



# Fisheries New Zealand

Tini a Tangaroa

## Using trawl surveys to provide partial quantitative assessments for rough skate (*Zearaja nasuta*) and smooth skate (*Dipturus innominatus*)

New Zealand Fisheries Assessment Report 2022/65

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## EXECUTIVE SUMMARY

Holmes, S.J.<sup>1</sup>; McKenzie, A.; Ballara, S.L.; MacGibbon, D.J.; Bian, R.; Dunn, M.R.; Jones, E.G. (2022). Using trawl surveys to provide partial quantitative assessments for rough skate (*Zearaja nasuta*) and smooth skate (*Dipturus innominatus*).

*New Zealand Fisheries Assessment Report 2022/65. 71 p.*

Rough skate (*Zearaja nasuta*, RSK) and smooth skate (*Dipturus innominatus*, SSK) occur throughout New Zealand waters, but are most abundant around the South Island in depths down to 500 m. Both were introduced into the quota management system (QMS) as separate species from 1 October 2003, and both fall under Group 2 of fish stocks managed under the National Inshore Finfish Fisheries Plan 2022. The objective of this project was to assess the status of all assumed rough and smooth skate stocks using partial quantitative assessments based on abundance indices from research trawl surveys. The project focused on survey indices because there was evidence of poor accuracy in species identification and under-reporting of the commercial catch.

The data for 10 trawl survey series were extracted from the NIWA ‘trawl’ database and analysed using the NIWA ‘SurvCalc’ software. An internal NIWA workshop considered collated analyses of the survey data and marked each survey series according to six criteria, e.g., the extent to which the depth range of the species was encompassed by each series. The conclusions from the workshop on which surveys provided sufficiently reliable relative abundance time series for partial quantitative assessment were presented to the Fisheries New Zealand Inshore Working Group (INSWG) on 28 February 2022, and a final set of survey series to take forward to the assessment phase was agreed.

Putative partial quantitative assessments were considered by the INSWG on 31 March 2022. To be accepted it was necessary to agree a reference period over which both survey biomass indices and commercial landings were relatively stable and not at reduced levels compared with other periods. Only the period after introduction of RSK and SSK into the QMS was considered because of concerns over inaccurate species allocation and under-reporting in earlier landings data.

Six survey time series were eventually accepted as providing reliable indices of abundance. For RSK these were the east coast South Island (ECSI) inshore surveys, and west coast South Island (WCSI) inshore surveys. For SSK the ECSI surveys, the Chatham Rise middle depth surveys, the WCSI inshore surveys, and west coast South Island (WCSI) offshore surveys were accepted. The recently re-instated west coast North Island (WCNI) survey series was considered as potentially providing reliable indices of abundance of RSK, but more years of data are needed before a firm conclusion can be reached. Only two partial quantitative assessments were accepted and incorporated into the May 2022 Fisheries New Zealand plenary document, for RSK in quota management area 3 (RSK 3) using the ECSI surveys, and SSK in management area 7 (SSK 7) using the WCSI offshore surveys.

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## 1. INTRODUCTION

Rough skate (*Zearaja nasuta*, RSK) and smooth skate (*Dipturus innominatus*, SSK) occur throughout New Zealand waters, but are most abundant around the South Island in depths down to 500 m, with smooth skate occurring slightly deeper (Beentjes & Stevenson 2000, 2001, Stevenson & Hanchet 2000). Both species were introduced into the quota management system (QMS) as a separate species from 1 October 2003, with about 83% of RSK landings and 60% of SSK landings coming from QMA 3 (east coast South Island and Sub-Antarctic) (Fisheries New Zealand 2022a). Most catch has been taken by bottom trawl, but skates have also been taken by longliners.

Both species fall under Group 2 of fish stocks managed under the National Inshore Finfish Fisheries Plan 2022 (Fisheries New Zealand 2022b). A management action of this Fisheries Plan for Group 2 stocks is to “Manage stocks using a partial quantitative stock assessment, based on a relative index of abundance or estimate of fishing mortality, to provide an indication of stock status in relation to MSY-compatible proxies and associated target (which may be above MSY) and limit reference points and/or thresholds for fishing mortality”.

A data informed qualitative risk assessment was completed on all chondrichthyans (sharks, skates, rays, and chimaeras) at the New Zealand scale in 2014 (Ford et al. 2015) and updated in 2017 (Ford et al. 2018). RSK was ranked number one (highest) and SSK initially number two in terms of risk of the eleven QMS chondrichthyan species. The subsequent review decreased the risk for both species due to greater confidence in stable abundance indices, but both remained amongst the highest risk QMS species. Data were described as existing but poor for the purposes of the assessment.

There were no estimates of current or reference biomass available for either skate species (Fisheries New Zealand 2022a), and nothing was known about stock structure or movement patterns. The Fisheries New Zealand Harvest strategy standard (MPI 2008) allows provision for the use of “conceptual proxies” for  $B_{MSY}$ ,  $F_{MSY}$ , and MSY that can be used in the absence of adequate information to directly estimate these reference points themselves. Conceptual  $B_{MSY}$  and  $F_{MSY}$  proxies may be valid where the relationship between commercial catch per unit effort (CPUE) or other biomass index and abundance can be assumed to be more or less proportional. Alternatively, where some other form of relationship has been derived from data, it may be reasonable to select an appropriate historical period when both biomass index and catches were relatively high and to use this biomass index level as a target. These  $B_{MSY}$  proxy assessments are referred to as Partial Quantitative Stock Assessments by Fisheries New Zealand.

Before the introduction of the skate species into the QMS in 2003 many fishers and processors did not distinguish rough and smooth skates in their landing returns, but instead coded them as ‘skates’ (SKA). It was also legal to discard both species before they were introduced to the QMS. A study in 2004 found the two species were being misidentified (Beentjes 2005), and it was not known if reporting accuracy had improved since then. Therefore, commercial CPUE was considered unlikely to provide reliable indices of abundance for skate stocks.

The derivation of  $B_{MSY}$  proxies in New Zealand has used biomass indices derived from trawl surveys or standardised commercial CPUE. Examples of survey based  $B_{MSY}$  proxy assessments include red gurnard (GUR 7) and stargazer (STA 3, STA 7) (Fisheries New Zealand 2021). The aim of this project INS2021-02 was to use trawl survey series to complete Partial Quantitative Stock Assessments for each skate stock where data were sufficient.

### **Overall Objective:**

To assess the status of smooth skates in SSK 1, SSK 3, SSK 7, and SSK 8 and rough skates in RSK 1, RSK 3, RSK 7, and RSK 8 based on trawl survey series of relative abundance.

### **Specific objective 1:**

To determine which trawl surveys provide reliable indices of abundance for rough and smooth skates in each QMA.

## Specific objective 2:

To undertake partial quantitative assessments for each QMA for which reliable relative abundance series are available.

With no information available on stock structure or movement patterns, it is currently considered that quota management areas (QMAs) would form appropriate management units in the absence of any information on biological stocks (Fisheries New Zealand 2022a). The QMA areas are the same for RSK and SSK and relate to Fisheries Management Areas (FMAs) as follows:

QMA 1 = RSK 1 = SSK 1 = FMA 1 & FMA 2

QMA 3 = RSK 3 = SSK 3 = FMA 3, FMA 4, FMA 5, FMA 6

QMA 7 = RSK 7 = SSK 7 = FMA 7

QMA 8 = RSK 8 = SSK 8 = FMA 8 & FMA 9

## 2. METHODS

### 2.1 Selection of surveys providing reliable indices of abundance

Data for 10 trawl survey series were extracted from the NIWA ‘trawl’ database (Mackay 2020) and processed using the NIWA ‘SurvCalc’ software (Francis & Fu 2012). The names, region (QMA), research vessel, and most recent report associated with each survey series are given in Table 1. Data from surveys conducted between 1997 and up to and including 2021 were employed for the analyses.

