Settlement indices for 2009 for the red rock lobster (*Jasus edwardsii*)

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EXECUTIVE SUMMARY

Forman, J.S.; McKenzie, A.; Stotter, D.S. (2011). Settlement indices for 2009 for the red rock lobster (*Jasus edwardsii*).

New Zealand Fisheries Assessment Report 2011/15.

This report addresses objective one of the Ministry of Fisheries project CRA200902.

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 2009, 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 2009 was average or below average at all key sites. Gisborne, Castlepoint, and Halfmoon Bay were close to their long-term means and Napier, Kaikoura, Moeraki, and Jackson Bay were below their long-term means.

In 2009, a series of below average settlement years ended for Gisborne and Halfmoon Bay (3 and 5 years respectively), but low levels of settlement continued for Moeraki (the sixth consecutive year) and Jackson Bay (the fourth consecutive year).

1. INTRODUCTION

Rock lobsters support one of New Zealand's most valuable fisheries. Understanding larval recruitment processes will greatly assist management of this fishery because it may explain changes in levels of recruitment to the fishery and enable prediction of trends in catch levels at least 4 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, being 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 3 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, according to project, 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 and 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 (= southeast 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 5 core, and 1 additional group of 5 collectors, at Gisborne; 5 core, and 1 additional group of 5 collectors, at Napier; 9 core, and 1 additional group of 5 collectors, at Castlepoint; 5 core, and 1 additional group of five collectors, at Kaikoura; 1 core group of 15 collectors (crevice and mesh), at Moeraki; 8 core collectors at Halfmoon Bay; and 5 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' to refers to the presence of pueruli and juveniles up to 14.5mm 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 data sets 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 so as to have an average value of 1 over all years.

Table 1: Method of collector deployment and number of collectors at each site 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
Wellington	3		WGT001	*Island Bay*	Shore
	3		*WGT002*	*Lyall Bay*	*Shore*
	3		WGT003	*Breaker Bay*	Shore
	3		WGT004	*Palmer Head*	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		*JAC003*	*Jackson Head Outer*	*Closing*
	3		*JAC004*	*Smoothwater Bay*	*Closing*

3. RESULTS

The standardised annual collector indices up to 2009 are shown in Table 2. In the following sections site-by-site descriptions of puerulus settlement for 2009 are given plus standardised annual graphs from each key site and monthly mean catch graphs for 2009 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	-	1.45	-	0.00	-	1.62	-
1981	-	1.96	-	1.52	-	7.78	-
1982	-	0.95	-	0.04	-	0.35	-
1983	-	1.18	1.42	1.21	-	4.24	-
1984	-	0.39	1.37	0.35	-	0.35	-
1985	-	0.18	0.88	0.50	-	0.00	-
1986	-	-	0.51	0.16	-	0.10	-
1987	-	-	1.71	1.73	-	1.51	-
1988	-	1.44	0.99	0.76	-	0.19	-
1989	-	1.04	1.54	1.27	-	0.51	-
1990	-	1.09	0.94	0.43	0.80	0.41	-
1991	1.46	2.20	1.97	8.43	0.00	0.80	-
1992	2.12	2.32	2.46	9.80	0.16	0.59	-
1993	1.81	1.84	1.50	4.92	0.00	0.00	-
1994	2.77	1.39	0.94	1.32	0.00	1.04	-
1995	1.08	1.03	0.90	1.55	0.12	0.30	-
1996	1.00	1.64	1.32	1.16	1.18	0.30	-
1997	1.04	1.25	1.16	2.45	0.74	0.50	-
1998	1.45	1.07	1.70	3.22	0.69	0.25	-
1999	0.10	0.28	0.35	2.17	0.14	0.23	1.08
2000	0.94	0.65	0.56	1.90	3.99	1.13	0.99
2001	1.13	1.37	0.77	0.71	2.53	1.62	1.19
2002	1.11	1.08	0.69	1.86	0.96	1.24	4.22
2003	2.22	1.26	0.76	7.90	7.36	3.27	2.17
2004	0.76	1.06	0.65	2.72	0.46	0.12	0.40
2005	2.46	1.23	1.18	3.55	0.12	0.00	5.00
2006	0.37	0.58	0.65	2.96	0.07	0.12	0.55
2007	0.30	1.01	0.90	1.99	0.04	0.43	0.60
2008	0.69	0.58	0.89	3.74	0.10	0.08	0.38
2009	1.07	0.75	0.93	0.80	0.54	0.89	0.34

Gisborne
Settlement levels in Gisborne improved from the previous three years of very low settlement to a level close to the long-term mean (Figure 2). Settlement at Whangara was low throughout the year and considerably lower than at Kaiti, which is unusual. Kaiti settlement was variable with high settlement recorded in May, July, and August, but very low settlement in June (Figure 3).

Napier
Napier had a slight increase in settlement from last year but is still below its long-term mean. For three out of the last four years settlement has been below average (Figure 4). Both sites recorded similar levels of settlement over most of the year, except for December when Cape Kidnappers had a sharp increase in settlement (Figure 5). The monthly settlement pattern at Cape Kidnappers was also closely aligned to settlement in Kaiti with high settlement in May and July and low settlement in June which is generally the highest settlement month.

Castlepoint
Settlement in Castlepoint was close to the long-term mean and very similar to the last two years. In the last 11 years settlement has been above average only once (2005) and in several of those years settlement has been some of the lowest recorded (Figure 6). Orui recorded very high settlement in February, but this was followed by very poor settlement for most of the year. Castlepoint also recorded high settlement over summer and at the end of the year, but settlement was below average for most months, especially during the normally high winter settlement period (Figure 7).

Kaikoura
For the first time since 2001, settlement fell below the long-term mean (Figure 8). Both groups had a similar pattern of settlement over the year with the peak settlement occurring earlier than normal in February. No settlement occurred during the normally high settlement months of May, June, and July (Figure 9). This pattern of settlement was similar to that of Castlepoint and Orui.

Moeraki
Although slightly higher than in the previous five years, annual settlement at Moeraki remained low (Figure 10). The highest monthly settlement was recorded in August (Figure 11).

Halfmoon Bay
In 2009 settlement in Halfmoon Bay increased to a level close to the long-term mean after 5 years of low settlement (Figure12). The highest monthly settlement in Halfmoon Bay was recorded in June, July, and August (Figure 13).

