EIS). It is considered that several years of surveys would be required to establish a suitable baseline of the cuttlefish population, as the population appears to be naturally variable.

Currently, annual surveys are undertaken during the peak population in late May/early June. Surveys consist of four 50 m x 2 m strip transects in each habitat (algal-dominated or urchin-barren reef) in each of 12 or 13 sites, which are further classified according to the history of protection (see Figure 17.23 of the Supplementary EIS).

The survey method adopted provides a population index or relative measure of the cuttlefish population, and is considered appropriate for comparisons between years, provided the surveys are undertaken at the same time of year. Surveys have consistently occurred during the population peak in late May to early June (see Appendix H9.3 of the Supplementary EIS). The methodology is considered a conservative estimate of the population as it assumes cuttlefish largely remain resident at the breeding aggregation. This assumption is based on the observations of peak numbers around the end of May in all sites and years, the results from tagging indicating that at least some cuttlefish remain in the aggregation area for most of the spawning season, and the declining condition of many cuttlefish throughout the season (see Appendix H9.3; Hall and Fowler 2003).

If cuttlefish were resident only briefly, then the current survey methodology would underestimate the number visiting the aggregation; however, it would still remain suitable as a relative measure for comparisons between years. Telemetry research on movement to and from, and residence duration at the breeding aggregation (Payne et al., in press) would help to establish aggregation patterns.

A more detailed survey to determine the absolute population, including the relative proportion of the two year classes (i.e. rapid growth and maturation within a year vs reproduction in the following year) would not necessarily provide an index of future population size, owing to the strong influence of environmental variables on recruitment success.

Comprehensive temporal surveys from 1998 to 2000 confirmed the peak in cuttlefish numbers to be at the end of May (see Appendix H9.3 of the Supplementary EIS). The results also suggested that the population peak may last for approximately a month (from mid-May to mid-June), and surveys in the middle of this period would occur in the population peak. In the unlikely event that population surveys were to occur outside the peak abundance period, the population estimates would be conservative (K Hall, consultant cuttlefish expert, pers. comm. 20 September 2010).

Analysis of the 1998 to 2000 cuttlefish survey data showed that differences between sites could be detected with the current level of replication (Hall and Fowler 2003). It is noted, however, that these surveys were not designed as a Before After Control Impact (BACI) monitoring program. A BACI monitoring program would be designed and implemented before construction of the proposed Point Lowly desalination plant.

In conclusion, the current methodology is considered appropriate for monitoring the cuttlefish population between years, and for the purpose of the EIS assessments. Population records over the past decade provide some indication of the variability of the population, but the causes of the fluctuations could not be identified.

Source: Hall and Fowler 2003

Figure 17.23 Survey transect locations of cuttlefish breeding aggregation

Issue:

Further information was requested on the species status of the Australian Giant Cuttlefish and its implications for protection levels.

Submission: 210

Response:

Microsatellite and morphometric data have revealed a complex population structure for *Sepia apama*, with distinct populations or stocks occurring in Streaky Bay, Spencer Gulf and Gulf St Vincent (Hall and Fowler 2003). As discussed in Appendix O5 of the Draft EIS, recent research suggests the population that spawns at Point Lowly has minimal interbreeding with the nearest population, just north of Wallaroo. These two populations have some characteristics of separate species, such as genetic separation, separate but adjacent distributions, differences in morphology that may indicate ecological differentiation, and different patterns of sexual dimorphism (B Gillanders, University of Adelaide and S Donnellan, South Australian Museum, pers. comm., 11 Dec 2007).

The population at Point Lowly/Whyalla is not currently recognised as a separate species. Although it is not a listed threatened species under federal or state legislation, it is protected by a year-round closure, administered by PIRSA Fisheries, banning the collection of all cephalopods in part of the aggregation area. The unique nature of the breeding aggregation and its accessibility make it of special conservation significance. Should the Australian Giant Cuttlefish be recognised as a separate species, it may trigger additional protection under state and federal legislation.

BHP Billiton would support all appropriate measures to ensure the long-term conservation of the cuttlefish breeding aggregation at Point Lowly.

17.10.4 SUSCEPTIBILITY OF THE CUTTLEFISH POPULATION TO RAPID DECLINE

Issue:

Concerns have been expressed regarding the biological susceptibility of cuttlefish to impacts due to its short lifespan and habit of breeding only once. It was suggested that predictive models of demographic loss and effects on populations should have been applied.

Submissions: 24, 199, 250, 271, 290, 319 and 376

Response:

As discussed in Section 16.3.6 and Appendix O5 of the Draft EIS, similar to many other cephalopod species, Australian Giant Cuttlefish are short-lived and semelparous (spawn once then die). As there is no accumulation of spawning biomass from one generation to the next, there is little buffer against years of poor recruitment or over-exploitation for many cephalopod species (O'Dor 1998). Such life cycles, coupled with spawning aggregations (as occur near Point Lowly), make cephalopod species particularly susceptible to impacts.

Sepia apama, however, exhibits two alternative life cycles that lessen its susceptibility to some degree (Hall and Fowler 2003; Hall et al. 2007). The first involves rapid juvenile growth during the first summer after hatching, with maturity being reached in seven to eight months. These relatively small cuttlefish return to spawn in their first year. The second life cycle involves much slower juvenile growth during the first summer, with maturity deferred until their second year, when they return to spawn as larger cuttlefish (Hall et al. 2007).

This split life cycle spreads the breeding effort over two years rather than one, and provides a risk-spreading strategy for survival in an unpredictable environment, while still ensuring that populations are flexible enough to take advantage of interannular fluctuations in environmental conditions (Hall and Fowler 2003). While the aggregation near Point Lowly is acknowledged as the most dense spawning location in Spencer Gulf, less concentrated spawning occurs in most areas of rocky reef throughout the species distribution (Hall and Fowler 2003).

The use of predictive models of demographic loss and effects on population, such as population viability analysis (Reed et al. 2002), has not been possible for the Australian Giant Cuttlefish. These models require considerable data, such as fecundity and the growth and survival for all life stages, which is presently unavailable for the Australian Giant Cuttlefish. Instead, the focus of the studies has been to demonstrate, with a large margin of safety, that return water dilutions would have no effect on the cuttlefish.

BHP Billiton agrees that utmost care must be taken to maintain the reproductive success of the Australian Giant Cuttlefish at Point Lowly.

17.10.5 POTENTIAL FOR RETURN WATER DISCHARGE TO IMPINGE ON CUTTLEFISH BREEDING HABITAT

Issue:

The potential for the return water plume to enter the cuttlefish breeding habitat as a result of poor dispersion during dodge tides has been questioned.

Submission: 103

Response:

As demonstrated in Sections 16.4.3 and 16.6.7 of the Draft EIS, the return water plume, as defined by the species protection trigger value (SPTV), would never overlap with the cuttlefish breeding habitat, even during extreme dodge tides with no wind. During the brief periods of no tidal flow, the dense return water would flow under the influence of gravity into the deeper sections of the gulf, rather than into the shallow cuttlefish breeding habitat. Predictions from the revised model for the modified diffuser design indicate that a dilution of 1:16, which would specifically protect the cuttlefish species, would always be achieved on the seafloor in the near-field mixing zone (i.e. within 100 m of the diffuser) (see Figure 17.24, Sections 17.7.5 and 17.7.6 and Appendix H7.2 of the Supplementary EIS).

The potential for wind-induced upwelling of return water into the cuttlefish habitat to occur during dodge tides with strong offshore winds was shown by detailed model runs to be non-existent (see Section 17.7.7 and Figure 17.17 of the Supplementary EIS).

The worst dilution modelled in the cuttlefish breeding habitat over the one-year simulation was 1:107 during a dodge tide, when minimal tidal movement has been shown to last for four to five hours (refer Table 17.4 and Section 17.7.2 of the Supplementary EIS). Relatively poor dilutions in the cuttlefish habitat were very infrequent, with dilutions exceeding 1:200 for 99% of the time (see Table 17.9 of the Supplementary EIS).

Further 'worst-case' model runs during a dodge tide, with and without wind, confirmed that the worst dilutions in the cuttlefish habitat during the one-year simulation were consistent with the dodge tide/no wind scenario. Wind stress during the dodge tide was shown to improve dilutions in the cuttlefish habitat (see Figures 3–26 and 3–27 in Appendix H7.2 of the Supplementary EIS).

Results of simulations using the revised model and diffuser design have confirmed that the return water plume (as defined by the 1:70 dilution contour) would never reach the cuttlefish habitat, with dilutions of at least 1:107 being achieved at all times (see Figure 17.15, Section 17.7.6 and Appendix H7.2 of the Supplementary EIS). It is concluded that there would be no effects on cuttlefish during dodge tides.

Issue:

The potential for the return water plume to enter the cuttlefish breeding habitat as a result of winds (offshore winds causing upwelling) or tides pushing the plume into the cuttlefish aggregation area, has been questioned.

Submissions: 40, 46, 80, 155, 192, 193, 217, 252, 320, 324 and 356

Response:

As discussed above, modelling over the full range of tides over 40 days (including three spring–neap periods) showed that the return water plume would not impinge on the cuttlefish breeding habitat. Furthermore, a strong (20-knot) south-easterly wind was modelled to determine whether the return water could be driven onto the breeding habitat. The increased wind-induced mixing, however, resulted in faster dispersion of the plume and better dilutions in the cuttlefish breeding habitat than the indicative worst-case scenario with dodge tide and windless conditions (refer Figures 3.22 and 3.34 and Appendix O11.4 of the Draft EIS). Similarly, strong offshore winds have been modelled to determine whether upwelling of return water into cuttlefish breeding habitat could occur. The model showed that in no circumstances could upwelling into cuttlefish habitat be induced to occur (see Section 17.7.7 of the Supplementary EIS).

Figure 17.24 Plume dilutions relative to cuttlefish effects threshold (EC_{10} = 1:16) and cuttlefish habitat

Issue:

The apparent contradiction between the vertical separation preventing impact of return water on cuttlefish habitat and 'periods of reduced vertical mixing are rare' has been questioned.

Submissions: 80 and 356

Response:

These statements are consistent as they describe different phases of the dispersion process. The vertical separation refers to the more saline return water plume falling to the seafloor under the influence of gravity upon discharge. Vertical mixing subsequently occurs under the influence of wave- and current-induced turbulence, resulting in the return water becoming progressively more dilute as it is dispersed into the water column. Dilutions of at least 1:107 would be attained in the cuttlefish habitat (see Table 17.9 in Section 17.7.6 of the Supplementary EIS).

Issue:

Further information was requested on the potential for injection into the water column to bring brine close to the cuttlefish habitat.

Submission: 102

Response:

The strategy of injecting return water into the water column would not result in it impinging on the cuttlefish habitat. Although the new diffuser design enables the dense return water plume to initially rise 10–15 m into the column, the plume would immediately fall to the seafloor, thereby maintaining the 20 m vertical and 600 m horizontal separation from the breeding habitat. Detailed modelling of the return water plume upon discharge undertaken after the Draft EIS was published has confirmed that return water would always fall to the seafloor upon discharge and never enter the breeding habitat (see Figures 17.16a and 17.16b of the Supplementary EIS). The minimum dilution in the shallow cuttlefish habitat would be 1:107, well above the effects threshold (EC_{10}) for cuttlefish of 1:16 (see Table 17.9 of the Supplementary EIS).

17.10.6 POTENTIAL EFFECTS OF THE SALINITY INCREASES ON CUTTLEFISH

Issue:

Further information was requested on the effects of increased salt concentrations on cuttlefish.

Submissions: 40 and 271

Response:

As discussed in Section 16.6.7 of the Draft EIS, the potential for the proposed desalination plant discharge to affect the cuttlefish population was assessed as negligible because rapid dispersion and dilution of the return water would ensure dilutions in the breeding habitat were safe at all times. The hydrodynamic modelling undertaken for the Draft EIS established that the minimum dilution at the closest cuttlefish site was 1:116, which is far in excess of the dilution of 1:16 required to protect the cuttlefish (refer Section 16.4.3 and Appendix O11.4 of the Draft EIS). The revised model and diffuser design presented in Section 17.7.6 and Appendix H7.2 of the Supplementary EIS have resulted in dilutions of greater than 1:200 for 99% of the time (minimum dilution of 1:107) in the breeding habitat, thus confirming the negligible impact presented in the Draft EIS.

These dilutions equate to salinity increases of 0.2 and 0.3 g/L above ambient, which are minor in comparison to the natural daily variability of salinity of about 1 g/L, the seasonal variability of 40–43 g/L at Point Lowly, and the north-south salinity gradient in Spencer Gulf (12 g/L) (refer Section 16.6.2 of the Draft EIS). In 2009, the salinity range at Point Lowly during late autumn and early winter, when cuttlefish arrive to breed, was 40.5–42.8 g/L (see Appendix H5.4 of the Supplementary EIS). Natural salinity changes of 1–1.5 g/L in the same day, across the breeding population area and between bottom and mid-water depths, occur regularly in the vicinity of Point Lowly. Furthermore, salinity at Backy Point, which supports high densities of breeding cuttlefish (see Appendix H9.3 of the Supplementary EIS), is up to 0.9 g/L greater, and on average 0.35 g/L greater, than at Point Lowly (Johnson 1981). The salinity range at Backy Point is 40.1–43.1 g/L (Johnson 1981).

Therefore, salinity increases resulting from the operation of the desalination plant would result in salinities similar to those experienced by cuttlefish in their natural breeding habitat at Backy Point.

Issue:

Given that other cephalopod studies have shown that increased salinity impedes egg development, which in turn may affect development of the hatchlings into normal adults, the potential for similar impacts occurring at Point Lowly has been questioned.

Submissions: 2, 40, 99, 144, 271, 319 and 348

Response:

The slight salinity increase at Point Lowly would have no effect on the development of cuttlefish eggs.

The natural occurrence of cuttlefish along the north-south salinity gradient in Spencer Gulf, and the slow (four to five months) development of their eggs result in developing embryos being exposed to a salinity range of 40–43 g/L. The maximum predicted salinity increase resulting from operation of the desalination plant in the breeding habitat is 0.3 g/L above ambient (1:107 dilution). However, salinity increases of less than 0.2 g/L (1:200 dilution) are predicted for greater than 99% of the time. A maximum salinity of 42.8 g/L was recorded at Point Lowly in autumn 2009 (Table 17.11 of the Supplementary EIS), whereas a maximum salinity of 43.1 g/L has been recorded at Backy Point (Johnson 1981), which supports dense cuttlefish breeding aggregations (see Appendix H9.3 of the Supplementary EIS). The predicted maximum salinity increase resulting from desalination (0.3 g/L) would therefore increase the salinity in the cuttlefish habitat at Point Lowly at the start of the breeding season to a level similar to the maximum recorded at Backy Point. The salinities at Point Lowly would then reduce rapidly to less than 42 g/L within a few weeks of the start of the breeding season.

As discussed in the Draft EIS (refer Section 16.4.2, Table 16.8 and Appendices O10.3 and O10.4) the salinities at which whole effluent toxicity (WET) studies showed an effect on the development of Australian Giant Cuttlefish embryos and hatchlings were 43.6 g/L and 45.6 g/L. The different threshold salinities may relate to the confounding influence of anti-scalant, which may have been partly responsible for the toxicity at a salinity of 43.6 g/L (see Appendix H4.3 of the Supplementary EIS).

Although some studies have shown that elevated salinity can inhibit hatching success, growth and development of cephalopods (Dupavillon and Gillanders 2009; Stewart 2008), critical salinity thresholds for *Sepia apama* would never be exceeded at Point Lowly. The laboratory experiments by Dupavillon and Gillanders showed reduced survival, mantle length and weight at a salinity of 46 g/L compared with salinities of 40 and 41 g/L, which is consistent with the Draft EIS result, albeit less precise (see Section 17.4.8 of the Supplementary EIS).

It is not known whether the northern extent of cuttlefish habitat is limited by salinity or the lack of suitable breeding habitat north of Backy Point. The evidence suggests that cuttlefish embryos and hatchlings can tolerate salinities up to 45.6 g/L with no measurable effect. Since these salinity thresholds would never be exceeded, it is concluded that operation of the desalination plant would have no effect on egg development.

Table 17.11 Natural variability of salinity in cuttlefish population during May (the month of arrival) (see Appendix H5.4)

Percentile	0	1	5	10	25	50	75	90	95	99	100
Point Lowly (25 m)	40.89	41.18	41.32	41.41	41.62	42.09	42.25	42.4	42.49	42.66	42.72
Stony Point (6 m)	40.46	40.52	40.65	40.75	41.06	41.45	41.76	42.26	42.58	42.76	42.84

Issue:

It was suggested that the ecotoxicology studies were inadequate as they focused only on survival and growth, but did not address the potential impacts of reduced fitness of hatchlings and implications for feeding and migration.

Submissions: 86 and 271

Response:

The slight salinity increase at Point Lowly would have no effect on the viability or survival of cuttlefish hatchlings. Fitness, feeding and migration are not likely to be affected.

As discussed in Section 16.4.2 of the Draft EIS, the safe dilution for cuttlefish was based not only on the survival and growth of embryos, but also of hatchlings. The tests were based on the ANZECC/ARMCANZ (2000) water quality guidelines, which recommend mortality, growth and reproduction as they are ecologically relevant endpoints (rather than mobility, swimming or feeding) (see Section 17.4.6 of the Supplementary EIS). The derived safe dilution of 1:16 for cuttlefish also protects hatchlings. As discussed in Section 16.4.3 of the Draft EIS, the safe dilution for cuttlefish would never be exceeded in their breeding habitat, so there would be no adverse effects on hatchlings.

Further evidence is provided by the salinity gradients in Spencer Gulf. As discussed in Section 16.6.2 of the Draft EIS, the north-south salinity gradient in the gulf results in organisms near the outfall at times being exposed to salinities that exist naturally 10 km to the north at Backy Point, where there is a cuttlefish breeding population. The population estimates from surveys in 2001 (4,000 individuals) and in 2008 to 2010 (9000, 10,000 and 20,000 respectively) suggest that the greater salinity at Backy Point (up to 43.1 g/L) has not impeded dispersal or natal homing. Cuttlefish migrate to and breed at this location and hatchlings must feed and disperse from this area, indicating that they are not impeded by the slightly greater salinity at Backy Point. This salinity is almost equivalent to the greatest salinity that would occur in the breeding habitat at Point Lowly resulting from operation of the desalination plant during May (43.1 g/L)(see Appendix H5.4 of the Supplementary EIS and previous issue).

It is concluded, therefore, that operation of the desalination plant would have no effect on fitness, feeding and migration of cuttlefish hatchlings.

17.10.7 POTENTIAL EFFECTS OF CHEMICALS, TEMPERATURE AND OXYGEN DEPLETION ON CUTTLEFISH

Issue:

Further information was requested on the potential impacts of the increased chemicals (including heavy metals), temperature and oxygen depletion of the return water discharge and the potential for cumulative impacts.

Submissions: 40 and 271

Response:

Chemicals and heavy metals contained in the discharge, increased temperature and oxygen depletion would not affect cuttlefish, as either separate entities or cumulatively. The median dilution of return water of 1:350 in the cuttlefish habitat would ensure that physiochemical effects on water quality were so low as to be unmeasurable.

Chemicals

Chemicals proposed for use in the reverse osmosis (RO) desalination plant listed in Table 16.7 of the Draft EIS include coagulants and flocculants, a chlorine biocide and its neutraliser, and two anti-scalants. Only some of these chemicals are discharged to sea in return water. Further details are provided below and in Sections 17.3.1 and 17.8.4 of the Supplementary EIS.

Coagulants and flocculants, used to remove suspended material in the intake water, are disposed of on land with the flocculated material.

The neutralisation of chlorine biocide with sodium metabisulphite results in negligible halogenated chlorine by-products and residual metabisulphite in return water (refer Section 16.4.1 of the Draft EIS). The concentration of halogenated organic compounds in effluent from reverse osmosis desalination plants is of ‘typically low content below harmful levels’ (Lattemann and Hoepner 2008) (see also Section 17.8.4 of the Supplementary EIS).

The anti-scalants currently being considered are sulphuric acid, and Nalco PermaTreat® PC-1020T. Testing of return water quality at the pilot desalination plant at Port Bonython returned a slightly lower (0.3 units) pH than ambient seawater, indicating that the addition of acid has only a slight effect (see Appendix H2.3 of the Supplementary EIS). Rapid dilution of the return water and the high buffering capacity of seawater would result in the pH being returned to ambient levels well within 100 m of the outfall (see Section 17.3.1 of the Supplementary EIS).

Similarly, anti-scalants are not expected to adversely affect cuttlefish. Not only are they reported to be of low toxicity (Lattermann and Hoepner 2003), but their median dilution of 1:350 in the cuttlefish habitat would render them virtually undetectable. Toxicity testing on cuttlefish using return water with anti-scalant resulted in a safe dilution of 1:16 (refer Section 16.4.2 and Appendix O10.4 of the Draft EIS and see Appendix H4.3 of the Supplementary EIS).

Heavy metals

There is some evidence in the literature that cuttlefish are susceptible to adverse effects from heavy metals. For example, metals are reported to retard the hatching and the swimming capability of cuttlefish (Dupavillon and Gillanders 2009; D’Aniello et al. 1989). Metals are also reported to readily assimilate into the tissue of the European Common Cuttlefish *Sepia officinialis* (Bustamante et al. 2002).

The operation of the desalination plant would result in a net reduction of metals being returned to the gulf (see Section 17.3.2 of the Supplementary EIS for details). Most heavy metals in the intake water would be adsorbed onto particulates, which would be removed during the pre-treatment process and disposed of on land. Although the solubility of some residual metals may increase in the return water due to the elevated salinity and lower pH, the total metal content would be lower. The residual metals in return water would be rapidly diluted and would reassociate with particulates in seawater, returning to background concentrations within a short distance of the diffuser.

Temperature

The temperature of the return water would be approximately 1ºC above ambient (refer Table 16.6 of the Draft EIS). Rapid dilution and dispersion of the return water would ensure a return to ambient temperature within metres of the diffuser, with no adverse effects on cuttlefish.

Dissolved oxygen

Although saturated, the dissolved oxygen concentration of return water would be 5.5–7 mg/L (i.e. slightly less than ambient seawater), due to the greater salinity (see Section 17.3.1 of the Supplementary EIS). Rapid dilution and dispersion of the return water would ensure a return to ambient levels of 6–10 mg/L within metres of the diffuser.

