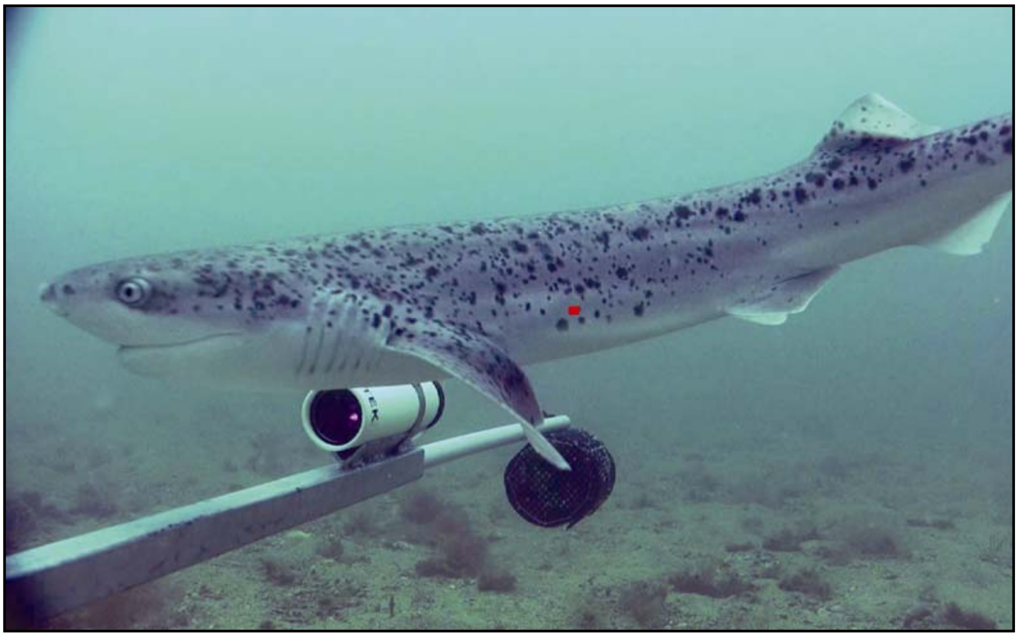
An assessment of fish assemblages adjacent to Port Stanvac

A report to AdelaideAqua for the Adelaide desalination plant project 2009 - 2010



Prepared by the Coast and Marine Conservation Branch
Department of Environment and Natural Resources
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Summary

A seawater desalination plant is now nearing the final stages of construction adjacent the former Mobil oil refinery site at Port Stanvac as part of the South Australian Government's plans to secure a future water supply for Adelaide. As an environmental monitoring program associated with this project, the then Department for Environment and Heritage (DEH), now Department of Environment and Natural Resources (DENR), were commissioned to undertake a study to collect baseline data on fish assemblages within two major habitat types in the vicinity of the saline concentrate zone prior to its commissioning.

Baited remote underwater video systems (BRUVS) were used to collect data at seasonal intervals over the period of one year to capture spatial and seasonal variation in fish assemblages. Stereo video footage is analysed to provide data on species types, relative abundances and length measurements.

Fish community assemblages at Pt Stanvac were found to be highly variable, both spatially and temporally. None the less, distribution patterns associated with habitat type, spatial patchiness and seasonal variation were found. Fish length information was also highly variable and showed no distinct pattern. Some evidence was found to indicate that this area may act as a nursery area for the Port Jackson shark (*Heterodontus portusjacksoni*). The resultant dataset and its inherent variability will now form a baseline against which future surveys can be compared once the desalination plant begins operation.

Introduction

In late 2009 the DEH (now DENR) Coast and Marine Conservation Branch was contracted by AdelaideAqua to conduct a baseline survey of fish assemblages as part of the environmental assessment process associated with the Adelaide desalination plant project at Port Stanvac, South Australia.

Using baited remote underwater video systems (BRUVS), this study assesses the relative abundance and size of fishes in the Port Stanvac marine area. It also examines spatial and temporal variability of fish assemblages over four seasons during 2009 and 2010 and in two habitat types; both within and outside the proposed salinity impact zone. This will form a baseline against which to monitor the effects from future plant operations.

BRUVS have been widely used to monitor changes in fish assemblages (Langloise *et al.* 2006; Malcolm *et al*. 2007; Kleczkowski *et al.* 2008), and advances in underwater videometric measurement can provide more accurate length measurements than diver underwater visual census (Harvey *et al*. 2004; Watson *et al.* 2005; Shortis *et al.* 2007). Furthermore, BRUVS is a non-extractive, non-destructive, repeatable method for quickly gathering data and building a permanent record.

To our knowledge, this technique has not yet been used to assess the impacts of desalination plant discharge on fish assemblages in the marine environment.

Aims

Determine:

- Species presence / absence
- Species abundance and richness
- Fish length for key taxa

Assess and compare:

- Fish assemblages within two habitats at sites; within versus distant, from the proposed saline concentrate zone over the duration of this study.

Materials and methods

Study area

Two sites were selected, within (Near sites), and two outside (Distant sites) the predicted zone of influence of the saline concentrate. The location of these sites was based on salinity plume dispersion models detailed in the Adelaide Desalination Plant Environmental Statement (South Australian Water Corporation 2008). Site selection also considered habitat and depth (Figure 1).

Modelling of the predicted saline concentrate suggests that the Near sites should experience dilution rates of less than 50:1 while dilution rates at the Distant sites should be greater than 100:1 (South Australian Water Corporation 2008).

Data was collected over habitats consisting of patchy sparse algae on soft sediment, and patchy low profile reef (referred to hereon as ‘Soft-bottom’, and ‘Reef’, respectively) within the Near and Distant sites. These sites were chosen using existing habitat maps (Figure 1; DEH 2008a,b) and combined to form the four study areas: Distant Soft; Distant Reef; Near Soft and Near Reef (Figure 1).

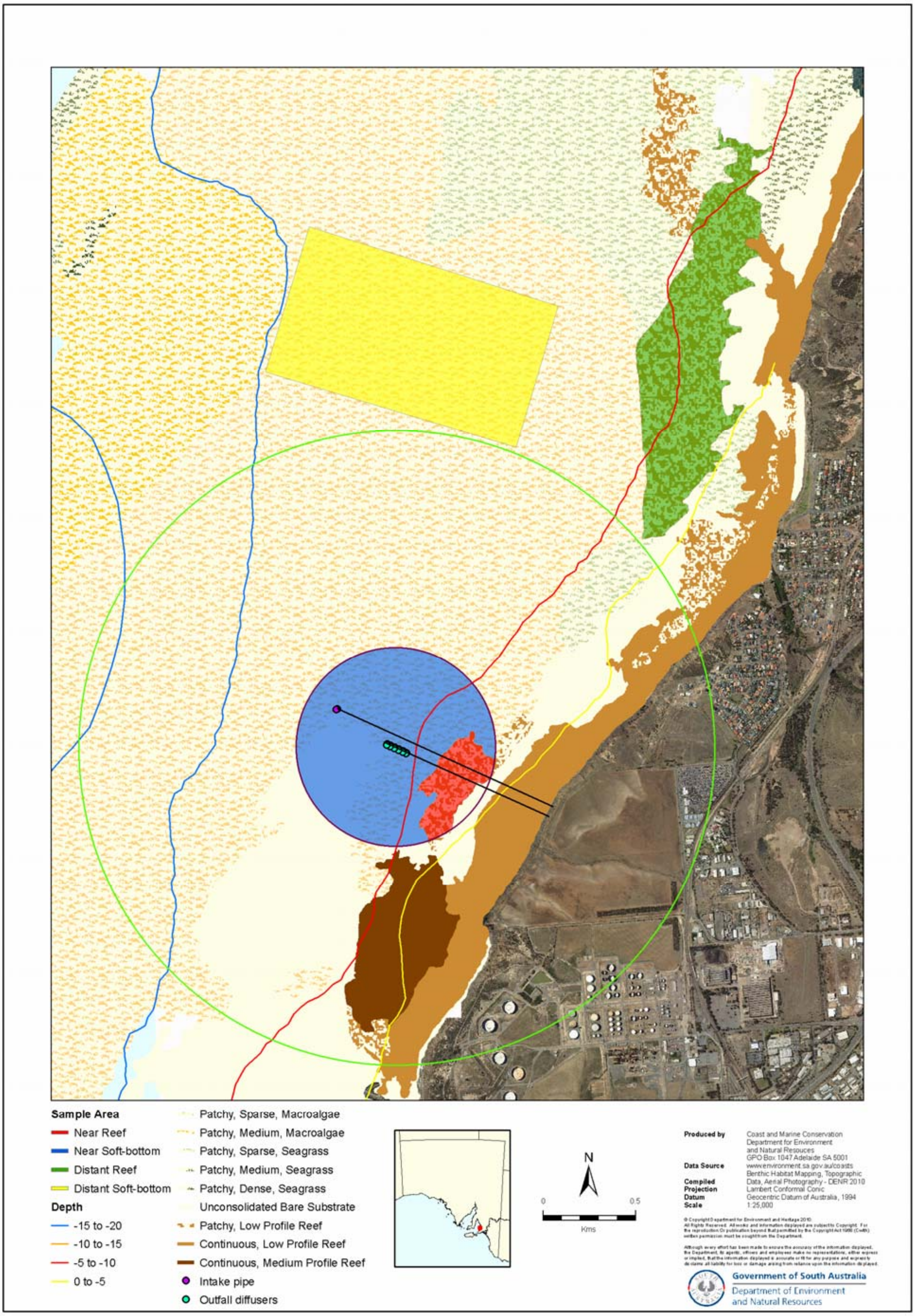


Figure 1: **Port Stanvac survey area showing BRUVS sampling areas and predicted dilution contours, 50:1 (inner red circle) and 100:1 (outer green circle), in relation to the outfall, and intake pipes.**

BRUV systems

Each BRUV system (Figure 2) consists of two video cameras orientated along a horizontal plane relative to the sea-floor. The cameras are fitted with 0.5x wide angle lenses and attached to a steel frame. The BRUVS are linked to the sea-surface via a floating rope and buoy system. Canon HV30 high definition and Sony DCR-HC52 standard definition camcorders are mounted within custom made high-density PVC housings with clear acrylic viewing ports. A bait bag containing ~ 800 grams of mashed pilchards (*Sardinops* sp.) was mounted on a pole, 1.5 m in front of the cameras. The pilchards create an odour plume which serves as an attractant.