Jackson Bay
For the fourth consecutive year, annual settlement in Jackson Bay was very low (Figure 14). The highest monthly settlement in Jackson Bay was recorded in December (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.

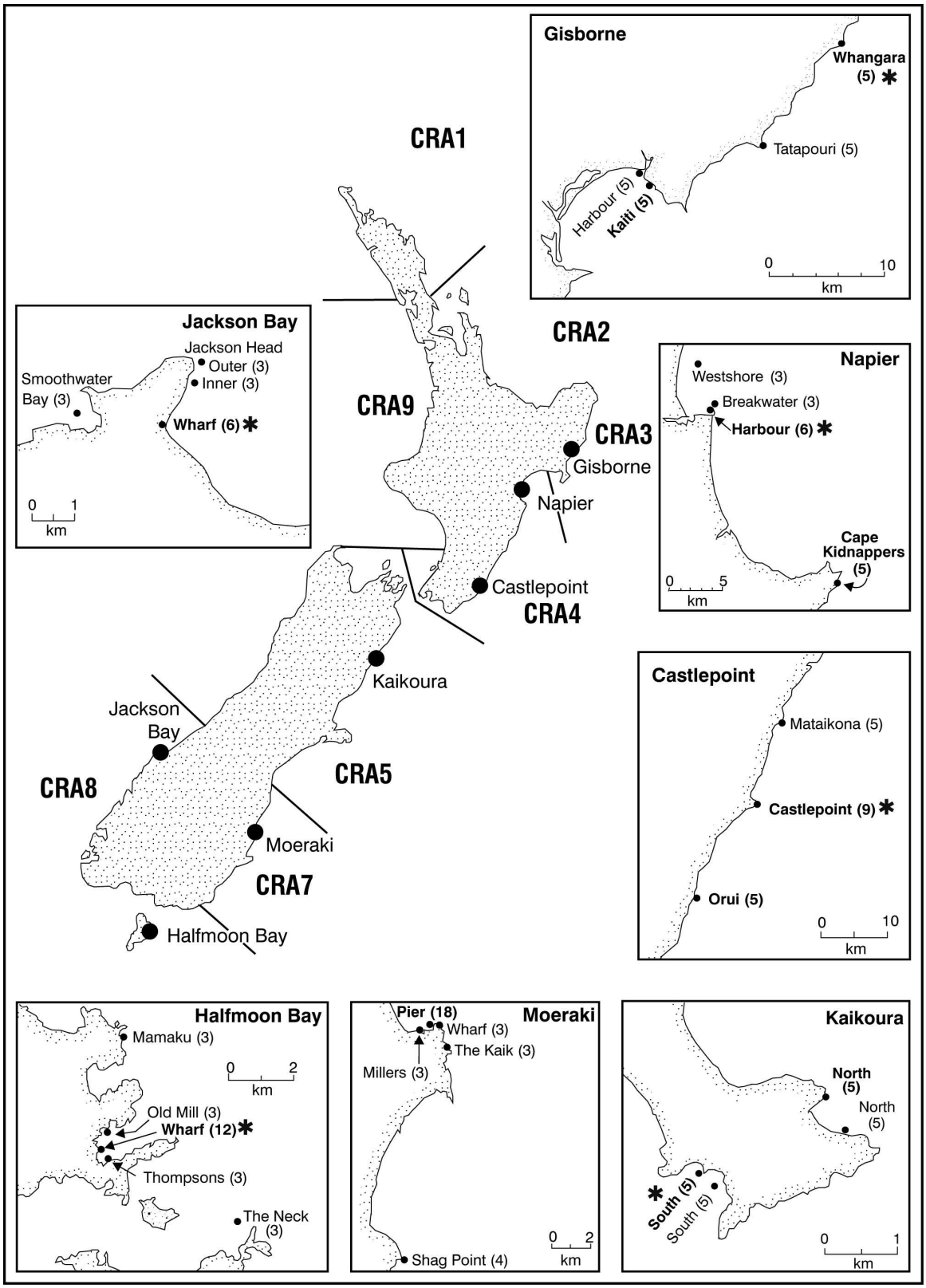

Figure 1: Map of New Zealand showing the location of collectors at the key monitoring sites (although not all groups are now checked). The sites that are checked are in bold and the number of collectors in that set is in brackets. * denotes a core group of collectors where one has been nominated. Also 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).

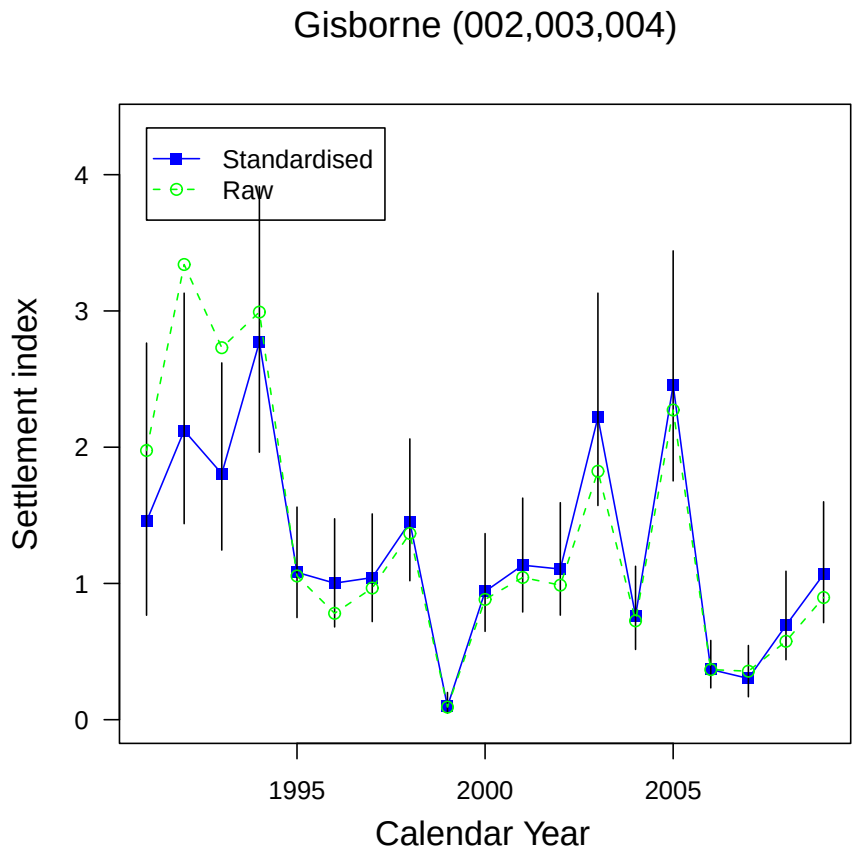

Figure 2: Gisborne–standardised and raw indices of annual settlement with 95% confidence intervals.