A detailed discussion of dissolved oxygen issues associated with operation of the desalination plant is provided in Section 17.12.3 of the Supplementary EIS, where the CAEDYM model is used to assess the potential for deoxygenation at Point Lowly. The model shows that the return water discharge would have no effect on deoxygenation in the cuttlefish habitat or at any other location off Point Lowly.

Cumulative impacts

The cumulative impact of elevated salinity and anti-scalants was assessed using whole effluent toxicity (WET) tests (refer Sections 16.2.3 and 16.4.2 of the Draft EIS). These tests are a reasonable proxy for the final effluent, containing appropriate levels of salinity and the proposed Nalco anti-scalant.

BHP Billiton has committed to undertaking further ecotoxicology studies to recalculate the species protection trigger value (SPTV) before the plant started operating if the return water chemical characteristics changed from those assessed. Should the tests be required and reveal that additional dilutions are required to attain a revised SPTV, which is considered very unlikely, the design or operation of the diffuser would be modified accordingly.

Issue:

Clarification was sought about the view, as expressed on the ABC's *Catalyst* program, that overseas scientists made it quite clear that the construction of a desalination plant at Point Lowly would certainly have an adverse effect on cuttlefish.

Submission: 226

Response:

Scientists have generally commented on the importance and vulnerability of the cuttlefish breeding population and the need for its protection. Only local oceanographer Dr Jochen Kaempf disputed the findings presented in the Draft EIS on that program and said there would certainly be an adverse effect. Comment on the modelling undertaken by Dr Kaempf, and his interpretation of the model outcomes, is provided in Section 17.5.2 and Appendix H5.3 of the Supplementary EIS.

17.10.8 POTENTIAL BEHAVIOURAL EFFECTS ON CUTTLEFISH

Issue:

The potential impacts of the return water discharge on adult and hatchling cuttlefish migration behaviours was questioned, given the lack of knowledge about cuttlefish outside the breeding aggregation and the general susceptibility of cuttlefish to increased salinity. It was suggested that acoustic tracking and beam trawl surveys were required to understand the use by cuttlefish of habitats adjacent to the spawning reef.

Submissions: 1, 24, 83, 86, 192 and 356

Response:

Discharge from the desalination plant would have no effect on cuttlefish migration as the return water plume on the seafloor would be virtually indistinguishable from natural saline plumes (Nunes and Lennon 1986; Lennon et al. 1987; Nunes Vaz et al. 1990) that traverse the Point Lowly area.

Return water dilutions in the deeper habitats adjacent to the cuttlefish breeding grounds would breach the safe level for the development of cuttlefish embryos and hatchlings only intermittently, over a very small area near the outfall, and several hundred metres from an area of relatively poor-quality breeding habitat on the tip of Point Lowly.

The largest extent of the plume, which occurs during extreme dodge tide and no wind, is shown in Figure 17.24 of the Supplementary EIS. The figure shows that a species protection trigger value (SPTV) of 1:70, greater than the most conservative dilution threshold to protect embryos and hatchlings (1:55) (refer Table 16.8 and Appendix O10.5 of the Draft EIS), is never breached in the cuttlefish breeding habitat. The revised dilution threshold for cuttlefish (1:16) is never breached outside the near-field mixing zone around the diffuser (i.e. within 100 m of the diffuser) (see Section 17.7.5, Table 17.9 and Appendix H7.2 of the Supplementary EIS).

Cuttlefish population surveys at Point Lowly over the past decade have shown that the majority of the breeding aggregation (>70%) occurs west of the Port Bonython jetty, several kilometres from the outfall (see Appendix H9.3 of the Supplementary EIS). A large proportion of the population is therefore likely to access the coast without traversing the return water plume.

Although a cuttlefish was never encountered during approximately 80 hours of deep-habitat dives completed for the EIS (refer Appendices O1 and O5 of the Draft EIS), it is possible that some cuttlefish would traverse the plume near the diffuser while accessing the Fitzgerald Bay and Backy Point breeding habitats. Surveys since 2008 indicate cuttlefish abundance at Backy Point may be increasing. This area supports 10–20% of the breeding aggregation and may involve cuttlefish migrating past the near-field mixing zone. The plume around the outfall, however, would be similar in intensity to naturally occurring saline plumes that regularly traverse the area during the early part of the cuttlefish breeding season (see Section 16.4.3 and Appendix O11.4 of the Draft EIS). Natural salinity changes of 1–1.5 g/L in the same day, across the breeding population area, and between bottom and mid-water depths, occur regularly in the vicinity of Point Lowly (see Section 17.8.2 and Appendix H.5.4 of the Supplementary EIS), which is greater than the maximum predicted salinity increase of 0.8 g/L within 100 m of the outfall (refer Section 7.7.6 of the Supplementary EIS). The plume within 100 m of the diffuser would therefore be consistent with natural saline plumes traversing the area, which cuttlefish would inevitably experience (see the animations in Appendix H7.4 of the Supplementary EIS). The evidence suggests that the plume associated with the return water discharge is unlikely to affect the behaviour of cuttlefish migrating to or from the breeding habitat, or otherwise using the adjacent habitats.

Further study of cuttlefish movements in adjacent habitats is therefore not considered to be necessary and, in the case of beam trawling, would be destructive.

Although the cumulative extremes of peak ambient salinities and return water discharge near the diffuser may result in slightly higher salinities than would be encountered naturally at Point Lowly, cuttlefish breed further north in Spencer Gulf at Backy Point, where salinities reach 43.1 g/L (Johnson 1981). Furthermore, an Australian Giant Cuttlefish has been recorded even further north near Douglas Bank during surveys using otter trawl nets in April (Hall & Fowler 2003), when salinities of 45 g/L have been recorded (Johnson 1981).

Although the movement of hatchlings from the breeding habitat is unknown, due to their small size and cryptic nature, it is considered that they would not be affected by the return water plume for the same reasons discussed above (i.e. the plume would be consistent with natural saline plumes that move down the gulf, particularly during winter).

It is concluded that the movement of cuttlefish to and from the breeding habitat would not be affected by return water plumes, and further study of cuttlefish movements in adjacent habitats is not necessary.

Issue:

The potential impacts of increased turbidity (reducing visual acuity) and salinity on the complex breeding behaviours have been questioned, given that poor breeding success may result when cuttlefish are stressed.

Submissions: 1, 40, 54, 86 and 271

Response:

As discussed in Section 16.6.7 of the Draft EIS, and reiterated in a response above, the return water would be rapidly dispersed and diluted to the extent that safe dilutions would never be exceeded in the shallow breeding habitat.

Increased water turbidity during construction would not affect breeding behaviour as construction of the intake pipeline would occur outside the breeding season. The outfall pipeline would be tunnelled.

Similarly, during operation of the plant there would be no adverse effects on turbidity as the return water would be much less turbid than the intake water due to the removal of suspended matter during filtration of intake water.

Issue:

More information was requested on egg laying and breeding behaviour; specifically, why do cuttlefish lay where they do, will they lay on artificial habitat, and will they return to their hatching location (natal home).

Submissions: 27 and 40

Response:

As discussed in Section 16.3.6 of the Draft EIS, the reef along the shores of Point Lowly/Whyalla provides an extensive area of suitable rock for cuttlefish to deposit eggs in crevices (Gostin et al. 1984; Edyvane 1999). The extensive availability of this habitat is the probable reason for cuttlefish aggregating in such great densities at Point Lowly (Hall 1998; Norman et al. 1999). Although maturing cuttlefish are capable of homing to their natal spawning grounds (Hall and Fowler 2003), the mechanism is unknown.

Pilot studies reported in Appendix O5.3 of the Draft EIS, in which cuttlefish were induced to deposit eggs on garden pavers, support previous observations that cuttlefish will deposit eggs on artificial habitat, such as tyre reefs, corrugated iron and breakwaters. The laying of eggs on artificial substrates suggests the area of breeding habitat available to cuttlefish can be increased. As discussed in Section 16.6.11 of the Draft EIS, additional breeding habitat may be created during construction by the armouring of the intake pipeline with rock.

17.10.9 CONTINGENCY MEASURES

Issue:

Submissions questioned the adequacy of contingency measures proposed to ensure potential adverse effects (particularly relating to cuttlefish) are detected and rectified.

Submissions: 2, 27, 83, 138, 155, 288, 302, 319, 324 and 358

Response:

Chapter 24 of the Draft EIS outlined the management framework for environmental management programs (EM Programs) and Section ID1.2 of Appendix U of the Draft EIS provided the Draft EM Program for Marine Disturbance. The Draft EM Program identified both general and specific monitoring programs for flora and fauna and water quality. Specifically, proposed monitoring to develop baseline conditions to identify changes included:

- seasonal surveys describing benthic communities at permanent underwater monitoring sites (Marine Flora and Fauna Monitoring Program)
- a seawater program to provide comprehensive water quality data (including salinity and dissolved oxygen) for Point Lowly. Salinity/temperature meters and data loggers would be used to monitor salinity at critical sites (Marine Water Quality Monitoring Program)
- a sediment sampling program at Point Lowly to provide further sediment quality information, including organic and inorganic pollutants and sediment oxygen demand.

For the Supplementary EIS, the following commitments have been made regarding marine monitoring:

- a detailed marine monitoring and management plan, incorporating habitat maps, would be developed in liaison with relevant stakeholders
- future monitoring of salinity levels would be undertaken for comparison against species protection trigger values (SPTV)
- monitoring would occur two years before the start of construction, and during construction and operation of the plant
- monitoring to verify the return water dispersion modelling results would occur during the first year of operation of the plant, and would include times of dodge tides.

With regard to contingency measures, the Draft EM Program provided in the Draft EIS noted that contingency measures would be developed as required. BHP Billiton has since committed to cease discharge from the desalination plant if agreed regulatory thresholds for return water dispersion were exceeded or monitoring identified unacceptable impacts (see Chapter 2 of the Supplementary EIS).

17.11 FISHERIES AND AQUACULTURE

17.11.1 POTENTIAL IMPACTS ON WILD FISHERIES

Issue:

It was suggested that the location of the desalination plant in Upper Spencer Gulf would result in unacceptable impacts to a number of economically valuable fisheries that depend on the upper reaches of the gulf for breeding, as a nursery area and as feeding habitat. The findings presented in the Draft EIS concerning effects on commercial species were disputed. Clarification was sought on a number of aspects of the assessment of potential impacts on these species.

Submissions: 27, 83, 138, 250, 288 and 302

Response:

As discussed in Sections 16.6.8, 16.6.9 and 16.6.10 of the Draft EIS, the effects of elevated salinity, deoxygenation and entrainment, respectively, on commercial species were generally assessed as being negligible. The only exception was the effect of elevated salinity in the immediate vicinity of the diffuser, where the effect was assessed as being moderate (i.e. reflecting a long-term impact on a local receiver) (refer Section 16.6.8 of the Draft EIS).

The ecological and economic importance of Upper Spencer Gulf to commercial fisheries in South Australia was discussed in Section 16.3.8 of the Draft EIS. Habitat and catch information for the 12 principal commercial species occurring in the Point Lowly region was summarised in Table 16.5 of the Draft EIS. A further 14 commercial and recreational species have been identified as utilising Upper Spencer Gulf coastal habitats at various life stages (Bryars 2003) (see Appendix H9.5 of the Supplementary EIS).

Many of the shallow marine habitats in Upper Spencer Gulf have been identified as breeding and nursery habitat for a number of commercial fish and crustacean species (refer Section 16.3.8 of the Draft EIS for details) (Bryars 2003). The unvegetated soft-bottom habitat in the deep channels, where the outfall would be located, is associated with 20 species as adults, 16 as juveniles, eight for either spawning and/or larval stages, and one during the egg life stage (see Appendix H9.5 of the Supplementary EIS).

Return water dispersion

Extensive plume dispersion modelling and ecotoxicology studies have been undertaken for the EIS to assess potential impacts on marine biota, including commercial species (refer Sections 16.2.4, 16.4.2 and 16.4.3 of the Draft EIS). The studies showed that detectable effects on the most sensitive species would be confined to the mixing zone around the diffuser (i.e. within 100 m of the diffuser).

Deoxygenation

As discussed in Section 16.6.9 of the Draft EIS, the duration of limited water movement (during dodge tides) is too short to enable deoxygenation of bottom waters to occur to the extent that organisms would be affected. Additional modelling of dissolved oxygen dynamics associated with return water discharge has been undertaken (using CAEDYM and ELCOM) to confirm the findings presented in the Draft EIS. As discussed in Section 17.12.3, the modelling has shown that return water discharge would have a negligible effect on the concentration of dissolved oxygen in seawater off Point Lowly.

Larval entrainment

As discussed in Section 16.6.10 of the Draft EIS, a number of approaches were used to demonstrate that the impact of entrainment of larvae on the marine ecosystem would be negligible. These included a review of entrainment impacts associated with existing desalination and power plants, comparisons with the amount of water entrained by the desalination plant compared with the volume of water in Spencer Gulf, and comparative losses of larvae caused by commercial prawn fisheries. An additional comparison is to consider the percentage of adult fish and crustaceans that may be lost to the ecosystem as a result of larval entrainment. Using the conservative assumptions that 2% of the water in Upper Spencer Gulf is entrained by the desalination plant annually, and 1% of larvae develop into adults, a simplistic assessment of entrainment by the desalination plant would estimate that one in 5,000 adults would be removed from the population annually (see also Section 17.13.2 of the Supplementary EIS).

Field investigations of larval communities in the vicinity of Point Lowly have been undertaken since the Draft EIS was published in an attempt to quantify the magnitude of entrainment, and investigate seasonal trends and species affected. These studies have confirmed that effects of larval entrainment on populations of commercial species would be negligible (see Section 17.13.3 of the Supplementary EIS).

Issue:

It was claimed that bottom-dwelling (benthic) species (e.g. King George Whiting, Yellowfin Whiting and Salmon) were not mentioned in the Draft EIS.

Submission: 122

Response:

Bottom-dwelling species were discussed in Sections 16.3.4 and 16.3.8, and in Appendix O6 of the Draft EIS. An extensive literature search identified fish species occurring in the region (refer Appendix O2 of the Draft EIS). The extent of information presented on bottom-dwelling species was considered to be sufficient for the purposes of an EIS. The assessment of potential impacts focused on bottom-dwelling species because the return water plume was shown by the plume dispersion modelling to form a layer on the seafloor. This assessment was undertaken by reference to the species protection trigger value (SPTV), which was derived from the ecotoxicology studies to protect 99–100% of species in Upper Spencer Gulf.

The hydrodynamic modelling and ecotoxicology studies showed that the effects on bottom-dwelling species would potentially occur only in the mixing zone around the diffuser. Mobile fish species would move from the vicinity of the diffuser if the prevailing salinity was too high.

Issue:

It was suggested that most of the Snapper in South Australia may originate in Upper Spencer Gulf and disperse throughout the State, supplementing less abundant populations. It was also suggested that the ecology of Snapper in the upper gulf, including the use of the rip off Point Lowly for feeding and migration by Snapper and Mulloway, was largely overlooked in the Draft EIS.

Submissions: 86, 181 and 340

Response:

The ecology and economic importance of Snapper were discussed in Section 16.3.8, Table 16.5 and Appendix O6 of the Draft EIS. It was noted in Section 16.3.8 that Snapper are common in the deep water channels off Point Lowly, and that similar habitat exists in the area.

The effects on Snapper and Mulloway inhabiting the rip off Point Lowly were considered to be negligible. The ecotoxicology studies revealed the safe dilutions for Snapper and Mulloway to be 1:5 and 1:11, respectively (refer Table 16.8 of the Draft EIS), which would be achieved at all times on the seafloor, and within metres above the diffuser.

The fishing zone encompassing Point Lowly historically provided the greatest and most consistent commercial Snapper catch in Spencer Gulf up until 2003–2004 (Fowler et al. 2010). The catch in the gulf's southern region exceeded that of the northern region for the first time in 2004–2005 and again in the following season. It is known that the Snapper stocks in South Australia derive from common origins in northern Spencer Gulf and northern Gulf St Vincent, with fish remaining in the nursery areas for at least their first three years before either migrating to other regional areas or remaining in the same region (Fowler et al. 2010). Studies in Spencer Gulf have shown that newly recruited fish occur predominantly at Western Shoal and near False Bay, where the substratum is muddy and the current regime is low (Fowler et al. 2010). Whereas smaller fish tend to migrate, older fish become 'resident' in regional areas and move relatively small distances (<20 km) (Fowler et al. 2010).

The most significant effect of the desalination plant on Snapper is likely to be that the outfall and intake structures would form artificial reef habitat that may be colonised by schools of Snapper and may become a target area for fishers.

17.11.2 POTENTIAL IMPACTS ON AQUACULTURE

Issue:

The potential for return water to affect Kingfish farms in Fitzgerald Bay was questioned.

Submissions: 83 and 302

Response:

The return water plume would not be detectable at the fish farms in Fitzgerald Bay. As described in Section 16.4.3 of the Draft EIS, the minimum dilution at the aquaculture sites would be 1:319, which is equivalent to a salinity increase of 0.1 g/L. With the safe dilution for Kingfish being 1:10 (refer Section 16.4.2 of the Draft EIS), the plume at aquaculture rings would be at least 30 times more dilute than is necessary to protect Kingfish. It is concluded that the desalination discharge would not affect the aquaculture of Kingfish.

Issue:

Concern was expressed over the proximity of the proposed sulphur storage to the fish farm located off Pelican Point Road, Outer Harbor.

Submission: 22

Response:

The unloading, storing and transporting of sulphur prill (a pelletised form of elemental sulphur designed to reduce the potential for dusting and combustion) at Outer Harbor would have no effect on the operation of the fish farm at Pelican Point Road.

As discussed in Section 5.9.5 of the Draft EIS, strict safeguards would be implemented to contain sulphur during unloading, storage and transportation and minimise the risk to adjacent industries. These safeguards would include fully enclosed conveyors and transfer points, dust curtains at entry and exit points, mist sprays to suppress dust during unloading, and washdown sumps to collect spilt or fugitive sulphur. Sulphur would be stored in an enclosed shed.

A risk management workshop to address risks associated with operation of the Sulphur Handling Facility identified no unacceptable risks (refer Section 7.16, Appendix C of the Draft EIS). The risk associated with a sulphur spill to water was assessed as being low, which reflected the consensus of the workshop participants after considering the likelihood of a spill occurring, and the ecological consequences of the spill. Important considerations in the assessment were the knowledge that spills rarely occur at other sulphur handling facilities, and the low solubility of sulphur prill significantly lessens the ecological consequences of a spill to water.

Control and/or management actions to minimise risks associated with sulphur transport and storage were detailed in the Transport and Handling of Hazardous Materials Program (refer Section ID 2.1, Appendix U of the Draft EIS). The updated Management of Hazardous Materials, and the Emergency Response Plan Management Plans would include specific spill management procedures for sensitive areas, such as the Port Adelaide River. These procedures would ensure that spills were controlled at source, contained on-site and cleaned up according to the requirements of the Material Safety Data Sheet (MSDS) for sulphur. Further risk identification and contingency options would be identified and detailed in the Environmental Management Program as they were developed (see Chapter 29 of the Supplementary EIS).

17.12 STRATIFICATION AND DEOXYGENATION

17.12.1 OXYGEN CONTENT OF THE RETURN WATER

Issue:

The oxygen content of the return water, and the units used to measure dissolved oxygen, have been questioned.

Submissions: 83, 130, 143 and 184

Response:

Before discharge, return water would pass over a series of weirs that would result in mixing and aeration to near-saturation or even super-saturation. However, the greater salinity (mean 75 mg/L) and slightly elevated temperature (+1°C) of the return water would reduce its oxygen content to about 80% of that of ambient seawater (i.e. approximately 5.5–7 mg/L compared with 7–8.5 mg/L in typical Spencer Gulf seawater) (refer Table 16.6 of the Draft EIS). It is also reported that for approximately one hour each day the dissolved oxygen content of return water may be reduced to zero as a result of excess sodium metabisulphite (used to remove chlorine in feed water) also scavenging oxygen (Simon Hunt, BHP Billiton, pers. comm. 11 November 2010). The effects of occasional periods of zero dissolved oxygen in return water are discussed in Section 17.12.3.

The oxygen content of return water has been reported in mg/L, which is the actual oxygen content of water at a particular salinity and temperature. Reporting in per cent saturation is less useful as rates of oxygen consumption and depletion are reported in mg/L. The Draft EIS consistently used mg/L because it was considered to be a more straightforward method of reporting oxygen content than converting from per cent oxygen saturation to mg/L.

17.12.2 POTENTIAL FOR STRATIFICATION

Issue:

Concern was expressed that, in the context of Spencer Gulf being an inverse estuary, Upper Spencer Gulf and Point Lowly would be susceptible to stratification.

Submissions: 83, 192, 288 and 350

Response:

Spencer Gulf is an inverse estuary and as such is susceptible to stratification due to the strong north-south salinity and temperature gradients that prevail in its upper reaches. Although strong currents during spring tides ensure good vertical mixing, during neap (dodge) tides the reduced currents can result in stratification, and the formation of gravity currents of greater salinity water that flow along the floor of the gulf. Modelling of salinity at Yarraville Shoal (a sheltered area with relatively weak currents), however, showed a maximum variation of 1 g/L between surface and bottom water, indicating that vertical stratification is weak (refer Figures 5.27 and 5.28 in Appendix O11.2 of the Draft EIS). Continuous salinity data collected off Point Lowly near the seafloor and in the overlying water column demonstrated that weak salinity stratification occurs mainly during dodge tides (see Figure 17.19 of the Supplementary EIS).

The likelihood of stratification occurring off Point Lowly is lower than in other areas as the narrowing of the gulf between Ward Spit and Point Lowly results in strong currents that improve turbulent mixing of the water column and minimise the opportunity for stratification. A current meter deployed off Point Lowly from April to June 2009 revealed that relatively strong residual currents persist during dodge tides, resulting in little opportunity for stratification to occur (see Section 17.7.2 and Table 17.4 of the Supplementary EIS).

Issue:

Further details have been requested on the duration and extent of potential significant stratification events off Point Lowly. In particular, the level of stratification required to limit oxygen exchange was questioned.

