Ministry for Primary Industries
Manatū Ahu Matua

Settlement indices for 2010 for the red rock lobster (*Jasus edwardsii*)

New Zealand Fisheries Assessment Report 2012/15

Forman, J.S.
McKenzie, A.
Stotter, D.R.

ISSN 1175-1584 (print)
ISSN 1179-5352 (online)
ISBN 978-0-478-38839-8 (online)

May 2012

New Zealand Government

Growing and Protecting New Zealand

Requests for further copies should be directed to:

Publications Logistics Officer
Ministry for Primary Industries
PO Box 2526
WELLINGTON 6140

Email: brand@mpi.govt.nz
Telephone: 0800 00 83 33
Facsimile: 04-894 0300

This publication is also available on the Ministry for Primary Industries websites at:
http://www.mpi.govt.nz/news-resources/publications.aspx
http://fs.fish.govt.nz go to Document library/Research reports

EXECUTIVE SUMMARY

Forman, J.S.; McKenzie, A.; Stotter, D.R. (2012). Settlement indices for 2010 for the red rock lobster (*Jasus edwardsii*).

New Zealand Fisheries Assessment Report 2012/15. 18 p.

This report addresses objective one of the Ministry of Fisheries project CRA200902B.

We update the information on annual patterns of settlement for the red rock lobster (*Jasus edwardsii*) on crevice collectors at key sites in CRA 3 (Gisborne), CRA 4 (Napier and Castlepoint), CRA 5 (Kaikoura), CRA 7 (Moeraki), and CRA 8 (Halfmoon Bay and Jackson Bay). In 2010, two groups of collectors in Gisborne, Napier, Castlepoint, and Kaikoura, and one group in Moeraki, Halfmoon Bay, and Jackson Bay were monitored. Each group has at least five collectors that are checked monthly when possible and a monthly mean catch per group of collectors is calculated. An annual raw and standardised index is produced from the groups of collectors at each site.

Puerulus settlement in 2010 was above average in all key sites except for Gisborne which recorded just over half its normal settlement. High levels of settlement were recorded in Jackson Bay, ending four years of extremely low settlement, and at Castlepoint, which had its best annual settlement since 1998. Kaikoura, with the exception of last year, has continued to have better than average settlement since 2001. Halfmoon Bay and Moeraki were just above their long-term mean, ending six consecutive years of below average settlement.

1. INTRODUCTION

Rock lobsters support one of New Zealand's most valuable fisheries. Understanding larval recruitment processes is expected to greatly assist management of this fishery by explaining changes in levels of recruitment to the fishery and enabling prediction of trends in catch levels at least four years in advance, allowing management and commercial strategies to be implemented. This report updates the patterns of spatial and temporal settlement of *Jasus edwardsii* on crevice collectors in New Zealand.

Rock lobsters spend several months as phyllosoma larvae in waters tens to hundreds of kilometres offshore. They return to the shore as postlarvae (pueruli) after metamorphosing near the shelf break. The puerulus is the settling stage: it resembles the juvenile in shape and is 9–13 mm in carapace length, but it is transparent. Pueruli settle when they cease extensive forward swimming and take up residence on the substrate. Some older pueruli and young juveniles, however, move after first settling elsewhere; post-settlement migration (secondary dispersal) such as this is not uncommon among invertebrates (e.g., Reyns & Eggleston 2004), the young redistributing from high-density settlement habitats. This is a way in which density-dependent mortality may be reduced. The puerulus moults into the first juvenile instar (sometimes referred to as the first-moult postpuerulus) a few days to three weeks after settlement, the earlier moulting occurring at higher water temperatures. Depending on sex and locality, the rock lobster then takes about 4–11 years to reach minimum legal size.

Development of sampling programmes to estimate levels of postlarval settlement that can be used to predict fishery performance is a goal for both palinurids (e.g. Phillips et al. 2000, Gardner et al. 2001) and homarids (e.g., Wahle et al. 2004), with, varying levels of encouraging or well-demonstrated success. In New Zealand there are significant correlations between settlement level and the fishery catch per unit effort (CPUE) for most fishery areas, with best correlations for those fisheries with shorter intervals between settlement and recruitment, and those with large contrasts in the settlement record (Booth & McKenzie 2008).

Monthly occurrence of pueruli and young juveniles on crevice collectors (Booth & Tarring 1986) has been followed at up to nine key sites within the main New Zealand rock lobster fishery since the early 1980s. The indices of settlement are now reported annually. It has become clear from this and other monitoring that settlement is not uniform in time or space. Settlement is mainly at night and at any lunar phase, is seasonal, and levels of settlement can vary by an order of magnitude or more from year to year (Booth & Stewart 1993). Since monitoring began, highest mean annual settlement has been along the east coast of the North Island south of East Cape (referred to as South East North Island or SENI), in the general region of highest abundance of phyllosoma larvae in adjacent offshore waters (Booth 1994).

For detailed further information on the puerulus sampling program in New Zealand see Booth et al. (2006).

OBJECTIVES

1. To determine trends in puerulus settlement at selected key sites around New Zealand.

Specific Objectives

To estimate monthly and annual indices of puerulus settlement at key sites in CRA 3, CRA 4, CRA 5, CRA 7 and CRA 8 (Gisborne, Napier, Castlepoint, Kaikoura, Moeraki, Halfmoon Bay, and Jackson Bay).

2. METHODS

2.1 Recording settlement on collectors

Levels of puerulus settlement are monitored using 'crevice' collectors (Booth & Tarring 1986, Booth et al. 1991, Phillips & Booth 1994) at seven key sites that encompass much of the main rock lobster fishing coast of New Zealand. The collector was developed in New Zealand to catch *J. edwardsii* pueruli and is now used throughout much of the range of *J. edwardsii*. They are inexpensive, easily set and checked, and provide (unlike many other types of collector) a standard settlement surface for between-month and between-site comparisons.

Each key site is separated from its neighbour by 150–400 km, and most sites were chosen after trying many locations (Figure 1). Criteria for the establishment of key sites included the distance from the neighbouring site, proximity to the open ocean, accessibility, tractability, and the level of puerulus catch.

At each key site collectors are set in groups of between 3 and 20, with at least 2–3 m between individual collectors. It is unclear whether or not there is interference in the catch between collectors at these spacings, but because the distances remain unaltered, any interference is likely to have a minimal impact on the overall monthly and annual index. At each site there is a core group of at least three (although usually five) collectors. At most sites there have been up to three additional groups of three or more collectors, set in both directions along the coast as conditions allow. Since 2002, however, fewer of these additional groups of collectors have been monitored; the focus is now on the core group (usually the one first established, and therefore with the longest record of settlement). Where feasible, one other group of collectors is also monitored.

There are five core, and one additional group of five collectors at Gisborne; five core, and one additional group of five collectors at Napier; nine core, and one additional group of five collectors at Castlepoint; five core, and one additional group of five collectors at Kaikoura; one core group of 15 collectors (crevice and mesh) at Moeraki; eight core collectors at Halfmoon Bay; and five core collectors at Jackson Bay wharf. Further alterations to the collector network may be made to improve the reliability of estimates. See Table 1 for a summary of the collector sites and the number of collectors by site and the method of collector deployment. Methods of deployment include: shore based collectors which are attached to concrete weights in sheltered subtidal locations; suspended collectors which are hung from wharf piles with the collectors suspended just off the bottom; closing collectors which have a closing mechanism that surrounds the collector as it is hauled up by boat.

Collectors are generally checked monthly as weather and tides allow and are cleaned of heavy growth so that the condition of collectors is consistent. Repairs required are noted at each collector check and these are made in the field where possible. Spare (and conditioned) collectors are maintained at each site or nearby as replacements. If possible, collector replacement is made outside the main settlement season.

At most sites, local people are employed to check the collectors, under NIWA's direction. Quality control of checks and equipment is maintained with direct contact once or twice a year. A standard result form is filled out and sent to NIWA after each check. At Castlepoint, NIWA staff check the collectors. Monthly checks, especially during the main winter settlement season, are not always possible for all groups of collectors because of logistical problems.

