18 Observations on the distribution, growth and reproductive biology of *Nemipterus theodorei* and *Nemipterus aurifilum* caught in the Queensland (Australia) East Coast Trawl Fishery

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18.1 ABSTRACT

This chapter examines the distribution and population dynamics of two species of nemipterid fish, *N. theodorei* and *N. aurifilum*, that make up the majority of the trawl-caught catch of "pinkies" in Queensland. Extremely little information has been published on these two species. *N. theodorei* is the main species contributing to landings and market value in Queensland, mainly because it is more abundant and the larger of the two species. Standard length-size class modes were 140 mm and 90 mm for *N. theodorei* and *N. aurifilum*, respectively. *N. theodorei* were more wide spread in their distribution and generally found in depths of less than 100 m, while *N. aurifilum* was found in depths greater than 100 m. Fifty per cent of females were found to be mature at 142 mm and 90 mm fork length, for *N. theodorei* and *N. aurifilum*, respectively. Preliminary estimates of the von Bertalanffy growth parameters were obtained for both species and sexes, based on otolith age readings and length-at-age analyses, but are likely to be affected by a lack of small/young sizes classes in the samples. Spawning for *N. theodorei* peaked in spring and summer, and was at a minimum in winter.

18.2 INTRODUCTION

In 1999, the Queensland Government passed legislation allowing trawl fishers operating in the Queensland East Coast Trawl Fishery to retain and market fishes belonging to the Nemipteridae family. The Management Plan [*Fisheries (East Coast Trawl) Management Plan 1999*] specifies that fishers can be in possession of up to 198 litres of nemipterids, of any size or species. This catch limit was not based on any quantitative assessment of the stock, but rather on the equivalent volume of a certain number of lug baskets. Processors generally only market individuals that are 200 mm in length or longer.

Previous observations on the bycatch from the fishery indicated that the nemipterid catches were largely comprised of two species, *Nemipterus theodorei* and *Nemipterus aurifilum*. The review of nemipterids undertaken as part of Objective 4 (Chapter 12, section 12.1.8) revealed that there had been very little published on the biology and population dynamics of these two species. This chapter presents preliminary observations on the distribution, biology and population dynamics of *N. theodorei* and *N. aurifilum* from the Queensland east coast, with the intention of providing management advice.

18.3 MATERIALS AND METHODS

18.3.1 Sampling methods

Samples of nemipterids were obtained throughout the project from the research charters' bycatch samples and from the opportunistic bycatch samples. In addition, a fishers (Mr Tony Sterling) agreed to provide samples to the project on a regular basis from April 2000 to November 2002. All samples were obtained from areas between Shoalwater Bay (22°30' S) and Southport (28° S), which reflected the distribution of reported commercial landings based on logbook data (Figure 18.3.1).

All samples had been frozen and were thawed in the laboratory before obtaining biological data. Standard length measures to the nearest 5 mm were obtained for every individual and used for length-frequency analysis, while standard length measures to the nearest 1 mm were used to derive length-weight relationships and growth rates. Wet weight was recorded to the nearest 0.1 g using electronic scales. Non-linear regression coefficients for the length-weight relationships were estimated using the function nlinfit from MATLAB® using finite difference approximation algorithms. 95% confidence intervals were calculated using the MATLAB function nlpredci.

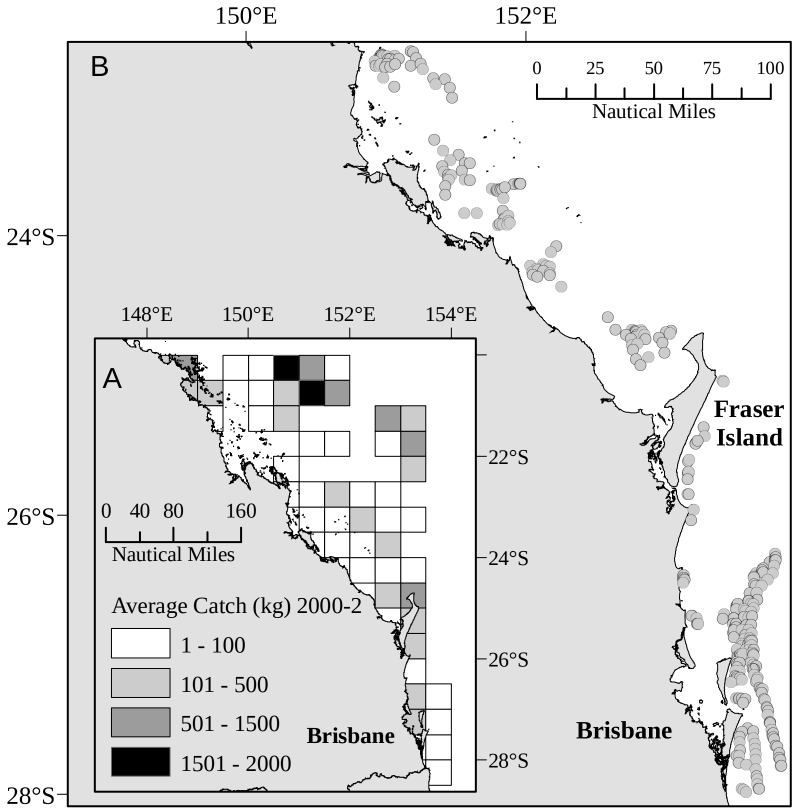

Figure 18.3.1. The reported commercial landings of nemipterids (2000–2002) from the Queensland East Coast Trawl Fishery and trawl locations from the opportunistic sampling and research charters where samples were collected

18.3.2 Ageing and growth

Otoliths were removed from fish, placed in labelled vials and forwarded to Mr Corey Green from the Victorian Department of Natural Resources and Environment Central Ageing Facility for age determination (see details of the otolith sectioning and ageing methods in Appendix 8, "Age estimates of two species of threadfin bream: *Nemipterus theodorei* and *Nemipterus aurifilum*").

The von Bertalanffy growth equation [$L_t = L_\infty(1-e^{-k(t-to)})$] was fitted to the length-at-age data for females and males, where L_∞ is the mean asymptotic length predicted by the equation, k is the growth coefficient, and t_o is the hypothetical age at which fish would have zero length. It was assumed that the lengths-at-age were normally distributed around the values predicted from the equation and that the variance of this distribution was constant for each sex over all ages. Growth equations were fitted to the observed length-at-age data by estimating the growth parameters with the SOLVER routine in Microsoft Excel and minimising the sum of squares.

18.3.3 Reproductive biology

Testes and ovaries were dissected from the fish that were provided each month by the commercial fisher and weighed to the nearest 0.01 g. Ovaries were staged macroscopically, based on a modification of the criteria used by Haddy and Pankhurst (1998) (Table 18.3.1). Gonadosomatic indices (GSIs) were determined using the equation:

$$GSI = W_1/W_2 * 100$$

where W_1 = weight of wet gonad; and W_2 = weight of the whole fish.

Table 18.3.1. Criteria for macroscopic classification of *Nemipterus* spp. ovaries

Stage	Classification	Macroscopic appearance
1	Immature	Ovary small clear threads
2	Regressed	Ovary enlarging but still clear
3	Vitellogenic	Ovary enlarging with opaque oocytes visible through epithelium
4	Hydrated	Ovary enlarged with opaque and hydrated oocytes visible through epithelium
5	Ovulated	Eggs in the oviduct can be extruded with gentle pressure
6	Spent	Ovary flaccid and bloody

18.4 RESULTS

Table 18.4.1 summarises the numbers of individuals used in the respective analyses.

Table 18.4.1. Sample sizes (number of fish) contributing to biological analyses conducted on *N. theodorei* and *N. aurifilum*

Species	Sex	Length-frequency analysis	Length-weight relationship	Ageing and growth rates	Gonado-somatic index
N. theodorei	M	4739	174	187	642
	F		129	161	264
N. aurifilum	M	1277	162	104	128
	F		213	97	207

There was a marked distinction in the distribution of the two species. *N. theodorei* were generally found in depths less than 100 m while *N. aurifilum* was found in depths greater than 100 m (Table 18.4.2). *N. theodorei* were more widespread in distribution with individuals occurring in 49.2% of trawls and distributed from Yeppoon in Central Queensland south to the Queensland/NSW border. *N. aurifilum* was caught in only 23.5% of trawls and restricted to depths greater than 75 m. *N. aurifilum* occurs in the deepwater eastern king prawn fishery, while *N. theodorei* occurs in both the shallow water eastern king prawn fishery and the scallop fishery.

Table 18.4.2. Summary of distribution data for *N. theodorei* and *N. aurifilum* based on the number of individuals caught during research charters and opportunistic sampling aboard commercial vessels. Sample sizes for *N. theodorei* and *N. aurifilum* were 3356 and 876 respectively. Standard errors in brackets.

Species	Size range and mean length (mm)	Depth range and mean (m)	Latitudinal range	% Occurrence in trawl shots	Average catch rate (g/ha)	Depth of highest individual catch rate (m)
N. theodorei	45 to 240 139.0 (0.5)	17 to 117 50.1 (3.43)	22º40.477 S to 27º59.200 S	49.2%	453.7 (40.6)	50
N. aurifilum	40 to 220 111.9 (1.7)	75 to 165 122.9 (2.4)	26º16.541 S to 27º47.570 S	23.5%	49.7 (8.6)	100

18.4.1 Length-frequency analyses

Figure 18.4.1 and Figure 18.4.2 show the length-frequency histograms for both *N. theodorei* and *N. aurifilum*, respectively. Very few small *N. theodorei* were caught particularly in size classes up to 120 mm. In contrast, a larger proportion of the smaller size classes were present in the catch of *N. aurifilum*. This may indicate that smaller individuals of *N. aurifilum* were present on the trawl grounds, while the fishery operates largely outside of areas that small or juvenile *N. theodorei* inhabit.

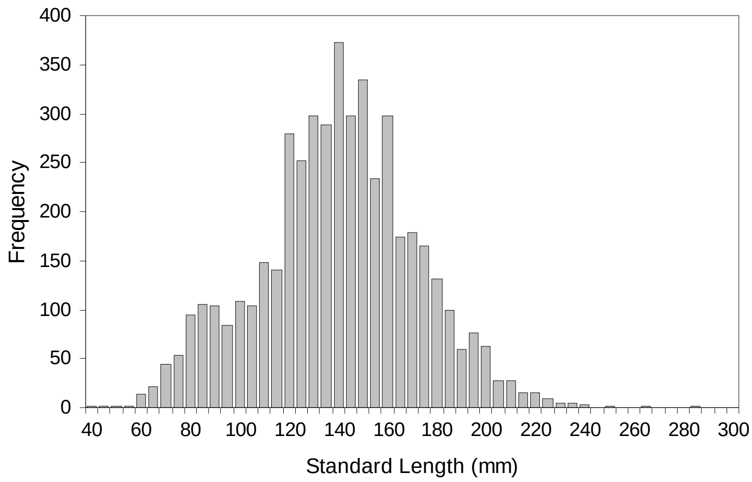

Figure 18.4.1. Length-frequency histogram for *N. theodorei* based on 4738 individuals obtained from trawl samples. Sexes pooled.

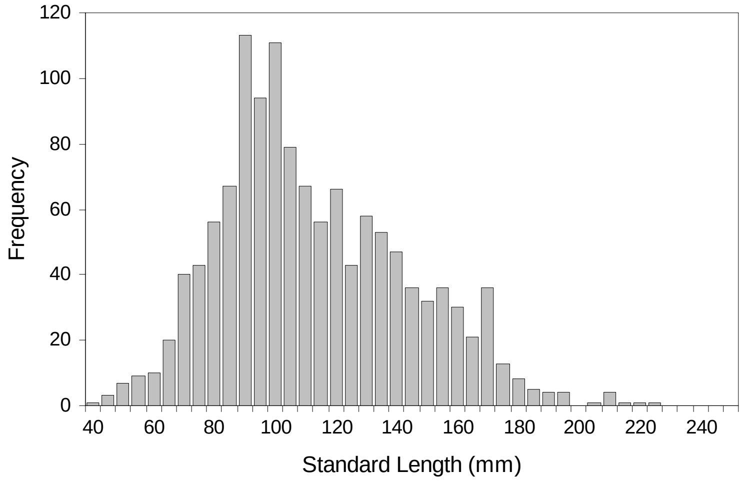

Figure 18.4.2. Length-frequency histogram for *N. aurifilum* based on 1276 individuals obtained from trawl samples. Sexes pooled.

