

NSW Tropical Fishes Monitoring Network Feasibility Phase: Final Report (2009-2011)



Report to NSW Department of Primary Industries - Fisheries
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INTRODUCTION

The ‘NSW Natural Resources Monitoring, Evaluation and Reporting Strategy 2010-2015’ guides the monitoring, evaluation and reporting of natural resources in NSW. The broad objective of this strategy is to assess changes in the state of and trends in the condition of, natural resource assets in the long-term. The NSW Department of Primary Industries - Fisheries (formerly Industry & Investment NSW - I&I NSW) leads the Marine Waters, Invasive Species and Socio-economic themes and must report on state-wide targets (e.g. ‘By 2015 there is no decline in the condition of marine waters and ecosystems’) by establishing cause and effect relationships, and developing indices, in addition to individual indicators. ‘Monitoring programs are designed to provide unbiased, quality-assured data that are spatially and temporally representative of the cumulative effects of all management activity, climate change and natural variability’ (DECCW 2010).

Climate change has been identified as a key threat to marine environments in NSW (http://www.environment.nsw.gov.au/soe/soe2009/chapter6/chp_6.5.htm#6.5.101).

Climate modelling predicts that Australian waters will warm by 1–2°C by 2070, with the greatest warming in SE Australia occurring due to increased strength and southward penetration of the East Australian Current (EAC) (Hobday *et al.* 2006b; Ridgway 2007). These changes could have significant effects on: marine species distribution and abundance; phenology or timing of life cycle events; physiology, morphology and behaviour (e.g. rates of metabolism, reproduction, development); biological communities (Hobday *et al.* 2006a). Despite this, specific impacts are poorly understood and there are few baseline data or ongoing monitoring programmes with which to assess potential changes (Hobday *et al.* 2006a; Wernberg *et al.* 2011).

Previous work by Booth *et al.* 2007 has demonstrated the importance of the EAC in driving larval settlement patterns of tropical coral reef fishes along the NSW coast during summer. While the biophysical environment in NSW is clearly suitable for many species of juvenile tropical fish, current average winter water temperatures in southern NSW (13-16 °C) act as key bottlenecks for long-term survival and population establishment (Figueira & Booth 2010). Evidence from manipulative experiments supports the model that lower water temperatures (≤ 17.5 °C) lead indirectly to reduced post-settlement survivorship through temperature-mediated reductions in feeding rates, growth and burst swimming ability and hence increased susceptibility to predation (Figueira & Booth 2010). Current warming

trajectories resulting from climate change, however, predict 100 % of winters will be survivable by several tropical species as far south as Sydney by 2080, facilitating possible range expansions of these species into NSW waters (Figueira & Booth 2010). Furthermore strengthening of the EAC may afford increased tropical-temperate connectivity exposing reefs in NSW to a greater diversity of tropical expatriates.

Given that the occurrence of tropical fishes in NSW is highly influenced by sea surface temperature and the behaviour of the EAC they make ideal candidates with which to monitor the progression of potential climate change effects in temperate waters of NSW. The purpose of this project was to initiate a tropical fish survey network along the coast of NSW in order to assess the utility of this system as a metric of change for inclusion in the MER program. The main long-term objective of the project was to establish a long-term sampling program which complemented ongoing surveys (since 2003) and provided baseline data on levels of recruitment of ‘tropical vagrant’ coral reef fishes, and the extent of their ‘over-wintering’ along the NSW coast against key environmental parameters. The project was designed with an initial two year feasibility phase with possible further extension to an ongoing program.

This report summarises information collected during the feasibility phase which covers 2009-2010 and 2010-2011 years (where ‘years’ are centred around the summer recruitment period and run from Nov – Oct). The aims of this report are to:

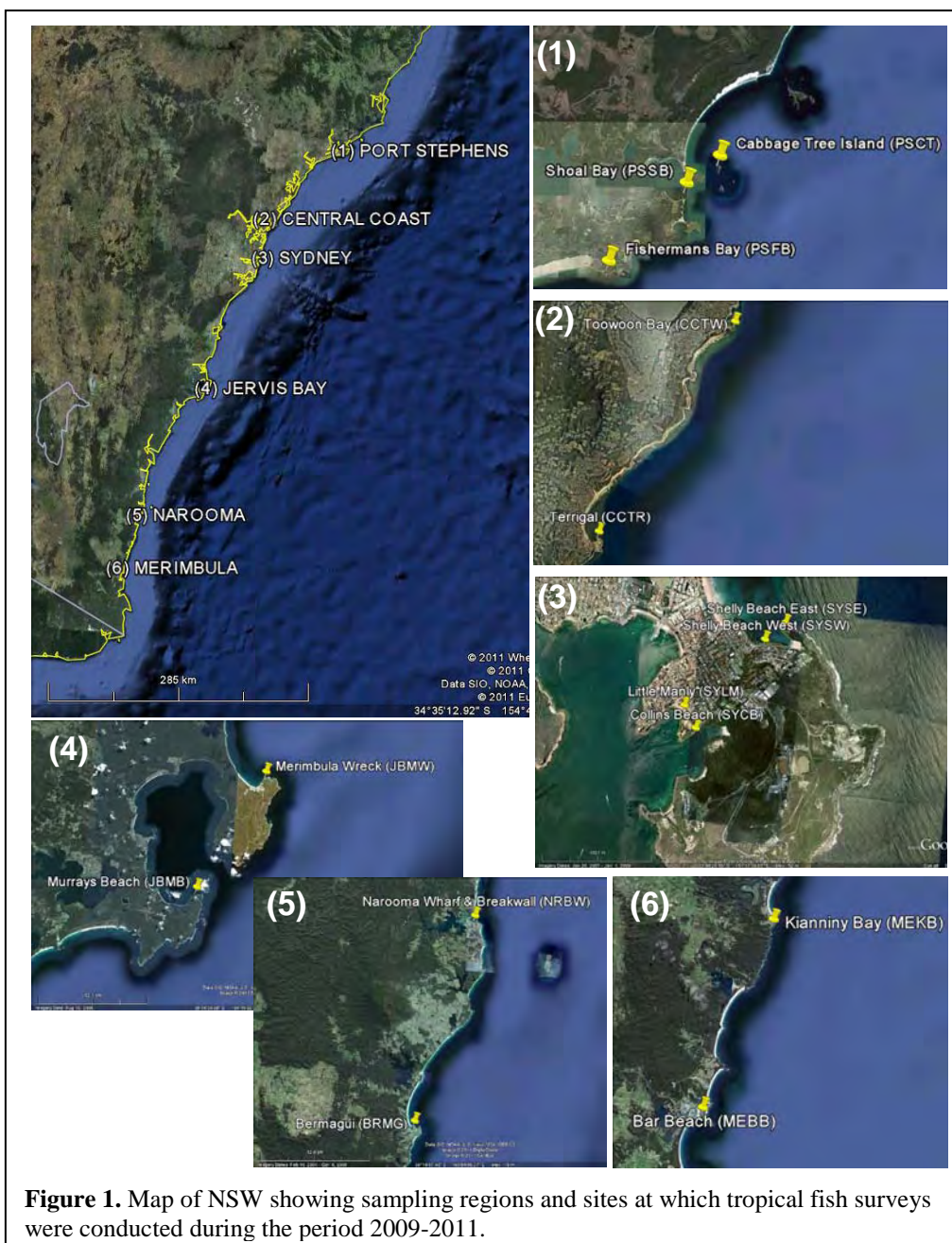
- 1) Describe the data collected as part of the survey program to date.
- 2) Review 2009-2011 patterns within the context of previous data (Booth *et al.* 2007) to assess natural variability and the level of sampling required to form a robust ‘baseline’ with which to assess future changes
- 3) Outline how data could be used within the context of MER as an indicator of climate change (e.g. metrics, shifting baseline) by providing testable hypotheses particularly in respect to changes in tropical-temperate connectivity patterns and sea surface temperature.

METHODS

Study sites and sampling of fishes

The occurrence of tropical fishes was examined at multiple spatial scales in temperate NSW where the greatest effects of climate change are expected to occur. Sampling was

focused on six regions (Port Stephens, The Central Coast, Sydney, Jervis Bay, Narooma and Merimbula). Within each region, two sites (typically separated by km to 10's km) were chosen based on local knowledge of where tropical fishes have been regularly observed (Figure 1). The use of such regions minimises the potential for bias in analyses due to lack of suitable habitat for tropical species. Three sites (East and West Shelly Beach, Sydney; Bar Beach, Merimbula) have been monitored approximately weekly during the recruitment year (Dec. – June) since 2003 by Booth et al. and in the future will allow for in-depth temporal analyses. The additional sites will allow a more comprehensive assessment of the occurrence of tropical fishes at temperate latitudes in NSW.



A state-wide tropical survey team was established in January 2010 consisting of DPI staff and contracted employees of UTS and SIMS. All surveyors had previous experience in counting fishes or were trained by Dr. Curley. Sampling was conducted using methods described in Booth et al. (2007). Briefly, this involved a weekly snorkel of a defined area ('the site') and was restricted to depths < 3 m. All tropical and subtropical fishes were identified to species level (where possible), counted and sizes estimated. During 2009-2010 we trialled the addition of specific temperate fishes to the counts and in 2010-2011 all surveyors were asked to count the following temperate fishes during all surveys: all sizes of *Achoerodus viridis*, *Acanthopagrus australis*, *Girella tricuspidata*, *Girella elevata*, and *Cheilodactylus fuscus*; and recruits of *Atypichthys australis*, *Parma microlepis*, *Parma unifasciata* and *Scorpiis lineolata*.

Historically individuals were assigned to one of three size categories (small, medium, large; size boundaries for different families are given in Booth et al 2007). During 2009-2010 we trialled the assignment of sizes to categories with the size of the interval being larger for larger fish (10-50mm: 5mm interval, 50-100mm: 10mm interval, 100-200: 25mm interval, 200-900: 50mm interval). This was fully implemented during 2010-2011.

The goal was to sample all sites approximately weekly during the peak recruitment period of Jan – May and less often thereafter depending on the number of fish present or size of new settlement events. Two temperature loggers (for redundancy) were deployed at each site to record water temperatures throughout the year. Deployment did not take place at some sites until March-April of 2010 due to the need to purchase new loggers for the project. Data from loggers were intermittently retrieved by surveyors.

Data acquisition, management and sharing protocols

Two databases were developed in Microsoft Access for fish survey and temperature logger data for efficient tracking of surveys/deployments, data retrieval and analysis. A metadata record was also created using the ANZmet Lite, a metadata entry tool implemented by ANZLIC (Australian and New Zealand Spatial Information Council) (Appendix, Table 1).

Data analyses

Graphical representations were used to provide preliminary analyses of spatial, temporal and temperature-related patterns of species richness, density, recruitment and overwinter survival.

RESULTS OF 2009-2011 SURVEYS & COMPARISON WITH PREVIOUS DATA

Effort

A total of 202 surveys across 15 sites were completed in 2010-2011, down slightly from the 238 completed during 2009-2010 (Table 1) despite the addition of the Fisherman’s Bay site in Port Stephens. Of the total, 183 and 142 were completed during the peak recruitment period for tropical fish (January – May) during the two years respectively.

Table 1. Summary of MER Tropical Fish Monitoring site details including number of surveys conducted during the entire year (Whole) or the period January – May (Peak) for both years from 2009-2011.