2.2 Calculating indices of settlement

The standardised index of annual settlement used here incorporates all settlement for the year for each site, irrespective of month. This approach to the standardisation was based on Bentley et al. (2004), but with the adjustments noted by Booth et al. (2004, 2006). The term 'settlement' refers to the presence of pueruli and juveniles up to 14.5 mm carapace length (CL), the maximum size for a first-instar juvenile observed in laboratory studies. All collectors were sampled at least 36 times (equivalent to three years of monthly sampling). No outliers were removed from any of the datasets after fitting (Bentley et al. (2004) removed outliers, but the effect on the standardised indices was minor).

The annual index takes into account changes in collector location and sampling to date. A generalised linear model framework was used, in which the response (dependent) variable is the log of numbers of settlers per collector sample and a Poisson distribution with dispersion is assumed. All independent variables were treated as factors. The year variable was included in all models; the other independent variables (group/collector and month) were added to the model in a stepwise process. At each step the variable that most improved the fit of the model was included.

Each set of annual indices is presented as the annual value divided by the geometric mean of the annual values, or where the annual values are close to zero (Moeraki and Halfmoon Bay) by dividing by the arithmetic mean of the annual values. In either case, a value for the index above 1 represents above average settlement for that year, and a value below 1 indicates less than average settlement. For comparison, a raw (unstandardised) form of this index is also given, which is also scaled to have an average value of 1 over all years.

Table 1: Method of collector deployment and number of collectors at each site. Groups no longer monitored from 1 October 2002 (or earlier in a few instances) are given in italics; changes after 1 October 2002 to monitored groups are denoted with strikethrough and underline. For definitions of collector type, see Booth & Tarring (1986) and Phillips & Booth (1994).

Site	No. collectors	Core group	Additional groups	Location	Method of deployment
Gisborne	5	GIS002		Whangara	Shore
	5		*GIS001*	*Harbour*	*Shore*
	5		GIS003	*Tatapouri*	Shore
	5		GIS004	Kaiti	Shore
Napier	5	NAP001		Harbour	Suspended
	3		*NAP002*	*Westshore*	*Closing*
	5		NAP003	C. Kidnappers	Shore
	3		*NAP004*	*Breakwater*	*Shore*
Castlepoint	9	CPT001		Castlepoint	Shore
	5		CPT002	Orui	Shore
	5		*CPT003*	*Mataikona*	Shore
Kaikoura	~~3~~ 5	KAI001		South 13–15	Shore
	3		*KAI002*	*South 31–33*	*Shore*
	~~3~~ 5		KAI003	North 10–12	Shore
	3		*KAI004*	*North 34–36*	*Shore*
Moeraki	*4*	*MOE001*		*Shag Point*	*Shore*
	3		MOE002	*Wharf*	Closing
	3		*MOE004*	*Millers Beach*	*Shore*
	3		*MOE005*	*The Kaik*	*Shore*
	3		*MOE006*	*Kakanui*	*Shore*
	15		MOE007	Pier	Suspended
Halfmoon Bay	~~3~~ 8	HMB001		Wharf	Suspended
	3		*HMB002*	*Thompsons*	*Closing*
	3		*HMB003*	*Old Mill*	*Closing*
	3		*HMB004*	*The Neck*	*Closing*
	3		*HMB005*	*Mamaku Point*	*Closing*
Jackson Bay	~~3~~ 5	JAC001		Jackson Bay Wharf	Suspended
	3		JAC002	*Jackson Head Inner*	Closing

3. RESULTS

The standardised annual collector indices up to 2010 are shown in Table 2. In the following sections site-by-site descriptions of puerulus settlement for 2010 are given plus standardised annual graphs from each key site and monthly mean catch graphs for 2010 from each group.

Table 2: Standardised annual settlement data for each key site. The groups of collectors used were GIS (002, 003, 004) for Gisborne, NAP (001, 002, 003, 004) for Napier, CPT (001, 002, 003) for Castlepoint, KAI (001, 002, 003, 004) for Kaikoura, MOE (001, 002, 007) for Moeraki, HMB (001, 002, 003, 004, 005) for Halfmoon Bay, JAC (001,002) for Jackson Bay. The numbers referring to collector sites and groups are shown in Table 1.

	Gisborne	Napier	Castlepoint	Kaikoura	Moeraki	Halfmoon Bay	Jackson Bay
1979	-	0.81	-	-	-	-	-
1980	-	1.46	-	0.00	-	1.71	-
1981	-	1.97	-	1.46	-	7.47	-
1982	-	0.96	-	0.04	-	0.35	-
1983	-	1.19	1.42	1.18	-	4.16	-
1984	-	0.39	1.35	0.34	-	0.35	-
1985	-	0.18	0.87	0.48	-	0.00	-
1986	-	-	0.50	0.15	-	0.10	-
1987	-	-	1.70	1.68	-	1.49	-
1988	-	1.45	0.98	0.74	-	0.19	-
1989	-	1.04	1.53	1.23	-	0.51	-
1990	-	1.09	0.94	0.41	0.79	0.41	-
1991	1.51	2.18	1.95	8.11	0.00	0.78	-
1992	2.19	2.31	2.41	9.41	0.15	0.57	-
1993	1.87	1.83	1.45	4.76	0.00	0.00	-
1994	2.86	1.37	0.92	1.27	0.00	1.03	-
1995	1.11	1.02	0.88	1.50	0.12	0.30	-
1996	1.03	1.62	1.29	1.12	1.13	0.29	-
1997	1.08	1.23	1.13	2.36	0.69	0.49	-
1998	1.49	1.05	1.66	3.13	0.66	0.24	-
1999	0.10	0.28	0.34	2.10	0.14	0.22	0.86
2000	0.97	0.63	0.55	1.83	3.93	1.11	0.81
2001	1.17	1.33	0.76	0.68	2.43	1.59	0.96
2002	1.14	1.07	0.67	1.79	0.95	1.22	3.50
2003	2.29	1.24	0.75	7.64	7.42	3.24	1.81
2004	0.79	1.04	0.64	2.64	0.42	0.12	0.34
2005	2.53	1.21	1.15	3.43	0.11	0.00	4.39
2006	0.38	0.57	0.63	2.86	0.06	0.12	0.45
2007	0.31	1.00	0.87	1.92	0.04	0.42	0.52
2008	0.71	0.57	0.88	3.62	0.10	0.08	0.33
2009	1.06	0.73	0.91	0.77	0.46	0.88	0.29
2010	0.58	1.25	1.59	2.85	1.40	1.56	7.08

Gisborne
Settlement in Gisborne was well below average, continuing a series of below average settlement. In four of the last five years settlement has been well below the long-term mean, with some of the lowest settlement since records began (Figure 2). Both Whangara and Kaiti had low monthly settlement most of which occurred between May and August (Figure 3).

Napier
Napier recorded settlement just above its long-term mean (Figure 4), however, this was mainly due to the very high settlement recorded from Cape Kidnappers in June and July (Figure 5). Settlement in Napier harbour was lower than normal reflecting the pattern seen at Gisborne.

Castlepoint
For only the second time since 1998, settlement at Castlepoint was above the long-term average (Figure 6). Higher than average settlement occurred throughout summer and autumn, particularly in Orui during April and May, but dropped off during winter, the period when settlement usually peaks (Figure 7).

Kaikoura
Settlement was also above average in Kaikoura (Figure 8) and apart from last year, continues a good run of annual settlement. A similar monthly pattern of settlement was recorded at both sites with settlement peaking in June (Figure 9).

Moeraki
Above average settlement was recorded in Moeraki for the first time since 2003 (Figure 10). Settlement peaked in June (Figure 11).

Halfmoon Bay
Like Moeraki, settlement was above average in Halfmoon Bay, ending six years of below average settlement (Figure 12). Settlement peaked in July (Figure 13).

Jackson Bay
High levels of settlement in 2010 ended four consecutive years of very low settlement in Jackson Bay (Figure 14). Settlement was highest in June (Figure 15).