18.4.2 Length-weight relationships

The relationship between standard length (SL) in mm and total wet weight (W) in g of each species was:

N. theodorei	Males	$W = 0.00004398\ SL^{2.8424}$
	Females	$W = 0.00001684\ SL^{3.0356}$
N. aurifilum	Males	$W = 0.00001964\ SL^{2.9857}$
	Females	$W = 0.00001107\ SL^{3.1054}$

The relationships are presented graphically in Figure 18.4.3, Figure 18.4.4, Figure 18.4.5 and Figure 18.4.6.

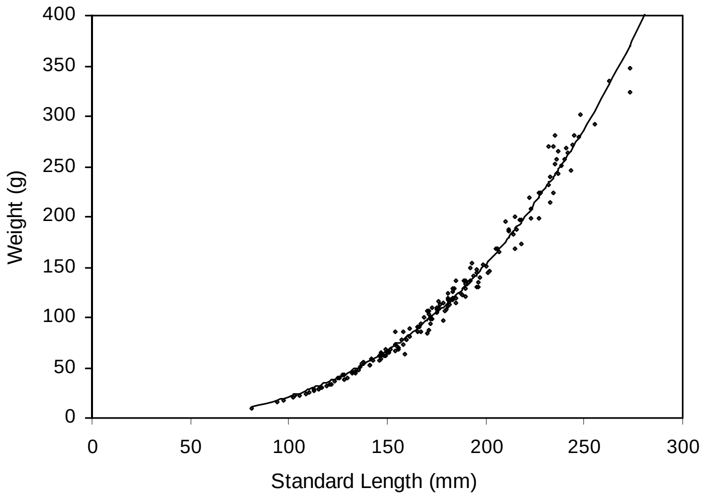

Figure 18.4.3 Length-weight relationship for male *N. theodorei*

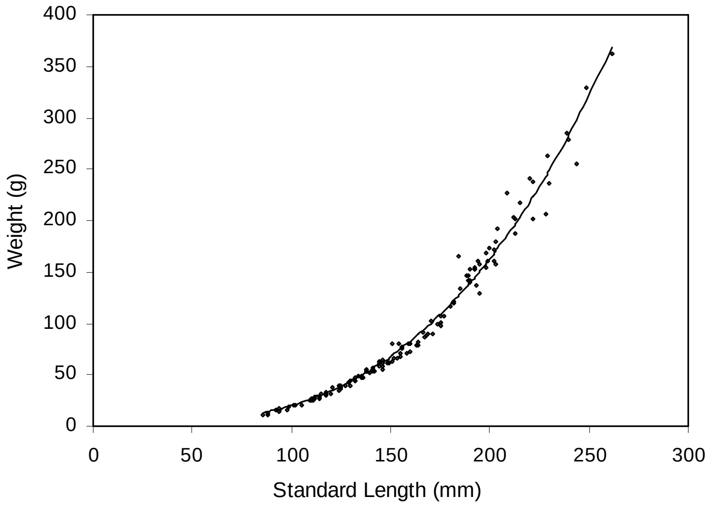

Figure 18.4.4. Length-weight relationship for female *N. theodorei*

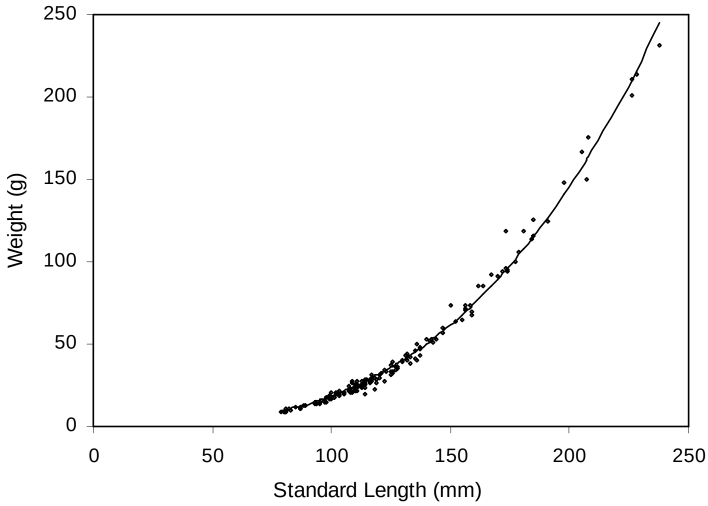

Figure 18.4.5. Length-weight relationship for male *N. aurifilum*

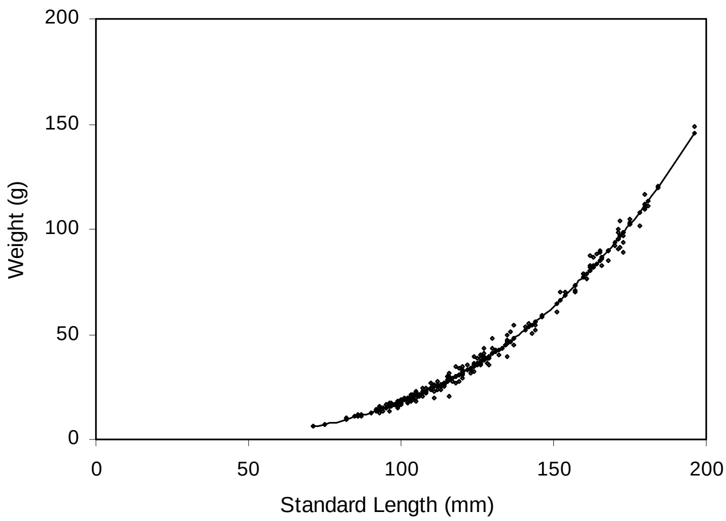

Figure 18.4.6. Length-weight relationship for female *N. aurifilum*

18.4.3 Age and growth

Estimates of the mean length-at-age, based on the ageing analyses undertaken at the Central Ageing Facility, are provided in Table 18.4.3. These data were used to estimate the growth parameters provided in Table 18.4.4. Because of the lack of small individuals in the length-frequency samples the von Bertalanffy model does not fit the data very well. The growth parameter estimates could be improved in future by including more of the smaller size classes and including their age estimates in the model fitting.

Table 18.4.3. Mean length (mm)-at-age for *N. theodorei* and *N. aurifilum* based individuals aged at the Central Ageing Facility. Methods for ageing are described in Appendix 8. Standard errors in brackets.

Species	**Sex**	**Adjusted Age (yrs)**				
		0	**1**	**2**	**3**	**4**
N. theodorei	Male	95.16 (2.49) n = 57	135.18 (3.41) n = 28	185.32 (2.59) n = 66	232.85 (2.29) n = 33	266.33 (15.38) n = 3
N. theodorei	Female	93.00 (2.23) n = 57	129.29 (2.79) n = 34	177.92 (2.83) n = 48	200.94 (5.06) n = 16	242.67 (5.36) n = 6
N. aurifilum	Male	88.68 (3.05) n = 41	129.34 (3.62) n = 38	175.05 (4.57) n = 19	204.17 (10.10) n = 6	-
N. aurifilum	Female	89.31 (3.20) n = 39	129.18 (3.60) n = 38	163.94 (3.89) n = 16	178.5 (8.05) n = 4	-

Table 18.4.4. von Bertalanffy growth parameter estimates for male and female *N. theodorei* and *N. aurifilum*

Species	**Sex**	**n**	**K**	**L∞**	t_o
N. theodorei	Male	187	0.10	614.8	-1.7
N. theodorei	Female	161	0.10	541.3	-1.9
N. aurifilum	Male	104	0.08	682.9	-1.8
N. aurifilum	Female	97	0.36	228.4	-1.4

18.4.4 Reproductive biology

Fifty per cent of female *N. theodorei* were found to have mature ovaries at 142 mm fork length, while 50% of female *N. aurifilum* were mature at 90 mm fork length.

The samples that were provided by the commercial fisher and used to examine seasonal variation in reproduction were limited to *N. theodorei*, mainly because he generally only retained *N. theodorei* which is the larger and more abundant of the two species. As such, no seasonal information on reproductive activity is provided for *N. aurifilum*.

The seasonal variation in ovary stages for female *N. theodorei* between November 2001 and December 2002 is provided in Figure 18.4.7 and suggests that spawning probably occurs over spring and summer. The incidence of stage 3 vitellogenic ovaries peaked from December to February and was at a minimum between June and

August. This seasonal trend is supported by the variation in GSIs (Figure 18.4.8 and Figure 18.4.9). Female GSIs peaked in spring (October to November) and were at a minimum in winter (July to August).

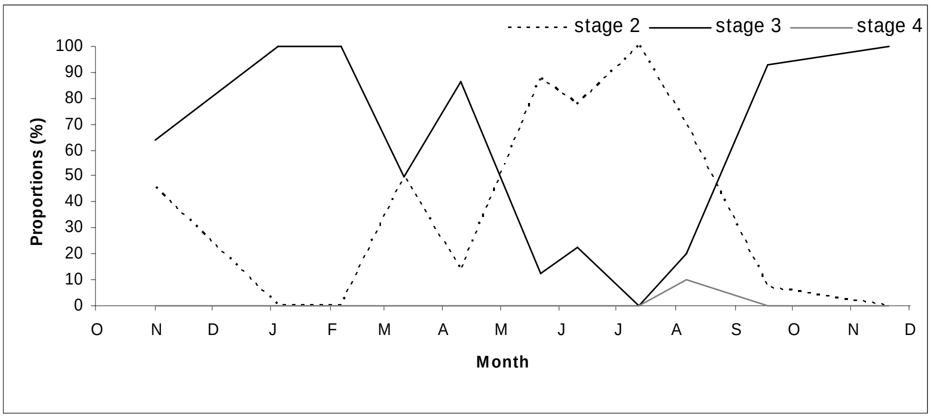

Figure 18.4.7. Changes in gonad stage for female *N. theodorei* between November 2001 and December 2002 based on classifications provided in Table 18.3.1

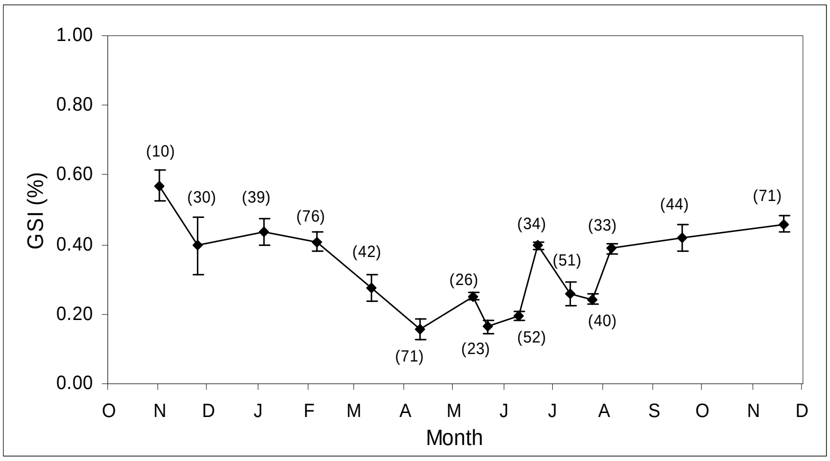

Figure 18.4.8. Gonadosomatic index for male *N. theodorei* between November 2001 and November 2002. Numbers in brackets indicate sample size

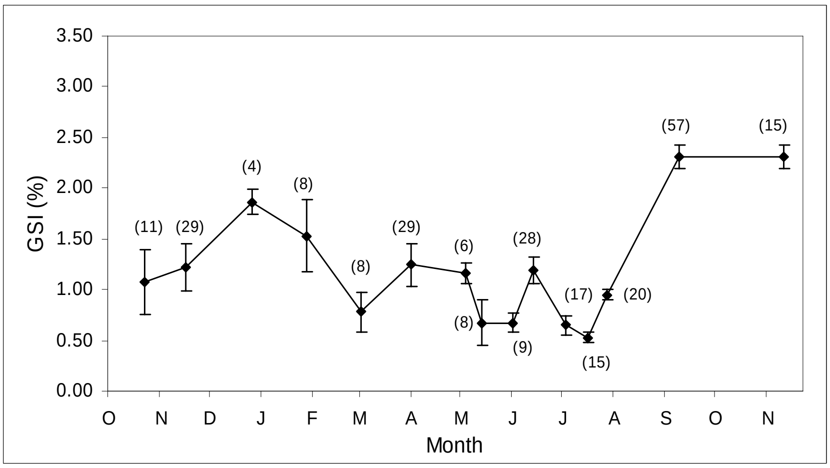

Figure 18.4.9. Gonadosomatic index for female *N. theodorei* between November 2001 and November 2002. Numbers in brackets indicate sample size

18.5 Discussion

Very little is known about the biology and population dynamics of *N. theodorei* and *N. aurifilum* and the results presented here represent a significant contribution towards understanding and managing these species. The results indicate that *N. theodorei* is likely to be the main species contributing to the landings and market value for pinkies in Queensland because its length-frequency distribution (Figure 18.4.1 and Figure 18.4.2) indicates that it is the larger and more abundant of the two species, and because processors generally only resell individuals larger than about 200 mm. Model sizes (sexes pooled) for *N. theodorei* and *N. aurifilum* were about 140 mm and 90 mm, respectively.

