Assessment of fish populations in the Estuary of the Heathcote and Avon Rivers/Ihutai: 2015

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Cover: Yellow-eyed mullet (Aldrichetta forsteri) and common smelt (Retropinna retropinna) captured during beach seine sampling. [Chris Woods, NIWA]

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Executive summary

In November 2015, NIWA surveyed the fish community in the Estuary of the Heathcote and Avon Rivers/Ihutai. This was the seventh such survey conducted by NIWA since 2005. The first three (annual) surveys (2005–07) were commissioned by the Christchurch City Council (CCC) to characterise estuary fish populations before completion of CCC's Ocean Outfall Project (OOP), which diverted treated wastewater from the Christchurch Water Treatment Plant (CWTP) from the estuary to Pegasus Bay. The fourth survey, initiated in December 2010 and funded by NIWA, was motivated primarily by synergies with an on-going large-scale NIWA/University of Canterbury research study on estuarine processes, and by the September 2010 Darfield earthquake. Subsequently, CCC contracted NIWA to undertake a further three (biennial) fish surveys in 2011, 2013 and 2015. The 2015 survey reported here is the third of the post-OOP surveys, and the final in the survey programme.

Sampling equipment and protocols for the 2015 survey were the same as for all previous surveys. We completed 12 beach seine tows at stations evenly distributed along the eastern, western, and southern shorelines, and 13 trawl tows in the permanently watered main channels of the estuary. All sampling stations were in the vicinity of stations used in previous NIWA surveys.

Seventeen fish species were recorded in total, similar to previous surveys (15–16 species) with the sole exception of the 2010 survey (11 species). Catches were dominated by yellow-eyed mullet and common smelt, as in previous surveys, followed by yellow-belly flounder, sand flounder, inanga, triplefin and spotty. Beach seine catches of juvenile yellow-belly flounder (mostly small recruits ca. 2 cm in length at the Ponds North station) and inanga (recorded on the East shore for the first time) were the highest to date. Less common and intermittent species caught in 2015 included slender sprat, stargazers, globefish, common sole, kahawai and short-finned eels. Black flounder were caught for the first time in 2015, and globefish were recorded for the first time since the 2006 survey.

As in previous surveys, by far the highest population densities (adjusted for sampling effort) were for seine-caught yellow-eyed mullet and common smelt, which peaked at 300/1000 m^2 (average of 215/1000 m^2 across all stations) and 77/1000 m^2 (average of 63.9/1000 m^2 across all stations), respectively. Only one other species (yellow-belly flounder) was recorded at a density exceeding 10/1000 m^2 (22.5/1000 m^2 averaged across all seine stations, with a maximum of 57/1000 m^2 along the West shore). Four species (inanga, sand flounder, slender sprat and triplefin) exceeded 1/1000 m^2 when averaged across all stations. The maximum density for trawl-caught fish was 1.9/1000 m^2 for sand flounder in the Avon channel, with only this species, yellow-belly flounder and yellow-eyed mullet averaging more than 1/1000 m^2 across all stations.

Comparison of data from all seven NIWA surveys showed no clear evidence of large-scale changes in the fish community of the estuary as a result of either the CWTP OOP, or the disruption caused by the 2010–11 Canterbury earthquakes.

1 Introduction

The Estuary of the Heathcote and Avon Rivers/Ihutai[1] (EHARI) acts as a nursery area for many fish species, particularly the commercially exploited flounders, and provides an essential migration route for culturally valuable diadromous species, such as freshwater eels, lamprey, common smelt and brown trout, which spend different phases of their lifecycles in freshwater and the ocean (Webb, 1972, 1973, McDowall 1976, Eldon & Kelly 1992). As many as 34 fish species have been documented in EHARI (James 1999), although many of these are either rare residents (in terms of population numbers) or occasional visitors (e.g., Webb 1973). Common resident fish in EHARI include species such as: yellow-eyed mullet (*Aldrichetta forsteri*), common smelt (*Retropinna retropinna*), yellow-belly flounder (*Rhombosolea leporina*), sand flounder (*Rhombosolea plebeia*), inanga (*Galaxias maculatus*), triplefins (Tripterygiidae), spotty (*Notolabrus celidotus*), common sole (*Peltorhamphus novaezelandiae*) and common bully (*Gobiomorphus cotidianus*) (Webb 1966, 1972, Knox & Kilner 1973, Kilner 1974, Nairn 1998).

In pre-European times, EHARI was an important and highly valued mahinga kai source for South Island Māori on the east coast as it was rich with fish, shellfish and waterfowl (Harris 1992, Boyd 2010, Fisher & Vallance 2010). Fish utilised as mahinga kai included eels, lamprey, inanga and flounder (James 1999). Today, tangata whenua and recreational fishers still catch finfish species, such as yellow-eyed mullet, sea-run trout, sand and yellow-belly flounders, kahawai, red cod and rig in the estuary, although fishing for the latter three is restricted more to around the estuary mouth/Moncks Bay. Whitebaiting is practiced in the lower reaches of the inflowing Avon/Ōtākaro and Heathcote/Ōpāwaho rivers, mostly above the extent of saltwater influence (James 1999, Fisher & Vallance 2010). Although quantitative data are lacking, anecdotal evidence indicates declines in estuary stocks of some fished species, such as red cod, common sole, sand and yellow-belly flounder and kahawai, within living memory at least (James 1999, Fisher & Vallance 2010).

Significant pollution issues have been recognised since the 1860s within EHARI, largely associated with various wastewater inputs, industrialisation and urban development (Knox & Kilner 1973, Deely 1991, Bolton-Ritchie 2005, Boyd 2010). In 1962, the Bromley Sewage Purification Works (now referred to as the Christchurch Wastewater Treatment Plant (CWTP)), was developed to improve wastewater treatment before discharge to the estuary. By 1973, the Bromley plant was also handling most of Christchurch's industrial and domestic wastewater (Knox & Kilner 1973, Robb 1974, Deely 1991, Bolton-Ritchie 2005). The discharge of treated wastewater from the CWTP was the largest source of allochthonous nutrient enrichment, contributing up to 90% of the nitrogen (predominantly as ammonium) and 98% of the phosphorous input (Bolton-Ritchie 2005 and references therein). These significant nutrient inputs were associated with the seasonal proliferation of some macroalgal species (principally *Ulva* sp. and *Gracilaria chilensis*), followed by large amounts of nutrients released from decaying algal matter, causing some sediments to become anoxic and potentially affecting estuarine food chains (Bolton-Ritchie 2005).

In 2005, Christchurch City Council (CCC) commissioned NIWA to undertake a series of annual fish community surveys in EHARI. These were motivated by the need to monitor any changes in fish populations following completion of CCC's Ocean Outfall Project (OOP) for the CWTP, originally scheduled for completion in late 2008, which would see CWTP's tertiary-treated wastewater discharged directly to Pegasus Bay via a 3.2 km pipe off New Brighton rather than into the estuary.

[1] Estuary of the Heathcote and Avon Rivers/Ihutai is the official name for this estuary according to the New Zealand Gazetteer of place names: http://www.linz.govt.nz/regulatory/place-names/find-place-name/new-zealand-gazetteer-place-names

The study design envisaged two series of three surveys. The first series, conducted annually from November 2005 to 2007, sought to characterise the estuary and its fish communities before completion of the OOP (James 2006, 2007, Hawke 2008). The second series, intended to begin two years after completion of the OOP (i.e., November 2010) and to be conducted biennially, was expected to characterise the post-OOP communities. The OOP was not completed until March 2010, so the first follow-up survey was deferred until November 2011 to reinstate the planned, two-year interval before beginning the post-OOP surveys.

In November 2010, NIWA conducted an additional fish community survey of the estuary using the same methodology as for the three pre-OOP surveys (Unwin & Hawke 2011). This was motivated primarily by the potential for synergies with an on-going three-year, Ministry of Science and Innovation (MSI)-funded research study (Nitrogen Reduction and Estuarine Recovery (NRER), initiated in 2009), led jointly by the University of Canterbury and NIWA, and based in part on field and laboratory studies. A strong secondary motivation was the magnitude 7.1 Darfield earthquake on 4 September 2010, given its potential for one-off effects associated with increased pollution and sedimentation in the estuary. Subsequent significant earthquakes (i.e., February, June and December 2011) potentially also introduced a new and completely unanticipated dimension to the pre- and post-OOP survey programme.

This report presents the results of the third and final contracted post-OOP fish community survey conducted in November 2015, following the 2011 (Unwin & Hawke 2012) and 2013 (Woods et al. 2014) post-OOP (and post-earthquake) surveys. Here, we analyse the 2015 survey results and review the data from all seven surveys of the EHARI fish communities. The analysis specifically explores pre- and post-OOP changes, and any potential earthquake-related effects.

2 Methods

2.1 Study area

The Estuary of the Heathcote and Avon Rivers/Ihutai (EHARI) is an 880 ha embayment east of Christchurch city (Figure 2-1), where it forms the southernmost extension of Pegasus Bay immediately north of Banks Peninsula. Approximately triangular in shape, two vertices are formed by the inflowing Avon/Ōtākaro and Heathcote/Ōpāwaho rivers, with the third comprising the estuary's natural outlet into Pegasus Bay. The eastern shore is bounded by the low-lying South New Brighton sand spit, and the western shore by salt marshes on either side of the CWTP oxidation ponds. The south shore is steeper and in some places rocky. Permanent water is limited to two main upper channels formed by the inflowing rivers, which meet approximately 1.5–2 km from the estuary mouth to form a common lower channel. The remainder of the estuary comprises extensive tidal mudflats.

Figure 2-1: Location of the Estuary of the Heathcote and Avon Rivers/Ihutai.

2.2 Sampling equipment and methodologies

We used seining and trawling to target juvenile and adult/sub-adult populations of fish species, respectively. We used a seine to sample tidal mudflats on the incoming high tide (hereafter, referred to as beach seining), and trawling to sample deeper water in the permanent channels from low to mid tide. The trawl and beach seine sampling gear employed in November 2015 was the same as that used in the NIWA previous surveys (2005–07, 2010, 2011 and 2013). Our gear was also as similar as possible to that used in the comprehensive 1965–66 survey of estuary fish populations (Webb 1967, 1972)[2].

2.2.1 Beach seining

A total of 12 beach seine tows (Figure 2-2) were made at similar stations to previous surveys, representing the east shore (inland of the New Brighton spit), the west shore (between the Avon/Ōtākaro and Heathcote/Ōpāwaho rivers), and the south shore (Heathcote/Ōpāwaho River to Shag Rock) (Figure 2-3). We henceforth use the terms East, West, and South shore, to collectively identify each location group of beach seine stations. Seining was undertaken over ca. 2.5 h around high tide to catch juvenile fish moving from the channels over the shallow flats. Stations were fished to use the incoming tide as we worked up the estuary, maintaining similar tidal conditions for each station.

The 2015 beach seine sampling conducted at the Shag Rock station was compromised by strong along-beach tidal currents, and large amount of suspended and floating debris (i.e., drift wood and sticks), which restricted the spreading of the seine and threatened the field team's safety due to high net-loads. Only one paddle crab (*Ovalipes catharus*) was caught in this sample. We consider that this is generally not a safe station to sample using the beach seine on the incoming tide. It is safe to sample across the tidal flats at low (slack) tide using the beach seine, but sampling at this time may not give comparable results to the other stations sampled on the incoming tide.

Figure 2-2: Example of the running (left) and retrieval (right) of the beach seine during the 2015 Estuary of the Heathcote and Avon Rivers/Ihutai fish community survey.

[2] Note that the seine employed in the NIWA surveys had a smaller mesh size (9 mm stretched) than that used by Webb (1966, 1972) (6.35 cm stretched) in order to more effectively sample juvenile fish.

Figure 2-3: Beach seine stations fished during the 2015 Estuary of the Heathcote and Avon Rivers/Ihutai fish community survey. Map data: Google, DigitalGlobe.

2.2.2 Trawling

Trawling was undertaken as near as possible to low tide using a small research otter trawl (Model: Florida Flyer; Table 2-1, Figure 2-4). In practice, this meant starting fishing 1 hour before low tide when currents slackened, fishing through the turn of the tide, and continuing afterwards until the incoming tide was considered too advanced and channels became obscure. This gave a 3-h sampling window, allowing six to seven trawl tows per sampling day. Each trawl tow was around 10 min duration; a protocol established in previous surveys (James 2006).

Table 2-1: Specifications of the seine and trawl sampling gear used in the 2015 Estuary of the Heathcote and Avon Rivers/Ihutai fish community survey.

Variable	Seine	Trawl
Head-rope length (m)	N/A	7.3
Net length (m)	11	N/A
Cod-end length (m)	4	5.5
Net depth (m)	2.3	0.8
Effective fishing width (m)	9	6.0
Mesh (stretched) (mm)	9	50
Otter board area (m^2)	N/A	0.56
Towing ropes (m)	20	20 & 30
Distance covered per tow/haul (m)	37–193	178–572
Area covered per haul (m^2)	720–1 350	1 068–3 432
Boat length (m)	N/A	5.2
Outboard motor horsepower (hp)	N/A	90

Figure 2-4: Example of the deployment and running of the otter trawl net during the 2015 Estuary of the Heathcote and Avon Rivers/Ihutai fish community survey.

A total of 13 trawl tows were conducted, comprising four trawls each in the Avon and Heathcote channels and five in the Main channel (Figure 2-5). We henceforth use these terms (Avon, Heathcote, and Main channels) specifically to identify each location group of stations. Trawl stations were as close as practicable to those used in previous surveys.

Figure 2-5: Trawl stations fished during the 2015 Estuary of the Heathcote and Avon Rivers/Ihutai fish community survey. Map data: Google, DigitalGlobe.

2.3 Fish processing

Fish catches were processed as soon as practicable after each seine or trawl tow to ensure fish could be returned to the water alive where possible (Figure 2-6). A sub-sample (n = 100) from any large catch of any fish species (i.e., yellow-eyed mullet or common smelt) (usually from beach seine tows) was kept alive in buckets of water for later measuring of fish length[3], while the remainder were counted from the net directly back into the water. In all other cases, all fish were transferred to buckets of water for measuring and release.

[3] Either fish fork length or total length was measured, depending on which was most appropriate for each species (i.e., fork length for fish with a forked tail such as kahawai, yellow-eyed mullet and common smelt; total length for fish with a non-forked or convex tail such as flounder, stargazers and triplefin). Fork length measures from the tip of the longest jaw to the centre of the fork in the caudal fin. Total length measures the length from the tip of the longest jaw or the end of the snout to the longest caudal lobe.

Figure 2-6: Example of the processing of fish from beach seine sampling during the 2015 Estuary of the Heathcote and Avon Rivers/Ihutai fish community survey.

2.4 Data analysis of 2015 survey

Data from the 2015 fish community survey were added to the database established for the previous six surveys. For each species caught, we generated data summaries for relevant groupings of sampling method (seine or trawl) and sampling location, based on total numbers caught, mean length, and catch per unit effort (CPUE, number of fish/1000 m^2 ±1 standard error). Total numbers and abundance estimates for any sub-sampled catches were derived by extrapolation. For seine sampling, where sampling stations have been very consistent across the surveys, we present catches of the main fish species alongside catches from all the previous surveys for each station to allow comparison. For trawl sampling, where sampling station consistency between years was less accurate, we present catches of the main fish species alongside catches from all the previous surveys for location (estuary channels) to allow comparison. We generated basic cross-tabulations and data summaries using Microsoft-Excel™, and used the statistical program R (R Development Core Team 2011) for data manipulation, statistical analyses and graphical displays.

2.5 Summary analysis of all NIWA fish community surveys

In order to investigate changes in estuary fish community composition over time (2005–07, 2010, 2011, 2013 and 2015 surveys) and between sampling locations, we used the statistical ordination technique of non-metric multidimensional scaling (NMDS). NMDS is an iterative indirect gradient analysis tool that represents the similarities of communities in space as accurately as possible in as few dimensions as possible. NMDS uses a rank-based approach in which original dissimilarity of communities is substituted with ranks. Using ranks reduces some issues, such as sensitivity to transformation, and results in a more flexible analysis technique than non-rank approaches.

Seine and trawl data were analysed separately using the number of each species caught as the dependant variables. To avoid rare fish species having an undue influence on the results, species that were encountered in only one survey for either seining or trawling techniques were excluded from the analyses. For seine data, this resulted in the removal of black flounder (*Rhombosolea retiaria*, MPI species code BFL), globefish (*Contusus richiei*, GLB), slender stargazer (*Crapatalus angusticeps*, SLZ) and speckled sole (*Peltorhamphus latus*, SPS). For trawl data, ahuru (*Auchenoceros punctatus*, PCO) were removed.