Submissions: 2, 83 and 181

Response:

Stratification events off Point Lowly would never be persistent or strong enough to result in oxygen depletion to levels that would adversely affect marine organisms. The strong prevailing currents and wave action off Point Lowly result in good vertical mixing of the water column and relatively weak and brief stratification events.

Stratification can occur in aquatic environments during still conditions when the denser cold or saline water accumulates near the bottom, forming layers of water of differing densities, and restricting vertical mixing of the water column and the exchange of oxygen-rich surface water with seabed water. With strong and persistent stratification, oxygen depletion can occur if benthic organisms and oxidation processes consume oxygen faster than the rate at which oxygen can be replaced by diffusion and mixing.

In the Draft EIS the duration and extent of stratification was investigated by modelling salinity over three dodge tides, and extracting dilutions throughout the water column at three sites off Point Lowly (refer Figures 3.7 to 3.9 of Appendix O11.4 of the Draft EIS). Evidence of salinity stratification was recorded at these sites, with salinities adjacent to the seafloor being up to 1 g/L greater than in the overlying water for up to six days at the discharge site, and two days at sites 200–600 m from the outfall.

The salinity stratification reported in the Draft EIS, however, was unrealistically high as residual current speeds during dodge tides are greater than initially modelled, and the elevated salinity on the seafloor near the diffuser was caused by injecting all the return water into the seafloor layer of the ELCOM model rather than the overlying water column (see Section 17.7.6 of the Supplementary EIS).

Subsequent modelling of the return water discharge for the Supplementary EIS (using the upgraded ELCOM model, and improved diffuser design) has shown that discharge-induced salinity stratification off Point Lowly would be weaker and of much shorter duration than reported in the Draft EIS (see Appendix H7.2 of the Supplementary EIS). Salinities adjacent to the seafloor were about 0.5 g/L greater than in the overlying water column (10 m above the seabed) at the diffuser (site ‘x’), and virtually the same as in the overlying water column 100 and 450 m from the outfall (i.e. sites ‘s’ and ‘y’ respectively) (see Figure 17.25 and Appendix H7.2 of the Supplementary EIS). The longest duration of measurable stratification events (i.e. seafloor salinity increases of about 0.5 g/L) within 100 m of the outfall is predicted to be two days and 2–3 hours 500–600 m from the outfall (see Table 17.9 of the Supplementary EIS). The rapid attenuation of salinity stratification with distance from the diffuser indicates that significant vertical mixing and associated dilution of the plume occurs within several hundred metres of the outfall.

The level of stratification induced by the discharge would therefore be weak and of short duration, and similar to natural salinity stratification events occurring in the area (see Figure 17.19 of the Supplementary EIS). The discharge-induced stratification events off Point Lowly would be too weak and too short to limit vertical mixing of the water column to the extent that dissolved oxygen would be depleted near the seafloor (see Section 17.12.3 below).

Issue:

It was suggested that more detailed bathymetry was necessary to determine the potential for pooling of hypersaline water in deep sections of Spencer Gulf.

Submissions: 2 and 346

Response:

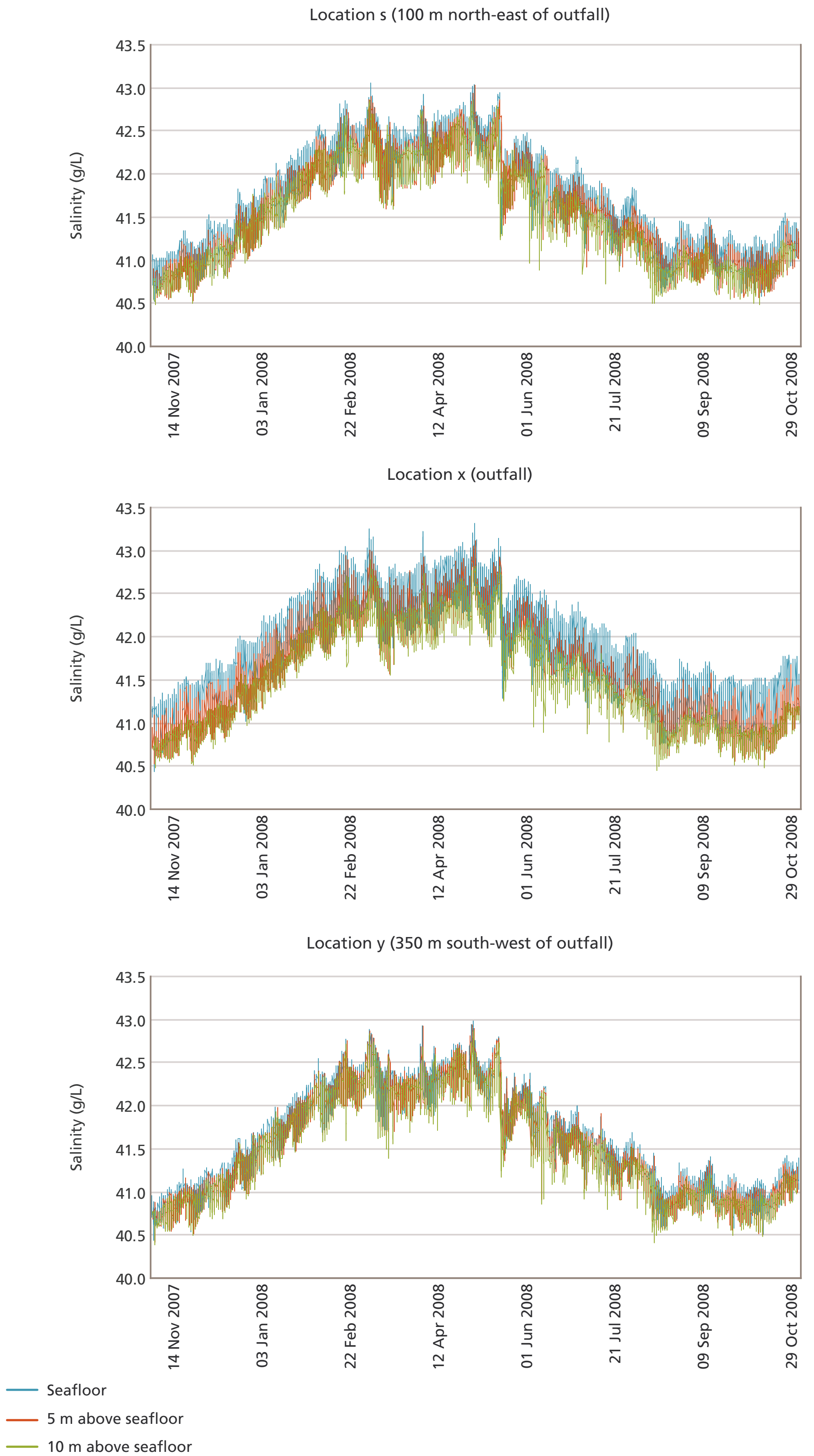
The hydrodynamic modelling resulted from a thorough review of existing information (refer Section 16.2.4 of the Draft EIS) including Admiralty and navigation charts (refer Appendix O11.2 of the Draft EIS). Admiralty and navigation charts were digitised and corrected to Australian Height Datum to create a single high-quality digital elevation model of Spencer Gulf that was used for all subsequent modelling. Further acoustic detailing of the bathymetry in the area surrounding Point Lowly using a swathe mapper was undertaken to further increase the reliability of the model in predicting the saline dispersion and its potential for ‘pooling’ in depressions.

Minimal movement of return water may occur near the outfall for up to 20 minutes during change of tides and up to five hours during dodge tides (see Section 17.7.2 and Table 17.4 of the Supplementary EIS). However, hypersaline water would not pool during these periods for the following reasons.

When return water is discharged at a salinity of 75 g/L from the diffuser, the plume would rise up to 15 m into the water column and be rapidly diluted as it fell to the seafloor. As discussed above, the maximum salinity increase on the seafloor within 100 m of the outfall would be about 0.8 g/L (return water dilution of 1:43) (see Section 17.7.6). Rather than being hypersaline, the return water would be close to the salinity of the ambient seawater in the area.

The rapid dilution and dispersion of return water, even during dodge tides, would result in salinity levels close to ambient levels near the diffuser. The extent of measurable salinity increase on the seafloor resulting from the return water discharge would be several hundred metres from the diffuser (refer Figure 17.15a locations ‘x’, ‘c’, ‘d’ and ‘p’), beyond which the salinity would be virtually indistinguishable from that of ambient seawater (see Sections 17.7.2 and 17.7.6 of the Supplementary EIS).

The pooling of very dilute return water near the outfall for relatively short periods during changes of tides and dodge tides would result in minor stratification and negligible depletion of dissolved oxygen near the seafloor (see Section 17.12.3 below).



See Figure 17.15a for locations

Figure 17.25 Modelled salinity levels on the seafloor and higher in the water column showing little evidence of stratification

17.12.3 POTENTIAL FOR OXYGEN DEPLETION

Issue:

The potential for sediment oxygen demand to cause ecologically significant oxygen depletion as a result of return water discharge stratifying has been questioned. The duration and spatial extent of the effect has also been questioned.

Submissions: 2, 138, 181, 356 and 376

Response:

Ecologically significant oxygen depletion would not occur off Point Lowly as sediment and biological oxygen demand is low, and constant tidal currents result in adequate mixing of the water column, even during dodge tides.

The oxygen demand of a marine system is expressed as biochemical oxygen demand (BOD) or sediment oxygen demand (SOD), and primarily results from microbial degradation of organic matter. The measurement period for SOD is shorter and always includes the contribution of nitrification. BOD and SOD are greater in fine organic sediments due to their greater surface area and high organic content compared to coarse, sandy sediments (Grant et al. 1991).

In the absence of adequate mixing during calm and stratified conditions, oxygen can be consumed by SOD at a greater rate than it can be replaced by turbulent mixing of oxygenated water from the surface. The severity and extent of the reduction in dissolved oxygen will depend on the oxygen demand of the marine system and the strength and duration of the stratified conditions constraining oxygen exchange.

The SOD used in the Draft EIS was 0.82 g/m^2/d, which was the mean value recorded over two years at Wallaroo, 100 km south of Point Lowly (Lauer 2005). Measurements at two other sites 30 and 50 km south of Point Lowly ranged from 0.33 to 0.70 g/m^2/day. The sites were at a depth of 23–27 m, which is similar to the proposed outfall site. The grain size and percent silt/clay was similar to the proposed outfall site off Point Lowly. As discussed in Section 16.6.9 of the Draft EIS, assuming a conservative dissolved oxygen value of 5.5 mg/L for the return water and a SOD of 0.33–0.82 g/m^2/day, it would take six to 15 days to reduce the dissolved oxygen to the critical threshold of 3 mg/L.

This estimate is conservative as it does not take into account the constant input of oxygen-saturated return water that would constantly displace the water adjacent to the seafloor near the diffuser. The discharge of return water up to 15 m into the water column would result in oxygenated seawater being entrained into the plume as it fell to the seafloor at a ratio of at least 1:43 and an induced flow rate of about 200 m^3/s. Rather than promoting stratification and oxygen depletion, the return water plume would tend to promote vertical mixing of the water column near the outfall. The initial dissolved oxygen content of the return water plume as it hit the seafloor would therefore be virtually the same as the ambient seawater (rather than the 30–40% less assumed in the model).

The longest period of minimal water movement recorded by a current meter deployed off Point Lowly during a severe dodge tide was 4.9 hours (see Section 17.7.2 and Table 17.4 of the Supplementary EIS), which is far less than the six to 15 days required to draw oxygen levels down to critical thresholds.

A simulation of the duration, severity and extent of oxygen depletion associated with return water discharge was undertaken using the three-dimensional ELCOM model coupled with the Computational Aquatic Ecosystem Dynamics Model (CAEDYM) (see Appendix H7.2 of the Supplementary EIS for details). CAEDYM models the oxygen dynamics of aquatic systems and provides continuous dissolved oxygen outputs throughout the water column. The 10-day simulation encompassed an extreme neap (dodge) tide, when the reduced tidal flows and turbulent mixing increase the likelihood of oxygen depletion occurring. Ambient oxygen content was conservatively set to 92% saturation (Johnson 1981), and SOD was assumed to be 0.921 g/m^2/day, which is slightly greater than the level used in the Draft EIS (0.82 g/m^2/day). In addition, wind speeds were set to zero to simulate worst-case conditions. Return water was assumed to be 100% saturated (at 75 g/L and 1ºC greater than ambient). Dissolved oxygen concentrations, without desalination (base case) and with the desalination plant operating (desalination case), were found to be virtually the same on the seafloor and at mid-depth during the normal tide component of the 10-day simulation (see Figure 17.26a and b).

During the neap (dodge) tide, however, oxygen stratification became evident, with the oxygen content of water near the seafloor being 1 mg/L less than the surface water (i.e. 6 mg/L compared with 7 mg/L) (see Figure 17.26 a and b). The oxygen stratification occurred equally in the base-case and desalination-case scenarios, indicating that it was a natural, rather than desalination-induced, phenomenon. Noticeable differences between the two scenarios were the occasional periods of elevated dissolved oxygen on the seafloor during the desalination-case scenario compared with the base-case scenario (see Figure 17.26 a, b and c). The probable reason is poorer dilution of the 100% saturated return water at times of little water movement.

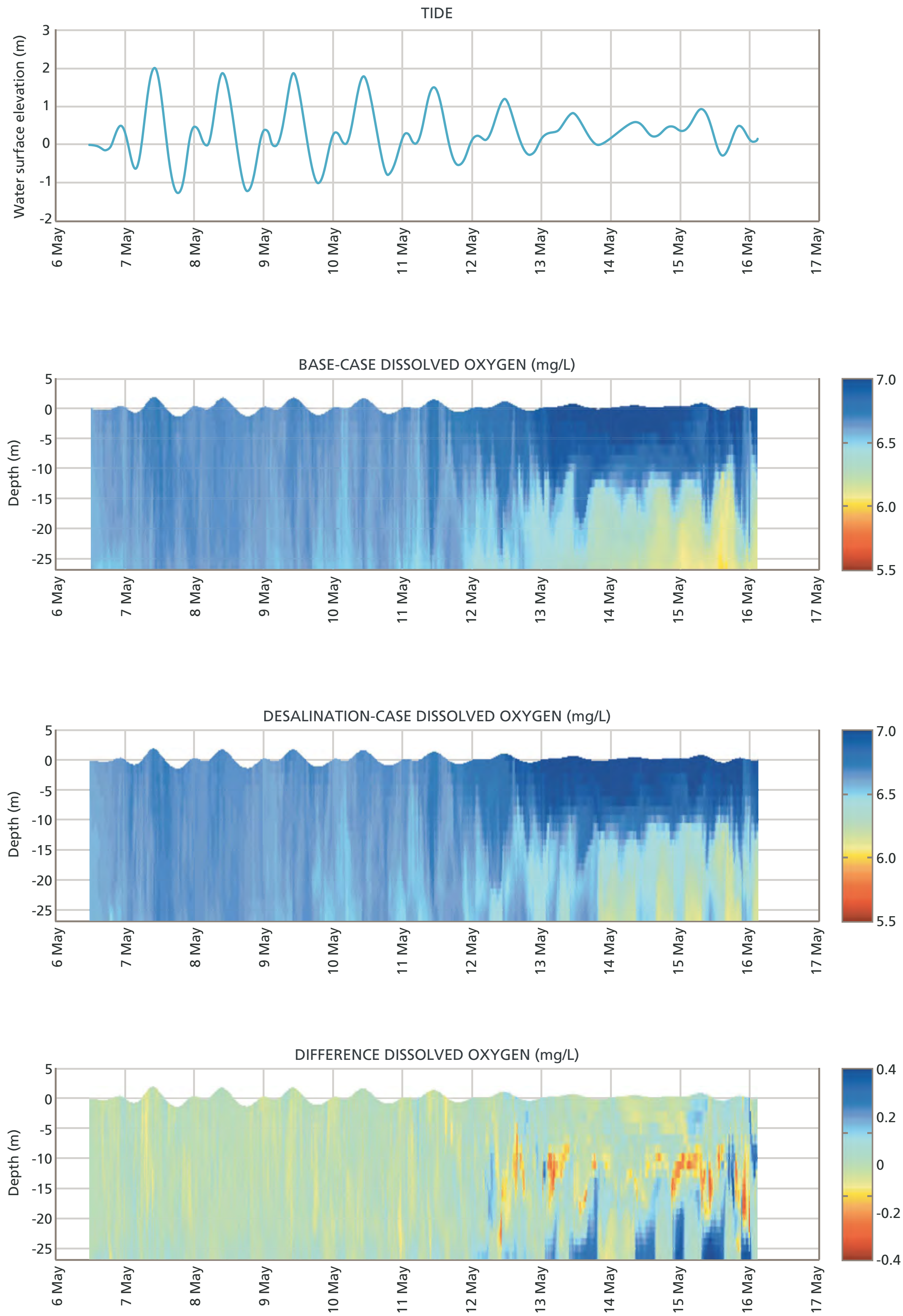


Figure 17.26a Profile of dissolved oxygen concentration at 100 m south-west of outfall

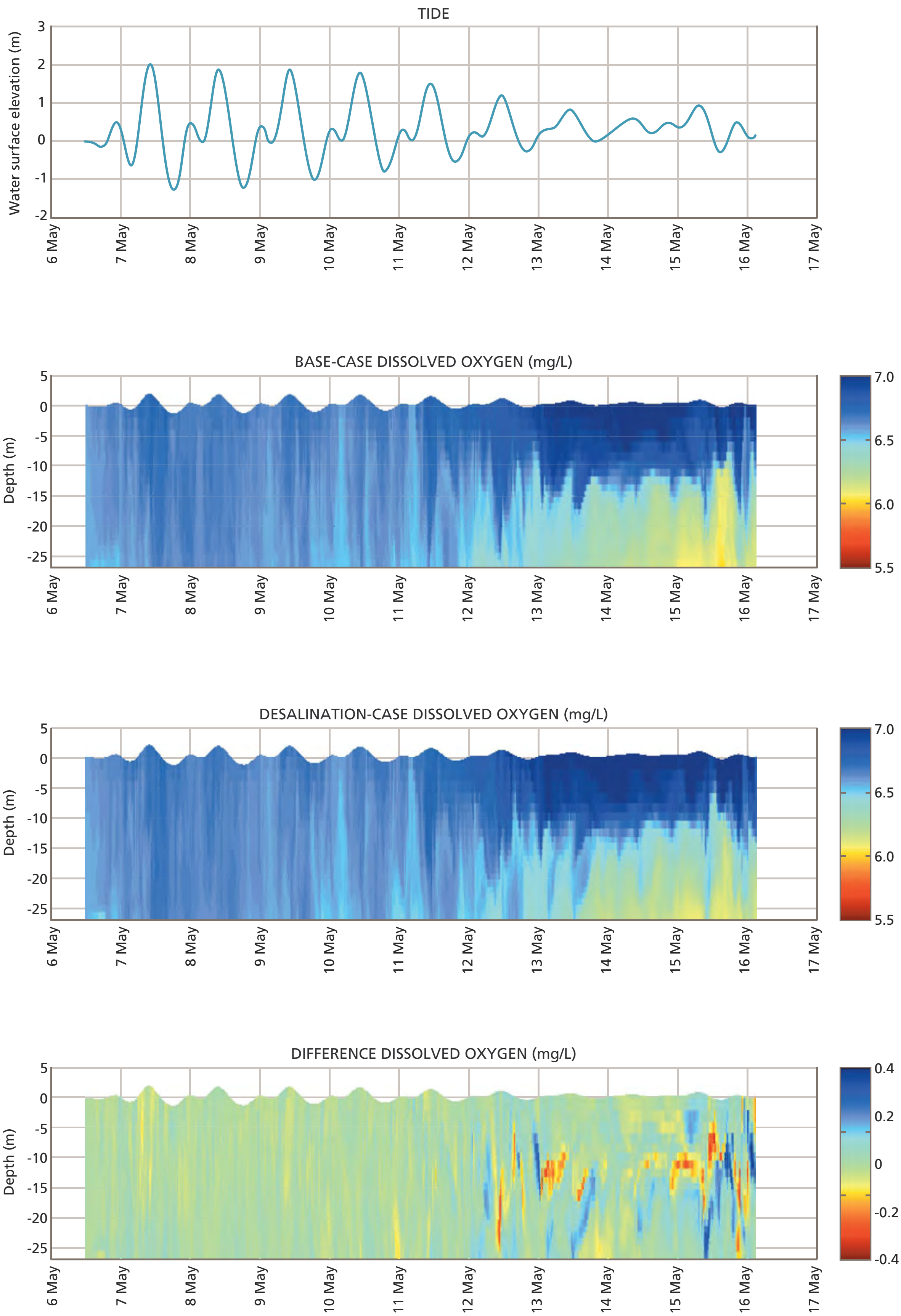
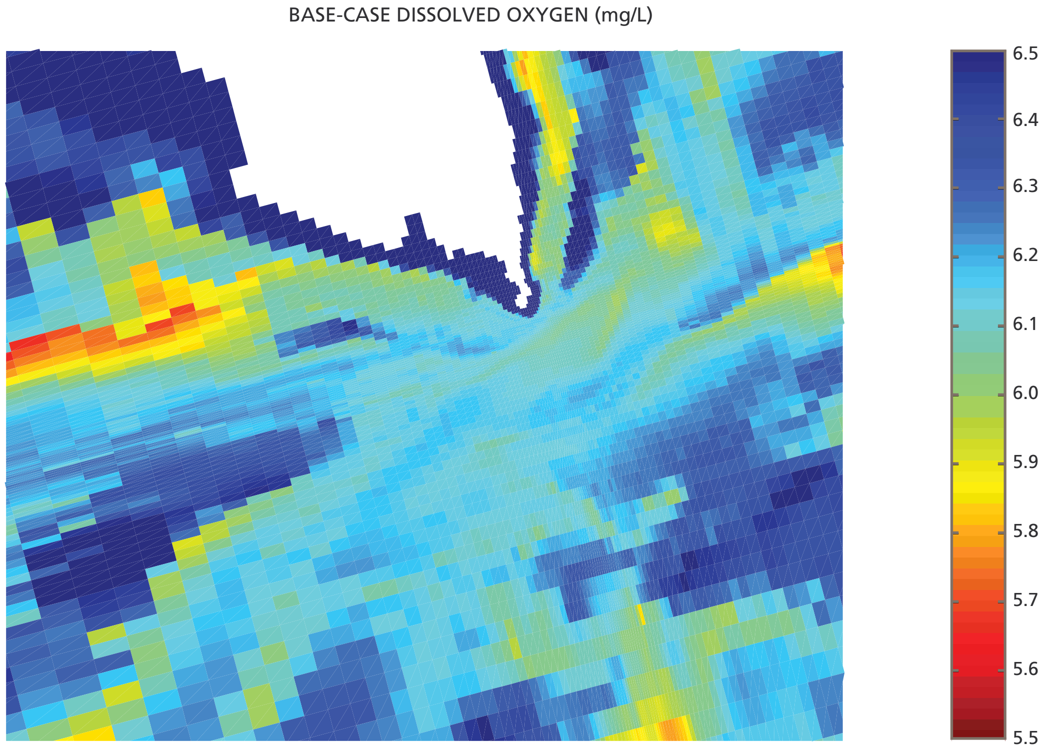