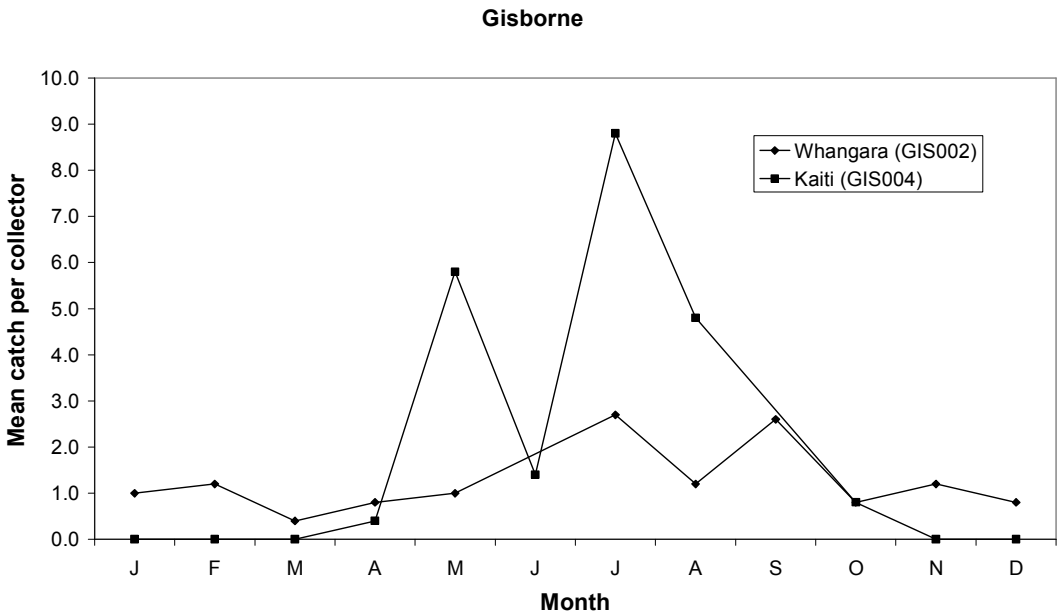

Figure 3: Whangara and Kaiti monthly settlement, 2009. Mean number of *Jasus edwardsii* pueruli + juveniles less than 14.5 mm carapace length per collector.

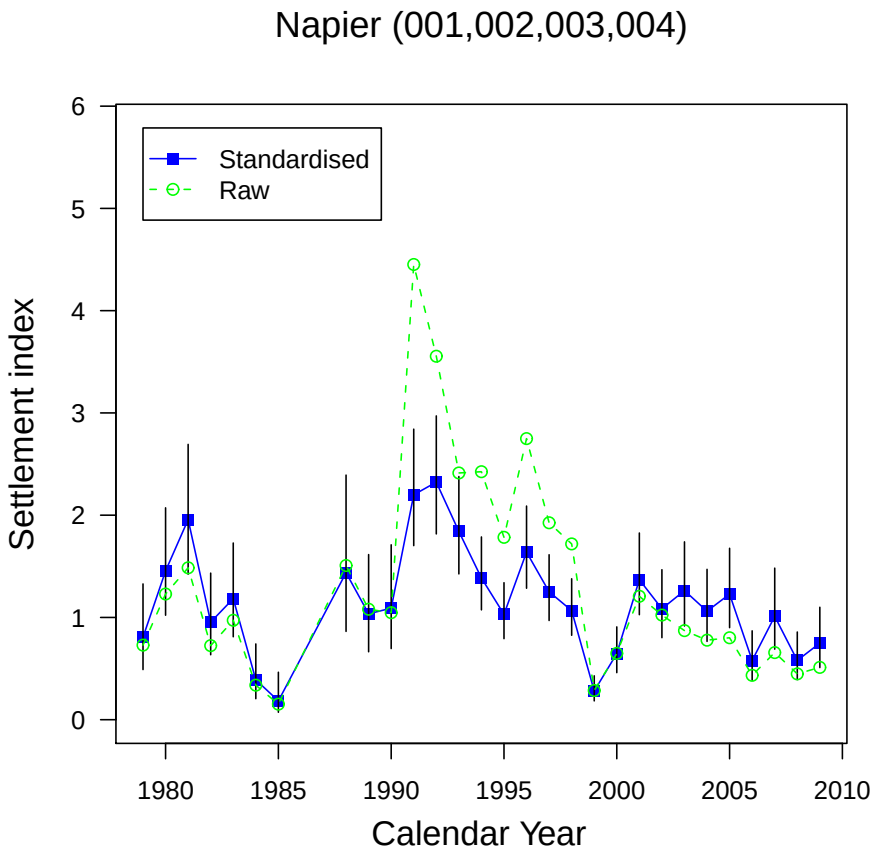

Figure 4: Napier—standardised and raw indices of annual settlement with 95% confidence intervals. Note that there were no checks in 1986–87.