Community composition data were transformed before analysis using the Hellinger transformation, which is recommended for use with species abundance data (Legendre & Gallagher 2001). Dissimilarity between the communities was calculated using the Bray-Curtis method. NMDS ordinations were run separately on seine and trawl data and plotted to visualise the community composition differences. We created three plots for each capture method, each using the same NMDS data, but with points colour coded by: 1) years, 2) years with additional ellipses showing 95% confidence intervals in the spread of data between stations for each year and, 3) sampling locations ('shores' for seine data and 'channels' for trawl data). The locations of species were also plotted on the sampling location graphs, with the location occurring near samples in which they were more abundant.

The influence of sampling year and sampling location (East, West or South shore for seine data; Main, Avon or Heathcote channels for trawl data) on community composition were tested using a multivariate permutational Analysis of Variance (adonis). The interaction between year and location was also tested for both seine and trawl data, as there were replicate stations within each location each year.

Significant results from the adonis tests can be caused either by differences in average community composition between years (or locations) or by differences in the variability of community composition between years (or locations). For example, two years (or locations) may have similar average community compositions across time, but the between-station variability may be high in one year and low in another. We tested whether this was the cause of any significant differences in community composition identified by the adonis test for year using a multivariate test of beta-dispersion (betadisper).

The community composition analyses were conducted using the package 'vegan' (Okansen et al. 2015) in the statistical program R (R Development Core Team 2011).

3 Results

3.1 Fish species diversity

Seventeen fish species were recorded during the 2015 survey, essentially the same as for all previous NIWA surveys (15–16 species) with the sole exception of 2010 (11 species; Table 3-1). Catches were dominated by yellow-eyed mullet and common smelt, as in all previous surveys, followed by yellow-belly flounder, sand flounder, inanga, triplefin, and spotty (Table 3-2 and Table 3-3). Estimated abundances for most species caught in 2015 were similar to those reported in previous years, albeit with some exceptions (see Section 3.2).

Other less-common and intermittent species caught in 2015 included slender sprat, stargazers, globefish, common sole, kahawai and short-finned eels. Species absent in 2015 but recorded in previous surveys were generally either rare species or species whose occurrence in the estuary was seasonally variable (e.g., Chinook salmon, giant bully).

The 2015 survey encountered one species, black flounder (*Rhombosolea retiaria*), which has not been recorded in previous NIWA surveys of EHARI.

3.2 Size, abundance and distribution

Length-frequency distributions for all fish measured for each of the 17 species caught from seine and trawl sampling during the 2015 survey are provided in Table 3-4, with discussion on the size, abundance and distribution for these species in the following subsections. Catch information is presented firstly for the four dominant fish species (yellow-eyed mullet, common smelt, yellow-belly flounder and sand flounder) which combined comprised 96.5% of the total number of fish caught, and secondarily for other more minor fish species. Species-specific contextual information from other pertinent studies is also given where appropriate.

Table 3-1: Fish taxa recorded from the Estuary of the Heathcote and Avon Rivers/Ihutai fish community surveys. Species are referred to by their common names throughout the text. Codes as used by the Ministry for Primary Industries (MPI) are included for each species. The 2015 results are shown in bold face and shaded column.

Common name	Scientific name	MPI code	2005	2006	2007	2010	2011	2013	2015
ahuru	*Auchenoceros punctatus*	PCO	-	-	-	-	-	Y	**-**
black flounder	*Rhombosolea retiaria*	BFL	-	-	-	-	-	-	**Y**
Chinook salmon	*Oncorhynchus tshawytscha*	SAM	-	Y	Y	-	-	-	**-**
clingfish	Gobiesocidae	CLI	Y	-	Y	-	Y	-	**Y**
common bully	*Gobiomorphus cotidianus*	GCO	-	-	-	-	Y	Y	**-**
common smelt	*Retropinna retropinna*	SME	Y	Y	Y	Y	Y	Y	**Y**
common sole	*Peltorhamphus novaezeelandiae*	ESO	Y	Y	Y	Y	Y	Y	**Y**
estuary stargazer	*Leptoscopus macropygus*	ESZ	Y	Y	Y	Y	-	Y	**Y**
giant bully	*Gobiomorphus gobioides*	GBU	Y	-	Y	-	Y	-	**-**
globefish	*Contusus richiei*	GLB	-	Y	-	-	-	-	**Y**
inanga	*Galaxias maculatus*	INA	-	-	Y	-	Y	Y	**Y**
kahawai	*Arripis trutta*	KAH	Y	Y	Y	-	Y	Y	**Y**
sand flounder	*Rhombosolea plebeia*	SFL	Y	Y	Y	Y	Y	Y	**Y**
short-finned eel	*Anguilla australis*	SFE	Y	Y	Y	Y	Y	Y	**Y**
slender sprat	*Sprattus antipodum*	SPA	Y	-	-	-	Y	Y	**Y**
slender stargazer	*Crapatalus angusticeps*	SLZ	-	Y	Y	Y	Y	Y	**Y**
speckled sole	*Peltorhamphus latus*	SPS	-	Y	-	-	-	-	**-**
spotted stargazer	*Genyagnus monopterygius*	SPZ	Y	Y	Y	Y	Y	Y	**Y**
spotty	*Notolabrus celidotus*	STY	Y	Y	Y	Y	Y	Y	**Y**
sprat	*Sprattus muelleri*	SPM	Y	Y	-	-	-	-	**-**
triplefin	Tripterygiidae	TRP	Y	Y	Y	Y	Y	Y	**Y**
yellow-belly flounder	*Rhombosolea leporina*	YBF	Y	Y	Y	Y	Y	Y	**Y**
yellow-eyed mullet	*Aldrichetta forsteri*	YEM	Y	Y	Y	Y	Y	Y	**Y**
Number of species		23	15	16	16	11	16	16	**17**

Table 3-2: Total number of individuals taken by seining and their mean length (cm, sub-sample of up to 100 fish from each seine tow) for all fish species caught in the Estuary of the Heathcote and Avon Rivers/Ihutai fish community surveys. The 2015 results are shown in bold face and shaded column.

	Total number							Mean length (cm)						
Species	**2005**	**2006**	**2007**	**2010**	**2011**	**2013**	**2015**	**2005**	**2006**	**2007**	**2010**	**2011**	**2013**	**2015**
ahuru														
black flounder							**1**							**5.0**
Chinook salmon		3	1						7.3	8.0				
clingfish														
common bully					5	7						3.2	3.4	
common smelt	1 564*	573	1 254*	1 211	1 030	1 117	**705**	6.8	6.9	7.4	6.4	6.9	7.7	**7.6**
common sole			12	7		6				4.7	4.6		6.5	
estuary stargazer														
giant bully														
globefish		207							2.0					
inanga			6		4	2	**34**			4.7		5.0	5.5	**5.4**
kahawai	2	12	12		2	7	**2**	6.0	6.1	5.6		11.5	7.0	**5.5**
sand flounder	130	137	180	147	170	16	**60**	4.3	3.9	5.2	3.9	4.8	5.9	**5.1**
short-finned eel		2	6	7		1	**2**		90.0	63.0	78.6		85.0	**94.5**
slender sprat	2				8	6	**17**	5.0				4.6	5.7	**5.9**
slender stargazer		1							15.0					
speckled sole		1							3.0					
spotted stargazer	3	4			2	1	**1**	9.7	7.8			6.0	11.0	**8.0**
spotty	2	5	1	11	30	18	**4**	6.0	6.2	13.0	5.5	5.6	5.9	**5.3**
sprat	3	101						5.3	7.1					
triplefin	28	27	10	54	82	150	**30**	5.2	5.2	6.3	5.4	5.8	5.7	**5.1**
yellow-belly flounder	79	29	49	150	99	41	**267**	8.4	11.8	6.9	4.4	4.5	6.0	**4.4**
yellow-eyed mullet	4 441*	2 307	4 702*	7 481	2 822	3 139	**2 433**	7.2	7.3	7.0	7.5	7.2	7.9	**7.7**

*Total number of fish (but not mean length) incorrectly reported for this species in the 2013 report.

Table 3-3: Total number of individuals taken by trawling and their mean length (cm, sub-sample of up to 100 fish from each trawl tow) for all fish species caught in the Estuary of the Heathcote and Avon Rivers/Ihutai fish community surveys. The 2015 results are shown in bold face and shaded column.

	Total number							Mean length (cm)						
Species	**2005**	**2006**	**2007**	**2010**	**2011**	**2013**	**2015**	**2005**	**2006**	**2007**	**2010**	**2011**	**2013**	**2015**
ahuru						1							13.0	
black flounder														
Chinook salmon														
clingfish	2		1		1		**1**	2.5		3.0		2.0		**5.0**
common bully														
common smelt														
common sole	1	6	4	4	3	4	**2**	41.0	27.8	19.3	9.3	21.3	23.8	**10.0**
estuary stargazer	6	1	1	2		1	**1**	17.5	16.0	33.0	15.0		22.0	**12.0**
giant bully	2		1		1			12.5		13.0		15.0		
globefish							**8**							**9.3**
inanga														
kahawai			3		1	4				17.3		15.0	16.8	
sand flounder	23	16	18	12	48	11	**15**	10.4	11.0	13.6	8.8	10.5	25.8	**8.9**
short-finned eel	4	1	4	2	2	1		75.5	75.0	88.0	83.5	92.5	85.0	
slender sprat														
slender stargazer		1	1	1	1	1	**5**		26.0	27.0	25.0	14.0	19.0	**18.8**
speckled sole														
spotted stargazer	7	9	13	6	3	8	**3**	14.9	19.8	25.4	16.7	15.7	18.4	**15.0**
spotty	18	17	20	21	13	18	**17**	13.4	16.0	16.6	15.1	15.7	17.4	**10.9**
sprat														
triplefin	1				4		**1**	7.0				6.8		**8.0**
yellow-belly flounder	41	34	35	9	38	38	**20**	31.2	34.1	27.9	30.4	27.3	34.6	**30.6**
yellow-eyed mullet	13	37	39	18	24	48	**27**	22.2	19.4	19.3	19.8	18.3	21.2	**19.8**

Table 3-4: Length-frequency distribution for all fish species caught in the 2015 Estuary of the Heathcote and Avon Rivers/Ihutai fish community survey. Totals indicate the number of fish actually measured, rather than the total catches, as in Tables 3.2 and 3.3. S, results for seine sampled population; t, results for trawl sampled population.

Fish length (cm)	black flounder	clingfish	common smelt	common sole	estuary stargazer	globefish	inanga	kahawai	sand flounder (s)	sand flounder (t)	short-finned eel	slender sprat	slender stargazer	spotted stargazer (s)	spotted stargazer (t)	spotty (s)	spotty (t)	triplefin (s)	triplefin (t)	yellow-belly flounder (s)	yellow-belly flounder (t)	yellow-eyed mullet (s)	yellow-eyed mullet (t)
2	-	-	-	-	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-	94	-	-	-
3	-	-	1	-	-	-	-	-	7	-	-	-	-	-	-	-	-	-	-	22	-	-	-
4	-	-	-	-	-	-	-	-	10	-	-	-	-	-	-	-	3	5	-	4	-	-	-
5	1	1	2	-	-	-	21	1	11	-	-	4	-	-	-	3	2	17	-	15	-	82	-
6	-	-	64	-	-	-	12	1	21	-	-	10	-	-	-	1	3	8	-	8	-	282	-
7	-	-	208	-	-	1	1	-	4	3	-	3	-	-	-	-	-	-	-	6	-	256	-
8	-	-	172	-	-	1	-	-	1	4	-	-	-	1	-	-	1	-	1	1	-	104	-
9	-	-	86	-	-	2	-	-	2	5	-	-	-	-	-	-	-	-	-	1	1	20	-
10	-	-	14	2	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	17	-
11	-	-	2	-	-	1	-	-	-	1	-	-	-	-	1	-	-	-	-	-	-	34	1
12	-	-	2	-	1	-	-	-	-	1	-	-	-	-	-	-	1	-	-	-	-	58	-
13	-	-	1	-	-	-	-	-	-	1	-	-	-	-	-	-	1	-	-	-	-	48	-
14	-	-	2	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	8	-
15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	2	-
16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-
17	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	2	-	-	-	-	7	3
18	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	2	-	-	-	-	2	3
19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	1	5
20	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1	-	-	-	-	-	-	1	3
21	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	7
22	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	1	-	-	-	-	1	2
23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	2
24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-
25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-
26	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
27	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
29	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
30	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-
31	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-
32	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-
36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
38	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	3	-	-
39	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
40	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
41	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-
42	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
43	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
44	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-
94	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
95	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
Total	1	1	554	2	1	8	34	2	60	15	2	17	5	1	3	4	17	30	1	160	20	925	27

3.2.1 Yellow-eyed mullet

Yellow-eyed mullet (Figure 3-1) was the most commonly caught species in the 2015 survey, accounting for 2,460 (67.3%) of the total 3,656 fish caught (beach seine and trawl sampling combined; Table 3-2 and Table 3-3). Seine-caught yellow-eyed mullet (2,433 fish; 5–22 cm in length) were predominantly juveniles (<15 cm in length, Webb 1972), with some sub-adult/adult fish, and their abundance was similar to that recorded in all previous surveys, except 2010, when catches were 2–3 times higher than in any other year. Juveniles of this schooling species become resident at ca. 2 cm in length and are found in sheltered harbours, estuaries and river mouths (Trnski 2015). Catches were highest along the West shore, particularly at the Ponds South station (1,044 fish). Overall, the species was widely distributed throughout the estuary, being caught at 11 of the 12 beach seine sampling stations (Table 3-5) (potentially present at the Shag Rock station; see Section 2.2.1). Juvenile yellow-eyed mullet sizes were similar between stations and between survey years (Table 3-5). As a highly mobile species, Webb (1972) observed that yellow-eyed mullet distribution in the estuary is complex and shows strong tidal and seasonal differences.

Sub-adult/adult yellow-eyed mullet (27 fish; 11–26 cm in length) were most commonly caught by trawling (juveniles start venturing into deeper water when >13 cm in length, Webb 1972), and comparable in numbers and sizes to those caught in previous surveys (aside from the peak in the 2013 survey when 48 fish were caught in trawls) (Table 3-6). Sub-adults/adults were caught in the Avon and Main channels (10 and 17 fish, respectively), with none caught in the Heathcote channel (where only 1–5 fish have been caught in previous surveys).

Figure 3-1: Yellow-eyed mullet (*Aldrichetta forsteri*) caught during the 2015 Estuary of the Heathcote and Avon Rivers/Ihutai fish community survey.

Table 3-5: Abundance and mean length (cm) of yellow-eyed mullet (*Aldrichetta forsteri*) caught by seining in the Estuary of the Heathcote and Avon Rivers/Ihutai fish community surveys. Within each area, stations are in order of increasing distance from the sea. The 2015 results are shown in the shaded column.

Location	Station	2005	2006	2007	2010	2011	2013	2015	Total
East shore	Tern Street	5 (6.0)	185 (7.6)	112 (5.6)	269 (6.8)	15 (5.7)	356 (8.6)	124 (6.3)	1 066 (7.1)
	Penguin Street	221 (6.6)	34 (6.7)	164 (5.6)	1 399 (6.9)	367 (7.4)	208 (8.3)	223 (6.8)	2 616 (7.0)
	Ebbtide Street	103 (6.3)	429 (7.5)	238 (6.2)	1 442 (6.9)	110 (6.9)	39 (8.6)	294 (7.9)	2 655 (7.2)
	Pleasant Point	39 (6.5)	383 (6.4)	650 (6.2)	1 290 (6.8)	85 (6.8)	102 (6.2)	87 (8.8)	2 636 (6.7)
Total, East shore		**368 (6.5)**	**1 031 (7.2)**	**1 164 (5.9)**	**4 400 (6.8)**	**577 (7.0)**	**705 (7.9)**	**728 (7.4)**	**8 973 (7.0)**
South shore	Shag Rock	799 (9.1)	24 (8.7)	308 (7.9)	42 (6.7)	8 (6.0)	57 (6.7)	-	1 238 (8.0)
	Redcliffs Park	294 (6.5)	272 (7.3)	188 (8.1)	1 191 (8.2)	397 (7.8)	373 (8.7)	155 (6.5)	2 870 (7.5)
	Causeway	65 (6.8)	30 (12.5)	7 (16.6)	1 (9.0)	-	16 (16.6)	113 (7.3)	232 (8.8)
	Mt Pleasant	331 (7.9)*	56 (8.6)	81 (9.7)	93 (8.5)	8 (9.1)	107 (7.6)	59 (10.3)	735 (8.3)
Total, South shore		**1 489 (7.7)**	**382 (8.1)**	**584 (8.7)**	**1 327 (7.9)**	**413 (7.8)**	**553 (8.3)**	**327 (7.7)**	**5 075 (8.0)**
West shore	Windsurfing	146 (5.3)*	80 (6.8)	390 (6.6)	978 (9.1)	418 (9.)	62 (6.3)	33 (7.8)	2 107 (7.4)
	Ponds South	172 (6.8)*	424 (7.1)	735 (6.2)	575 (6.8)	200 (6.2)	93 (7.4)	1 044 (7.2)	3 243 (6.9)
	Ponds Middle	2 043 (6.3)*	274 (6.8)	432 (8.2)	136 (7.0)	942 (6.6)	1 090 (7.9)	256 (9.9)	5 173 (7.6)
	Ponds North	223 (6.4)	116 (7.3)	1 397 (7.6)*	65 (9.8)	272 (6.6)	636 (7.8)	45 (7.1)	2 754 (7.4)
Total, West shore		**2 584 (6.2)**	**894 (7.0)**	**2 954 (7.1)**	**1 754 (8.1)**	**1 832 (7.1)**	**1 881 (7.5)**	**1 378 (8.3)**	**13 277 (7.3)**
Total, all locations		**4 441 (7.2)**	**2 307 (7.3)**	**4 702 (7.0)**	**7 481 (7.5)**	**2 822 (7.2)**	**3 139 (7.9)**	**2 433 (7.7)**	**27 325 (7.4)**

*Station-specific number of fish (but not mean length) incorrectly reported in this species-specific table in the 2013 report. Table sub-total and total fish counts have been adjusted accordingly.