Mean settlement by month over all years is shown in Figure 16. With the exception of Jackson Bay, where settlement is irregular, highest settlement generally occurs in winter and the lowest settlement is in spring.

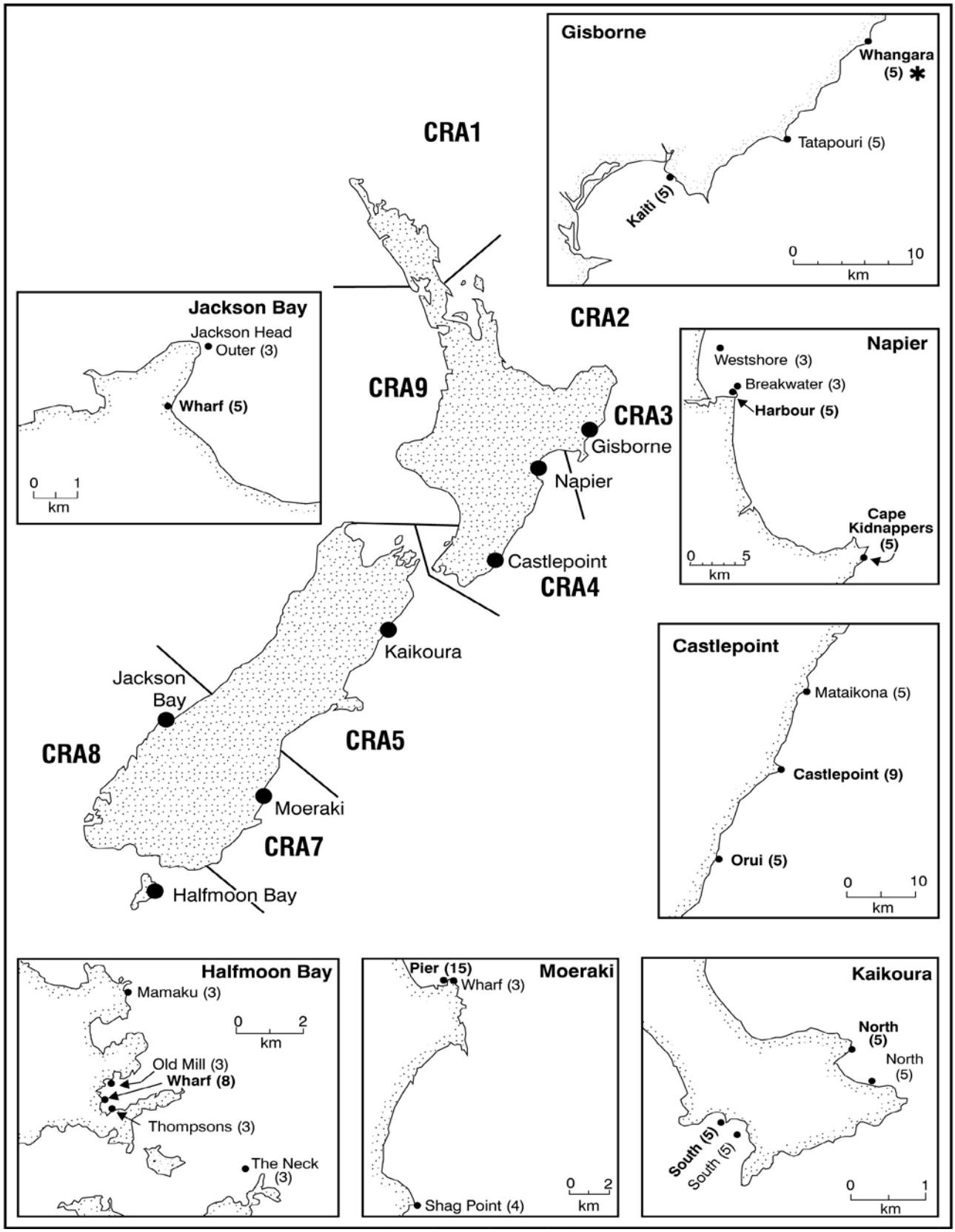

Figure 1: Map of New Zealand showing the location of collectors at the key monitoring sites (although not all groups are now checked). The sites that are checked are in bold and the number of collectors in that set is in brackets. * denotes a core group of collectors where one has been nominated. Also shown are the CRA areas; CRA 6 is the Chatham Islands and CRA 10 is the Kermadec Islands (to the northeast of the North Island).

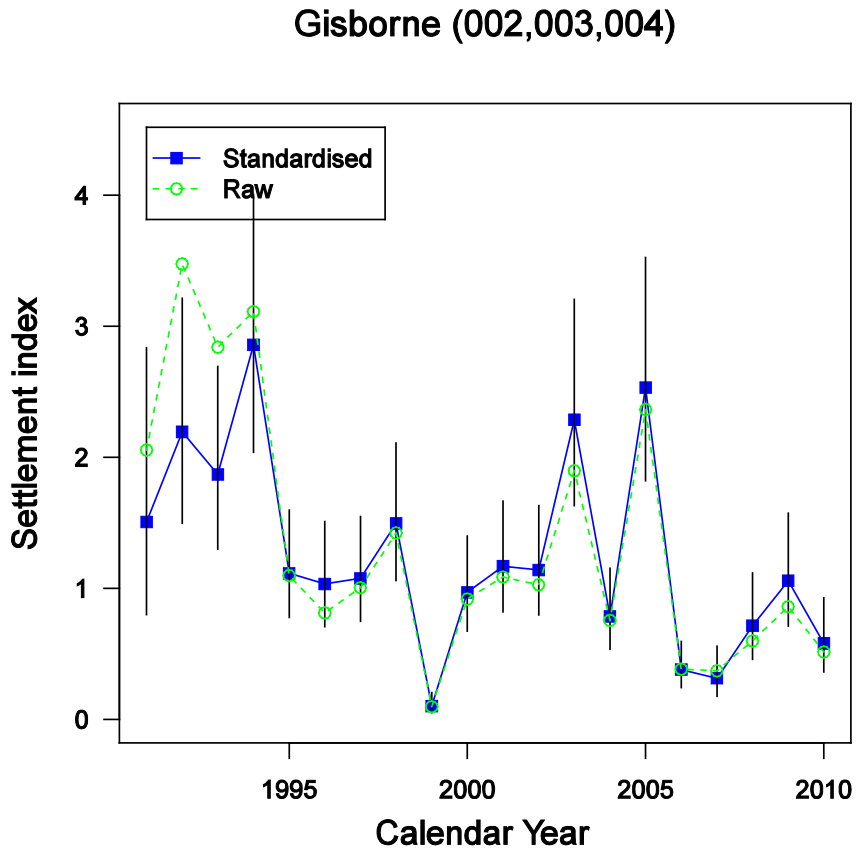

Figure 2: Gisborne–standardised and raw indices of annual settlement with 95% confidence intervals.