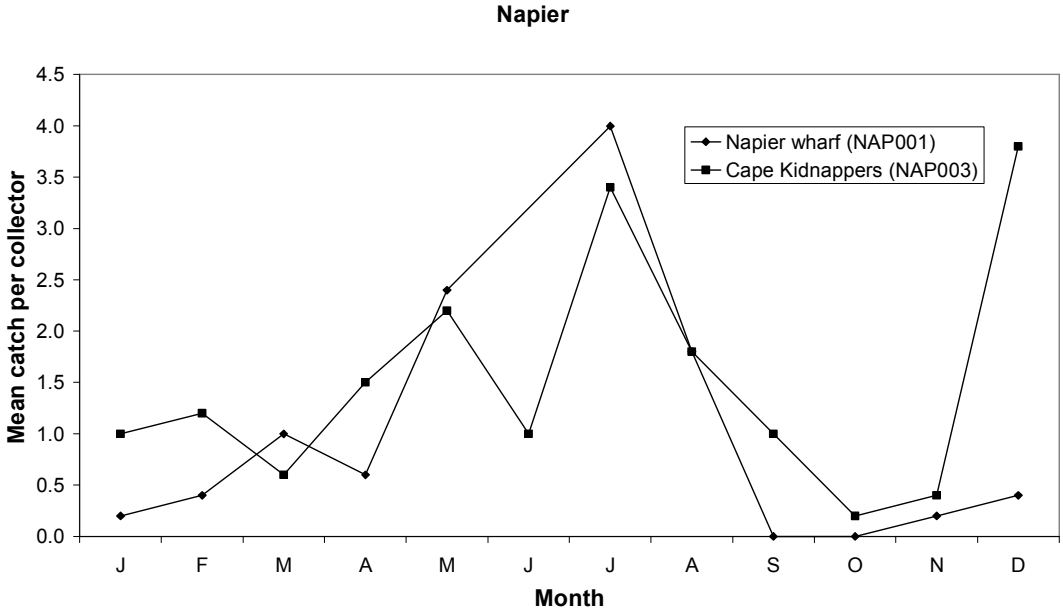

Figure 5: Napier wharf and Cape Kidnappers monthly settlement, 2009. Mean number of *Jasus edwardsii* pueruli + juveniles less than 14.5 mm carapace length per collector.

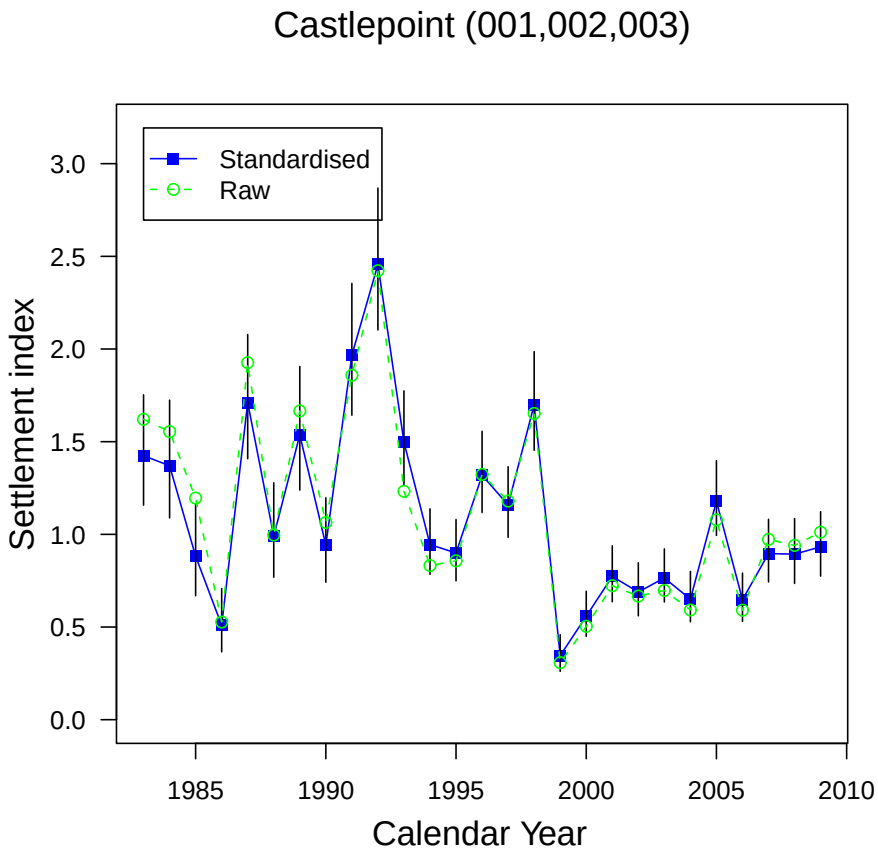

Figure 6: Castlepoint—standardised and raw indices of annual settlement with 95% confidence intervals.

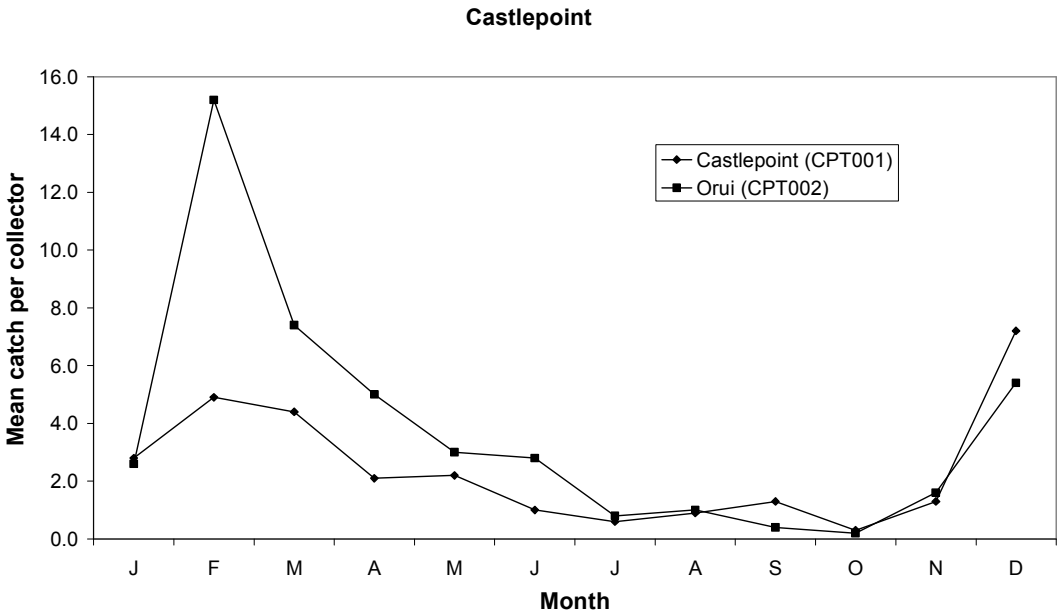

Figure 7: Castlepoint and Orui monthly settlement, 2009. Mean number of *Jasus edwardsii* pueruli + juveniles less than 14.5 mm carapace length per collector