Figure 17.26b Profile of dissolved oxygen concentration at 500 m south-west of outfall



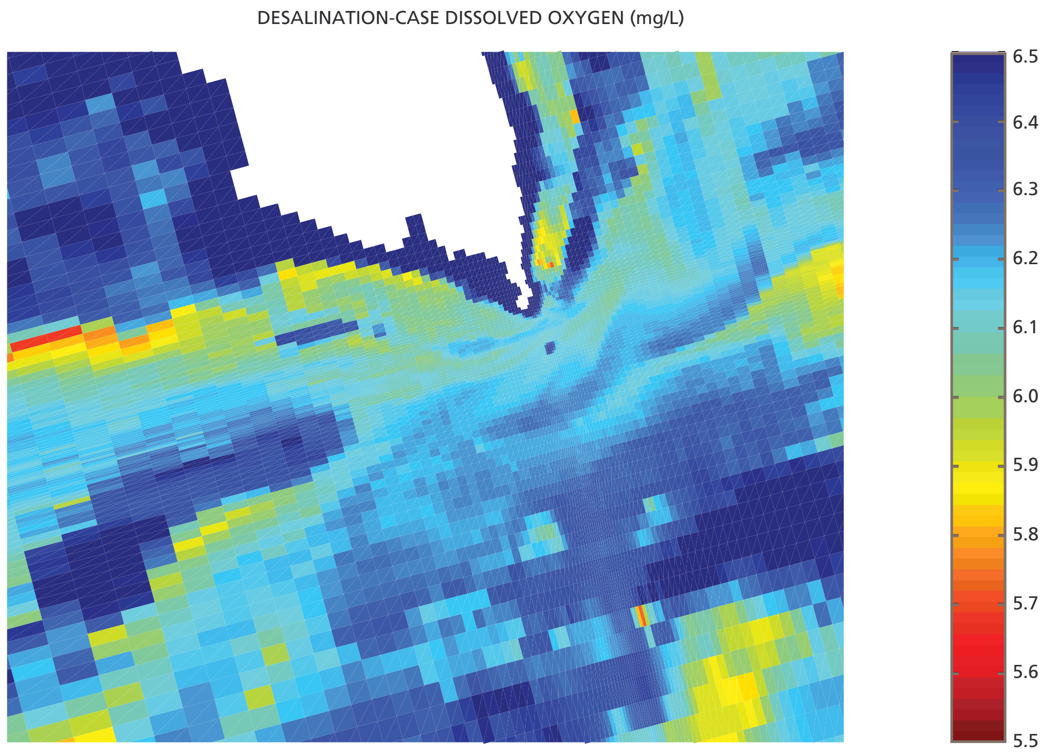


Figure 17.26c Bottom layer dissolved oxygen concentration at the end of the neap (dodge) tide period

The compounding effect of occasional zero dissolved oxygen in return water (about one hour each day) is expected to be minimal because initial mixing of return water upon discharge would result in virtually instantaneous mixing with well-oxygenated seawater from the mid-water column at a minimum dilution of 1:43, which would result in about a 2% reduction in the oxygen content of the entrained ambient seawater that fell to the seafloor. The 2% reduction in dissolved oxygen would be less than natural spatial and temporal variation, and would have no adverse ecological effects.

The simulations show that operating the desalination plant would not contribute to oxygen depletion adjacent to the seafloor off Point Lowly, even during extreme dodge tides.

Issue:

It was questioned whether the sequence of events concerning stratification and deoxygenation at the Cockburn Sound site of Perth's desalination plant would provide lessons applicable to Upper Spencer Gulf.

Submissions: 83 and 192

Response:

The low dissolved oxygen (DO) levels recorded for Cockburn Sound are informative for the proposed Spencer Gulf desalination plant, as DO was both measured and modelled in the deepwater basin in Cockburn Sound. Relative to Point Lowly, Cockburn Sound is a low-energy environment that occasionally has naturally low levels of DO in the deep channels. A combination of modelling and monitoring has enabled the relative contribution of the Cockburn Sound desalination plant and natural processes to dissolved oxygen levels to be clearly differentiated (Okely et al. 2007a, 2007b; Water Corporation and 360 Environmental 2008). The results show that periods of reduced DO were natural phenomena in Cockburn Sound, and the desalination plant's contribution is minimal. Consequently, the conditions concerning DO that were initially put in place by the regulatory authorities in Western Australia have been relaxed.

17.12.4 OXYGEN REQUIREMENTS OF MARINE ORGANISMS

Issue:

Several submissions requested further information on the oxygen requirements of marine organisms to substantiate the conclusions regarding effects on marine organisms. In particular, the physiological oxygen requirement of marine organisms has been questioned.

Submissions: 83, 171, 288 and 356

Response:

The critical oxygen threshold of 3 mg/L used in the Draft EIS, based on the recommendation of Diaz and Rosenberg (1995), is considered appropriate for seafloor (benthic) communities. The tolerance of marine organisms to oxygen depletion is both species- and life stage-dependent, with early life stages usually being more sensitive to reduced dissolved oxygen (DO) (Stiff et al. 1992).

A review of the literature on the effects of low DO on estuarine organisms led to the establishment of four class-limiting thresholds: no effects >8 mg/L; low-risk of effects >4 mg/L; possible effects >2 mg/L; and probable effects below 2 mg/L (Nixon et al. 1995). Alternatively, levels of 2 mg/L and 5 mg/L have been proposed for the protection of 50% and 95% of species, respectively (Stiff et al. 1992). The threshold level of 4.5 mg/L has been suggested for marine fish (Poxton and Allouse 1982), and 2 mg/L for benthic communities (Nixon et al. 1995). Since the community most at risk from oxygen depletion at Point Lowly is the benthic community, the 3 mg/L threshold used in the Draft EIS is considered to be both appropriate and conservative.

17.12.5 POTENTIAL ECOLOGICAL EFFECTS OF OXYGEN DEPLETION

Issue:

Several submissions requested further information on the critical oxygen thresholds for particular species and whether the effects of oxygen depletion could extend to the ecosystem level (biodiversity/food chain). The specific issues raised included the following:

- Could Upper Spencer Gulf marine communities be adversely affected?
- Could the combined effects of low dissolved oxygen and high salinity affect biodiversity?
- Could fisheries be adversely affected?
- Could juvenile life stages be adversely affected?
- Could important or particularly sensitive species (cuttlefish, snapper, abalone) be adversely affected?

Submissions: 83, 120, 122, 130, 138, 143, 160, 171, 184, 191, 194, 325 and 350

Response:

The operation of the desalination plant would have no adverse effects on marine communities at Point Lowly through oxygen depletion.

As described in Section 16.6.9 of the Draft EIS and in Section 17.12.3 (above), the durations of low water movement are insufficient to result in oxygen depletion to levels below the critical threshold for normal respiratory functioning of marine organisms.

A threshold dissolved oxygen (DO) level of 2–3 mg/L is recommended for benthic communities (Nixon et al. 1995, Diaz and Rosenberg 1995). As demonstrated in the Draft EIS (Section 16.6.9), it would take six to 15 days to reduce the DO level (in the bottom 2 m layer of water) to 3 mg/L (assuming the sediment oxygen demand is 0.33–0.82 g/m^2/day). The deployment of a current meter at the outfall for two months has shown that still (i.e. less than 0.1 m/s) conditions during dodge tides last for no more than 4.8 hours (see Section 17.7.2 and Table 17.4 of the Supplementary EIS). The duration of stratification events is therefore far too short for significant oxygen depletion to occur.

A threshold DO level of 5 mg/L is recommended for fish and species more susceptible to low DO (Poxton and Allouse 1982, Nixon et al. 1995). It would take four to eight days to reduce DO levels to 5 mg/L, which is far longer than the longest period of still, potentially stratified water during a dodge tide. It is also noted that during dodge tides mobile species such as fish would be able to avoid areas of lower water quality, such as the immediate vicinity of the diffuser (Birtwell and Kruzynski 1989).

A threshold DO level of 8 mg/L (i.e. ambient) is recommended for juvenile fish and nursery areas (Nixon et al. 1995). It is noted, however, that ambient DO levels in the Point Lowly region may only be 7 mg/L. The nearest nursery areas are the Point Lowly reef habitat for cuttlefish, and mangrove/seagrass habitats in False Bay and Fitzgerald Bay for juvenile fish and crustaceans. As discussed in Section 16.4.3 of the Draft EIS, the modelling results indicate that return water would have dispersed to background concentrations in the shallow nursery habitats and there would be no likelihood of stratification or oxygen depletion as a result of the desalination discharge.

Cuttlefish migrating to the Point Lowly breeding habitat would not be affected by oxygen depletion in the channels off Point Lowly, as the severity, duration and extent of lowered DO is unlikely to be measurable in the context of natural variability.

It is concluded that any ecological effects associated with occasional minor oxygen depletion in the vicinity of the outfall off Point Lowly would be unmeasurable.

17.12.6 ADDITIONAL STUDIES

Issue:

Additional information on the natural range of oxygen concentrations in relation to tidal flows in Upper Spencer Gulf was requested.

Submissions: 2 and 81

Response:

Section 16.3.2 of the Draft EIS provided two DO measurements in the vicinity of Point Lowly: 6–10 mg/L (Johnson 1981; B Gillanders, University of Adelaide, pers. comm., 3 Dec 2008) and 7.8–8.8 mg/L (P Lauer, PIRSA Aquaculture, pers. comm., 26 May 2008). A Sonde water-quality meter was deployed off the Port Bonython jetty from May 2007 to December 2009 (see Appendix H2.2 of the Supplementary EIS). DO measurements, however, were found to be inaccurate due to instrument drift, which illustrates the need for regular instrument calibration during future monitoring programs.

Modelling of the dissolved oxygen concentrations off Point Lowly over 10 days (including a dodge tide) has shown that the water is well mixed vertically (greater than 6.5 mg/L) outside the neap tide period. During the longest period of minimal tidal movement (approximately four days), some stratification occurs and DO reduces to approximately 6 mg/L at 10 m depth, compared with 7 mg/L at the surface (see Figures 17.26a and b).

Further studies for precise and accurate measurement would be directed to establishing baseline data for monitoring purposes.

Issue:

Further on-site work was requested to validate the model predictions regarding oxygen concentrations.

Submission: 2

Response:

Ongoing water quality monitoring (including dissolved oxygen) would occur for two years before the desalination plant was constructed and during construction to ensure an adequate baseline was established, and during operation of the plant to ensure water quality thresholds were not exceeded.

17.13 ENTRAINMENT

17.13.1 CHARACTERISATION OF ENTRAINED ORGANISMS

Issue:

Concern was expressed that eggs, larvae, hatchlings, microorganisms and nutrients would be entrained by the proposed desalination plant intake. Clarification was sought regarding their fate.

Submissions: 36, 79, 84, 88, 172, 188, 190, 211, 219, 271, 302 and 383

Response:

The susceptibility of different types of organisms to entrainment would vary significantly. The degree to which organisms would be entrained is discussed below. The effect of entrainment on adult populations and the broader ecosystem is discussed in Section 17.13.2 of the Supplementary EIS.

Microorganisms (phytoplankton and zooplankton), which have low or no motility (the ability to move spontaneously and actively), would be entrained into the desalination plant, in quantities directly proportional to the volume of water entrained.

The eggs of marine organisms would not necessarily be entrained. The eggs of many species do not occur in the water column; the Australian Giant Cuttlefish, for example, attach their eggs under rocky ledges, the Blue Swimmer Crab *Portunus armatus*[6] carry their eggs, and the Bluespot Goby *Pseudogobius olorum* and Southern Sea Garfish *Hyporhamphus melanochir* attach their eggs to the seafloor (Allen 1989; Noell and Ye 2008). Eggs of species such as the Australian Anchovy *Engraulis australis* and Grubfish *Parapercis* spp., which occur in the water column (Robertson 1975), would be entrained.

[6] Formerly *P. pelagicus*

The susceptibility of larvae to entrainment is related to their stage of development. Whereas immature larvae would be entrained, more mature larvae would be able to swim against the intake current. For example, Syngnathids are live bearers and their larvae are well developed when released from the brood pouch.

Entrainment of cuttlefish hatchlings is not expected to occur as cuttlefish are generally bottom-dwelling organisms (the intake would be positioned 2–5 m off the bottom), and they have some ability to swim against the intake current (see Section 17.13.4 of the Supplementary EIS for details).

In the context of submissions on entrainment, ‘nutrients’ appears to refer to the ‘food’ provided by microorganisms. The impact of the desalination process on marine food chains is discussed in Section 17.13.2.

Entrained organisms would be retained and disposed of on land rather than being discharged to Spencer Gulf.

Issue:

It was suggested that plankton surveys are required to characterise the organisms that would be entrained, and that such surveys should extend over an annual cycle and several control areas. It was also suggested the study should be based on organisms entrained into the pilot plant.

Submissions: 2, 36 and 80

Response:

As discussed in Section 16.6.10 of the Draft EIS, field studies were initiated to determine the seasonal diversity and abundance of fish and crustacean larvae off Point Lowly. These surveys did not use the pilot plant intake, located on the Port Bonython jetty, because:

- initial investigations showed that larvae are damaged by the impeller in the intake pump, preventing reliable identification
- the location of the proposed intake structure is in Fitzgerald Bay rather than near Port Bonython
- a different methodology would have been required at comparison sites.

Larvae were sampled by towing nets by boat through the water column at the location of the proposed intake structure and a number of other locations, as shown in Figure 17.27 of the Supplementary EIS. The surveys, completed for the Supplementary EIS, covered an annual (seasonal) cycle from spring 2008 to winter 2009. With respect to the larval communities that occur in the vicinity of Point Lowly, the seasonal surveys established the following (see Appendix H10.1 of the Supplementary EIS for details):

- there was a strong seasonal pattern of abundance, with concentrations in summer being an order of magnitude higher than in spring and two orders of magnitude higher than in autumn and winter
- the dominant taxa were (in approximate percentages) the Australian Anchovy *Engraulis australis* (70%), Bluespot Goby *Pseudogobius olorum* (20%), Grubfish *Parapercis* spp. (3%) and Western Striped Trumpeter *Pelates octolineatus* (3%)
- Anchovy eggs were observed in almost every sample
- there were very few larvae of six fish taxa, other than Anchovy, of recreational and/or commercial importance (Yellowfin Whiting *Sillago schomburgkii*, Mackerel *Trachurus* sp., Skipjack Trevally *Pseudocaranx wrighti*, Southern Sea Garfish *Hyporhamphus melanochir*, Flathead *Platycephalus* sp. and Large-tooth Flounder *Pseudorhombus arsius*)
- concentrations of Western King Prawn *Melicertus latisulcatus* larvae were influenced by tide, with the highest concentrations recorded during flood tides
- very few larvae of a number of Syngnathids, which are protected under state and national legislation, were recorded. These were the Spotted Pipefish *Stigmatopora argus*, the seahorse *Hippocampus* sp., the pipefish *Campichthys* sp. and the Tiger Pipefish *Filicampus tigris*
- the larval fish assemblage was typical of protected bays and estuaries with seagrass beds and sandy/rocky bottoms
- the number of families and fish taxa recorded was low compared to similar coastal ecosystems.

The spatial patterns in the composition and abundance of larval communities around Point Lowly and Fitzgerald Bay are discussed in Section 17.13.2 and Appendix H10.1 of the Supplementary EIS.

It was not considered necessary to characterise the phytoplankton and zooplankton communities for the purpose of impact assessment (as explained in Section 17.13.6). Entrained organisms would be monitored during the first 12 months of the desalination plant’s operations by sampling the intake stream.

Figure 17.27 Locations of larval surveys

17.13.2 POTENTIAL ECOLOGICAL EFFECTS

Issue:

Concern was expressed about the ongoing effects of entrainment on breeding cycles (as breeding occurs throughout the year).

Submissions: 2, 36, 79, 88, 171, 188, 190 and 383

Response:

Eggs and immature larvae are the only life stages in breeding cycles that are likely to be entrained by the proposed desalination intake because adults, juveniles and more mature larvae would be able to swim against the relatively low intake speed of less than 0.2 m/s (through the bars) and avoid entrainment (refer Section 16.6.10 of the Draft EIS).

The impact of entrainment on the ecology of Upper Spencer Gulf was assessed in Section 16.6.10 of the Draft EIS and categorised as being negligible (reflecting no measurable impact). The assessment was based on:

- entrainment associated with the much larger volumes of cooling water intake for power stations having no proven adverse effects on breeding cycles
- the annual volume of intake water being only 0.04% and 2% of the volume of Spencer Gulf and Upper Spencer Gulf, respectively
- comparisons between the number of prawn larvae that may be lost through entrainment and larval losses associated with removal of spawning adults from the commercial fishery, which estimated that the loss of larvae through entrainment would equate to 0.24% of the loss associated with the commercial catch.

Further work undertaken for the Supplementary EIS supports the above assessment. A more resolved estimate of the source water for entrainment has been undertaken using particle tracking modelling, which takes into account natural tides and currents, the position of the intake in the water column, and aspects of the natural history of larvae (see Appendix H7.2 of the Supplementary EIS). Particles representing plankton were introduced into the model evenly across an area of Spencer Gulf north of Port Broughton at regular intervals during a simulation that ran for 120 days over summer, when larval populations are at their peak (see Appendix H10.1 of the Supplementary EIS). The particles expired after 30 days, which is at the upper end of typical larval durations (see Appendix H10.2 of the Supplementary EIS).

Based on volumetric proportions alone, it would be expected that 0.07% of these particles would be entrained (see Appendix H7.2 of the Supplementary EIS). Integrated counts of particles from the model simulations showed, however, that larvae would not remain evenly distributed throughout Upper Spencer Gulf, but would concentrate towards the north-west of Upper Spencer Gulf and, locally, in the northern part of Fitzgerald Bay, with the intake in an area of relatively low density (see Figure 17.28 of the Supplementary EIS). These patterns were consistent with the findings of field surveys (see Appendix H10.1 of the Supplementary EIS; Bruce and Short 1992).

Although the simulations showed a gradient of decreasing larval concentrations with distance offshore near the intake (see Appendix H7.2 of the Supplementary EIS), field studies showed that there would be no decrease in larval concentration within at least 500 m offshore from the proposed intake (see Appendix H10.1 of the Supplementary EIS).

The model predicted an overall 0.05% reduction in larvae due to entrainment, with larvae being drawn from an area extending 30 km north of Point Lowly and to the eastern side of the gulf. A maximum local reduction of 1.5% was predicted for larvae originating closer to Point Lowly (see Appendix H7.2 and Figure 17.29a of the Supplementary EIS). The maximum local reduction is consistent with the results of modelling undertaken for the Victorian Desalination Plant (DSE 2008).

Modelling of larvae spawned by more localised breeding populations (e.g. inhabitants of the inshore reef shown in Figure 17.27 of the Supplementary EIS) showed an overall reduction of less than 1%, with local reductions (near the intake) of <5% (see Appendix H7.2 and Figure 17.29b of the Supplementary EIS).

It is also noted that reductions in larvae do not generally translate into an equivalent reduction in the adult population because of the high spatial and temporal variability of larval populations and the episodic nature of successful replenishment events, the large size of larvae populations relative to adult populations, and the fact that few larvae naturally survive to adulthood (CEE Consultants 2008; Steinbeck et al. 2007).

The daily mortality of larvae ranges among species from 1–50% and commonly exceeds 10% (Houde and Bartsch 2009; Houde 2002; Houde 1989). Based on the water volume entrained, the daily mortality of larvae in Upper Spencer Gulf, arising from the desalination plant intake, would be 0.005%. The increase in mortality arising from the desalination plant would therefore be 500 to 25,000 times less than naturally occurring mortality in Upper Spencer Gulf.