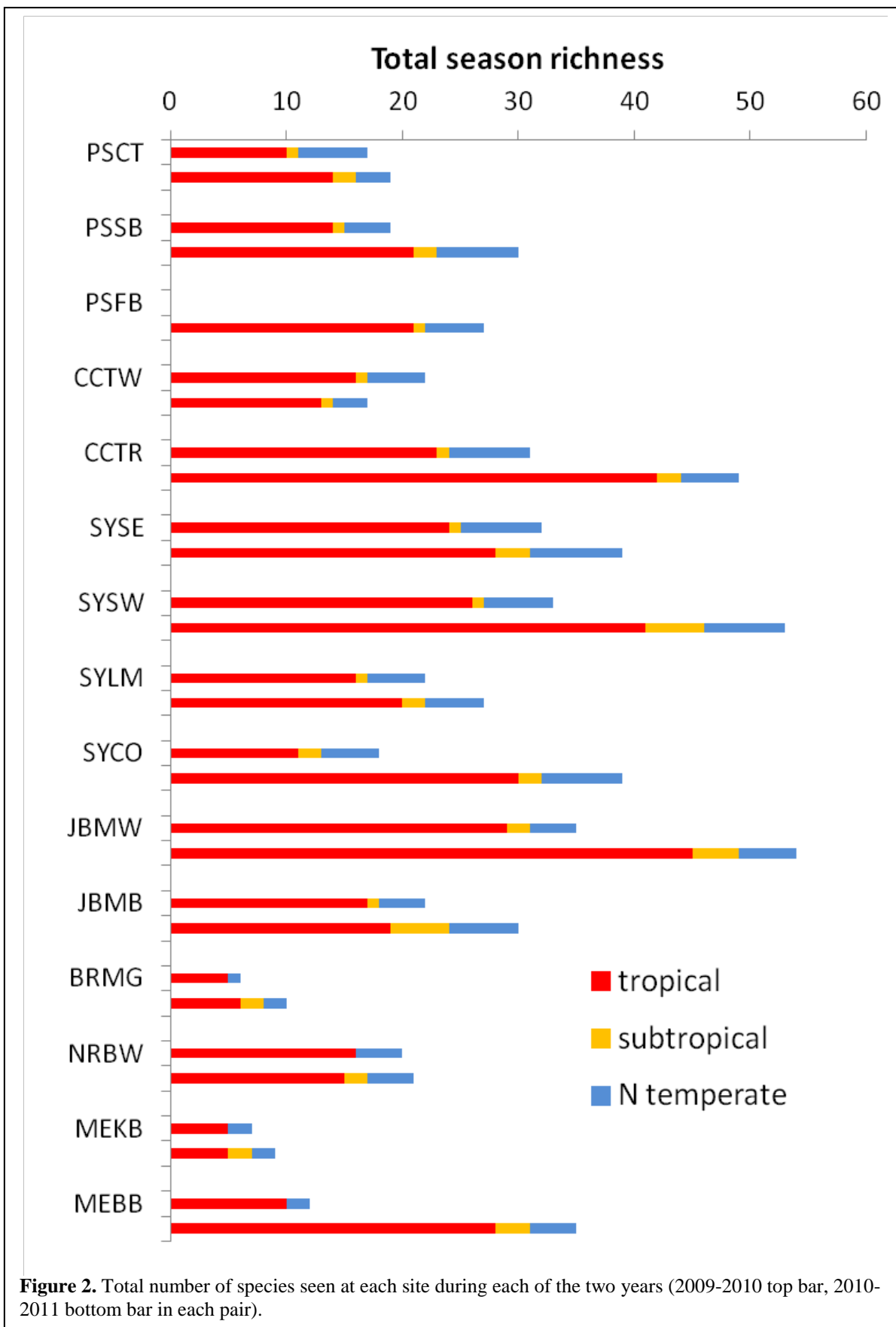
Site name	Site Code	Location (dd)		Area (m ²)	Number of Surveys			
		Latitude	Longitude		Whole 2009-	Whole 2010-	Peak 2009-	Peak 2010-
Port Stephens - Cabbage Tree Isl.	PSCT	-32.68673	152.2226	13,493	7	1	5	1
Port Stephens - Shoal Bay	PSSB	-32.71332	152.1838	7,174	18	8	13	6
Port Stephens - Fishermans Bay	PSFB	-32.78979	152.0932	9,479	0	10	0	7
Central Coast - Toowoan Bay	CCTW	-33.36232	151.5032	2,382	25	22	20	16
Central Coast - Terrigal Wall	CCTR	-33.44632	151.4496	1,603	24	22	18	16
Sydney - Shelly East	SYSE	-33.79948	151.2967	1,196	22	21	17	13
Sydney - Shelly West	SYSW	-33.80069	151.2955	1,165	23	21	17	14
Sydney - Little Manly	SYLM	-33.80807	151.2869	3,046	18	16	13	10
Sydney - Collins Beach	SYCB	-33.80873	151.2882	1,087	6	16	3	10
Jervis Bay - Merimbula Wreck	JBMW	-35.00459	150.8293	4,135	15	13	10	9
Jervis Bay - Murray's Beach	JBMB	-35.12445	150.7548	200	19	11	13	7
Narooma - Wharf and Breakwall	NRBW	-36.21534	150.1312	2,240	17	11	15	8
Bermagui	BRMG	-36.42345	150.0735	840	13	10	11	8
Merimbula - Kianniny Bay	MEKB	-36.73728	149.9834	1,441	13	8	13	8
Merimbula - Bar Beach	MEBB	-36.89453	149.9235	3,316	18	12	15	9
TOTAL					238	202	183	142

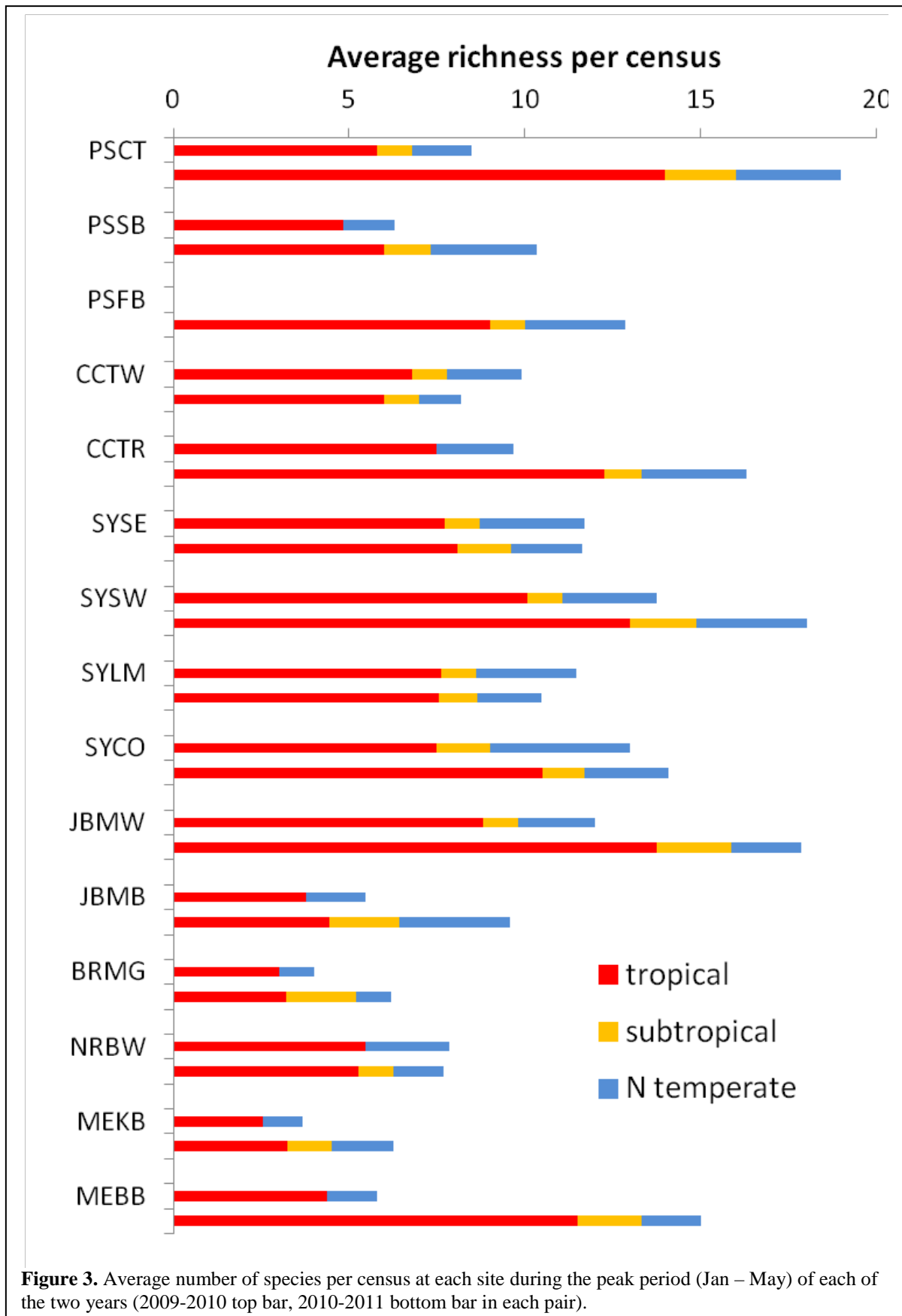
Trends in richness with latitude

The number of tropical and subtropical / north temperate species observed increased from 65 & 16 (respectively) in 2009-2010 to 94 and 19 (respectively) in 2010-2011. This increased the total number of species observed during the two years of the program to 129 tropical and 20 subtropical/northern temperate from 23 different families (Appendix,

Tables 2 & 3). Many of these species are rare with only about 59% of tropical and 67% of subtropical / northern temperate species occurring at more than one site during either year of the program.

In general the total annual richness was greater within regions located in central NSW (Central Coast and Sydney) than in far southern regions (Narooma and Merimbula) (Figure 2). Total annual richness also tended to be greater in 2010-2011 than 2009-2010. When looking at richness in terms of the average number of species per survey during the peak recruitment period, the trends are similar though not quite as clear (Figure 3). As above, for most sites, values in 2010-2011 were greater than the previous year. Richness does still tend to be higher in the central coast to Sydney region although there are some very high values for Cabbage Tree Island in Port Stephens and Bar Beach in Merimbula for 2010-2011. It should be noted that in the case of Cabbage Tree Island, this is based on only 1 survey (see Table 1).