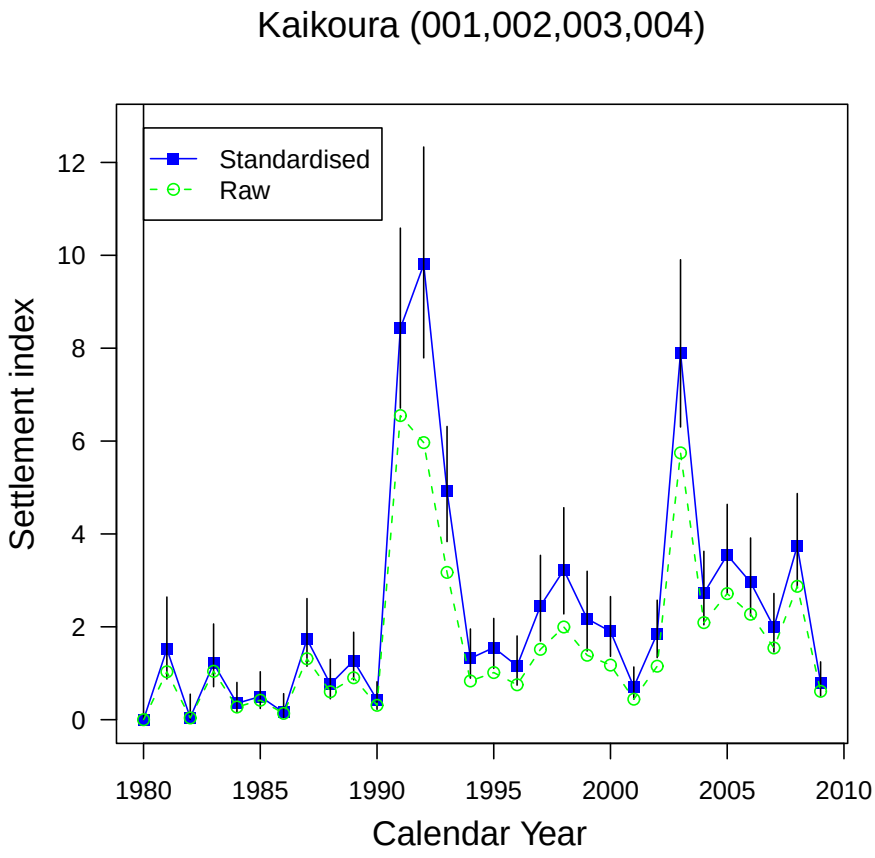

Figure 8: Kaikoura—standardised and raw indices of annual settlement with 95% confidence intervals.

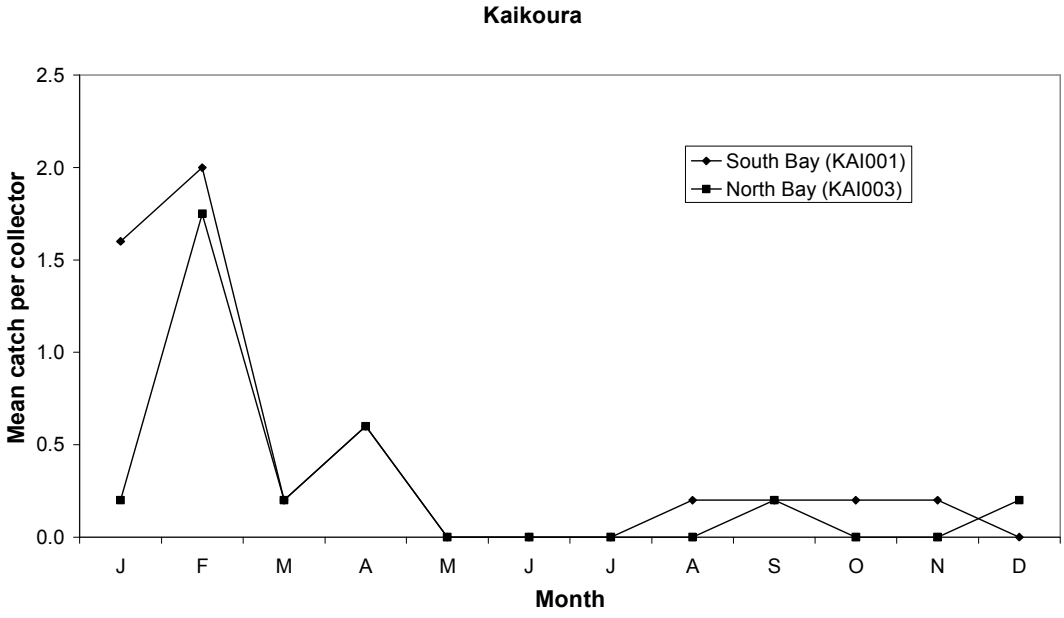

Figure 9: South Bay and North Bay monthly settlement, 2009. Mean number of *Jasus edwardsii* pueruli + juveniles less than 14.5 mm carapace length per collector.