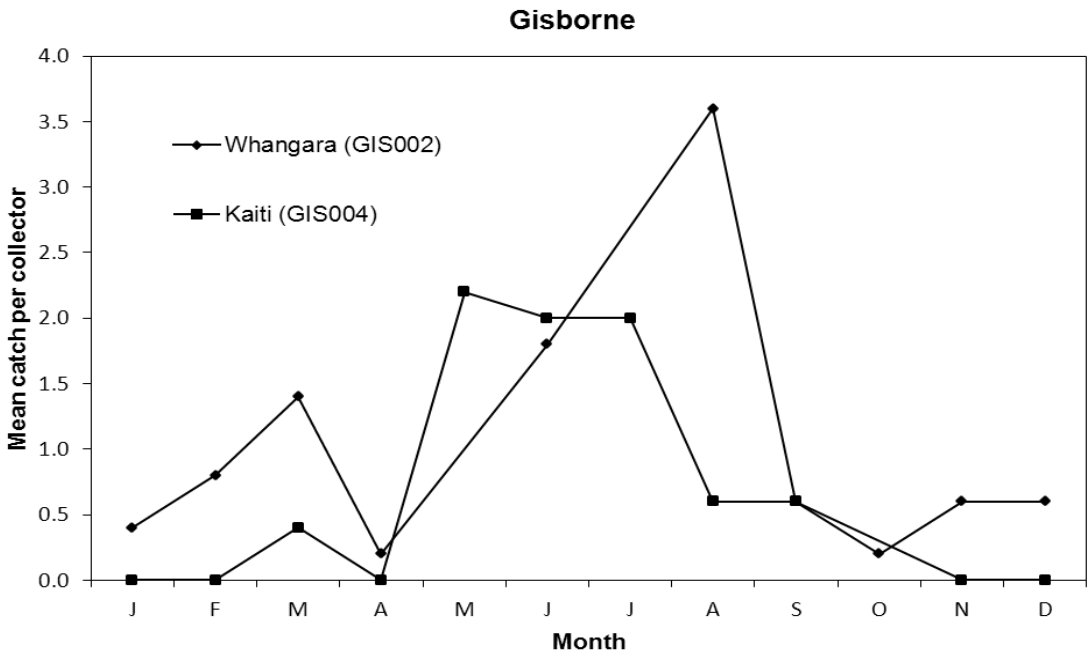

Figure 3: Whangara and Kaiti monthly settlement, 2010. Mean number of *Jasus edwardsii* pueruli + juveniles less than 14.5 mm carapace length per collector.

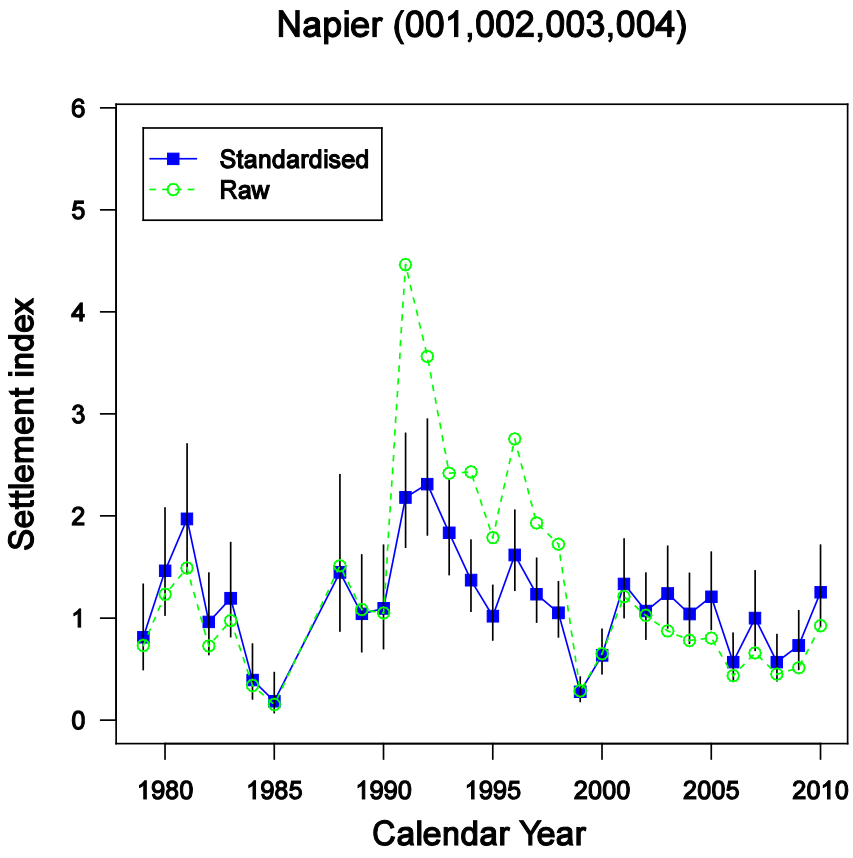

Figure 4: Napier – standardised and raw indices of annual settlement with 95% confidence intervals. Note that there were no checks in 1986–87.

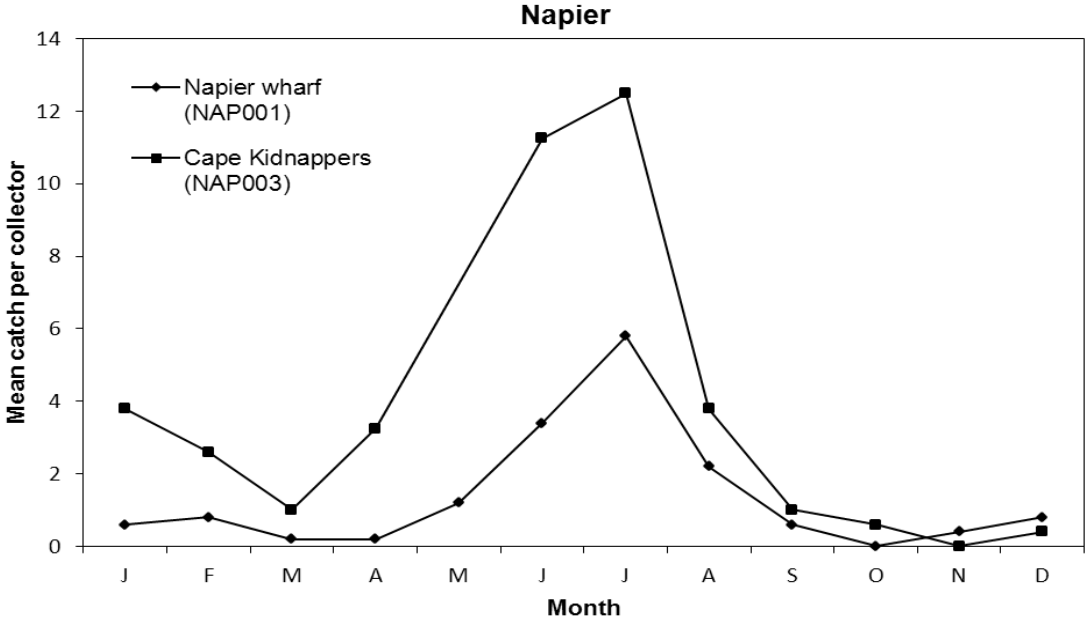

Figure 5: Napier harbour and Cape Kidnappers monthly settlement, 2010. Mean number of *Jasus edwardsii* pueruli + juveniles less than 14.5 mm carapace length per collector.

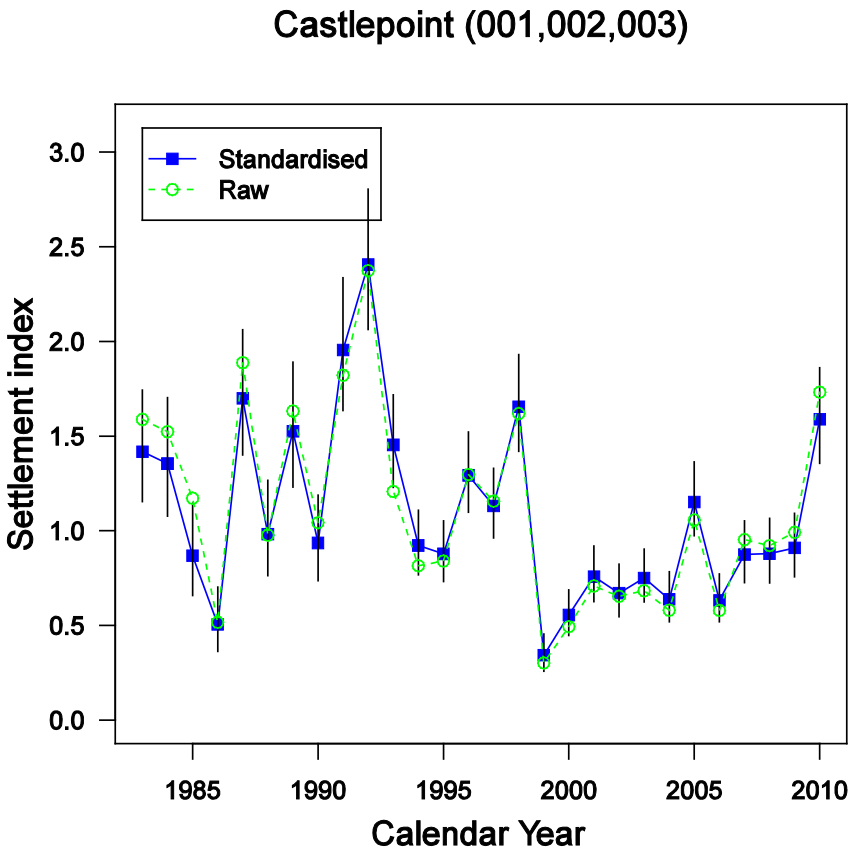

Figure 6: Castlepoint—standardised and raw indices of annual settlement with 95% confidence intervals.