There were distinct differences in the distribution of the two species. *N. theodorei* was generally obtained from depths less than 100 m, while *N. aurifilum* was generally found in greater depths. *N. theodorei* was also more widespread than *N. aurifilum.* Growth analyses indicate that males grow to larger maximum sizes than females, for both species. Maximum ages for *N. theodorei* and *N. aurifilum* were about four years and three years, respectively. Growth parameter estimates could be improved in future by including more small size classes.

There was marked seasonal variation in spawning for *N. theodorei*, with most egg production occurring in spring and summer. Reproductive activity was at a minimum in winter. Future reproductive studies would benefit from having access to fresh and unfrozen samples, as freezing tended to make staging of ovaries and testes difficult.

18.5.1 Management advice

N. theodorei and *N. aurifilum* appear to be abundant in south-east Queensland coastal waters. They have relatively short life spans, in the order of 3–4 years and reproduce at relatively small size classes; 50% of females were mature at 142 and 90 mm fork length for *N. theodorei* and *N. aurifilum*, respectively. It is difficult to provide specific management recommendations for these species. For example, minimum legal sizes would have little impact because most, if not all, undersized individuals would die after being trawled before being returned to the water, or shortly after. Similarly, total allowable catches (TACs) would not adequately limit or control the level of exploitation because many more individuals would continue to die in incidental catches while targeting prawns and scallops, after the TAC had been reached. The level of fishing mortality applied to the stocks is likely to be directly related to the level of trawl fishing effort applied to the prawns and scallops. Seasonal or spatial closures also appear to be inappropriate because they would impact upon catches of the main target species. If the level of fishing mortality applied to *N. theodorei* and *N. aurifilum* is considered to be excessive, then the fusiform body shape of the fish suggests radial escape section BRDs may be an appropriate method for lowering mortality.

18.6 References

Haddy, J.A. and Pankhurst, N.W., 1998. Annual change in reproductive condition and plasma concentrations of sex steroids in black bream, *Acanthopagrus butcheri* (Munro) (Sparidae). Mar. Freshwat. Res. 49, 389-397.

19 Benefits and adoption

The Queensland East Coast Trawl Fishery, which is comprised of the largest prawn trawl fleet in Australia, benefits from the research because stakeholders, including fishers, management agencies, conservation groups and the public now have access to robust objective information on a) the bycatch composition in each of the major sectors, b) the performance of BRDs that are being used by fishers, and c) the potential reductions in bycatch that could be achieved, based on research charters.

Stakeholders are in a much more informed position to a) assess how well bycatch reduction initiatives (i.e., the implementation of TEDs and BRDs) have performed since being introduced in 2000, and b) plan future bycatch reduction initiatives.

The research charters provided stakeholders with information on the expected reductions in a) total bycatch and b) individual bycatch species, should fishers decide to use those devices that were tested. For example, the research charter results presented in Chapter 5 showed fishers that they could reduce their incidental catch rate of stout whiting *S. robusta* in the shallow water eastern king prawn fishery by a mean of 57%, compared to a standard net, by using a radial escape section BRD with a TED (Table 5.4.2). In the saucer scallop fishery we demonstrated that total bycatch rates could be reduced by a mean of 77% by using a square mesh codend BRD with a TED, compared to a standard net (Table 7.4.1). Importantly this was achieved with no loss of legal sized scallops, and a 63% reduction in the catch rate of undersized scallops.

Any reduction in bycatch rate, and the subsequent reduction in incidental fishing mortality on bycatch species, is likely to be deemed as a “benefit” to coastal ecosystems and biodiversity. This is difficult to quantify, but as an example, if all scallop fishery operators adopted the combination of TED and square mesh codend BRD trialled in Chapter 7, a reduction in bycatch of over 10,000 t could be achieved annually, compared to pre-TED and pre-BRD levels. Such benefits are likely to be highly valued by society.

Although not quantified by the project, the large reduction in bycatch rates achieved in the scallop fishery charter would almost certainly reduce vessel fuel consumption. If the amount of bycatch in the net is reduced by 77%, then the drag on the nets would most likely be reduced, thus reducing fuel costs and benefiting fishers. Similar benefits could be applied to deepwater eastern king prawn fishers who choose to use square mesh codends. Another benefit from the scallop fishery charter is the reduction in catch rate of undersized scallops. By reducing the number of undersized scallops that are retained in the net, brought to the surface, dropped onto the sorting tray, passed through a grading tumbler and returned to the sea, the incidental fishing mortality on the stock is likely to be reduced. This is likely to benefit the stock and have positive effects on biomass and catch rates of legal sized scallops, thus benefiting fishers.

The project has also benefited research and management in other prawn and scallop trawl fisheries. Details of the performance of square mesh codends in the scallop fishery were provided to Dr Mervi Kangas, Department of Fisheries, Western Australia, who was considering trialling the devices in the Shark Bay scallop fishery.

We have also had requests for information on our TED and square mesh codend charter in the scallop fishery from Dr Jeff Gearhart, NOAA Fisheries, USA, who is trialling bycatch reduction devices in a USA east coast scallop trawl fishery. Jeff wrote "*Thanks very much, I read through your reports today and they are excellent. I'll send along our reports when they are complete. Thanks again. Jeff*".

We believe the fishery would benefit by adopting square mesh codends in the scallop and deepwater eastern king prawn sectors, for the abovementioned reasons. Square mesh codends may also be applicable in the black tiger prawn brood stock collection fishery and other sectors, but the project did not assess the device in these sectors. At the time of writing, the number of operators using square mesh codend BRDs was low, although a separate FRDC-funded project (FRDC 2005/054 *A collaborative extension program by the Queensland Department of Primary Industries and Fisheries, Seanet and Ecofish for the development and adoption of square mesh codends in select prawn and scallop trawl fisheries in Queensland*) was making steady progress with adoption rates.

The research charters have also quantified the effects of TEDs and BRDs on the targeted species of prawns, scallops and Moreton Bay bugs (Table 7.4.2), and also on the permitted species such as Balmain bugs (Figure 9.4.2). Quantifying the effects of the devices on target and permitted species catch rates is an important step in producing accurate time series of standardised catch rates and undertaking stock assessments. For example, catch rates of Moreton Bay bugs are likely to have declined by about 21% (Table 7.4.2) due to the introduction of TEDs, and not because of a decline in biomass. Quantifying the impacts of TEDs and BRDs improves the quality of stock assessment advice provided on these species, thus benefiting fishers.

Changes introduced in the Management Plan (*Fisheries (East Coast Trawl) Management Plan 1999*) not only addressed bycatch but also included the provision for fishers to legally retain and market a suite of byproduct species, referred to as the permitted species. These include barking crayfish (*Linuparus trigonus*), Balmain bugs (*Ibacus* spp.), three spot crabs (*Portunus sanguinolentus*), mantis shrimps, (Stomatopoda), cuttlefish (*Sepia* spp.), octopus (*Octopus* spp.), pipehorses (*Solegnathus* spp.) and pinkies (*Nemipterus* spp.). Landings data indicate that collectively these species are valued at $1–2 million annually (Figure 12.1.1) and that they require management attention. The project has made major contributions to a) understanding of the biology of these species, b) improving their management, and c) reducing the risk of overfishing. Through the research presented in Chapters 12 to 18 and by presenting the results to the Trawl Fishery Scientific Advisory Group (TrawlSAG), we identified and recommended minimum legal sizes for barking crayfish (*L. trigonus*), Balmain bugs (*Ibacus* spp.) and three spot crabs (*P. sanguinolentus*). We now have a much clearer understanding of the three species that make up the Balmain bug landings in Queensland, which species are the most valuable and what further research is required. Similarly, the project has provided a clearer understanding of a) the distribution and species composition of nemipterid catches (i.e., pinkies), and b) key population parameter values that can be used to manage them. These are the first reported descriptions of the population dynamics for *N. theodorei* globally. The research, recommendations and management measures that have come from the project will help to maximise the value of these resources and reduce the risk of overfishing.

20 Further development

The research charters showed that bycatch rates in the saucer scallop fishery and the deepwater eastern king prawn fishery could be reduced by a mean of 77% and 29% respectively, by using square mesh codend BRDs with TEDs, with no loss of marketable scallops or prawns. These levels of reduction are much considerably greater than those currently achieved by vessels operating in these sectors. The 77% and 29% reductions equate to several thousands tonnes of bycatch annually when extrapolated upwards to the fleets operating these sectors. We recommend that square mesh codends be made mandatory in these two sectors.

A detailed strategic policy and direction on trawl bycatch in Queensland needs to be developed, which should include future research priorities. While the 40% bycatch reduction review event in the Trawl Management Plan was well intentioned, it is not practically possible to measure with statistical confidence. An alternative policy with clearly stated objectives is required. Importantly, any review of trawl bycatch policy in Queensland should acknowledge that, at present, individual fishers are not legally required to reduce or minimise their bycatch rates, but rather they are only required to install BRDs. Specific questions need to be addressed: a) What are the objectives of bycatch reduction? b) How much bycatch reduction is adequate for (i) individual fishers? and (ii) the fleet? c) Should bycatch monitoring programs be implemented? d) Can change in bycatch species catch rates be detected? and e) If a decline is detected, what action, if any, should be taken?

The project made a significant contribution to understanding the population dynamics of, and providing management advice on, barking crayfish, three spot crabs, mantis shrimp, Balmain bugs, pipehorses and nemipterid fishes, but further research is required to optimise and sustain the value of these stocks. Although some cuttlefish and octopus data were collected during the project, the limited duration for the permitted species research (i.e., project funds and duration were limited to two years only for the permitted species) and lack of specific funding to purchase regular samples and process statoliths for age determination prevented us from providing robust advice on these species. Consideration needs to be given to a) how to attract research funding for these relatively low-value species, and b) fishery-independent monitoring. For some permitted species (i.e., Balmain bugs, nemipterids, pipehorses, three spot crabs, cuttlefish and octopus) fishery-independent monitoring might be achieved by incorporating it into the principal target species' monitoring programs. Barking crays do not appear to be associated with any of the principal target species, and so a separate monitoring program may be required for them. There are problems with a) how the permitted species are differentiated by fishers and therefore recorded in logbooks, and b) incidental catches for many permitted species that are not retained or recorded by fishers. Fishery-independent monitoring would help alleviate some of these problems.

21 Planned outcomes

1. <u>Better understanding of bycatch rates and composition, and quantitative information on the effects of TEDs and BRDs in the Queensland trawl fishery</u>

One of the planned outcomes is a much more informed understanding by commercial and recreational fishers, the Queensland Government, the Great Barrier Reef Marine Park Authority and the public of what the bycatch is comprised of in each of the major Queensland trawl sectors. We have achieved this by: a) measuring bycatch rates from 1619 individual trawls; b)weighing 49.1 t of bycatch on board vessels; c) processing 9.8 t of bycatch to species level in the laboratories; d) documenting the catch rates, mean size and frequency of occurrence for over 1300 bycatch species; e) and importantly, by disseminating this information.

Some of the planned outcomes went beyond what was required of the project. For example, the project:

- not only included documenting the bycatch rates and composition, but we also examined how bycatch assemblages vary with latitude, depth and BRD-type in each of the major sectors;
- went much further than assessing the effects of TEDs and BRDs on mean bycatch rates (i.e., all species pooled). The project went to great lengths to quantify the effects of TEDs and BRDs on the catch rate and mean length of those individual bycatch species that comprise the bulk (i.e., around 90%) of the bycatch weight in each sector; and
- did not limit sampling to either the research charters or the opportunistic measures of bycatch rates, but rather adopted both approaches in order to provide stakeholders with information from both controlled scientific experiments as well as “real world” commercial vessel data.

An important planned outcome from the project is that the fishery managers can use the information to assess how well bycatch reduction management initiatives are progressing in Queensland.

By quantifying the mean catch rates and variances for many bycatch species and undertaking power analyses, managers and decision makers are now in a much better position to design and implement a bycatch monitoring program that is capable of detecting impacts on bycatch species’ populations.