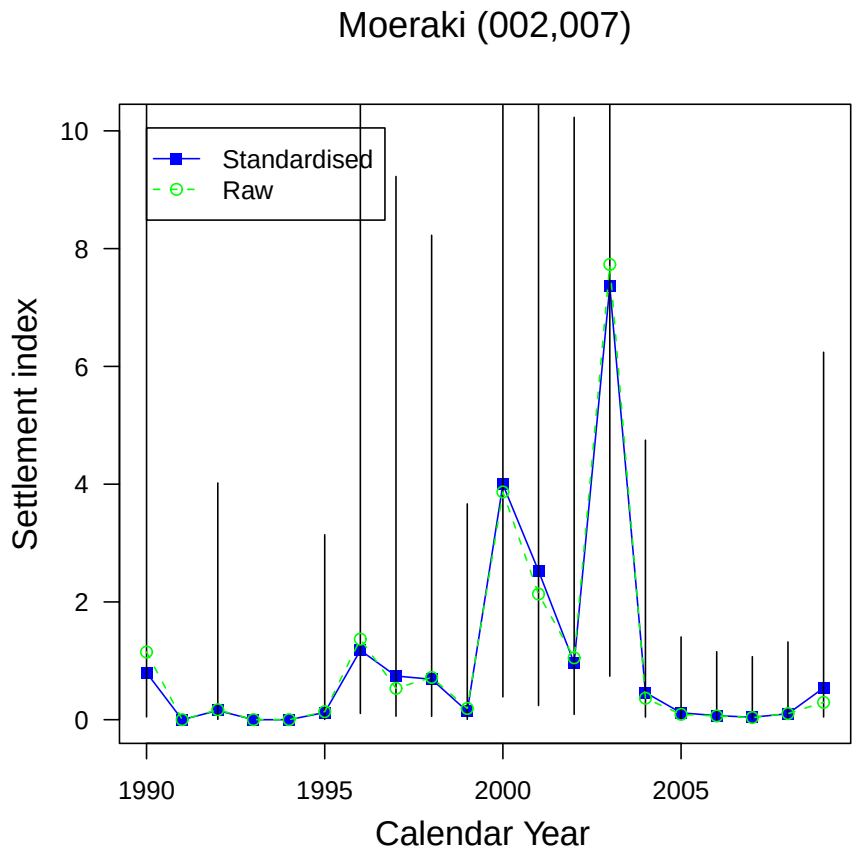

Figure 10: Moeraki—standardised and raw indices of annual settlement with 95% confidence intervals.

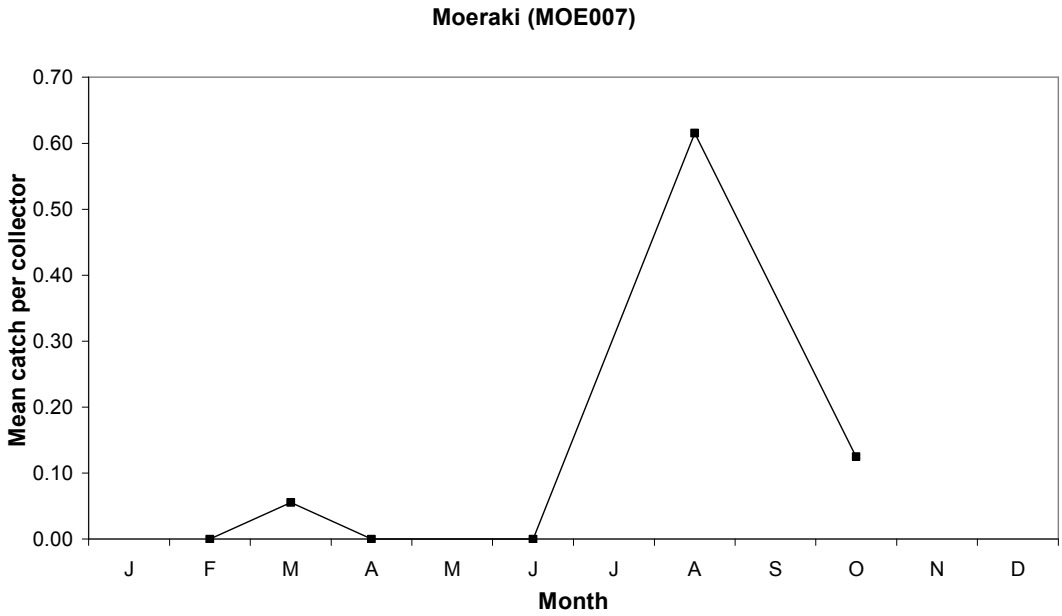

Figure 11: Moeraki monthly settlement, 2009. Mean number of *Jasus edwardsii* pueruli + juveniles less than 14.5 mm carapace length per collector.

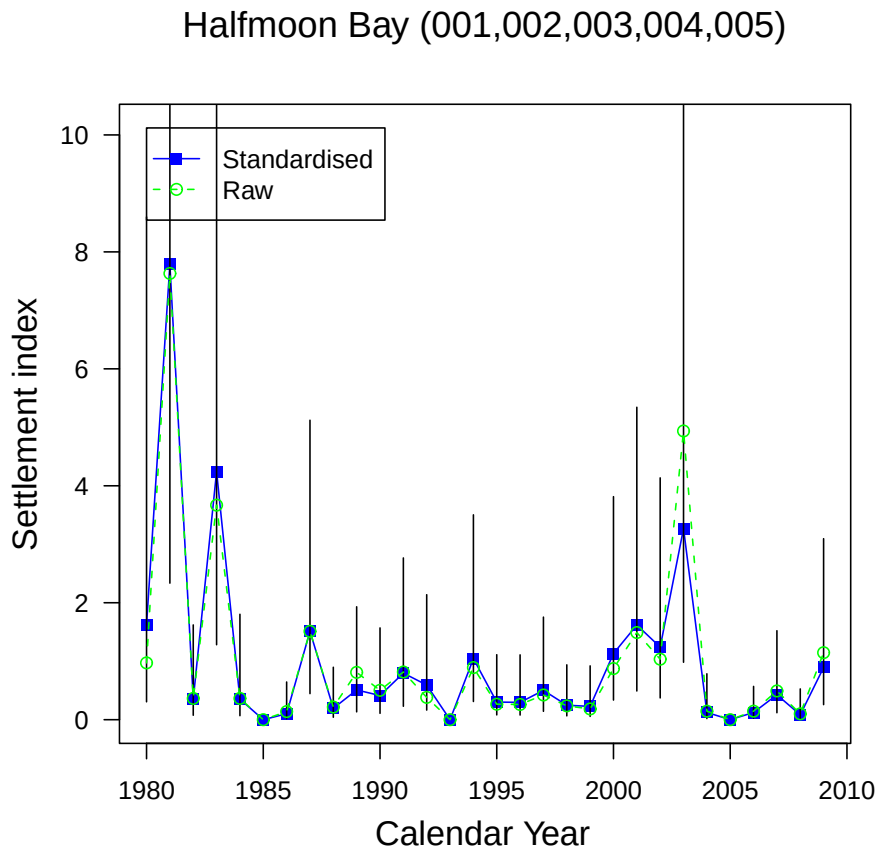

Figure 12: Halfmoon Bay—standardised and raw indices of annual settlement with 95% confidence intervals. The 95% confidence bounds were large because of high collector catch variability and the data not fitting the standardisation model well because of the large number of zero catches.