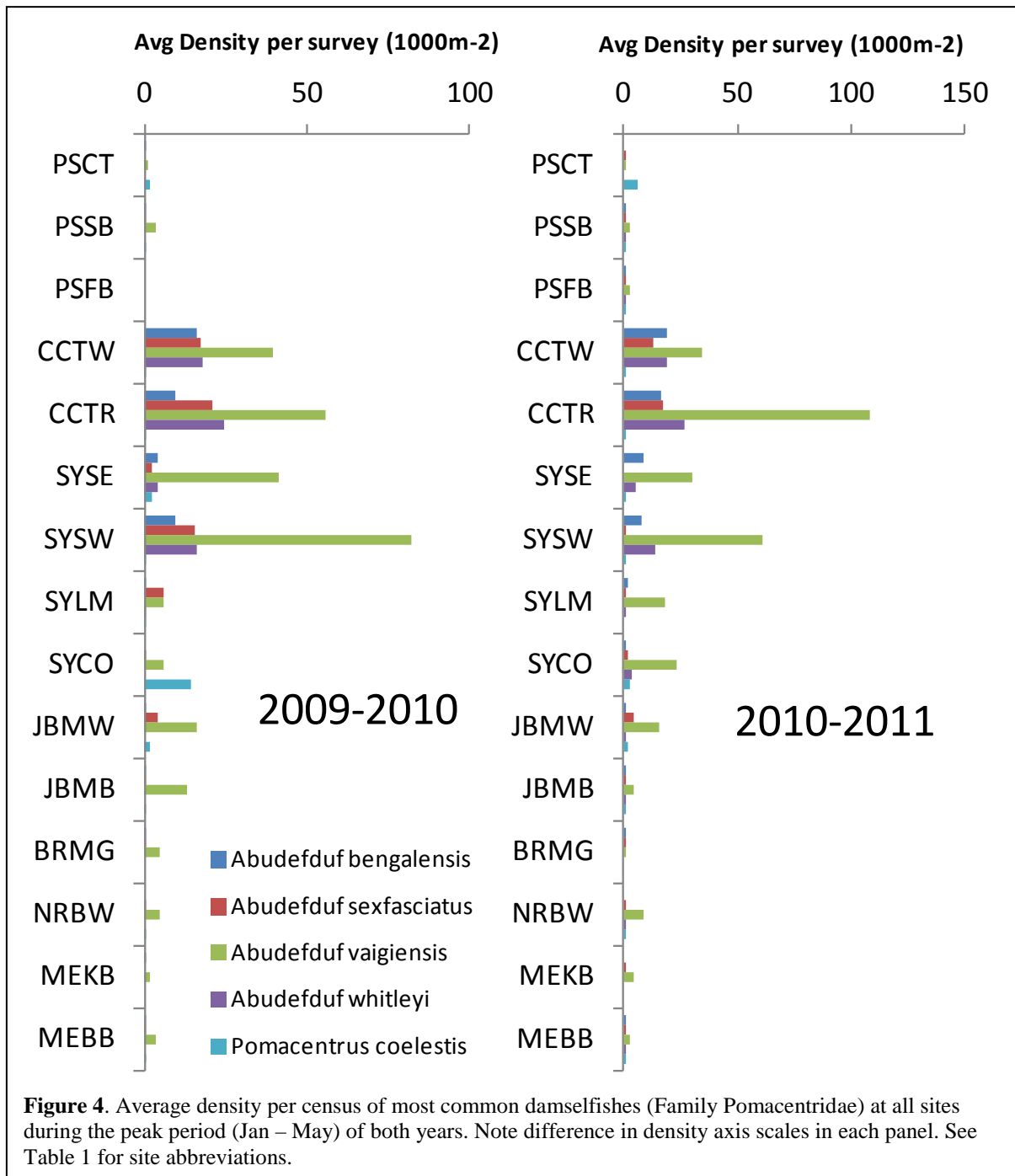


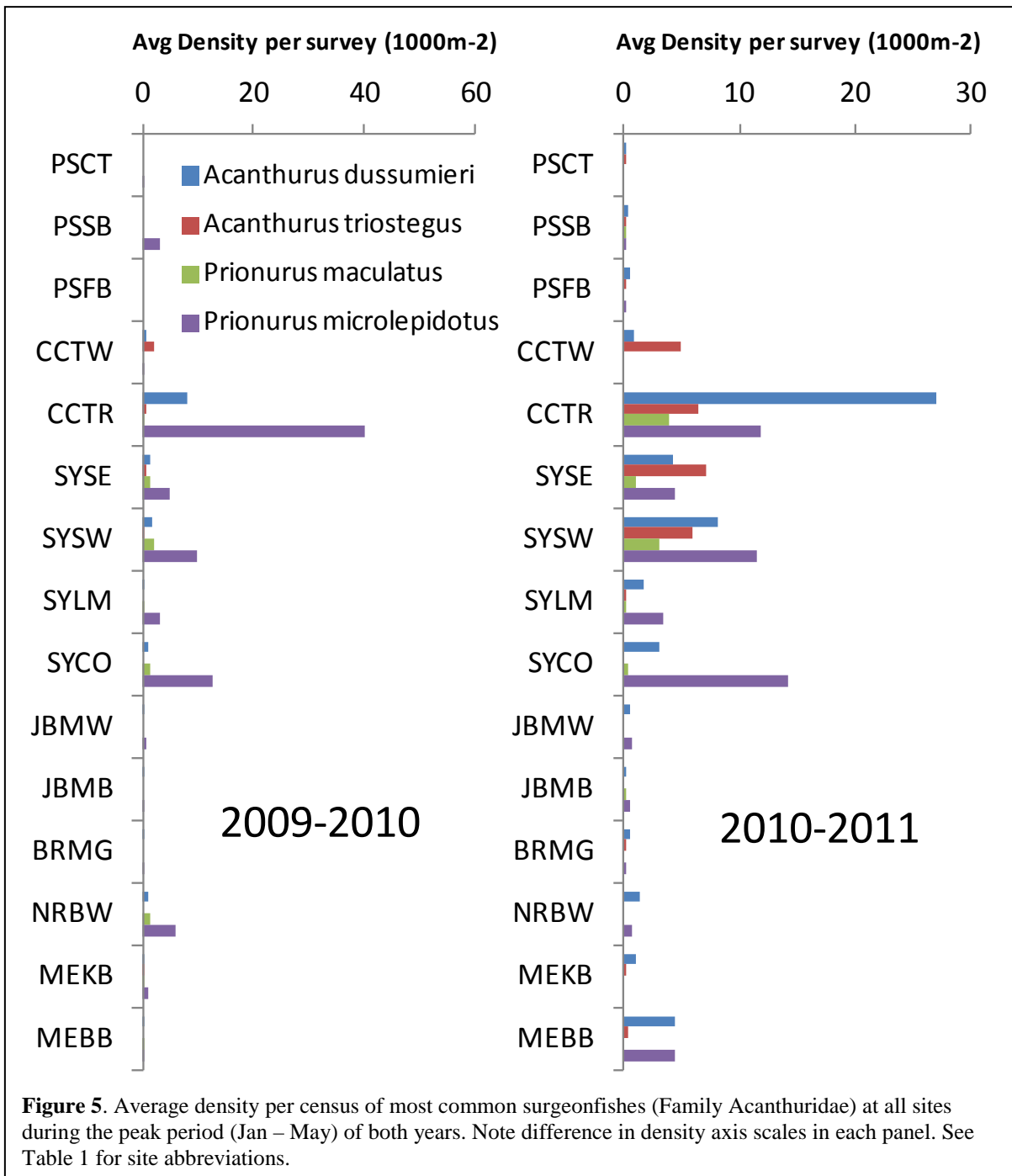
Numerically important fishes – patterns of abundance

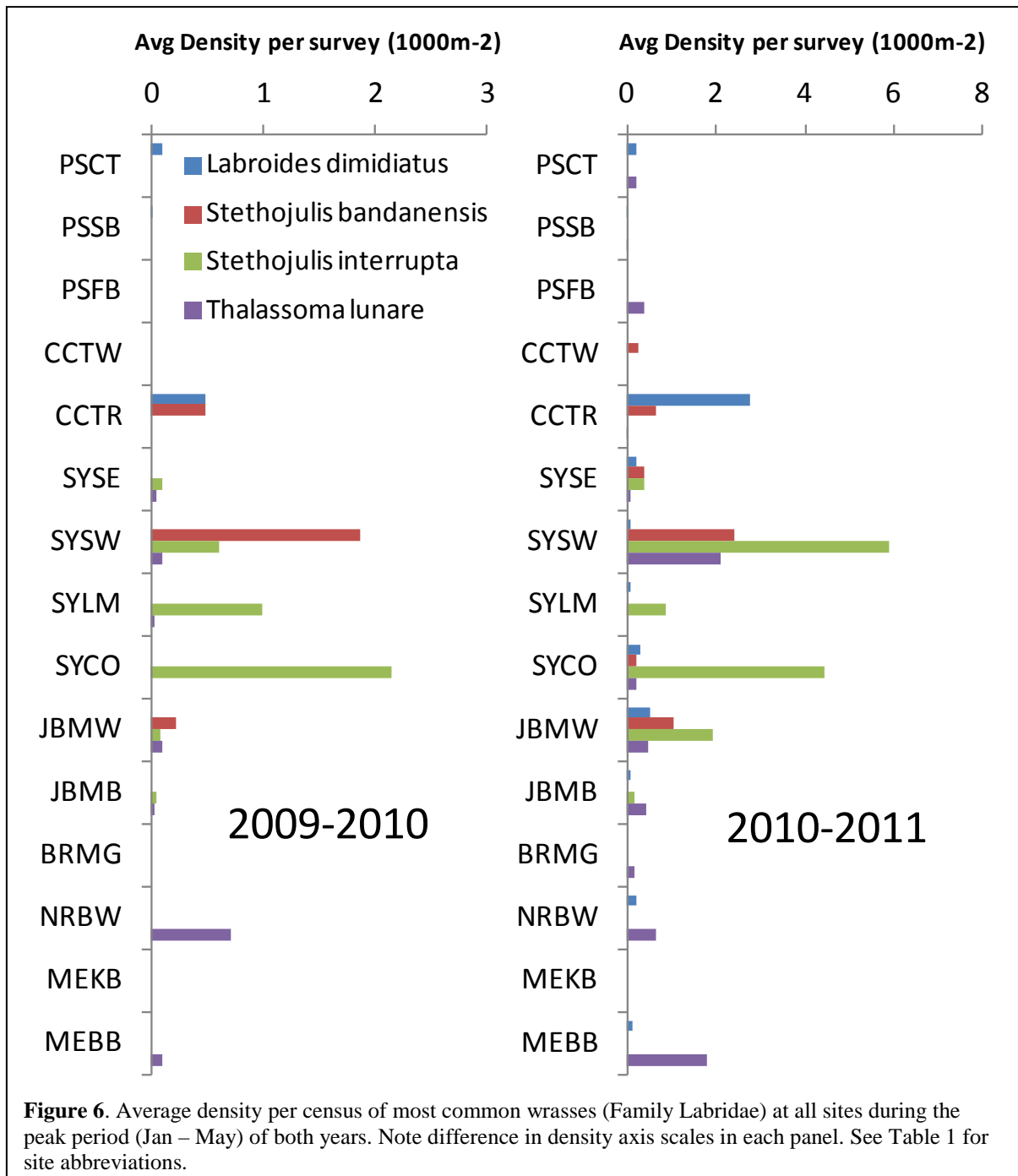
The most widely distributed tropical species (present at $\geq 12/14$ sites) were *Abudefduf vaigiensis*, *Abudefduf bengalensis*, *Pomacentrus coelestis*, *Abudefduf sexfasciatus* and *Acanthurus dussumieri*. *Chaetodon auriga*, *Thalassoma lunare*, *Stethojulis interrupta*, *Chaetodon guentheri*, *Zanclus cornutus*, *Abudefduf whitleyi*, *Stegastes gascoynei*, *Naso unicornis* and *Acanthurus triostegus* were also relatively common in both years (present at 5-9/15 sites). Abundant subtropical/northern temperate species included *Prionurus microlepidotus*, *Parma unifasciata*, *Mecaenichthys immaculatus* (present at $\geq 10/15$ sites), and *Parupeneus signatus*, *Parma polylepis* and *Parma oligolepis* (present at 5-9/15 sites). Family names are given in Appendix Table 1.

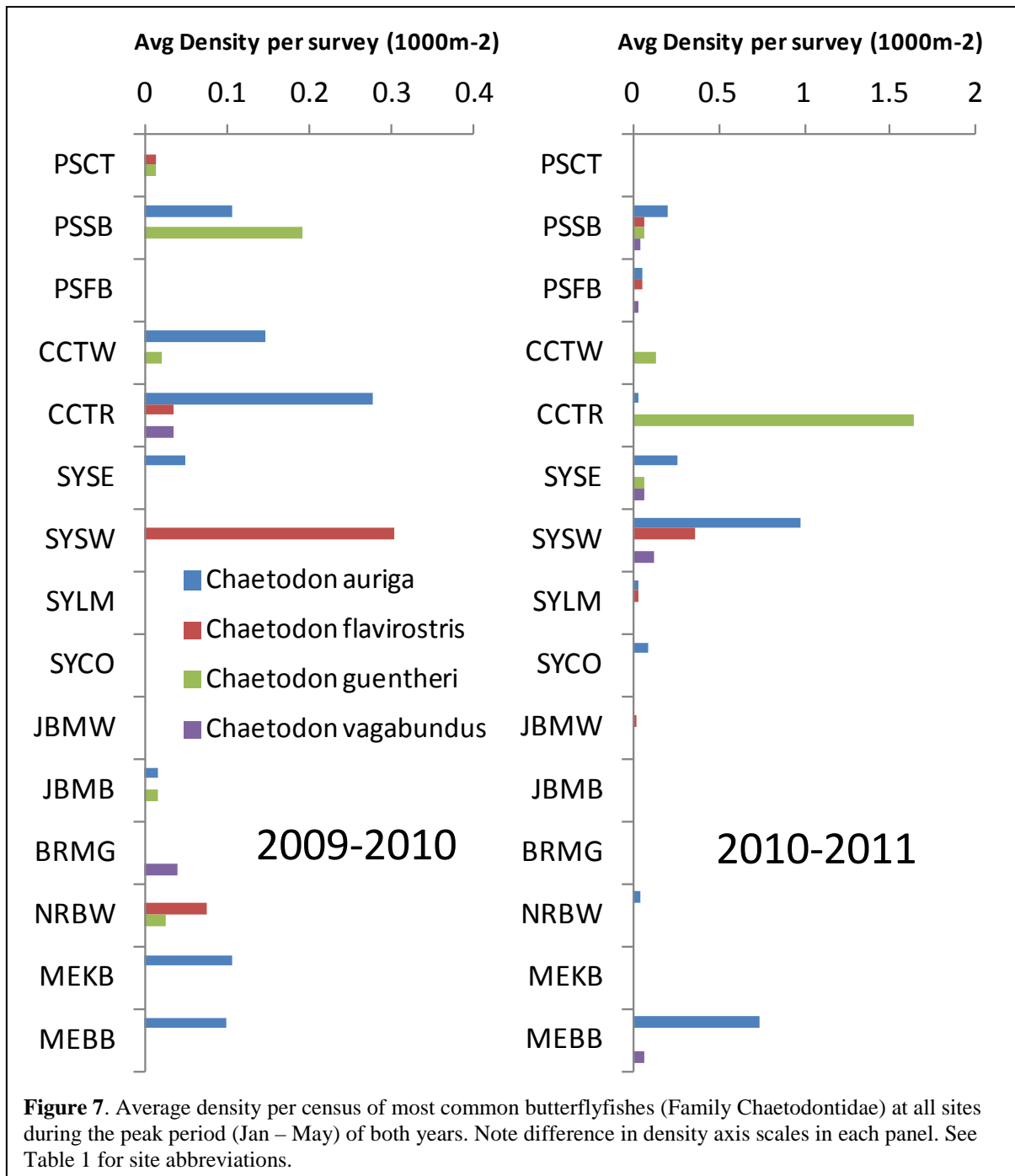
Five species of damselfishes were generally observed at the highest average density per survey (Figure 4) when compared to all other tropical taxa including the most commonly observed surgeonfishes (Figures 5), wrasses (Figure 6) and butterflyfishes (Figure 7). Despite substantial variation in density of some groups between sampling years (e.g. surgeonfishes) relative patterns of abundance across latitudes remained consistent. Both damselfishes and surgeons tended to be most dense at the central coast and Sydney sites, declining quite sharply in abundance to the south and occurring in only very low numbers to the north. A similar pattern is seen for the labrids and butterfly fishes, though the patterns of occurrence are much more variable and include, in the case of butterflyfishes, relatively high densities at the most southerly location of Merimbula.

In general, numerically important species and latitudinal variation in density were consistent with those identified by Booth et al 2007. Exceptions were *A. dussumieri* and *P. microlepidotus* which were not individually counted/recorded in the latter study (they were pooled at the family level). *Pomacentrus coelestis* abundances peaked around Sydney with individuals rarely occurring at Merimbula or to the south (they also surveyed at Bittangabee, just north of the NSW-Victoria border). Booth *et al.* 2007 noted that the observed distribution of Chaetodons were within the predicted southern extent based on a pre-settlement phase of 45-47 days, and under the assumption that larvae were sourced from the southern Great Barrier Reef. All other species were found further south than expected for GBR-sourced larvae based on a pre-settlement phase of 18-24 days.