Table 3-6: Abundance and mean length (cm) of yellow-eyed mullet (*Aldrichetta forsteri*) caught by trawling in the Estuary of the Heathcote and Avon Rivers/Ihutai fish community surveys. The 2015 results are shown in the shaded column.

Location	2005	2006	2007	2010	2011	2013	2015	Total
Main channel	12 (22.1)	11 (20.8)	32 (18.9)	2 (20.5)	11 (18.9)	26 (21.4)	17 (19.9)	111 (20.2)
Avon channel	-	15 (17.8)	6 (21.2)	15 (19.7)	12 (17.8)	17 (21.6)	10 (19.5)	75 (19.5)
Heathcote channel	1 (23.0)	11 (20.3)	1 (21.0)	1 (19.0)	1 (18.0)	5 (18.6)	-	20 (19.9)
Total, all locations	**13 (22.2)**	**37 (19.4)**	**39 (19.3)**	**18 (19.8)**	**24 (18.3)**	**48 (21.2)**	**27 (19.8)**	**206 (19.9)**

3.2.2 Common smelt

Common smelt (total catch 705 fish; 3–14 cm in length) (Figure 3-2) was the second most abundant species, accounting for 19.3% of the total catch. The 2015 total catch was lower than in previous surveys, apart from the 2006 survey when 576 fish were caught. As with yellow-eyed mullet, common smelt were well distributed throughout the estuary, being caught at 11 of the 12 beach seine sampling stations (Table 3-7) (no catch at the Shag Rock station; see Section 2.2.1). Catches of common smelt and yellow-eyed mullet were usually positively correlated. For the first time since the 2006 survey, common smelt were caught at the Causeway station. On the East shore, common smelt abundance increased markedly with increasing distance inland and increasing freshwater influence, with the highest catch taken at the uppermost (i.e., furthest inland) station (87% of the East shore catch). Catches at the West and South shore stations did not exhibit such a clear association with freshwater input. Common smelt sizes were generally similar between stations and between surveys, apart from a smaller mean size of a small number of fish caught on the East shore in 2010 (Table 3-7). McDowall and Stewart (2015) noted that common smelt usually prefer still or slow-flowing waters, and may return to freshwater habitats from their larval stage at sea at around 5 cm in length or spend nearly their entire lives at sea and return only as adults. Webb (1972) did not record the abundance/distribution of common smelt throughout the estuary (only one smelt was caught), but this is probably a reflection of the larger mesh net used (6.35 cm stretched mesh herring net cf. our 9 mm stretched mesh beach seine). No smelt have ever been caught in the larger-meshed trawl net used in the NIWA surveys.

Figure 3-2: Common smelt (*Retropinna retropinna*) caught during the 2015 Estuary of the Heathcote and Avon Rivers/Ihutai fish community survey.

Table 3-7: Abundance and mean length (cm) of common smelt (*Retropinna retropinna*) caught by seining in the Estuary of the Heathcote and Avon Rivers/Ihutai fish community surveys. Within each location, stations are in order of increasing distance from the sea. The 2015 results are shown in the shaded column.

Location	Station	2005	2006	2007	2010	2011	2013	2015	Total
East shore	Tern Street	-	4 (6.5)	8 (5.9)	-	1 (6.0)	16 (8.3)	3 (9.0)	32 (7.5)
	Penguin Street	52 (7.7)	-	1 (7.0)	8 (5.9)	6 (7.0)	28 (8.1)	9 (8.2)	104 (7.7)
	Ebbtide Street	49 (6.4)	20 (6.6)	5 (6.8)	3 (7.3)	6 (7.8)	34 (8.1)	20 (7.9)	137 (7.2)
	Pleasant Point	34 (6.6)	66 (6.5)	24 (6.9)	15 (6.3)	192 (6.7)	178 (7.7)	219 (7.3)	728 (7.0)
Total, East shore		**135 (6.9)**	**90 (6.5)**	**38 (6.7)**	**26 (6.3)**	**205 (6.8)**	**256 (7.9)**	**251 (7.5)**	**1 001 (7.2)**
South shore	Shag Rock	-	3 (6.3)	12 (7.4)	-	12 (6.7)	5 (8.2)	-	29 (7.2)
	Redcliffs Park	-	8 (8.6)	39 (7.6)	2 (6.5)	11 (6.6)	17 (8.5)	110 (7.6)	187 (7.7)
	Causeway	10 (7.0)	1 (8.0)	-	-	-	-	21 (8.6)	32 (8.1)
	Mt Pleasant	5 (5.8)*	13 (6.8)	4 (8.5)	8 (3.9)	300 (7.4)	202 (7.7)	7 (8.0)	549 (7.3)
Total, South shore		**15 (6.6)**	**25 (7.5)**	**55 (7.6)**	**10 (4.4)**	**323 (7.2)**	**224 (7.8)**	**138 (7.8)**	**790 (7.5)**
West shore	Windsurfing	93 (6.4)*	25 (7.4)	96 (6.8)	1 070 (6.4)	280 (6.6)	80 (7.1)	11 (7.7)	1 616 (6.7)
	Ponds South	218 (6.9)*	65 (7.0)	1 (10.0)	45 (6.8)	7 (7.0)	41 (8.8)	97 (8.1)	334 (7.5)
	Ponds Middle	1 026 (6.9)*	327 (7.0)	900 (8.9)	31 (6.8)	166 (6.9)	79 (8.0)	122 (7.6)	1 705 (7.5)
	Ponds North	77 (6.6)	44 (6.7)	164 (6.9)*	29 (6.2)	49 (6.5)	437 (7.3)	86 (7.1)	886 (6.9)
Total, West shore		**1 414 (6.7)**	**461 (7.0)**	**1 161 (7.5)**	**1 175 (6.5)**	**502 (6.7)**	**637 (7.6)**	**316 (7.6)**	**5 666 (7.2)**
Total, all locations		**1 564 (6.8)**	**576 (6.9)**	**1 254 (7.4)**	**1 211 (6.4)**	**1 030 (6.9)**	**1 117 (7.7)**	**705 (7.6)**	**7 457 (7.2)**

*Station-specific number of fish (but not mean length) incorrectly reported in this species-specific table in the 2013 report. Table sub-total and total fish counts have been adjusted accordingly.

3.2.3 Sand flounder and yellow-belly flounder

Sand flounder (total catch 75 fish; 2–13 cm in length) (Figure 3-3) accounted for 2.1% of the total catch. Juvenile (i.e., seine-caught) sand flounder (60 fish; 2–9 cm in length) were relatively lower in number compared to previous surveys (130–180 for 2005–11), but higher than the low of 16 fish caught in the 2013 survey (Table 3-2). Mean length for seine-caught sand flounder (5.1 cm) is consistent with previous surveys (3.9–5.9 cm; Figure 3-5; Table 3-8). Seine-caught sand flounder were well distributed throughout the estuary, but most were taken along the East (21 fish) and West (32 fish) shores, with only seven fish taken on the South shore (Table 3-8). Kilner (1974) found that juvenile sand flounder recruited to EHARI around October to December and were more abundant in the middle reaches compared to nearer the estuary mouth or upper reaches. Kilner (1974) conducted movement studies on age 0+ (yr) (<12 cm in length) sand flounders and suggested that, although they can move up to 350 m from the channels onto the mudflats with each rising tide, they appear to remain close to the location where they settled as metamorphosing larvae, with progressive movement towards the channels and estuary mouth as they approach age 1+ (yr). Kilner (1974) also found that age 0+ (yr) sand flounder were negatively affected by salinities <4 ppt, with very small fish more affected than larger 0+ (yr) fish. This correlated with field distribution; very small fish were found in streams and pools where salinity remained high (>21 ppt), and larger fish in the channel where salinity dropped to 5 ppt at low tide.

Catches of sub-adult (i.e., trawl-caught) sand flounder (15 fish; 7–13 cm in length) are consistent with catches of adults/sub-adults in all previous years, except 2011 (2005–10: 12–23; 2011: 48; Table 3-3). No large adult sand flounder (i.e., >20 cm in length) were recorded (Figure 3-5), which was also the case in 2010. Mean length was 8.9 cm, consistent with most other surveys where mean lengths ranged from 8.8 to 13.6 cm and very few individuals exceeding 20 cm in length (Figure 3-5), apart from the 2013 survey (mean fish length of 25.8 cm) when several very large fish were caught. Most were caught in the Avon channel (10 fish), with four and one fish caught in the Heathcote and Main channels, respectively (Table 3-9). Webb (1972) found larger sand flounder in all three channels, but with greater numbers at Moncks Bay in the Main channel (numbers apparently depending on the previous year's breeding success, the intensity of commercial fishing at sea, and the amount of amateur fishing in the estuary).

Yellow-belly flounder (total catch 287 fish; 2–44 cm in length) (Figure 3-3) accounted for 7.9% of the total catch. Total seine-caught yellow-belly flounder catch (267 fish; 2–44 cm in length) was the highest of all the surveys to date (29–150 fish previously; Table 3-2). This is the result of an unusually large catch at the Ponds North station (207 fish; 2–44 cm in length; 77.5% of total seine catch), the majority of which were juveniles ca. 2 cm in length. Mean length for seine-caught yellow-belly flounder (4.4 cm in length) is consistent with that for previous seasons, but, as in 2005, 2006, 2013 and 2015 surveys, mean length estimates for this species were partly confounded by the presence of a small number of large adults (Figure 3-5). Excluding these larger fish (seven fish ranging from 23 to 44 cm in length, taken along the West and South shores) resulted in a small mean length of 3.1 cm; a reflection of the large numbers of very small juvenile recruits caught in this survey (Figure 3-5). Given the large number of juveniles ca. 2 cm in length at the Ponds North station, it is likely that the catch here was yet under-represented as even smaller recruits may not have been captured by the seine mesh (see Figure 3-4). Munroe (2015) stated that juvenile yellow-belly flounder recruit to shallow-water nurseries in July–December (varies with location). Seine-caught yellow-belly flounder were well distributed throughout the estuary, but most were taken along the West (237 fish) shore, followed by East (16 fish) and South (14) shores (Table 3-10).

Sub-adult/adult yellow-belly flounder (i.e., trawl caught) (20 fish; 9–43 cm in length) were less abundant compared to the previous surveys (total catch 34–41), with only the 2010 survey (nine fish) having a lower catch (Table 3-3). Mean length of sub-adult/adult yellow-belly flounder (30.6 cm) is consistent with previous surveys (27.3–34.6 cm; Table 3-11; Figure 3-5), but, like the 2010 survey, there was no strong cohort of >30 cm length fish. Although catches were too sparse to provide robust comparisons between the three channels, for the first time, the most trawl-caught yellow-belly flounder came from the Avon channel (10 fish, compared to seven from the Heathcote channel and three from the Main channel) (Table 3-11). This contrasts with results from 1965–66, when yellow-belly flounder at Moncks Bay were larger and more abundant than in the river channels; Webb (1972) attributed this to their lower tolerance to riverine pollution.

Webb (1972) found that, for both commercially important flounder species, the numbers of larger fish within the estuary decreased in summer and increased in winter, and the distribution of adults within the estuary changed associated with migratory breeding behaviour.

Figure 3-3: Sand (*Rhombosolea plebeia*) and yellow-belly (*Rhombosolea leporina*) flounder caught during the 2015 Estuary of the Heathcote and Avon Rivers/Ihutai fish community survey.

Figure 3-4: Juvenile yellow-belly founder (*Rhombosolea leporina*) ca. 2 cm in length compared with beach seine net mesh (9 mm stretched).

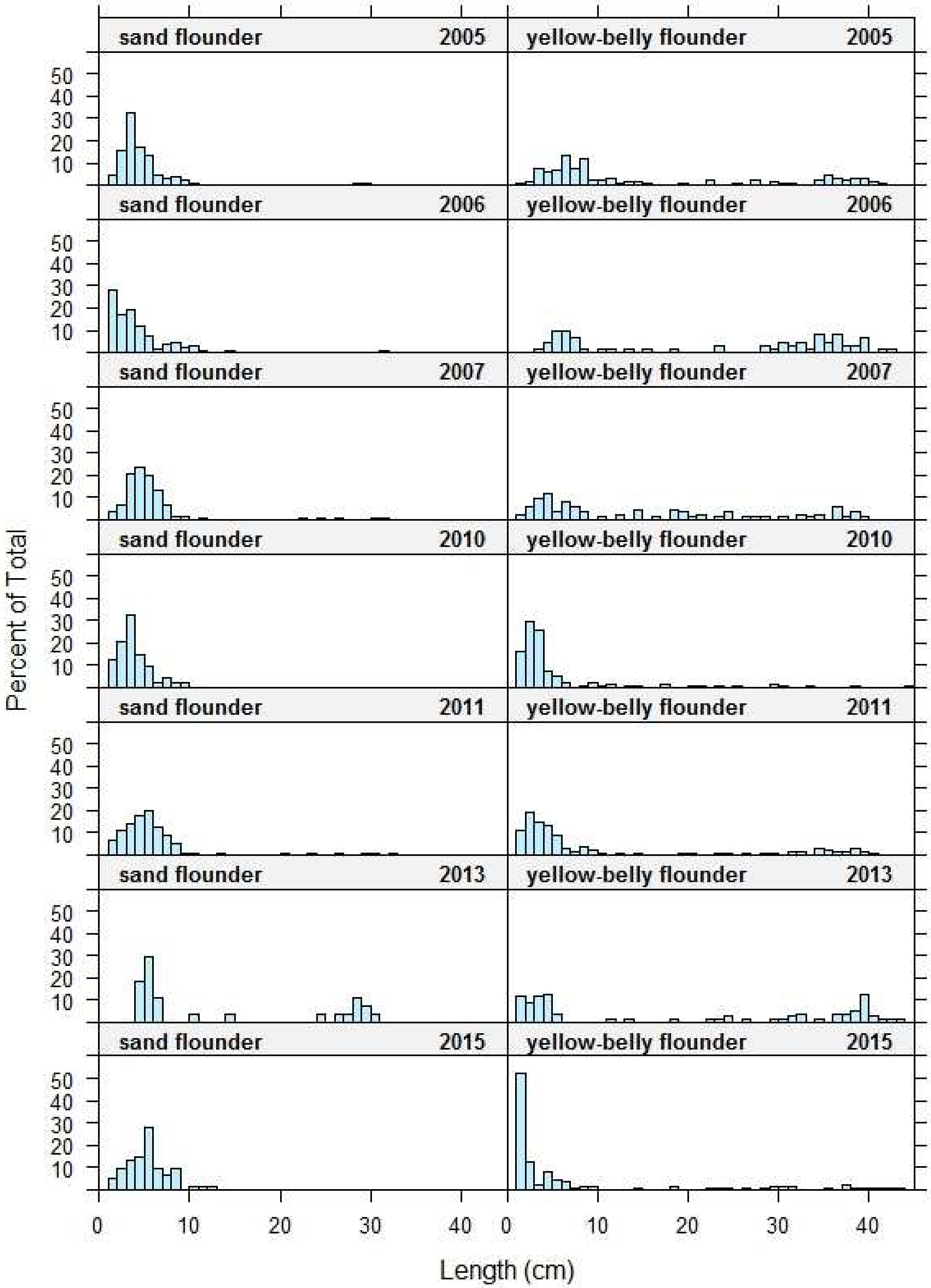

Figure 3-5: Length-frequency distributions for sand flounder (*Rhombosolea plebeia*) (left) and yellow-belly flounder (*Rhombosolea leporina*) (right) by year, pooled across all seine and trawl stations.