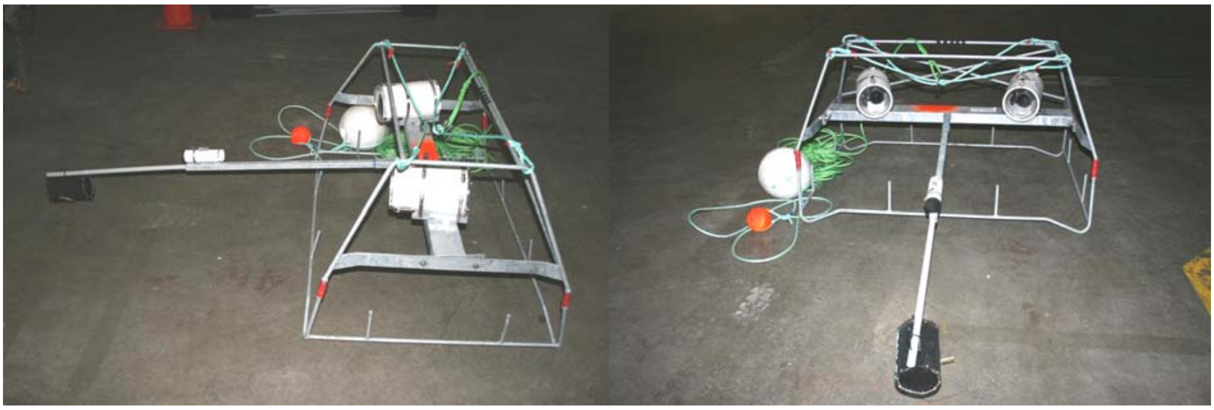


Figure 2: BRUVS unit used for fish surveys (side and front views).

Prior to field use, all stereo BRUVS are calibrated in a swimming pool and the data processed using SeaGIS *Cal* software (http://www.seagis.com.au/bundle.html). Calibration ensures accurate length measurements can be made during video analysis (Harvey *et al*. 2001; 2003; Shortis *et al*. 2007). Fish measurements were made up to a range of ~4 m from the cameras. Beyond this distance, precision and accuracy decrease significantly. Limiting observations to this distance also serves as a form of standardisation to compensate for variations in visibility due to water quality.

Deployment

During each sampling season, six BRUVS were deployed at each of the four study sites, in daylight hours, over two consecutive days. Three BRUVS were deployed on each site on each day, with the deployment order being reversed on the second day so that sampling times for each site/habitat type were comparable.

BRUVS units were deployed in groups of 3 with an average time separation of between 5 and 10 minutes. Typically, they were placed a minimum of 200m apart where possible to avoid the bait plume for one unit influencing the response of fish at another unit, and to achieve a level of independence between samples. Each BRUVS was lowered to the seafloor and left to record 60 minutes of footage before retrieval. Recordings with a full field of view were kept for analysis.

Sampling occurred in September (Winter) & November (Spring) 2009, and February (Summer) & May (Autumn) 2010. Nearly all samples were accepted except for those on the Reef habitat during the Winter sampling period where the visibility was poor and a number of samples were thus unusable. This was caused by a well-defined band of extremely turbid water which was observed near-shore at the survey site and enveloped much of the Reef habitat. This turbidity resulted from the combined effect of a period of extended rainfall, high winds, and a discharge of water from a holding pond on the Port Stanvac desalination plant construction site. This event resulted in a relative paucity of data for Reef sites for the Winter sampling period.

Video analysis

Video footage was analysed to produce species abundance and length data. Footage from the right-side camera was analysed using SeaGIS *EventMeasure* software (http://www.seagis.com.au/event.html) to identify fish and estimate abundance. Fish identification was carried out with the aid of reference books (Gomon *et al.* 2008, Edgar 2008, and Kuiter 2001).

The total number of individual fish (for each species/taxa) observed in a single frame throughout the duration of a single sample recording is given as a *MaxN* value. *MaxN* should be considered a conservative estimate of abundance, particularly where large numbers of fish are present. This technique of estimating abundance has been reviewed in detail by Cappo *et al.* (2003, 2004) and Willis *et al*. (2000).

Fish length measurements were obtained from paired stereo images using SeaGIS *PhotoMeasure* software (http://www.seagis.com.au/photo.html). Associated files from *EventMeasure* software (which is used to provide *MaxN* abundance values) are loaded into *PhotoMeasure*. The time coordinates from the event file are used to locate the point in the video where the *MaxN* event occurred for each species. All length measurements for each species are performed at this point in time for each sample, preventing fish being measured twice.

Fish were measured using fork length rather than total length. Fork length is a more accurate measure which reduces potential errors resulting from fin damage. Some fish such as those belonging to the Labridae and Monacanthidae families do not have a forked tail and so standard length was used. These measures were applied to all fish except for the rays, belonging to the genera *Dasyatis* and *Trygonorrhina,* where the disc length was measured instead.

Statistical analysis

Statistical analyses were performed separately for the two habitat types to reduce the overall variability in the dataset and thus increase the ability to discriminate between seasons and treatments. Data for each season within each habitat were analysed using the multivariate statistical package *PRIMER* v.6 (Plymouth Marine Laboratories).
The null hypothesis of no difference in assemblage structure between treatments and between seasons was tested using a two-way crossed analysis of similarities (ANOSIM). Pairwise tests between seasons and treatments were also performed and the Bonferroni correction applied to the Significance level to determine significance.

A Bray-Curtis dissimilarity matrix, based on square-root transformed data, was used to generate a multidimensional scaling (MDS) ordination plot to visually depict variation in assemblage structure (Clarke 1993) across treatments and seasons.

Taxa responsible for driving dissimilarity in fish assemblages between site and seasons were determined using the SIMPER routine in *PRIMER*. A cut-off point of ≥ 5% contribution to dissimilarity and a “Diss/SD” (Average contribution to dissimilarity/Standard deviation) ratio value >1 were used to identify taxa that were consistently important in differentiating between treatments, and seasons. A “Diss/SD” ratio value >1 indicates that a given taxa is consistently important in its contribution to dissimilarity between samples in the two groups (eg Distant versus Near; Clarke and Gorley 2006).

Fish length data for those fish taxa found to be important in determining differences between treatments (Near and Distant) and seasons in the above analysis were also examined by averaging length data based on treatment and season. The authors recognise that there is no relevant link between abundance effects (which are examined above) and any effects that may be evident in the length data. Therefore, the selection of these taxa for reporting is arbitrary. However, as the dataset grows through time, patterns relating to saline concentrate discharge may become evident and other taxa become relevant to this analysis. A full set of length data is available in the appendices.

Results

Fish Communities in the Pt Stanvac area.

Approximately 53 species of fishes, belonging to 28 families were detected in the vicinity of Port Stanvac over 4 seasons. These included 6 species of Chondrichthyes (cartilaginous fishes) representing 6 families, and 47 species of Actinopterygii (ray-finned fishes) representing 22 families. The Chondrichthyes sampled consisted of 2 species of rays and 4 species of sharks. The most speciose families overall were Monacanthidae and Labridae.

The rate at which taxa accumulate over the deployment period is used to confirm that deployment times are appropriate. Accumulation times in this study were similar in Summer, Autumn and Spring, and were beginning to level out by 60 minutes, which while not ideal (a flat top to the curve indicates all species are being captured), suggests the majority of taxa are being captured in sampling (Figure 3). In spring there is an apparent sharp rise in the number of species after 55 minutes (and to a lesser degree in Summer) which potentially contradicts this conclusion. However, this relates to a small number of deployments in those seasons where large individuals (sharks and rays) came in late and vigorously agitated the bait leading to an increase in the bait plume being released into the water column (resulting in a subsequent rise in the number of visitors to the bait). This tends to be a relatively random event (i.e. it could happen at any time during a deployment), is unavoidable, and not consistent with the general pattern observed. Logistically, we are currently limited by the length of the recording media (i.e. 60 min. tapes), therefore the current 60 minute deployment is still favoured and if necessary more samples could be considered in the future to overcome this (although this would entail extra field and processing costs).

In Winter, the accumulation curve is less ideal with fewer genera being sampled overall. Probably due to the poor conditions (explained above) experienced during that sampling period and which resulted in an incomplete sample set. However, the possibility that accumulation rates may differ in winter needs to be kept in mind and this question can be resolved when results from the next Winter sampling become available.

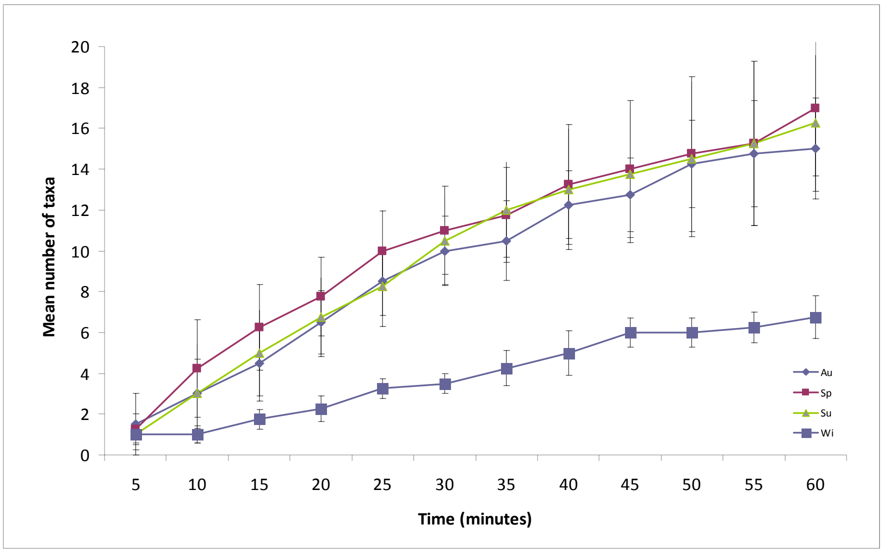


Figure 3: Seasonal accumulation curves of genera taken from data across all sites from 0-60 minutes. Au = Autumn, Wi = Winter, Sp = Spring, Su = Summer.

A total of 2743 fish was observed from the pooled *MaxN* data over four seasons. The most consistently abundant genera across sites were *Parequula, Heterodontus, Pseudocaranx* and *Sillago.*

Image quality and morphological similarities between species resulted in a number of individuals only being identified to genus level. These were:

Pseudocaranx spp. – possibly *P.georgeanus* or *P. wrighti*

Platycephalus spp. – *P. bassensis, P. speculator* or *P. aurimaculatus*

Aracana spp. – *A. aurita* or *A. ornata*

Sillago spp. – probably *S. bassensis* but could also be *S. schomburgkii*

Acanthaluteres sp. – probably *A. spilomelanurus*

Trachurius sp. – possibly *T. declivis*

Meuschenia spp. - many

Notolabrus sp. – probably *N. parilus*

In addition, the following were only reliably identified to family level:

Monacanthidae (leatherjacktes: sp, sp1, sp2) – difficult to differentiate using video alone due to morphological similarities.

Clupeidae – many

Sillaginidae – either *Sillaginodes* or *Sillago*

As a result, much of the analyses were carried out at the genus level. Due to the functional similarity of fish at this taxonomic level, the ability to discriminate differences between seasons and treatments is unlikely to be affected. Those listed at family level were included in the analyses at that level.

Multivariate Analysis of Fish community assemblages at Pt Stanvac

This study aims to detect differences between the sites inside (Near) and outside (Distant) of the predicted saline concentrate area after desalination begins. The two habitat types found at Port Stanvac (Soft-bottom and Reef) were found to be statistically different from one another (1 way ANOSIM, $R = 0.188$, $P=0.0001$) and as a result, further analyses were carried out on individual habitats rather than the complete dataset. In taking this approach we sought to reduce the dataset and therefore the variability that relates to different habitat types. In this way it is hoped we could achieve more power to discriminate possible differences between the sites inside and outside the saline concentrate zone.