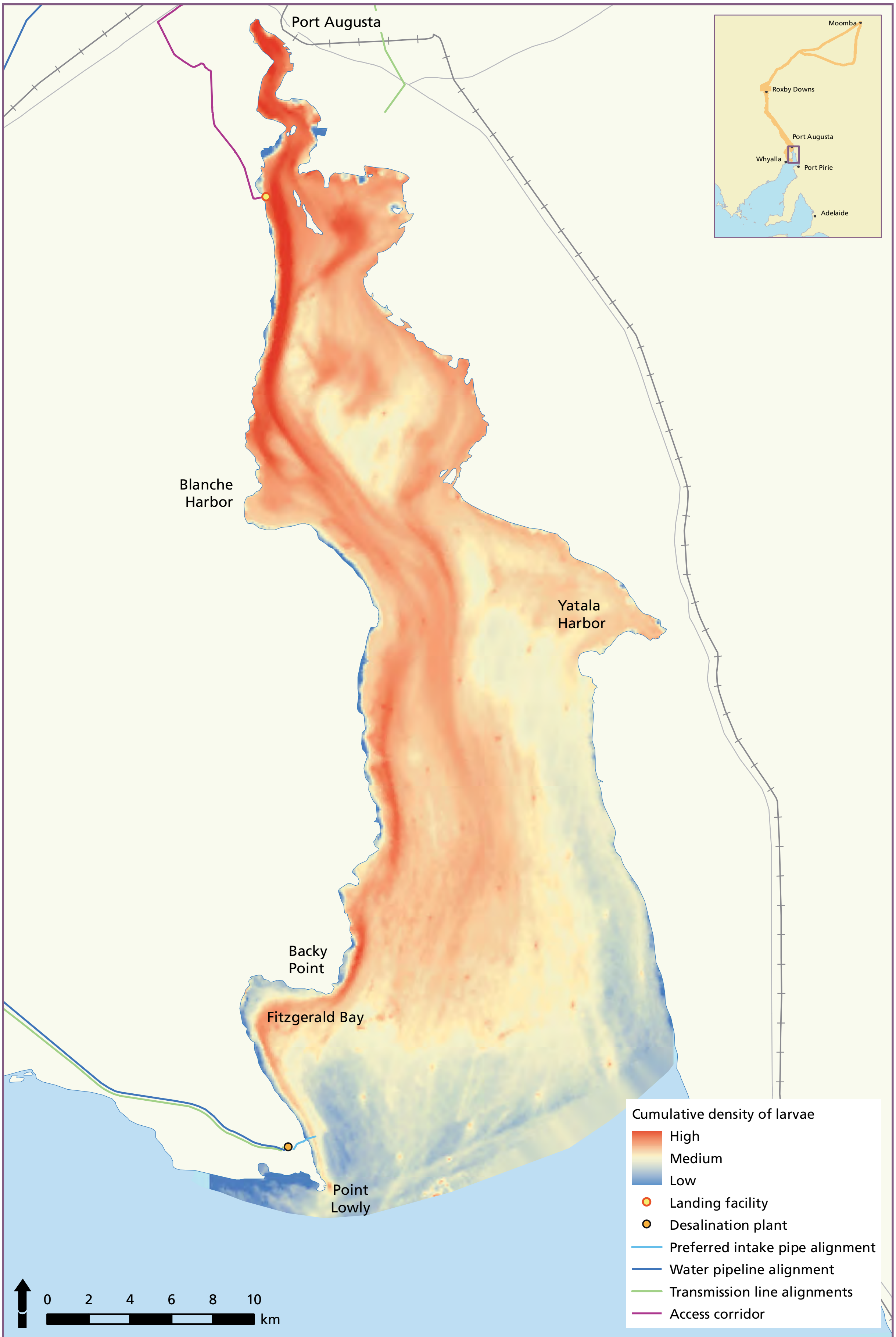


Figure 17.28 Cumulative density of larvae in Upper Spencer Gulf over a 120 day simulation

Larvae spawned regionally

Larvae spawned in Point Lowly reef habitat

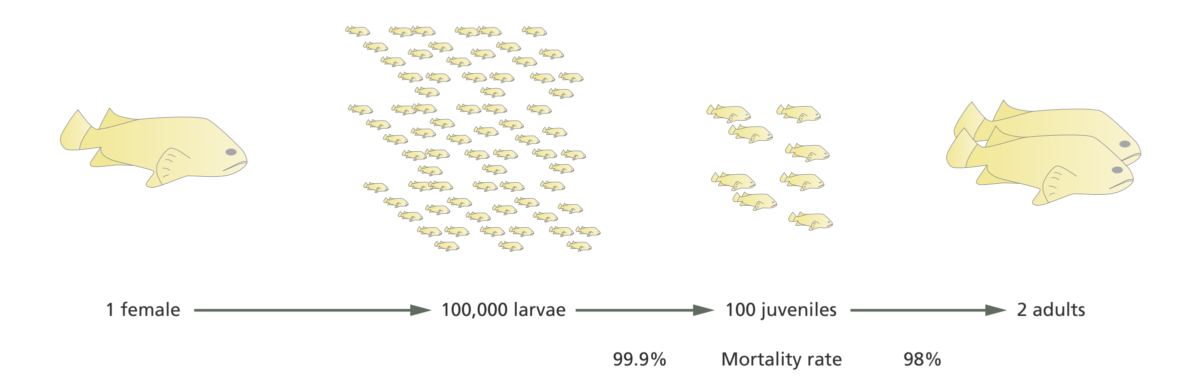
Figure 17.29 Percentage of larvae entrained after regular release from specific locations in Upper Spencer Gulf during a 120-day simulation

The high natural mortality rate of larvae results in only 0.0001–1% becoming adults (i.e. cumulative mortality is 99–99.9999%), which is sufficient to sustain adult populations (DSE 2008, CEE Consultants 2008, Raimondi 2008) (see Figure 17.30 of the Supplementary EIS). Assuming 2% of the larvae in Upper Spencer Gulf are entrained (see above), it is estimated that about one in 5,000–50,000,000 adult fish or crustaceans (depending on species) in Upper Spencer Gulf may be lost each year as a result of entrainment into the desalination plant.

This discussion also applies to egg losses, given that there is additional (and generally higher) mortality between the egg and larval stages (Houde and Bartsch 2009; Houde 2002).

Further consideration of the impact of entrainment on breeding cycles is provided by the site-specific assessment (see Appendix H10.2 of the Supplementary EIS), which was informed by seasonal larval surveys (see Appendix H10.1 of the Supplementary EIS). This assessment confirmed that there is no credible threat to adult fish and crustacean populations arising from entrainment of larvae into the desalination plant.

To conclude, while the proposed intake structure would entrain eggs and larvae, the effect on natural populations in Upper Spencer Gulf would be so minor as to be immeasurable.



Source: Raimondi 2008

Figure 17.30 Typical recruitment of larvae to adult populations

Issue:

Concern was expressed that the intake is in a shallow fish nursery.

Submissions: 79, 84, 190 and 383

Response:

Field data collected for the Supplementary EIS demonstrates that the intake structure is located away from the shallow fish nursery areas in Upper Spencer Gulf.

On a regional scale, higher larval fish concentrations have been recorded in the northern part of the gulf (near Red Cliff Point) relative to the rest of the gulf (Bruce and Short 1992).

Bryars (2003) identified Fitzgerald Bay as an important area for a range of juvenile species and the eggs and larvae of several fish and invertebrate species. Surveys of fish larvae during 2008–2009 showed that the highest abundance of larvae was found in the northern section of Fitzgerald Bay (see Site 2 in Figure 17.31 of the Supplementary EIS), which supports a dense seagrass community (*Posidonia* sp.) at a depth of 8 m (see Figure 17.27 of the Supplementary EIS).

In contrast, the proposed intake is situated in a 13–14 m-deep channel in sand/silt habitat, away from inshore reef and seagrass (see Figure 17.32 of the Supplementary EIS). When larval abundances are at their highest (i.e. in summer, at night), the abundance of larvae at the intake site (Site 1) was significantly less than at Site 2, and comparable with Sites 3 and 4 further to the south off Point Lowly (see Figure 17.31 of the Supplementary EIS).

Modelling of larval dispersion in Upper Spencer Gulf also confirmed that the intake area has a lower density of larvae relative to other areas both locally (in Fitzgerald Bay) and regionally (see Figure 17.28 of the Supplementary EIS).

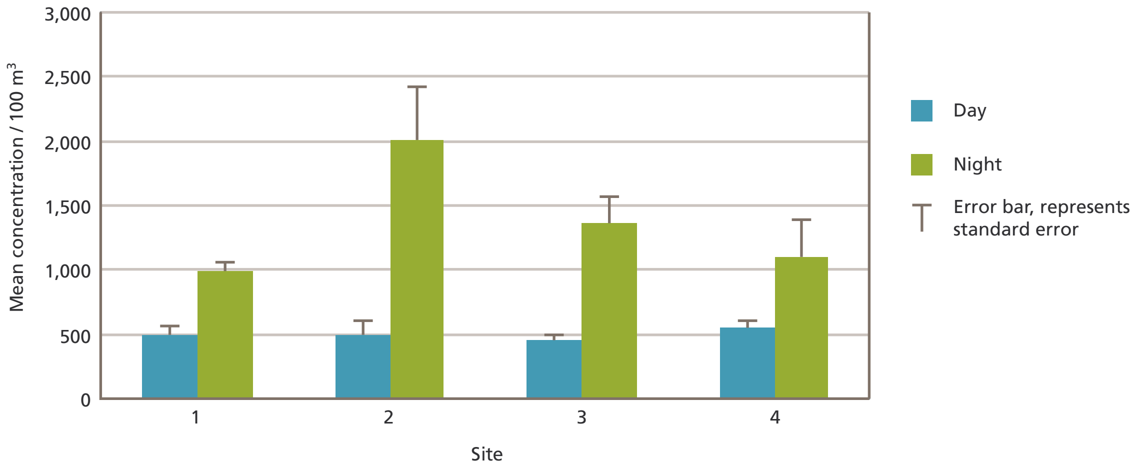


Figure 17.31 Mean concentrations of all larval fishes combined from summer plankton samples

Issue:

Concern was expressed about the effects of entrainment on food chains.

Submissions: 36, 79, 84, 86, 88, 193 and 271

Response:

The effects of entrainment from desalination plants on phytoplankton and zooplankton communities are not a significant issue due to the large abundances, wide distribution and short generation times of these communities (Steinbeck et al. 2007; CEE Consultants 2008). It is expected that plankton lost to entrainment would be replaced within days to weeks (CEE Consultants 2008).

Modelling of plankton dispersion (including larvae and eggs) for periods of up to 120 days predicted that overall reductions due to the desalination plant would be 0.05% for plankton originating from an area of Spencer Gulf north of Port Broughton, with a maximum localised reduction of 1.5% near the desalination plant intake (see Figure 17.29a and Appendix H7.2 of the Supplementary EIS). Such reductions in plankton abundance are neither likely to affect planktonic recruitment processes, nor be measurable (CEE Consultants 2008).

As discussed in Section 17.13.1 of the Supplementary EIS, only phytoplankton, zooplankton, eggs and larvae are likely to be entrained. As there would be negligible impact on these organisms, which are near the base of the food chain, there would also be a negligible impact on the food chain.

Issue:

Concern was expressed that planktonic stages of rare and restricted-range species in the vicinity of the intake (e.g. from the sponge community) may be lost through entrainment.

Submission: 80

Response:

A range of assessment tools has been used to demonstrate that entrainment would not affect rare and restricted-range species in the vicinity of the intake.

None of the species listed as threatened or rare under national or South Australian legislation (refer Section 16.3.5 of the Draft EIS) has life stages at risk of entrainment into the desalination plant (they include mammals, reptiles, a shark and a seagrass). A number of other non-listed species identified in the Draft EIS as being endemic to Upper Spencer Gulf or Spencer Gulf, or uncommon (refer Appendix O2 of the Draft EIS), are nevertheless known from a number of locations in Upper Spencer Gulf (see Section 17.9.1 of the Supplementary EIS) and would therefore be unlikely to be affected across their distribution.

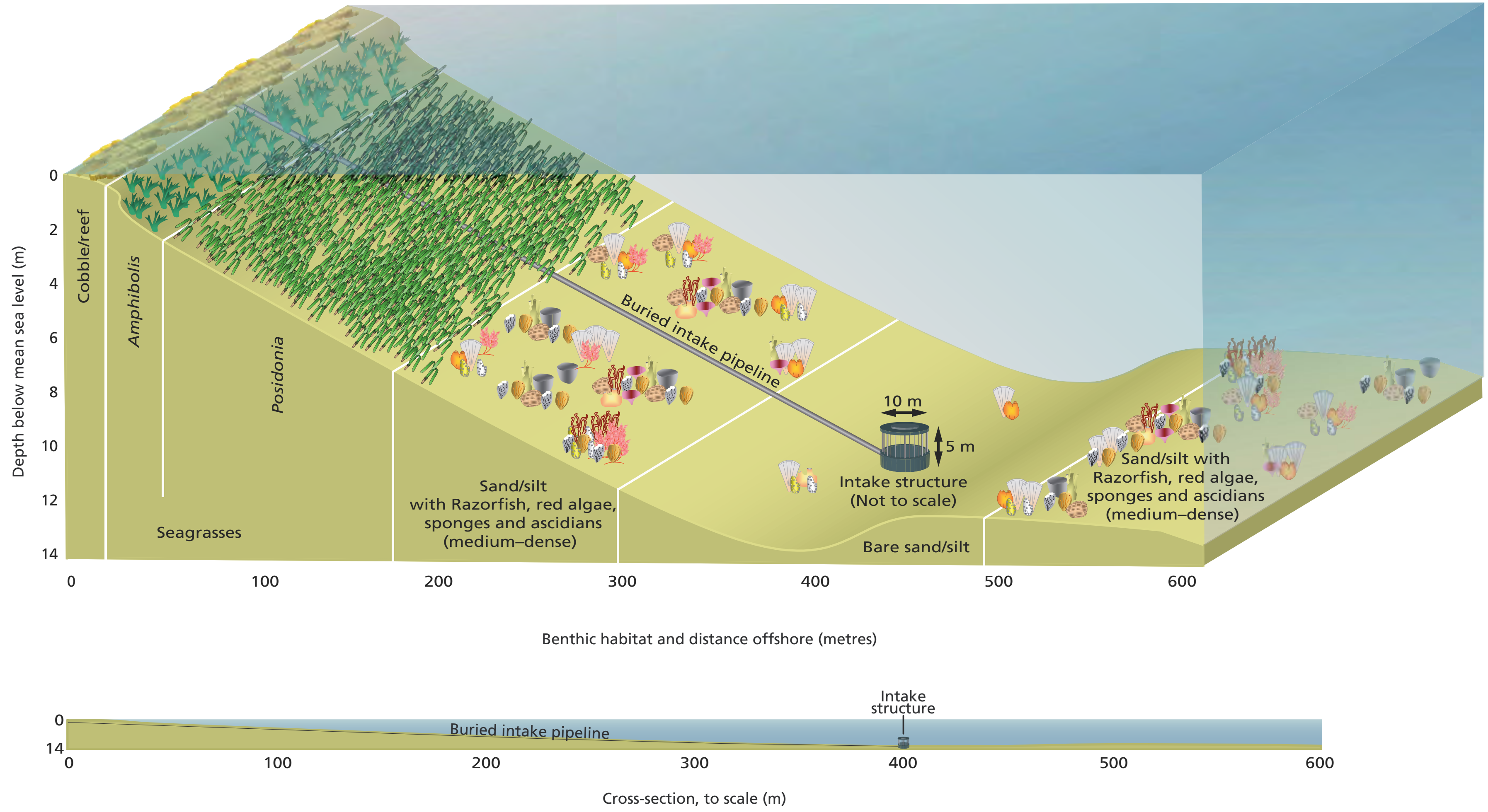


Figure 17.32 Schematic cross-section showing benthic habitats in the vicinity of the proposed intake pipe

Further evidence that rare and restricted-range fish species are unlikely to be entrained was provided by the seasonal fish larval surveys undertaken in 2008–2009 (see Section 17.13.1). The composition of the larval fish assemblage was considered typical of protected bays and estuaries elsewhere in temperate Australia with seagrass beds and sandy/rocky bottoms (see Appendix H10.1).

Acknowledging that there may be marine species with poorly understood distributions, a surrogacy approach, whereby habitat types are used as a proxy for the distribution of species, has been widely applied in conservation management and planning (Rodrigues and Brooks 2007). As such, rare and restricted-range species in Upper Spencer Gulf are likely to be associated with regionally uncommon habitat types such as the narrow band of coastal reef to the west and north of Point Lowly, and the deep-water sponge community near Point Lowly.

Modelling of larval dispersion from the reef and sponge habitats was undertaken over a period of 30 to 90 days, which would generally exceed the short larval periods of invertebrates such as bryozoans, sponges and ascidians that inhabit reef and sponge communities – generally from hours and days to weeks (CEE Consultants 2008). The model predicted that less than 1% and 0.2% of such larvae would be entrained in the desalination plant intake, respectively for reef and sponge communities (see Appendix H7.2 of the Supplementary EIS). Considering the low proportion of larvae entrained and the high natural mortality (as for previous responses in this section), the effect of larval entrainment on the populations restricted to these habitats would be negligible.

Issue:

Concern was expressed that there are already entrainment losses from the Port Augusta power stations.

Submission: 84

Response:

It is correct that there are entrainment losses from the Northern and Playford power stations at Port Augusta and that there would be additional losses from the proposed desalination plant. However, as noted in a response above and detailed in Section 16.6.10 of the Draft EIS, the operation of the Northern and Playford power stations has had no measurable effect on the ecosystems of Upper Spencer Gulf and the intake from the proposed desalination plant would contribute very little to an already immeasurable effect.

As discussed in Table 16.17 and Section 16.6.10 of the Draft EIS, the Northern and Playford power stations have combined cooling water intakes of 2,329 ML/d, which is approximately four times the average annual intake for the desalination plant. The power stations' level of intake represents approximately 7% of water in Upper Spencer Gulf, and the desalination plant intake would represent less than 2% of water in Upper Spencer Gulf, on an annual basis. The relative increase in the number of larvae entrained due to the proposed desalination plant, however, is likely to be less than that suggested by the volumetric comparisons alone (which assume the even distribution of larvae throughout the source water), because:

- higher larval fish concentrations have been recorded in the northern part of Spencer Gulf (near Red Cliff Point) relative to the rest of the gulf (Bruce and Short 1992)
- larval fish concentrations at the intake location are less than at other sites around Point Lowly/Fitzgerald Bay (see Figure 17.31)
- the design and mid-water position of the proposed desalination plant intake may result in less larvae being entrained than in the power station inlets, which extract water from near the seafloor (Kinhill 1982).

Particle modelling has confirmed this prediction, finding that entrainment into the proposed desalination plant would be 18% of entrainment into the power station intakes. The proportion of larvae entrained was less than that predicted by volumetric analysis at Point Lowly (0.05% compared with 0.07%), and greater at Port Augusta (0.28% compared with 0.25%) (see Appendix H7.2 of the Supplementary EIS).

Although the proposed desalination plant would marginally increase the overall number of larvae removed from Upper Spencer Gulf, the cumulative impact on adult populations (and any associated fisheries) would be negligible, due to the large number of larvae relative to adults, and the low percentage of larvae that naturally survive to adulthood (see Section 17.13.2 of the Supplementary EIS).

17.13.3 POTENTIAL EFFECTS ON FISHERIES

Issue:

Concern was expressed about the ecological and economic effects of egg/larvae loss on statewide commercial and recreational fisheries.

Submissions: 2, 171 and 188

Response:

A detailed assessment of the impact of entrainment on species of importance to recreational and commercial fisheries has been provided in Appendix H10.2 of the Supplementary EIS. Based on field studies, most species were considered unlikely to have high numbers of larvae entrained, and the exceptions have distributions or life history characteristics that naturally mitigate the effect of such entrainment.

The species of significance to fisheries considered to possibly have a high abundance of larvae entrained by the proposed desalination plant were the Australian Anchovy *Engraulis australis*, Western King Prawn *Melicertus latisulcatus*, and Blue Swimmer Crab *Portunus armatus*[7]. It is considered, however, that entrainment would have no measurable impact on the adult populations of these species, or the associated fisheries.

Anchovy spawn throughout shelf, bay and gulf waters in southern Australia (Dimmlich et al. 2004). The highest densities occur in Spencer Gulf and Gulf St Vincent, with Spencer Gulf (north of Wallaroo) and Gulf St Vincent providing critical habitat. As the overall area of spawning and critical habitat is relatively large, the effect of entrainment on the Australian Anchovy would be negligible. Modelling has shown that only 0.05% of the larvae originating from an area north of Port Broughton would be entrained (see Appendix H7.2 of the Supplementary EIS).

To provide context to the negligible impact of likely entrainment to the Western King Prawn, an approach that considers the natural mortality of larvae and the proportion recruiting to the adult population can be applied. Carrick (2003) estimated a natural mortality of 5% per week in Spencer Gulf nurseries during winter (a cumulative mortality of 70% over a six-month period). There is also evidence of density-dependent mortality in nursery grounds (Kangas 1999), reinforcing that not all larvae are required to populate nursery grounds.

Western King Prawn larvae are broadly distributed in Spencer Gulf, with the densities increasing with distance north. Based on volumetric proportions, the desalination plant would remove approximately 0.03% of prawn larvae from Upper Spencer Gulf per week during the previous summer/autumn spawning period. Assuming (from the cumulative mortality above) that 30% of prawn larvae survive to become adults, and that approximately 0.2% are entrained during their larval duration of 40 days, then approximately one in 1,500 prawns in Upper Spencer Gulf may be lost to the adult population as a result of entrainment. This confirms that the effect of entrainment on adult Western King Prawn populations would be negligible.

The broad-scale distribution of Blue Swimmer Crab larvae in South Australia is largely unknown (Svane and Bryars 2005). The distribution of juveniles in Spencer Gulf appears skewed towards the eastern coastline and in particular to between Port Pirie and Port Broughton (McDonald et al. 2005). Larval mortality has been estimated as 98% to >99% (Ingles and Braum 1989; Bryars 1997), and the larval duration up to 45 days (Bryars 1997). The desalination plant would remove approximately 0.21% of Blue Swimmer Crab larvae from Upper Spencer Gulf over 45 days. Assuming that 2% of crab larvae survive to become adults, and that 0.2% are entrained during their 45-day larval duration, approximately one in 25,000 Blue Swimmer Crabs in Upper Spencer Gulf may be lost to the adult population as a result of entrainment. As such, the effect of entrainment on Blue Swimmer Crab populations would be negligible.

The negligible effect of entrainment on adult populations of the above species suggests that an impact on related fisheries would also be negligible.

[7] Formerly *P. pelagicus*

Issue:

Concern was expressed that larval entrainment would breach undersize fish regulations under fisheries legislation.

Submission: 84

Response:

If the entrainment of organisms constitutes the take of undersize fish under the *Fisheries Management Act 2007*, then BHP Billiton would seek, or seek to rely on, available exemptions under that Act.

17.13.4 POTENTIAL EFFECTS ON CUTTLEFISH

Issue:

It was suggested that no evidence was presented in the Draft EIS to support the statement that hatchlings were able to avoid entrainment (e.g. the swimming speed of hatchings was not given). It was maintained that the slow swimming speeds of hatchlings of around 2 cm/s (extrapolated from adult swimming speeds of 1.2 body lengths per second) may result in hatchlings being unable to avoid entrainment.

Submissions: 2 and 86

Response:

Entrainment of cuttlefish hatchlings is expected to be negligible for several reasons.