Table 3-8: Abundance and mean length (cm) of sand flounder (*Rhombosolea plebeia*) caught by seining in the Estuary of the Heathcote and Avon Rivers/Ihutai surveys. Within each location, stations are in order of increasing distance from the sea. The 2015 results are shown in the shaded column.

Location	Station	2005	2006	2007	2010	2011	2013	2015	Total
East shore	Tern Street	3 (3.7)	1 (1.0)	-	9 (3.3)	2 (3.0)	-	8 (3.5)	23 (3.3)
	Penguin Street	3 (3.0)	-	38 (4.7)	-	-	-	4 (5.0)	45 (4.6)
	Ebbtide Street	8 (5.3)	1 (6.0)	39 (6.2)	8 (4.3)	67 (4.5)	-	6 (4.2)	129 (5.0)
	Pleasant Point	15 (4.2)	6 (5.2)	4 (5.0)	2 (4.5)	34 (4.4)	1 (7.0)	3 (5.7)	65 (4.6)
Total, East shore		**29 (4.3)**	**8 (4.8)**	**81 (5.4)**	**19 (3.8)**	**103 (4.4)**	**1 (7.0)**	**21 (4.3)**	**262 (4.7)**
South shore	Shag Rock	-	-	6 (6.0)	-	1 (6.0)	-	-	7 (6.0)
	Redcliffs Park	6 (5.0)	4 (5.3)	24 (5.1)	18 (4.7)	1 (6.0)	5 (5.6)	5 (4.8)	63 (5.0)
	Causeway	-	-	1 (5.0)	1 (5.0)	3 (5.0)	1 (5.0)	2 (6.0)	8 (5.3)
	Mt Pleasant	15 (4.1)	8 (4.0)	1 (8.0)	10 (5.0)	10 (5.8)	4 (6.0)	-	48 (4.9)
Total, South shore		**21 (4.3)**	**12 (4.4)**	**32 (5.4)**	**29 (4.8)**	**15 (5.7)**	**10 (5.7)**	**7 (5.1)**	**126 (5.0)**
West shore	Windsurfing	7 (4.6)	8 (5.5)	-	3 (6.7)	23 (5.5)	-	1 (7.0)	42 (5.5)
	Ponds South	2 (3.0)	3 (5.3)	10 (5.8)	54 (3.0)	11 (5.7)	4 (6.0)	3 (5.3)	87 (4.0)
	Ponds Middle	29 (4.4)	34 (3.6)	15 (4.3)	19 (4.9)	5 (5.0)	1 (6.0)	-	103 (4.3)
	Ponds North	42 (4.1)	72 (3.5)	42 (4.7)	23 (4.0)	13 (5.1)	-	28 (5.5)	220 (4.3)
Total, West shore		**80 (4.3)**	**117 (3.7)**	**67 (4.8)**	**99 (3.7)**	**52 (5.4)**	**5 (6.0)**	**32 (5.6)**	**452 (4.3)**
Total, all locations		**130 (4.3)**	**137 (3.9)**	**180 (5.2)**	**147 (3.9)**	**170 (4.8)**	**16 (5.9)**	**60 (5.1)**	**840 (4.5)**

Table 3-9: Abundance and mean length (cm) of sand flounder (*Rhombosolea plebeia*) caught by trawling in the Estuary of the Heathcote and Avon Rivers/Ihutai surveys. The 2015 results are shown in the shaded column.

Location	2005	2006	2007	2010	2011	2013	2015	Total
Main channel	3 (9.0)	4 (9.8)	7 (8.6)	1 (8.0)	15 (8.5)	3 (28.0)	1 (9.0)	34 (10.4)
Avon channel	15 (10.9)	7 (9.4)	6 (10.5)	4 (8.5)	23 (9.3)	4 (21.5)	10 (8.5)	69 (10.3)
Heathcote channel	5 (9.8)	5 (14.2)	5 (24.4)	7 (9.0)	10 (16.2)	4 (28.5)	4 (10.0)	40 (15.5)
Total, all locations	**23 (10.4)**	**16 (11.0)**	**18 (13.6)**	**12 (8.8)**	**48 (10.5)**	**11 (25.8)**	**15 (8.9)**	**143 (11.8)**

Table 3-10: Abundance and mean length (cm) of yellow-belly flounder (*Rhombosolea leporina*) caught by seining in the Estuary of the Heathcote and Avon Rivers/Ihutai surveys. Within each location, stations are in order of increasing distance from the sea. The 2015 results are shown in the shaded column.

Location	Station	2005	2006	2007	2010	2011	2013	2015	Total
East shore	Tern Street	-	-	-	9 (3.1)	2 (3.0)	1 (5.0)	5 (3.0)	17 (3.2)
	Penguin Street	-	-	3 (2.7)	9 (3.9)	1 (40.0)	1 (5.0)	4 (3.8)	18 (5.7)
	Ebbtide Street	-	-	8 (5.0)	4 (3.8)	3 (3.7)	6 (4.7)	5 (2.8)	26 (4.2)
	Pleasant Point	17 (5.9)	6 (5.5)	15 (7.7)	20 (4.7)	31 (4.1)	12 (4.1)	2 (5.0)	103 (5.1)
Total, East shore		**17 (5.9)**	**6 (5.5)**	**26 (6.3)**	**42 (4.1)**	**37 (4.9)**	**20 (4.4)**	**16 (3.4)**	**164 (4.8)**
South shore	Shag Rock	-	1 (19.0)	-	-	-	-	-	1 (19.0)
	Redcliffs Park	-	-	-	18 (4.0)	5 (4.6)	6 (3.3)	8 (8.1)	37 (4.9)
	Causeway	-	-	-	-	2 (5.0)	-	3 (4.7)	5 (4.8)
	Mt Pleasant	7 (8.9)	3 (7.7)	4 (12.8)	7 (11.6)	15 (4.4)	3 (3.7)	3 (12.3)	42 (7.9)
Total, South shore		**7 (8.9)**	**4 (10.5)**	**4 (12.8)**	**25 (6.1)**	**22 (4.5)**	**9 (3.4)**	**14 (8.3)**	**85 (6.5)**
West shore	Windsurfing	2 (12.5)	2 (24.0)	1 (17.0)	1 (4.0)	19 (4.8)	9 (5.3)	12 (10.8)	46 (7.9)
	Ponds South	-	1 (16.0)	4 (5.3)	22 (3.2)	13 (3.7)	1 (4.0)	6 (3.2)	47 (3.8)
	Ponds Middle	25 (8.4)	6 (17.7)	6 (5.0)	13 (4.4)	3 (3.0)	2 (38.5)	12 (2.5)	67 (7.8)
	Ponds North	28 (9.4)	10 (9.8)	8 (6.9)	47 (4.2)	5 (3.8)	-	207 (3.6)	305 (5.0)
Total, West shore		**55 (9.1)**	**19 (14.1)**	**19 (6.5)**	**83 (4.0)**	**40 (4.2)**	**12 (10.8)**	**237 (4.1)**	**465 (5.7)**
Total, all locations		**79 (8.4)**	**29 (11.8)**	**49 (6.9)**	**150 (4.4)**	**99 (4.5)**	**41 (6.0)**	**267 (4.4)**	**714 (5.6)**

Table 3-11: Abundance and mean length (cm) of yellow-belly flounder (*Rhombosolea leporina*) caught by trawling in the Estuary of the Heathcote and Avon Rivers/Ihutai fish community surveys. The 2015 results are shown in the shaded column.

Location	2005	2006	2007	2010	2011	2013	2015	Total
Main channel	16 (28.3)	12 (32.5)	19 (24.9)	-	16 (24.9)	26 (33.6)	3 (25.3)	92 (29.0)
Avon channel	11 (29.5)	10 (34.8)	9 (30.0)	1 (31.0)	8 (19.3)	3 (35.7)	10 (35.9)	52 (30.6)
Heathcote channel	14 (36.0)	12 (35.2)	7 (33.4)	8 (30.4)	14 (34.7)	9 (37.3)	7 (25.1)	71 (33.8)
Total, all locations	**41 (31.2)**	**34 (34.1)**	**35 (27.9)**	**9 (30.4)**	**38 (27.3)**	**38 (34.6)**	**20 (30.6)**	**215 (31.0)**

3.2.4 Other species

Inanga

Thirty-four inanga (5–7 cm TL) (Figure 3-6) were caught by seining along the East, West and South shores (Table 3-2). This is the highest abundance recorded during the NIWA surveys, and the first time inanga have been caught on the East shore (Table 3-12). The reasons for the relatively large catch this year are not known, although the 2015 Canterbury whitebaiting season was considered very productive. Low catches across all surveys are probably due to poor retention of these small, thin fish by the seine net's mesh size. Inanga were recorded as seasonally present in the permanently watered channels of the estuary, along the rocky shoreline from Moncks Bay to Redcliffs Park, and up to the rush-covered shoreline by Jellicoe Park on the East shore by Webb (1972). He also observed shoals in the vicinity of Bridge Street and the Heathcote Bridge (Webb 1972, 1973). No inanga were caught in the larger-meshed trawl net used in the NIWA surveys.

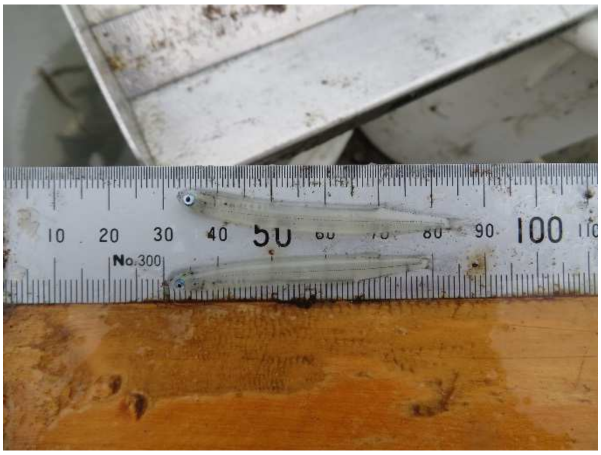

Figure 3-6: Juvenile inanga (*Galaxias maculatus*) caught during the 2015 Estuary of the Heathcote and Avon Rivers/Ihutai fish community survey.

Table 3-12: Abundance and mean length (cm) of inanga (*Galaxias maculatus*) caught by seining in the Estuary of the Heathcote and Avon Rivers/Ihutai fish community surveys. Within each location, stations are in order of increasing distance from the sea. The 2015 results are shown in the shaded column.

Location	Station	2005	2006	2007	2010	2011	2013	2015	Total
East shore	Tern Street	-	-	-	-	-	-	2 (5.0)	2 (5.0)
	Penguin Street	-	-	-	-	-	-	-	-
	Ebbtide Street	-	-	-	-	-	-	-	-
	Pleasant Point	-	-	-	-	-	-	3 (5.3)	3 (5.3)
Total, East shore		**-**	**-**	**-**	**-**	**-**	**-**	**5 (5.2)**	**5 (5.2)**
South shore	Shag Rock	-	-	6 (4.7)	-	3 (5.0)	-	-	9 (4.8)
	Redcliffs Park	-	-	-	-	-	1 (6.0)	3 (5.0)	4 (5.3)
	Causeway	-	-	-	-	-	-	-	-
	Mt Pleasant	-	-	-	-	-	-	1 (5.0)	1 (5.0)
Total, South shore		**-**	**-**	**6 (4.7)**	**-**	**3 (5.0)**	**1 (6.0)**	**4 (5.0)**	**14 (4.9)**
West shore	Windsurfing	-	-	-	-	-	-	1 (5.0)	1 (5.0)
	Ponds South	-	-	-	-	-	1 (5.0)	21 (5.6)	22 (5.5)
	Ponds Middle	-	-	-	-	-	-	-	-
	Ponds North	-	-	-	-	1 (5.0)	-	3 (5.3)	4 (5.3)
Total, West shore		**-**	**-**	**-**	**-**	**1 (5.0)**	**1 (5.0)**	**25 (5.5)**	**27 (5.5)**
Total, all locations		**-**	**-**	**6 (4.7)**	**-**	**4 (5.0)**	**2 (5.5)**	**34 (5.4)**	**46 (5.3)**

Triplefins

Triplefin caught during beach seining (30 fish; 4–6 cm in length) were more abundant along the South shore (24 fish) between Mount Pleasant and Redcliffs Park, compared to the East (two fish) and West (four fish) shores (Table 3-13). This does not continue the trend of increasing numbers along the South shore, which appeared in the 2010, 2011 and 2013 surveys. Only one triplefin (8 cm in length) was caught during trawling, consistent with very low and sporadic trawl catches in previous surveys (Table 3-14). Webb (1972) did not record triplefin in his estuary fish community study.

Table 3-13: Abundance and mean length (cm) of triplefin (Tripterygiidae) caught by seining in the Estuary of the Heathcote and Avon Rivers/Ihutai fish community surveys. Within each location, stations are in order of increasing distance from the sea. The 2015 results are shown in the shaded column.

Location	Station	2005	2006	2007	2010	2011	2013	2015	Total
East shore	Tern Street	-	1 (4.0)	-	-	-	-	2 (5.0)	3 (4.7)
	Penguin Street	-	4 (4.5)	-	-	-	-	-	4 (4.5)
	Ebbtide Street	-	-	-	-	-	1 (5.0)	-	1 (5.0)
	Pleasant Point	5 (5.2)	-	1 (7.0)	-	4 (5.3)	-	-	10 (5.4)
Total, East shore		**5 (5.2)**	**5 (4.4)**	**1 (7.0)**	**-**	**4 (5.3)**	**1 (5.0)**	**2 (5.0)**	**18 (5.1)**
South shore	Shag Rock	-	-	-	-	1 (4.0)	-	-	1 (4.0)
	Redcliffs Park	3 (6.7)	3 (5.7)	7 (6.3)	45 (5.2)	20 (5.6)	18 (5.1)	15 (5.1)	111 (5.4)
	Causeway	7 (5.0)	1 (4.0)	-	2 (6.0)	12 (5.5)	13 (5.2)	3 (4.3)	38 (5.2)
	Mt Pleasant	13 (4.9)	10 (5.3)	1 (6.0)	7 (5.9)	16 (5.8)	93 (5.9)	6 (5.3)	146 (5.7)
Total, South shore		**23 (5.2)**	**14 (5.3)**	**8 (6.3)**	**54 (5.4)**	**49 (5.6)**	**124 (5.7)**	**24 (5.1)**	**296 (5.5)**
West shore	Windsurfing	-	5 (5.6)	-	-	-	-	-	5 (5.6)
	Ponds South	-	-	-	-	1 (7.0)	-	-	1 (7.0)
	Ponds Middle	-	1 (6.0)	-	-	1 (5.0)	1 (6.0)	-	3 (5.7)
	Ponds North	-	2 (5.5)	1 (6.0)	-	27 (6.2)	24 (5.8)	4 (5.3)	58 (5.9)
Total, West shore		**-**	**8 (5.6)**	**1 (6.0)**	**-**	**29 (6.2)**	**25 (5.8)**	**4 (5.3)**	**67 (5.9)**
Total, all locations		**28 (5.2)**	**27 (5.2)**	**10 (6.3)**	**54 (5.4)**	**82 (5.8)**	**150 (5.7)**	**30 (5.1)**	**381 (5.6)**

Table 3-14: Abundance and mean length (cm) of triplefin (Tripterygiidae) caught by trawling in the Estuary of the Heathcote and Avon Rivers/Ihutai fish community surveys. The 2015 results are shown in the shaded column.

Location	2005	2006	2007	2010	2011	2013	2015	Total
Main channel	-	-	-	-	1 (6.0)	-	1 (8.0)	2 (7.0)
Avon channel	1 (7.0)	-	-	-	3 (7.0)	-	-	4 (7.0)
Heathcote channel	-	-	-	-	-	-	-	-
Total, all locations	**1 (7.0)**	**-**	**-**	**-**	**4 (6.8)**	**-**	**1 (8.0)**	**6 (7.0)**

Spotty

As in previous surveys, juvenile spotty (four fish; 5–6 cm in length) (Figure 3-7) were caught almost exclusively along the South shore during beach seining (particularly at the Causeway station) in similar numbers to previous surveys, apart from the 2010, 2011 and 2013 surveys when there were more juvenile spotty (Table 3-13). This species has not been recorded on the East shore to date during beach seining, and only once along the West shore, with four fish taken in seine tows at the northernmost station (Ponds North) in the 2013 survey. Adult and juvenile spotty (17 fish; 4–22 cm in length) caught by trawling in the Avon (seven fish), Heathcote (four fish) and Main (six fish) channels were similar in size and abundance to those recorded in previous surveys (Table 3-14). Webb (1972) found spotty to be mainly restricted to the Main channel, and only extending into the initial reaches of the Avon and Heathcote channels during late spring and summer.