Soft-bottom Habitat

There was no difference between treatment sites (Near versus Distant from the zone of influence of the saline concentrate) within Soft-bottom habitats (Table 1A). Samples appeared variable and interspersed in the MDS plot for these sites (Figure 4A). Seasonal differences were however apparent for sites within this habitat type (Table 1B). Pairwise comparisons suggest these differences are largest between Summer and Winter, and Summer and Spring (Table 2).

While statistically different, the dissimilarity between fish assemblages through seasons in the Soft-bottom habitats was difficult to link to specific taxa. SIMPER analysis (which aims to identify taxa driving similarity within, and differences between sites) of the Spring/Summer and Winter / Summer comparisons found almost no taxa that consistently contributed to differences between these seasons (Table 4A). The lack of consistent contributors to these differences may suggest this seasonal pattern is not particularly strong.

Reef Habitat

The same seasonal differences were apparent for the sites located in Reef habitat (Table 1B) with pairwise comparisons indicating differences between fish assemblages in Winter compared to Autumn, Spring and Summer respectively for this habitat type (Table 2; although if the more conservative Bonferroni corrected significance level is used the Spring/Winter difference is not significant). Unlike comparisons for the Soft-bottom habitat, a number of taxa were consistent drivers of the differences observed (Table 4B). *Parequula* (Silverbelly) contributed significantly to the differences between all three seasonal comparisons with lower numbers being recorded in Winter than for the other months (Table 4B, Figure 7). In addition, for the Autumn / Winter comparison *Torquigener* (Toadfish) and *Aracana* (Cowfish) proved important, with both being less abundant in Winter.

A more important observation was that for Reef habitat, the Near and Distant sites were significantly different (Table 1A). This is also true for all seasons bar Winter (Table 3; although if the more conservative Bonferroni corrected significance level is used there is no significance in Spring). Evidence of this difference is also seen in the multivariate plot of Reef data (Figure 4B) with many of a majority of Near data points ordinating to the left of the plot and Distant points group to the right (with the exception of the Winter points where the opposite was the case).

Parequula (Silverbelly) and *Torquigener* (Toadfish) were consistent contributors to the differences between the Near and Distant sites (Table 4A) Numbers of *Parequula* were relatively high at the Impact / Near sites for all seasons except Winter, while *Torquigener* numbers were higher at the Distant sites (mainly in Spring and Autumn; Figure 7).

Table 1: Results of ANOSIM showing the significance of differences in assemblage structure between treatments (Near and Distant) and seasons. Significance where *P* < 0.05

	Soft-bottom sites	Reef sites
A. Treatments across all season groups		
Sample statistic (Global *R*)	0.125	0.458
Significance level of sample statistic (*P*)	0.052	**0.002**
B. Seasons across all treatment groups		
Sample statistic (Global *R*)	0.157	0.253
Significance level of sample statistic (*P*)	**0.006**	**0.0008**

Table 2: Pairwise tests showing significance between specific seasons across all treatments for Reef and Soft-bottom habitats. All comparisons are significant at *P* <0.05 and comparisons marked Y are significant when Bonferroni correction is applied (a more conservative level often used for pairwise comparisons (in this case *P* < 0.08). Wi = Winter, Sp=Spring, Su=Summer, and Au = Autumn.

Pairwise tests for differences between Seasons across all Treatment groups

	Groups	*R* statistic	*P*	Sig Bonf.Cor.
Soft-bottom	Su, Wi	0.394	**0.005**	Y
	Sp, Su	0.196	**0.035**	N
Reef	Au, Wi	0.618	**0.0006**	Y
	Su, Wi	0.421	**0.005**	Y
	Sp, Wi	0.388	**0.009**	N

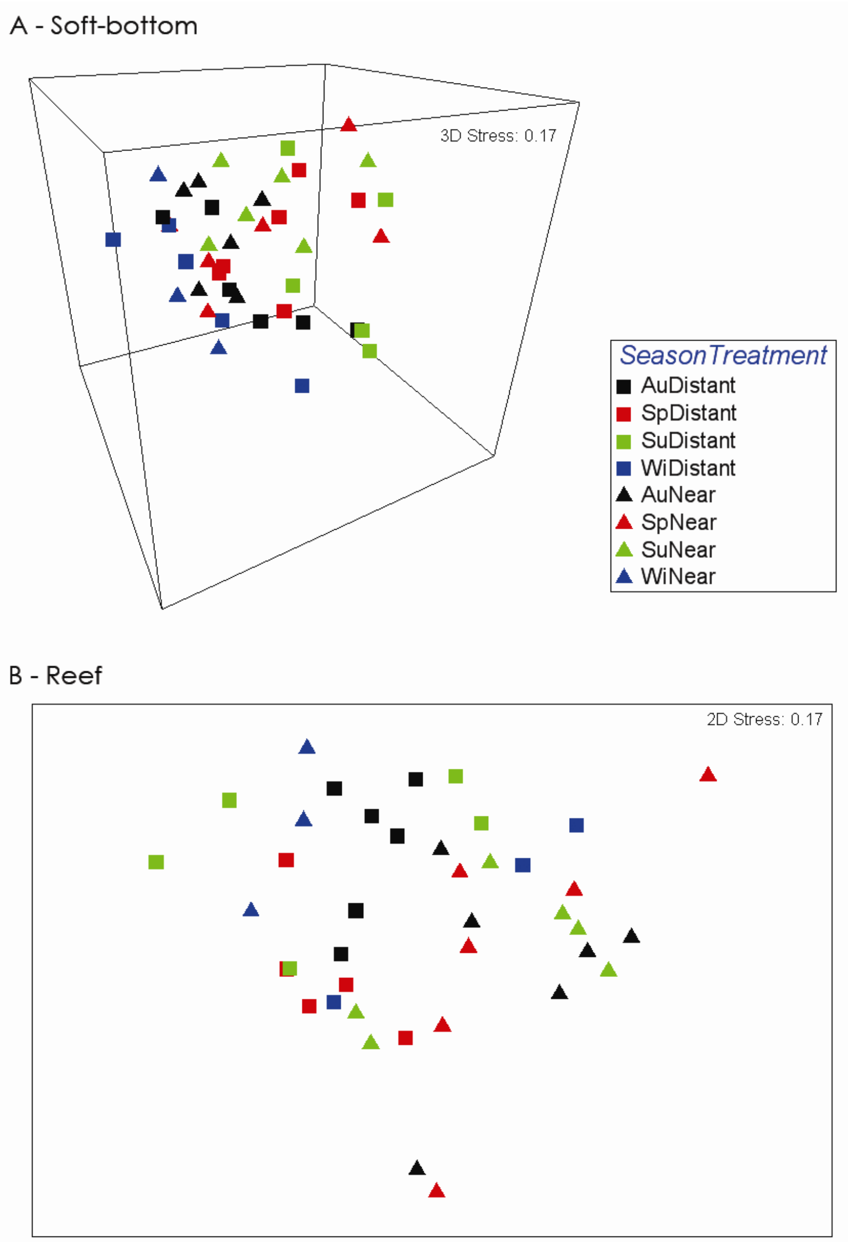


Figure 4: MDS plots visually depicting differences between treatments and seasons for Reef and Soft-bottom sites. Wi = Winter, Sp = Spring, Su = Summer, and Au = Autumn.

Table 3. Pairwise comparison for Near versus Distant sites for Reef habitat. Bold '*P*' values denotes significance (Bonferroni significance level, 0.0125). Wi = Winter, Sp = Spring, Su = Summer, and Au = Autumn.

Pairwise tests for differences between treatments within seasons in Reef habitat				
Groups		*R* statistic	*P*	Sig Bonf.Cor.
WiDistant, WiNear	0.296	30.00	N	
SpDistant, SpNear	0.371	**0.013**	N	
SuDistant, SuNear	0.393	**0.019**	Y	
AuDistant, AuNear	0.612	**0.002**	Y	

Table 4: (A). Major contributing taxa identified by SIMPER analysis to dissimilarities between seasons across Reef and Soft-bottom habitats; (B). Pairwise tests between Near & Distant sites for each season. δ/SD = dissimilarity divided by standard deviation of the dissimilarity; δ% = % contribution to the dissimilarity. Species with values highlighted in bold are consistent contributors.

A

REEF		**Distant vs Near**		
Genus	Control Av. Abun.	Impact Av. Abun.	δ/SD	δ%
Torquigener	1.47	0.45	**1.25**	10.82
Parequula	0.51	1.49	**1.09**	11.82
Pseudocaranx	2.51	0.79	0.78	15.18
Chrysophrys	0.00	0.88	0.67	5.77
Sillago	0.53	1.06	0.66	8.56
SOFT-BOTTOM				
Heterodontus	0.98	1.14	0.92	7.26
Aracana	0.56	0.48	0.86	6.41
Arripis	0.00	1.73	0.75	11.71
Platycephalus	0.47	0.54	0.75	6.26
Sillago	0.94	0.50	0.73	9.06
Parequula	0.79	0.65	0.64	9.37
Pseudocaranx	1.59	1.11	0.63	11.46
Upeneichthys	0.51	0.11	0.55	5.20

B

Reef	Autumn vs Spring		Autumn vs Summer		Autumn vs Winter		Spring vs Winter		Spring vs Summer		Summer vs Winter	
Taxon	δ/SD	δ%	δ/SD	δ%	δ/SD	δ%	δ/SD	δ%	δ/SD	δ%	δ/SD	δ%
Aracana	1.10	6.4	1.11	7.05	1.02	7.22						
Parequula					1.31	15.90	1.36	12.75			1.14	14.11
Torquigener					1.14	10.36						

Relative abundance and species richness across seasons, habitat and treatments

The mean numbers of individual fish and number of taxa (richness) were generally variable (particularly individual numbers) and differences were evident between habitats, season and Near/Distant of the saline concentrate zone in some sites (Figure 5). Spring and Summer had the highest number of individuals and values were quite variable for the Soft-bottom sites. Spring, Summer and Autumn had the highest number of species relative to Winter (Figure 5). The mean number of individuals was low in Winter for both richness and abundance.

These two indices differed between Reef and Soft-bottom habitat types at several location/times. This was apparent for species numbers at both treatment sites during Spring sampling. The mean number of individuals appeared different between habitats in Winter at the Distant site (Figure 5)

There were no obvious differences between Near and Distant sites in terms of the number of taxa, however there was a difference between the mean number of individuals between Near and Distant sites in the Reef habitat during Winter and Spring (with numbers appearing lower at the Near site; Figure 5). It was difficult to detect other differences in mean numbers due to high variability in this index.

Mean abundances for individual taxa for each season and habitat showed no clear patterns (Figure 6, Figure 7). As this is a baseline survey there is little need for further interpretation at this stage.