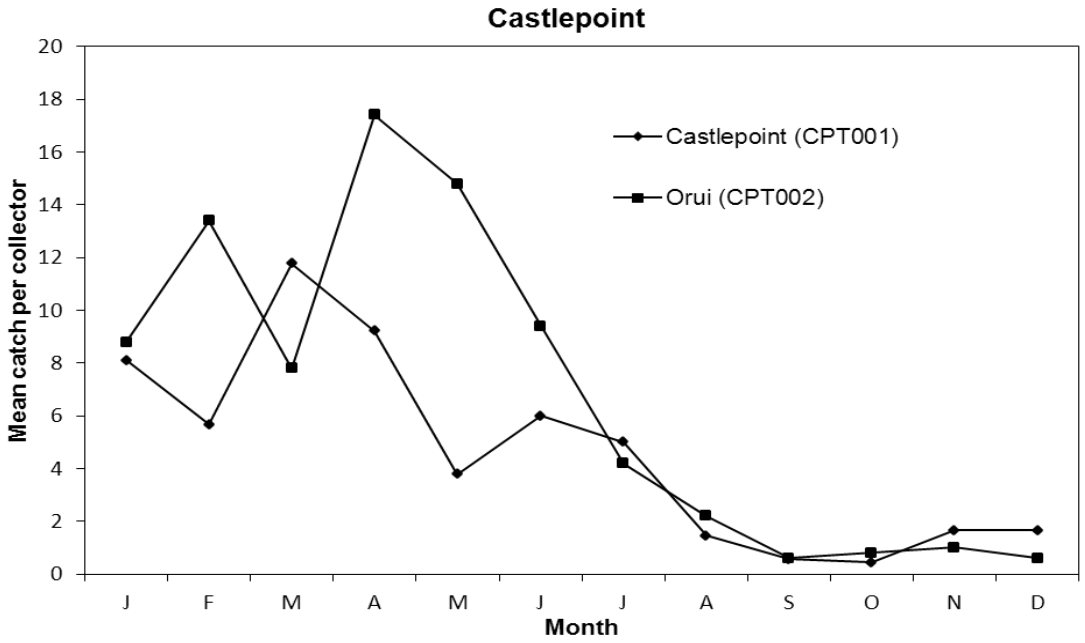

Figure 7: Castlepoint and Orui monthly settlement, 2010. Mean number of *Jasus edwardsii* pueruli + juveniles less than 14.5 mm carapace length per collector.

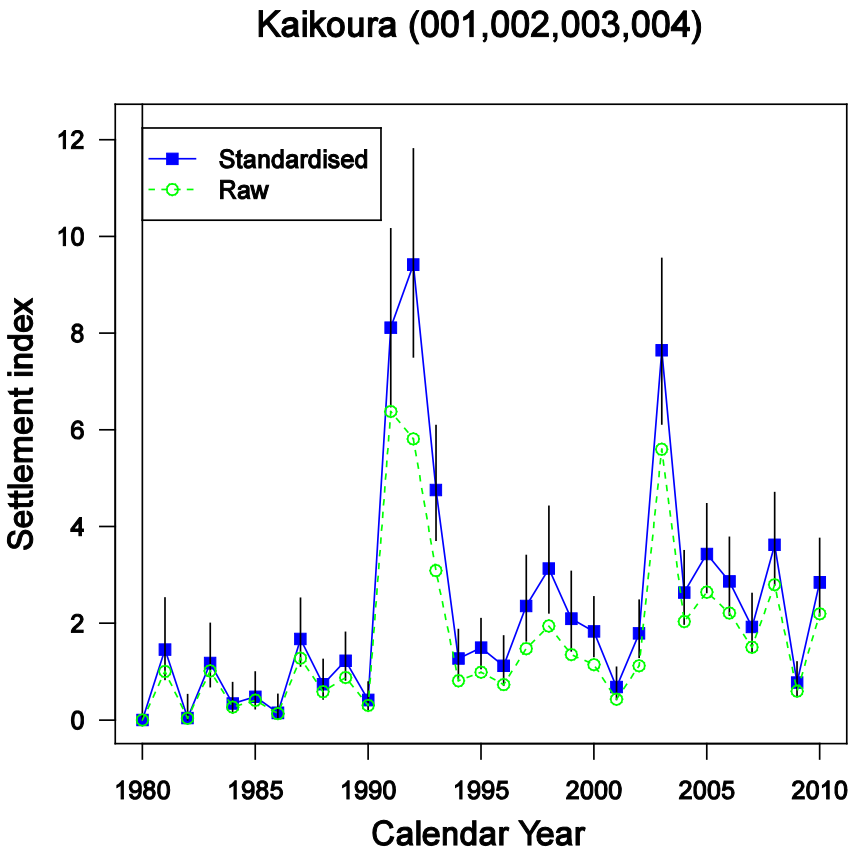

Figure 8: Kaikoura – standardised and raw indices of annual settlement with 95% confidence intervals.

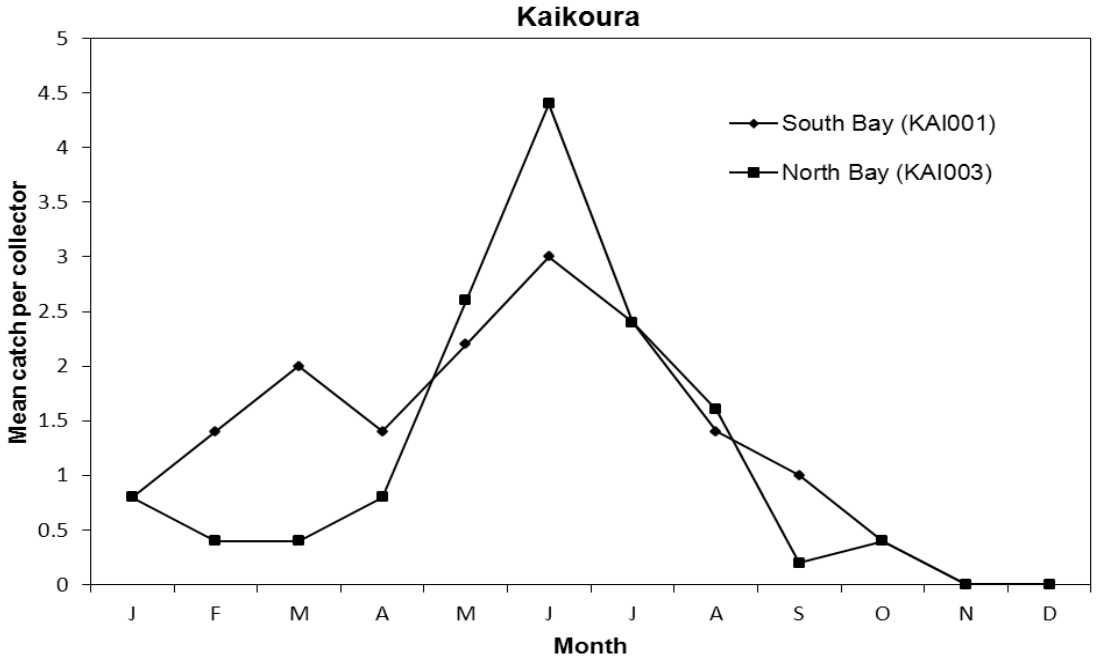

Figure 9: South Bay and North Bay monthly settlement, 2010. Mean number of *Jasus edwardsii* pueruli + juveniles less than 14.5 mm carapace length per collector.