Temporal patterns of settlement and association with water temperature

Settlement of all tropical species, as indicated by the density of small size class fish in the surveys, seemed to have been more sporadic and overall lower during 2010-11 than 2009-10 (Figure 8). During 2009-10 most recruitment occurred during a 6-8 week period beginning in mid- February when water temperatures regularly exceeded 23 °C (see Figure 9 for summary of water temperatures at the sites given in Figure 8). Settlement was strongest on the Central Coast during this period and slightly more protracted than the

other regions (Sydney for instance). In 2010-2011 settlement was much lower but occurred steadily from mid February through May again most strongly on the Central Coast, Sydney and Jervis Bay. The arrival of new settlers ceased by late May / early June during both years at the northern regions where water temperatures were about 19°C. Settlement at the most southerly regions (Narooma and Merimbula) ceased by about mid April in both years, when the water temperatures dropped below about 19-20°C. Growth of settled individuals can be seen in the progression of the settlement mode for each size class at all the sites. Large individuals were first observed at the more northerly sites as early as mid February in some cases in both years but not until April or May at the more southerly ones (if at all, Figure 8).

The overall density of tropical fishes declined in tandem with local water temperatures at all sites. For the mid coast sites (Central coast, Sydney and Jervis Bay) there was a gradual reduction in the number of fish through to early August in 2009-2010 which is in contrast to a rather dramatic drop in late June during the 2010-2011 year (Figure 8). These changes correspond to similar changes in temperature which decreased gradually from about 19.5 to 17°C from early June to early August in 2009-2010 but experienced this same drop in 2010-2011 over a two week period from early to mid June (Figure 9). Patterns among years are similar at the most southerly sites (Narooma and Merimbula) although declines occur about 6 weeks earlier than the mid coast sites in 2009-2010 which corresponds to the cooler temperatures experienced to the south. Interestingly, the timing of decline does not seem to differ greatly among central NSW coast versus southern sites in the 2010-2011 year and indeed water temperatures were quite similar between Merimbula and Jervis Bay leading up to the dramatic temperature drop in early to mid June of that year (Figure 9). The role of water temperature in driving declines is especially evidenced by the different patterns observed between JBMW and MEBB in 2009-10 versus 2010-11. During 2009-10, declines happened 4-6 weeks sooner at MEBB than JBMW, corresponding to the roughly 1.5°C difference in water temperatures between the sites. However in 2010-11, water temperatures were nearly identical up to the dramatic drop in June at which time densities of tropical fishes at both sites quickly declined (Figures 8 & 9). In general these correlations between water temperatures $\leq 17.5^\circ\text{C}$ and the disappearance of tropical fishes are consistent with previous studies (Figueira & Booth 2010).

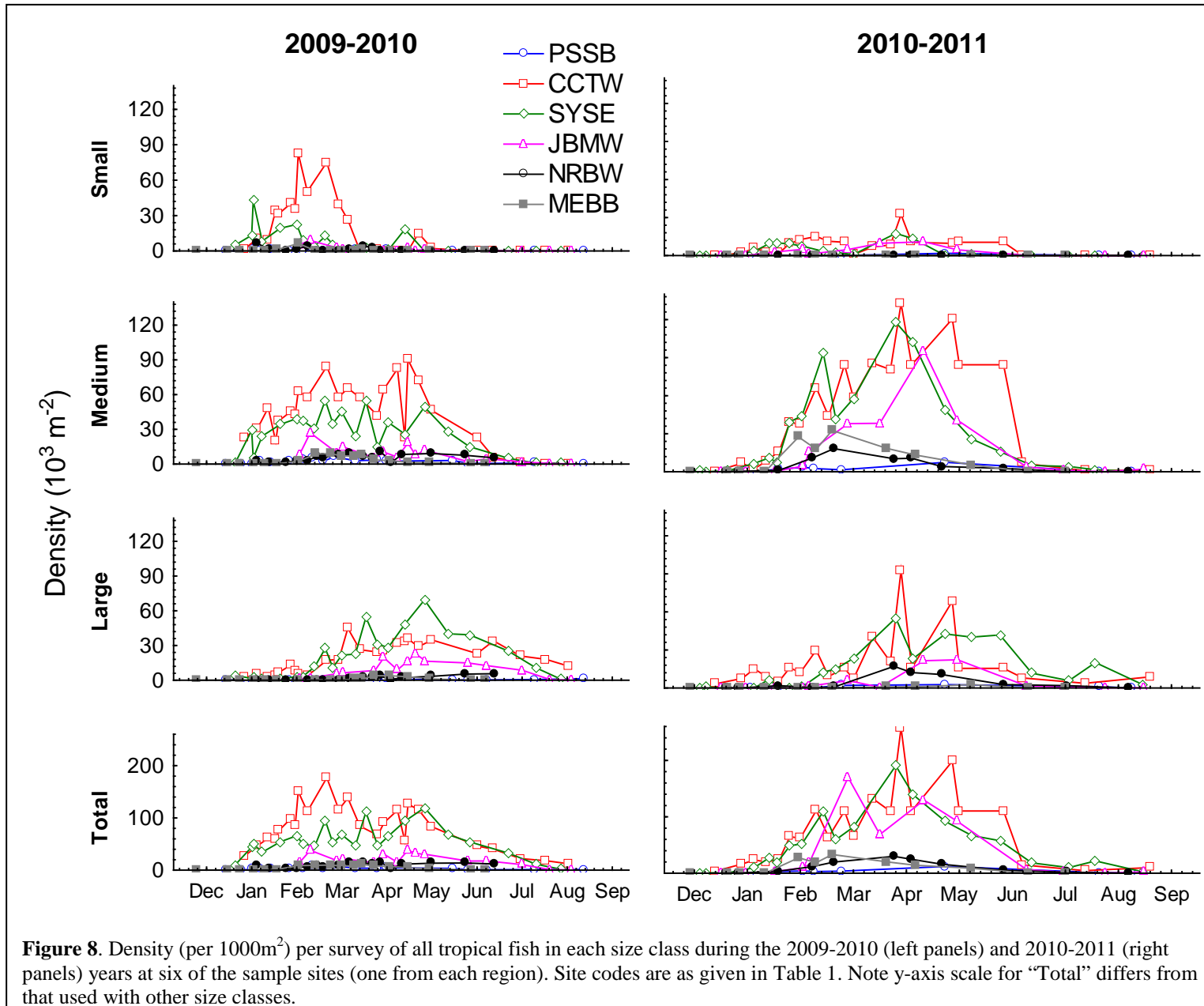
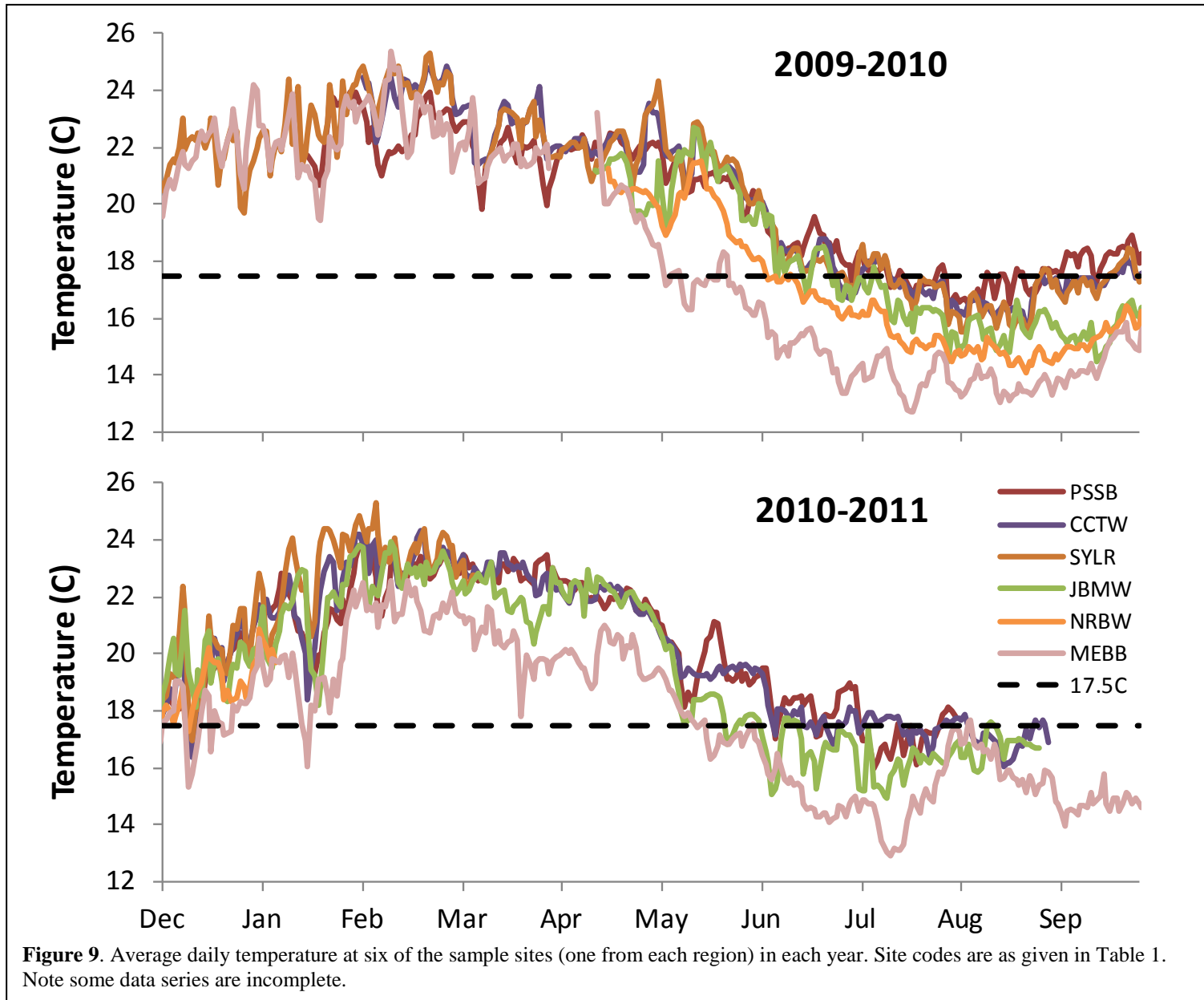


Figure 8. Density (per 1000m²) per survey of all tropical fish in each size class during the 2009-2010 (left panels) and 2010-2011 (right panels) years at six of the sample sites (one from each region). Site codes are as given in Table 1. Note y-axis scale for “Total” differs from that used with other size classes.



Evidence for overwinter survival of tropical species

There were relatively high densities of large-sized tropical fishes in many surveys following the winter of each year (surveys conducted between Aug-Dec of each year, Figure 10, left panel). Densities were especially high at the central coast sites, dropping off quickly south of Sydney with none observed south of Jervis Bay. The proportion of all tropical fishes observed during these post-winter surveys that were large was generally quite high (Figure 10, right panel) indicating little chance of any winter recruitment occurring.

Preliminary data on the maximum sized individuals observed at various sites supports the notion that at least some individuals are reaching sizes anywhere from 50-100% of observed maximum sizes in their natal ranges (Table 2). There also seems to be a trend for reduced maximum sizes from the central coast southward for several of these species.

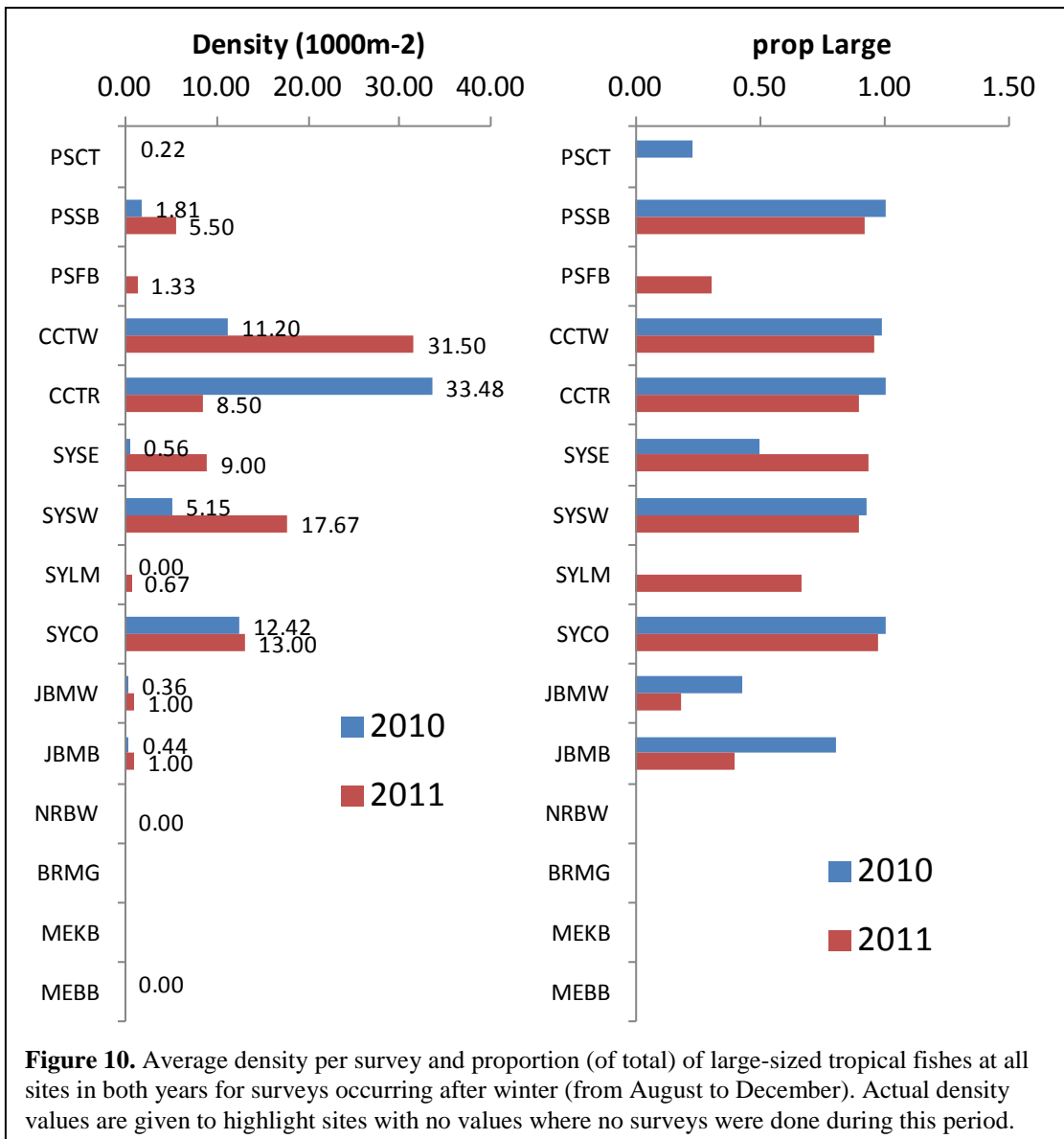


Table 2. Comparison of observed maximum sizes at all sites during both years with those observed in core range for selected species. Observed values within 2cm of the maximum size and above are in bold.