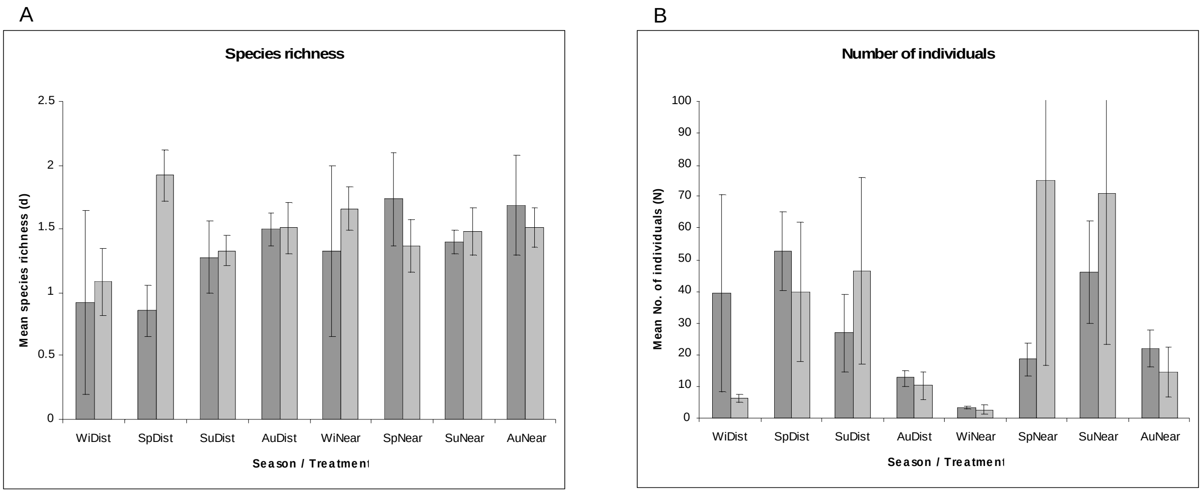
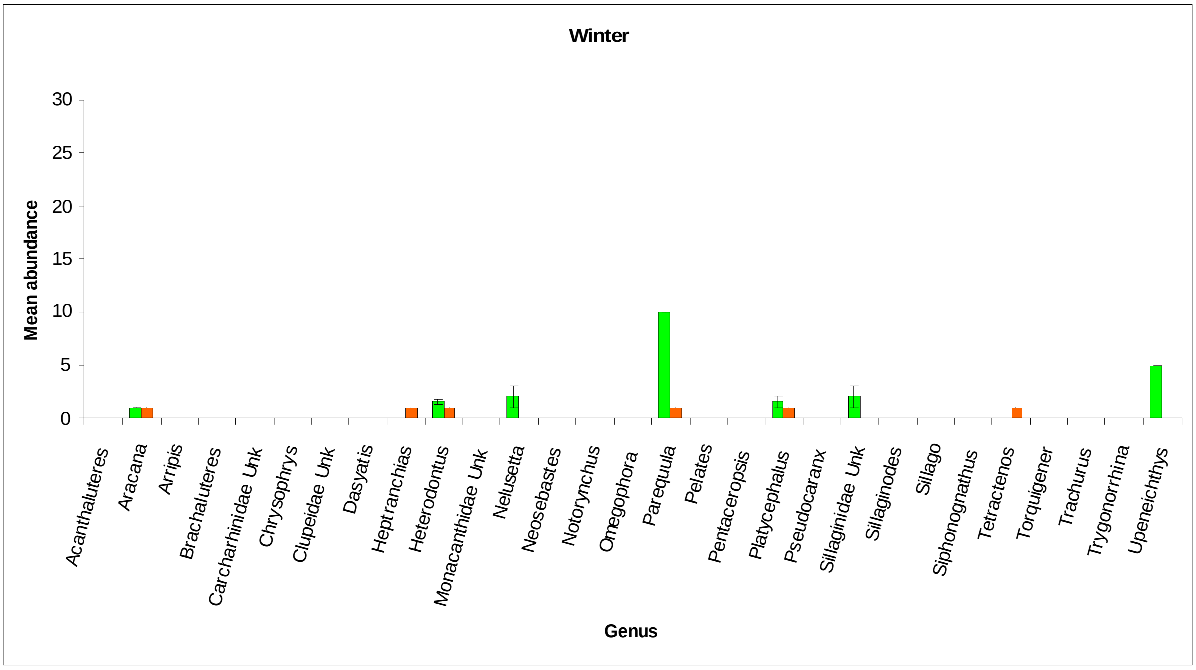
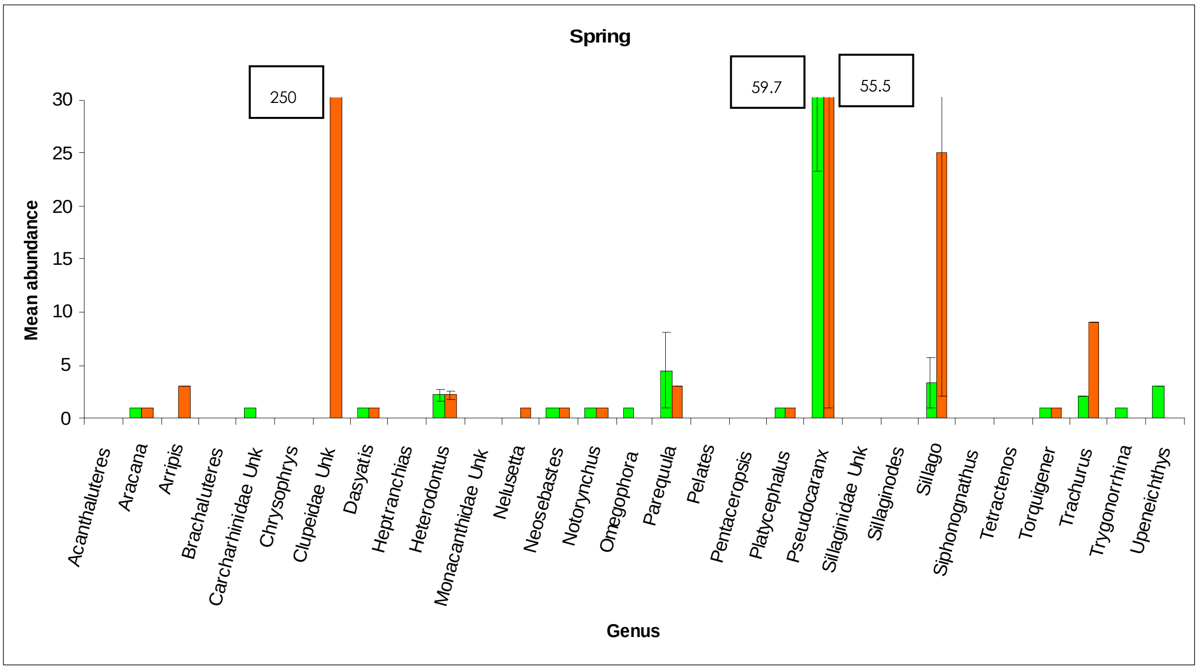
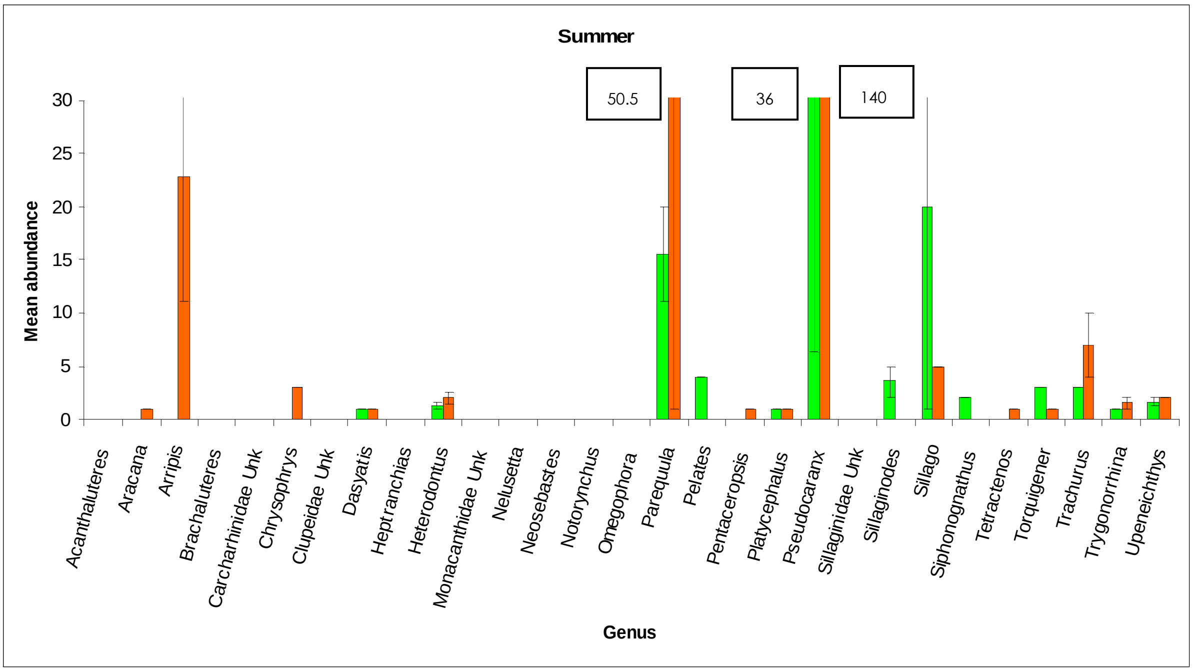


Figure 5: Mean species richness and number of individuals found seasonally at each each site. Wi = Winter, Sp = Spring, Su = Summer, Au = Autumn, Dist = Distant. Light grey bars = Soft-bottom, Dark grey bars = Reef.