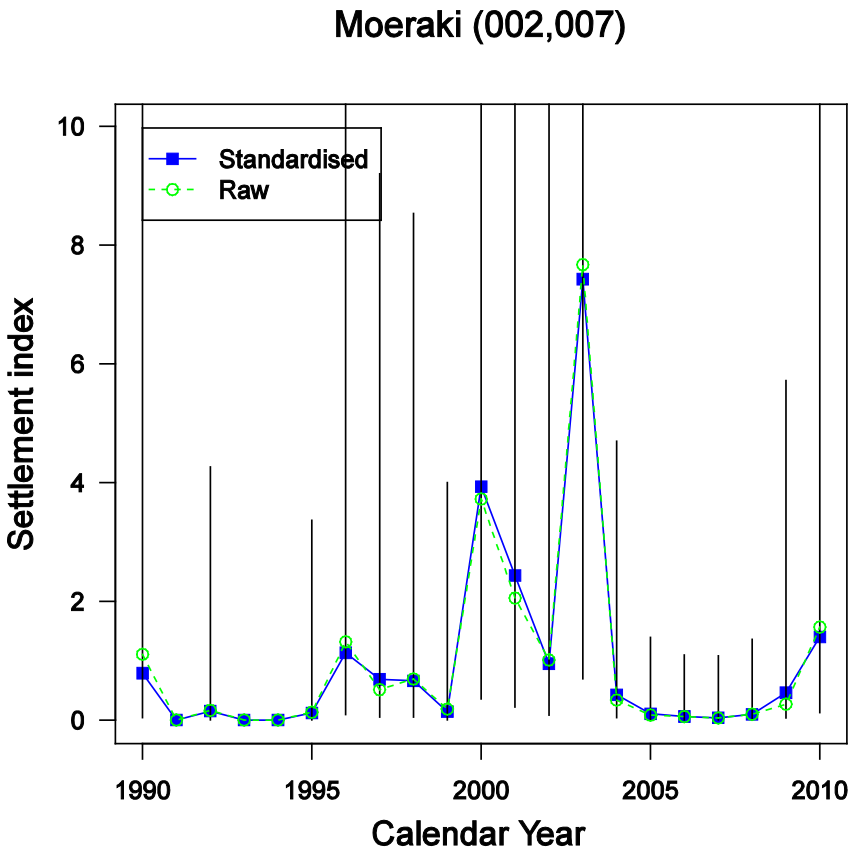

Figure 10: Moeraki – standardised and raw indices of annual settlement with 95% confidence intervals.

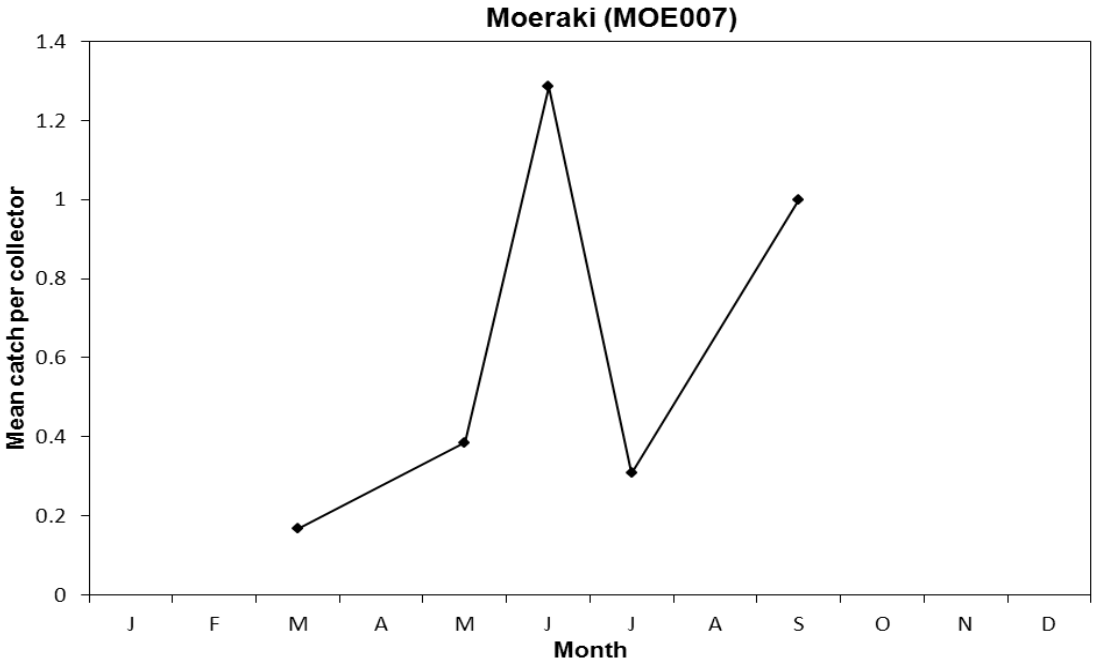

Figure 11: Moeraki monthly settlement, 2010. Mean number of *Jasus edwardsii* pueruli + juveniles less than 14.5 mm carapace length per collector.

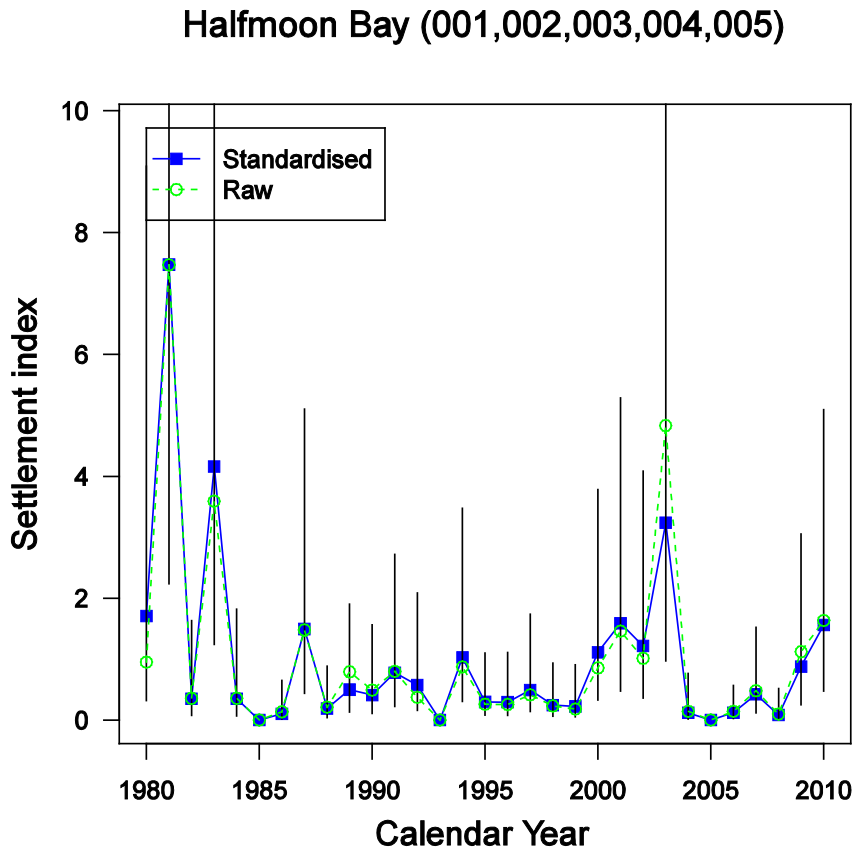

Figure 12: Halfmoon Bay—standardised and raw indices of annual settlement with 95% confidence intervals. The 95% confidence bounds were large because of high collector catch variability and the data not fitting the standardisation model well because of the large number of zero catches.