**Table 1: Surveys from the trawl database considered for the partial quantitative assessment of rough and smooth skates.**

QMA	Survey (acronym)	Vessel	Latest survey report	Survey series review
1	Hauraki Gulf (HAGU)	<i>Kaharoa</i>	Parsons & Bian (2022)	
1	Bay of Plenty (BPLE)	<i>Kaharoa</i>	Parsons & Bian (2022)	Morrison et al. (2001a)
3	East coast South Island (ECSI)	<i>Kaharoa</i>	Beentjes et al. (2022)	Beentjes & MacGibbon (2013)
3	Chatham Rise	<i>Tangaroa</i>	Stevens et al. (2021)	O’Driscoll et al. (2011)
3	Sub-Antarctic Summer (SUBA)	<i>Tangaroa</i>	Stevens et al. (2022)	Bagley et al. (2013)
7	West coast South Island Inshore (WCSI)	<i>Kaharoa</i>	MacGibbon et al. (2022)	Stevenson & Hanchet (2000, 2007)
7	West coast South Island Offshore (WCSI)	<i>Tangaroa</i>	O’Driscoll & Ballara (2019)	
8	West coast North Island (WCNI)	<i>Kaharoa</i>	Jones et al. (2022)	Morrison et al. (2001b), Jones et al. (in press)
Discontinued surveys				
3	Sub-Antarctic Autumn	<i>Tangaroa</i>	Bagley & McMillan (1999)	
3	Stewart-Snares	<i>Tangaroa</i>	Bagley & Hurst (1996)	

A range of criteria have been used previously to assess the adequacy of different survey series for monitoring species abundance (e.g., Bagley et al. 2013 and Beentjes & MacGibbon 2013). Similar to these reviews, six criteria were used to assess whether a survey series provided a reliable index of skate abundance. These were:

- Coverage of the known depth and geographic range of the species.
- Coefficient of variation (CV) of the survey, derived from the relative biomass time series. A CV of 40% was established as a rule of thumb threshold for acceptable precision, following Bagley et al. (2013).
- Between year consistency of the surveys, derived from the relative biomass time series.
- Number of fish caught and measured.

- Consistency of length frequency data between years.
- Size selection in survey compared with the commercial catch.

To enable the comparison of size selection in a survey series to the commercial catch, observer data were extracted from the NIWA ‘COD’ database (Sanders & Fisher 2022). Raw observations were aggregated over the RSK and SSK quota management areas, across all years from which observer data were available (2003–2021). Given juveniles and adults of many species are often geographically distinct (or have distinct depth ranges), the lengths recorded by surveys were also considered with respect to length at 50% maturity (Table 2).

Each survey series was assessed against the six criteria outlined above at a meeting of NIWA experts with knowledge of the trawl surveys, elasmobranch biology and stock assessment. Each criterion was assessed as ‘very good’, ‘good’, ‘reasonable’, of ‘limited use’ or ‘poor’ using expert judgement. The conclusions were reviewed by the Fisheries New Zealand Inshore Working Group (INSWG). A survey series that was judged ‘reasonable’ (or better) against all criteria was taken forwards for use in a putative partial quantitative assessment. In general, if any criterion was judged to rule out a survey series completely, further criteria were not assessed. Two discontinued survey series were considered in the context of better informing the usefulness of current surveys, but were not intended for use in a partial quantitative assessment.

**Table 2: Pelvic lengths (cm) at 50% maturity for rough skate (RSK) and smooth skate (SSK). Source: Francis et al. (2001a, b).**

Species	Female	Male
RSK	59	52
SSK	112	93

## 2.2 Partial quantitative assessments

The Partial Quantitative Assessment approach that has been applied to New Zealand stocks to derive  $B_{MSY}$  and  $F_{MSY}$  proxies required identification of a period of years where:

1. The abundance index was relatively stable and did not represent a period of lower-than-normal abundance.
2. Catch was relatively stable and did not represent a period of lower-than-normal catch.

If a suitable reference period was identified, the arithmetic mean of the survey indices over the reference period was calculated as the  $B_{MSY}$  proxy. A soft limit of 50%  $B_{MSY}$  and a hard limit of 25%  $B_{MSY}$  was also calculated. If a stable period of abundance could be identified, but at a reduced level of biomass compared with other period(s) in the abundance series, the mean over this period could be judged indicative of a hard or soft limit reference point. Because of the unreliability of landings data before skates entered the QMS, only landings data from 2003–04 were considered.

Fishing intensity (catch/biomass index) was not estimated because the quality of species identification in commercial landings was unknown and because of potentially unreported discarding. However, it was assumed that any bias in landings was sufficiently stable to allow the trend in (or stability of) landings to be used as an indicator when searching for a reference period.

## 3. RESULTS

### 3.1 Surveys providing reliable indices of abundance

The following gives a brief background for each survey series considered and information on acceptance/rejection criteria. Figures showing the survey strata for each series, together with a list of

strata depth ranges, are given in Appendix 1 (Figures 14–21). Figures showing time series of relative biomass are given in Appendix 2 (Figures 22–27). Relative biomass time series, as well as the number of fish measured for length frequency data are given in Table 3 for RSK and Table 4 for SSK and figures of raised length frequency distributions for surveys with sufficient length measurements are given in Appendix 3 (Figures 28–33). Lengths of fish and depths of hauls from observer data are given in Appendix 4 (Figures 34–41). Locations of positive catches from all research trawl surveys, divided into six length classes of roughly equal width but distinguishing fish above 50% maturity, are given in Appendix 5 Figure 42–45).

### **Observer length frequencies**

Of the quota management areas defined for RSK and SSK, only QMA 1 and QMA 3 provided sufficient length measurements from observer data to give a representative picture of the depth distribution and length distribution of RSK and SSK caught commercially (see Appendix 4, Figure 34 to Figure 37 for depths, Figure 38 to Figure 41 for lengths).

### **Hauraki Gulf (HAGU); QMA 1**

Surveys in the Hauraki Gulf were conducted in 1984–1990, 1992–94, 1997, 2000, and re-initiated in 2019. The focus of these surveys was initially on adult snapper but shifted in the mid-1980s to pre-recruit snapper. This is also the target for the re-initiated survey series, and the deep shelf stratum from the older survey time series (75–150 m) has been removed (Parsons et al. 2021). The deepest strata now only extend to 75 m (see Figure 14 in Appendix 1). Table 3 provides the adjusted relative biomass estimate and CV, and number of individuals measured, from strata < 75 m depth for the surveys to 2000.

RSK were caught in low numbers (usually <10 individuals) in some HAGU surveys up to 2000, and in only one of the two surveys since 2019 (Table 3). SSK were only caught in two of the HAGU surveys up to 2000 and have not been caught in more recent surveys (Table 4). Observer records from QMA 1 indicated RSK and SSK were regularly caught from 25 m to depths of 75–125 m and 75–150 m, respectively (see Figure 34 and Figure 35). This survey was therefore not considered further for RSK or SSK.

### **Bay of Plenty (BPLE); QMA 1**

Surveys in the Bay of Plenty (BPLE) were conducted in 1983, 1985, 1990, 1992, 1996, 1999, and re-initiated in 2020 (Parsons et al. 2021). The depth range of historical surveys varied, extending from 150 m to as deep as 300 m (Morrison et al. 2001), but, like the HAGU survey, the re-initiated survey is focused on targeting pre-recruit snapper, and deeper strata (> 100 m) have been removed (see Figure 15).

RSK were regularly recorded in BPLE surveys up to 2000 in small numbers, although they were not identified to species in 1990. They have been caught in small numbers again (< 5 measured) in the two surveys from 2020 (Table 3). SSK were only caught in two of the BPLE surveys up to 2000 and have not been caught in the surveys since 2020 (Table 4). However, fish caught at depths of 100–125 m (RSK) and 100–150 m (SSK) appeared regularly in the observer data for QMA 1 (see Figure 34 and Figure 35). This survey was therefore not considered further for RSK or SSK.