Figure 3-7: Juvenile spotty (*Notolabrus celidotus*) caught during the 2015 Estuary of the Heathcote and Avon Rivers/Ihutai fish community survey.

Table 3-15: Abundance and mean length (cm) of spotty (*Notolabrus celidotus*) caught by seining in the Estuary of the Heathcote and Avon Rivers/Ihutai fish community surveys. Within each location, stations are in order of increasing distance from the sea. The 2015 results are shown in the shaded column.

Location	Station	2005	2006	2007	2010	2011	2013	2015	Total
East shore	Tern Street	-	-	-	-	-	-	-	-
	Penguin Street	-	-	-	-	-	-	-	-
	Ebbtide Street	-	-	-	-	-	-	-	-
	Pleasant Point	-	-	-	-	-	-	-	-
Total, East shore		**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
South shore	Shag Rock	-	-	1 (13.0)	-	-	-	-	1 (13.0)
	Redcliffs Park	-	4 (6.0)	-	9 (5.6)	4 (6.0)	1 (6.0)	1 (5.0)	19 (5.7)
	Causeway	1 (6.0)	1 (7.0)	1	2 (5.0)	26 (5.5)	10 (5.8)	3 (5.3)	43 (5.6)
	Mt Pleasant	1 (6.0)	-	-	-	-	3 (5.7)	-	4 (5.8)
Total, South shore		**2 (6.0)**	**5 (6.2)**	**1 (13.0)**	**11 (5.5)**	**30 (5.6)**	**14 (5.3)**	**4 (5.3)**	**67 (5.7)**
West shore	Windsurfing	-	-	-	-	-	-	-	-
	Ponds South	-	-	-	-	-	-	-	-
	Ponds Middle	-	-	-	-	-	-	-	-
	Ponds North	-	-	-	-	-	4 (6.5)	-	4 (6.5)
Total, West shore		**-**	**-**	**-**	**-**	**-**	**4 (6.5)**	**-**	**4 (6.5)**
Total, all locations		**2 (6.0)**	**5 (6.2)**	**1 (13.0)**	**11 (5.5)**	**30 (5.6)**	**18 (5.9)**	**4 (5.3)**	**71 (5.8)**

Table 3-16: Abundance and mean length (cm) of spotty (*Notolabrus celidotus*) caught by trawling in the Estuary of the Heathcote and Avon Rivers/Ihutai fish community surveys. The 2015 results are shown in the shaded column.

Location	2005	2006	2007	2010	2011	2013	2015	Total
Main channel	7 (21)	10 (17.8)	16 (17.8)	12 (13.3)	6 (17.8)	8 (20.3)	6 (6.8)	65 (16.6)
Avon channel	8 (8.3)	3 (16.0)	1 (7.0)	2 (19.0)	4 (9.3)	4 (9.0)	7 (12.1)	29 (10.9)
Heathcote channel	3 (9.3)	4 (11.5)	3 (13.3)	7 (17.3)	3 (20.0)	6 (19.3)	4 (15.0)	30 (15.7)
Total, all locations	**18 (13.4**	**17 (16.0)**	**20 (16.6)**	**21 (15.1)**	**13 (15.7)**	**18 (17.4)**	**17 (10.9)**	**124 (15.1)**

Slender sprat

Slender sprats (17 fish; 5–7 cm in length) (Figure 3-8) were relatively sparse and caught by seining on the West and South shores, making their fourth appearance in the seven surveys conducted to date, and their third in succession since 2011 (Table 3-17). Webb (1972) did not record slender sprat in his estuary fish community study. No slender sprat were caught in the larger-meshed trawl net used in the NIWA surveys.

Figure 3-8: Slender sprat (*Sprattus antipodum*) caught during the 2015 Estuary of the Heathcote and Avon Rivers/Ihutai fish community survey.

Table 3-17: Abundance and mean length (cm) of slender sprat (*Sprattus antipodum*) caught by seining in the Estuary of the Heathcote and Avon Rivers/Ihutai fish community surveys. Within each location, stations are in order of increasing distance from the sea. The 2015 results are shown in the shaded column.

Location	Station	2005	2006	2007	2010	2011	2013	2015	Total
East shore	Tern Street	-	-	-	-	-	-	-	-
	Penguin Street	-	-	-	-	-	3 (5.7)	-	3 (5.7)
	Ebbtide Street	-	-	-	-	-	-	-	-
	Pleasant Point	-	-	-	-	2 (4.5)	-	-	2 (4.5)
Total, East shore		**-**	**-**	**-**	**-**	**2 (4.5)**	**3 (5.7)**	**-**	**5 (5.2)**
South shore	Shag Rock	-	-	-	-	1 (4.0)	-	-	1 (4.0)
	Redcliffs Park	-	-	-	-	-	1 (4.0)	-	1 (4.0)
	Causeway	-	-	-	-	-	-	-	-
	Mt Pleasant	2 (5.0)	-	-	-	-	-	2 (6.5)	4 (5.8)
Total, South shore		**2 (5.0)**	**-**	**-**	**-**	**1 (4.0)**	**1 (4.0)**	**2 (6.5)**	**6 (5.2)**
West shore	Windsurfing	-	-	-	-	2 (4.0)	2 (6.5)	15 (5.9)	19 (5.7)
	Ponds South	-	-	-	-	-	-	-	-
	Ponds Middle	-	-	-	-	1 (4.0)	-	-	1 (4.0)
	Ponds North	-	-	-	-	2 (6.0)	-	-	2 (6.0)
Total, West shore		**-**	**-**	**-**	**-**	**5 (4.8)**	**2 (6.5)**	**15 (5.9)**	**22 (5.7)**
Total, all locations		**2 (5.0)**	**-**	**-**	**-**	**8 (4.6)**	**6 (5.7)**	**17 (5.9)**	**33 (5.5)**

Stargazers (three species: spotted, slender and estuary)

Stargazers (family Leptoscopidae) were relatively sparse and patchily distributed, consistent with the general trend for previous surveys. Five slender stargazers (17–22 cm in length; all in the Main channel), three spotted stargazers (11–20 cm in length; one each in the Avon, Heathcote and Main channels) (Figure 3-9) and one estuary stargazer (12 cm in length; Main channel) were caught during trawling (Table 3-18, Table 3-19 and Table 3-21). Most individuals of these both bottom-dwelling species were caught by trawling during the NIWA surveys (Table 3-2 and Table 3-3). A single spotted stargazer (8 cm in length) was caught in a beach seine along the Causeway station (South shore) (Table 3-20). This is the first year that slender stargazers have (just) out-numbered spotted stargazers; the latter were the more common of the three species present (e.g., Table 3-3). No estuary stargazers and only one slender stargazer (2006; Shag Rock station; 15 cm in length) were caught in beach seines during previous NIWA surveys. Webb (1972, 1973) also recorded few slender (Moncks Bay) and spotted (Moncks Bay, Redcliffs shoreline and what he termed the 'lower Avon-Heathcote channel') stargazers in his estuary fish community study.

Figure 3-9: Spotted stargazer (*Genyagnus monopterygius*) caught during the 2015 Estuary of the Heathcote and Avon Rivers/Ihutai fish community survey.

Table 3-18: Abundance and mean length (cm) of estuary stargazer (*Leptoscopus macropygus*) caught by trawling in the Estuary of the Heathcote and Avon Rivers/Ihutai fish community surveys. The 2015 results are shown in the shaded column.

Location	2005	2006	2007	2010	2011	2013	2015	Total
Main channel	2 (18.5)	1 (16.0)	1 (33.0)	-	-	-	1 (12.0)	5 (19.6)
Avon channel	2 (12.5)	-	-	-	-	-	-	2 (12.5)
Heathcote channel	2 (21.5)	-	-	2 (15.0)	-	1 (22.0)	-	5 (19.0)
Total, all locations	**6 (17.5)**	**1 (16.0)**	**1 (33.0)**	**2 (15.0)**	**-**	**1 (22.0)**	**1 (12.0)**	**12 (18.2)**

Table 3-19: Abundance and mean length (cm) of slender stargazer (*Crapatalus angusticeps*) caught by trawling in the Estuary of the Heathcote and Avon Rivers/Ihutai surveys. The 2015 results are shown in the shaded column.

Location	2005	2006	2007	2010	2011	2013	2015	Total
Main channel	-	-	-	1 (25.0)	-	1 (19.0)	5 (18.8)	7 (19.7)
Avon channel	-	-	-	-	-	-	-	-
Heathcote channel	-	1 (26.0)	1 (27.0)	-	1 (14.0)	-	-	3 (22.3)
Total, all channels	**-**	**1 (26.0)**	**1 (27.0)**	**1 (25.0)**	**1 (14.0)**	**1 (19.0)**	**5 (18.8)**	**10 (20.5)**

Table 3-20: Abundance and mean length (cm) of spotted stargazer (*Genyagnus monopterygius*) caught by seining in the Estuary of the Heathcote and Avon Rivers/Ihutai fish community surveys. Within each location, stations are in order of increasing distance from the sea**.** The 2015 results are shown in the shaded column.

Location	Station	2005	2006	2007	2010	2011	2013	2015	Total
East shore	Tern Street	-	-	-	-	-	-	-	-
	Penguin Street	-	-	-	-	-	-	-	-
	Ebbtide Street	-	-	-	-	-	-	-	-
	Pleasant Point	-	-	-	-	-	-	-	-
Total, East shore		**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
South shore	Shag Rock	-	-	-	-	-	-	-	-
	Redcliffs Park	-	-	-	-	-	-	-	-
	Causeway	-	-	-	-	1 (5.0)	-	1 (8.0)	2 (6.5)
	Mt Pleasant	-	-	-	-	-	-	-	-
Total, South shore		**-**	**-**	**-**	**-**	**1 (5.0)**	**-**	**1 (8.0)**	**2 (6.5)**
West shore	Windsurfing	3 (9.7)	4 (7.8)	-	-	-	1 (11.0)	-	8 (8.9)
	Ponds South	-	-	-	-	-	-	-	-
	Ponds Middle	-	-	-	-	-	-	-	-
	Ponds North	-	-	-	-	1 (7.0)	-	-	1 (7.0)
Total, West shore		**3 (9.7)**	**4 (7.8)**	**-**	**-**	**1 (7.0)**	**1 (11.0)**	**-**	**9 (8.7)**
Total, all locations		**3 (9.7)**	**4 (7.8)**	**-**	**-**	**2 (6.0)**	**1 (11.0)**	**1 (8.0)**	**11 (8.3)**

Table 3-21: Abundance and mean length (cm) of spotted stargazer (*Genyagnus monopterygius*) caught by trawling in the Estuary of the Heathcote and Avon Rivers/Ihutai surveys. The 2015 results are shown in the shaded column.

Location	2005	2006	2007	2010	2011	2013	2015	Total
Main channel	-	-	-	-	1 (15.0)	-	1 (14.0)	2 (14.5)
Avon channel	5 (15.0)	5 (15.4)	7 (25.7)	-	1 (15.0)	3 (18.3)	1 (20.0)	22 (19.2)
Heathcote channel	2 (14.5)	4 (25.3)	6 (25.0)	6 (16.7)	1 (17.0)	5 (18.4)	1 (11.0)	25 (20.0)
Total, all channels	**7 (14.9)**	**9 (19.8)**	**13 (25.4)**	**6 (16.7)**	**3 (15.7)**	**8 (18.4)**	**3 (15.0)**	**49 (19.4)**

Globefish

Eight globefish (7–11 cm in length) (Figure 3-10) were caught by trawling in the Avon (one fish), Heathcote (two fish) and Main (five fish) channels. This is the first time since the 2006 survey (when 207 very small (ca. 2 cm in length) specimens were caught at the Shag Rock station by beach seining) that globefish have been caught in the NIWA survey programme (Table 3-2). This is a widespread coastal species that can periodically appear in very large numbers (Stewart & Roberts 2015). Webb (1972) noted that this was the main seasonal fish in his study (named as *Sphaeroides richei*), but only caught in trawls between October–May and with a reduction in numbers from Moncks Bay (Main channel) to the river channels.

Figure 3-10: Globefish (*Contusus richiei*) caught during the 2015 Estuary of the Heathcote and Avon Rivers/Ihutai fish community survey.

Kahawai

Two juvenile kahawai (5 and 6 cm in length) (Figure 3-11) were caught by beach seining at the Ponds South (one fish) (West shore) and Mount Pleasant (one fish) (South shore) stations (Table 3-22). This is the first year that kahawai have been caught by seining at Ponds South station. This species is normally only caught (in both beach seines and trawls) in sparse numbers, and relatively widely distributed throughout the estuary as juveniles (Table 3-22), but restricted more to the Main Channel as larger fish (Table 3-23). Webb (1972) found that for most of the year (April 1965 to April 1966) kahawai kept to Moncks Bay (Main channel) with only a few individuals moving into the lower reaches of the river channels in summer, and that this species is difficult to catch in slow-moving sampling nets.

Figure 3-11: Juvenile kahawai (*Arripis trutta*) caught during the 2015 Estuary of the Heathcote and Avon Rivers/Ihutai fish community survey.

Table 3-22: Abundance and mean length (cm) of kahawai (*Arripis trutta*) caught by seining in the Estuary of the Heathcote and Avon Rivers/Ihutai fish community surveys. Within each location, stations are in order of increasing distance from the sea**.** The 2015 results are shown in the shaded column.

Location	Station	2005	2006	2007	2010	2011	2013	2015	Total
East shore	Tern Street	-	-	4 (5.3)	-	-	-	-	4 (5.3)
East shore	Penguin Street	-	1 (5.0)	-	-	-	-	-	1 (5.0)
East shore	Ebbtide Street	-	-	-	-	-	-	-	-
East shore	Pleasant Point	-	11 (6.2)	1 (5.0)	-	-	1 (6.0)	-	13 (6.1)
Total, East shore		**-**	**12 (6.1)**	**5 (5.2)**	**-**	**-**	**1 (6.0)**	**-**	**18 (5.8)**
South shore	Shag Rock	-	-	5 (5.8)	-	-	1 (7.0)	-	6 (6.0)
South shore	Redcliffs Park	-	-	1 (6.0)	-	-	3 (6.7)	-	4 (6.5)
South shore	Causeway	-	-	-	-	-	-	-	-
South shore	Mt Pleasant	2 (6.0)	-	-	-	1 (17.0)	-	1 (6.0)	4 (8.8)
Total, South shore		**2 (6.0)**	**-**	**6 (5.8)**	**-**	**1 (17.0)**	**4 (6.8)**	**1 (6.0)**	**14 (6.9)**
West shore	Windsurfing	-	-	-	-	-	-	-	-
West shore	Ponds South	-	-	-	-	-	-	1 (5.0)	1 (5.0)
West shore	Ponds Middle	-	-	1 (6.0)	-	1 (6.0)	2 (8.0)	-	4 (7.0)
West shore	Ponds North	-	-	-	-	-	-	-	-
Total, West shore		**-**	**-**	**1 (6.0)**	**-**	**1 (6.0)**	**2 (8.0)**	**1 (5.0)**	**5 (6.6)**
Total, all locations		**2 (6.0)**	**12 (6.1)**	**12 (5.6)**	**-**	**2 (11.5)**	**7 (7.0)**	**2 (5.5)**	**37 (6.4)**

Table 3-23: Abundance and mean length (cm) of kahawai (*Arripis trutta*) caught by trawling in the Estuary of the Heathcote and Avon Rivers/Ihutai fish community surveys. The 2015 results are shown in the shaded column.

Location	2005	2006	2007	2010	2011	2013	2015	Total
Main channel	-	-	3 (17.3)	-	1 (15.0)	2 (17.0)	-	6 (16.8)
Avon channel	-	-	-	-	-	-	-	-
Heathcote channel	-	-	-	-	-	2 (16.5)	-	2 (16.5)
Total, all locations	**-**	**-**	**3 (17.3)**	**-**	**1 (15.0)**	**4 (16.8)**	**-**	**8 (16.8)**

Common sole

Two sub-adult common sole (both 10 cm in length) were caught in a trawl in the Main channel (Monks Bay to Shag rock). This continues a pattern of intermittent and spatially patchy catches which has been maintained since the surveys began in 2005 (Table 3-2 and Table 3-3). Previously, juveniles were taken as far inland as Penguin Street (on the East shore) and the Causeway station (alongside McCormacks Bay on the South shore) during beach seining (Table 3-24), whereas adults and sub-adults were taken predominantly by trawling (in the same area of the Main channel (below Moncks Bay) (Table 3-25). This species was characterised as “the most stenohaline and least tolerant of pollution of pleuronectids found in the estuary” by Webb (1972), who did not collect it beyond Moncks Bay (Main channel).