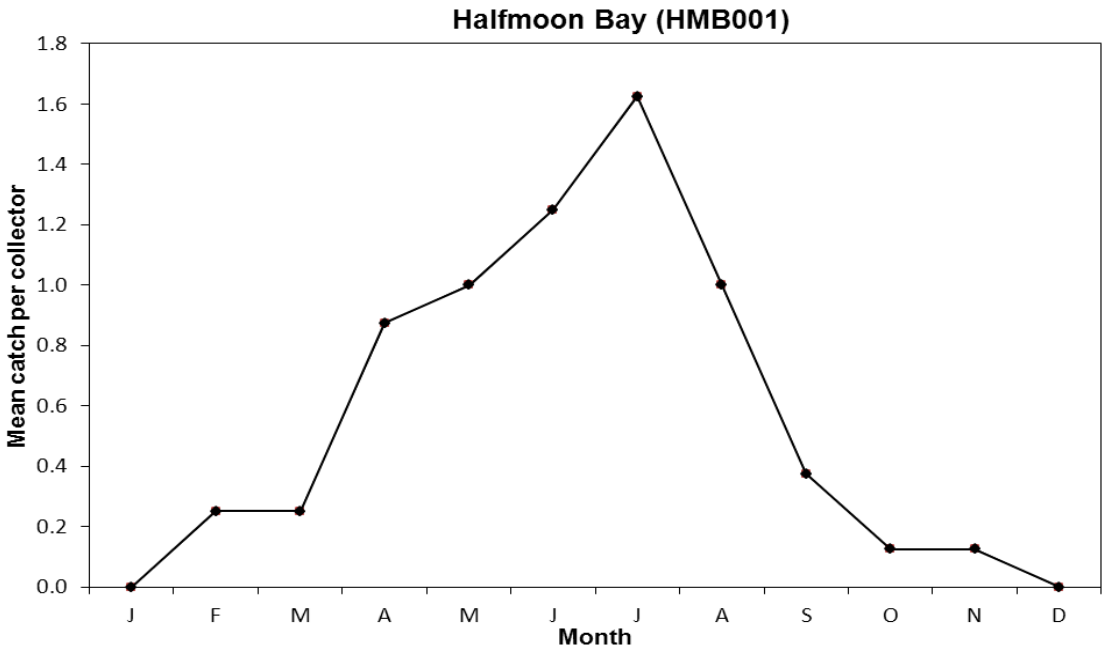

Figure 13: Halfmoon Bay monthly settlement, 2010. Mean number of *Jasus edwardsii* pueruli + juveniles less than 14.5 mm carapace length per collector.

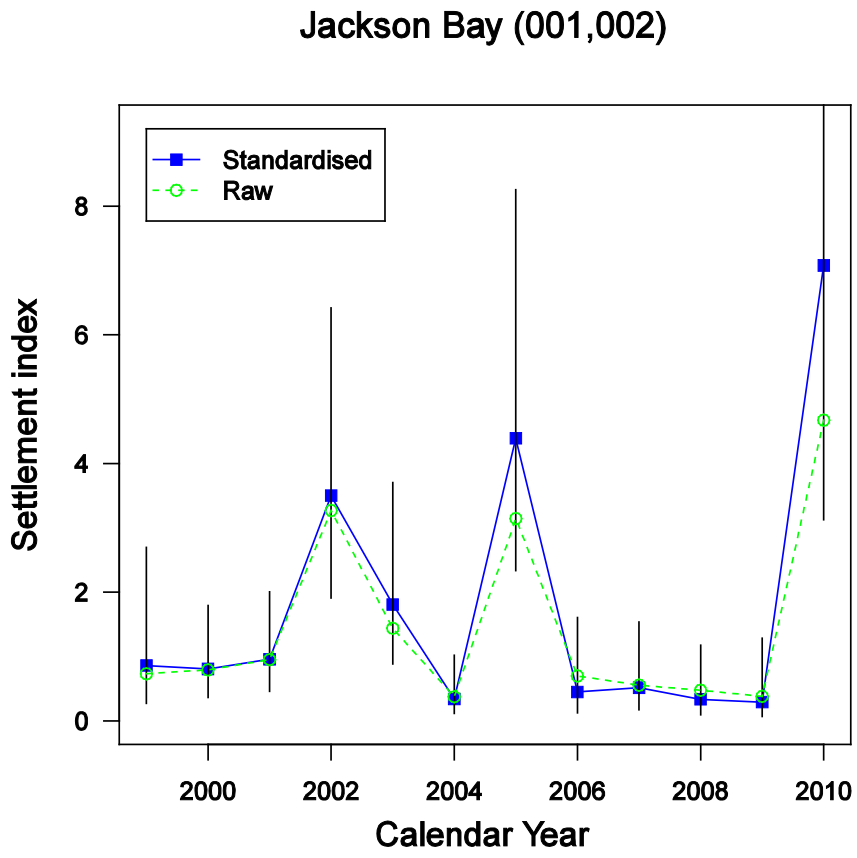

Figure 14: Jackson Bay – standardised and raw indices of annual settlement with 95% confidence intervals.

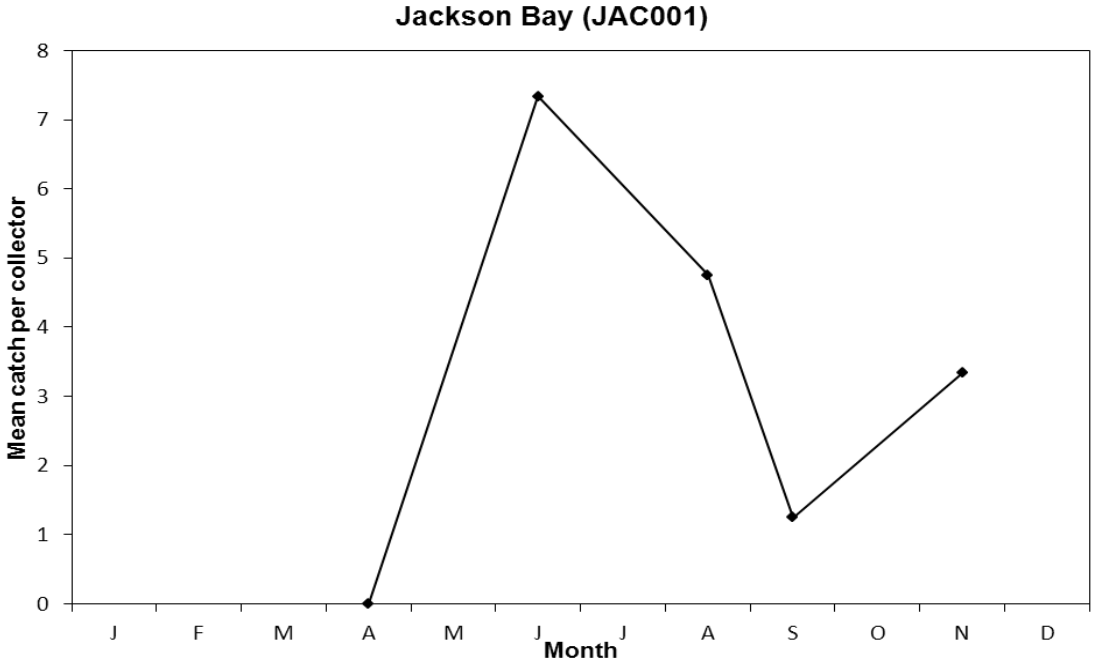

Figure 15: Jackson Bay monthly settlement, 2010. Mean number of *Jasus edwardsii* pueruli + juveniles less than 14.5 mm carapace length per collector.