### **East coast South Island (ECSI); QMA 3**

Surveys of the east coast South Island (ECSI) encompass inshore waters from the Waiau river to Shag Point and were originally conducted in winter (May–June) between 1991 and 94 and in 1996 before being discontinued and replaced with summer surveys between 1996 and 2000 (Beentjes & MacGibbon 2013). Winter surveys resumed in 2007 and, starting in 2012, have been conducted every second year with the exception that the COVID pandemic caused the 2020 survey to be delayed to 2021 (Beentjes et al. 2022). A review of QMS species to be included in the time series was completed following the resumption of winter surveys and the working group recommended that both RSK and SSK be included in survey reports (Beentjes and MacGibbon 2013).

**Table 3: RSK relative biomass estimates (t) and associated % CVs, and number of fish measured for length frequency data from candidate survey time series (see Table 1 for full survey names). A ‘-’ indicates no survey (or no CV possible) and a ‘0’ indicates no fish caught (or if CV present <0.5 t). For surveys where alternative series depending on choice of strata were considered, the series judged most appropriate for the species is presented.**

Year	HAGU*			BPLE*			ECSI (inc. 10–30 m strata)			Chatham Rise (core strata)			SUBA (core strata)			WCSI inshore (all strata)			WCSI offshore (all strata)			WCNI (inc. southern strata)		
	B (t)	CV	No.	B (t)	CV	No.	B (t)	CV	No.	B (t)	CV	No.	B (t)	CV	No.	B (t)	CV	No.	B (t)	CV	No.	B (t)	CV	No.
1983	-	-	-	47	34	42	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1984	33	97	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1985	0	-	0	0	-	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1986	21	72	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1987	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1988	78	34	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1989	2	100	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1990	0	-	0	0	-	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1991	-	-	-	-	-	-	-	-	-	-	-	42	73	0	-	-	-	-	-	-	-	50	46	23
1992	0	-	0	0	-	0	-	-	94	63	0	52	69	0	173	28	0	-	-	-	-	-	-	-
1993	25	35	8	-	-	-	-	-	55	83	0	133	57	0	-	-	-	-	-	-	-	-	-	-
1994	0	100	1	-	-	-	-	-	221	44	0	-	-	-	196	23	0	-	-	-	-	-	-	-
1995	-	-	-	-	-	-	-	-	76	43	0	-	-	-	251	22	0	-	-	-	-	-	-	-
1996	-	-	-	53	39	0	-	-	11	100	1	-	-	-	-	-	-	-	-	-	-	-	-	-
1997	0	-	0	-	-	-	-	-	12	58	3	-	-	-	185	31	137	-	-	-	-	-	-	-
1998	-	-	-	-	-	-	-	-	10	100	1	-	-	-	-	-	-	-	-	-	-	-	-	-
1999	-	-	-	48	35	5	-	-	34	60	3	-	-	-	-	-	-	-	-	-	-	-	-	-
2000	0	-	0	-	-	-	-	-	0	-	0	201	56	12	186	23	154	-	-	-	-	-	-	-
2001	-	-	-	-	-	-	-	-	72	59	6	158	51	5	-	-	-	-	-	-	-	-	-	-
2002	-	-	-	-	-	-	-	-	37	65	3	55	47	9	-	-	-	-	-	-	-	-	-	-
2003	-	-	-	-	-	-	-	-	32	64	4	78	43	9	43	34	44	-	-	-	-	-	-	-
2004	-	-	-	-	-	-	-	-	22	60	2	25	72	6	-	-	-	-	-	-	-	-	-	-
2005	-	-	-	-	-	-	-	-	89	45	15	116	46	8	58	30	36	-	-	-	-	-	-	-
2006	-	-	-	-	-	-	-	-	56	59	3	159	74	8	-	-	-	-	-	-	-	-	-	-
2007	-	-	-	-	-	-	1 261	16	531	29	95	1	115	67	9	256	23	184	-	-	-	-	-	-
2008	-	-	-	-	-	-	-	-	0	-	0	362	57	15	-	-	-	-	-	-	-	-	-	-
2009	-	-	-	-	-	-	-	-	23	67	3	190	52	7	114	22	93	-	-	-	-	-	-	-
2010	-	-	-	-	-	-	-	-	0	-	0	-	-	-	-	-	-	-	-	-	-	-	-	-
2011	-	-	-	-	-	-	-	-	154	55	15	106	62	6	347	23	221	-	-	-	-	-	-	-
2012	-	-	-	-	-	-	1 414	16	826	0	-	0	68	75	4	-	-	12	39	17	-	-	-	-
2013	-	-	-	-	-	-	-	-	38	78	3	-	-	-	243	24	206	8	40	13	-	-	-	-
2014	-	-	-	-	-	-	1 597	28	769	37	69	3	11	93	2	-	-	-	-	-	-	-	-	-
2015	-	-	-	-	-	-	-	-	-	-	-	-	-	-	139	20	92	-	-	-	-	-	-	-
2016	-	-	-	-	-	-	1 576	22	742	47	65	5	6	100	2	-	-	4	48	4	-	-	-	-
2017	-	-	-	-	-	-	-	-	-	-	-	-	-	-	270	21	194	-	-	-	-	-	-	-
2018	-	-	-	-	-	-	1 213	14	497	10	83	2	466	90	25	-	-	5	51	6	100	37	15	-
2019	27	62	3	-	-	-	-	-	-	-	-	-	-	-	132	26	122	-	-	-	172	35	31	-
2020	0	-	0	9	75	2	-	-	0	-	0	130	57	6	-	-	-	-	-	-	132	21	36	-
2021	-	-	-	1	100	1	2 486	19	970	-	-	-	-	-	123	26	60	5	48	9	-	-	-	-

\* Values re-calculated using strata < 75 m depth for the surveys to 2000 (HAGU), < 100m depth for surveys to 1999 (BPLE).

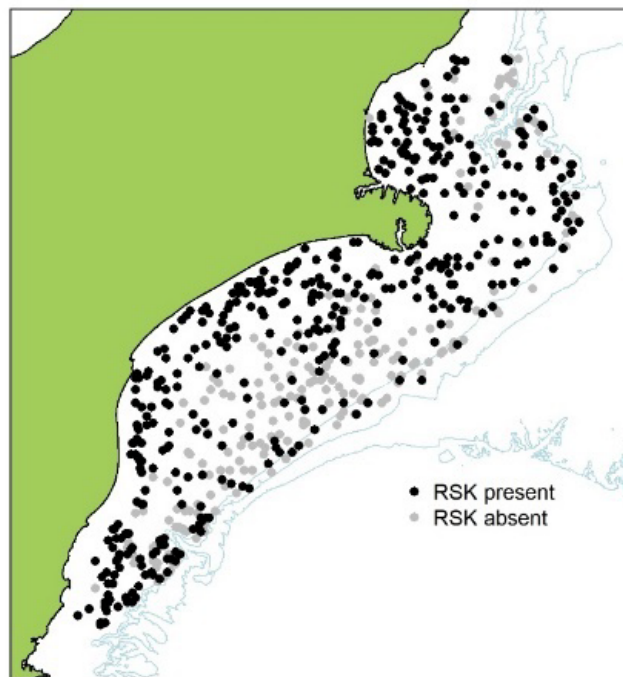
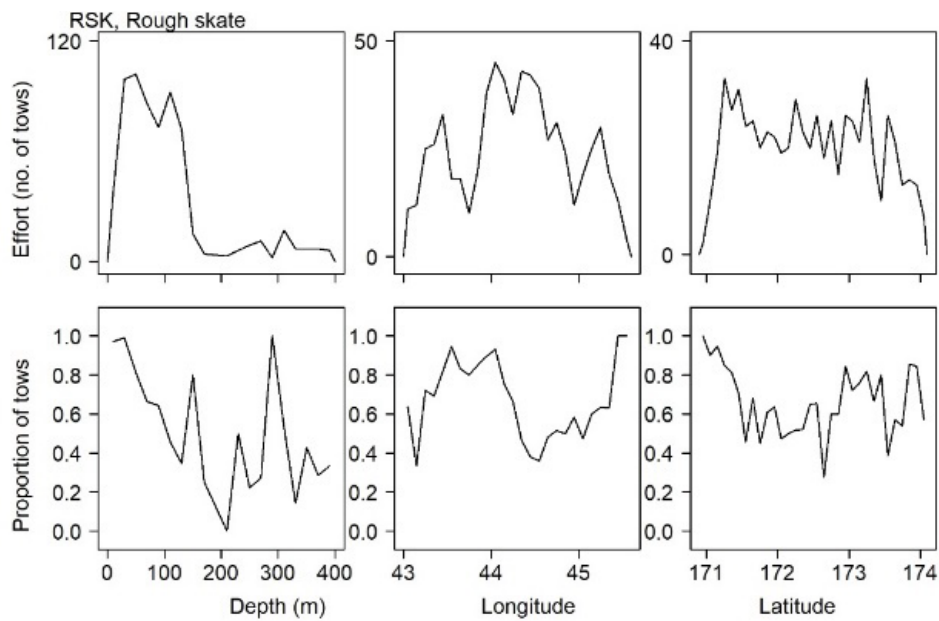
**Table 4: SSK relative biomass estimates (t) and associated % CVs, and number of fish measured for length frequency data from candidate survey time series (see Table 1 for full survey names). A ‘-’ indicates no survey (or no CV possible) and a ‘0’ indicates no fish caught (or if CV present <0.5 t). For surveys where alternative series depending on choice of strata were considered, the series judged most appropriate for the species is presented.**