The density of hatchlings in the vicinity of the intake would be low. The reef habitat near the intake supports less than 4% of the breeding population in the Point Lowly/Fitzgerald Bay region (and generally <0.5% over the past decade) (see Appendix H9.3 of the Supplementary EIS). Furthermore, the intake is located in soft-bottom habitat, 250 m from the nearest cuttlefish breeding habitat.

The location of the intake 2–5 m above the seafloor would also reduce the likelihood of entrainment as cuttlefish hatchlings tend to shelter and feed on the seafloor.

It is correct that no data on the swimming speed of cuttlefish hatchlings was provided in the Draft EIS. In the submission the swimming speed of hatchlings was extrapolated from the swimming speed of adults (1.2 body lengths per second) and reported to be 0.02 m/s, which is considered to be conservative. The intake would be designed to have a maximum intake speed of 0.2 m/s through the bars, which would rapidly attenuate to about 0.01–0.02 m/s within metres of the structure (SA Water 2008; GHD Fichtner 2005). In the event of a cuttlefish hatchling passing within metres of the intake, the risk of entrainment would therefore be minimal as hatchlings would probably be capable of swimming away from the intake.

Entrained organisms would be monitored during the first 12 months of the desalination plant operating by sampling the intake stream.

17.13.5 CONCERNS REGARDING IMPACT ASSESSMENT AND MITIGATION

Issue:

It was suggested that results from Sydney and California noted in the Draft EIS with regard to entrainment have no relevance to Upper Spencer Gulf.

Submission: 84

Response:

Examples from existing seawater intake operations can provide important insight into potential ecological issues associated with entrainment. The overall composition of the larval fish assemblage identified at Point Lowly is typical of enclosed marine bays/ estuarine systems across temperate Australia (see Appendix H10.1 of the Supplementary EIS). Therefore, the conclusion that the larger Sydney desalination plant would have little effect on planktonic larval populations at a regional scale (TEL 2005) is considered to be relevant to potential entrainment effects in Spencer Gulf.

Similarly, the greater abundance of zooplankton in the more nutrient-rich waters of California suggests that entrainment loss may potentially be an unacceptable ecological risk in California, which is not reported to be the case. The comparison suggests that entrainment is even less likely to be an ecological issue in Upper Spencer Gulf, given the nutrient-poor waters of southern Australia (Edyvane 1999).

Issue:

It was suggested that specific, robust evidence (via a risk approach) is required to support claims of negligible impact from entrainment.

Submissions: 2, 36, 80 and 84

Response:

An assessment of the likelihood and consequences of significant larval entrainment in Upper Spencer Gulf has been undertaken for species that:

- have abundant larval populations near Point Lowly
- are important for local recreational and commercial fisheries
- are listed as protected or threatened species.

Details of this assessment are provided in Appendix H10.2 of the Supplementary EIS. The assessment has concluded that entrainment does not present a credible threat to populations in Upper Spencer Gulf.

Issue:

Concern was expressed that entrainment was not addressed by the slow intake speed.

Submissions: 36 and 302

Response:

The Draft EIS does not state that the slow velocity of water into the intake structure fully addresses entrainment. Rather, considerable effort was made in the Draft EIS to qualify the likely impacts of entrainment and to provide context to this impact.

The slow intake speed of 0.2 m/s (through the bars) would enable virtually all mobile biota, including the older larvae of many species, to swim away from the intake. The intake current would be an order of magnitude less than 0.2 m/s, a few metres away from the intake (SA Water 2008; GHD Fichtner 2005).

Only early, non-motile life stages of larvae would be entrained.

Leis (2006) reviewed the literature on the critical swimming speeds of larvae (i.e. that allow them to maintain position against a flow for several minutes). Although the swimming speeds were age-dependent, the upper range for seven of the eight families exceeded the proposed intake speed of 0.2 m/s (the other having an upper speed of 0.16 m/s). The conclusion is that the slow intake speed would reduce the intake of larvae.

Issue:

Clarification was sought about mitigation measures planned to minimise entrainment of eggs/larvae.

Submission: 124

Response:

The entrainment of eggs and larvae into the desalination plant has been minimised by:

- the location of the desalination plant
- the location of the intake structure
- the position of the intake structure in the water column
- the design of the intake structure.

On a regional scale, the location of the desalination plant avoids the northern reaches of Spencer Gulf where Bruce and Short (1992) found the highest concentrations of fish larvae.

Locally, the proposed intake avoids a larval sink in northern Fitzgerald Bay (see Appendix H10.1 of the Supplementary EIS for details).

Consistent with practices that have generally been recommended and adopted for other desalination plants (Lattemann and Hoepner 2008; SA Water 2008; CEE Consultants 2008), the proposed location of the intake is offshore from the coastal fringing reef and seagrass habitats, over sand/silt sediment supporting a relatively low diversity of species. The offshore location also avoids higher concentrations of plankton that can occur close to shore (CEE Consultants 2008).

The intake position in the water column, 2–5 m from the seafloor, reduces the entrainment of larvae and plankton that concentrate near the surface or on the seafloor (Leis 2006).

The design of the intake would result in the intake water stream being horizontal (which fish are able to sense) and a slow intake speed, both of which help fish and larvae avoid entrainment.

Issue:

Clarification was sought about what contingencies BHP Billiton would have in place, in the event that entrainment resulted in the catastrophic collapse of Spencer Gulf fisheries and associated loss of income and employment opportunities for local residents.

Submissions: 79, 143, 190 and 383

Response:

As discussed in Section 16.6.10 of the Draft EIS, and in previous responses, entrainment would have a negligible effect on the Spencer Gulf ecosystem, including breeding cycles and food chains. Cooling water intakes for the Northern and Playford power stations have been operating in Upper Spencer Gulf for five decades (State Library of South Australia 2010) with no evidence of a catastrophic collapse.

17.13.6 ADDITIONAL STUDIES

Issue:

It was suggested that a study of the effects of entrainment on the gulf ecosystem is required (including the effects on plankton composition and food webs).

Submissions: 2, 36, 79, 86, 190 and 383

Response:

As discussed in Section 17.13.1 of the Supplementary EIS, only phytoplankton, zooplankton, eggs and larvae are likely to be entrained. As noted in responses above, the operation of the proposed desalination plant would have an immeasurable effect on these organisms in Upper Spencer Gulf, which are near the base of the food webs. Consequently, the effect on the food webs and the broader ecosystem would also be negligible. As a result of this overall assessment of plankton, further study into the composition of plankton is considered unnecessary.

Nevertheless, entrained organisms would be monitored during the first 12 months of operation of the desalination plant by sampling the intake stream. Furthermore, as discussed in Section 17.1.2 of the Supplementary EIS, BHP Billiton would establish a program to monitor the composition of marine communities around Point Lowly. The program would include a suite of indicator species, including planktivores (i.e. invertebrates that feed on plankton), which would be susceptible to potential changes in the abundance of plankton resulting from entrainment.

Issue:

Data was requested on the breeding seasons of prawns, blue swimmer crabs and fish species that occur in the area.

Submission: 36

Response:

Information on the breeding season of the relevant fish and crustacean species is provided in Appendix H10.2 of the Supplementary EIS. Briefly,

- the Western King Prawn breeds from October to April (particularly November to February)
- the Blue Swimmer Crab from January to April

- Snapper from November to January
- King George Whiting from March to May (in lower gulf areas)
- Anchovy from November to March (particularly January to March).

Issue:
Clarification was sought about future monitoring of the impact of entrainment on the reproduction and growth of marine invertebrates.

Submission: 84

Response:

As discussed above and in Section 17.1.2 of the Supplementary EIS, BHP Billiton would establish a program to monitor the composition of marine communities around Point Lowly.

The program would include a suite of invertebrate indicator species, including planktivores (i.e. invertebrates that feed on plankton), which would be susceptible to potential changes in the abundance of plankton resulting from entrainment.

As discussed in Section 17.13.1 of the Supplementary EIS, entrained organisms would be monitored during the first 12 months of operation of the desalination plant by sampling the intake stream. This would ensure that species with relatively high levels of larval entrainment were included in the broader long-term monitoring program.

17.14 MARINE CONSTRUCTION

It is noted that since the Draft EIS was published, and as detailed in Section 1.4 of the Supplementary EIS, BHP Billiton has reappraised construction methods and decided to tunnel the outfall pipeline. The intake pipeline, however, would utilise a cut and fill method of construction, as described and assessed in the Draft EIS.

17.14.1 ECOLOGICAL EFFECTS OF PIPELINE INSTALLATION

Issue:
It was suggested that trenching to install the intake and outfall pipelines would result in significant ecological impacts.

Submissions: 1 and 211

Response:

The ecological effects associated with trenching operations were assessed in Section 16.6.11 of the Draft EIS as moderate. The extent and duration of trenching operations described in the Draft EIS, however, have lessened considerably with BHP Billiton's decision to tunnel the outfall pipeline. Trenching would still occur along the 400 m-long intake pipeline, as the greater thickness of sediment (3–4 m) over the underlying bedrock would minimise the need for blasting.

With regard to the ecological effects of trenching, Section 16.6.11 and Appendix O12.1 of the Draft EIS presented the findings of modelling undertaken to establish potential impacts associated with silt plumes generated from installing the proposed intake and outfall pipelines. As discussed in the Draft EIS (Section 16.6.11), the sediment plume during construction would be detectable for a cumulative total of one hour per fortnight (i.e. >2 mg/L above ambient). When compared with natural levels of total suspended sediments at Point Lowly (2–20 mg/L), the effects are considered minor. The amount of suspended sediment generated during construction would be considerably less with only the shorter intake pipe being trenched.

In the Draft EIS, assessment of the impact of constructing both the intake and outfall pipelines established that the effects of turbidity and siltation on seagrass communities would be minor as the Point Lowly area supports relatively sparse seagrass communities, the impact would be temporary and seagrasses would in most instances quickly recover following the pipeline installation activities. With the decision to trench the intake pipeline only, the potential impacts associated with construction would be less than those predicted in the Draft EIS.

Issue:

It was suggested that trenching associated with the installation of the intake and outfall pipelines would result in permanent alteration of the seabed due to the massive currents off Point Lowly.

Submission: 122

Response:

Trenching during construction would have no long-term effects on the stability of the seabed. After trenching of a short (about 50–100 m) section of the pipeline alignment was complete, the pipeline would be installed and the trench backfilled, initially with the sand/silt removed to bed the pipeline, followed by a cover of rock to armour the pipeline from erosion by the strong currents. Although some accretion and scouring of sediment around the rock covering may initially occur, the seabed would regain its inherent stability in a relatively short time.

17.14.2 EFFECTS ON SEAGRASS

Issue:

Further information on the causes of the seagrass loss presented in the Draft EIS (trenching, hypersaline water, propeller wash etcetera) was requested.

Submission: 2

Response:

The Draft EIS states that 2.5 ha of seagrass would be lost during installation of the intake and outfall pipelines, and less than 1 ha during construction of the proposed landing facility. For the intake and outfall pipelines, these losses were calculated as 0.64 ha of direct seagrass removal through clearance along the pipeline easements, and an additional 1.8 ha of seagrass loss attributed to potential smothering by silt fallout within 25 m either side of each pipeline easement. However, with BHP Billiton's commitment to tunnel the outfall pipeline, the area of seagrass loss at Point Lowly presented in the Draft EIS would reduce from about 2.5 to 1.5 ha.

For the proposed landing facility, 0.35 ha of seagrass would be lost as a result of construction of the 70 m x 35 m rock pad at the barge landing site, and 0.15 ha as a result of construction of jetty piles. Propeller wash would be unlikely to result in seagrass loss as little seagrass occurs in the deeper sections of seafloor where tugs would manoeuvre.

Issue:

It was suggested that increased shipping during construction would have adverse effects on seagrass communities.

Submission: 83

Response:

Increased shipping in Upper Spencer Gulf would have little effect on seagrass communities. As discussed in Appendix O13 of the Draft EIS, Upper Spencer Gulf is subject to strong currents, mobile bottom sediments and relatively high levels of suspended sediments, particularly in the main deep channels. Consequently, shipping channels in the region are generally devoid of seagrass. The operation of barges and ships would have an insignificant effect on the load of suspended sediments in the water column compared with the naturally high levels of suspended sediment in the area. The effect on the ecology of Upper Spencer Gulf would not be measurable. Propeller wash would not affect seagrass communities at the landing facility, as the nearest seagrass would be at least 50–100 m from the area where tugs would manoeuvre. The propeller wash would dissipate rapidly and be incapable of damaging seagrass at that distance (see Appendix H11 of the Supplementary EIS).

Issue:

It was questioned how seagrass would recover from the effect of silt deposition after construction activities were complete.

Submissions: 211

Response:

As discussed in Section 16.6.11 of the Draft EIS, significant silt deposition (i.e. greater than 10 mm over two weeks) would be restricted to within 200 m of the construction activities. Although some smothering of seagrass immediately adjacent to the pipeline installation sites would inevitably occur, the extent of the most severe effect would probably be limited to a strip about 25 m either side of the pipelines. In areas where the silt deposition was less than about 50 mm, it is likely that the seagrass would recover as the silt would be dispersed by wave and tidal action relatively quickly (i.e. in one to two months). A silt dispersion trial undertaken in the shallow reef habitat at Point Lowly demonstrated that most of the silt in 50 mm-deep test trays had been removed and dispersed within one month.

The loss of some seagrass through siltation effects has been taken into account in the vegetation clearance Significant Environmental Benefit calculations presented in Section 15.5.1 of the Draft EIS.

17.14.3 EFFECTS ON AQUACULTURE OPERATIONS

Issue:

The effects of construction operations on aquaculture operations in Fitzgerald Bay were questioned. Issues raised included the safety of aquaculture divers, potential economic impacts on aquaculture operations and possible compensation should adverse effects occur.

Submission: 2

Response:

As discussed in Section 24.4 of the Draft EIS, BHP Billiton would prepare a marine construction management plan before construction began. The plan would be prepared in consultation with the South Australian Department of Primary Industries and Resources (PIRSA) and the Cleanseas Tuna Limited and Southern Star aquaculture companies, and would detail strategies that would be adopted to ensure the effects on aquaculture operations were avoided or minimised.

As discussed in Section 16.6.11 of the Draft EIS, blasting would have no detectable effects on kingfish in the nearest aquaculture rings (3 km from the blast sites) as blasts of the size proposed may affect biota no further than 600 m from the blast sites. Silt plume modelling (Section 16.6.11 of the Draft EIS) has shown that the plume would be detectable for about one hour per fortnight at the nearest rings. The increase of about 2 mg/L would be well within the range of natural suspended sediment load variation in Fitzgerald Bay (2–20 mg/L). The effects on kingfish are therefore predicted to be undetectable.

Close liaison with the commercial divers (mainly Whyalla Diving Services) and Cleanseas and Southern Star would ensure that diving operations at the Fitzgerald Bay aquaculture rings were timed to ensure divers were not underwater during blasts.

In the very unlikely event that construction or operation of the desalination plant had a significant adverse effect on aquaculture operations in Fitzgerald Bay, any compensation arrangements would be consistent with due legal processes.

17.14.4 EFFECTS ON DOLPHINS

Issue:

Details of measures that would be adopted to mitigate the potential effects of pile-driving and blasting on cetaceans have been requested

Submissions: 1 and 2

Response:

Since the Draft EIS was published, seasonal surveys of dolphins have begun at Point Lowly to provide detailed information on the numbers traversing the Point Lowly coast, the timing of their visits and their behaviour when in the area (see Appendix H9.4 of the Supplementary EIS). The surveys have been conducted by Dr Sue Gibbs using land-based observers with binoculars located on high points in the coastal terrain, including the Point Lowly lighthouse. Underwater acoustic recordings have also been made to investigate their usefulness in detecting the presence of dolphins in the area.

The purpose of the surveys is to determine whether it would be feasible to time blasts and, to a lesser extent, pile-driving activity, to minimise the risk of harming dolphins. The expert consultant used to survey dolphins in the vicinity of Point Lowly has established that it would be possible to detect dolphins in the construction area, and therefore monitor their potential presence within 600 m of blast sites before blasting (see Appendix H9.4 of the Supplementary EIS). As noted in the Draft EIS, marine blasting to install the intake pipe would start only if there was a high degree of certainty that there were no dolphins within 1 km. Note that blasting would only occur on the intake pipeline (within about 100 m of shore) for several minutes every two or three days. The outfall pipeline would be constructed via tunnelling and would not therefore require blasting.

17.14.5 EFFECTS ON AUSTRALIAN GIANT CUTTLEFISH

Issue:

The effect of construction operations on the breeding aggregation of the Australian Giant Cuttlefish was raised as an issue of concern. Specifics included the effect of turbidity, silt deposition, noise and vibration, the arrival of cuttlefish at Point Lowly earlier than May each year, the quality of the reinstated reef as cuttlefish breeding habitat, and whether the cuttlefish community would return to its pre-construction condition.

Submissions: 86 and 346

Response:

Significant attention was paid to investigating and reporting the potential impacts on the Australian Giant Cuttlefish in the Draft EIS. With specific relevance to the concerns raised above, Section 16.6.11 of the Draft EIS noted that construction of the intake and outfall pipelines would occur outside the May to October cuttlefish breeding season. Noise, vibration and siltation (turbidity) effects associated with construction would therefore have negligible effect on the breeding aggregation. Although some cuttlefish arrive at Point Lowly in early May, peak arrivals occur in mid- to late May, two to three weeks after construction would have ceased for the breeding season.

As discussed in the Draft EIS and detailed in Appendix O12.1, some siltation of the reef (cuttlefish breeding) habitat would occur within about 100–200 m of the construction sites. It was predicted, however, that the accumulated silt would be quickly remobilised and dispersed by occasional wind-generated storm waves and the prevailing strong currents. This prediction was confirmed to some extent by the silt dispersion trial undertaken in the shallow reef habitat at Point Lowly, which demonstrated that most of the silt in 50 mm-deep test trays had been removed and dispersed within one month.

Section 16.6.11 of the Draft EIS noted that disturbed sections of reef would be reinstated with rock when construction was completed. Moreover, it is likely the broken rock used to reinstate the intake and outfall pipelines would provide suitable crevices in which cuttlefish could attach eggs, and the broken rock used to reinstate the pipelines may provide better breeding habitat than some sections of existing reef as it may have a greater variety and density of suitable crevices. This assumption was tested by stacking concrete pavers on the seafloor with gaps of various sizes between the pavers (i.e. resembling broken rock). Cuttlefish quickly located and utilised these pavers as attachment sites for eggs (refer Appendix O5.3 of the Draft EIS).

17.14.6 BASELINE SURVEYS

Issue:

It was suggested that detailed baseline surveys of intertidal and sub-tidal communities are required along the intake and outfall pipeline alignments.

Submission: 80

Response:

It is acknowledged in Section 16.6.11 of the Draft EIS that construction of the intake and outfall pipelines would result in significant temporary disturbance to the marine communities in the vicinity. Detailed baseline surveys of the proposed construction sites and suitable control sites would be undertaken before construction began, consistent with the principles of Before and After Control Impact (BACI) monitoring. The baseline surveys would focus on intertidal, sub-tidal reef and sub-tidal soft-bottom communities and be undertaken at least twice a year for at least two years before the start of construction.

17.15 MARINE BLASTING

As noted above, since the Draft EIS was published, and as described in Section 1.4 of the Supplementary EIS, BHP Billiton has reappraised construction methods and decided to tunnel the outfall pipeline. Although the intake pipeline would continue to use a cut and fill method, the need for blasting has been significantly reduced from the entire length of the outfall pipeline/diffuser (approximately 800 m), to about a 100 m section of the intake pipeline adjacent to the shore. The deeper sections of the intake pipeline would not require blasting as there is sufficient depth of sediment to enable the pipeline to be buried without the need to excavate bedrock.

17.15.1 IMPACT OF BLASTING ON THE MARINE ENVIRONMENT

Issue:

It was suggested that blasting during construction would have a much greater detrimental effect than salt discharges.

Submissions: 2 and 122

Response:

The commitment to tunnel the outfall pipeline has significantly reduced the extent of marine blasting required. As discussed in Section 16.6.11 and Appendix O12.2 of the Draft EIS, blasting may affect marine biota up to about 600 m from blast sites.

Implementation of a Blasting Management Plan and appropriate blasting mitigation measures would ensure that effects on marine biota were minimised. Localised effects on marine communities would be relatively brief (with blasting likely to occur for several minutes every two or three days for one to two months), and the communities would recover rapidly as successions of marine species from adjacent areas colonised the disturbance area.

17.15.2 BLASTING MITIGATION MEASURES

Issue:

Questions were raised about the measures that would be used to mitigate the impacts of blasting on marine species, particularly dolphins and whales.

Submissions: 1, 2 and 346

Response:

An assessment of the potential impacts due to blasting and mitigation measures proposed to reduce these impacts was presented in Section 16.6.11 and Appendix O12.2 of the Draft EIS. It was also noted that these measures would be further developed in consultation with PIRSA, DENR and the EPA during the preparation of a blast management plan.

The following measures were discussed and would be adopted or refined further to mitigate the effects of blasting:

- test blasts would be undertaken to ensure that charge sizes were the minimum required to fracture the rock and result in as little energy as possible entering the water column. Charge size and effect would be monitored and adjustments made as required
- bubble curtains or other energy-screening measures may be used around the blast sites
- blasting would not occur during the Australian Giant Cuttlefish breeding season
- acoustic deterrents, currently being trialled on the Thames Gateway Project in England, may be used if proven to be effective
- the area within 600 m of the blast would be monitored for dolphins for at least 30 minutes before each blast. If any dolphins were noted within 600 m of the site, the blast would be delayed until they had left the area. To provide a further level of safety the blast would begin only if there was a high degree of certainty that there were no dolphins within at least 1 km
- close liaison with Cleanseas Tuna Limited, Southern Star and commercial divers (mainly Whyalla Diving Services) during blasting operations would ensure that potential effects were avoided or minimised. In particular, procedures would be established to ensure that divers were not in the water during blasting.

Consideration would be given to the suggestion that the aquaculture rings nearest to the blasting operations be moved to alternative locations in Fitzgerald Bay during the construction period. The impact assessment, however, suggests that this would not be required.

17.15.3 ALTERNATIVES TO BLASTING

Issue:

It was suggested that greater discussion is needed on alternative marine construction methods for the installation of the intake and outfall pipelines – methods that do not require blasting.