2. <u>Improved understanding of, and advice on, the permitted species</u>

Although no specific planned outcomes were provided for the permitted species research in the original project agreement, the project has made a major contribution to understanding the population dynamics of these species and implementing robust management measures. An important outcome from the project was the introduction of a minimum legal size for three spot crabs, which was a direct result of our yield-per-recruit analysis and advice. Another important outcome was that we identified that the Queensland Balmain bug catches were comprised of three species, all with different distributions and population dynamics, and we have provided advice on minimum legal sizes of each of these species to managers and the Trawl Scientific Advisory Group (TrawlSAG). By providing the first description of the reproductive biology and distribution of barking crayfish *L. trigonus*, the fishery managers are now in a much stronger position to implement management measures for this species. Managers are now in a much more informed position to make decisions about mantis shrimp catches. Based on our findings on catch rates, distribution, sizes and faunal community associations for pipehorses *Solegnathus* spp., which are considered vulnerable and are listed on the International Union for the Conservation of Nature

Red List, the fishery managers are in a much stronger position to make informed decisions about these species.

The project's efforts to inform stakeholders and disseminate information, which contribute directly to the planned outcomes, are reflected in the publications, conferences and presentations that project staff contributed to:

Scientific papers in journals of international standing

1. Haddy, J. A., Roy, D. P., Courtney, A. J., 2003. The fishery and reproductive biology of barking crayfish, *Linuparus trigonus* (Von Siebold, 1824) in the Queensland East Coast Trawl Fishery. *Crustaceana* 76(10):1189-1200.

2. Haddy, J. A, Courtney, A. J., Roy, D. P., 2004. Aspects of the reproductive biology and growth of Balmain bugs (Ibacus spp.) (Scyllaridae). *Journal of Crustacean Biology*. 25(2):263–273

3. Courtney, A. J., Tonks, M. J., Campbell, M., Roy, D. P, Gaddes, S.W., O'Neill, M. F., 2006. Quantifying the effects of bycatch reduction devices in Queensland's (Australia) shallow water eastern king prawn (*Penaeus plebejus*) trawl fishery. *Fisheries Research* 80:136-147.

4. Kyne, P.M., Johnson, J.W., Courtney, A.J., Bennett, M.B., 2005. New biogeographical information on Queensland chondrichthyans. *Memoirs of the Queensland Museum* 50(2): 321-327.

5. Marshall, A.D., Kyne, P.M., Bennett, M.B., (In prep.). Comparative dietary analysis of two sympatric urolophid elasmobranchs from subtropical Australian waters [Planned submission to *Journal of Fish Biology*].

6. Kyne, P.M., Courtney, A.J., Bennett, M.B., (In prep.). Aspects of the reproductive biology and diet of *Dipturus polyommata* (Ogilby, 1910) (Elasmobranchii: Rajidae) from southern Queensland, Australia [Planned submission to *Journal of Fish Biology*].

7. Turner, T.B., Kyne, P.M., Bennett, M.B., 2003. Description of *Paeon asymboli* n. sp. (Copepoda: Sphyriidae), parasitic on *Asymbolus* catsharks, and a new host record for *Paeon australis* Kabata, 1993. *Systematic Parasitology* 56: 235–239.

8. Kyne, P.M., Courtney, A.J., Campbell, M.J., Chilcott, K.E., Gaddes, S.W., Turnbull, C.T., van der Geest, C.C., Bennett, M.B., 2002. An overview of the elasmobranch bycatch of the Queensland East Coast Trawl Fishery (Australia). *NAFO Scientific Research Council Document* 02/97.

9. Johnson, J. W., 2004. Two new species and two new records of Aploactinid fishes (Pisces: Scorpaeniformes) from Australia. Australian Museum 56:179–188.

10. Kyne, P.M., Courtney, A.J., Bennett, M.B., 2006. Additional records of the rock shrimp *Sicyonia australiensis* Hanamura and Wadley, 1998 (Decapoda, Sicyoniidae) from eastern Australia, Western Central Pacific. *Crustaceana* 79(9):1141-1144.

Book contributions

11. Haddy, J.A., Stewart, J,. Graham, K.J., (2007) Fishery and biology of commercially exploited Australian fan lobsters (*Ibacus* spp.) In: Lavalli, K., Spanier, E., (eds.) The Biology and Fisheries of the Slipper lobster. CRC Press. Taylor & Francis Group Publishers, New York.

Conference presentations

12. Peter M. Kyne, David J. Mossop, Ross K. Daley, Rob W. Day, Terence I. Walker and Michael B. Bennett. Comparative reproductive biology of the orange-spotted catshark, *Asymbolus rubiginosus* Last, Gomon & Gledhill, 1999, from eastern Australia. Seventh Indo-Pacific Fish Conference, Taipei, Taiwan, 16–20 May 2005. Oral presentation.

13. Peter M. Kyne, Anthony J. Courtney and Michael B. Bennett. Life history and bycatch of the argus skate *Dipturus polyommata* Ogilby, 1910 in the Queensland East Coast Trawl Fishery, Australia. Conservation and Management of Deepsea Chondrichthyan Fishes, Dunedin, New Zealand, 27–29 November 2003. Poster presentation.

14. Courtney, A.J., Tonks, M. L., Campbell, M. J., Chilcott, K. E., Gaddes, S. W., Roy, D. P., Haddy, J. A., Kyne, P. M., Turnbull, C., van der Geest, C., 2002. Bycatch composition and the effect of bycatch reduction devices in the Queensland trawl fishery. In "Proceedings of the Australian Society for Fish Biology Annual Conference" August 2002, Cairns, Queensland.

15. Campbell, M., Chilcott, K., Courtney, A. J. Gaddes, S., Kyne, P., Roy, D., Tonks, M., Turnbull, C., van der Geest, C., 2003. Reducing bycatch in Queensland's trawl fishery – experimental charters using nets with square mesh codends show promising results. In: "Proceedings of the Australian Society for Fish Biology Annual Conference", 29 June – 4 July 2003, Wellington, New Zealand.

16. Courtney, A.J., Campbell, M., Tonks, M., Roy, D., Chilcott, K., Gaddes, S. W., O'Neill, M., van der Geest, C., Turnbull, C., Rose, C., Kistle, S., Kyne, P., 2004. Quantifying bycatch and the effects of BRDs in Queensland's Trawl Fishery: observations from fishing vessels and research charters. In: "Proceedings of the National Prawn Industry Conference", 28–30 November 2004, Cairns, Queensland.

17. Peter M. Kyne, Anthony J. Courtney, Matthew J. Campbell, Keith E. Chilcott, Shane W. Gaddes, Clive T. Turnbull, Claire C. van der Geest, Michael B. Bennett. An overview of the elasmobranch bycatch of the Queensland East Coast Trawl Fishery (Australia). Symposium on Elasmobranch Fisheries:

Managing for Sustainable Use and Biodiversity Conservation, Santiago de Compostela, Spain, 11–13 September 2002.

18. Courtney, A. J., Campbell, M. J., Tonks, M. L., Roy, D. P., Chilcott, K. E., Gaddes, S. W., O'Neill, M. F., Kyne, P. M., 2005. Round scallops and square meshes: promising field trials with bycatch reduction devices (BRDs) reduce both bycatch and undersized scallop catches. 15^{th} International Pectinid Workshop, Mooloolaba, Queensland, Australia, 21–26 April 2005.

19. Haddy, J. A., Aspects of the reproductive biology and growth of Balmain bugs (*Ibacus* spp.). Australian Marine Sciences Association (AMSA) Annual Conference, Brisbane, July 2003.

20. Courtney, A. J., Campbell, M. J., Tonks, M. L., Roy, D. P., Chilcott, K. E., Gaddes, S. W., O'Neill, M. F., van der Geest, C., Turnbull, C., Rose., C., Kistle, S., Kyne, P. M., Ballam, D. Research and extension on trawl bycatch reduction in Queensland. Presented at "Investigating options to improve bycatch reduction in tropical prawn fisheries: a workshop for fishers" Cairns Yacht Squadron, Cairns, Queensland, 21–22 November 2006.

Non-refereed articles

21. Kyne, P. (2002). Elasmobranch bycatch in Queensland's East Coast Trawl Fishery. *Queensland Regional Ripples* 8(4): 4.

22. Brown, I.W., Courtney, A.J., Campbell, M.J., Chilcott, K.E. and McLennan, M. (2003). *Winter (diver) whiting trawl bycatch in southern Hervey Bay*. AFFS Report to the Queensland Fisheries Service.

23. Courtney, A. J. (2002). Research results on the effects of bycatch reduction devices in the eastern king prawn fishery. *Queensland Fisherman* 20(6):20-23.

24. Courtney, A. J. and M. Campbell (2003). Square mesh BRDs show good results. *Queensland Fisherman* 21(1):32-35.

25. Campbell, M. and Courtney, A. J. (2003). Square mesh BRDs show good results. *Professional fisherman* 25(4):12-16.

26. Campbell, M. and Courtney, A. J. (2003). Reducing bycatch in the Queensland scallop fishery. *Professional fisherman* 25(8):18-19.

27. Courtney, A. J. and M. Campbell (2003). DPI studies bycatch in scallop fishery. *Queensland Fisherman* 21(9):39-43.

28. Courtney, A. J., Tonks, M. L., Roy, D. P., Haddy, J. A., Jebreen, E. J. and Campbell, M. J. (2003). *Exploring associations between pipehorse (Solegnathus cf. hardwickii) abundance and bycatch faunal communities in the Queensland trawl fishery*. AFFS Report to the Queensland Fisheries Service.

Presentations

29. Peter M. Kyne. Catching sharks by accident. Elasmobranch bycatch of the Queensland East Coast Trawl Fishery. Natural Sciences Postgraduate Day 2002 (organised by The Royal Society of Queensland and The Queensland Museum), Brisbane, Australia, 26 October 2002. Oral presentation.

30. M. J. Campbell. Results of Research – The effects of TEDs and BRDs in the Queensland trawl fishery. QFS Workshops at Mooloolaba, Southport, Scarborough, Bundaberg, Gladstone, Mackay, Bowen, Townsville and Cairns, 22 April – 2 May 2004.

31. M. J. Campbell. Bycatch reduction using square mesh codends in the Queensland scallop fishery. Southern Fisheries Centre Seminar Series, Deception Bay, 20 June 2003.

32. M. J. Campbell. TEDs in Queensland: a summary of a TED and BRD extension project. QFS TED workshop, Brisbane, 21 May 2003.

33. M. J. Campbell. Research results from a charter in the shallow water eastern king prawn fishery. QFS Bycatch workshop, Brisbane, 23 May 2002.

34. J. A. Haddy. Biology and population dynamics of byproduct in the Queensland East Coast Trawl Fishery (QECTF). Presentation to the Queensland Trawl Fishery Scientific Advisory Group (TrawlSAG). February 2003.

22 Conclusion

Objective 1
Describe the bycatch species composition and catch rates under standard trawl net conditions (non-TED and non-BRD) in Queensland’s major trawl sectors (eastern king prawn, scallop and tiger/endeavour prawn sectors).
Objective 2
Describe the bycatch species composition and catch rates when nets have TEDs and BRDs installed in Queensland’s major trawl sectors (eastern king prawn, scallop and tiger/endeavour prawn sectors).
Objective 3
Test and quantify the impact of different combinations of TEDs and BRDs on bycatch and target species against standard nets under controlled experimental conditions using chartered commercial trawlers in the eastern king prawn, scallop and tiger/endeavour prawn sectors.

The project obtained 1619 measurements of trawl bycatch rates and sub-samples of bycatch from dedicated research charters and from opportunistically sampling the commercial fishing vessels throughout the major Queensland trawl fishery sectors. From the opportunistic measures we quantified the effects of the bycatch reduction devices (both TEDs and BRDs) that fishers are using on prawn, scallop and bycatch

catch rates. The research charters provided information on potential bycatch reduction that could be achieved with select devices. In general, the research charters demonstrated that bycatch can be reduced by significantly greater amounts than what is occurring in the commercial fishery.

No significant reduction was detected in the mean total bycatch rate in the combined prawn sectors due to TEDs and BRDs (Table 10.4.3). However, a significant reduction of 25% was detected when large fauna were omitted from the analyses (i.e., bycatch excluding monsters, Table 10.4.3). The reductions achieved in the research charters conducted in the prawn sectors were substantially greater than this. For example, the deepwater eastern king prawn fishery charter demonstrated that the mean total bycatch rate could be reduced by 29% (Table 9.4.1) compared to a standard net, by using a TED and square mesh codend, with no loss of prawns. Collectively, the results suggest that in the prawn trawl sectors, fishers could do more to increase their bycatch reduction. In the scallop fishery, fishers have decreased their mean total bycatch rate substantially (68% reduction in mean total bycatch rates, Table 10.4.7), mainly due to the TEDs excluding large sponges which comprise much of the bycatch weight in the sector.