Year	HAGU*			BPLE*			ECSI (core strata)			Chatham Rise (core strata)			SUBA (core strata)			WCSI inshore (west coast strata)			WCSI offshore (‘all’ strata)			WCNI (inc. southern strata)		
	B (t)	CV	No.	B (t)	CV	No.	B (t)	CV	No.	B (t)	CV	No.	B (t)	CV	No.	B (t)	CV	No.	B (t)	CV	No.	B (t)	CV	No.
1983	-	-	-	0	-	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1984	0	-	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1985	0	-	0	0	-	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1986	0	-	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1987	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1988	0	-	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1989	0	-	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1990	0	-	0	75	48	30	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1991	-	-	-	-	-	-	-	-	-	-	-	386	23	0	-	-	-	-	-	-	-	379	100	0
1992	0	-	0	0	-	0	605	18	0	1 062	28	0	119	45	0	325	19	0	-	-	-	-	-	-
1993	0	-	0	-	-	-	658	25	0	1 072	18	0	118	43	0	-	-	-	-	-	-	-	-	-
1994	232	28	7	-	-	-	306	25	0	976	23	0	-	-	-	341	18	0	-	-	-	-	-	-
1995	-	-	-	-	-	-	-	-	-	715	31	0	-	-	-	315	20	0	-	-	-	-	-	-
1996	-	-	-	0	-	0	385	24	35	1 511	30	29	-	-	-	-	-	-	-	-	-	-	-	-
1997	182	50	72	-	-	-	-	-	-	1 932	22	54	-	-	-	294	27	70	-	-	-	-	-	-
1998	-	-	-	-	-	-	-	-	-	1 425	26	28	-	-	-	-	-	-	-	-	-	-	-	-
1999	-	-	-	8	84	0	-	-	-	1 738	20	38	-	-	-	-	-	-	-	-	-	-	-	-
2000	0	-	0	-	-	-	-	-	-	1 369	23	50	435	66	8	140	29	59	-	-	-	-	-	-
2001	-	-	-	-	-	-	-	-	-	2 321	19	89	636	43	7	-	-	-	-	-	-	-	-	-
2002	-	-	-	-	-	-	-	-	-	2 111	17	83	299	65	12	-	-	-	-	-	-	-	-	-
2003	-	-	-	-	-	-	-	-	-	1 355	21	64	475	60	11	91	79	14	-	-	-	-	-	-
2004	-	-	-	-	-	-	-	-	-	2 006	21	50	331	52	12	-	-	-	-	-	-	-	-	-
2005	-	-	-	-	-	-	-	-	-	1 780	24	47	34	86	4	63	33	17	-	-	-	-	-	-
2006	-	-	-	-	-	-	-	-	-	1 521	29	40	995	43	11	-	-	-	-	-	-	-	-	-
2007	-	-	-	-	-	-	709	20	300	1 922	17	55	483	52	11	46	49	23	-	-	-	-	-	-
2008	-	-	-	-	-	-	554	18	277	1 376	26	40	1 406	51	9	-	-	-	-	-	-	-	-	-
2009	-	-	-	-	-	-	736	23	406	1 162	18	68	648	76	11	67	61	14	-	-	-	-	-	-
2010	-	-	-	-	-	-	-	-	-	1 576	21	49	-	-	-	-	-	-	-	-	-	-	-	-
2011	-	-	-	-	-	-	-	-	-	1 009	32	39	1 660	79	18	177	34	44	-	-	-	-	-	-
2012	-	-	-	-	-	-	1 025	35	366	813	22	37	680	74	7	-	-	-	239	30	66	-	-	-
2013	-	-	-	-	-	-	-	-	-	1 494	20	42	-	-	-	187	29	52	272	23	81	-	-	-
2014	-	-	-	-	-	-	637	20	204	1 309	22	38	1 012	37	18	-	-	-	-	-	-	-	-	-
2015	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	342	25	68	-	-	-	-	-	-
2016	-	-	-	-	-	-	663	17	205	1 662	22	53	323	50	4	-	-	-	238	45	27	-	-	-
2017	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	62	37	19	-	-	-	-	-	-
2018	-	-	-	-	-	-	664	23	205	1 529	22	38	141	92	5	-	-	-	225	22	49	192	66	4
2019	0	-	0	-	-	-	-	-	-	-	-	-	-	-	-	190	29	35	-	-	-	250	40	12
2020	0	-	0	0	-	0	-	-	-	847	29	19	803	60	10	-	-	-	-	-	-	154	39	7
2021	-	-	-	0	-	0	909	28	259	-	-	-	-	-	-	103	43	27	212	31	48	-	-	-

\* Values re-calculated using strata < 75 m depth for the surveys to 2000 (HAGU), < 100m depth for surveys to 1999 (BPLE).