Species	Distribution	Max size (cm)	Observed max size (cm) at each site in each year															
			Seas.	PS			CC		SY			JB		BR	NR	ME		
				CT	SB	FB	TW	TR	SE	SW	LM	CO	MW	MB	MG	BW	KB	BB
<i>Abudefduf bengalensis</i>	WA (Dongara), NT, QLD to NSW (Merimbula)	18	2009-				16	9	8	18	4		8	6	3	4	4	4
			2010-		6	5	20	20	7	13	8	7	5	4	3			4
<i>Chromis nitida</i>	QLD (Cairns) to NSW (Merimbula)	6	2009-								7	8				5		
			2010-								9							
<i>Lethrinus nebulosus</i>	QLD to NSW (Montague Island)	86	2009-						45		35	35						
			2010-						30		25							
<i>Parma oligolepis</i>	QLD (Cairns) to NSW (Sydney)	19	2009-	15					18	18	20	15						
			2010-	13	18	18					18	18						
<i>Parma polylepis</i>	QLD (Capricorn group) to NSW (Bass Pt)	20	2009-	8	10			8	18	18								
			2010-															
<i>Parupeneus signatus</i>	WA(Geographe Bay), NT, QLD, NSW to Vic	47	2009-				20	14	25	25	15	25	12					
			2010-	7	13	15	13	18	15	20	20	25	30	25	8	20	8	13
<i>Prionurus maculatus</i>	QLD to NSW (Bass Pt)	50	2009-					12	14	25	12	15			7	5	9	
			2010-		6			8	9	13	45	10	25					
<i>Prionurus microlepidotus</i>	QLD (Townsville) to NSW (Merimbula)	70	2009-				14	9	12	15	45	45	30	35	6	10	5	10
			2010-		7	8		20	15	35	55	60	18	45	6	6		10
<i>Stegastes gascoynei</i>	QLD to NSW (Montague Island)	14	2009-	8				9	15	10								
			2010-	4	2	10		13	15	13			2					

DISCUSSION

Summary of patterns relative to previous data

Analysis of the 2009-2011 data has provided general support for many of the patterns and processes described in the interim report and in Booth *et al* 2007. There is a general pattern of both decreasing richness and density of tropical fishes with increasing south latitude along the coast of NSW. The coastal sites at Port Stephens continue to exhibit anomalously low diversity relative to sites to the south, even including data from Fisherman's Bay which was surveyed for the first time in 2010/11. Very high diversity was observed at Cabbage Tree Island, but this was based on only one survey. It is quite likely these offshore island locations may exhibit uniformly high diversity of tropical fishes though additional monitoring would be needed to confirm this. The previously observed tendency for butterflyfishes to be found more commonly further south was true to a degree. There were certainly more found in Merimbula than any sites up to Sydney, but they were quite common on occasion at a few Sydney and Central Coast sites in both years.

Settlement patterns were variable among sites and years, but the onset of settlement did correspond closely to water temperatures. The onset of settlement during 2009-2010 occurred slightly earlier (early versus mid-late January) than in 2010-2011 corresponding to early onset of warm conditions during 2009-10 relative to 2010-11 (it was about 1°C cooler at the beginning of Jan. 2011 than Jan. 2010). There does also seem to be a clear role for temperature in driving persistence patterns over the year. The density of tropical fishes declined steadily through the sampling years concomitant with temperature decreases at all sites. More compelling evidence for the role of temperature comes from the rapid drop in densities at all sites coincident with a drop in temperature of about 1.5°C over only a few weeks during 2010-2011. This decline crosses over the 17.5°C threshold of average winter temperatures required for overwinter survival as reported by Figueira and Booth (2010). In contrast, during 2009-2010 the drop in temperature across this threshold occurred much more gradually, over a 6-8 week period and decreases in tropical fish density were also much more gradual. We also saw overwinter survivors at the Central Coast and Sydney sites in both years although few elsewhere.

Previous laboratory studies (Figueira *et al.* 2009) with one of the most numerically abundant tropical fish species in NSW waters, *A. vaigiensis*, has indicated that both feeding and growth rates decrease at temperatures below 25°C. Indeed there is evidence from this dataset that water temperatures may be playing a role in the growth of individuals at the various sites. There is a general pattern of reduced maximum size with increasing south latitude for several species though

the patterns are quite variable and a more thorough and quantitative analysis of these data is needed before we can comment further.

Monitoring change

Past and current data suggest that tropical fishes are ideal candidates with which to monitor the progression of potential climate change effects in temperate waters of NSW because: (1) tropical species tend to be conspicuous and therefore easy to monitor; (2) latitudinal patterns appear to be robust for the period 2002-2011, thus providing a strong baseline against which future changes can be assessed; (3) tropicals demonstrate a clear response to ‘ecological stress’ or changes predicted to occur due to climate change (i.e. increase in sea surface temperature, changes in the EAC).

Furthermore, it has been shown that less abundant species often exhibit greater shifts in distribution than more common species, providing a major challenge for monitoring climate change (Stuart-Smith *et al.* 2010). We propose the development of a multi-metric tropical fish index similar to that currently used for other natural resources in NSW (e.g. estuarine condition (e.g. estuarine condition, fish (Harrison & Whitfield 2004)). This index would allow the quantification of impacts of a changing coastal marine climate on tropical fishes in temperate waters. Potential constituent metrics to this index are listed in Table 3. It’s important to note that these metrics do not currently account for hypothesised effects of climate change on the biology of larval and adult fish (inhabiting tropics) that may interact with physical processes to influence observed patterns. For example, warmer water may lead to more rapid development and growth of larvae, subsequent decrease in PLD and earlier onset of behavioural traits (e.g. directional swimming) used to actively influence dispersal/settlement (Munday *et al.* 2009). This could lead to a reduced spatial scale of larval dispersal and connectivity and increasing level of self recruitment (Munday *et al.* 2009). Given this, it is important that metrics are reviewed in the future as new data become available.

Table 3: Ecological measures proposed for a Tropical fish Community Index (TFCI) and their response to climate change relative to baseline conditions.

TFCI measures	Response relative to baseline
Species diversity and composition	
Total number of tropical taxa	Increase
Rare tropical species	Increase
Species composition	Increase
Species abundance	
Species relative abundance	Increase
Number of species that make up 90 % of the abundance	Increase
Settlement	
Absolute annual settlement	Increase
Latitudinal peaks in settlement	Move south
Timing of first settlement peak	Delayed

Number of settlement peaks	Increase
Persistence	
Overwinter survivors	Increase
Post-settlement growth rates	Increase
Presence of adults	Increase
Presence of reproductively active individuals	Increase

While it would be difficult to discern climate effects with only two years of data, it is worth considering how the data currently collected would inform these various classes of metrics:

Species diversity and composition

We saw a relatively large increase in the total number of tropical species observed at all sites in 2010-11 compared to 2009-10 (Figures 2&3). Much of this is possibly due to increases in identification abilities of new surveyors. However, this may not be entirely the case as these increases were also observed in Merimbula by an observer who has been involved with this program since it began in 2002. There were also more rarely observed taxa during 2009-10 compared to 2010-11.

Species abundance

The overall density of tropical fishes was generally higher at all sites in 2010-11 than 2009-10 (Figure 8) and this holds for nearly all of the most commonly occurring species (Figures 4-8). Despite these density differences, there was no clear indication that the mode of latitudinal distribution for these species has shifted uniformly. For the damselfishes (Figure 4) and wrasses (Figure 6) the mode has, if anything, shifted towards the equator while the opposite is true for the surgeonfishes (Figure 5) and butterflyfishes (Figure 8).

Settlement

Settlement, as estimated by the density of small individuals, was much higher in 2009-2010. However, the pattern for the density of medium sized individuals is the opposite. This would suggest that recently settled individuals (small size category) are generally not being very effectively enumerated either because they are cryptic or the frequency of sampling is too low to capture them before they grow out of this size class. While it is unlikely we will be able to increase sampling frequency to capture true settlers due to financial and logistical constraints, we should be able to use the raw size data (rather than size categories) to tease out settlement peaks from the time series. However from the raw density data we can highlight the slightly delayed settlement in 2010-11 as compared to 2009-10 (Figure 8) due, presumably, to the much cooler waters during the former relative to the latter year (Figure 9).

Persistence

Where post-winter survivors (large sized fish) were found, there was a general trend for them to be present in greater densities after the winter of 2011 than 2010 (Figure 10). Notable exceptions to this were at Terrigal on the Central Coast Terrigal where the pattern was the opposite and at Collins Beach in Sydney where there was little difference between years. This pattern is consistent with the milder winter experienced in 2011 as compared to 2010 though more rigorous analysis of patterns at individual sites is needed to fully explore these patterns and determine if they are consistent with the overwinter threshold temperatures observed by (Figueira & Booth 2010).

RECOMMENDATIONS & PRIORITIES FOR FUTURE RESEARCH

- Annual sampling should be continued over a minimum of 5 years. Power analyses should be completed on 2010 and 2011 data to test level of sampling (both temporal and spatial) that will be sufficient to detect changes over longer time periods.
- Habitat should be comprehensively mapped at each site.
- The feasibility of extending the sampling program to include Batemans Bay, Newcastle and Seal Rocks should be investigated. Seal Rocks should be prioritised as this is an important region in terms of EAC behaviour (separation point and upwelling) and we have little information upon which to base the categorisation of Port Stephens as anomalous.
- Given the anomalously low diversity at coastal Port Stephens sites and high diversity of Cabbage Tree Island, this region should be surveyed to the same level as the other sites.
- Fish survey data should be reviewed for all Marine Parks to check for adult tropicals.
- A validation study on size estimates should be initiated to allow for comparison among data collected by different surveyors.
- Growth/age study of key species should be completed across all regions using otoliths.

ACKNOWLEDGEMENTS

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REFERENCES

- Booth D.J., Figueira W.F., Gregson M.A., Brown L. & Beretta G. (2007). Occurrence of tropical fishes in temperate southeastern Australia: role of the East Australian Current. *Estuarine Coastal and Shelf Science*, 72, 102-114.
- DECCW (2010). New South Wales Natural Resources Monitoring, Evaluation and Reporting Strategy 2010–2015. In. State of NSW and Department of Environment, Climate Change and Water NSW Sydney, NSW, p. 40.
- Figueira W.F., Biro P., Booth D.J. & Valenzuela V.C. (2009). Performance of tropical fish recruiting to temperate habitats: role of ambient temperature and implications of climate change. *Marine Ecology Progress Series*, 384, 231-239.
- Figueira W.F. & Booth D.J. (2010). Increasing ocean temperatures allow tropical fishes to survive overwinter in temperate waters. *Global Change Biology*, 16, 506-516.
- Harrison T.D. & Whitfield A.K. (2004). A multi-metric fish index to assess the environmental condition of estuaries. *Journal of Fish Biology*, 65, 683-710.
- Hobday A., Okey T., Poloczanska E., Kunz T. & Richardson A. (2006a). Impacts of climate change on Australian marine life - Part A: Executive Summary. Project Report. CSIRO Marine and Atmospheric Research, Canberra, Australia. In.
- Hobday A., Okey T., Poloczanska E., Kunz T. & Richardson A. (2006b). Impacts of climate change on Australian marine life - Part B: Technical Report. Technical Report. CSIRO Marine and Atmospheric Research, Canberra, Australia.
- Munday P., Leis J., Lough J., Paris C., Kingsford M., Berumen M. & Lambrechts J. (2009). Climate change and coral reef connectivity. *Coral Reefs*, 28, 379-395.
- Ridgway K.R. (2007). Long-term trend and decadal variability of the southward penetration of the East Australian Current. *Geophysical Research Letters*, 34, L13613.
- Stuart-Smith R.D., Barrett N.S., Stevenson D.G. & Edgar G.J. (2010). Stability in temperate reef communities over a decadal time scale despite concurrent ocean warming. *Global Change Biology*, 16, 122-134.
- Wernberg T., Russell B.D., Moore P.J., Ling S.D., Smale D.A., Campbell A., Coleman M.A., Steinberg P.D., Kendrick G.A. & Connell S.D. (2011). Impacts of climate change in a global hotspot for temperate marine biodiversity and ocean warming. *Journal of Experimental Marine Biology and Ecology*, In Press, Corrected Proof.