With respect to describing the bycatch and the effects of bycatch reduction devices on bycatch species, project staff weighed 49.1 t of bycatch on board vessels and processed 9.8 t of bycatch to species level in the QDPI&F Northern Fisheries Centre and Southern Fisheries Centre laboratories. The project quantified catch rates, mean length and frequency of occurrence of about 1320 bycatch species in the major sectors (see Appendices 1–5). The effects of TEDs and BRDs on the catch rate and mean length of the dominant species in each sector were also analysed. The project demonstrated that some species could be almost eliminated from the bycatch in certain sectors (Table 7.4.3).

In addition to considering the effects of TEDs and BRDs on individual bycatch species, we also examined how the bycatch assemblages varied with depth and latitude and codend treatment type. In general, the bycatch assemblages appeared unlikely to change significantly as a result of TEDs and BRDs, with the exception of the scallop fishery where a marked difference was apparent, mainly due to the square mesh codend (Figure 7.5.1).

Objective 4
Review the known biology and distribution of all recently approved "permitted fish" species associated with the trawl fishery.
Objective 5
Quantify key population parameter estimates, including growth rates, size at maturity, distribution and landings, for all recently approved "permitted fish" species.

When the Trawl Fishery Management Plan [*Fisheries (East Coast Trawl) Management Plan 1999*] was altered and fishers were permitted to retain a large number of incidentally captured species [i.e., barking crayfish (*L. trigonus*), Balmain bugs (*Ibacus* spp.), three spot crabs (*P. sanguinolentus*), mantis shrimps, (Stomatopoda), cuttlefish (*Sepia* spp.), octopus (*Octopus* spp.), pipehorses (*Solegnathus* spp.) and pinkies (*Nemipterus* spp.)] it was apparent that significantly more research was required to manage these species on a sustainable basis. While it was beyond the scope of the project to quantify the key population parameter estimates for all permitted species (i.e., there are over 50 species that make up the permitted species), the research presented in Chapters 12–18 represents a significant contribution to this cause. Minimum legal sizes for barking crayfish, Balmain bugs and three spot crabs, based on quantitative biological information from the project, have been recommended. Although the range of management options for pipehorses is limited (i.e., minimum legal sizes seem inappropriate, closures and gear restrictions would impact on target species), managers are now in a much more informed position to make decisions about these species, based on the information provided on their distribution, catch rates, depth of capture, size class frequencies and the faunal communities that they are associated with. The project provided the first detailed information on the distribution, length-frequencies, growth rates, size at maturity and seasonal variation in reproduction for pinkies *N. theodorei* and *N. aurifilum,* and represents the first records of the population dynamics reported for *N. theodorei.*

Objective 6
Apply power analysis to determine how many trawl samples are needed to detect various levels of change in individual bycatch species catch rates.

This objective was achieved by using the mean catch rates and variance estimates of several bycatch species from the north Queensland tiger/endeavour prawn charter (section 6.4.4) and the deepwater eastern king prawn charter (section 9.4.5). Power analyses were considered for species with catch rate distributions that conform to gamma or binomial distributions. A monitoring program with two levels of trawl sampling effort were considered, one based on 30 trawl samples and one based on 300. We also considered two levels of change or “bycatch reference points” that managers might consider: a 40% decline in catch rate, and an 80% decline in catch rate. The power to detect change in bycatch species catch rates increases with a) decreasing variance, b) increasing probability of capture, and c) increasing size of the change. The results can be used to develop monitoring programs and detect changes with confidence. Perhaps a more challenging problem pertains to what actions should be taken if or when a change is detected for one of more bycatch species.

Objective 7
Provide advice on the guidelines and definitions of BRDs and TEDs so that the Boating and Fisheries Patrol can confidently enforce regulations.

Project staff actively contributed to improving the guidelines and definitions of BRDs and TEDs throughout the project, and continue to do so. Two project staff, Tony Courtney and Matthew Campbell, are members of the trawl fishery Technical Working Group, which includes Boating and Fishing Patrol Officers and was formed specifically to address TED and BRD technical issues. Project staff provided advice by a) participating in the Technical Working Group, b) running courses on the design and definitions of TEDs and BRDs with fishers and Patrol Officers, c) working cooperatively with the Patrol on TED and BRD prosecutions as expert witnesses, d) promoting improvements to BRD definitions and specifications, e) developing rigorous procedures and methodologies to evaluate recognised BRDs (i.e., already listed in the Plan) and new designs as they are put forward, and f) presenting results from the project’s research charters that tested TEDs and BRDs. Examples of project staff involvement with the Patrol on matters pertaining to TEDs and BRDs are provided in the following table.

Examples of project staff improving TED and BRD definitions, specifications and interaction with the Queensland Boating and Fisheries Patrol.

Date	Event	Purpose
July 2001	Technical Working Group meeting, Brisbane	To discuss the definitions and specifications of BRDs. Project staff successfully argued that the definitions required improvement and obtained a commitment from the Group, industry and government to improve the technical specifications of BRDs, making them more effective.
September 2001	Reviewed the definitions of TEDs and BRDs	Provide further advice to managers and Patrol to improve BRDs
September 2001	Legal infringement of TED and BRD	Provided advice as expert witness
October 2001	Patrol sought project staff advice	Provide advice on TED designs for beam trawl fishery
November 2001	Patrol sought advice from project staff	Certain fishers were arguing to increase the TED bar spacings from 12 cm to 15 cm. This would have resulted in a higher proportion of small/young turtles passing through the TED and into the codends. Project staff successfully argued against this.
February 2002	Patrol sought advice on disseminating BRD guidelines	Project staff undertook detailed drawings of BRDs and provided them to Patrol
August 2002	Technical Working Group meeting, Cairns	To present research charter results on the performance of TEDs and BRDs. Successfully argued to amend several BRD definitions, including limiting the distance of several BRDs to 100 meshes of the drawstring.
May 2002	QFS Bycatch workshop, Brisbane	To communicate research results from the shallow water eastern king prawn charter that tested a TED and radial escape section BRD
May 2003	QFS TED workshop, Brisbane	Presentation of the results on TEDs in Queensland and summary of TED and BRD extension project
April to May 2004	QFS workshops at Mooloolaba, Southport, Scarborough, Bundaberg, Gladstone, Mackay, Bowen, Townsville and Cairns	Present project research results on the effects of TEDs and BRDs on bycatch rates
March 2003, May 2004, June 2005 and February 2006	Boating and Fisheries Patrol educational course, Southern Fisheries Centre, Deception Bay	Demonstrate several TED and BRD designs to new Patrol recruits, so they could become familiar with policing the devices

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24 Intellectual property

No intellectual property has arisen from the work.

25 Staff

Dr Tony Courtney, Senior Fisheries Biologist (Principal Investigator)
Mr Clive Turnbull, Senior Fisheries Biologist (Co-investigator)
Dr James Haddy, Fisheries Biologist
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Mr Shane Gaddes, Fisheries technician
Mr Michael O'Neill, Senior Fisheries Biologist

Mr Peter Kyne, Ph.D. candidate from the University of Queensland, was heavily involved in the project but was not a staff member.

Appendix 1. List of 406 taxa in the bycatch of the Queensland shallow water (< 91 m) eastern king prawn trawl fishery based on bycatch sub-samples from 204 individual net trawls from the research charter and opportunistically sampling the commercial fleet between April 2000 and April 2002. Mean catch rates are in grams and numbers per hectare, mean lengths (mm) are fork length or standard length for fish, carapace length for crustaceans, disc width or length for elasmobranchs, total length for echinoderms, and shell length for molluscs. Includes small or undersize principal target and permitted species. Frequency is the percentage occurrence in 204 net trawls. Standard error in brackets.

Species	Mean catch rate g ha^{-1}	Mean catch rate n ha^{-1}	Mean length mm	Frequency of capture (%)
Abalistes stellaris	0.023 (0.022)	0.002 (0.002)	55 (0)	0.5
Acalyptophis peronii	0.118 (0.113)	0.009 (0.009)		0.5
Acanthocepola limbata	0.118 (0.112)	0.001 (0.001)	500 (0)	0.5
Actinopyga miliaris	0.099 (0.095)	0.004 (0.004)	105 (0)	0.5
Aesopia sp.	0.023 (0.022)	0.001 (0.001)	105 (0)	0.5
Albunea occultus	0.046 (0.044)	0.006 (0.006)	18 (0)	0.5
Alima sp.	0.045 (0.036)	0.004 (0.003)	22 (2)	1
Ambiserrula jugosa	0.036 (0.034)	0.001 (0.001)	155 (0)	0.5
Amusium balloti	77.741 (28.288)	3.779 (1.037)	56.71 (0.81)	34.3
Anacanthus barbatus	0.041 (0.039)	0.003 (0.003)	170 (0)	0.5
Anchisomus multistriatus	0.422 (0.402)	0.006 (0.006)	100 (0)	0.5
Ancillista velesiana	0.487 (0.222)	0.01 (0.005)	66.4 (5.87)	2.5
Anoplocapros inermis	61.982 (11.821)	0.172 (0.031)	179.75 (2.81)	15.7
Antennarius hispidus	0.002 (0.002)	0.001 (0.001)	40 (10)	0.5
Antennarius striatus	1.447 (0.391)	0.082 (0.019)	53.75 (2.17)	12.7
Anthenea sp.	0.241 (0.164)	0.006 (0.004)	110 (25)	1
Antigonia rhomboidea	0.26 (0.089)	0.046 (0.015)	36.5 (1.37)	8.8
Apistus carinatus	15.365 (4.864)	0.526 (0.19)	92.91 (1.89)	11.8
Aploactis aspera	0.151 (0.06)	0.039 (0.015)	50.31 (2.26)	4.9
Aplysia dactylomela	0.132 (0.126)	0.008 (0.008)	90 (0)	0.5
Apogon brevicaudata	0.345 (0.328)	0.017 (0.016)	76.67 (8.82)	0.5
Apogon capricornis	1.206 (0.402)	0.142 (0.049)	65.68 (1.24)	5.4
Apogon ellioti	0.416 (0.215)	0.028 (0.012)	72.5 (6.68)	2.9
Apogon fasciatus	2.136 (0.643)	0.172 (0.051)	69.64 (1.26)	7.4
Apogon nigripinis	5.184 (1.025)	0.449 (0.083)	56.89 (1.22)	18.1
Apogon poecilopterus	0.397 (0.225)	0.018 (0.01)	80 (5.77)	1.5
Apogon semilineatus	2.837 (0.875)	0.282 (0.089)	67.46 (1.49)	10.3
Apogon septemstriatus	0.289 (0.113)	0.055 (0.019)	54.55 (2.47)	4.4
Apogon sp.	0.002 (0.002)	0.002 (0.002)	35 (0)	0.5
Aptychotrema rostrata	93.27 (10.735)	0.507 (0.094)	412.83 (9.17)	45.1
Arcania elongate	0.004 (0.003)	0.001 (0.001)	17 (0)	0.5
Arnoglossus elongatus	0.073 (0.069)	0.006 (0.006)	115 (10)	0.5
Arnoglossus fisoni	80.871 (13.553)	6.25 (1.057)	107.59 (0.53)	16.7
Arnoglossus sp.	0.03 (0.028)	0.006 (0.006)	75 (0)	0.5
Arnoglossus waitei	0.346 (0.112)	0.065 (0.018)	73.37 (1.95)	9.3
Arothron stellatus	0.06 (0.044)	0.011 (0.008)	32.5 (2.5)	1
Arotrolepis filicauda	0.316 (0.173)	0.035 (0.021)	59.17 (6.25)	1.5
Aseraggodes macleayanus	4.107 (1.712)	0.071 (0.029)	145.83 (5.74)	4.4
Aseraggodes melanospilus	0.067 (0.064)	0.004 (0.004)	100 (0)	0.5
Aseraggodes melanostictus	0.328 (0.191)	0.017 (0.009)	110 (10)	1.5
Ashtoret lunaris	0.787 (0.29)	0.12 (0.04)	33.28 (1.55)	4.9
Astele bularra	0.124 (0.118)	0.019 (0.019)	26.67 (1.67)	0.5
Astele speciosum	0.031 (0.03)	0.005 (0.005)	25 (0)	0.5
Asterorhombus intermedius	0.054 (0.051)	0.005 (0.004)	100 (0)	0.5