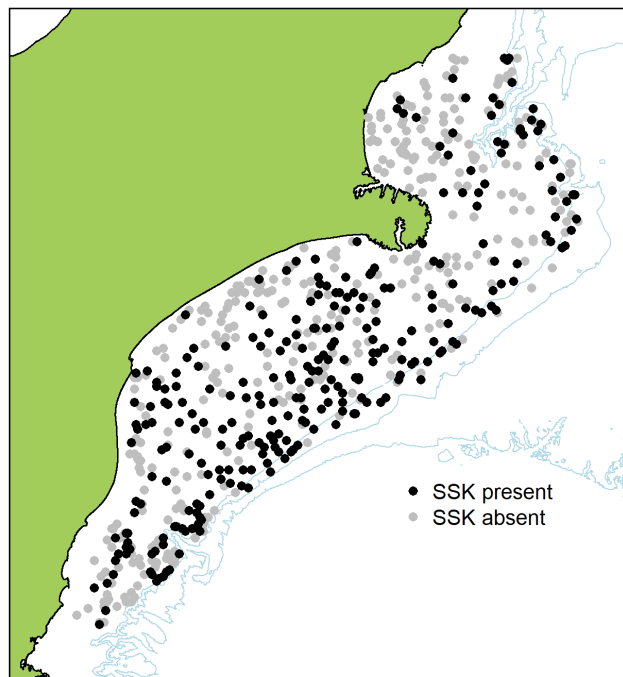
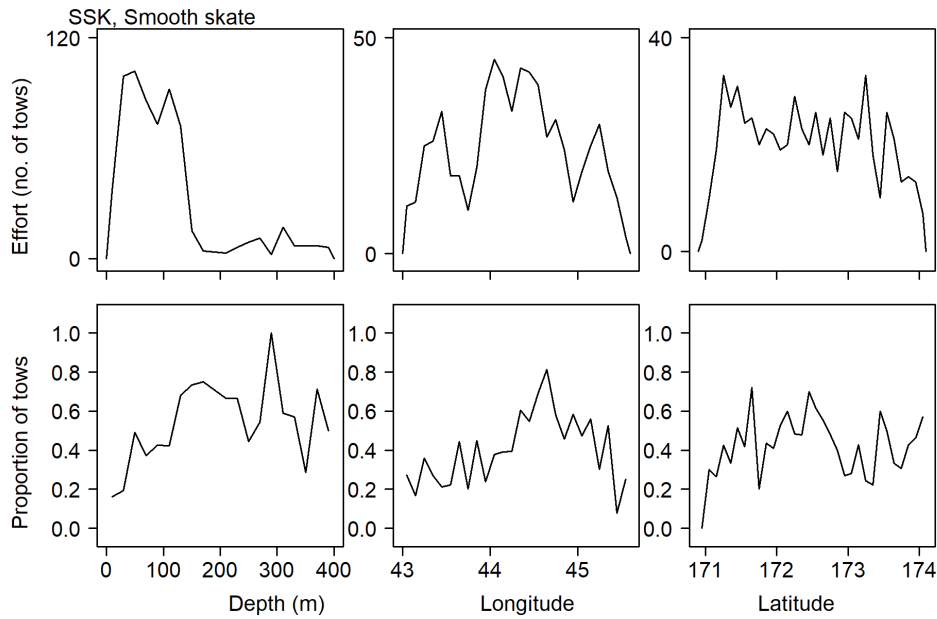
In the current updated analysis, the results from the 1991 survey were not included because all skates were recorded as RSK, and it is possible no distinction was made between rough and smooth skates in that year. Core strata (sampled from 1991) span depths from 30 to 400 m. In 2007, strata covering depths of 10–30 m were added. RSK were caught in 10–400 m, with distribution plots showing the shallow strata to be especially important and reduced occurrence deeper than 200 m (Figure 1a). As such, the time series including the 10–30 m strata starting from 2007 was considered. SSK was caught in 10–400 m, but the shallow strata were much less important (Figure 1b), so the full core strata time series going back to 1992 was considered.

a)



**Figure 1: Distribution of ECSI survey tows showing locations of positive catches for a) RSK and b) SSK. (Continued on next page)**

b)



**Figure 1: continued.**    b) SSK.

Both species of skate were commonly caught in this survey, with the highest numbers of any of the surveys considered (Table 3 and Table 4). Beentjes & MacGibbon (2013) reported that rough skate were caught in 25–61% of tows, although abundance overall compared with other species was low. The RSK relative biomass CVs were all less than 30% (14–28%) and the number of fish measured for length frequencies was considered very good with > 500 measured in almost every year (Table 3). Between-year consistency of the relative biomass estimates was judged as very good (Table 3 and Figure 22a).

Observers recorded some RSK deeper than the 400 m maximum depth of the ECSI survey (Figure 36), but recorded lengths of both males (15–70 cm) and females (15–75 cm) in the surveys were representative of the full range sampled in the commercial catch in QMA 3 (Figure 40 cf. Figure 28).

Plotting positive catches across all research surveys indicates RSK of all lengths remain in the area surveyed by the ECSI survey (Figure 16, Figure 42, and Figure 43). The population scaled length frequency distributions for both sexes covered both juvenile and adults, with an adult male mode distinguishable in more recent surveys only. Consistency of the length frequency data between years was considered very good (Figure 28). This survey was taken forward as a candidate for partial quantitative assessment.

In their previous review, Beentjes & MacGibbon (2013) reported that smooth skate were present in 25–50% of all tows, but not abundant. For SSK relative biomass, CVs were all less than 30% (except for 2012). Between year consistency of the relative biomass estimates was judged as very good (Table 4 and Figure 22b). From 2007 the number of fish measured was considered good with > 200 individuals per survey (Table 4). The length range sampled was also considered representative, comprising multiple year classes, but with clear modes absent from most surveys (Figure 29). For males, length ranged from 14 to 120 cm, representative of the size range sampled in the commercial catch in QMA 3 (Figure 41 cf. Figure 29), but with the majority of fish sampled below the length at 50% maturity in both the commercial and survey samples. Female SSK sampled in the survey ranged from 12 to 145 cm, although numbers of mature fish above 100 cm were very low. Observer data recorded SSK deeper than the maximum depth of the ECSI survey (Figure 37), with large, mature, female SSK recorded, but also in low numbers (Figure 41). Presence-absence data by classes of fish length, displayed for all trawl research surveys, showed an increase in female SSK catch locations on Chatham Rise and a reduction of locations in the ECSI survey area for female lengths approaching and above length at 50% maturity (Figure 44). This survey was taken forwards as a candidate for partial quantitative assessment but with the proviso it was possibly considered a juvenile index.

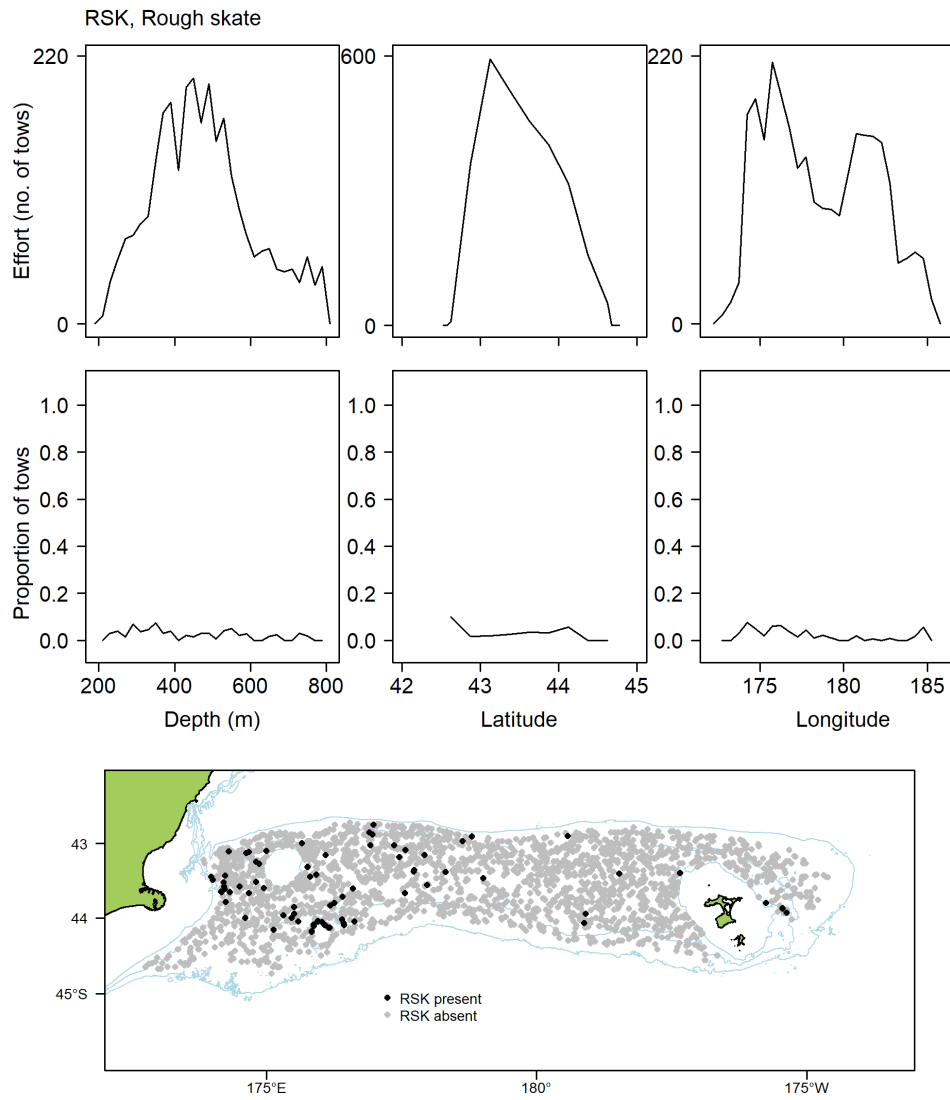
### **Chatham Rise; QMA 3**

Chatham Rise middle depth surveys were conducted annually from 1992 to 2014, and then in 2016, 2018, 2020, and 2022 (but the 2022 survey results were not available at the time of these analyses). From the first survey these included ‘core’ strata covering depths of 200–800 m. Since 2010, deepwater strata have been added (Figure 17), extending the depth range to 1300 m, but very few skate are caught deeper than the core strata (Figure 23), allowing the full time series from 1992 to be considered for abundance indices.