APPENDIX**Table 1.** Metadata statement for tropical fish project**General Properties**

File Identifier	3D5641DF-284F-4E0E-AC28-F870A31A3544
Hierarchy Level	Dataset
Hierarchy Level Name	Dataset
Standard Name	ANZLIC Metadata Profile: An Australian/New Zealand Profile of AS/NZS ISO 19115:2005, Geographic information - Metadata
Standard Version	1.1
Date Stamp	2011-02-09
Resource Title	Monitoring the occurrence of tropical fishes along the NSW coast Booth DJ, Figueira WF, Gregson MA, Brown L, Beretta G (2007) Occurrence of tropical fishes in temperate south-eastern Australia: role of the East Australian Current. Estuarine Coastal and Shelf Science 72 (1-2):102-114 Figueira WF, Booth DJ (2010) Increasing ocean temperatures allow tropical fishes to survive overwinter in temperate waters. Global Change Biology 16 (2):506-516
Other Resource Details	
Format Name	*.mdb
Format Version	Unknown

Key Dates and Languages

Date of publication	2011-02-09
Metadata Language	eng
Metadata Character Set	utf8
Dataset Languages	eng
Dataset Character Set	utf8
Abstract	The main objective of the project was to investigate the feasibility of establishing a long-term (initially 5 years) sampling program (to complement ongoing surveys by the Booth & Figueira since 2002) to document the level of recruitment of 'tropical vagrant' coral reef fishes, and the extent of their 'over-wintering' along the NSW coast against key environmental parameters.
Purpose	Natural Resource Management Monitoring, Evaluation, Reporting (MER)

Metadata Contact Information

Name of Individual	David Booth
Organisation Name	University of Technology
Position Name	Professor of Marine Ecology
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 Name of Individual **Australia**
 Organisation Name **Name withheld**
 Position Name **University of Technology**
 Role **Professor of Marine Ecology**
 Voice **principal Investigator**
 Facsimile **61-2-9514 4053**
 Email Address **61-2-9514 4079**
 Address **david.booth@uts.edu.au**

Sydney NSW 2007
Australia

Credit

W Figueira
 B Curley
 B Creese
 S Newson
 G Graham
 R Laird
 J Vanderbilt
 M Gregson
 G Beretta
 L Brown

Lineage Statement

The tropical fish project is based on the methodology developed by Booth et al. (2007). As such, it makes use of existing datasets for some sites along the coast that have been monitored annually since 2001/02. The project initially focuses on the area south from Seal Rocks as the greatest changes in supply and survival of tropicals are predicted to occur within this region. The sampling design developed by Booth et al (2007) involves sampling two sites at readily accessible locations where tropicals are known to occur. The two long-term locations sampled by Booth et al are Sydney and Merimbula. Additional sites at Port Stephens, Central Coast, Sydney, Jervis Bay, Narooma and Merimbula were added to the program in 2010. Fish sampling involves a weekly snorkel search of a defined area ('the site') which takes 1-1.5 hours. The number and size of all tropical species sighted are recorded. Intensive sampling is conducted from Jan to early March, with a lower frequency of sampling (every 2-3 weeks) from mid-March to June to check for 'late pulse' and longer-term survivorship. Two temperature loggers are also deployed at each site to record water temperatures throughout the year. The project is ongoing.

Jurisdictions

New South Wales
Australia

Search Words

ECOLOGY-Ecosystem
CLIMATE-AND-WEATHER-Climate-change
CLIMATE-AND-WEATHER-Temperature
FAUNA-Native
MARINE-Biology

	MARINE-Coasts
	MARINE-Reefs
	OCEANOGRAPHY-Physical
<i>Themes and Categories</i>	
Topic Category	biota
<i>Status and Maintenance</i>	
Status	ongoing
Maintenance and Update Frequency	annually
Date of Next Update	2011-12
<i>Reference system</i>	
Reference System	4283 (GDA94)
<i>Dataset Access Constraints</i>	
Identifier	intellectualPropertyRights
Annotation	Please contact project officer
<i>Dataset Use Constraints</i>	
Identifier	intellectualPropertyRights
Annotation	
<i>Additional Extents - Geographic</i>	
Identifier	aus
Identifier	NSW
<i>Additional Extent - Temporal</i>	
Date/Time	2002

Table 2. Tropical species recorded across regions and sampling sites in 2009-10 and 2010-11 survey years. Shown are the average number of individuals recorded per survey during the peak recruitment period from Jan-May at each site as well as the total percent of sites at which that species occurred each year (%). Site codes are as given in Table 1.

Family name	Scientific name	Comm name	Year	PS			CC		SY				JB		BR	NR	ME		%	
				CT	SB	FB	TW	TR	SE	SW	LM	CO	MW	MB	MG	BW	KB	BB		
Acanthuridae	Acanthurid - unknown	Acanthurid - unknown	2009-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0.03	0	0	7
			2010-11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Acanthuridae	Acanthurus albipectoralis	Whitefin surgeonfish	2009-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			2010-11	0	0.05	0	0	0	0.06	0.06	0.20	2.58	0	0	0	0	0	0	0	0
Acanthuridae	Acanthurus dussumieri	Pencil Surgeon	2009-10	0	0	0	0.65	8.18	1.23	1.62	0.35	0.92	0.10	0.12	0.24	1.07	0.48	0.16	80	
			2010-11	0.30	0.35	0.57	0.97	27.0	4.31	8.22	1.81	3.04	0.64	0.19	0.60	1.38	1.13	4.39	100	
Acanthuridae	Acanthurus leucosternon?	Blue surgeon	2009-10	0	0	0	0	0	0	0	0.03	0	0	0	0	0	0	0	7	
			2010-11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Acanthuridae	Acanthurus lineatus	Lined Surgeon	2009-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
			2010-11	0	0	0.03	0	0	0.13	0	0	0	0	0.03	0	0	0	0	0	20
Acanthuridae	Acanthurus mata	Pale surgeonfish	2009-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
			2010-11	0	0	0	0	0.04	0	0	0	0	0	0	0	0	0	0	0.03	13
Acanthuridae	Acanthurus nigrofuscus	Dusky surgeon	2009-10	0	0	0	0	0	0.49	0.76	0	0	0	0	0	0	0	0	13	
			2010-11	1.19	0.21	0.42	0	1.05	6.88	7.05	0.10	0.46	1.61	0.13	0	0	0.35	0.07	80	
Acanthuridae	Acanthurus olivaceus	Yellow Surgeon	2009-10	0	0	0	0.04	0.10	0	0	0	0	0	0	0	0	0	0	13	
			2010-11	0.37	0.07	0.39	0	1.09	0	0.55	0	0.09	0.59	0.03	0	0	0	0.34	60	
Acanthuridae	Acanthurus triostegus	Convict Surgeon	2009-10	0	0	0	1.93	0.80	0.59	0.40	0	0	0	0	0	0.27	0	33		
			2010-11	0.07	0.23	0.05	5.01	6.51	7.20	5.95	0.23	0	0	0	0.05	0	0.17	0.34	73	
Acanthuridae	Ctenochaetus binotatus	Two-spot Bristlefish	2009-10	0	0	0	0	0.03	0	0	0	0	0.02	0	0	0	0	13		
			2010-11	0	0	0	0.05	3.86	0	1.29	0	0.37	0	0	0	0	0	0.03	33	
Acanthuridae	Ctenochaetus striatus	Lined Bristletooth	2009-10	0	0	0	0	0.66	0.15	0.45	0	0	0	0	0	0	0	20		
			2010-11	0	0	0	0	8.27	0.26	0.55	0	0.55	0	0	0	0	0	0	27	
Acanthuridae	Naso brevirostris	Spotted Unicornfish	2009-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
			2010-11	0	0	0	0	0.04	0.06	0.12	0	0	0	0	0	0	0	0	20	
Acanthuridae	Naso sp.	Unicornfish	2009-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
			2010-11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Acanthuridae	Naso unicornis	Bluespine Unicornfish	2009-10	0	0	0	0	0	1.97	2.88	0.53	0	1.52	0.08	0	0	0	33		
			2010-11	0	0.09	0.02	0	0	0.58	1.72	0.13	0.46	1.37	0.03	0	0	0	0	53	
Acanthuridae	Naso vlamingii	bignose unicornfish	2009-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
			2010-11	0	0	0	0	0	0	0.06	0	0.09	0.03	0.03	0	0	0	0	27	
Acanthuridae	Zebrasoma flavescens	Yello Tang	2009-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
			2010-11	0	0	0	0	0.04	0	0	0	0	0	0	0	0	0	0	7	

Family name	Scientific name	Comm name	Year	PS			CC		SY				JB		BM	NR	ME		%	
				CT	SB	FB	TW	TR	SE	SW	LM	CO	MW	MB	MG	BW	KB	BB		
Acanthuridae	Zebrasoma veliferum	Sailfin Tang	2009-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			2010-11	0	0	0	0	0	0	0	0.06	0	0	0	0	0	0	0	0	0
Apogonidae	Apogon apogonides	plain cardinalfish	2009-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			2010-11	0	0	0	0	0	0	0	0	0	0	0.08	0	0	0	0	0	0
Balistidae	Rhinecanthus aculeatus	Blackbar Triggerfish	2009-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			2010-11	0	0	0	0	0.08	0	0	0	0	0	0	0	0	0	0	0	0
Balistidae	Rhinecanthus rectangulus	Wedge-tail Triggerfish	2009-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			2010-11	0	0	0	0	0.04	0	0	0	0	0	0.03	0	0	0	0	0	0
Balistidae	Sufflamen chrysopteron	Eye-stripe Triggerfish	2009-10	0	0	0	0	0.03	0	0	0	0	0	0	0	0	0	0	0	7
			2010-11	0	0	0	0	0.12	0	0	0	0	0.18	0.13	0	0	0	0	0	0
Belonidae	Strongylura leiura	Slender Longtom	2009-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			2010-11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Belonidae	Tylosurus gavialoides	Stout Longtom	2009-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			2010-11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Blenniidae	Aspidotus taeniatus	False Cleanerfish	2009-10	0	0	0	0	0	0	0	0	0	0.29	0.02	0	0	0	0	0	13
			2010-11	0	0	0	0	0.51	0	0	0	0	0.19	0.03	0	0	0	0	0	0
Blenniidae	Plagiotremus rhinorhynchos	Bluestriped Fang Blenny	2009-10	0	0	0	0	0	0	0	0	0	0.02	0	0	0	0	0	0	7
			2010-11	0	0	0	0	0	0	0	0	0	0	0	0	0	0.10	0	0	7
Blenniidae	Plagiotremus tapeinosoma	Piano Fang Blenny	2009-10	0	0	0	0	0	0	0	0	0	0.10	0	0	0.45	0	0.18	20	
			2010-11	0	0.02	0.06	0	0.78	0	0	0	0	0.21	0.06	0	0.52	0	0.03	47	
Brachaeluridae	Brachaelurus waddi	blind shark	2009-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			2010-11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chaetodontidae	Chaetodon auriga	Threadfin Butterflyfish	2009-10	0	0.11	0	0.15	0.28	0.05	0	0	0	0	0.02	0	0	0.11	0.10	47	
			2010-11	0	0.21	0.06	0	0.04	0.26	0.98	0.03	0.09	0	0	0	0.05	0	0.74	60	
Chaetodontidae	Chaetodon citrinellus	Speckled Butterflyfish	2009-10	0	0	0	0	0	0.05	0	0	0	0	0	0	0	0	0	7	
			2010-11	0	0.02	0	0	0.04	0.06	0.12	0	0	0	0	0	0	0	0	0	27
Chaetodontidae	Chaetodon flavirostris	Dusky butterflyfish	2009-10	0.01	0	0	0	0.03	0	0.30	0	0	0	0	0	0.08	0	0	27	
			2010-11	0	0.07	0.06	0	0	0	0.37	0.03	0	0.03	0	0	0	0	0	0	33
Chaetodontidae	Chaetodon guentheri	Günther's Butterflyfish	2009-10	0.01	0.19	0	0.02	0	0	0	0	0	0	0.02	0	0.03	0	0	33	
			2010-11	0	0.07	0	0.13	1.64	0.06	0	0	0	0	0	0	0	0	0	0	27
Chaetodontidae	Chaetodon kleinii	Klein's Butterflyfish	2009-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
			2010-11	0	0	0	0.16	0	0.06	0	0	0	0.08	0	0	0	0	0	0	20
Chaetodontidae	Chaetodon lordhowensis	Lordhowe Butterfly	2009-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
			2010-11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chaetodontidae	Chaetodon lunula	Racoon Butterflyfish	2009-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
			2010-11	0	0	0	0	0.04	0	0	0	0	0	0	0	0	0	0	0	7
Chaetodontidae	Chaetodon melannotus	Blackback Butterflyfish	2009-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
			2010-11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Family name	Scientific name	Comm name	Year	PS			CC		SY				JB		BM	NR	ME		%	
				CT	SB	FB	TW	TR	SE	SW	LM	CO	MW	MB	MG	BW	KB	BB		
Chaetodontidae	Chaetodon	Dot-Dash	2009-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	pelewensis	Butterflyfish	2010-11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chaetodontidae	Chaetodon	Truncate	2009-10	0	0	0	0	0	0	0	0	0	0	0.08	0	0	0	0	0	7
	truncatus	Coralfish	2010-11	0	0	0	0	0.08	0	0	0	0	0	0	0	0	0	0	0	7
Chaetodontidae	Chaetodon	Vagabond	2009-10	0	0	0	0	0.03	0	0	0	0	0	0	0.04	0	0	0	0	13
	vagabundus	Butterflyfish	2010-11	0	0.05	0.03	0	0	0.06	0.12	0	0	0	0	0	0	0	0	0.07	33
Chaetodontidae	Chelminops	Eastern	2009-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	truncatus	Talma	2010-11	0	0	0	0	0	0	0	0	0	0	0.09	0	0	0	0	0	7
Chaetodontidae	Chrysiptera	Yellowfin	2009-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	flavipinnis	Damsel	2010-11	0	0	0	0	0.31	0	0	0	0	0	0	0	0	0	0	0.03	13
Chaetodontidae	Chrysiptera	Surge	2009-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	leucopoma	Damselfish	2010-11	0	0.02	0.05	0	0	0	0	0	0	0	0	0	0	0	0	0	13
Chaetodontidae	Heniochus	Longfin	2009-10	0	0	0	0	0	0	0.10	0	0	0	0	0	0.15	0	0	0	13
	acuminatus	Bannerfish	2010-11	0	0	0	0	0.12	0	0	0	0	0	0	0	0	0	0	0	7
Chaetodontidae	Heniochus	Pennant	2009-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	chrystostomus	Bannerfish	2010-11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cirrhitidae	Cirrhitichthys	Blotched	2009-10	0	0	0	0	0	0	0	0	0	0	0	0	0.44	0	0.02	13	
	aprinus	Hawkfish	2010-11	0	0	0	0	0	0	0	0	0	0	0	0	0.10	0	0	7	
Cirrhitidae	Cirrhitichthys	Dwarf	2009-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	falco	hawkfish	2010-11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fistulariidae	Fistularia	Smooth	2009-10	0	0	0	0	0	0	0	0	0	0.07	0	0	0	0	0	0	7
	commersonii	Flutemouth	2010-11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Grammistidae	Diploprion	Barred	2009-10	0	0	0	0	0	0	0.05	0	0	0	0	0	0	0	0	0	7
	bifasciatum	Soapfish	2010-11	0	0	0	0	0.19	0.06	0	0.03	0.18	0	0	0	0	0	0	0	27
Labridae	Anampses caer-	Diamond	2009-10	0.03	0.02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13
	uleopunctatus	Wrasse	2010-11	0	0	0	0	0	0.39	0.61	0	0	0.43	0	0	0	0	0	0	20
Labridae	Anampses	geographic	2009-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	geographicus	wrasse	2010-11	0	0	0	0	0	0	0.06	0	0	0	0	0	0	0	0	0	7
Labridae	Anampses	new guinea	2009-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	neoguinaicus	wrasse	2010-11	0	0	0	0	0	0	0	0	0	0.05	0	0	0	0	0	0	7
Labridae	Anampses	Anampses	2009-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		wrasse sp	2010-11	0	0	0	0	0	0	0	0	0	0.16	0	0	0	0	0	0	7
Labridae	Choerodon	Purple	2009-10	0	0	0	0	0	0	0.71	3.41	3.99	0	0	0	0	0	0	0	20
	cephalotes	Tuskfish	2010-11	0	0	0	0	0	0	0	0.16	1.29	0	0	0	0	0	0	0	13
Labridae	Coris	Pinklined	2009-10	0	0	0	0	0	0	0	0	0	0.10	0	0	0	0	0	0	7
	dorsomacula	Wrasse	2010-11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Labridae	Diproctacanthus	yellowtail	2009-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	xanthurus	wrasse	2010-11	0	0	0	0	0	0	0	0	0	0.05	0	0	0	0	0	0	7