Winter
Mean abundance
30
25
20
15
10
5
0
Acanthaluteres
Aracana
Arripis
Brachaluteres
Carcharhinidae Unk
Chrysophrys
Clupeidae Unk
Dasyatis
Heptranchias
Heterodontus
Monacanthidae Unk
Nelusetta
Neosebastes
Notorynchus
Omegophora
Parequula
Pelates
Pentaceropsis
Platycephalus
Pseudocaranx
Sillaginidae Unk
Sillaginodes
Sillago
Siphonognathus
Tetractenos
Torquigener
Trachurus
Trygonorrhina
Upeneichthys
Genus


Spring
250
59.7
55.5
Mean abundance
30
25
20
15
10
5
0
Acanthaluteres
Aracana
Arripis
Brachaluteres
Carcharhinidae Unk
Chrysophrys
Clupeidae Unk
Dasyatis
Heptranchias
Heterodontus
Monacanthidae Unk
Nelusetta
Neosebastes
Notorynchus
Omegophora
Parequula
Pelates
Pentaceropsis
Platycephalus
Pseudocaranx
Sillaginidae Unk
Sillaginodes
Sillago
Siphonognathus
Tetractenos
Torquigener
Trachurus
Trygonorrhina
Upeneichthys
Genus



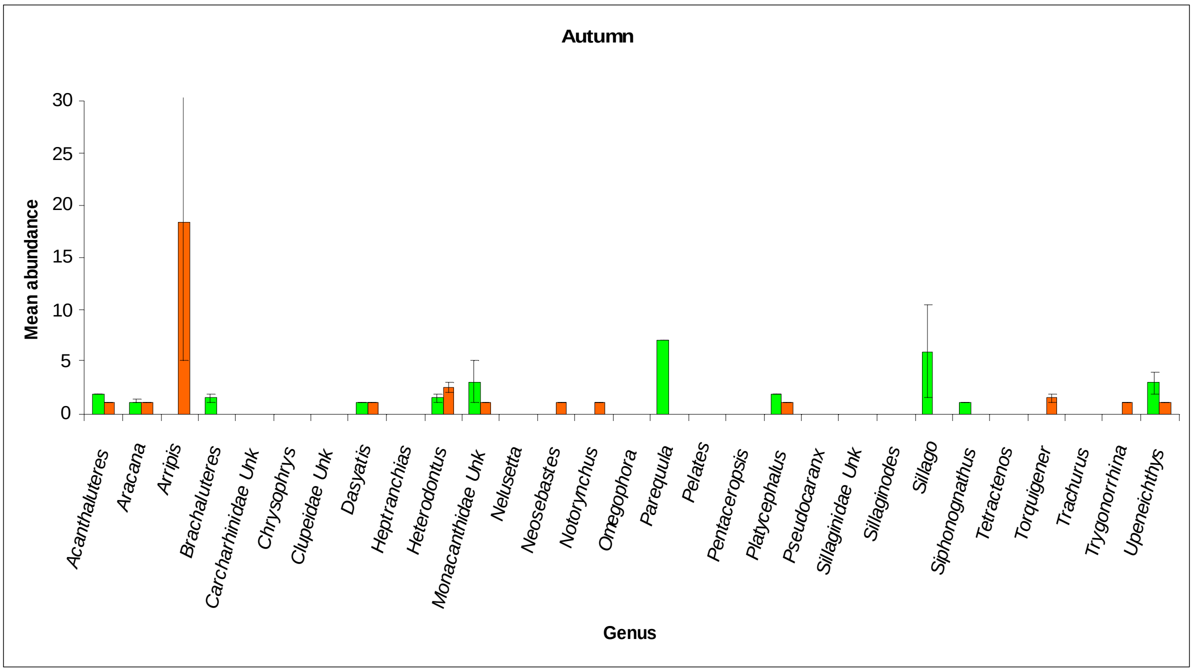
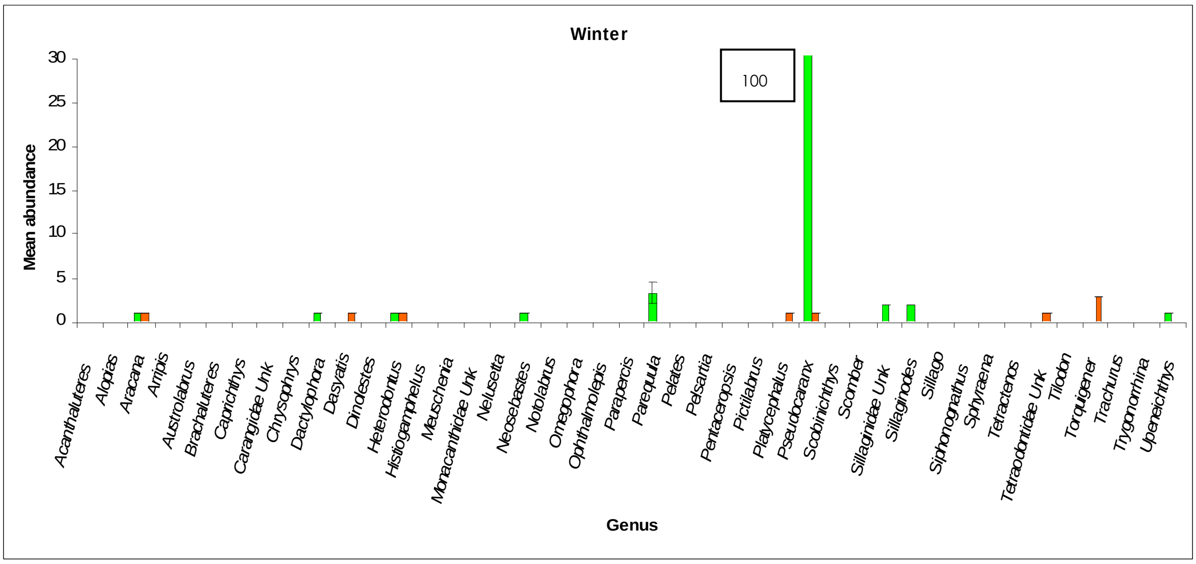


Figure 6: Seasonal relative mean abundance (and standard error) of genera between Distant and Near sites within Soft-bottom habitats (orange = the Near outfall site and green = the Distant site). Values in box denote the value for graph bars that have been cut short due to the scaling of the Y axis.


Winter
Mean abundance
Genus
100
Acanthaluteres
Alopias
Aracana
Arripis
Austrolabrus
Brachaluteres
Caprichthys
Carangidae Unk
Chrysophrys
Dactylophora
Dasyatis
Dinolestes
Heterodontus
Histiogamphelus
Meuschenia
Monacanthidae Unk
Nelusetta
Neosebastes
Notolabrus
Omegophora
Ophthalmolepis
Parapercis
Parequula
Pelates
Pelsartia
Pentaceropsis
Pictilabrus
Platycephalus
Pseudocaranx
Scobinichthys
Scomber
Sillaginidae Unk
Sillaginodes
Sillago
Siphonognathus
Sphyraena
Tetractenos
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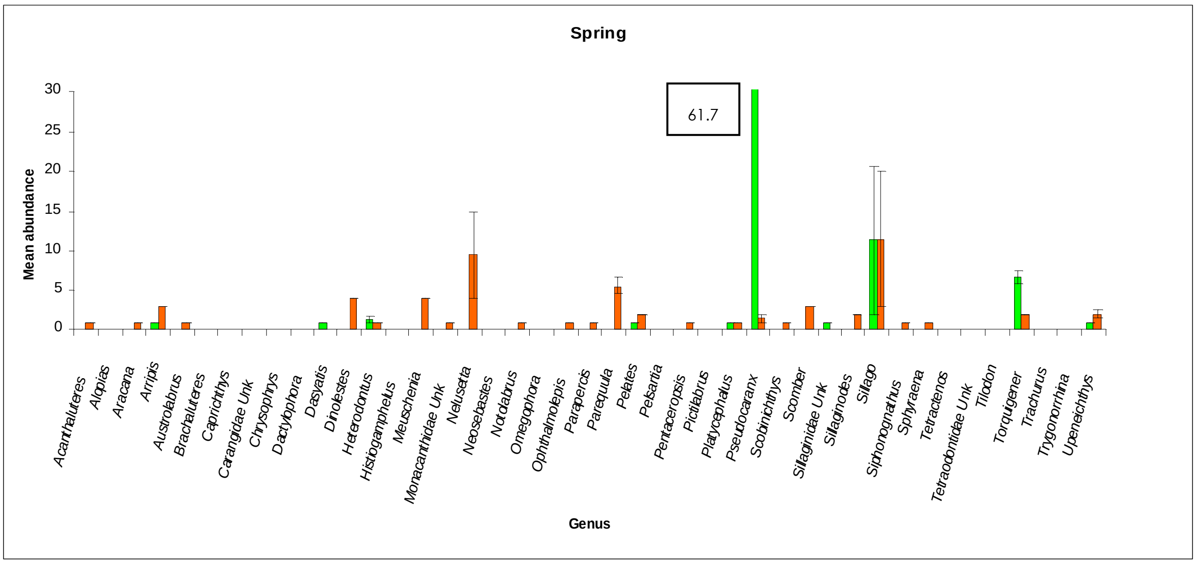
Tilodon
Torquigener
Trachurus
Trygonorrhina
Upeneichthys