Species	Mean catch rate g ha^{-1}	Mean catch rate n ha^{-1}	Mean length mm	Frequency of capture (%)
Astropecten sp.	2.323 (0.526)	0.226 (0.038)	74.16 (3.03)	22.1
Asymbolus analis	1.598 (0.818)	0.004 (0.002)	462.5 (4.79)	2
Asymbolus rubiginosus	0.809 (0.77)	0.003 (0.003)	456.5 (1.5)	0.5
Athrinomorus ogilbyi	0.027 (0.026)	0.002 (0.002)	90 (0)	0.5
Aulopus curtirostris	0.255 (0.119)	0.034 (0.015)	74.48 (1.84)	3.4
Aulotrachichthys sp.	0.138 (0.07)	0.034 (0.015)	46.7 (0.85)	5.9
Basket star	0.048 (0.023)	0.004 (0.002)	36 (6)	2.5
Batrachomoeus dubius	3.427 (1.77)	0.117 (0.058)	89.17 (5.03)	2.5
Bellosquilla laevis	7.594 (1.952)	0.52 (0.13)	23.44 (0.34)	10.8
Bolma aureola	0.209 (0.193)	0.007 (0.005)	31.33 (8.51)	1.5
Brachaluteres taylori	0.621 (0.283)	0.08 (0.035)	40 (1.54)	4.9
Brittle star	0.134 (0.055)	0.039 (0.015)	113.13 (19.84)	4.4
Calappa lophos	4.198 (1.842)	0.041 (0.02)	86.78 (5.85)	3.9
Calappa philargius	6.428 (2.097)	0.089 (0.028)	73 (5.27)	4.9
Calliactus sp.	0.988 (0.325)	0.055 (0.018)	38.29 (2.83)	7.8
Callionymus calcaratus	283.475 (42.293)	11.479 (1.9)	122.73 (0.45)	49.5
Callionymus grossi	0.12 (0.084)	0.004 (0.003)	147.5 (7.5)	1
Callionymus japonicus	26.987 (5.732)	1.502 (0.293)	116.42 (1.17)	35.3
Callionymus limiceps	276.111 (38.847)	13.278 (2.118)	119.64 (0.61)	46.1
Callionymus margaretae	0.044 (0.042)	0.001 (0.001)	160 (0)	0.5
Callionymus moretonensis	0.921 (0.256)	0.083 (0.019)	91.75 (2.63)	14.7
Cantheschenia longipinnis	0.275 (0.261)	0.005 (0.004)	115 (0)	0.5
Canthigaster callisterna	0.161 (0.084)	0.011 (0.005)	55.71 (7.11)	3.4
Carangoides equula	1.172 (0.259)	0.095 (0.019)	68.59 (1.92)	14.7
Carangoides hedlandensis	0.13 (0.091)	0.013 (0.009)	60 (5)	1
Carangoides humerosus	0.417 (0.397)	0.006 (0.006)	130 (0)	0.5
Carangoides sp.	0.031 (0.026)	0.005 (0.004)	60 (5)	1
Carangoides talamparoides	0.313 (0.298)	0.012 (0.012)	82.5 (22.5)	0.5
Carid sp.	0.001 (0.001)	< 0.001	14 (0)	0.5
Centroberyx affinis	0.001 (0.001)	< 0.001	30 (0)	0.5
Centropogon australis	2.841 (0.962)	0.216 (0.075)	66.43 (1.37)	6.4
Chaetodermis penicilligrus	0.195 (0.146)	0.004 (0.003)	97.5 (32.5)	1
Chaetodon citrinellus	0.018 (0.017)	0.003 (0.003)	50 (0)	0.5
Chaetodon guentheri	0.14 (0.088)	0.006 (0.003)	77.5 (5.95)	2
Champsodon nudivittis	0.009 (0.007)	0.002 (0.001)	65 (15)	1
Charybdis bimaculata	1.205 (0.241)	0.101 (0.02)	37.36 (0.28)	13.7
Charybdis feriatus	7.343 (4.887)	0.051 (0.016)	74.11 (12.89)	4.4
Charybdis jaubertensis	0.037 (0.036)	0.005 (0.005)	25 (0)	0.5
Charybdis miles	0.145 (0.1)	0.002 (0.001)	77.5 (0.5)	1
Charybdis natator	6.992 (2.437)	0.121 (0.035)	57.05 (4.32)	7.4
Charybdis sp.	0.11 (0.105)	0.003 (0.003)	50 (0)	0.5
Charybdis truncata	0.34 (0.188)	0.035 (0.02)	33 (3.45)	2
Chelidonichthys kumu	4.75 (1.788)	0.042 (0.015)	173.5 (2.88)	7.4
Chloeia sp.	0.023 (0.015)	0.008 (0.006)	43.75 (6.57)	1.5
Choerodon cephalotes	0.326 (0.311)	0.004 (0.003)	130 (0)	0.5
Choerodon frenatus	2.643 (0.594)	0.147 (0.033)	81.16 (1.75)	17.2
Choerodon venustus	0.058 (0.056)	0.003 (0.003)	81.67 (13.02)	0.5
Chromis abyssicola	0.102 (0.056)	0.004 (0.002)	79 (3.32)	2
Cleidopus gloriamaris	3.898 (1.413)	0.028 (0.01)	123.75 (7.12)	3.9
Conger wilsoni	0.296 (0.229)	0.002 (0.001)	487.5 (12.5)	1
Crossorhombus azureus	15.087 (4.809)	0.938 (0.292)	99.37 (1.2)	18.6
Cubiceps whiteleggii	0.04 (0.027)	0.011 (0.008)	47.5 (2.5)	1
Cymbiolista hunteri	0.451 (0.322)	0.004 (0.003)	120 (5)	1
Cynoglossus sp.	15.07 (2.441)	0.511 (0.076)	139.77 (1.82)	33.3

Species	Mean catch rate g ha^{-1}	Mean catch rate n ha^{-1}	Mean length mm	Frequency of capture (%)
Cypraea subviridis	0.018 (0.017)	0.004 (0.003)	30 (0)	0.5
Cypselurus sp.	0.105 (0.071)	0.007 (0.006)	107.5 (37.5)	1
Dactyloptena macracantha	0.045 (0.043)	0.001 (0.001)	110 (0)	0.5
Dactyloptena orientalis	0.121 (0.115)	0.005 (0.004)	100 (0)	0.5
Dactyloptena papilio	31.992 (7.785)	1.372 (0.333)	87.06 (0.91)	33.8
Dardanus arrosor	0.552 (0.263)	0.016 (0.007)	28.14 (3.52)	4.9
Dardanus callichela	0.42 (0.378)	0.015 (0.013)	29.5 (0.5)	1
Dardanus crassimanus	0.017 (0.016)	0.002 (0.002)	21 (0)	0.5
Dardanus gemmatus	0.044 (0.042)	0.01 (0.009)	16.5 (1.5)	0.5
Dardanus imbricatus	0.296 (0.203)	0.017 (0.009)	22.33 (3.53)	1.5
Dardanus lagopodes	0.275 (0.253)	0.008 (0.006)	23 (3.16)	1
Dardanus pedunculatus	0.031 (0.029)	0.004 (0.003)	22 (0)	0.5
Dardanus sp.	0.001 (0.001)	0.001 (0.001)	13 (0)	0.5
Dasyatis kuhlii	11.778 (4.259)	0.018 (0.006)	262.92 (19.5)	4.9
Decapterus macrosoma	0.45 (0.428)	0.004 (0.004)	225 (0)	0.5
Decapterus russellii	1.089 (0.651)	0.024 (0.014)	98.75 (15.17)	2
Dendrochirus brachypterus	0.26 (0.115)	0.023 (0.009)	59.29 (6.76)	3.4
Dendrochirus zebra	0.879 (0.831)	0.013 (0.011)	91.25 (24.01)	1.5
Dendrodoris tuberculosa	1.586 (0.422)	0.102 (0.033)	56.61 (2.82)	9.3
Dentex spariformis	0.416 (0.233)	0.036 (0.016)	65.56 (1.8)	4.4
Diagramma pictum	1.022 (0.511)	0.047 (0.019)	79.38 (5.21)	2.9
Diodon holocanthus	6.668 (5.367)	0.036 (0.027)	129.44 (6.74)	1
Dipturus polyommata	0.021 (0.02)	0.001 (0.001)	110 (0)	0.5
Distorsio reticulata	0.006 (0.006)	0.001 (0.001)	34 (0)	0.5
Dorippe quadridens	0.084 (0.08)	0.004 (0.004)	35 (0)	0.5
Eduarctus martensii	0.044 (0.03)	0.012 (0.009)	16.5 (0.5)	1
Eklonia radiata	25.56 (4.339)		60 (0)	34.3
Emmelichthys strusakeri	0.005 (0.005)	0.001 (0.001)		0.5
Engraulis australis	0.083 (0.047)	0.014 (0.009)	90 (8.22)	2
Engyprosopon grandisquama	119.374 (15.849)	11.27 (1.441)	89.95 (0.39)	54.4
Engyprosopon macroptera	14.853 (3.122)	1.147 (0.201)	97.82 (1.04)	29.4
Engyprosopon sp.	22.247 (8.428)	1.286 (0.51)	115.74 (1.18)	10.8
Entomonyx depressus	0.007 (0.004)	0.003 (0.002)	25.75 (3.25)	1.5
Ephippias endeavouri	0.131 (0.125)	0.001 (0.001)	57 (0)	0.5
Epinephelus sp.	0.015 (0.015)	< 0.001	115 (0)	0.5
Eplumula australiensis	0.021 (0.009)	0.091 (0.038)	5.53 (0.16)	5.4
Erosa erosa	2.162 (0.67)	0.108 (0.027)	52.12 (3.7)	10.3
Etrumeus teres	0.358 (0.341)	0.006 (0.006)	160 (0)	0.5
Eubalichthys mosaicus	0.007 (0.007)	0.002 (0.001)	50 (0)	0.5
Eumedonus vicinus	0.02 (0.008)	0.032 (0.013)	11 (0.53)	3.4
Euprymna sp. *B*	0.066 (0.02)	0.023 (0.007)	17.83 (0.75)	6.4
Euprymna sp. *C*	0.025 (0.009)	0.017 (0.006)	13.16 (0.57)	3.9
Euprymna tasmanica	1.601 (0.324)	0.229 (0.051)	22 (0.48)	19.6
Euristhmus nudiceps	4.057 (1.969)	0.068 (0.027)	250 (19.06)	4.4
Eurypegasus draconis	0.008 (0.008)	0.003 (0.003)	50 (0)	0.5
Ficus subintermedia	0.406 (0.226)	0.021 (0.012)	63.33 (3.33)	1.5
Fistularia petimba	0.033 (0.022)	0.001 (0.001)	415 (70)	1
Foetorepus calauropomus	15.479 (4.015)	0.561 (0.143)	105.4 (1.75)	19.1
Fungia sp.	0.054 (0.051)	0.003 (0.003)	55 (0)	0.5
Galearctus timidus	0.03 (0.014)	0.005 (0.002)	19.14 (1.37)	2.5
Gerres subfasciatus	4.072 (2.011)	0.136 (0.068)	100 (2.94)	4.9
Glaucosoma scapulare	13.873 (3.96)	0.876 (0.196)	62.25 (0.98)	23
Gnathophis grahamii	31.552 (6.267)	0.597 (0.117)	286.2 (3.36)	27
Gonorynchus greyi	4.86 (1.172)	0.071 (0.016)	207.5 (9.13)	10.8