Table 3-24: Abundance and mean length (cm) of common sole (*Peltorhamphus novaezelandiae*) caught by seining in the Estuary of the Heathcote and Avon Rivers/Ihutai fish community surveys. Within each location, stations are in order of increasing distance from the sea. The 2015 results are shown in the shaded column.

Location	Station	2005	2006	2007	2010	2011	2013	2015	Total
East shore	Tern Street	-	-	-	-	-	-	-	-
	Penguin Street	-	-	1 (3.0)	-	-	-	-	1 (3.0)
	Ebbtide Street	-	-	-	-	-	-	-	-
	Pleasant Point	-	-	-	-	-	-	-	-
Total, East shore		**-**	**-**	**1 (3.0)**	**-**	**-**	**-**	**-**	**1 (3.0)**
South shore	Shag Rock	-	-	6 (5.8)	-	-	6 (6.5)	-	12 (6.2)
	Redcliffs Park	-	-	4 (3.8)	7 (4.6)	-	-	-	11 (4.3)
	Causeway	-	-	1 (3.0)	-	-	-	-	1 (3.0)
	Mt Pleasant	-	-	-	-	-	-	-	-
Total, South shore		**-**	**-**	**11 (4.8)**	**7 (4.6)**	**-**	**6 (6.5)**	**-**	**24 (5.2)**
West shore	Windsurfing	-	-	-	-	-	-	-	-
	Ponds South	-	-	-	-	-	-	-	-
	Ponds Middle	-	-	-	-	-	-	-	-
	Ponds North	-	-	-	-	-	-	-	-
Total, West shore		**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Total, all locations		**-**	**-**	**12 (4.7)**	**7 (4.6)**	**-**	**6 (6.5)**	**-**	**25 (5.1)**

Table 3-25: Abundance and mean length (cm) of common sole (*Peltorhamphus novaezelandiae*) caught by trawling in the Estuary of the Heathcote and Avon Rivers/Ihutai fish community surveys. The 2015 results are shown in the shaded column.

Location	2005	2006	2007	2010	2011	2013	2015	Total
Main channel	1 (41.0)	5 (31.6)	4 (19.3)	4 (9.3)	2 (25.5)	4 (23.8)	2 (10.0)	22 (21.8)
Avon channel	-	-	-	-	-	-	-	-
Heathcote channel	-	1 (9.0)	-	-	1 (13.0)	-	-	2 (11.0)
Total, all locations	**1 (41.0)**	**6 (27.8)**	**4 (19.3)**	**4 (9.3)**	**3 (21.3)**	**4 (23.8)**	**2 (10.0)**	**24 (20.9)**

Shortfin eel

Two adult shortfin eels (94 and 95 cm in length, both female) were caught by beach seining at the Ponds North station; a location consistent with the sparse beach seine catches for this species along the West shore (with the exception of the Ponds South station) in previous years (Table 3-26). No shortfin eels were caught in trawls this survey, but have been sparsely caught during previous survey trawling predominantly in the Heathcote and Main channels (Table 3-27). Webb (1966) observed that the main migration of adult shortfin eels from the rivers through the estuary to the sea started around September–October, with the majority of the adult eels appearing to originate from the Heathcote River. He considered that juvenile shortfin eels could be longer term residents of the estuarine fish population, living in selected locations in the estuary, such as the rocky shoreline from Redcliffs Park to Moncks Bay.

Table 3-26: Abundance and mean length (cm) of shortfin eels (*Anguilla australis*) caught by seining in the Estuary of the Heathcote and Avon Rivers/Ihutai fish community surveys. Within each location, stations are in order of increasing distance from the sea. The 2015 results are shown in the shaded column.

Location	Station	2005	2006	2007	2010	2011	2013	2015	Total
East shore	Tern Street	-	-	-	-	-	-	-	**-**
	Penguin Street	-	-	-	-	-	-	-	**-**
	Ebbtide Street	-	-	-	-	-	-	-	**-**
	Pleasant Point	-	-	-	-	-	-	-	**-**
Total, East shore		**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
South shore	Shag Rock	-	-	-	-	-	-	-	**-**
	Redcliffs Park	-	-	-	-	-	-	-	**-**
	Causeway	-	-	-	-	-	-	-	**-**
	Mt Pleasant	-	-	-	-	-	-	-	**-**
Total, South shore		-	-	-	-	-	-	-	**-**
West shore	Windsurfing	-	-	2 (11.5)	3 (73.7)	-	1 (85.0)	-	**6 (54.8)**
	Ponds South	-	-	-	-	-	-	-	**-**
	Ponds Middle	-	2 (90.0)	2 (84.0)	-	-	-	-	**4 (87.0)**
	Ponds North	-	-	2 (93.5)	4 (82.3)	-	-	2 (94.5)	**8 (88.1)**
Total, West shore		**-**	**2 (90.0)**	**6 (63.0)**	**7 (78.6)**	**-**	**1 (85.0)**	**2 (94.5)**	**18 (76.8)**
Total, all locations		**-**	**2 (90.0)**	**6 (63.0)**	**7 (78.6)**	**-**	**1 (85.0)**	**2 (94.5)**	**18 (76.8)**

Table 3-27: Abundance and mean length (cm) of shortfin eels (*Anguilla australis*) caught by trawling in the Estuary of the Heathcote and Avon Rivers/Ihutai fish community surveys. The 2015 results are shown in the shaded column.

Location	2005	2006	2007	2010	2011	2013	2015	Total
Main channel	4 (75.5)	1 (75.0)	2 (90.0)	-	1 (88.0)	-	-	8 (80.6)
Avon channel	-	-	-	-	1 (97.0)	-	-	1 (97.0)
Heathcote channel	-	-	2 (86.0)	2 (83.5)	-	1 (88.0)	-	5 (84.8)
Total, all locations	**4 (75.5)**	**1 (75.0)**	**4 (88.0)**	**2 (83.5)**	**2 (92.5)**	**1 (88.0)**	**-**	**14 (83.3)**

Black flounder

A single juvenile black flounder (5 cm in length) was caught by beach seining at Redcliffs Park (South shore) (Table 3-2). This represents the first catch of this species in the NIWA series of surveys. Webb (1966) also only caught one black flounder in his study of EHARI fish populations. Widespread in coastal waters, juveniles of this species are known to migrate from marine waters into rivers (e.g., the Avon/Ōtākaro River, Eldon & Kelly 1992) and coastal lakes (they are an important fishery in Lake Ellesmere/Te Waihora, Jellyman 2011) in spring (Munroe 2015).

3.3 Catch per unit effort

Unbiased estimates of population density, based on mean catch per unit effort (CPUE) standardised by area sampled by each seine or trawl net (Figure 3-12 and Figure 3-13; Table 3-28), confirm the general trends observed in previous surveys. By far the highest densities were for seine-caught yellow-eyed mullet and common smelt, which peaked at 300/1000 m^2 (average 215/1000 m^2 across all stations) and 77/1000 m^2 (average 63.9/1000 m^2 across all stations), respectively (Table 3-28). Only one other species (yellow-belly flounder) was recorded at a density exceeding 10/1000 m^2 (22.5/1000 m^2 averaged across all seine stations, maximum of 57/1000 m^2 along the West shore), and only four species (inanga, sand flounder, slender sprat and triplefin) exceeded 1/1000 m^2 when averaged across all stations. The maximum density for trawl-caught fish was 1.9/1000 m^2 for sand flounder in the Avon channel, with only this species and yellow-belly flounder and yellow-eyed mullet averaging more than 1/1000 m^2 across all stations.

Population densities for the most common seine- and trawl-caught species continued to vary markedly between years, with little evidence of any clear trends (Figure 3-12 and Figure 3-13), particularly for trawl-caught species with overall catches markedly less than seine catches. Ten-fold variation between years was not unusual, and variation by a factor of three or four appears normal. For seine-caught species, there is a suggestion of increased (post-2011) densities of common smelt along the East and South shores, and triplefin along the South shore (Figure 3-12).

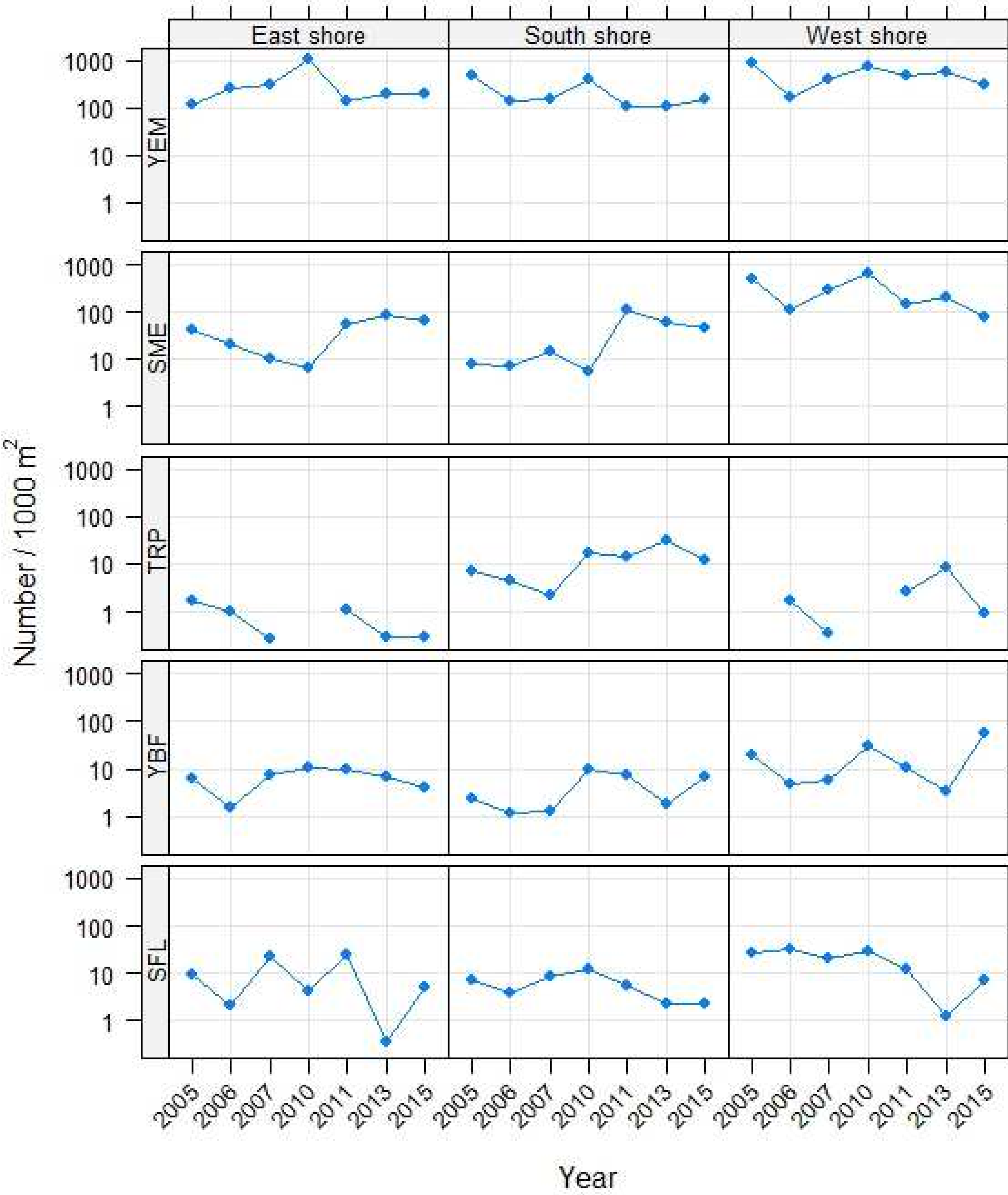

Figure 3-12: Catch per unit effort (CPUE, number/1000 m^2) for the five most abundant fish species caught by seine netting in the Estuary of the Heathcote and Avon Rivers/Ihutai fish community surveys. Species are identified as YEM (yellow-eyed mullet); SME (common smelt); TRP (triplefin); YBF (yellow-belly flounder); and SFL (sand flounder). Note that the vertical scale is logarithmic.

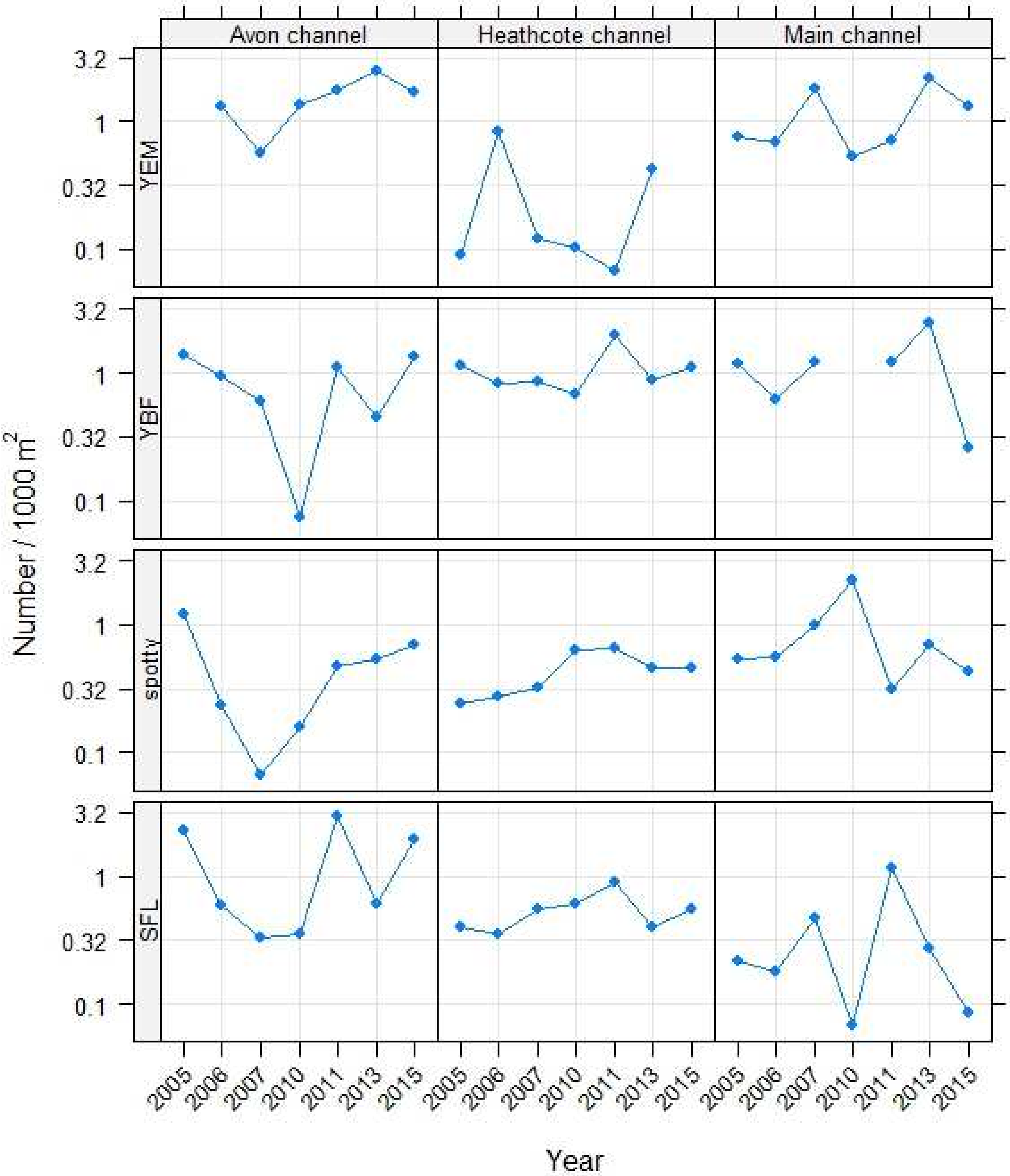

Figure 3-13: Catch per unit effort (CPUE, number/1000 m²) for the four most abundant fish species caught by trawling in the Estuary of the Heathcote and Avon Rivers/Ihutai fish community surveys. Species codes are as for Figure 3-10. Note that the vertical scale is logarithmic.

Table 3-28: Fish density (number/1000 m^2 ± 1 standard error) by method and location for all fish species caught in the 2015 Estuary of the Heathcote and Avon Rivers/Ihutai fish community survey. Means for each species and method are the mean of the three location means for each sampling technique. Data means and standard errors are presented to two decimal places due to instances of small decimal values.