Spring
Mean abundance
Genus
61.7

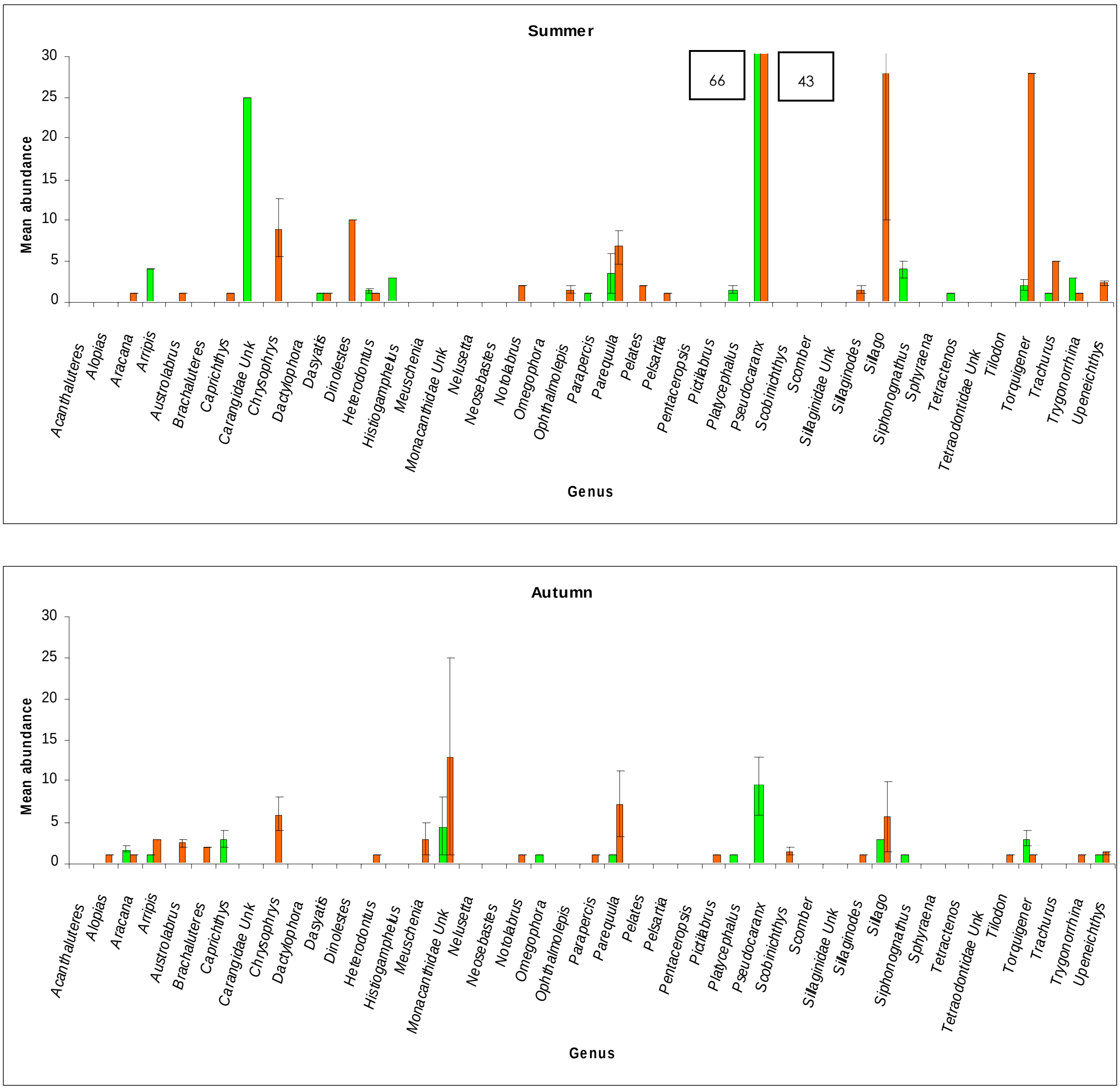


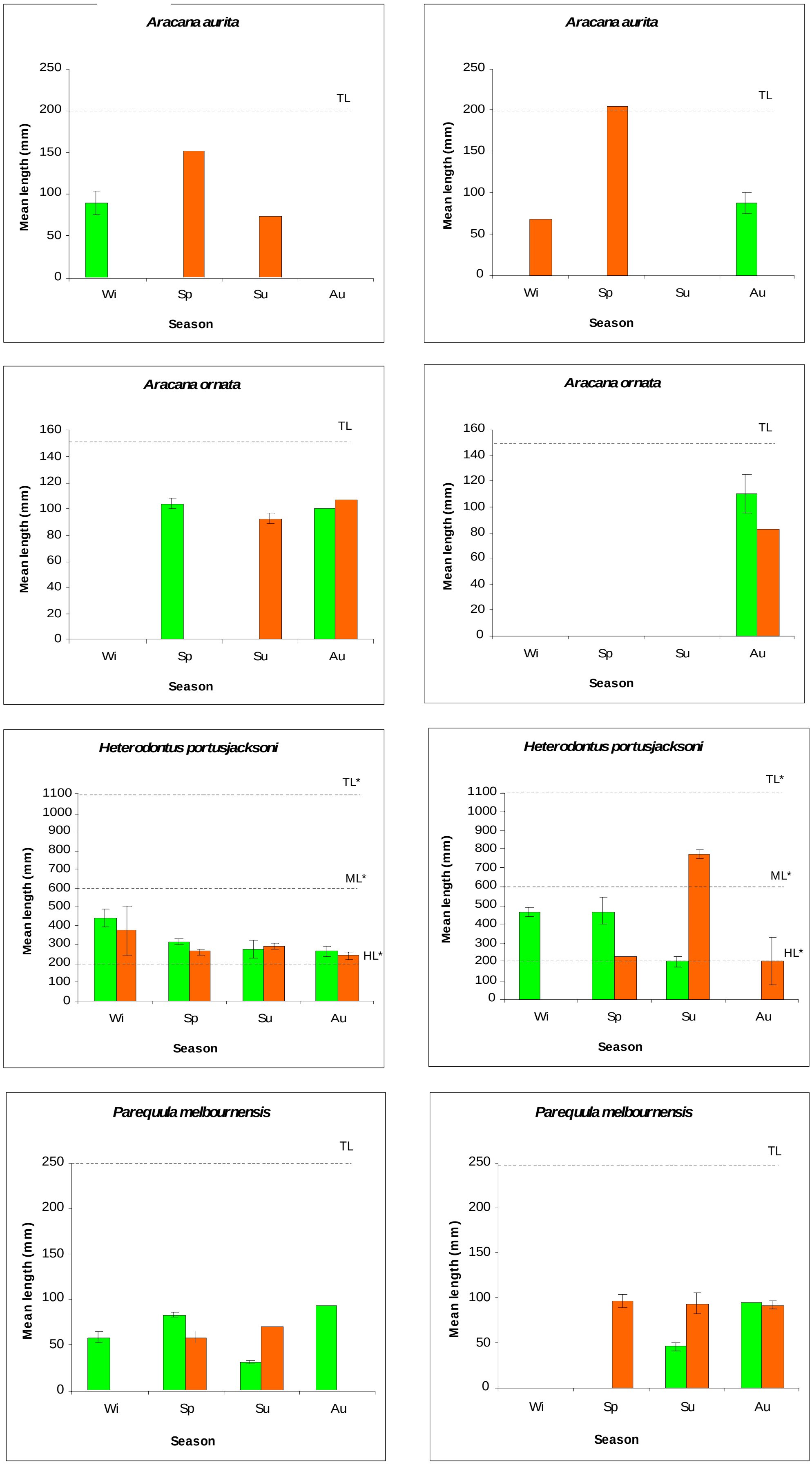
Figure 7: Seasonal relative abundance of genera between Distant and Near sites within Reef habitats (orange = Near outfall site and green = Distant site). Values in boxes denote the value for graph bars that have been cut short due to the scaling of the Y axis.

Fish lengths

A total of 641 fish were measured during this survey representing 34 genera. Six species were identified as being important in consistently contributing to differences between seasons and treatments (Table 3; Table 4; Figure 8). See the methods section for justification of the use of these taxa. Overall, fish length data was quite variable. No consistent patterns were observed in the length data between Near and Distant sites.

Some interesting patterns were however observed for *Heterodontus portusjacksoni* (Port Jackson sharks). Lengths for this species were more consistent on soft habitat and variable on Reef. In soft habitats seasonal variation was evident with larger individuals present during Winter and numbers throughout the year being consistently below the age of maturity (Figure 8; approximately 550-600mm, Rodda pers. comm. 2010) suggesting this habitat is important for juveniles and sub-adults. Larger individual were recorded around the Reef site which is where this species could lay eggs.

Soft-bottom | Reef



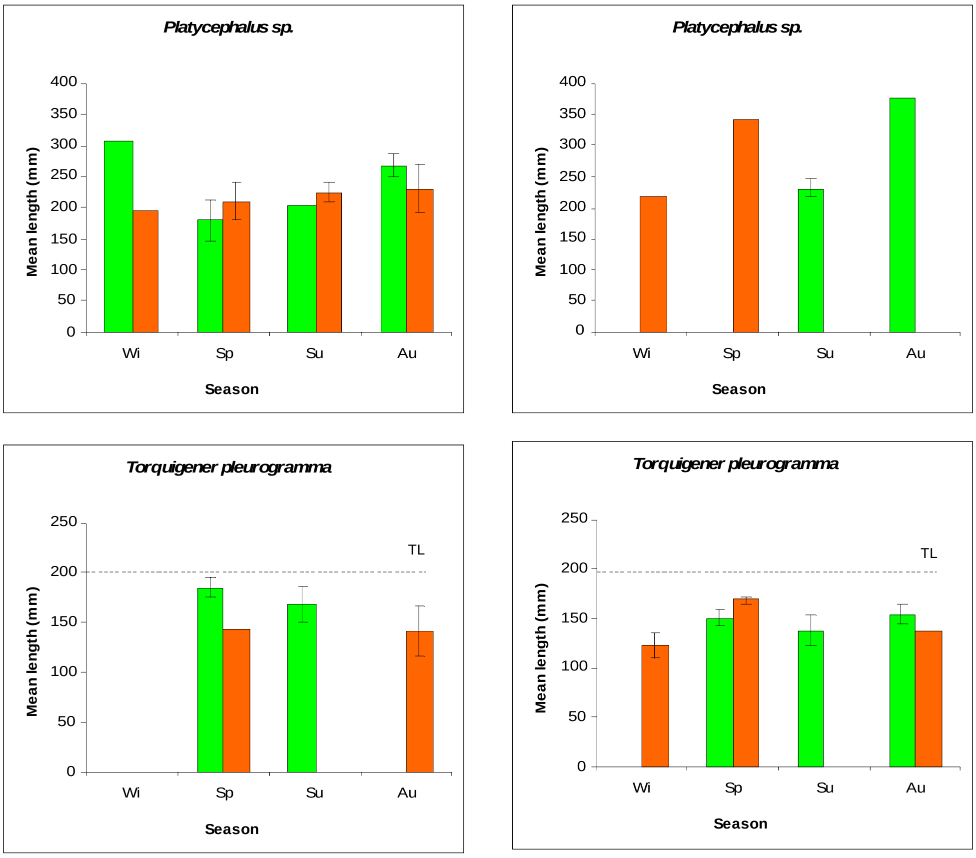


Figure 8: Mean lengths of targeted taxa and maximum adult lengths. green = Distant, orange = Near. TL = Total Length (Gomon *et al*, 2008). TL* = Total Length, ML* = Mature Length, HL* = Hatchling Length (* apply to *H. portusjacksoni* only and are based on *Pers Comm.* K Rodda of SARDI)

Discussion

There is a paucity of literature addressing the effects of brine discharge from desalination plants on fish community assemblages, possibly making this study unique. This survey has produced data on the fish communities around the Port Stanvac desalination plant which will form a baseline against which future data can be compared after the plant becomes operational.

This study has produced a diverse list of taxa present at the study site; however, results need to be considered in the context of the BRUVS technique. This technique seeks to attract fish using bait and so consideration needs to be given to the fish species that are likely to be attracted versus those that are not. That said, a greater proportion of the fish observed did not feed (rather came to investigate the activity occurring). This has also been observed by other authors (Cappo *et al* 2003, Watson *et al* 2005), and suggests it is safe to assume that the assemblage being sampled is far broader than those that would feed only.

The dataset collected in this study contains considerable variability, both spatially and temporally. This is evident in both the abundance data and the small number of clear differences between seasons, sites and treatments seen in the multivariate analyses. Several factors could explain this, although due to their high mobility, variability is not uncommon in fish community datasets.

These include factors such as the effect of tide and current on bait plumes, as well those relating to the nature of the habitats being sampled. The Reef sites overall displayed higher variability than the Soft-bottom sites and many of the species overlapped these habitats. The Soft-bottom habitat sampled in this survey generally had algal cover while the Reef habitat was generally patchy, low reef with algal cover. As such, both habitat types (and particularly the Reef habitat) rather than representing the extremes of their type, may represent transition habitats. At Port Stanvac where higher profile reef exists inshore, it may be that the patchy reef surveyed in this study is in fact a ‘mixing zone’.

Despite the underlying variability and patterns, assuming no impact has occurred thus far (for example, resulting from construction activities or other influences in the general area), detection of the potential impact of the saline concentrate can be achieved by overlaying any potential new states for the fish assemblages in the area, with this datatset representing the background “noise”. That is to say, what has been observed in this study represents the background spatial patterns and any potential future observed effect would represent an interaction with the effect of the saline concentrate.

This study found differences in fish assemblages both between seasons (for both habitat types) and between the sites, near the outfall, and those at Distant sites within the Reef habitat (except in Winter). Overall however, there was a paucity of consistent drivers for these differences. *Heterodontus* (Pt Jackson sharks) stood out as an indicator of seasonal and habitat differences with higher numbers in the soft habitats. Two other taxa stood out as seasonal drivers for reef habitat, namely *Paraquula* (Silverbelly) and *Torquigener* (Toadfish) which were both lower in abundance in Winter, although this result needs to be considered in the context of the lower visibility and resultant truncation of the dataset for that season.