Species	Mean catch rate g ha^{-1}	Mean catch rate n ha^{-1}	Mean length mm	Frequency of capture (%)
Grammatobothus polyophthalmus	2.325 (0.581)	0.138 (0.03)	111.79 (4.98)	13.2
Gymnocranius audleyi	0.292 (0.232)	0.028 (0.023)	62.14 (1.01)	1
Hemigaleus australiensis	1.784 (1.699)	0.006 (0.006)	440 (0)	0.5
Heterodontus galeatus	12.616 (8.895)	0.006 (0.003)	541.75 (108.36)	2
Heteroscyllium colcloughi	6.916 (4.943)	0.003 (0.002)	717.5 (52.5)	1
Hippocampus queenslandicus	0.086 (0.057)	0.014 (0.007)	105 (10.21)	2
Holothuria ocellata	48.646 (12.396)	0.258 (0.066)	203.77 (4.88)	14.2
Holothurian sp.	1.573 (1.445)	0.025 (0.017)	68 (12.1)	2.5
Holothurian sp. *5*	0.005 (0.005)	0.003 (0.003)	40 (10)	0.5
Holothurian sp. *Z*	1.696 (0.847)	0.198 (0.09)	39.77 (0.97)	6.9
Homola orientalis	0.002 (0.002)	0.001 (0.001)	14 (0)	0.5
Hyastenus campbelli	0.01 (0.008)	0.002 (0.002)	20.5 (1.5)	1
Hyastenus diacanthus	0.03 (0.02)	0.005 (0.003)	21.67 (3.28)	1.5
Hyperlophus vittatus	0.064 (0.061)	0.011 (0.01)	77.5 (2.5)	0.5
Hypnos monopterygius	18.247 (6.402)	0.013 (0.004)	311.36 (25.73)	5.4
Ibacus brucei	0.009 (0.007)	0.002 (0.001)	22.5 (2.5)	1
Ibacus chacei	4.226 (0.753)	0.253 (0.046)	27.64 (0.62)	19.6
Ichthyscopus sannio	1.657 (0.938)	0.031 (0.014)	90 (9.13)	2.9
Inegocia japonica	177.984 (21.797)	6.671 (0.84)	118.55 (0.8)	54.9
Inimicus caledonicus	0.56 (0.363)	0.012 (0.007)	108.33 (6.01)	1.5
Jonas leuteanus	0.017 (0.01)	0.002 (0.001)	34 (2.89)	1.5
Kanekonia queenslandica	0.012 (0.011)	0.005 (0.005)	35 (0)	0.5
Kelp	107.904 (33.436)			7.4
Lactoria diaphana	0.026 (0.025)	0.004 (0.003)	35 (0)	0.5
Laevicardium attenuatum	0.061 (0.058)	0.005 (0.005)	39 (0)	0.5
Lagocephalus sceleratus	0.013 (0.012)	0.007 (0.006)	40 (0)	0.5
Lagocephalus spadiceus	1.37 (1.015)	0.006 (0.003)	162.5 (10.63)	2.5
Leiognathus moretoniensis	0.275 (0.109)	0.109 (0.039)	43.83 (1.31)	6.9
Lepidoperca caesiopercula	2.857 (1.234)	0.092 (0.039)	92.94 (1.8)	8.8
Lepidotrigla argus	1420.314 (106.719)	81.432 (6.244)	86.82 (0.3)	76
Lepidotrigla callodactyla	0.112 (0.107)	0.005 (0.005)	97.5 (12.5)	0.5
Lepidotrigla cf japonica	1.095 (0.475)	0.046 (0.018)	92.14 (5.34)	3.9
Lepidotrigla grandis	1.532 (1.011)	0.058 (0.041)	101.18 (5.47)	1.5
Lepidotrigla papilio	0.908 (0.378)	0.042 (0.018)	97.73 (3.12)	3.4
Lepidotrigla umbrosa	268.817 (58.626)	13.839 (3.002)	86.49 (0.49)	18.6
Leptomithrax weitei	0.3 (0.286)	0.001 (0.001)	100 (0)	0.5
Lethrinus genivittatus	6.934 (3.13)	0.078 (0.036)	132.14 (6.08)	2.9
Lobophora sp.	0.046 (0.044)	< 0.001		0.5
Lophiomus setigerus	8.563 (1.952)	0.154 (0.032)	100.24 (3.9)	15.2
Lophosquilla costata	0.077 (0.073)	0.007 (0.007)	21 (0)	0.5
Lovenia sp.	0.004 (0.004)	0.001 (0.001)	35 (0)	0.5
Luidia maculata	4.754 (1.884)	0.039 (0.014)	282.5 (61.25)	3.9
Lupocyclus philippinensis	0.361 (0.094)	0.08 (0.02)	21.85 (0.43)	11.3
Lupocyclus rotundatus	0.004 (0.004)	0.002 (0.002)	21 (0)	0.5
Lutjanus malabaricus	0.003 (0.003)	0.005 (0.005)	25 (0)	0.5
Lutjanus sebae	0.15 (0.142)	0.006 (0.006)	80 (0)	0.5
Lyreidus tridentatus	0.011 (0.01)	0.002 (0.001)	33 (6)	1
Macrorhamphosus molleri	0.008 (0.005)	0.003 (0.002)	76.67 (10.14)	1.5
Macrorhamphosus scolopax	0.038 (0.017)	0.009 (0.004)	68 (1.11)	2.5
Matuta inermis	0.625 (0.394)	0.063 (0.038)	26.54 (0.89)	2.9
Maxillicosta whitleyi	63.889 (12.813)	15.185 (3.076)	44.88 (0.19)	47.5
Melo georginae	1.64 (1.115)	0.011 (0.008)	107.5 (2.5)	1
Metapenaeopsis lamellata	0.04 (0.033)	0.006 (0.005)	14 (1)	1

Species	**Mean catch rate g ha^{-1}**	**Mean catch rate n ha^{-1}**	**Mean length mm**	**Frequency of capture (%)**
Metapenaeopsis palmensis	3.19 (0.808)	0.789 (0.203)	15.19 (0.24)	24.5
Metapenaeopsis provocatoria	0.003 (0.002)	0.008 (0.005)	7.7 (0.58)	2
Metapenaeopsis velutina	0.002 (0.002)	0.001 (0.001)	10 (1)	0.5
Metapenaeus bennettae	0.023 (0.022)	0.005 (0.005)	18 (0)	0.5
Metapenaeus ensis	0.039 (0.037)	0.005 (0.004)	23 (0)	0.5
Metasepia pfefferi	2.081 (0.604)	0.065 (0.018)	39.5 (2.88)	7.8
Microcanthus strigatus	0.931 (0.319)	0.026 (0.01)	100 (4.26)	4.4
Minous trachycephalus	0.007 (0.007)	0.003 (0.003)	35 (0)	0.5
Minous versicolor	1.199 (0.397)	0.053 (0.017)	74.09 (4.15)	4.9
Mollusc egg mass	1.568 (0.762)	0.009 (0.006)		2
Monacanthus chinensis	0.253 (0.186)	0.009 (0.007)	80 (0)	1
Muraenesox bagio	0.32 (0.305)	0.002 (0.002)	600 (0)	0.5
Mursia australiensis	0.04 (0.021)	0.005 (0.002)	35.5 (1.81)	2.5
Mustelus sp. *C*	0.272 (0.259)	0.002 (0.001)	377 (0)	0.5
Myra mammillaris	0.488 (0.371)	0.019 (0.014)	35.5 (0.5)	1
Nebrius ferrugineus	2.79 (1.968)	0.001 (0.001)		1
Nelusetta ayraudi	0.055 (0.052)	0.003 (0.003)	90 (0)	0.5
Nemipterus aurifilum	5.008 (1.177)	0.206 (0.046)	95.98 (1.17)	13.7
Nemipterus peronii	0.012 (0.011)	0.001 (0.001)	75 (0)	0.5
Nemipterus theodorei	610.756 (81.798)	12.325 (2.062)	121.16 (0.68)	70.1
Neomerinthe sp.	0.009 (0.006)	0.002 (0.001)	57.5 (2.5)	1
Neosebastes cf entaxis	0.01 (0.005)	0.004 (0.002)	36.25 (3.75)	2
Neosebastes incisipinnis	2.046 (0.859)	0.032 (0.013)	115 (15.3)	4.4
Octopus australis	4.808 (1.955)	0.066 (0.02)	39.81 (3.59)	7.8
Octopus exannulatus	0.022 (0.021)	0.002 (0.002)	30 (0)	0.5
Octopus kagoshimensis	5.776 (1.391)	0.092 (0.019)	45.08 (1.12)	12.7
Octopus marginatus	0.227 (0.151)	0.025 (0.017)	17.86 (3.04)	1.5
Octopus sp.	1.596 (0.605)	0.033 (0.01)	46.84 (3.69)	4.9
Octopus sp. *D*	0.001 (0.001)	< 0.001	25 (0)	0.5
Odontodactylus japonicus	0.297 (0.151)	0.015 (0.008)	24.43 (1.6)	2.9
Ophichthus sp.	0.808 (0.769)	0.003 (0.003)	690 (0)	0.5
Ophidion muraenolepis	0.049 (0.028)	0.003 (0.002)	131.67 (13.64)	1.5
Optivus sp. *1*	82.41 (10.229)	5.983 (0.743)	78.51 (0.22)	52.5
Oratosquilla nepa	0.081 (0.077)	0.006 (0.006)	24 (0)	0.5
Oratosquilla quinquedentata	0.826 (0.458)	0.022 (0.012)	34.75 (3.59)	1.5
Oratosquilla sp.	0.013 (0.012)	0.002 (0.002)	21 (0)	0.5
Oratosquilla woodmasoni	0.038 (0.036)	0.005 (0.005)	20 (0)	0.5
Orectolobus maculatus	1.094 (0.671)	0.005 (0.002)	330 (52.2)	1.5
Ostichthys japonicus	0.183 (0.122)	0.007 (0.004)	66.67 (19.22)	1.5
Pagrus auratus	0.424 (0.364)	0.006 (0.005)	117.5 (2.5)	1
Parabothus kiensis	0.018 (0.017)	0.002 (0.002)	100 (2.89)	0.5
Paracentropogon longispinis	0.188 (0.127)	0.012 (0.008)	72.5 (2.5)	1
Paramonacanthus lowei	1.235 (0.723)	0.032 (0.023)	92.5 (5.52)	1.5
Paramonacanthus otisensis	38.169 (6.257)	1.675 (0.287)	77.52 (0.95)	36.3
Parapercis binivirgata	0.031 (0.022)	0.002 (0.002)	125 (12.58)	1
Parapercis nebulosa	28.941 (5.009)	0.457 (0.08)	141.74 (2.58)	26
Parapercis sp. *A*	0.034 (0.033)	0.001 (0.001)	120 (0)	0.5
Paraplagusia unicolor	144.467 (29.243)	2.563 (0.552)	206.16 (0.95)	19.1
Parapriacanthus ransonneti	0.099 (0.055)	0.018 (0.01)	58.33 (1.67)	1.5
Pardachirus hedleyi	0.442 (0.303)	0.008 (0.005)	150 (0)	1
Parthenope longimanus	0.067 (0.054)	0.004 (0.003)	28.5 (4.5)	1
Parupeneus signatus	0.49 (0.32)	0.012 (0.007)	113.33 (20.88)	1.5
Parupeneus sp.	0.588 (0.365)	0.015 (0.009)	116.67 (12.63)	1.5
Pecten fumatus	0.686 (0.473)	0.012 (0.008)	62.5 (2.5)	1

Species	Mean catch rate g ha^{-1}	Mean catch rate n ha^{-1}	Mean length mm	Frequency of capture (%)
Pegasus volitans	9.923 (1.684)	1.644 (0.28)	113.53 (0.41)	23.5
Pelates sexlineatus	17.518 (7.48)	0.352 (0.118)	119.29 (2.2)	8.8
Pempheris affinis	0.089 (0.085)	0.004 (0.003)	95 (0)	0.5
Pentaceraster sp.	1.311 (1.054)	0.006 (0.005)	210 (20)	1
Peronella sp.	6.136 (1.687)	0.152 (0.033)	72.89 (4.84)	14.2
Petrarctus demani	0.49 (0.3)	0.04 (0.021)	23 (1.33)	2.9
Phalangipus australiensis	0.371 (0.105)	0.178 (0.062)	14.48 (0.63)	6.9
Phalangipus cf hystrix	0.01 (0.01)	0.003 (0.003)	20 (0)	0.5
Phalium areola	10.259 (4.071)	0.243 (0.093)	66.95 (1.17)	5.9
Phalium bandatum	4.385 (3.037)	0.121 (0.082)	64.72 (1.92)	1
Philine angasi	1.922 (1.143)	0.551 (0.348)	40.08 (0.9)	3.4
Photololigo sp.	38.488 (5.589)	1.117 (0.158)	82.7 (1.83)	43.6
Pilumnus hirsutus	0.144 (0.137)	0.012 (0.011)	40 (5)	0.5
Plagiopsetta glossa	0.696 (0.19)	0.026 (0.008)	158.1 (6.63)	6.9
Platycephalus arenarius	56.029 (16.897)	0.578 (0.133)	211.27 (3.23)	19.6
Platycephalus caeruleopunctatus	77.48 (14.431)	0.389 (0.08)	275.11 (4.06)	22.5
Platycephalus longispinis	301.145 (32.898)	11.152 (1.286)	142.09 (0.47)	64.2
Platycephalus marmoratus	0.43 (0.24)	0.003 (0.001)	261.67 (15.9)	1.5
Plesionika laurentae	1.519 (0.561)	0.415 (0.147)	16.4 (0.19)	11.8
Plotosus lineatus	53.125 (45.897)	2.026 (1.134)	92.87 (3.64)	13.2
Polycarpa sp.	0.028 (0.026)	0.002 (0.002)	45 (0)	0.5
Pomatomus saltatrix	6.906 (2.724)	0.049 (0.017)	186.88 (14.45)	3.9
Portunus argentatus	82.664 (17.305)	21.201 (4.506)	31.87 (0.12)	49.5
Portunus haanii	0.728 (0.311)	0.034 (0.013)	51.88 (6.38)	3.4
Portunus orbitosinus	0.543 (0.179)	0.128 (0.042)	26 (0.78)	5.4
Portunus pelagicus	74.762 (11.117)	1.007 (0.229)	94.46 (2.45)	26
Portunus rubromarginatus	215.207 (17.098)	15.367 (1.702)	44.33 (0.18)	84.3
Portunus sanguinolentus	58.195 (15.598)	1.342 (0.372)	86.86 (1.46)	16.2
Priacanthus macracanthus	2.676 (1.132)	0.02 (0.008)	162.14 (17.89)	3.4
Prionocidaris sp.	75.689 (13.314)	1.881 (0.277)	34.3 (0.32)	48
Pristigenys niphonia	0.149 (0.104)	0.005 (0.003)	68.33 (24.89)	1.5
Pristotis jerdoni	0.544 (0.268)	0.043 (0.02)	65 (8.13)	2.5
Psettina gigantea	1.254 (0.256)	0.162 (0.03)	89.19 (1.64)	18.6
Psettina iijimai	0.103 (0.035)	0.041 (0.014)	63.75 (1.41)	5.4
Psettina sp.	0.02 (0.014)	0.007 (0.005)	65 (2.89)	1.5
Pseudorhombus argus	0.23 (0.219)	0.005 (0.004)	180 (0)	0.5
Pseudorhombus arsius	47.639 (8.596)	0.374 (0.065)	217.6 (4.46)	17.6
Pseudorhombus diplospilus	0.081 (0.077)	0.002 (0.002)	160 (0)	0.5
Pseudorhombus dupliciocellatus	24.407 (4.282)	0.525 (0.068)	149.66 (4.29)	31.4
Pseudorhombus jenynsii	4.854 (1.805)	0.054 (0.019)	197.5 (7.24)	3.9
Pseudorhombus sp.	0.006 (0.006)	0.001 (0.001)	117.5 (17.5)	0.5
Pseudorhombus spinosus	1.1 (0.463)	0.04 (0.016)	144 (7.56)	2.9
Pseudorhombus tenuirastrum	119.628 (10.888)	1.931 (0.188)	194.12 (0.94)	60.8
Pterois volitans	0.27 (0.143)	0.023 (0.012)	70 (3.87)	2
Quollastria gonypetes	1.045 (0.232)	0.135 (0.031)	20.29 (0.28)	13.7
Rabdosargus sarba	0.567 (0.54)	0.008 (0.008)	120 (5)	0.5
Randallia eburnea	0.009 (0.009)	0.001 (0.001)	21 (0)	0.5
Rapana rapiformis	1.024 (0.633)	0.023 (0.014)	60 (2.04)	1.5
Ratabulus diversidens	45.214 (7.655)	0.543 (0.08)	180.4 (3.41)	30.9
Rhinopias frondosa	0.822 (0.783)	0.009 (0.009)	130 (0)	0.5
Rogadius patriciae	0.196 (0.12)	0.022 (0.013)	83.75 (3.15)	1.5
Samaris macrolepis	0.251 (0.118)	0.012 (0.005)	121.82 (7.02)	2.9