Submissions: 1 and 2

Response:

As detailed in Section 1.4 of the Supplementary EIS, BHP Billiton has reappraised construction methods and decided to tunnel the outfall pipeline. While blasting would therefore no longer be required on the outfall pipeline, the intake pipeline would continue to utilise a cut and fill method of construction, and blasting may be required along the section of the intake pipeline near the shore (as was described in Section 16.6.11 of the Draft EIS).

Studies of alternative marine construction methods have been undertaken by the Halcrow Group Australia to determine cost-effective, low-risk and environmentally acceptable methods of installing the outfall pipeline and associated infrastructure. The alternative methods are described in Section 1.4 of the Supplementary EIS.

Once a construction method had been selected, a detailed construction management plan would be prepared, describing the potential environmental effects associated with each aspect of operations, and detailing the methods that would be adopted to avoid or minimise potential impacts. The plan would include detailed descriptions of environmental goals, performance criteria and monitoring protocols.

One of the most significant issues associated with tunnelling operations is likely to be the management, treatment and disposal of seawater recovered from dewatering excavated spoil, and seawater that may enter the tunnels during construction. Although every effort would be made to avoid or limit ingress of seawater, there is potential for relatively large volumes to enter the tunnels during construction, depending to some degree on the tunnelling method selected.

A suitable-sized retention dam would need to be constructed on land to store, treat and manage the controlled release of seawater to the marine environment. The retention dam would need to be large enough to ensure that all recovered seawater could be stored, and allow enough time for suspended particulates to settle out.

The turbidity effects associated with tunnelling operations would be significantly less than with the trench and fill operations assessed in the Draft EIS. The use of an adequately designed retention dam to treat recovered seawater would ensure the effects on turbidity off Point Lowly were low (i.e. within compliance limits).

17.16 LANDING FACILITY

17.16.1 GENERAL EFFECTS ON THE MARINE ENVIRONMENT

Issue:

The development of the landing facility in Upper Spencer Gulf has been questioned in the context of previous State Government recommendations to close the region to shipping (and dredging) for environmental reasons.

Submissions: 109 and 211

Response:

The main reason for the recommended shipping closure in the PIRSA report (Dainis 1994) was to prevent the dredging and maintenance of shipping channels to enable access to ports in Upper Spencer Gulf.

The development and use of the landing facility, however, does not require the dredging or maintenance of shipping channels as the barges and tugs used to transport equipment to the facility have a relatively shallow draft. Hydrographic surveys of the approaches to the landing facility undertaken for the Draft EIS have revealed that existing water depths in the channels are sufficient and dredging of a navigation channel is not required. The large ships used to transport equipment to Spencer Gulf would be moored in deep water south of the landing facility, and similarly would not therefore require a navigation channel to be dredged. Equipment would be transferred to barges before transport through the upper reaches of the gulf to the landing facility.

Issue:

It was suggested that the development and ongoing use of the landing facility would result in the degradation of the Upper Spencer Gulf marine environment.

Submissions: 68, 109, 212, 263, 333 and 386

Response:

Chapter 16.6.12 and Appendix O13 of the Draft EIS discuss in detail the potential impacts on the marine environment of Upper Spencer Gulf as a consequence of the proposed construction and operation of the landing facility. BHP Billiton has confidence, based on advice from expert consultants, that the development and operation of the landing facility would have a minor short-term effect and negligible long-term effect on the marine environment. As discussed in this and other sections of the Supplementary EIS (Sections 17.16.2 to 17.16.7), the main reasons for this view are:

- that the footprint of the landing facility is very small, resulting in the loss of less than 0.5 ha of seagrass
- no dredging for a navigational channel is required
- shipping movements would occur predominantly in the deeper channels that generally support filter-feeding benthic fauna rather than seagrass.

The occasional effects of winnowing of sediments by shipping movements would be consistent with the effect of strong currents in the region and would have a minor short-term effect on turbidity.

Issue:

It was suggested that the development and operation of the landing facility would adversely affect fishing.

Submission: 333

Response:

It is very unlikely that development and operation of the landing facility would have an adverse effect on fishing in the area. An extremely small percentage (2–3 ha) of benthic habitats in the area would be disturbed by the landing facility, and shipping operations would be only intermittent (averaging one trip every 11 days). It is more likely that the jetty, wharf and rock pad would create reef habitat that would attract reef fish such as Snapper to the area.

Issue:

It was suggested that the development and operation of the landing facility would result in the loss of important areas of mangroves and samphires.

Submission: 231

Response:

As discussed in Sections 15.5.1 and 16.6.12 of the Draft EIS, construction of the landing facility using a piered rather than solid causeway structure would result in the direct clearance of three immature Southern Mangrove *Avicennia marina* plants covering about 0.2 ha, and a very small area of samphire (<0.1 ha). Furthermore, coastal process modelling presented in Section 16.6.12 of the Draft EIS demonstrated that the landing facility would have a very minor localised effect on tidal flows and sediment/sand movement along the coast, and would therefore have no measurable effect on the mangrove and samphire community in the bay immediately north of the proposed development. There may, in fact, be a very slight promotion of mangroves in the lee of the facility in response to the slight reduction in wave energy reaching the coast.

Issue:

It was suggested that the development and operation of the landing facility would result in marine life becoming contaminated by pollutants.

Submissions: 135 and 310

Response:

Construction and operation of the landing facility would not result in the discharge of any effluent to the marine environment.

BHP Billiton would ensure that ballast water management was consistent with international, Australian and local requirements, with no discharge into Australian waters (see Section 17.17.2 of the Supplementary EIS). Ships under charter to BHP Billiton are required to comply with all international and local laws and regulations in force, including the 'International Convention for the Control and Management of Ships' Ballast Water and Sediments'. The convention sets out the requirements for all ships to have a Ballast Water Management Plan and maintain records of all ballast water exchange activities undertaken on each voyage. In international waters, all ships using ballast water exchange should conduct this exchange at least 200 nautical miles from the nearest land and in water at least 200 m deep. Owners and masters are also required to comply with Australian Quarantine and Inspection Service (AQIS) requirements if intending to discharge ballast water in Australian coastal waters. At the landing facility, ballast water would be discharged to, and from, barges via temporary storage tanks located onshore.

Existing pollutants (particularly heavy metals) in the Upper Spencer gulf marine environment would be unlikely to be remobilised by shipping operations as they generally occur in association with particulates in the low-energy sediment sinks rather than the deep shipping channels where tidal currents are strong. Sediment quality in the deep channels of Upper Spencer Gulf has generally been assessed as good (EPA 2004).

17.16.2 EFFECTS OF BOW WAVES

Issue:

It was suggested that bow waves associated with tugs and barges moving to and from the landing facility in Upper Spencer Gulf would cause coastal erosion and damage coastal homes and mangroves.

Submissions: 68, 106, 261, 354 and 355

Response:

Bow waves generated by tugs and barges would have a negligible effect on coastal erosion, mangroves and coastal homes in Upper Spencer Gulf.

There is no evidence that the regular passage of large ships through Spencer Gulf and Gulf St Vincent is having an adverse effect on the coast of either gulf.

As part of the studies conducted for the Supplementary EIS, AMOG Consulting investigated the potential effects of bow waves generated by tugs and barges in Upper Spencer Gulf, and concluded that (see Appendix H11 of the Supplementary EIS for the full report):

- the highest waves caused by vessels in Upper Spencer Gulf would be of the order of 0.3 m
- as bow waves approached shore they would reduce in height to about 0.2 m
- bow waves would be about 50% smaller than waves generated by strong (25-knot) onshore winds in Upper Spencer Gulf, where wave climate modelling (refer Appendix O13 of the Draft EIS) has shown that strong south-easterly winds can generate waves up to 1 m in height
- the effect of wind-generated waves on the coast would be significantly more severe than bow waves as they would last for many hours, as opposed to a few individual waves generated by the passage of a tug or barge
- maximum wave heights associated with commercial vessels would be only slightly higher than those generated by some recreational vessels in the area (see Appendix H11 of the Supplementary EIS).

AMOG Consulting concluded that the impact of vessel-generated waves would be less significant than waves caused by natural causes. Effects on coastal erosion, mangroves or coastal homes would be insignificant.

17.16.3 EFFECTS OF PROPELLER WASH ON BIOTA

Issue:

It was suggested that propeller wash associated with tug operations adjacent to the landing facility would affect seagrass communities and associated biota.

Submissions: 68, 106, 122, 211, 285, 291, 332, 341 and 355

Response:

The effects of propeller wash on seagrass and associated benthic biota have been assessed as negligible, representing no detectable effect to a local receiver (as per the impact assessment criteria listed in Section 1.6.2 of the Draft EIS).

There would be no impact on seagrasses in the deeper sections of Upper Spencer Gulf as the currents are too strong for seagrass to establish in the deep shipping channels, and light penetration into water deeper than about 10 m is inadequate for seagrass growth (Shepherd 1983a).

At the landing facility there is a narrow (100 m) band of dense seagrass (*Posidonia* spp) adjacent to the shore to a depth of about 7–8 m. Tugs would manoeuvre in the deep channel at least 50–100 m from the nearest seagrass communities. Although strong currents would initially be induced by propeller wash, they would dissipate rapidly within 50 m and be incapable of causing physical damage to adjacent seagrass communities near the shore (see Appendix H11 of the Supplementary EIS). The effect of propeller wash is likely to be similar in intensity to the effect of wind-driven waves on the shallow seagrass communities.

17.16.4 EFFECTS OF SEDIMENT WINNOWING ON TURBIDITY

Issue:

It was suggested that winnowing of sediments by shipping operations in Upper Spencer Gulf would have adverse effects on the marine environment. In particular, the effect of winnowing of sediments on turbidity and seagrass was raised.

Submissions: 68, 121, 135, 261, 263, 272 and 285

Response:

Winnowing of sediments by shipping would have a negligible effect on turbidity and the marine ecosystem of Upper Spencer Gulf, representing no detectable effect (as per the impact assessment criteria listed in Section 1.6.2 of the Draft EIS).

As discussed in Appendix O13 of the Draft EIS, Upper Spencer Gulf is subject to strong currents, and wind-generated waves up to 1 m that regularly re-suspend sediments, resulting in periods of relatively high turbidity. In the context of the highly variable natural turbidity levels in Upper Spencer Gulf, the effects of shipping movements on turbidity is likely to be negligible.

About 35 shipping movements a year along Upper Spencer Gulf during the construction period (i.e. about one every 10 days), and associated docking operations at the landing facility would result in the re-suspension of sediment and temporary increases in turbidity as a result of propeller wash. AMOG Consulting estimated that the maximum amount of sediment mobilised by the action of propellers would be approximately 2 mm during each vessel passage (see Appendix H11 of the Supplementary EIS for details). Although re-suspended material would generally settle out in minutes during calm conditions, it would remain in suspension longer during periods of strong tides and high winds that may last for up to several days. Seagrass death, however, is reported to require complete light deprivation for 38 days (Port of Melbourne Authority 2008).

After comparing sediment settlement durations in Upper Spencer Gulf and turbidity limits for seagrass (Port of Melbourne Authority 2008), AMOG Consulting concluded that periodic increases in turbidity associated with propeller wash would have a negligible effect on the viability of seagrass communities in Upper Spencer Gulf (see Appendix H11 of the Supplementary EIS).

Issue:

It was suggested that re-suspended silt would not be flushed away and would therefore persist for a long time because Spencer Gulf has a slow flushing time.

Submission: 354

Response:

Areas of the Upper Spencer Gulf marine environment are sediment 'sinks', where fine sediments settle out and are regularly re-suspended by strong currents and waves, which at times results in a relatively high background load of suspended sediments (Johnson 1981). The fate of re-suspended material, however, is unrelated to the flushing time of Upper Spencer Gulf. Rather, material suspended by shipping operations would initially be dispersed by prevailing currents, but would settle out during calm conditions at the turn of the tide and when wave energy was low, particularly in low-energy environments. The shallow tidal flats of much of Upper Spencer Gulf are the ultimate 'sediment sinks' where fine sediments settle out and accumulate. Consistent with natural processes, suspended sediment associated with shipping operations in Upper Spencer Gulf would quickly disperse and settle out.

Issue:

It was suggested that increased turbidity associated with shipping operations would adversely affect recreation.

Submission: 333

Response:

It is acknowledged that docking operations associated with about 35 shipping movements a year (i.e. about one every 10 days) would result in a temporary increase in turbidity around the landing facility and nearby beaches. The prevailing currents would, however, quickly disperse the suspended material and water clarity would return to normal levels generally in less than an hour of the completion of docking operations. This effect on turbidity at beaches is considered to be negligible in the context of the relatively large natural variation in turbidity in the area caused by wind-generated waves and strong currents.

17.16.5 REMOBILISATION OF METALS

Issue:

It was suggested that increased shipping in Upper Spencer Gulf would result in the remobilisation of contaminated sediments, which would adversely affect marine communities.

Submissions: 84 and 231

Response:

Although shipping movements in Upper Spencer Gulf would tend to mobilise sediments to some degree, field data has shown that the sediments in the deep channels are generally free of contamination (EPA 2004).

A comprehensive survey by the EPA of heavy metal contamination in Upper Spencer Gulf classified the sediments in the vicinity of the landing facility as being 'good' (i.e. less than the species protection trigger value) when compared with aquatic ecosystem guidelines (EPA 2004). The metals investigated were cadmium, chromium, copper, lead, nickel and zinc. The study found no contamination in the relatively high-energy deep channels near the landing facility site. There would therefore be no effects on marine life through re-suspension of contaminated sediments at the proposed landing facility.

As discussed in Appendix O7 of the Draft EIS, surficial sediments in the deep channels off Point Lowly and the landing facility were also sampled and analysed for contaminants by Australian Laboratory Services (a NATA-accredited laboratory). Consistent with the EPA (2004) findings, no samples returned contaminant concentrations above the ANZECC/ARMCANZ (2000) Interim Sediment Quality Guideline values.

17.16.6 EFFECTS ON MARINE MAMMALS

Issue:

Several respondents have questioned the effect of increased shipping in Upper Spencer Gulf on whales, dolphins and seals. Issues raised included ships striking mammals, and causing disturbance through noise and vibration.

Submissions: 272, 285 and 355

Response:

The effect of shipping on marine mammals, particularly whales, in Upper Spencer Gulf was assessed and reported in the Draft EIS as negligible (see Section 16.6.6). With only about 35 shipping movements a year occurring in Upper Spencer Gulf, and the passage of whales through Upper Spencer Gulf uncommon, the likelihood of shipping coming close to whales is considered to be low. The additional risk of a barge, tug or ship actually striking a whale is considered to be very low. Shipping movements in Upper Spencer Gulf would occur generally during daylight hours, when whales would be relatively visible, enabling vessels to alter course to some degree to avoid collisions or disturbance. Furthermore, shipping movements would be relatively slow, which would give whales more opportunity to avoid vessels. Collisions with dolphins and seals would be negligible as they are fast swimmers and able to easily avoid slow-moving vessels.

It is acknowledged that noise and vibration emanating from ships may result in disturbance to the behaviour of marine mammals, but the effect associated with the proposed landing facility would be infrequent, brief and minor.

17.16.7 EFFECTS OF THE ROCK PAD

Issue:

The effect of the proposed rock pad associated with the landing facility on the local marine environment was questioned. In particular, the removal of seagrass for the rock pad to land barges was raised as a significant issue.

Submissions: 285 and 355

Response:

Section 5.9.5 and Figure 5.48 of Chapter 5 of the Draft EIS discussed and illustrated the size and location of the proposed rock pad to provide a solid base for landing barges. As discussed in Section 16.6.12 of the Draft EIS, the construction of the 75 m x 50 m pad at the landing facility would have a negligible effect on the Upper Spencer Gulf marine ecosystem. Marine surveys conducted at this location as part of the Draft EIS assessment established the presence of seagrass communities in the shallow water (<7–8 m), and soft-bottom communities in the deeper water (>8 m) (refer Section 16.6.12 and Appendix O1.3 of the Draft EIS). Less than 0.5 ha of each community would be affected by the construction of the pad. This represents a very small fraction of these communities in Upper Spencer Gulf.

Section 15.5.1 discussed the significant environmental benefit (SEB) to offset vegetation losses associated with the project. BHP Billiton has chosen to make a monetary contribution (based on the formula provided in the Native Vegetation Council Guidelines) to the Native Vegetation Fund to offset the seagrass loss (details were presented in Appendix N9.5.3 of the Draft EIS). Further offsetting the loss to some degree, the rock pad would provide habitat for a diversity of reef species that inevitably would colonise the site. Colonisation of similar built structures in Spencer Gulf has occurred on rock breakwaters at Whyalla, Point Lowly and numerous other locations.

Issue:

Concern was raised that the rock pad would disrupt natural tidal flows and affect sand movement along the beach.

Submissions: 68, 211, 213 and 274

Response:

As discussed in Section 16.6.12 and Appendix O13 of the Draft EIS, construction of the landing facility using a piered rather than solid causeway structure would result in negligible disruption to coastal processes. The associated rock pad rising 4 m above the seafloor would have a negligible effect on tidal flows in the vicinity of the landing facility. Modelling of hydrodynamic processes using ELCOM has shown that the pad would result in a minor increase in the speed of tidal flows above the pad during both ebb and flood tides. The modelling shows the pad would in no way disrupt natural tidal flows.

The pad would have a negligible effect on sand movement in the vicinity of the landing facility. As discussed in Section 16.6.12 and Appendix O13 of the Draft EIS, modelling of coastal processes using the ELCOM, SWAN and TRANSPOR models established that the pad would have an insignificant effect on sand movement along the coast. There is little natural movement of sand along the coast, and sand would readily move around the structure. The main impact on sediment transport is likely to be some minor scouring around the toe of the pad, which is considered to be consistent with natural processes in the area.

Issue:

It was suggested that the rock pad should be built of large boulders and pipes to provide reef habitat for certain species of fish. It was also suggested that BHP Billiton should compensate the community by establishing an artificial reef offshore.

Submission: 211

Response:

The function of the rock pad would be to provide barges with a stable platform on which to rest during unloading operations. As such, the pad would be constructed of coarse rock (rather than large boulders) to ensure the surface was as even as possible. Consequently, the rock pad would inevitably be colonised by a variety of reef species. BHP Billiton would not propose to establish additional reef habitat offshore, as the ecological benefits of artificial reefs are currently being questioned by state regulatory authorities.

17.17 INTRODUCED PESTS

17.17.1 MARINE PEST RISKS

Issue:

Concern was raised regarding the potential introduction of marine pests and diseases as a result of increased shipping in Upper Spencer Gulf. Doubt was expressed that 'minimising the risk' of pest introductions would actually prevent them from occurring.

Submissions: 1, 60, 68, 80, 106, 121, 183, 211, 263, 276 and 386

Response:

The risk of marine pests and diseases being introduced is considered to be low in view of the strict safeguards that would be implemented.

Risks and management measures associated with the increased potential for introducing marine pests were discussed in Chapter 24 and Appendix U of the Draft EIS.

All vessels contracted to BHP Billiton to operate in Upper Spencer Gulf ports must comply with regulatory and non-regulatory marine pest controls established by international, national and local authorities. These controls aim to ensure the safe, efficient movement of cargo with no impacts on the marine environment in which they operate.

Measures to manage risks associated with ballast water and biofouling are currently being developed by the National System for the Prevention and Management of Marine Pest Incursions (DAFF 2010).

Under existing quarantine requirements the Australian Quarantine and Inspection Service (AQIS) is responsible for inspecting ships, crews and/or cargo on arrival at the first Australian port. In order for them to disembark/unload, AQIS must issue a 'Free Pratique' or Clean Bill of Health, certifying that:

- no contagious disease was known to exist when the certificate was issued
- the vessel is free from all such diseases, unwanted or banned animals, organisms and plant life
- the vessel is safe for carrying people and/or edible cargo
- the master of the vessel has complied with a ballast management program, as stipulated under Australian law.

The issue of a Free Pratique provides official permission from AQIS for the crew and cargo to make physical contact with shore. Without the Free Pratique the ship may be required to wait at quarantine anchorage for clearance.

BHP Billiton would prepare and implement a management plan for shipping operations in Upper Spencer Gulf, describing all mandatory requirements and protocols for managing ballast water and minimising the risk of introducing marine pests and diseases to Upper Spencer Gulf.

17.17.2 VECTORS OF CONCERN

Issue:

Further information was sought on the management of ballast water for vessels entering Upper Spencer Gulf, in particular heavy-load vessels using the landing facility.

Submissions: 2, 68, 80, 83, 212, 213, 263, 272, 274, 334 and 355

Response:

BHP Billiton would ensure that ballast water management was consistent with international, Australian and local requirements, with no discharge into Australian waters.

Currently, Australian ballast water is managed in accordance with the International Convention for the Control and Management of Ships' Ballast Water and Sediments (DAFF 2008; IMO 2008).

As stated in Section 16.6.13 of the Draft EIS, BHP Billiton would develop and implement a Ballast Water Management Plan to minimise the risk of pest introductions to Upper Spencer Gulf. The plan would be consistent with Australia's commitment to the International Convention, national ballast water management requirements (DAFF 2008), and requirements of the port operator.

As standard practice, ocean vessels would be required to discharge ballast water outside Australian waters. The operation of barges and heavy-load vessels in Upper Spencer Gulf, however, would require the discharge and taking on of ballast water as part of unloading operations at the landing facility. Ballast water, however, would only be discharged at the landing facility to onshore tanks. When taking on ballast before leaving the landing facility, vessels would source water from the onshore tanks.

Issue:

Concern was expressed regarding the potential for pests and diseases to be introduced via ships' hulls, and information was sought on how this would be managed.

Submissions: 80, 211, 274 and 355

Response:

Mandatory compliance of vessels contracted to BHP Billiton with national and international guidelines for biofouling management would minimise the risks of introducing marine pest species into Spencer Gulf.

Maintenance of a clean hull is in the best interests of the ship operator as it optimises performance and minimises fuel costs. National guidelines developed by the National System for the Prevention and Management of Marine Pest Incursions provide practical information on managing biofouling on hulls and niche areas. The national biofouling management guidelines for commercial vessels provide information on:

- managing biofouling when operating in Australian waters
- preparing a vessel before arrival in Australia (or any other country) to ensure it is free of marine pests on entry
- developing maintenance contracts that will meet best practice in biofouling management and ensure optimal performance.