The same two taxa were the only consistent drivers for differences between the Near and Distant sites (in the Reef habitat) although it is unclear why and in the context of a “baseline” this can only be looked at in the context of background spatial variability. Only when an effect that can be related to the saline concentrate discharge is observed, can possible mechanisms be surmised. It should also be noted that it is likely that while the taxa mentioned above are the important drivers with respect to the community patterns currently observed, it is likely that different taxa will be important in demonstrating any impacts in the future.

Summer and Winter appear as extremes for how the fish communities appear. The highest abundances appear to be in Summer and the lowest in Winter (although this could relate to the more limited dataset). Taxa richness is lowest in Winter and high in Summer although it is also high in Spring and Autumn but this is not surprising since mixing of Summer and Winter species would be expected in those seasons.

Overall, fish lengths provide little interpretable information at this point. Until a longer-term dataset is available it is not possible to choose which taxa would be relevant in an examination of potential effects of saline concentrate discharge. For this report, the authors provide data on taxa of important in driving differences in abundance patterns. However, we recognise that this index has little relevance to fish length data. A full set of length data is available in the appendices.

Nonetheless, one species stood out as displaying interesting patterns relating to season and habitat, namely *Heterodontus portusjacksonii* (Port Jackson sharks). Many juvenile sized *H. portusjacksoni* were observed in this area suggesting it may be a nursery area for this species. *H. portusjacksoni* lay their eggs in reef and there are a number of sites both immediately adjacent (the shallower reefs in-shore of the survey sites, and further afield (e.g. Christies, Noarlunga and Hallett Cove reefs) which may provide suitable habitat for breeding and egg laying.

Conclusion

This study found a diversity of fish species at the Port Stanvac marine site. These were associated with habitat type, spatial patchiness and seasonal variation. Fish length information was also highly variable and showed no readily apparent patterns. The dataset from this study (taking account for the inherent background variability) will now form a baseline against which to compare fish community assemblages observed once the desalination plant begins operation.

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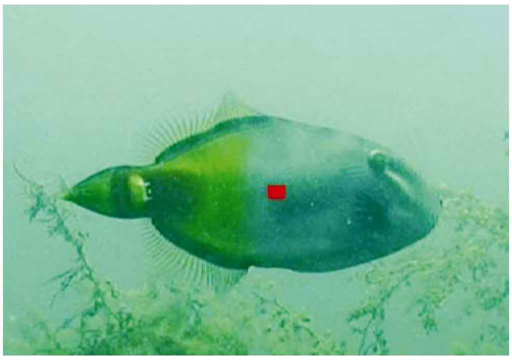
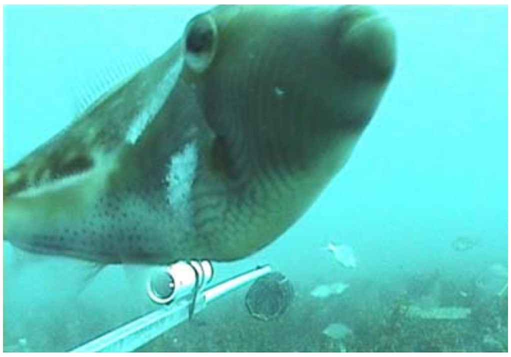
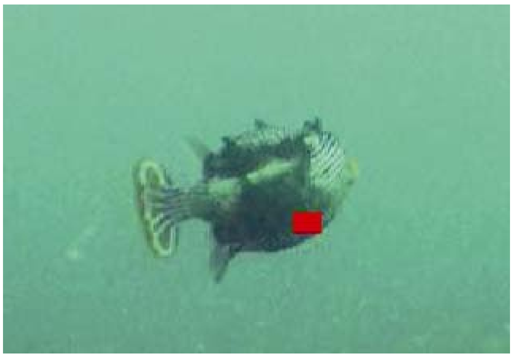
Appendix A. Still images of fish species identified in the Port Stanvac area.



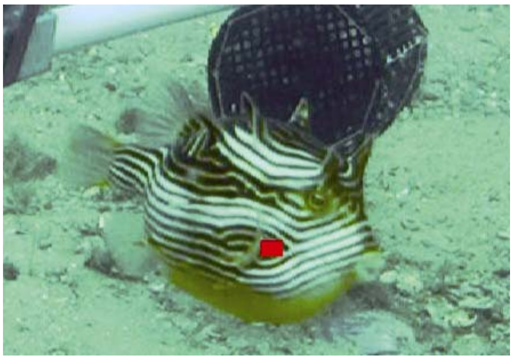
Acanthaluteres brownii



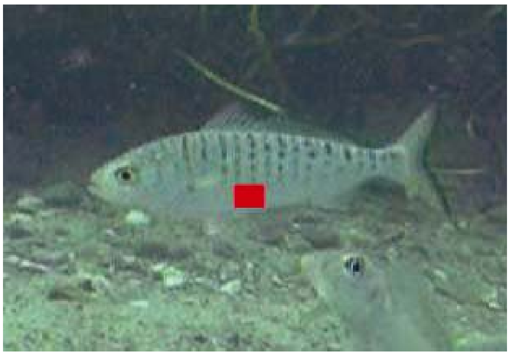
Acanthaluteres vittiger



Aracana ornata

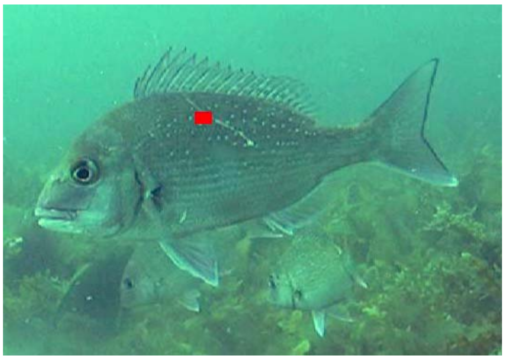


Aracana aurita

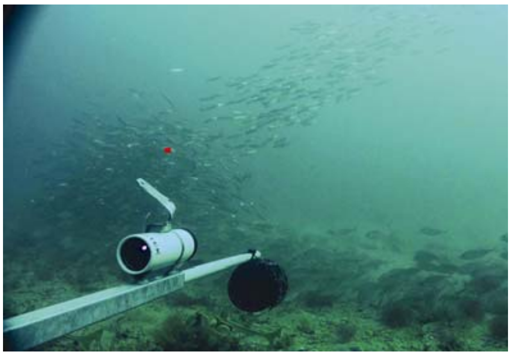


Arripis truttaceus

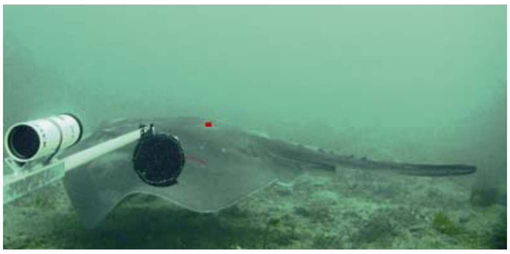
Austrolabrus maculatus

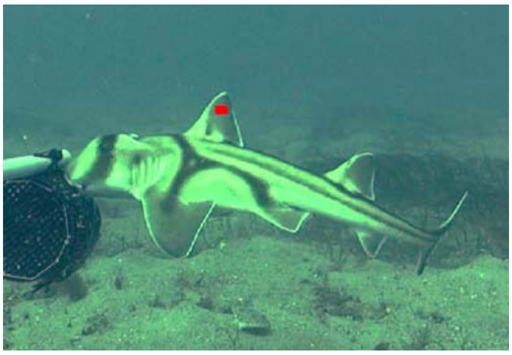


Chrysophrys auratus

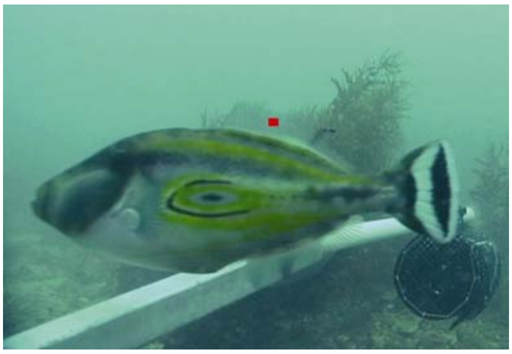


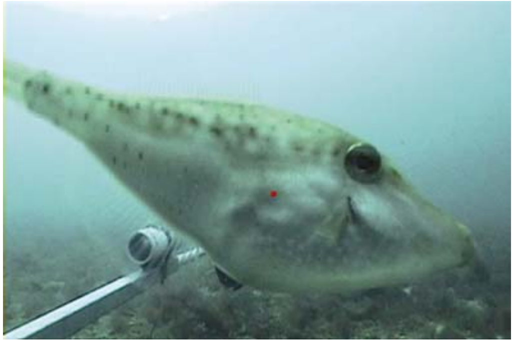
Clupeidae spp.

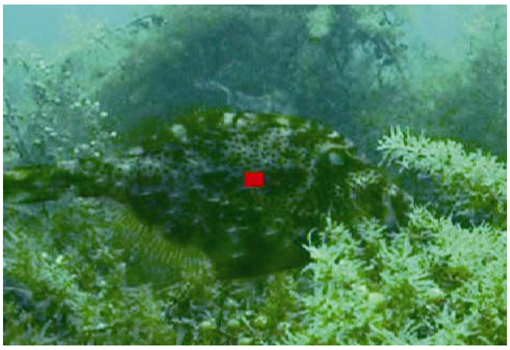

Dasyatis brevicaudata


Heterodontus portusjacksoni

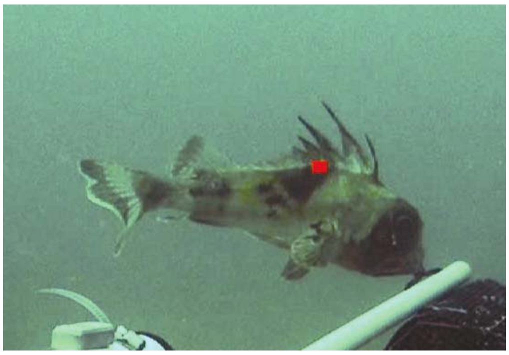

Meuschenia freycineti


Meuschenia hippocrepis

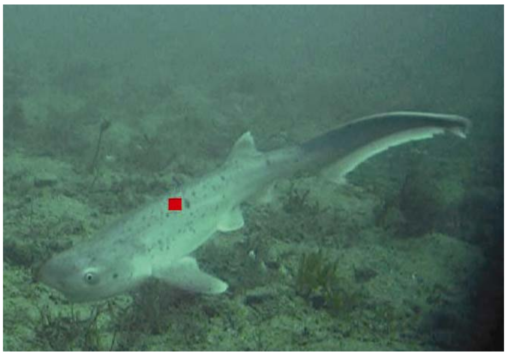

Monacanthidae spp.