Species	Mean catch rate g ha^{-1}	Mean catch rate n ha^{-1}	Mean length mm	Frequency of capture (%)
Sargassum sp.	0.293 (0.216)			1
Saurida filamentosa	43.933 (11.944)	1.094 (0.391)	159.54 (2.59)	20.1
Saurida grandisquamis	770.875 (79.153)	4.809 (0.545)	253.59 (2.2)	77
Scomber australisicus	0.546 (0.415)	0.005 (0.003)	181.67 (9.28)	1.5
Scorpaena cardinalis	0.362 (0.205)	0.006 (0.003)	115 (2.89)	1.5
Scorpaenopsis brevifrons	0.037 (0.035)	0.002 (0.002)	60 (0)	0.5
Scylla serrata	0.873 (0.831)	0.001 (0.001)	188 (0)	0.5
Scyllarus sp. *A*	0.014 (0.013)	0.003 (0.003)	17.25 (0.95)	0.5
Scyphozoa	3.769 (3.316)	0.008 (0.005)	200 (80)	1
Sea pen	0.59 (0.562)	0.003 (0.003)	220 (0)	0.5
Sea star	0.553 (0.481)	0.022 (0.013)	70.71 (8.24)	1.5
Sea star 103	0.069 (0.066)	0.005 (0.005)	100 (0)	0.5
Sea star 3	0.061 (0.05)	0.005 (0.003)	103.33 (29.2)	1.5
Sea star 6	2.351 (1.969)	0.054 (0.046)	127.78 (2.52)	1
Sea star 71	0.005 (0.005)	0.004 (0.004)	85 (0)	0.5
Sea star 77	1.803 (1.717)	0.011 (0.01)	135 (0)	0.5
Sea Urchin 105	0.101 (0.097)	0.006 (0.005)	55 (0)	0.5
Sea Urchin 2	0.013 (0.013)	0.001 (0.001)	40 (0)	0.5
Sea Urchin 3	2.268 (1.131)	0.045 (0.019)	47.11 (4.69)	2.9
Sea Urchin 6	0.645 (0.354)	0.114 (0.068)	28.65 (1.59)	3.4
Sea Urchin 67	0.08 (0.054)	0.006 (0.004)	47.5 (7.5)	1
Sea Urchin 68	0.606 (0.235)	0.034 (0.012)	41.74 (2.85)	5.9
Sea Urchin 70	0.103 (0.098)	0.006 (0.006)	42.5 (5.73)	0.5
Sea Urchin 71	0.038 (0.036)	0.001 (0.001)	95 (0)	0.5
Sepia limata	0.404 (0.086)	0.092 (0.021)	32.82 (0.43)	14.2
Sepia mira	0.077 (0.073)	0.011 (0.01)	45 (0)	0.5
Sepia opipara	1.923 (0.437)	0.043 (0.009)	69.18 (2.94)	11.8
Sepia papuensis	0.038 (0.028)	0.007 (0.005)	33.33 (3.33)	1.5
Sepia plangon	100.407 (12.878)	3.62 (0.404)	58.61 (0.59)	61.8
Sepia rex	0.006 (0.006)	0.001 (0.001)	31.67 (1.67)	0.5
Sepia rozella	0.734 (0.421)	0.012 (0.006)	67.5 (10.26)	3.9
Sepia smithi	6.771 (2.283)	0.254 (0.098)	50.3 (2.63)	7.4
Sepia whitleyana	13.631 (4.238)	0.576 (0.187)	48.6 (1.99)	7.4
Sepioloidea lineolata	1.886 (0.507)	0.133 (0.032)	32.01 (0.87)	10.3
Sicyonia cristata	0.547 (0.127)	0.12 (0.027)	14.3 (0.43)	12.7
Siganus fuscescens	0.104 (0.099)	0.005 (0.004)	90 (0)	0.5
Sillago ciliata	0.503 (0.479)	0.005 (0.005)	190 (0)	0.5
Sillago flindersi	1.057 (0.441)	0.017 (0.008)	163 (3.96)	4.4
Sillago maculata	0.17 (0.162)	0.005 (0.005)	135 (0)	0.5
Sillago robusta	690.89 (98.126)	20.599 (3.043)	130.91 (0.67)	38.7
Solegnathus dunckeri	0.008 (0.007)	0.007 (0.007)	122.5 (7.5)	0.5
Solegnathus hardwickii	0.258 (0.082)	0.045 (0.014)	212 (11.98)	5.9
Soleichthys heterorhinos	0.352 (0.236)	0.011 (0.008)	132.5 (7.5)	1
Solenocera bifurcata	0.103 (0.034)	0.03 (0.009)	16.95 (0.68)	5.4
Solenocera choprai	0.153 (0.045)	0.056 (0.016)	15.47 (0.39)	6.9
Sorsogona tuberculata	0.537 (0.175)	0.05 (0.017)	83.33 (2.56)	4.9
Sphenopus marsupialus	16.163 (5.387)	0.642 (0.195)	42.05 (1.1)	8.3
Spondylus wrightianus	0.711 (0.417)	0.013 (0.008)	59.6 (2.07)	1.5
Stellaster sp.	0.035 (0.028)	0.003 (0.002)	70 (0)	1
Sympagurus sp.	0.013 (0.006)	0.006 (0.003)	12.25 (1)	2.9
Synagrops japonicus	0.06 (0.049)	0.004 (0.003)	88.75 (4.27)	1
Synchiropus rameus	32.255 (7.622)	1.21 (0.262)	99.3 (1.11)	27.5
Synodus hoshinonis	1.546 (0.621)	0.032 (0.01)	144.38 (5.95)	6.4
Synodus macrops	0.018 (0.017)	0.001 (0.001)	145 (0)	0.5

Species	Mean catch rate g ha^{-1}	Mean catch rate n ha^{-1}	Mean length mm	Frequency of capture (%)
Temnopleurus sp.	0.03 (0.029)	0.002 (0.002)	47.5 (2.5)	0.5
Tetrosomus concatenatus	111.307 (21.362)	3.116 (0.511)	73.26 (1.32)	54.9
Thalamita sima	0.11 (0.071)	0.012 (0.008)	34 (2.08)	1.5
Thamnaconus hypargyreus	0.196 (0.137)	0.01 (0.006)	87.69 (3.03)	2
Thamnaconus tessellatus	0.018 (0.018)	0.001 (0.001)	100 (0)	0.5
Tonna chinensis	0.156 (0.149)	0.004 (0.004)	71.4 (1.62)	0.5
Tonna tetracotula	3.632 (1.888)	0.038 (0.017)	86.36 (8.29)	3.4
Tonna variegata	4.825 (2.873)	0.03 (0.018)	116.43 (8.84)	2.5
Torquigener altipinnis	73.989 (12.006)	2.81 (0.451)	80.73 (0.68)	37.7
Torquigener pallimaculatus	1.65 (1.084)	0.059 (0.037)	82 (3.68)	2.5
Torquigener perlevis	5.736 (1.709)	0.08 (0.02)	110.94 (6.34)	7.4
Torquigener pleurogramma	2.289 (0.988)	0.052 (0.022)	101.33 (2.56)	2.5
Torquigener sp.	0.002 (0.001)	0.002 (0.001)	28.33 (3.33)	1.5
Trachinocephalus myops	105.497 (12.1)	2.427 (0.311)	135.46 (1.32)	55.4
Trachurus novaezelandiae	96.797 (33.384)	1.855 (0.657)	143.75 (0.67)	10.8
Trachypenaeus curvirostris	81.864 (15.38)	22.725 (4.284)	16.2 (0.08)	78.4
Tragulichthys jaculiferus	0.463 (0.441)	0.002 (0.002)	140 (0)	0.5
Tricanthodes sp.	0.036 (0.034)	0.004 (0.003)	60 (0)	0.5
Tripodichthys angustifrons	1.363 (1.298)	0.01 (0.01)	180 (15)	0.5
Trygonoptera testacea	98.387 (22.236)	0.75 (0.173)	218.94 (5.9)	20.1
Trygonorrhina sp. *A*	1.14 (0.7)	0.005 (0.002)	344 (45.65)	1.5
Unidentified Ascidian	2.454 (1.081)	0.045 (0.017)	58.57 (4.97)	3.4
Unidentified Bivalve	0.012 (0.012)	0.001 (0.001)	38 (0)	0.5
Unidentified Crinoid	2.766 (0.997)	0.066 (0.023)	380 (0)	5.9
Unidentified Gorgonian	0.014 (0.013)	0.001 (0.001)		0.5
Unidentified Hydroid	0.687 (0.491)	0.004 (0.004)	131.96 (2.19)	2
Unidentified Polychaete	0.036 (0.034)	0.004 (0.004)		0.5
Unidentified Sponge	2.17 (0.911)	0.004 (0.002)		3.4
Unidentified Stomatopod	0.143 (0.136)	0.012 (0.011)	24.5 (0.5)	0.5
Upeneichthys lineatus	15.164 (5.293)	0.188 (0.058)		11.8
Upeneus asymmetricus	85.648 (17.32)	3.075 (0.646)	107.05 (0.51)	24
Upeneus tragula	32.185 (5.503)	1.292 (0.221)	96.52 (0.67)	38.2
Uranoscopus terraereginae	1.54 (0.92)	0.032 (0.011)	75.88 (9.3)	5.9
Urolophus kapalensis	20.346 (9.54)	0.102 (0.043)	261.03 (6.19)	8.3
Valenciennea sp.	0.117 (0.092)	0.008 (0.005)	95 (10)	1
Vepricardium multispinosum	0.272 (0.259)	0.005 (0.005)	55 (0)	0.5
Xenophora peroniana	0.499 (0.172)	0.028 (0.009)	65.75 (3.69)	4.9
Zanclistius elevatus	1.167 (1.111)	0.003 (0.003)	240 (0)	0.5
Zebrias craticula	0.772 (0.444)	0.012 (0.006)	163.33 (6.67)	1.5
Zebrias scalaris	8.255 (2.171)	0.208 (0.054)	144.76 (1.8)	12.7
Zeus faber	0.019 (0.013)	0.003 (0.002)	50 (0)	1