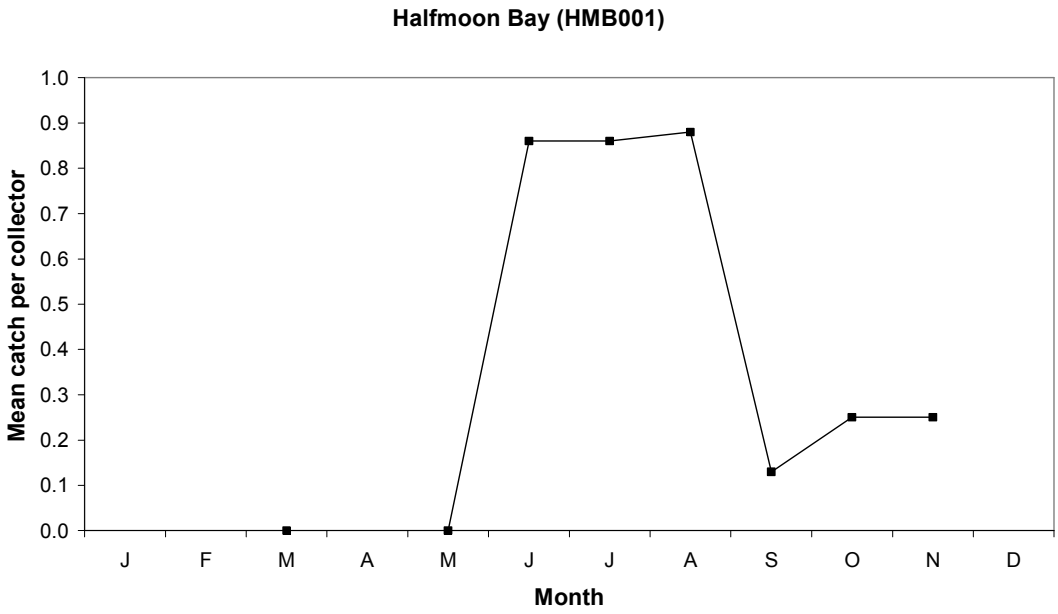

Figure 13: Halfmoon Bay monthly settlement, 2009. Mean number of *Jasus edwardsii* pueruli + juveniles less than 14.5 mm carapace length per collector.

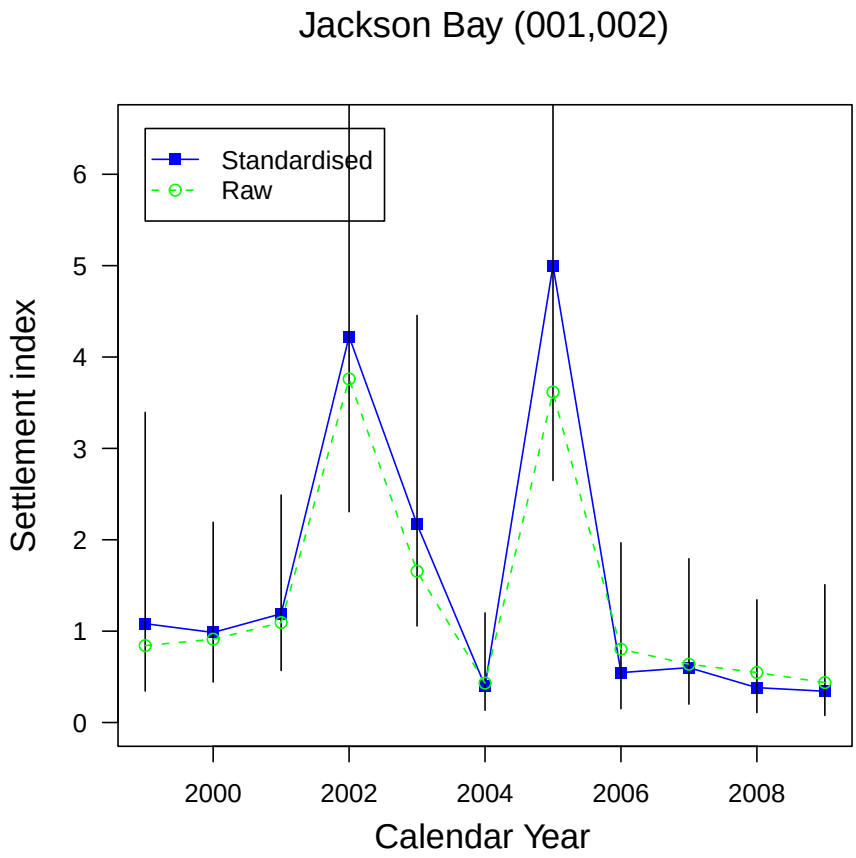

Figure 14: Jackson Bay—standardised and raw indices of annual settlement with 95% confidence intervals.