In addition, all cargo-carrying vessels (including barges) used by BHP Billiton would be operated 'under class', requiring them to have suitable vessel hull management strategies. These strategies consist of inspections and the application of anti-fouling initiatives during dry-docking operations, verification systems that demonstrate correct procedures and processes have been followed during the dry-docking, and maintenance during operational periods to ensure the integrity of the anti-fouling solution.

Compliance with the hull management strategy would be policed by the Australian Maritime Safety Authority (AMSA) and border control (Customs and AQIS), which can inspect vessels and detain and issue orders or instructions to the vessel/owners.

While the code of practice focuses on all vessels, it is generally accepted by authorities that cargo-carrying vessels present a relatively low-risk as they operate using appropriate pest management systems, are in port for only a few days, and are continually operating. On the other hand, survey ships, oil platforms or vessels that have been moored for extended periods are considered to present a higher risk, as there is greater opportunity for marine pests to colonise hulls.

It is concluded that the risk of introducing pests or diseases to Upper Spencer Gulf on a ship's hull is low.

17.17.3 FACTORS THAT INCREASE RISKS

Issue:

It was suggested that construction of artificial substrates such as the pipeline and landing facility might facilitate establishment by invasive species.

Submission: 86

Response:

Consistent with the National System for the Prevention and Management of Marine Pest Incursions, a marine monitoring program would be implemented for the construction areas before and during construction and operation of the facilities. This would include surveys of the artificial substrates for introduced marine pests. Should invasive species be detected during post-construction monitoring surveys, control measures would be implemented in consultation with PIRSA (Biosecurity SA) should they be required.

Issue:

It was suggested that discharge of high-salinity water and anti-scalants could promote invasion and colonisation of the area by more tolerant foreign species.

Submission: 80

Response:

Rapid dilution and dispersion of the return water discharge would ensure that detectable ecological effects were confined to the area in the zone of ecological effect, as described in Section 16.6.5 of the Draft EIS. Communities potentially affected within 100 m of the diffuser include benthic marine invertebrates and those living in the sediment (infauna). The effects on community structure are predicted to be minor, and would present limited opportunity for establishment and proliferation of pest species.
The deep location of the diffuser (27 m), strong currents and distance from potential invasive species sources (vessels berthed at piers), lessen the risk that non-indigenous species would become established.

The communities near the diffuser would be monitored before construction and during operation of the plant to assess the impacts of the return water discharge. Monitoring would be consistent with the National System for the Prevention and Management of Marine Pest Incursions, and would specifically target pest species.

Issue:

It was suggested that increased shipping is contrary to the advice of Harbison and Wiltshire presented in the Resource Processing Strategy for Upper Spencer Gulf.

Submission: 83

Response:

The recommendations of Harbison and Wiltshire (1993) concerning shipping activity north of Point Lowly were made in relation to dredging of channels and the transport of bulk toxic materials rather than the introduction of pest species. The proposed development is not in breach of either recommendation. Access to the landing facility would be restricted to barges and heavy-load vessels that were able to negotiate the existing channels, which eliminates the need to dredge the channels. The materials to be transported would be construction parts. No bulk toxic materials would be transported to or from the landing facility.

17.17.4 POTENTIAL ECOLOGICAL RISKS

Issue:
It was suggested that there are inherent risks and uncertainties concerning the ecological consequences of pest invasions. Can it be guaranteed that the introduction of a marine pest would have negligible rather than disastrous ecological effects?

Submissions: 122 and 386

Response:

Risks associated with pest introductions occur in shipping ports throughout the world. The risk that a marine pest would become established in Upper Spencer Gulf and cause significant ecological consequences was considered in the risk assessment undertaken for the Draft EIS (Arup 2008). The findings of this assessment were that the consequence of such an event was categorised as 'serious', and the likelihood as 'rare', resulting in a 'moderate' risk ranking (and this a 'tolerable' risk as per the risk assessment method detailed in Chapter 26 and Appendix C of the Draft EIS). The likelihood of this event occurring was categorised as 'rare' because of the proven nature of proposed and international controls (see Section 29.1 of the Supplementary EIS for details), such as:

- compliance with the strict state and federal marine pest controls
- implementing a ballast water management plan for barges and ships
- implementing a marine monitoring program before and during construction and operation of the facilities.

Control measures and management plans are further discussed in Chapter 24 and Appendix U of the Draft EIS and Chapter 29 of the Supplementary EIS.

Issue:
It was noted that pest introductions might affect farmed shellfish and razorfish communities (that occur in only a few places in the world).

Submission: 386

Response:

Consistent with the National System for the Prevention and Management of Marine Pest Incursions, all reasonable measures would be taken to minimise the likelihood of introducing pest species. It is considered that the risk to shellfish operations and razorfish communities is low.

Issue:
Pearl Oysters are an example of what can happen with tropical species being introduced to Upper Spencer Gulf.

Submissions: 68, 122, 291 and 333

Response:

The Pearl Oyster has been observed in Upper Spencer Gulf for at least 10 years, but was not recorded during earlier extensive surveys of the area (Shepherd 1983). Marine surveys for the Draft EIS identified the Pearl Oyster in seagrass habitat near the landing facility (refer Appendix O1 of the Draft EIS), and it has also been recorded at Point Lowly. There are concerns that the Pearl Oyster is spreading in Upper Spencer Gulf, however its current distribution and its impacts on the ecosystem are not well known.

Increased awareness of the spread of introduced pests such as the Pearl Oyster by vessels has led to tighter controls and management of pest introductions. It is likely that the current regime of controls (had they been in place) would have prevented the introduction of the Pearl Oyster to Upper Spencer Gulf.

17.17.5 MITIGATION MEASURES

Issue:

Further details have been requested on arrangements for quarantine inspections of vessels for marine pests.

Submission: 2

Response:

The Australian Quarantine and Inspection Service (AQIS) is responsible for inspecting ships, crew and cargo on arrival at the first Australian port. In order for them to disembark/unload, AQIS must issue a 'Free Pratique' or Clean Bill of Health, certifying that:

- no contagious disease was known to exist when the certificate was issued
- the vessel is free from all such diseases, unwanted or banned animals, organisms and plant life
- the vessel is safe for carrying people and/or edible cargo
- the master of the vessel has complied with a ballast management program, as stipulated under Australian law.

The issue of a Free Pratique exempts the vessel from being quarantined on arrival and provides official permission from AQIS for the crew and cargo to make physical contact with shore. Otherwise the ship may be required to wait at quarantine anchorage for clearance.

Issue:

It was suggested that monitoring is required to detect introduced marine pests (e.g. the comb jellyfish, dinoflagellates). Further information was sought on how their spread would be prevented if they were introduced.

Submissions: 140 and 211

Response:

A National System for the Prevention and Management of Marine Pest Incursions was implemented in 2009. Australia has worked with New Zealand to develop National Marine Pest Monitoring Guidelines together with a manual that would be used to design and implement each of the monitoring programs that form part of the national system (DAFF 2010). This system aims to prevent new marine pests arriving, respond when a new pest does arrive and minimise the spread and impact of pests already established in Australia.

All construction or operational management plans developed for the desalination plant that have an introduced marine pest component would be consistent with the national system. As discussed in Section 16.6.5 of the Draft EIS, before the desalination plant began operating, seasonal baseline surveys would be undertaken to describe the benthic communities at permanent underwater monitoring sites. The surveys would target introduced marine pests and take into account any guidelines developed for the National System for the Prevention and Management of Marine Pest Incursions.

As discussed in Section 16.2.2 of the Draft EIS, 37 sites within 4 km of Point Lowly were surveyed for the Draft EIS, which provided a high level of confidence that the introduced marine pests of most concern, including the Northern Pacific Seastar *Asterias amurensis*, Japanese Wakame seaweed *Undaria pinnatifida*, New Zealand Screwshell *Maoricolpus roseus*, and Lady Crab *Charybdis japonica*, were not present.

Recent increases in the prevalence of jellyfish in the world's oceans have been attributed to overfishing, eutrophication (increased concentration of chemical nutrients), climate change, translocation and habitat modification (Richardson et al. 2009). While jellyfish may be introduced to gulf waters via vessels, their establishment and spread would depend on their ability to adapt to the high salinity of Upper Spencer Gulf and numerous other environmental factors.

Monitoring to detect pest species would be consistent with the National System for the Prevention and Management of Marine Pest Incursions. It would target all potential pest species including comb jellyfish. Should invasive species be detected, control measures may be implemented in consultation with PIRSA (Biosecurity SA).

17.18 CLIMATE CHANGE

17.18.1 EFFECT ON SALT ACCUMULATION IN UPPER SPENCER GULF

Issue:

Further information was sought about the cumulative impact of the desalination plant and climate change on the Upper Spencer Gulf marine ecosystem.

Submissions: 2, 80, 114, 127, 136, 138, 170, 171, 172 and 271

Response:

Modelling and analysis of field data has shown that climate change would result in negligible increases in the salinity of Upper Spencer Gulf up to the year 2030 (<0.25 g/L), and minor increases (<0.78 g/L) by 2070. Desalination would not significantly exacerbate the impact of climate change on the marine ecosystems of Upper Spencer Gulf.

Two preliminary studies related to the cumulative effects of the desalination plant and climate change were presented in the Draft EIS. One examined salinity changes in Upper Spencer Gulf over the past 25 years, in response to historically high temperature and evaporation over this period (see Figure 17.7 of the Supplementary EIS), and the other modelled salinity changes in response to climate change (refer Section 16.6.14, Appendix O9.4 and Appendix O11.4 of the Draft EIS). The main findings were that:

- increased evaporation since the 1980s has resulted in the salt content of Upper Spencer Gulf increasing by 0–2%
- a 2˚C temperature increase would result in a salinity increase of 0.01–0.09%, or 0.01–0.04 g/L.

Considerable refinement of both studies has occurred since the Draft EIS was completed (see Appendices H8.1 and H7.2 of the Supplementary EIS, respectively). Dr Rick Nunes-Vaz has derived future net evaporation in two ways from predictions of rainfall and air temperature under various climate change scenarios provided by Suppiah and others (2006). As discussed in Section 17.6.3 and Appendix H8.1 of the Supplementary EIS, a relationship between cumulative net evaporation over a six-month period and the salt load (or mean salinity) of Upper Spencer Gulf north of Point Lowly was derived and used to quantify the effects on net evaporation and hence salinity.

The results showed climate change (up to 2030) and desalination would result in the mean salinity north of Point Lowly increasing by up to 0.07 and 0.011 g/L respectively, resulting in a long-term cumulative mean salinity increase of up to 0.18 g/L. By 2070, the cumulative salinity increase was predicted to be up to 0.33 g/L (at least four times that of the proposed desalination plant). As discussed in a response below, Dr Nunes-Vaz considered that the natural mechanisms that regulate salinity in Upper Spencer Gulf would accommodate the effects of climate change (see Appendix H8.1 of the Supplementary EIS).

The climate change scenarios developed using the refined hydrodynamic model predicted a mean long-term salinity increase north of Point Lowly of 0.24 g/L by 2030, and 0.78 g/L by 2070. Desalination was predicted to increase the long-term mean salinity by 0.1 g/L, resulting in a cumulative increase of 0.34 g/L and 0.88 g/L for 2030 and 2070 respectively (see Appendix H7.2 of the Supplementary EIS).

The results of both studies are summarised in Table 17.12 and Figure 17.33 of the Supplementary EIS. The differences between the results of the two studies can probably be attributed to differences in relative humidity at the ocean boundary (modelled) compared with measurements from a land-based station at Price (the source of net evaporation data for the study by Dr Nunes-Vaz). Both studies, however, have shown that the salinity increases arising from desalination and climate change up to 2030 would be negligible. Although greater increases are predicted for 2070, the relative contribution of desalination would be small.

Although the combined salinity increase may result in some subtle changes to the marine ecosystem by 2070, they are unlikely to be measurable.

Table 17.12 Summary of influences on mean salinity of waters north of Point Lowly

Study	Influence	Change of mean salinity (g/L)	Inferred mean salinity (g/L)
Analysis of field data by Dr Nunes-Vaz	Annual variation (mean 1982 to 2009)	1.38	41.56
	Desalination	<0.11	41.67
	Climate change 2030 (P method[1])	<0.07	41.63
	Climate change 2030 (P and T method[2])	<0.05	41.61
	Climate change 2070 (P method)	<0.22	41.78
	Climate change 2070 (P and T method)	<0.16	41.72
Modelling by BMT WBM Pty Ltd	Annual variation (mean 2004 to 2068)	2.97	41.72
	Desalination	<0.10	41.82
	Climate change 2030	<0.24	41.96
	Climate change 2070	<0.78	42.50

1 Evaporation calculated from predictions of precipitation (see Appendix H8.1)
2 Evaporation calculated from precipitation and temperature, using bulk aerodynamic formula (see Appendix H8.1)

Issue:

Concern was expressed that climate change could be used as a scapegoat for potential increases in salt concentration in Upper Spencer Gulf caused by the desalination plant.

Submission: 288

Response:

BHP Billiton would use a number of techniques to differentiate the relative effects of climate change and desalination on the salinity of Upper Spencer Gulf. In 2008–2009, Dr Rick Nunes-Vaz undertook a rigorous examination of the relationship between historical measurements of salinity and cumulative evaporation over previous months, finding that the mean salinity of Upper Spencer Gulf, north of Point Lowly, reflects, in a consistent and measurable way, the integrated influences of net evaporation during the preceding six months (see Appendix H8.1 of the Supplementary EIS).

As discussed in the previous response, this relationship allows a clear delineation of the relative impacts of desalination and climate change on the mean salinity of waters north of Point Lowly, and provides a baseline for monitoring the impact of the desalination plant that takes into account natural changes in evaporation.

Similarly, as demonstrated above, the hydrodynamic model can be used to differentiate changes arising from climate variation and desalination. After the desalination plant began operating, the model could be forced with concurrent climatic data and the salinity predictions validated with salinity measurements taken throughout Upper Spencer Gulf.

Issue:

Concern was expressed that climate change may affect thermally dependent gravity currents.

Submission: 80

Response:

The sensitivity of the salt exchange mechanism in Upper Spencer Gulf to perturbations caused by desalination or climate change has been examined by Dr Rick Nunes-Vaz (see Appendix H8.1 of the Supplementary EIS).

Dr Nunes-Vaz considered gravitational circulation, and turbulent diffusion and dispersion, which are the dominant mechanisms whereby salt is exported from the gulf. He found that neither mechanism was sufficiently close to a stability limit to disrupt the equilibrium between salt inflow and outflow. He concluded that both would adapt smoothly and modestly to water temperature changes predicted for typical climate change scenarios (see Appendix H8.1 of the Supplementary EIS).

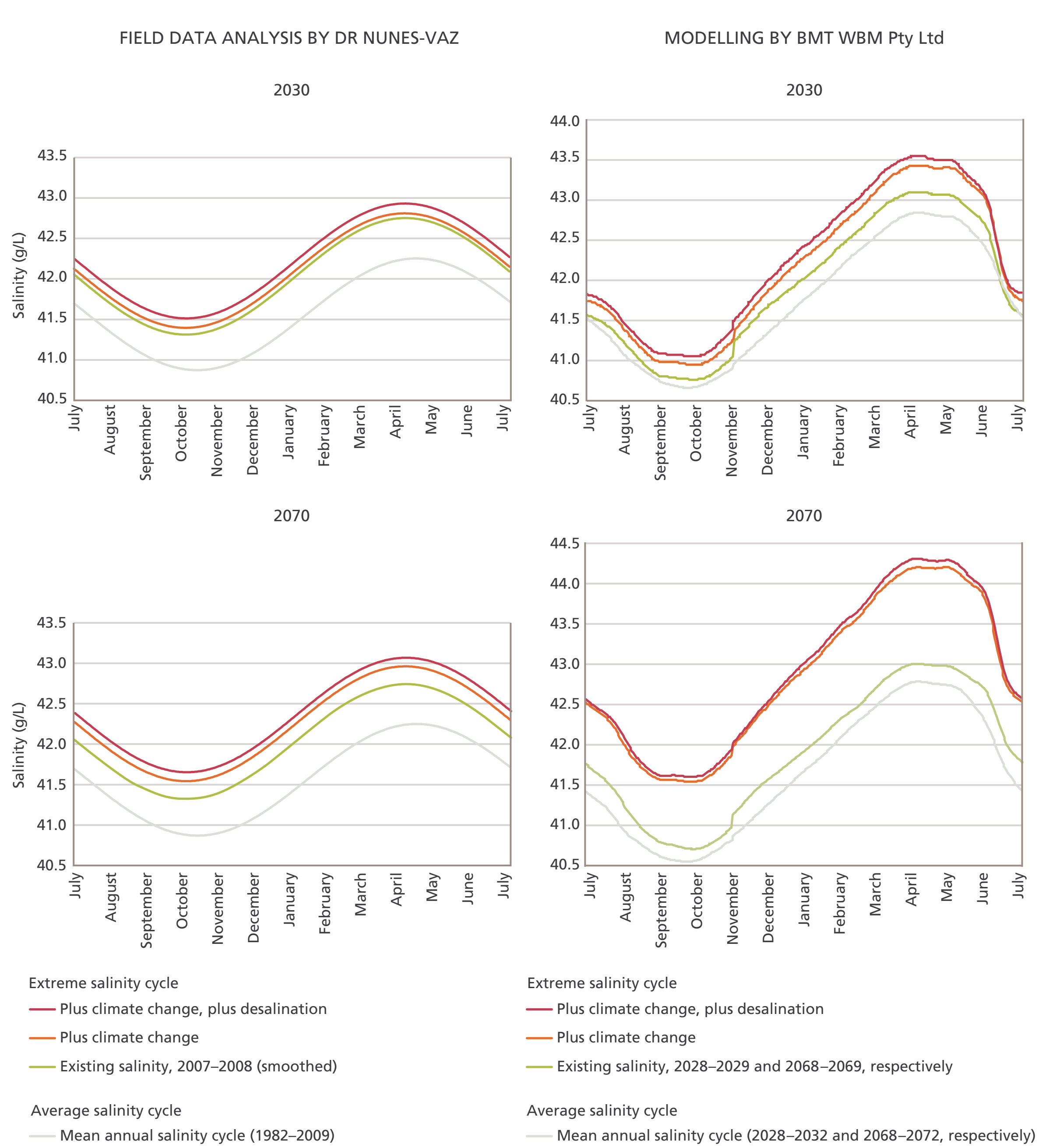


Figure 17.33 The cumulative impact of climate change and desalination on the salinity of northern Spencer Gulf relative to the existing extreme salinity cycle

17.18.2 EFFECTS OF INCREASED pH AND TEMPERATURE

Issue:

Further information was sought about the synergistic effects of desalination discharge and climate change stressors, including acidification and ocean warming.

Submission: 80

Response:

The desalination plant would contribute to the salinity increases to some degree, but would have a negligible effect on temperature and acidity. There may be combined effects of salinity, temperature and acidity increases on Spencer Gulf under future climate change scenarios, but the small contribution of desalination would be limited. These parameters would be monitored before and during the operational phase of the desalisation plant, and considered for future ecotoxicology programs.

In addition to the salinity changes discussed in responses above, climate change is predicted to increase the temperature and acidity of marine waters. There is extensive literature documenting changes in abundance and distribution of populations and timing of biological processes in response to temperature change (Brierley and Kingsford 2009; Hobday et al. 2006). There is also evidence to suggest that acidification can affect calcification, the process by which animals such as molluscs make shells and plates from calcium carbonate (Secretariat CBD 2009; Brierley and Kingsford 2009; The Royal Society 2005; Hobday et al. 2006; Kleypas et al. 2006). Additive or synergistic effects resulting from the cumulative impact of increases in salinity, temperature and acidity are also possible (Hobday et al. 2006; Brierley and Kingsford 2005).

The predicted effects of climate change and desalination on salinity, sea surface temperature and pH are summarised in Table 17.13 of the Supplementary EIS. The desalination plant return water would have a negligible effect on the temperature of Spencer Gulf, because the volume of water discharged annually at approximately 1°C above ambient would be mixed with more than 5,000 times more seawater. The return water would also have a negligible effect on the acidity of the gulf, due to mixing and buffering by the ambient seawater. Furthermore, less acid would need to be used in the desalination process if the ambient acidity increased through climate change (see Section 17.3.1 of the Supplementary EIS). The desalination plant would marginally contribute to the overall increase in salinity in the gulf, resulting in a cumulative increase of up to 0.88 g/L, rather than the 0.78 g/L predicted from the 2070 climate change scenario alone (see Table 17.12 of the Supplementary EIS).

Synergistic impacts arising from the combination of temperature rises and salinity increases would be mitigated to some degree in Spencer Gulf by the potential southerly migration of some species to a zone of the gulf where the temperature and salinity were consistent with the pre-climate change and desalination regime. It is possible that the effects of climate change and desalination may be additive or synergistic. However, the contribution of desalination is likely to be small. Salinity, temperature and pH would be included in the long-term water quality monitoring program for Upper Spencer Gulf. Consideration would be given to including test solutions with temperatures and pH comparable with the climate change scenarios in future ecotoxicology studies, should they be required.

Table 17.13 Summary of predicted effects of climate change and desalination on water quality in Spencer Gulf

	Desalination	Climate change 2030[1]	Climate change 2070[1]
Salinity	0.08 g/L	0.24 g/L[2]	0.78 g/L[2]
Temperature	Negligible	1.6°C[3]	4.7°C[3]
Acidity (decrease in pH)	Negligible	Approximately 0.1[4]	Approximately 0.2[4]

[1] See Section 17.18.1.
[2] Based on worst-case outcome from climate analysis (see Appendix H8) and hydrodynamic modelling (see Appendix H7.2).
[3] Based on worst-case increased air temperature scenarios from Suppiah and others (2006) for the Northern and Yorke Natural Resource Management Region and coastal area (<200 km from the coast). Note, however, that increases in water temperature near the mouth of Spencer Gulf over the past 50 years have been shown to be approximately half of the air temperature rises, and more general predictions of Australian sea surface temperature rise are 1–2°C (Hobday et al. 2006).
[4] Based on model predictions (The Royal Society 2005; Hobday et al. 2006). Predictions of 0.4–0.5 by Caldeira and Wickett (2003), referred to in Submission 80, are for the year 2100.