Monacanthidae spp.2

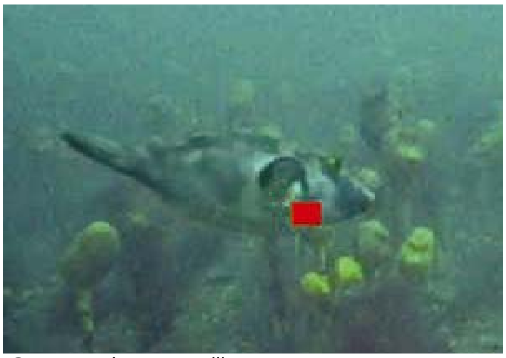

Nelusetta ayraud


Neosebastes scorpaenoides

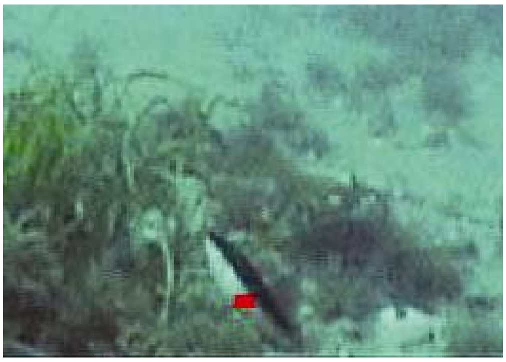
Notolabrus parilus



Notorynchus cepedianus

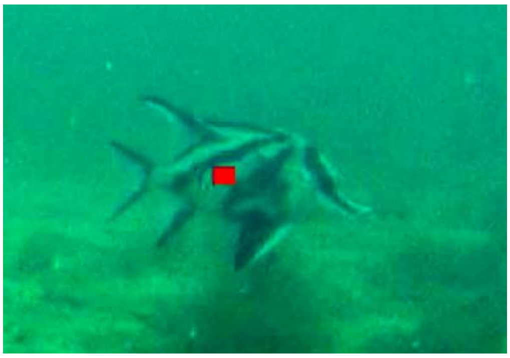


Omegaphora armilla

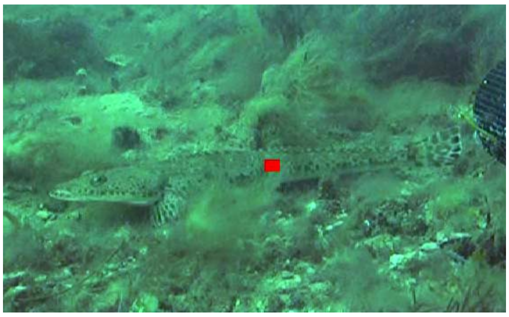


Opthalmolepis lineolata

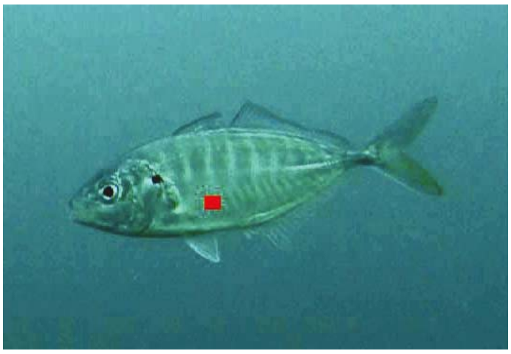
Parequula melbournensis



Pentaceropsis recurvirostris

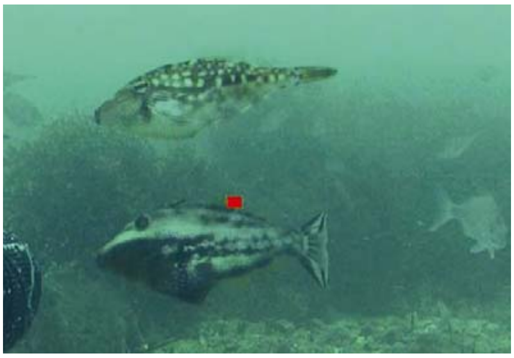


Platycephalus bassensis

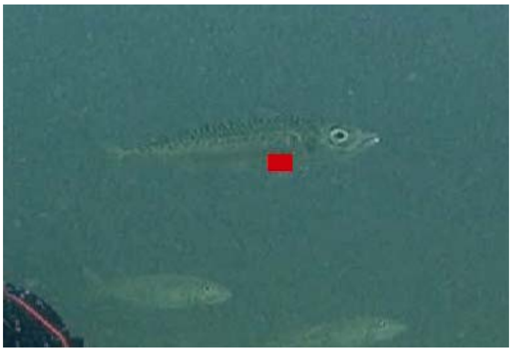


Pseudocaranx spp.

Pseudocaranx spp. (large school)

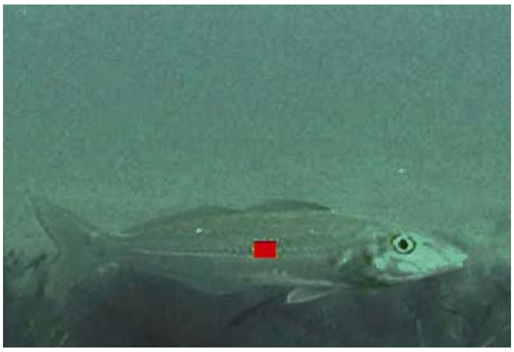


Scobinichthys granulatus



Scomber australasicus

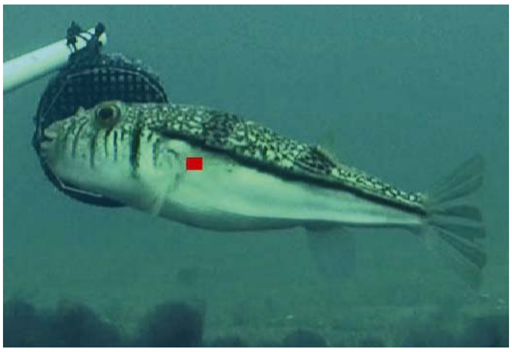
Sillaginodes punctata



Sillago spp.

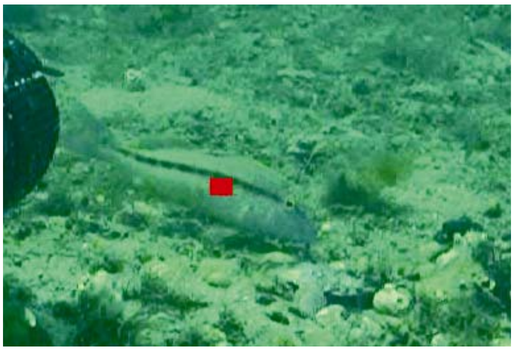
Siphonognathus attenuatus

Siphonognathus beddomei



Torquigener pleurogramma

Trygonorrhina fasciata



Upeneicthyes vlamingii

Appendix B: Species identified adjacent to Port Stanvac

Class	Family	Genus	Species	Common name	Caab Code
Chondrichthyes	Alopiidae	*Alopias*	*vulpinus*	Thresher shark	37012001
	Carcharhinidae	Carcharhinidae Unk	spp	Whaler shark	
	Dasyatidae	*Dasyatis*	*brevicaudata*	Smooth ray	37035001
	Heterodontidae	*Heterodontus*	*portusjacksoni*	Port Jackson shark	37007001
	Hexanidae	*Notorynchus*	*cepedianus*	Broad-nose seven gill shark	37005002
	Rhinobatidae	*Trygonorrhina*	*fasciata*	Southern fiddler ray	37027006
Actinopterygii	Arripidae	*Arripis*	*georgianus*	Australian herring	37344001
	Arripidae	*Arripis*	*truttaceus*	West Australian salmon	
	Carangidae	Carangidae Unk	spp	Trevally	
	Carangidae	*Pseudocaranx*	spp	Trevally	
	Carangidae	*Trachurus*	spp	Mackerel or Scad	
	Cheilodactylidae	*Cheilodactylus*	*nigripes*	Magpie perch	37377001
	Clupeidae	Clupeidae Unk	spp	Anchovie or Pilchard	
	Dinolestidae	*Dinolestes*	*lewini*	Longfin pike	37327002
	Gerridae	*Parequula*	*melbournensis*	Melbourne silverbelly	37349001
	Labridae	*Austrolabrus*	*maculatus*	Black-spotted wrasse	37384025
	Labridae	*Notolabrus*	*parilus*	Brown-spotted wrasse	37384022
	Labridae	*Ophthalmolepis*	*lineolatus*	Southern Maori wrasse	37384040
	Labridae	*Pictilabrus*	*laticlavius*	Senator wrasse	37384020
	Monacanthidae	*Acanthaluteres*	*brownii*	Spiny-tail leatherjacket	37465001
	Monacanthidae	*Acanthaluteres*	spp	Leatherjacket	
	Monacanthidae	*Brachaluteres*	*jacksonianus*	Southern pygmy leatherjacket	37465025
	Monacanthidae	*Meuschenia*	*freycineti*	Six-spine leatherjacket	37465036
	Monacanthidae	*Meuschenia*	*hippocrepis*	Horseshoe leatherjacket	37465004
	Monacanthidae	*Meuschenia*	spp	Leatherjacket	
	Monacanthidae	Monacanthidae Unk	spp	Leatherjacket	
	Monacanthidae	Monacanthidae Unk	spp2	Leatherjacket	
	Monacanthidae	*Nelusetta*	*ayraud*	Ocean jacket	37465006
	Monacanthidae	*Scobinichthys*	*granulatus*	Rough leatherjacket	37465007
	Mullidae	*Upeneichthys*	*vlamingii*	Blue-spotted goatfish	37355029

Neosebastidae	*Neosebastes*	*scorpaenoides*	Common gurnard perch	37287005
Odacidae	*Siphonognathus*	*attenuatus*	Slender weed whiting	37385004
Odacidae	*Siphonognathus*	*beddomei*	Pencil weed whiting	37385006
Ostraciidae	*Aracana*	*aurita*	Shaw's cowfish	37466003
Ostraciidae	*Aracana*	*ornata*	Ornate cowfish	37466001
Pentacerotidae	*Pentaceropsis*	*recurvirostris*	Long-snout boarfish	37367003
Pinguipedidae	*Parapercis*	*haackei*	Wavy grubfish	37390004
Platycephalidae	*Platycephalus*	*aurimaculatus*	Toothy flathead	37296035
Platycephalidae	*Platycephalus*	*bassensis*	Southern sand flathead	37296003
Platycephalidae	*Platycephalus*	spp	Flathead	
Scombridae	*Scomber*	*australasicus*	Blue mackerel	37441001
Scorpididae	*Tilodon*	*sexfasciatus*	Moonlighter	37361003
Sillaginidae	Sillaginidae Unk		Whiting	
Sillaginidae	*Sillaginodes*	*punctata*	King George whiting	37330001
Sillaginidae	*Sillago*	spp	Whiting	
Sparidae	*Chrysophrys*	*auratus*	Snapper	37353001
Sphyraenidae	*Sphyraena*	*novaehollandiae*	Snook	37382002
Terapontidae	*Pelates*	*octolineatus*	Western striped grunter	37321020
Terapontidae	*Pelsartia*	*humeralis*	Sea trumpeter	37321021
Tetraodontidae	*Omegophora*	*armilla*	Ringed toadfish	37467002
Tetraodontidae	*Tetractenos*	*glaber*	Smooth toadfish	37467003
Tetraodontidae	Tetraodontidae Unk	spp		
Tetraodontidae	*Torquigener*	*pleurogramma*	Weeping toadfish	37467030