	Seine				Trawl			
Species	East shore	South shore	West shore	All seine locations	Avon channel	Heathcote channel	Main channel	All trawl locations
black flounder	-	0.28 ± 0.34	-	**0.09 ± 0.09**	-	-	-	**-**
clingfish	-	-	-	**-**	-	-	0.07 ± 0.08	**0.02 ± 0.02**
common smelt	67.2 ± 64.39	47.51 ± 27.96	76.98 ± 26.27	**63.9 ± 8.67**	-	-	-	**-**
common sole	-	-	-	**-**	-	-	0.20 ± 0.22	**0.07 ± 0.07**
estuary stargazer	-	-	-	**-**	-	-	0.08 ± 0.09	**0.03 ± 0.03**
globefish	-	-	-	**-**	0.14 ± 0.17	0.22 ± 0.25	0.38 ± 0.32	**0.25 ± 0.07**
inanga	1.09 ± 0.87	1.83 ± 1.14	5.27 ± 4.35	**2.73 ± 1.29**	-	-	-	**-**
kahawai	-	1.0 ± 1.23	0.2 ± 0.23	**0.4 ± 0.31**	-	-	-	**-**
sand flounder	4.8 ± 0.88	2.34 ± 1.5	7.4 ± 6.91	**4.84 ± 1.46**	1.93 ± 1.49	0.56 ± 0.3	0.08 ± 0.09	**0.86 ± 0.55**
short-finned eel	-	-	0.45 ± 0.52	**0.15 ± 0.15**	-	-	-	**-**
slender sprat	-	2.0 ± 2.45	7.31 ± 8.44	**3.1 ± 2.18**	-	-	-	**-**
slender stargazer	-	-	-	**-**	-	-	0.46 ± 0.34	**0.16 ± 0.16**
spotted stargazer	-	0.48 ± 0.59	-	**0.16 ± 0.16**	0.14 ± 0.17	0.11 ± 0.13	0.07 ± 0.08	**0.11 ± 0.02**
spotty	-	1.72 ± 1.62	-	**0.57 ± 0.57**	0.71 ± 0.53	0.46 ± 0.36	0.44 ± 0.3	**0.54 ± 0.09**
triplefin	0.29 ± 0.33	11.6 ± 4.87	0.9 ± 1.04	**4.26 ± 3.67**	-	-	0.07 ± 0.08	**0.02 ± 0.02**

	Seine				Trawl			
Species	**East shore**	**South shore**	**West shore**	**All seine locations**	**Avon channel**	**Heathcote channel**	**Main channel**	**All trawl locations**
yellow-belly flounder	3.82 ± 0.94	6.66 ± 1.65	57.04 ± 50.21	**22.5 ± 17.29**	1.35 ± 0.65	1.11 ± 0.61	0.26 ± 0.12	**0.91 ± 0.33**
Yellow-eyed mullet	188.49 ± 23.76	156.25 ± 17.7	300.19 ± 208.28	**215 ± 43.61**	1.68 ± 1.49	-	1.31 ± 0.67	**1.0 ± 0.51**

3.4 Notes on fish health

Fish health was not specifically investigated in the EHARI fish community survey programme. However, virtually all fish examined in the 2015 survey appeared to be in good external condition and health, with no obvious signs of disease, physical abnormalities or malnourishment. Some instances of historical injuries were observed (i.e., due to predator attacks or fin damage), as were fresh injuries incurred during sampling when debris and other hard materials were also caught in the nets (Figure 3-14), but these were the exception. External and oral cavity crustacean parasites (e.g., sea lice or leeches) were also occasionally observed (Figure 3-14).

Figure 3-14: Evidence of historical fin damage to (left), and an external parasite (leech) (right) on, a yellow-belly flounder (*Rhombosolea leporina*).

Several instances of unexplained mortalities of mature kahawai were observed during sampling. During beach seining at the Ponds North station, several relatively recently dead large kahawai (Figure 3-15) were observed cast up. During trawling in the Avon channel, we observed a very recently deceased floating kahawai (Figure 3-15). Workers on the stormwater system at the Moncks Bay yacht club also commented that they had observed people catching several poorly-swimming kahawai there with their hands. This was reported to CCC, Environment Canterbury, MPI and the Department of Conservation at the time.

Figure 3-15: Dead kahawai (*Arripis trutta*) observed during beach seine (left) and trawl sampling (right).

3.5 Summary analysis of all NIWA fish community surveys (2005 to 2015)

3.5.1 Beach seining

The stress of the NMDS analyses was acceptable at 0.09, indicating acceptable model fit.

The community of fish captured by beach seining varied significantly between years (adonis year: $F_{6, 62} = 2.2$, P = 0.002; Figure 3-16A and B), but the difference in community composition explained by the year effect was relatively small ($R^2 = 0.13$). This significant difference in fish community composition was not due to community composition being more different or more similar between locations within any particular years (i.e., beta dispersion; betadisper year: $F_{6, 76} = 0.54$, P = 0.8). The lack of any obvious trend or change in direction of fish community composition time indicates that the differences are more likely due to random variations in catches between years, rather than any response to the OOP or the Canterbury earthquakes. However, the three points that are most different from the others (most negative NMDS2 scores) are located at the Causeway station post-earthquakes (2011, 2013 and 2015).

Seine-caught fish communities did not change differently at each location over the period surveyed (adonis, year:location interaction: $F_{12, 62} = 1.1$, P = 0.3). However, location within the estuary (the shore on which the sampling was conducted) did influence the composition of fish communities captured using the beach seine (adonis location: $F_{2, 62} = 7.3$, P = 0.001). Communities on the South shore were associated more with spotty (STY), triplefin (TRP) and sprat (SPM), whereas the West shore was associated more with slender sprat (SPA), inanga (INA), shortfin eel (SFE) and common bully (GCO) (Figure 3-16C) (also refer to Table 3-2).

3.5.2 Trawling

The stress of the NMDS was acceptable at 0.1, indicating acceptable model fit.

Fish communities captured in trawls did not differ significantly between years (adonis year: $F_{6, 86} = 1.5$, P = 0.07, Figure 3-17A and B). The between location variability was also not different over time (betadisper year: $F_{6, 100} = 2.1$, P = 0.05). However, the 2005 catch (the only year in which slender stargazer were not caught) does appear to be slightly more variable than other years.

The community of fish did differ significantly between the locations (Avon, Heathcote and Main channels; adonis location: $F_{2, 86} = 4.6$, P = 0.001). The Avon and Main channels showed relatively different communities, while the Heathcote channel sites were less distinct (Figure 3-17C). Clingfish (CLI) were on average twice as common in Main channel sites compared to the other channels. Likewise, estuary stargazers (ESZ) were twice as common in Main and Heathcote channels compared to the Avon channel. Slender stargazers were also more common in Main channel sites and, on average, less abundant in the Heathcote channel, and absent from the Avon channel (Figure 3-17 C). Other fishes associated with more positive NMDS axis 1 scores were more common in the Avon than Main channel trawls. For example, spotted stargazer (SPZ) were more abundant in the Avon and Heathcote channels and sand flounder (SFL) were more abundant in the Avon channels (also refer to Table 3-3).

There was no significant difference in community composition over time within the different locations (channels) (adonis year:location: $F_{12, 86} = 1.1$, P = 0.3).

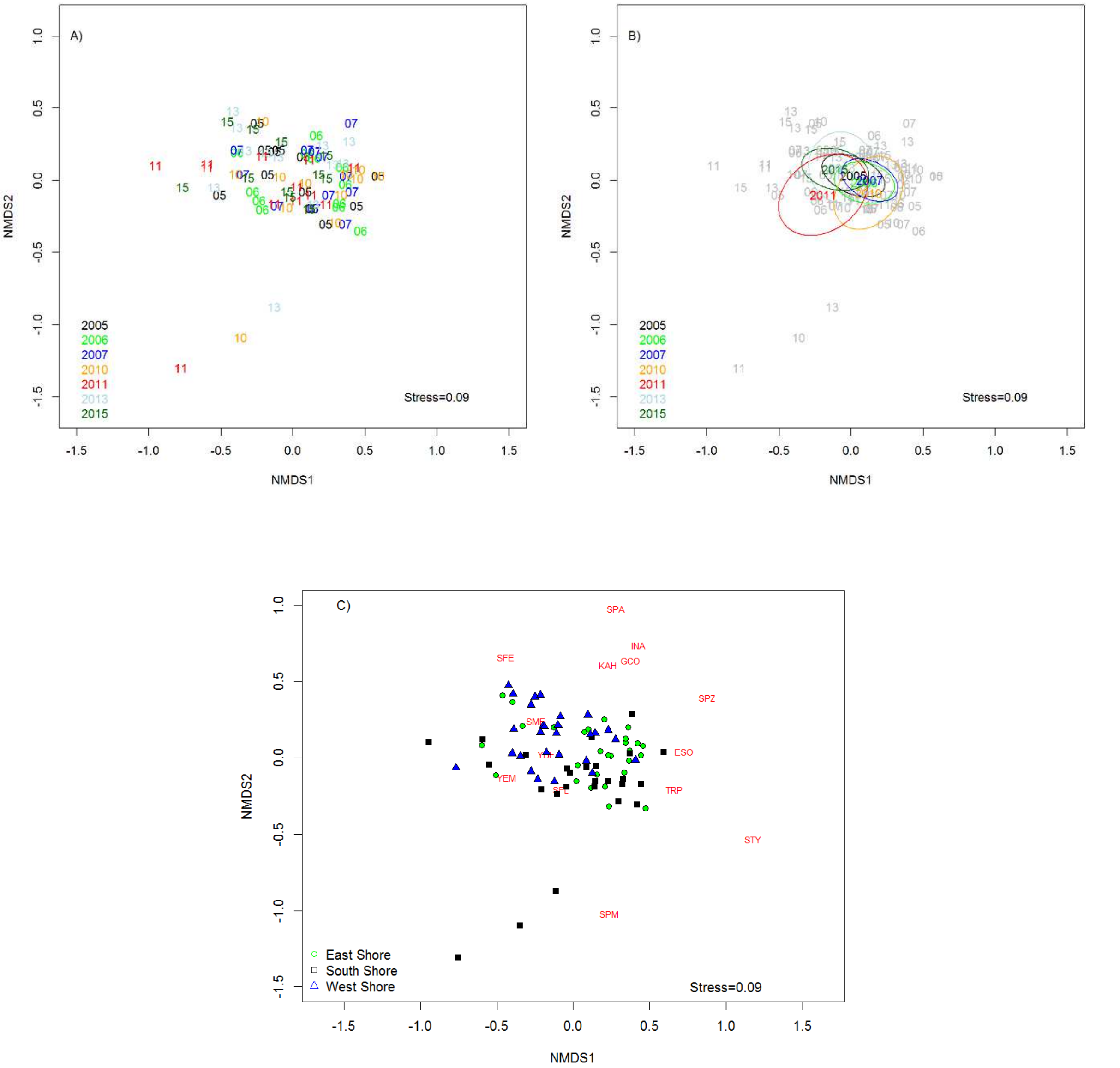

Figure 3-16: Visual representation (non-metric multidimensional scaling: NMDS, stress = 0.09) of similarities between the fish community captured using beach seines over seven different sampling years (2005–07, 2010, 2011, 2013 and 2015) within the Estuary of the Heathcote and Avon Rivers/Ihutai. Points closer together in space have more similar fish communities than points further apart. The same ordination is shown with points identified by A) sampling year, B) sampling year with ellipses showing 95% confidence interval and C) the estuary shore sampled. The influence of different fish taxa is shown in red text in C), with taxa occurring close to samples in which they occur more commonly. The three samples with the most negative axis two (NMDS 2) scores are all from the Causeway sampling station.

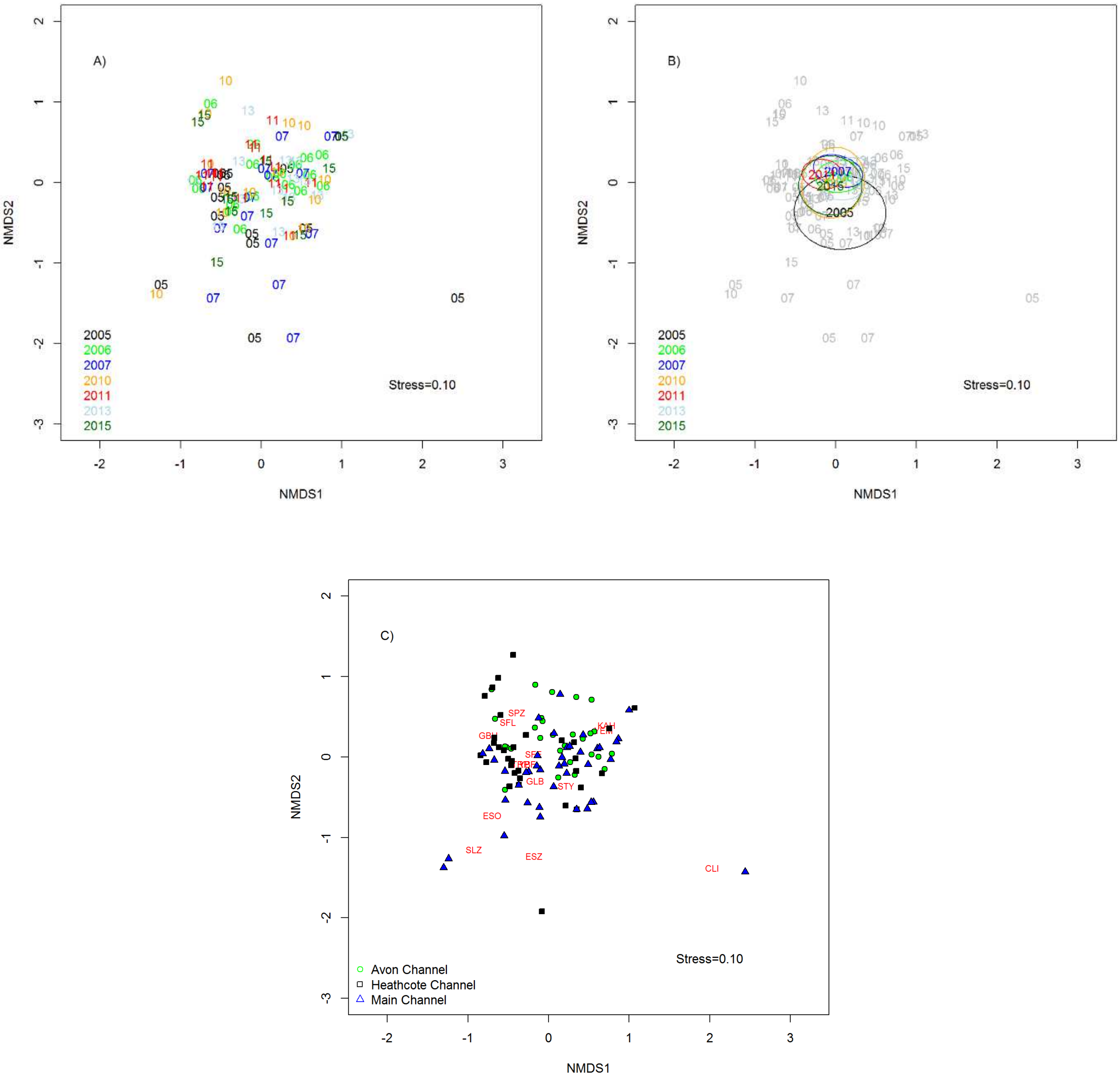

Figure 3-17: Visual representation (non-metric multidimensional scaling: NMDS, stress = 0.1) of similarities between the fish community captured using trawling over seven different sampling years (2005–07, 2010, 2011, 2013 and 2015) within the Estuary of the Heathcote and Avon Rivers/Ihutai. Points closer together in space have more similar fish communities than points further apart. The same ordination is shown with points identified by A) sampling year, B) sampling year with ellipses showing 95% confidence interval of station variation and C) the estuary channel in which sampling was conducted. The influence of different fish taxa is shown in red text in C), with taxa occurring close to samples in which they occur more commonly.

3.6 Other biota

Beach seines (Figure 3-18) commonly caught abundant invertebrates. These included: mudflat snails (*Amphibola crenata*, particularly abundant at the Ponds North station), spotted top shells (*Melagraphia aethiops*), purple-mouthed whelks (*Cominella glandiformis*), Tuangi cockles (*Austrovenus stutchburyi*), glass shrimp (*Palaemon affinis*) and crabs (*Hemiplax hirtipes*, *Hemigrapsus crenulatus* and *Halicarcinus* spp.). The green alga *Ulva* spp. (sea lettuce) was also common and abundant, as were various red algae (e.g., *Myriogramme* sp., *Gigartina* spp.). The red alga *Gracilaria chilensis* was less abundant at the Ponds North (West shore) and Mount Pleasant (South shore) compared to earlier surveys. Seagrass (*Zostera capricorni*) was common on the East shore stations, except at Pleasant Point.