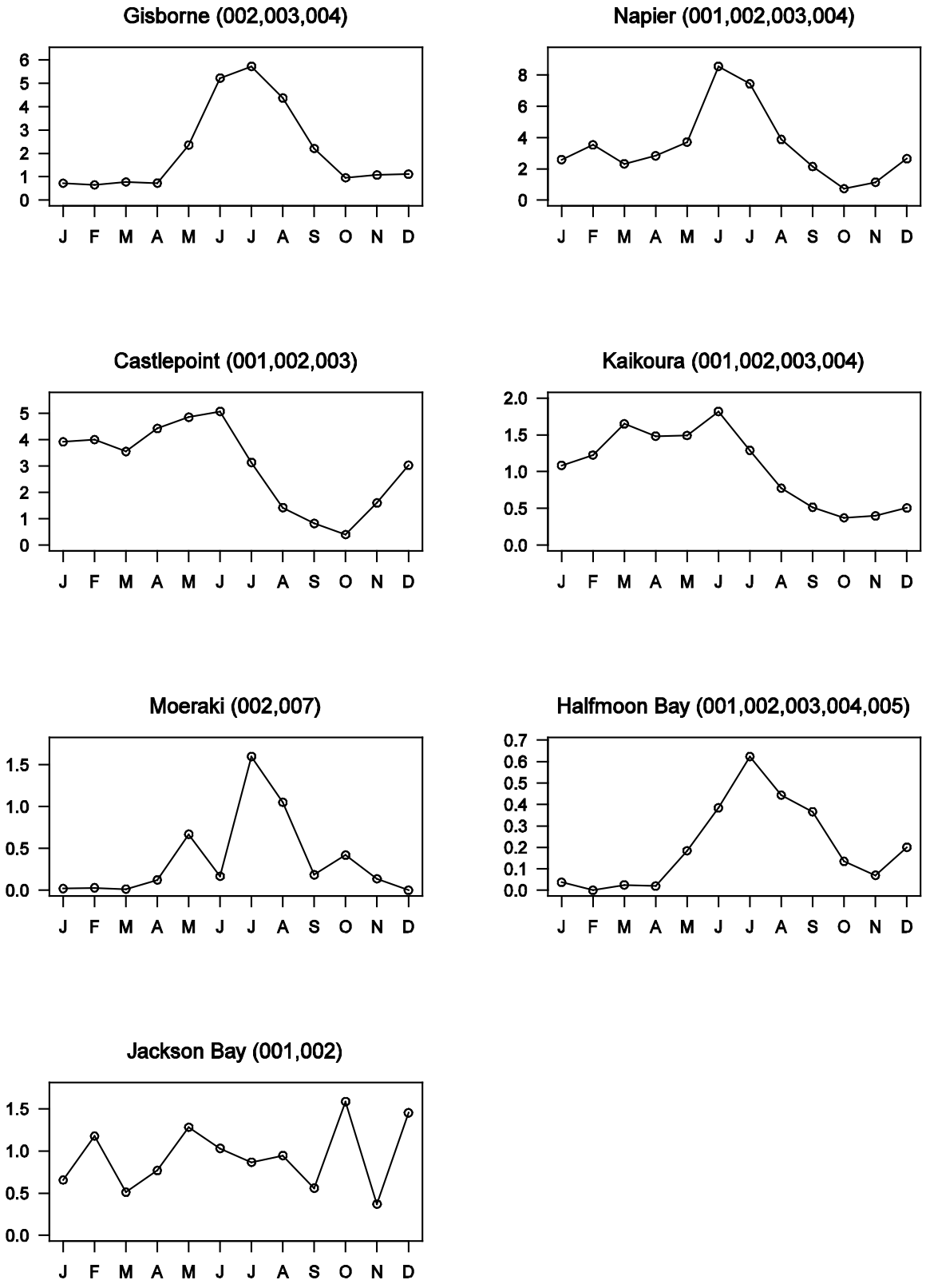

Figure 16: The mean settlement by month, over all years, for each key collector site. See Table 1 for the collector groups.

4. CONCLUSIONS

In 2010, above average levels of puerulus settlement was recorded in all key sites except for Gisborne (CRA 3). The low levels of settlement that were recorded in Gisborne in 2010 are a continuation of below average settlement over the last five years which has included some of the lowest settlement on record. In CRA 4, settlement was low at the wharf site in Napier but well above average at Cape Kidnappers, Castlepoint and Orui with very high settlement occurring at Cape Kidnappers in June and July, and Orui in April and May. In Kaikoura (CRA 5), settlement has been above average since 2002 (with the exception of 2009). Moeraki (CRA 7) and Halfmoon Bay (CRA 8) were just above their long-term mean, ending six consecutive years of below average settlement. In Jackson Bay (CRA 8), high levels of settlement ended four consecutive years of very low settlement.

5. ACKNOWLEDGMENTS

Thank you to Andy Bassett, Clint Brown, Neil Burden, Phred Dobbins, Wiremu Kaa, Matt Langley, Craig Petherick, Port of Napier, Neil Rose, Bob Street, and Merv Velenski for collector checks and field assistance. Nokome Bentley has kindly made available to us his code to generate the standardised settlement indices. This project was funded by the Ministry of Fisheries under project CRA200902. Also a thank you to Reyn Naylor for reviewing this report.

6. REFERENCES

Bentley, N.; Booth, J.D.; Breen, P.A. (2004). Calculating standardised indices of annual rock lobster settlement. *New Zealand Fisheries Assessment Report 2004/32*. 45 p.

Booth, J.D. (1994). *Jasus edwardsii* larval recruitment off the east coast of New Zealand. *Crustaceana 66*: 295–317.

Booth, J.D.; Carruthers, A.D.; Bolt, C.D.; Stewart, R.A. (1991). Measuring depth of settlement in the red rock lobster, *Jasus edwardsii*. *New Zealand Journal of Marine and Freshwater Research 25*: 123–132.

Booth, J.D.; Forman, J.S.; Stotter, D.R.; McKenzie, A. (2004). Settlement indices for 2002 for the red rock lobster (*Jasus edwardsii*). *New Zealand Fisheries Assessment Report 2004/30*. 37 p.

Booth, J.D.; McKenzie, A. (2008) Strong relationships between levels of puerulus settlement and recruited stock abundance in the red rock lobster (*Jasus edwardsii*) in New Zealand. *Fisheries Research 95*: 161–168.

Booth, J.D.; McKenzie, A.; Forman, J.S.; Stotter, D.R. (2006). Monitoring puerulus settlement in the red rock lobster (*Jasus edwardsii*), 1974-2005, with analyses of correlation between settlement and subsequent stock abundance. Final Research Report for Ministry of Fisheries Research Project CRA2004-02. 76 p. (Unpublished report held by MFish, Wellington).

Booth, J.D.; Stewart, R.A. (1993). Puerulus settlement in the red rock lobster, *Jasus edwardsii*. *New Zealand Fisheries Assessment Research Document 93/5*. 39 p. (Unpublished report held in NIWA Greta Point library,Wellington.)

Booth, J.D.; Tarring, S.C. (1986). Settlement of the red rock lobster, *Jasus edwardsii*, near Gisborne, New Zealand. *New Zealand Journal of Marine and Freshwater Research 20*: 291–297.

Gardner, C.; Frusher, S.D.; Kennedy, R.B.; Cawthorn, A. (2001). Relationship between settlement of southern rock lobster pueruli, Jasus edwardsii, and recruitment to the fishery in Tasmania, Australia. *Marine and Freshwater Research 52*: 1067–1075.

Phillips, B.F.; Booth, J.D. (1994). Design, use, and effectiveness of collectors for catching the puerulus stage of spiny lobsters. *Reviews in Fisheries Science 2:* 255–289.

Phillips, B.F.; Cruz, R.; Caputi, N.; Brown, R.S. (2000). Predicting the catch of spiny lobster fisheries. *In*: Spiny lobsters. Fisheries and culture. Phillips, B.F.; Kittaka, J. (eds) pp. 357–375. Blackwell Science, Oxford.

Reyns, N.B.; Eggleston, D.B. (2004). Environmentally-controlled, density-dependent secondary dispersal in a local estuarine crab population. *Oecologia 140*: 280–288.

Wahle, R.A.; Incze, L.S.; Fogarty, M.J. (2004). First projections of American lobster fishery recruitment using a settlement index and variable growth. *Bulletin of Marine Science 74*: 101–114