Family name	Scientific name	Comm name	Year	PS			CC		SY				JB		BM	NR	ME		%	
				CT	SB	FB	TW	TR	SE	SW	LM	CO	MW	MB	MG	BW	KB	BB		
Labridae	Halichoeres	Golden	2009-10	0	0	0	0.02	0	0	0	0	0	0	0	0	0	0	0	0	7
	chrysus	Wrasse	2010-11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Labridae	Halichoeres	dusky	2009-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	marginatus	wrasse	2010-11	0	0	0	0	0	0	0.06	0	0	0.05	0	0	0	0	0	0	13
Labridae	Halichoeres	Cloud	2009-10	0	0	0	0	0	0	0.05	0	0	0.15	0.07	0	0	0	0	0	20
	nebulosus	Wrasse	2010-11	0	0	0	0	0	0	0.06	0	0	1.40	0	0	0	0	0	0	13
Labridae	Halichoeres	twotone	2009-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	prosopeion	wrasse	2010-11	0	0	0	0	0	0	0	0	0	0.05	0	0	0	0	0	0	7
Labridae	Halichoeres	Three-spot	2009-10	0	0	0	0.02	0	0	0	0	0	0	0	0	0	0	0	0	7
	trimaculatus	Wrasse	2010-11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Labridae	Labrichthys	tubelip	2009-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	unilineatus	wrasse	2010-11	0	0	0	0	0	0	0	0	0	0.03	0	0	0	0	0	0	7
Labridae	Labroides	Cleaner	2009-10	0.09	0.01	0	0	0.49	0	0	0	0	0	0	0	0	0	0	0	20
	dimidiatus	Wrasse	2010-11	0.22	0.02	0	0	2.77	0.19	0.06	0.07	0.28	0.51	0.06	0	0.19	0	0.13	0	73
Labridae	Macropharyngo	Leopard	2009-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	don meleagris	Wrasse	2010-11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Labridae	Pseudocoris	Pink Wrasse	2009-10	0	0	0	0	0.03	0	0	0	0	0	0	0	0	0	0	0	7
	yamashiroi		2010-11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Labridae	Stethojulis	Redspot	2009-10	0	0	0	0	0.49	0	1.87	0	0	0.22	0	0	0	0	0	0	20
	bandanensis	Wrasse	2010-11	0	0	0	0.26	0.62	0.39	2.39	0	0.18	1.05	0	0	0	0	0	0	40
Labridae	Stethojulis	Brokenline	2009-10	0	0	0	0	0	0.10	0.61	0.98	2.15	0.07	0.05	0	0	0	0	0	40
	interrupta	Wrasse	2010-11	0	0	0	0	0	0.39	5.89	0.85	4.42	1.93	0.16	0	0	0	0	0	40
Labridae	Stethojulis	three ribbon	2009-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	strigiventer	wrasse	2010-11	0	0	0	0	0	0	0	0	0.28	0	0	0	0	0	0	0	7
Labridae	Stethojulis	Three-lined	2009-10	0	0	0	0	0	0	0.10	0	0	0	0	0	0	0	0	0	7
	trilineata	wrasse	2010-11	0	0	0	0	0	0	0.31	0	0	0	0	0	0	0	0	0	7
Labridae	Thalassoma	Blue-headed	2009-10	0	0	0	0	0.03	0	0	0	0	0	0	0	0	0	0	0	7
	amblycephalum	Wrasse	2010-11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.17	7
Labridae	Thalassoma	Jansen's	2009-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	janseni	wrasse	2010-11	0.30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7
Labridae	Thalassoma	Moon	2009-10	0	0	0	0	0	0.05	0.10	0.03	0	0.10	0.03	0	0.71	0	0.10	47	
	lunare	Wrasse	2010-11	0.22	0.02	0.38	0	0.04	0.06	2.08	0	0.18	0.46	0.41	0.16	0.67	0	1.81	80	
Labridae	Thalassoma	Green moon	2009-10	0	0	0	0	0	0	0	0	0	0.02	0	0	0	0	0	0	7
	lutescens	Wrasse	2010-11	0	0	0	0	0	0	0	0	0	0	0	0	0.05	0	0.03	13	
Labridae	Thallosoma	Thallosoma -	2009-10	1.41	0.03	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13
	species	unknown	2010-11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Labridae	Xyrichtys	Leaf wrasse	2009-10	0	0	0	0	0	0	0	0	0	0.12	0	0	0	0	0	0	7
	dea		2010-11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Family name	Scientific name	Comm name	Year	PS			CC		SY				JB		BM	NR	ME		%	
				CT	SB	FB	TW	TR	SE	SW	LM	CO	MW	MB	MG	BW	KB	BB		
Lethrinidae	Lethrinus	Spangled	2009-10	0	0	0	0	0	0	0	0.51	4.29	0	0	0	0	0	0	0	13
	nebulosus	Emperor	2010-11	0	0	0	0	0	0.06	0	0.30	0	0	0	0	0	0	0	0	13
Lutjanidae	Lutjanus	Blackspot	2009-10	0	0	0	0.06	0	0.10	0	0	0	0	0	0	0	0	0	0	13
	fulviflamma	Snapper	2010-11	0	0	0	0	0	0	0	0	0.09	0.03	0	0	0.05	0	0.03	27	
Lutjanidae	Lutjanus	blue-striped	2009-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	kasmira	snapper	2010-11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.07	7	
Lutjanidae	Lutjanus	five-lined	2009-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	quinclineatus	snapper	2010-11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.03	7	
Lutjanidae	Paracaesio	Yellowtail	2009-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	xanthura	blue snapper	2010-11	0.07	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	
Monacanthidae	Paraluteres	Blacksaddle	2009-10	0	0	0	0.17	0	0	0	0	0	0	0	0	0	0	0	7	
	prionurus	Filefish	2010-11	0	0	0	0	0.04	0	0	0	0	0	0	0	0	0	0	7	
Monacanthidae	Pervagor	yellow-eye	2009-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	alternans	filefish	2010-11	0	0	0	0	0	0	0	0	0	0.03	0	0	0	0	0	7	
Mullidae	Parupaneus	Banded	2009-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	multifasciatus	Goatfish	2010-11	0	0	0	0	0.04	0	0	0	0.18	0.08	0	0	0	0	0	20	
Mullidae	Parupeneus	White Sadl	2009-10	0	0	0	0	0	0	0	0	0	0	0.07	0	0	0	0	7	
	ciliatus	Goatfish	2010-11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Ostraciidae	Ostracion	Yellow	2009-10	0	0.05	0	0	0	0	0	0.15	0.31	0	0	0	0	0	0	20	
	cubicus	Boxfish	2010-11	0	0	0	0	0.23	0	0	0	0	0	0	0	0.29	0	0.03	20	
Ostraciidae	Ostracion	white-spot	2009-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	meleagris	boxfish	2010-11	0	0	0	0	0.04	0	0	0	0	0	0	0	0	0	0	7	
Ostraciidae	Ostracion sp	Cowfish	2009-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
			2010-11	0	0	0	0	0.04	0	0	0	0	0	0	0	0	0	0	7	
Pomacanthidae	Centropyge	Damsel	2009-10	0	0	0	0	0	0	0	0	0	0.02	0	0	0	0	0	7	
	flavicauda	Angelfish	2010-11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Pomacanthidae	Centropyge	Keyhole	2009-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	tibicen	Angelfish	2010-11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.03	7	
Pomacanthidae	Centropyge	Pearlscale	2009-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	vroliki	Angelfish	2010-11	0	0	0	0	0.04	0	0	0	0	0	0.03	0	0	0	0	13	
Pomacanthidae	Chaetodontoplu	conspicuous	2009-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	s conspicillatus	angelfish	2010-11	0	0	0	0	0	0	0	0	0	0	0.03	0	0	0	0	7	
Pomacentridae	Abudefduf	Bengal's	2009-10	0.01	0.02	0	16.3	9.32	3.98	9.75	0.15	0	0.27	0.19	0.56	0	0.05	0.78	80	
	bengalensis	Sergeant	2010-11	0	0.19	0.44	19.0	16.7	8.81	8.09	2.00	1.01	0.94	0.06	0.22	0	0	0.34	80	
Pomacentridae	Abudefduf	Scissor-tail	2009-10	0	0.58	0	17.1	21.1	2.21	15.9	5.88	0.31	4.14	0.25	0.88	0.15	0	0.04	80	
	sexfasciatus	Sergeant	2010-11	0.67	0.33	0.26	13.0	17.4	0	0.43	0.23	2.02	4.51	0.16	0.27	0.57	0.26	0.90	93	
Pomacentridae	Abudefduf	Night	2009-10	0	0	0	0.29	1.14	0	0	0	0	0	0.03	0	0	0	0	20	
	sordidus	Sergeant	2010-11	0	0	0	0.21	0	0	0	0	0	0.27	0	0	0	0	0	13	