Relative biomass CVs for RSK were greater than 40% in all years (Table 3). Scaled length frequencies have not been calculated, because too few were caught and measured (< 100 across the series) (Table 3, Figure 2a). Therefore, the Chatham Rise survey was judged to not provide a reliable index of RSK abundance, especially when compared with the ECSI survey series which surveys RSK in the same QMA.

For SSK relative biomass CVs ranged from 17 to 31% (Table 4). Between-year consistency of the relative biomass estimates was judged as very good (Table 4 and Figure 23b) and the number of fish measured as reasonable, ranging from 19 to 89 per survey (Table 4). The survey encompasses the maximum depths associated with SSK (Figure 2b showing results for core strata), but not the shallower depths < 200 m around the Chatham Islands and Mernoo Bank, and SSK are found in shelf waters surveyed by the ECSI survey (Figure 1b). SSK caught by the Chatham Rise survey are predominantly over 50 cm in length, with smaller juveniles associated with shallower depths in other areas absent from this survey (Figure 30, Figure 44, and Figure 45). Fish of smaller lengths are caught in the commercial catch in QMA 3 other than on Chatham Rise (Figure 41). Although the smaller end of the length range is truncated, the survey does sample fish up to the maximum known lengths of both sexes, as observed in the commercial catch (Figure 41 and Figure 30). Consistency of the length frequency data was considered good. This survey was taken forward as a candidate for partial quantitative assessment.

a)



**Figure 2: Distribution of Chatham Rise survey tows showing locations of positive catches for a) RSK and b) SSK. (Continued on next page)**

b)

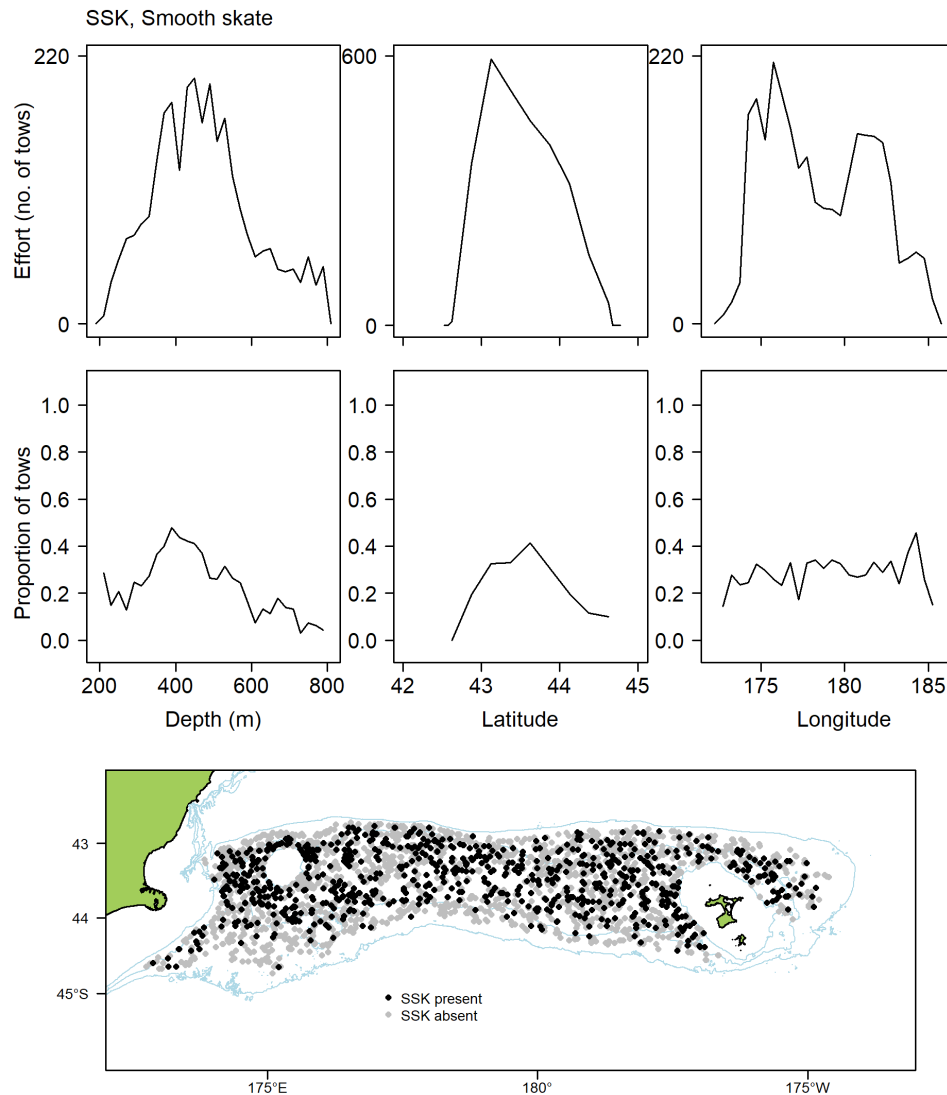


Figure 2: *continued.* b) SSK.