Trawls caught (Figure 3-18) juvenile paddle crabs (*Ovalipes catharus,* 3–8 mm carapace width) in lower numbers than the 100s/trawl recorded in 2010. Catches of these crabs rarely exceeded 10/trawl in the Avon and Heathcote channels during 2015, but reached up to 30/trawl in the Main channel. Their distribution ranged from Moncks Bay to far up the Avon and Heathcote channels. As in the 2011 and 2013 surveys and in contrast to previous years, we caught no pie-crust crabs (*Metacarcinus novaezelandiae*). Hairy-handed crabs (*H. crenulatus*), cushion sea-stars (*Patiriella regularis*), mussels (*Perna canaliculus* and *Mytilus galloprovincialis*) and pipis (*Paphies australis*) were caught to a lesser extent in trawls. We did not record any large isopods (*Euidotea* sp.) amongst the *Ulva* trawl by-catch, unlike the 2010, 2011 and 2013 surveys. As for the beach seines, the green alga *Ulva* spp. (sea lettuce) was also common and abundant in trawls, as well as various red algae (e.g., *Myriogramme* sp., *Gigartina* spp.).

Figure 3-18: Example of biota incidentally captured during the 2015 Estuary of the Heathcote and Avon Rivers/Ihutai fish community survey along with fish in beach seines (left) and trawls (right).

4 Discussion

4.1 Effects of wastewater diversion and the Canterbury earthquakes on the estuary

The estuary's water quality is strongly influenced by the Avon/Ōtākaro and Heathcote/Ōpāwaho rivers, local discharges of stormwater, wastewater overflows, waterfowl and coastal water from Pegasus Bay (Bolton-Ritchie 2005, 2015). Historically, the CWTP was the largest point source of allochthonous eutrophication (nitrogen and phosphorous) to EHARI (Robb 1974, Bolton-Ritchie 2005, Barr et al. 2012). This significant nutrient input ceased in March 2010 with first operation of the OOP, and represented an important step in the estuary's remediation. Indeed, in the six months following treated wastewater diversion, dissolved inorganic nitrogen concentrations decreased significantly (ca. 90%) with a corresponding reduction in chlorophyll content of *Ulva* sp. (Barr et al. 2012). Treatment pond wastewater also historically contributed significant numbers of freshwater phytoplankton and zooplankton (e.g., rotifers, cladocerans and copepods) to the estuary (Robb 1974, Roper et al. 1983), providing food for some planktivorous fish species within the estuary (e.g., yellow-eyed mullet, Webb 1966).

Thus, the fish surveys commissioned by CCC (2005–07, 2011, 2013 and 2015), and the additional 2010 NIWA survey provide an opportunity to elucidate any effects of treated wastewater diversion via the OOP on EHARI's fish community (i.e., would reduction of nutrient input directly/indirectly result in an increase in fish community diversity and fish abundance/growth/health). However, the 2010–11 Canterbury earthquakes introduced an unanticipated, confounding complex of environmental factors to the post-OOP results.

The 2010–11 Canterbury earthquakes substantially damaged the city's wastewater infrastructure, resulting in significant untreated wastewater discharges into estuary and tributaries for at least eight months. Most repairs were completed (Bartram 2013) prior to the 2013 and 2015 surveys, although less frequent, event-based wastewater overflows have occurred periodically until recently (Bolton-Ritchie 2014). These nutrient inputs were reflected in spiked estuary and river nitrogen-loading, although these were minor when compared to the ca. 90% reduction in estuary nitrogen achieved via the OOP (Barr et al. 2012, Ren et al. 2014).

The magnitude 6.3 Christchurch earthquake on 22 February 2011 has affected and permanently changed the modern estuary in numerous ways. The earthquake resulted in substantial co-seismic changes in elevation across the estuary, with uplift exceeding 0.5 m along the southern shore from Heathcote to the estuary mouth, and subsidence of up to 0.5 m at its northern apex (Measures et al. 2011). Mean estuary elevation increased by 0.14 m, suggesting a reduction in the tidal prism volume (i.e., the volume between mean low tide level and mean high tide level) by ca. 14% (1 million m^3). The largest changes in inundated extent occur at mid tide, with the exposed area increased by 18%. In particular, in the southwestern part of the estuary, large areas formerly wet at mid tide, are now dry. This will influence wave-energy distribution, substrate stability and habitat (Measures et al. 2011). The northern subsidence was predicted to result in flooding along this shore during extreme high tides and likely erosion of the reed banks due to deeper water and consequent increased wave energy and swifter tidal currents (Measures et al. 2011). Indeed, estuary elevation changes have seen commensurate site-specific changes in intertidal saltmarsh vegetation, sediment grain size and even distribution patterns of some benthic biota (e.g., tunnelling crabs and the mud snail *Amphibola* *crenata*) post-earthquake (Cochran et al. 2014), and are predicted to affect macroalgal growth and distribution in the estuary (Barr et al. 2012, Ren et al. 2014).

The February 2011 earthquake also produced significant localised liquefaction effects (mud/sand volcanoes) in the estuary (Reid et al. 2012), which covered 17–39% of the estuary surface, according to aerial surveys several days after the earthquake (Measures et al. 2011), and 30–65% based on ground surveys 5–10 weeks later (Zeldis et al. 2011). This caused localised mortality of benthic biota through burying, altered topography and altered sediment grain size (to coarser sediments) (Zeldis et al. 2011). The exhumed (and geologically older) sediments contained lower levels of heavy metals and organic matter (i.e., cleaner sediment) than the pre-existing surficial mudflats (Zeldis et al. 2011), and were generally less favourable to benthic microalgal recolonisation and growth post-earthquake, with variable direct and indirect effects on benthic invertebrates such as polychaetes, gastropods and crabs (Hutt 2013).

Despite the significant reduction of allochthonous nutrient input to the estuary via both the OOP and repairs to earthquake-related damaged wastewater infrastructure, recent water quality testing does demonstrate ongoing water quality issues at some stations within EHARI that could potentially affect fish communities. For example, 2014 sampling at Sandy Point (our Ponds South station) identified 'very poor' water quality, particularly with regard to nitrite-nitrate nitrogen, dissolved inorganic nitrogen, dissolved reactive phosphorus, total suspended solids and turbidity (Bolton-Ritchie 2015).

Any or all of the significant post-March 2010 anthropogenic actions and natural events as described above (OOP and the Canterbury earthquakes) have the potential to affect the estuary's fish communities.

4.2 Changes to the estuary's fish communities (2005 to 2015 NIWA surveys)

In 2015, the estuary's fish communities were dominated by juvenile yellow-eyed mullet and common smelt, followed by yellow-belly flounder, sand flounder, inanga, triplefin, and spotty. This is generally consistent with the previous six NIWA surveys, and also similar to previous studies of the estuary's fish fauna (Webb 1966, 1972; Nairn 1998). Catches of less common species (e.g., slender sprat, stargazers, common sole, kahawai and short-finned eels) were also generally consistent with the variability within catches of these species encountered in prior NIWA surveys. The total number of fish species caught (17 species) was essentially the same as for all previous NIWA surveys (15–16 species; except 2010: 11 species), and also similar to that reported by other studies of the estuary's fishes (Webb 1966, 1972; Nairn 1998) when seasonally-restricted, rare or infrequent vagrant species are discounted.

Three findings of the 2015 survey were notable compared to the previous NIWA surveys. First, beach seine catches of juvenile yellow-belly flounder (mostly small recruits ca. 2 cm in length at the Ponds North station) and inanga (and recorded on the East shore for the first time) were the highest to date. Second, globefish were caught for the first time since the 2006 NIWA survey. Third, we encountered one specimen of black flounder, a species not detected in the six preceding surveys. More common in Lake Ellesmere/Te Waihora (Jellyman 2011), this species has only been caught in very low numbers historically in EHARI (Webb 1972) or the Avon/Ōtākaro River (Eldon & Kelly 1992.

Continued high catches of juvenile yellow-eyed mullet (a minor commercial and important recreational species) and common smelt (both important forage species for other fishes) are evidence of successful recruitment to the estuary. Recruitment appears to have been relatively consistent for both species of flounder in recent years, apart from fewer sand flounder in 2013 and more yellow-belly flounder in 2015. Use of EHARI as a nursery area by euryhaline marine species was well noted in earlier studies (Webb 1972, Kilner 1974, Nairn 1998), and has been amply illustrated in the NIWA surveys.

Overall, NIWA's seven estuary fish surveys (2005–07, 2010, 2011, 2013 and 2015) showed no clear evidence of any consistent long-term trends in fish abundance, size, spatial distribution or species diversity since the first pre-OOP survey conducted in 2005. When comparing fish catches across these surveys, differences in fish communities captured by beach seining and trawling were reasonably small between years and showed no obvious (significant) trend or change in direction or magnitude. This indicates that the differences we observed primarily reflect random, between-year variation in the communities, rather than any systemic environmental change potentially associated with either the OOP or Canterbury earthquakes.

A possible caveat is that the three points with the most negative post-earthquake NMDS 2 scores in the beach seine fish community analysis were located at the Causeway station. Although there was no significant between-station variation over time, this disparity could be related to changes in presence and abundance of certain species such as triplefin and spotted stargazer. The Causeway station has undergone some geomorphologic change since the earthquakes (see above), with a rise in the Heathcote channel bed (ca. 0.2–0.3m, Measures et al. 2011), reduced tidal retention within McCormacks Bay and associated change in channel hydraulic regime (R. Measures, NIWA, pers. comm.). The adjacent McCormack's Bay causeway has also been redeveloped and its western culvert replaced. These factors alone or in combination may underlie a potential change in fish communities at the Causeway station post-earthquakes.

Population densities (CPUE) for the most common seine- and trawl-caught species varied markedly between years, with little evidence of any clear trends associated either with the OOP or the Canterbury earthquakes (particularly the 2011 earthquake). The first post-earthquake survey in November 2010 appears unusual for some species and stations, but the exceptions seem just as likely to be anomalously high (e.g., seine-caught common smelt and yellow-belly flounder on the West shore, seine-caught yellow-eyed mullet on the East shore, trawl-caught sand flounder in the Main channel) as they are to be anomalously low (e.g., seine-caught common smelt on the South shore, trawl-caught spotty in the Main channel, trawl-caught yellow-belly flounder in the Avon channel).

An equivalent survey of fish and invertebrates in the lower Avon/Ōtākaro River (from the Fitzgerald Avenue Bridge downstream to Bridge Street where the river joins the estuary) 10 months after the 22 February 2011 earthquake found little difference from results of two previous (1990, 1992) surveys (James & McMurtrie 2012). This was despite the Avon/Ōtākaro River undergoing extreme fine sediment mobilisation and significant inputs of untreated sewage. The only difference observed was that the uppermost section had fewer fish compared to the other sections and lower invertebrate taxa richness than in 1990.

4.3 Survey considerations

Our fish community surveys were subject to random short-term variation associated with factors such as prevailing weather patterns and tidal conditions. For example, strong winds can drive pelagic species, such as yellow-eyed mullet, to certain sides of the estuary on incoming tides, or restrict them to deeper channels (Webb 1966). They were also subject to variation associated with commercial (and to a lesser extent recreational) fishing pressure, such as inshore trawling for sand flounder and yellow-belly flounder around the Canterbury Bight, which may affect migrating adult fish and larval/juvenile recruitment to the estuary. Longer term climatic variation is also likely to influence fish abundance and distribution. For example, if the breeding season for sand flounder and yellow-belly flounder is advanced because of favourable climatic conditions, then a single survey may miss capturing a large proportion of adult fish which have migrated out of the estuary for spawning. In 2013, adult yellow-belly flounder (particularly those from the Main channel where the majority of adults were caught) were observed to be very gravid. In contrast, fewer adult yellow-belly flounder were caught in the 2015 survey (particularly in the Main channel), and those that were did not appear very gravid. This suggests that the 2013 survey captured the start of a spawning migration, whereas the 2015 survey may have missed it. Such factors affect our ability to contrast pre- and post-OOP, and earthquake-related changes in fish abundance and distribution within EHARI.

The NIWA fish community surveys were consistently conducted at approximately the same time each year (November–December) to maximise between-survey comparability. However, although they capture the dominant fish species (at the time of sampling), the total number of fish species which utilise the estuary is likely to be underestimated (e.g., 10–17 species in our surveys versus 28 in 1965–66 (Webb 1972)). Species likely to be missed in a single survey include those that are rare and/or seasonally variable, or those that utilise habitat not suited to sampling via seine and trawl-netting (such as clingfish or rockfish). Webb (1973) recorded 19 fish species of slight or irregular occurrence in samples taken from EHARI. These included species (e.g., clingfish, giant bully, slender and spotted stargazer) that we also recorded infrequently and/or at very low abundance, as well as species that we did not encounter (e.g., red cod, garfish, barracouta, thornfish, rig). It must also be noted that our survey's very restricted sampling window (one week within each survey interval) precluded gathering more detailed data on within- and between-season changes in size, distribution, and abundance of sub-adult and adult individuals (cf. Webb 1967, 1972), which would yield a better indication of resident population dynamics and any possible OOP- and earthquake-related effects.

Webb's 1965–66 study of the fish populations of EHARI (Webb 1966, 1972) remains the most comprehensive to date in terms of temporal/spatial sampling over a year. Kilner's 1970–71 study on the biology of sand flounder in EHARI (Kilner 1974) also provides comprehensive information for this species over a year. Whilst comparisons between NIWA's surveys and these historical surveys should be treated with a degree of caution (e.g., differences in beach seine mesh size, possibility that earlier annual surveys encountered unusual years etc.), there is limited evidence of a decline in estuary sand flounder (and possibly also common sole and kahawai) populations, with a commensurate change in the ratio of sand flounder to yellow-belly flounder (ca. 3–4:1 in 1965–66 cf. 1.1:1 over 2005–2015 (seine and trawl data combined for both studies)). This apparent decline was also suggested by Nairn (1998) and James (1999).This recent lower relative abundance of sand flounder to yellow-belly flounder may be attributable to pollution input, as Webb (1972; without giving reasons other than the distribution patterns of the two flounder species) regarded yellow-belly flounder as more sensitive to pollution than sand flounder (which utilise the same habitat). Lower numbers of adult sand flounder could also result from increased fishing pressure[4] or breeding migration from the estuary, whilst lower numbers of juveniles may result from reduced breeding stocks, a poor breeding season and/or poor recruitment, or simply a mismatch between sampling activity and the timing of the recruitment influx into the estuary.

[4] For management purposes, landings of all flatfish species are combined under the generic species code FLA and managed within the Quota Management System (QMS) essentially as a single species comprising four stocks (FLA 1, FLA 2, FLA 3 (3, 4, 5 and 6 combined), FLA 7 and FLA 10). Thus, elucidating fishing pressure on sand flounder, yellow-belly flounder and common sole is confounded.

5 Conclusions

1. The 2015 fish community survey of EHARI showed that fish communities were generally consistent with the previous six NIWA surveys (2005–07, 2010, 2011 and 2013).

2. The 2005–15 fish community surveys of EHARI showed no clear, consistent, long-term trends in fish abundance, size, spatial distribution, or species diversity since the first pre-OOP survey conducted in 2005. There is little evidence of any changes or trends associated either with the OOP or the 2010–11 Canterbury earthquakes.

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7 Glossary of abbreviations and terms

BFL	black flounder (*Rhombosolea retiaria*)
CCC	Christchurch City Council
CLI	clingfish (Gobiesocidae)
CPUE	catch per unit effort
CWTP	Christchurch Wastewater Treatment Plant
ESO	common sole (*Peltorhamphus novaezelandiae*)
ESZ	estuary stargazer (*Leptoscopus macropygus*)
GBU	giant bully (*Gobiomorphus gobioides*)
GCO	common bully (*Gobiomorphus cotidianus*)
GLB	globefish (*Contusus richiei*)
INA	Inanga (*Galaxias maculatus*)
KAH	kahawai (*Arripis trutta*)
MPI	Ministry for Primary Industries
NIWA	National Institute of water & Atmospheric Research Ltd
NMDS	non-metric multidimensional scaling
OOP	Ocean Outfall Project
PCO	ahuru (*Auchenoceros punctatus*)
SAM	Chinook salmon (*Oncorhynchus tshawytscha*)
SFE	short-finned eel (*Anguilla australis*)
SFL	sand flounder (*Rhombosolea plebeia*)
SLZ	slender stargazer (*Crapatalus angusticeps*)
SME	common smelt (*Retropinna retropinna*)
SPA	slender sprat (*Sprattus antipodum*)
SPM	sprat (*Sprattus muelleri*)
SPS	speckled sole (*Peltorhamphus latus*)
SPZ	spotted stargazer (*Genyagnus monopterygius*)
STY	spotty (*Notolabrus celidotus*)
TRP	triplefin (Tripterygiidae)
YBF	yellow-belly flounder (*Rhombosolea leporina*)
YEM	yellow-eyed mullet (*Aldrichetta forsteri*)

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