Family name	Scientific name	Comm name	Year	PS			CC		SY				JB		BM	NR	ME		%
				CT	SB	FB	TW	TR	SE	SW	LM	CO	MW	MB	MG	BW	KB	BB	
Pomacentridae	Abudefduf	Sergeant	2009-10	1.10	3.36	0	39.6	56.0	41.6	82.1	5.88	6.13	16.3	12.9	4.63	5.00	1.92	3.70	93
	vaigiensis	Major	2010-11	0.96	3.32	2.94	35.0	108	30.7	61.5	18.4	23.6	16.2	4.91	1.26	8.84	4.34	2.95	100
Pomacentridae	Abudefduf	Whitley's	2009-10	0	0	0	17.9	24.5	4.43	16.2	0.25	0	0	0	0	0	0	0	33
	whitleyi	Sergeant	2010-11	0	0.35	0.35	18.8	27.1	5.15	14.1	1.15	3.77	0.54	0.03	0	0.14	0	0.34	80
Pomacentridae	Acanthochromis	Spiny Puller	2009-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	polyacanthus		2010-11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pomacentridae	Chromis	Half and Half Puller	2009-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	iomelas		2010-11	0	0	0	0	0.04	0	0	0	0	0	0	0	0	0	0	0
Pomacentridae	Chromis	Bicolor	2009-10	0	0	0	0	0	0.05	0	0	0	0	0	0	0	0	0	7
	margaritifer		2010-11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pomacentridae	Chromis nitida	Yellow-back Puller	2009-10	0	0.20	0	0	0	0	0	0	0.03	12.6	0	0	0	0.06	0	0
			2010-11	0	0	0	0	0	0	0	0	0	12.0	0	0	0	0	0	0
Pomacentridae	Chromis viridis	Blue-green chromis	2009-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			2010-11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pomacentridae	Chromis weberi	Weber's chromis	2009-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			2010-11	0	0	0	0	0.51	0	0.06	0	0	0	0.11	0	0	0	0	0
Pomacentridae	Chrysiptera biocellata	Twospot Demoiselle	2009-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			2010-11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pomacentridae	Chrysiptera brownriggii	surge damselfish	2009-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			2010-11	0	0	0	0	0	0	0	0	0	0	0.03	0	0	0	0	0
Pomacentridae	Chrysiptera starcki	Starck's Demoiselle	2009-10	0	0	0	0	0	0	0	0	0	0.02	0	0	0	0	0	7
			2010-11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pomacentridae	Dascyllus trimaculatus	Three-spot damselfish	2009-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			2010-11	0	0	0.02	0	0	0	0	0	0	0	0	0	0	0	0	0
Pomacentridae	Neopomacentrus asyzron	Yellowtail Demoiselle	2009-10	0	0	0	0	0.03	0	0	0	0	0	0	0	0	0	0	7
			2010-11	0	0	0	0	0	0	0	0	0	0	0	0	0	0.05	0	0
Pomacentridae	Neopomacentrus bankieri	Chinese Demoiselle	2009-10	0	0	0	0	0	0	0	0	0.28	0	0	0	0	0	0	7
			2010-11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pomacentridae	Neopomacentrus nigrorsis	Black -gold Chromis	2009-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			2010-11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pomacentridae	Plectroglyphidodon lacrymatus	Whitespotted Devil	2009-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			2010-11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pomacentridae	Plectroglyphidodon leucozonus	Singlebar Devil	2009-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			2010-11	0	0	0.03	0	0	0.06	0.31	0	0	0.05	0	0	0	0	0	0
Pomacentridae	Pomacentrus australias	Australian Damselfish	2009-10	0	0	0	0	0.07	0	0.50	0	0	0	0	0	0.05	0	0.02	
			2010-11	0	0	0	0	0	0	0.61	0	0	0	0	0	0	0	0	
Pomacentridae	Pomacentrus bankanensis	Speckled Damsel	2009-10	0	0	0	0	0	0	0.10	0	0	0	0	0	0.03	0	0	
			2010-11	0.07	0	0.02	0	0	0	0	0.12	0.03	0	0.38	0	0	0	0	

Family name	Scientific name	Comm name	Year	PS			CC		SY				JB		BM	NR	ME		%	
				CT	SB	FB	TW	TR	SE	SW	LM	CO	MW	MB	MG	BW	KB	BB		
Pomacentridae	Pomacentrus chrysurus	White-tail	2009-10	0	0	0	0	0	0	0	0	0	0	0.02	0	0	0	0	0	7
		Damsel	2010-11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pomacentridae	Pomacentrus coelestis	Neon	2009-10	2.08	0.10	0	0.02	0.66	2.41	0.71	0.30	14.1	1.60	0.03	0	0.27	0	0.28	80	
		Damsel	2010-11	6.37	0.12	0.24	0.08	1.60	0.26	0.06	0	3.31	2.20	0.03	0	0.38	0	0.40	80	
Pomacentridae	Pomacentrus nagasakiensis	bluescribble	2009-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
		d damselfish	2010-11	0	0	0	0	0	0	0	0.06	0	0.09	0	0	0	0	0	0	13
Pomacentridae	Pomacentrus wardi	Ward's	2009-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
		Damsel	2010-11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pomacentridae	Stegastes apicalis	Australian	2009-10	0	0	0	0	0	0.05	0	0	0	0	0	0	0	0	0	0	7
		Gregory	2010-11	0	0	0	0	0	0	0	0.06	0	0	0	0	0	0	0	0	7
Pomacentridae	Stegastes brachialis	Charcoal	2009-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Damsel	2010-11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pomacentridae	Stegastes gascoynei	Coral Sea	2009-10	0.06	0	0	0	0.17	2.36	0.50	0	0	0	0	0	0	0	0	0	27
		Gregory	2010-11	0.15	0.02	0.21	0	0.31	2.51	0.25	0	0	0	0.03	0	0	0	0	0	47
Ptereleotridae	Ptereleotris evides	Arrow	2009-10	0	0	0	0	0	0	0	0	0	0	0.02	0	0	0	0	0	7
		Dartgoby	2010-11	0	0	0	0	0	0	0	0.49	0	0	18.0	0	0	0	0	0	13
Scaridae	Scarus chameleon	Chameleon	2009-10	0	0	0	0	0	0	0	0.50	0.08	1.23	0	0	0	0	0	0	20
		Parrotfish	2010-11	0	0	0	0	0	0	0	0.06	0.13	1.38	0	0	0	0	0	0	20
Scorpaenidae	Pterois sp	Scorpaenid -	2009-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		unknown	2010-11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scorpaenidae	Pterois volitans	Common	2009-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Lionfish	2010-11	0	0	0	0	0.04	0	0	0	0	0	0	0	0	0	0	0.03	13
Serranidae	Anthias squamipinnis	lyretail	2009-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		anthias	2010-11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Serranidae	Cephalopholis sonnerati	tomato	2009-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		rockcod	2010-11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.03	7
Serranidae	Epinephelus cyanopodus	Purple	2009-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Rockcod	2010-11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.10	7
Serranidae	Pseudanthias squamipinnis	Orange	2009-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Seaperch	2010-11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tetraodontidae	Arothron hispidus	Stars-Stripes	2009-10	0	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7
		Toadfish	2010-11	0	0	0	0	0.04	0	0	0	0.03	0	0	0	0	0	0	0	13
Tetraodontidae	Canthigaster bennetti	Bennets	2009-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Puffer	2010-11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.10	7
Zanclidae	Zanclus cornutus	Moorish Idol	2009-10	0.09	0	0	0	0	0.10	0.15	0	0	0.17	0	0	0.05	0	0	0	33
			2010-11	0.07	0	0	0	0.19	0	0.18	0	0.18	0.11	0	0	0	0	0	0	33

Table 3. Subtropical / Northern Temperate species recorded across regions and sampling sites in 2009-10 and 2010-11 survey years. Shown are the average number of individuals recorded per survey during the peak recruitment period from Jan-May at each site as well as the total percent of sites at which that species occurred each year (%). Site codes are as given in Table 1.

Family name	Sci. name	Com. name	Year	PS			CC		SY				JB		BR	NR	ME		%
				CT	SB	FB	TW	TR	SE	SW	LM	CO	MW	MB	MG	BW	KB	BB	
Acanthuridae	Prionurus	Spotted	2009-10	0	0	0	0	0.10	1.33	2.22	0.43	1.53	0	0	0	1.57	0.16	0.18	53
	maculatus	Sawtail	2010-11	0	0.19	0	0	3.98	1.16	3.13	0.07	0.37	0	0.13	0	0	0	0	47
Acanthuridae	Prionurus	Sawtail	2009-10	0	0	0	1.15	4.92	0	0	0	0	0	0	0	0	0	0	13
	microlepidotus	(White Tail)	2010-11	0.44	3.24	0	0.31	40.0	4.97	10.0	3.26	12.6	0.82	0.30	0.28	6.10	1.01	0.46	93
Acanthuridae	Prionurus	Sawtail	2009-10	0	0	0	1.57	4.05	0	0	0	0	0	0	0	0	0	0	13
	microlepidotus	(Yellow Tail)	2010-11	0	0.02	0	0.03	1.64	0.06	0	0	0	0	0.03	0	0.10	0	1.88	47
Acanthuridae	Prionurus	Sawtail	2009-10	0	0.07	0.27	0	11.8	4.50	11.5	3.48	14.2	0.73	0.66	0.27	0.67	0	4.42	80
	microlepidotus	(positive ID)	2010-11	0	0.44	0.03	0	0	0.19	0.12	0	0.46	0	0	1.59	5.37	3.21	14.4	60
Blenniidae	Petrosirtes	Yellow Sabr-	2009-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	fallax	t. Blenny	2010-11	0	0	0	0	0.12	0	0	0	0	0	0	0	0	0	0	7
Girellidae	Girella zebra	zebra fish	2009-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			2010-11	0	0	0	0	0	0	0	0	0	0.03	0.03	0	0	0	0	13
Gobiidae	Valenciennea	Blueband	2009-10	0.03	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7
	strigata	Glider Goby	2010-11	0	0	0	0	0	0	0	0	0	0.03	0	0	0	0	0	7
Labridae	Anampses	Elegant	2009-10	0	0	0	0	0	0.15	0	0	0	0	0	0	0	0	0	7
	elegans	Wrasse	2010-11	0	0	0	0	0	0.13	0	0	0	0	0	0	0	0	0	7
Labridae	Suezichthys	Gracillis	2009-10	0	0	0	0.02	0	0	0	0	0	0	0	0	0	0	0	7
	devisi	Wrasse	2010-11	0	0	0	0	0	0	0.18	0	0	0	0	0	0	0	0.67	13
Mugilidae	Mugil cephalus	Sea Mullet	2009-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			2010-11	7.41	1.16	0	0	0	20.2	0.92	3.28	0	61.27	46.5	26.22	1.43	6.94	5.36	73
Mullidae	Parupeneus	Black-spot	2009-10	0	0	0	0	0	1.82	5.91	35.1	71.1	0	0	0	0	0	0	27
	signatus	Goatfish	2010-11	5.93	5.78	4.13	12.8	33.2	13.8	16.2	45.1	66.5	2.15	1.91	3.46	17.9	12.9	15.1	100
Pomacentridae	Chrysiptera	Southern	2009-10	0.25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7
	notialis	Demoiselle	2010-11	0	0	0	0	0	0	0.12	0	0	0	0	0	0	0	0	7
Pomacentridae	Mecaenichthys	Immaculate	2009-10	0	0.53	0	0	0	0.30	0.10	0.23	2.15	0.05	0	0	0	0	0	40
	immaculatus	Damsel	2010-11	0.22	0.09	0.26	0.05	0.74	0.26	0.12	0.43	3.31	0.03	0.09	0	0	0.26	0	80
Pomacentridae	Parma	Bigscale	2009-10	0	0	0	0	0	0.10	0.05	0.08	0.31	0	0	0	0	0	0	27
	oligolepis	Scalyfin	2010-11	0.07	0.05	0.03	0	0	0	0.43	0	0.09	0	0	0	0	0	0	33
Pomacentridae	Parma	Banded	2009-10	0	0	0	0	0.03	0.05	0.10	0	0	0	0	0	0	0	0	20
	polylepis	Scalyfin	2010-11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pomacentridae	Parma	Girdled	2009-10	0	0	0	0.88	10.5	3.34	4.54	0.20	0.61	6.41	0.42	0	0.66	0	0	60
	unifasciata	Parma	2010-11	0.15	0.44	0.36	0.92	11.6	0.51	3.13	0.20	0.46	1.13	0.16	0	0	0	0	73

Family name	Sci. name	Com. name	Year	PS			CC		SY				JB		BR	NR	ME		%	
				CT	SB	FB	TW	TR	SE	SW	LM	CO	MW	MB	MG	BW	KB	BB		
Ptereleotridae	Ptereleotris	Lyre-tail	2009-10	0	0	0	0	0	0	0	0	0.31	4.57	0	0	0	0	0	0	13
	monoptera	Dartgoby	2010-11	0	0	0	0	0	0	0	0	0.18	197.6	0.69	0	0	0	0	0	20
Serranidae	Epinephelus	Black	2009-10	0	0	0	0	0	0	0	0	0	0	0.12	0	0	0	0	0	7
	daemelli	Rockcod	2010-11	0	0	0	0	0	0.06	0	0	0	0	0.22	0	0.10	0	0	0	20
Siganidae	Siganus	Happy	2009-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	nebulosus	moments	2010-11	0	0	0	0	0	0.26	3.37	0	0	0	0.22	0	0	0	0	0	20
Tetraodontidae	Canthigaster	Clown Toby	2009-10	0	0	0	0	0	0	0	0	0	0	0	0	0.03	0	0	0	7
	callisterna		2010-11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.03	7