### Sub-Antarctic (SUBA) summer survey; QMA 3

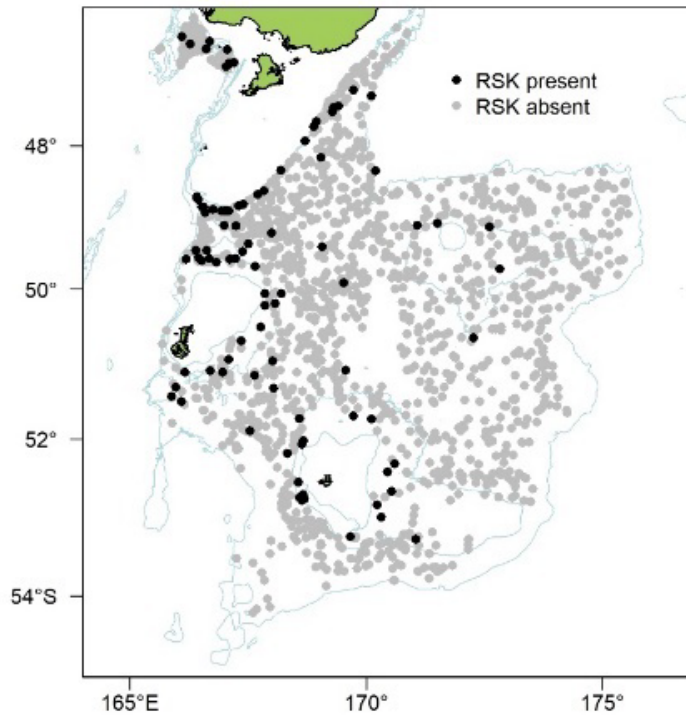
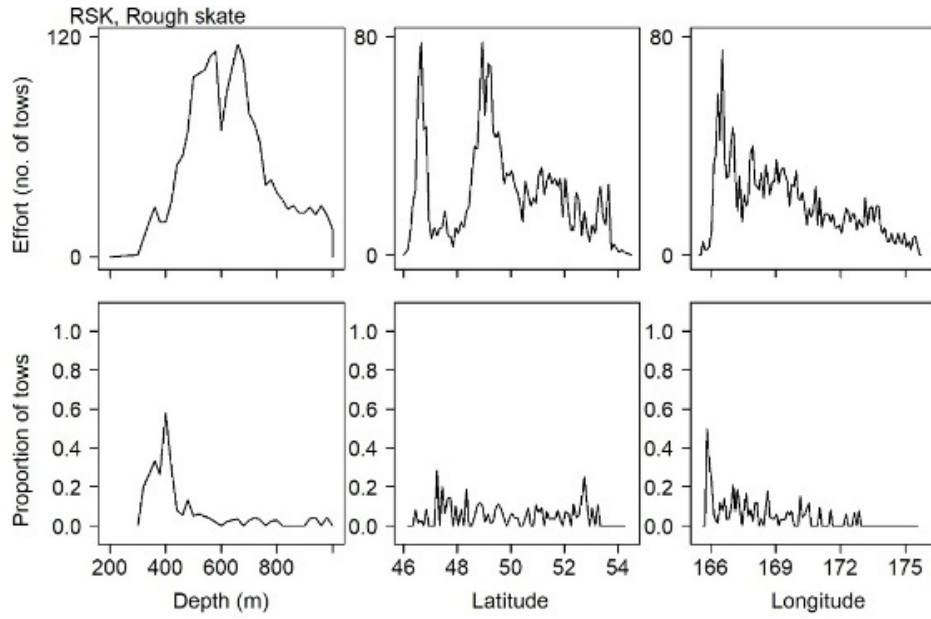
The Sub-Antarctic (SUBA) summer survey was conducted in November–December of 1991–93, 2000–09, 2011–12, 2014, 2016, 2018, and 2020. The survey encompasses the area to the south of New Zealand including Southland and Sub-Antarctic waters around Stewart Island, the Auckland Islands, and the Southern Plateau. Core strata cover depths of 300–800 m and additional ‘deep’ strata cover depths of 800–1000 m. For both RSK and SSK there was little difference in relative biomass indices between core strata and core plus deep strata (Figure 24). The core strata time series were assessed.

In their review of the summer Sub-Antarctic survey, Bagley et al. (2013) noted that rough skate are found shallower than the survey area. Data from the adjacent, discontinued Stewart-Snares shelf survey confirmed significant numbers of RSK caught on the Stewart-Snares shelf as shallow as 30 m (Figure 3). Rough skate were found in up to 60% of tows shallower than 400 m in the SUBA survey, but with steeply declining occurrence at greater depths. Numbers measured were low, generally less than 20 per survey and it was not considered possible to calculate scaled length frequencies. Relative biomass CVs for RSK were greater than 40% in all years and often considerably higher (Table 3). This survey was judged to not provide a reliable index of RSK abundance and was not taken forward as a candidate for partial quantitative assessment.

For SSK the same arguments against using the survey as an index of abundance applied. Figure 4 indicated that occurrence of smooth skate was higher on the Stewart-Snares shelf, but with occurrence in tows around 20% or lower at most depths. The Stewart-Snares shelf survey showed that SSK also occur at the shallower depths (Figure 4). All but two biomass CVs for SSK were greater than 40% and they were often considerably higher (Table 4). Numbers measured from this survey were low (< 20 per survey), with the size range of fish measured at 39–132 cm. This survey was judged to not provide a reliable index of SSK abundance and was not taken forward as a candidate for partial quantitative assessment.

Data from the Sub-Antarctic Autumn surveys, conducted in 1992–93, 1996, and 1998 showed very few of either skate species had been caught. There was insufficient information to provide further insights into fish movements or location, or habitat preferences.

a)



**Figure 3: RSK: Distribution of a) Sub-Antarctic Summer survey and b) Stewart-Snares survey showing locations of positive catches. (Continued on next page)**

b)

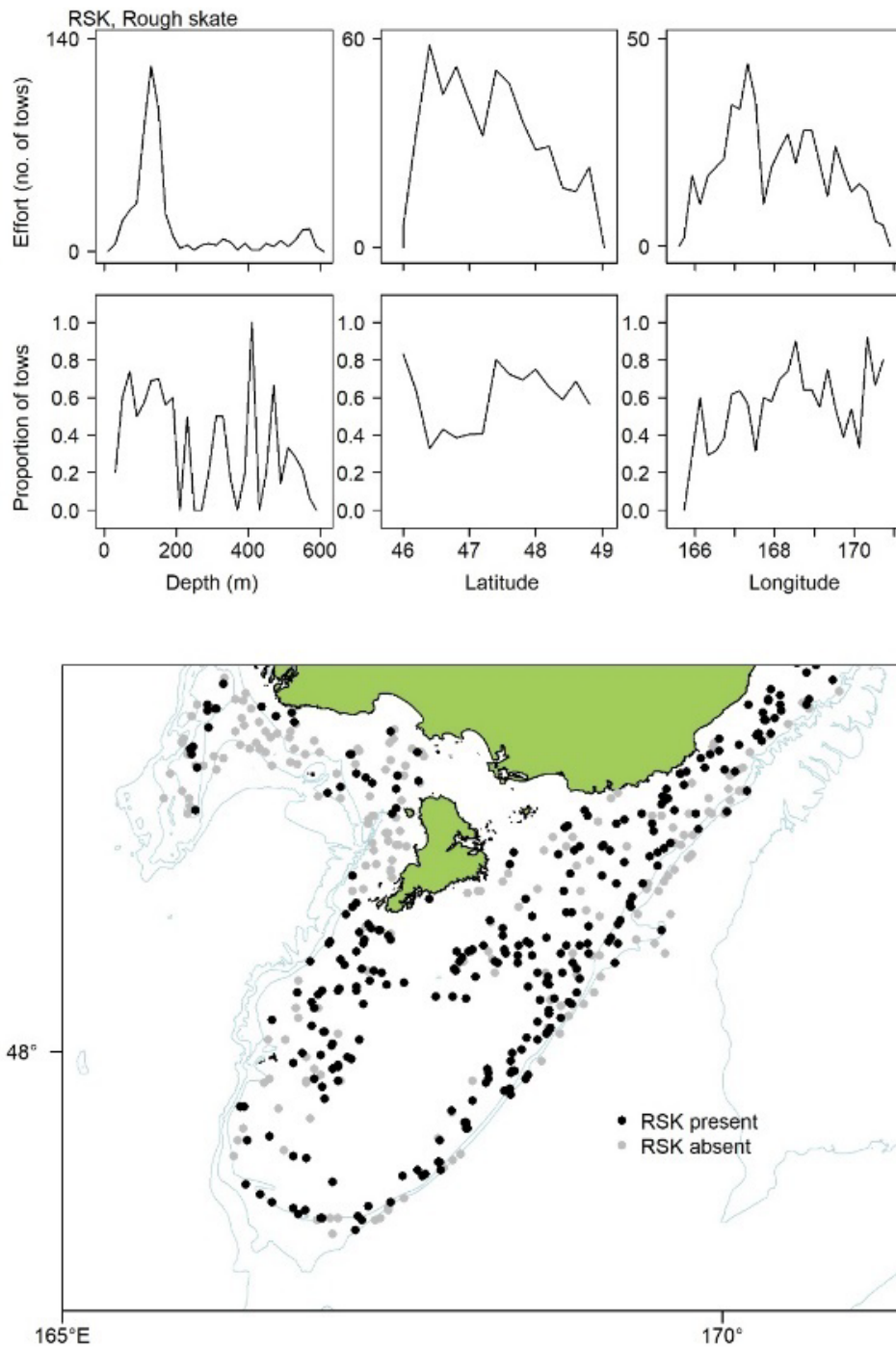
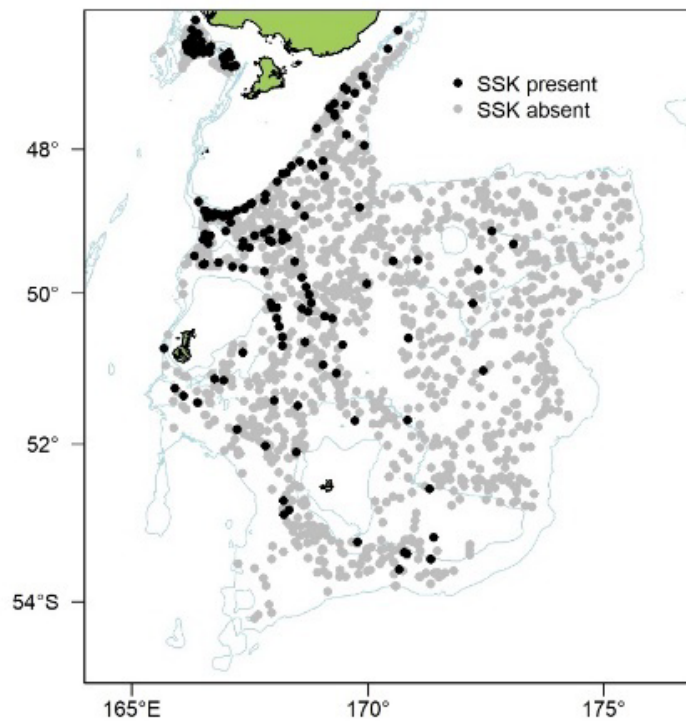
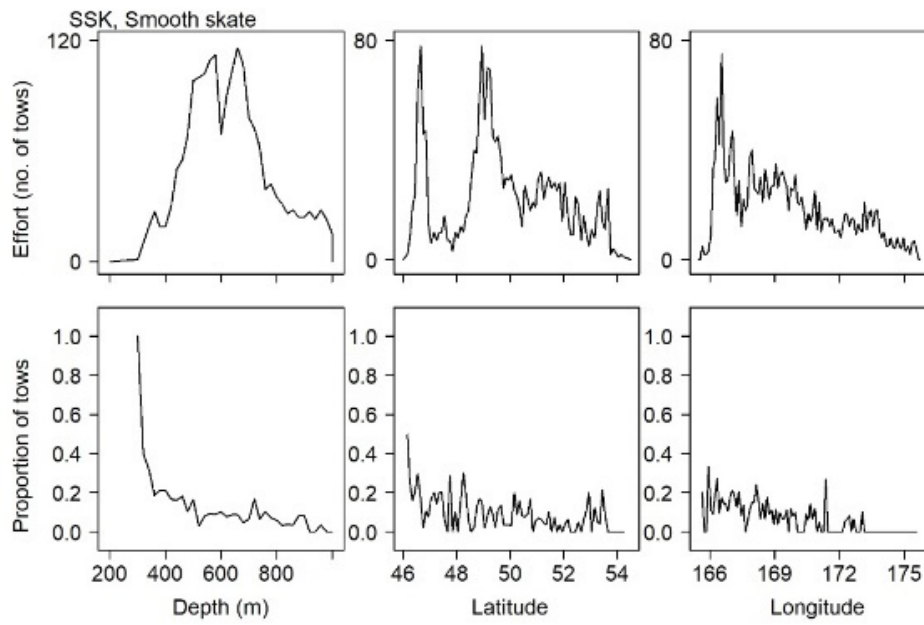