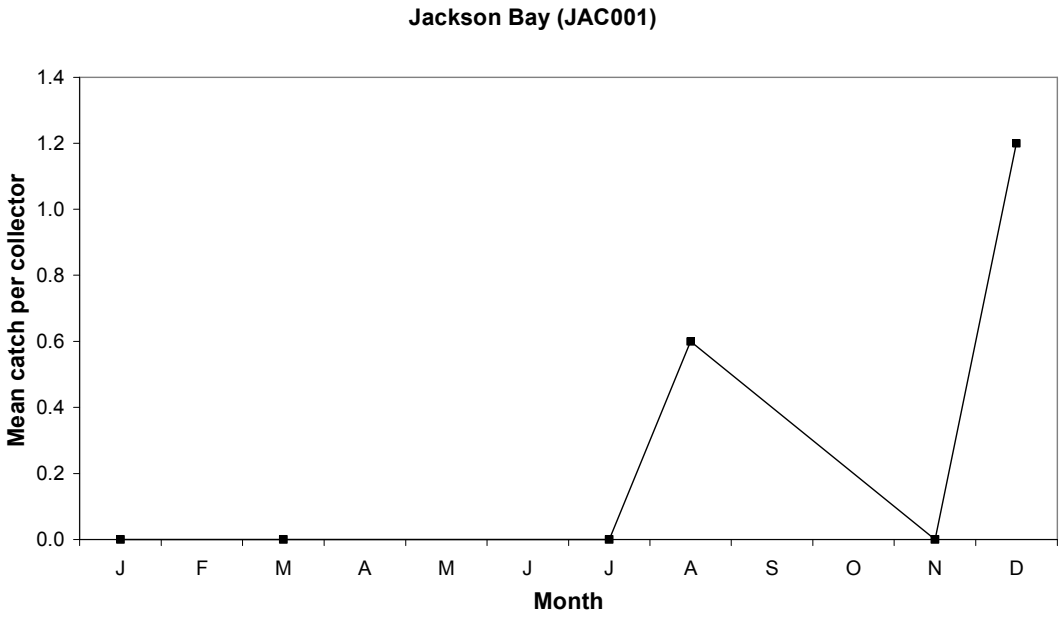

Figure 15: Raw monthly settlement, 2009. Mean number of *Jasus edwardsii* pueruli + juveniles less than 14.5 mm carapace length per collector

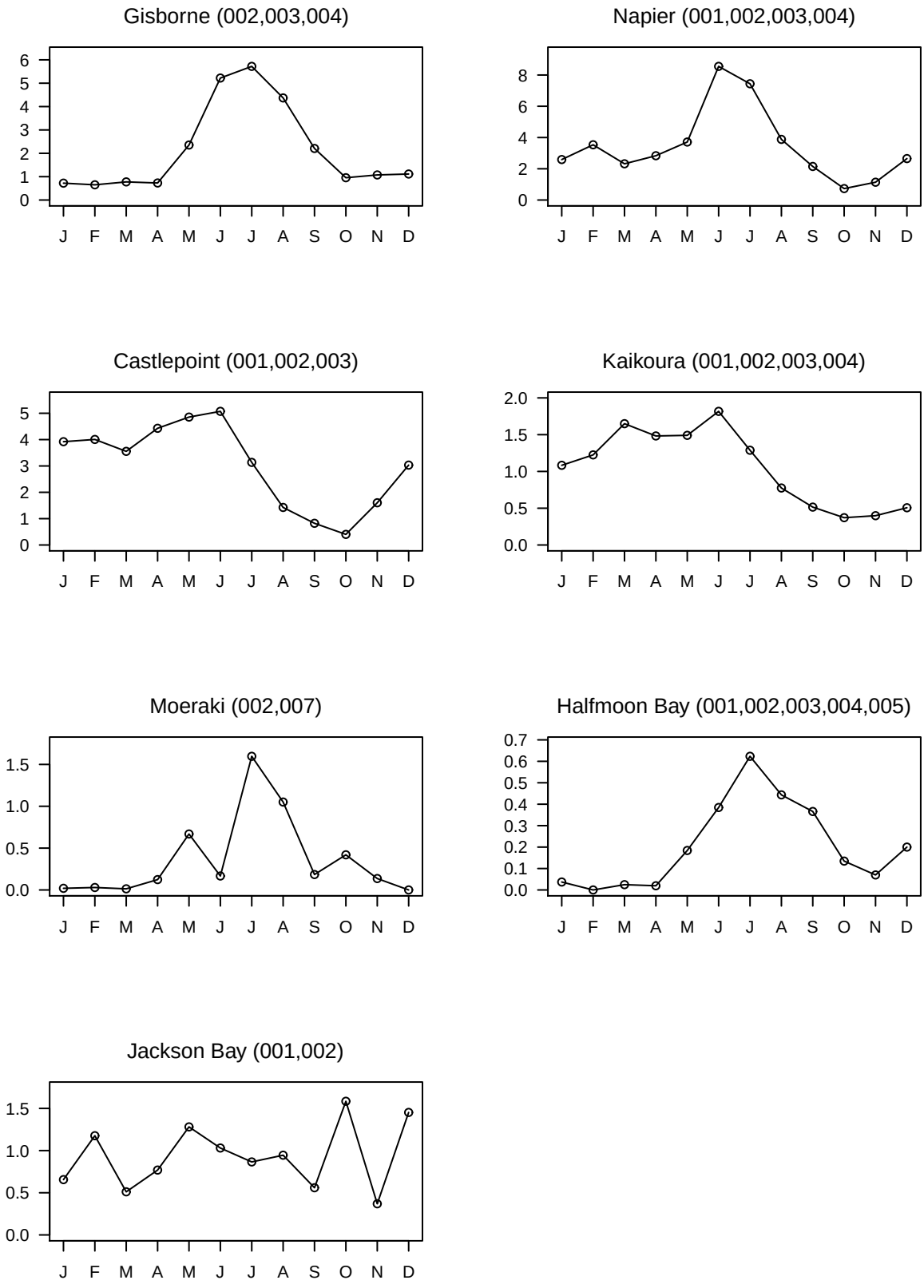

Figure 16: The mean settlement by month, over all years, for each key collector site. See Table 1 for the collector groups.

4. CONCLUSIONS

In 2009, low levels of puerulus settlement were recorded at Moeraki (CRA 7), Jackson Bay (CRA 8), Kaikoura (CRA5), and Napier (CRA4) and average settlement was recorded at Gisborne (CRA3), Castlepoint (CRA4), and Halfmoon Bay (CRA8).

After three years of very low settlement, Gisborne recorded average settlement in 2009. In the last 11 years, 2003 and 2005 are the only years where high settlement was recorded.

Unlike Gisborne, Napier and Castlepoint (CRA4) have missed out on exceptionally high settlement years. There has been a decadal shift from regular high levels of settlement in the 1990s to only average and below average settlement in the 2000s.

Kaikoura recorded its lowest level of settlement since 2001; however, the last seven years have been above average and in 2003 recorded settlement was exceptionally high.

Moeraki (CRA7) had slightly improved settlement from previous years but was still well below the long-term mean. Settlement in CRA7 has been below average for the last six years but was exceptionally high in 2003.

In Halfmoon Bay, after five years of very low settlement, recorded settlement in 2009 increased to a level close to the long-term mean. Very low levels of settlement continued for a fourth consecutive year in Jackson Bay.

5. ACKNOWLEDGMENTS

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