Figure 3: *continued.* b) Stewart-Snares survey showing locations of positive catches.

a)



**Figure 4: SSK: Distribution of a) Sub-Antarctic Summer survey and b) Stewart-Snares survey showing locations of positive catches. (Continued on next page)**

b)

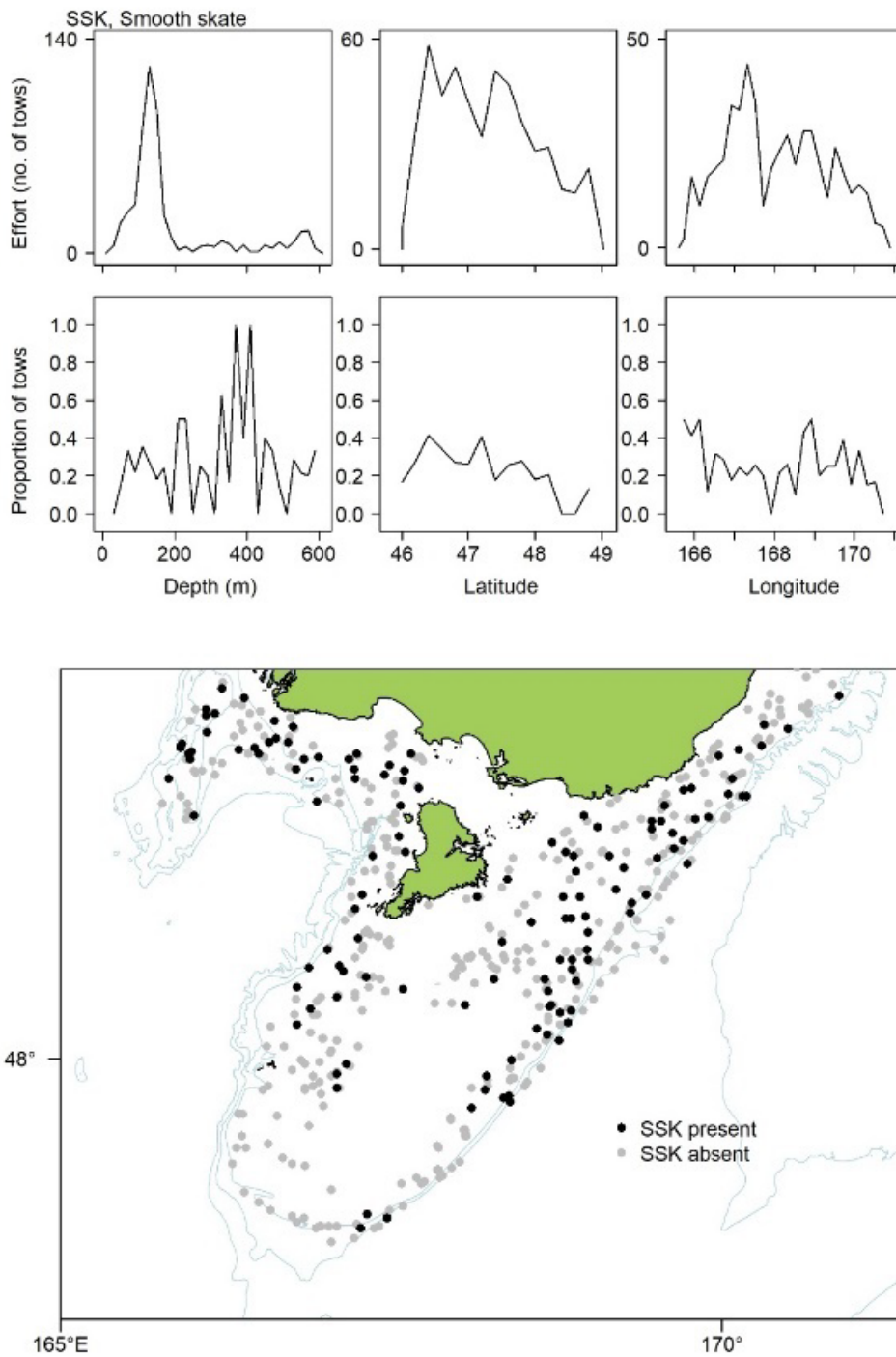


Figure 4: *continued.* b) Stewart-Snares shelf survey showing locations of positive catches.

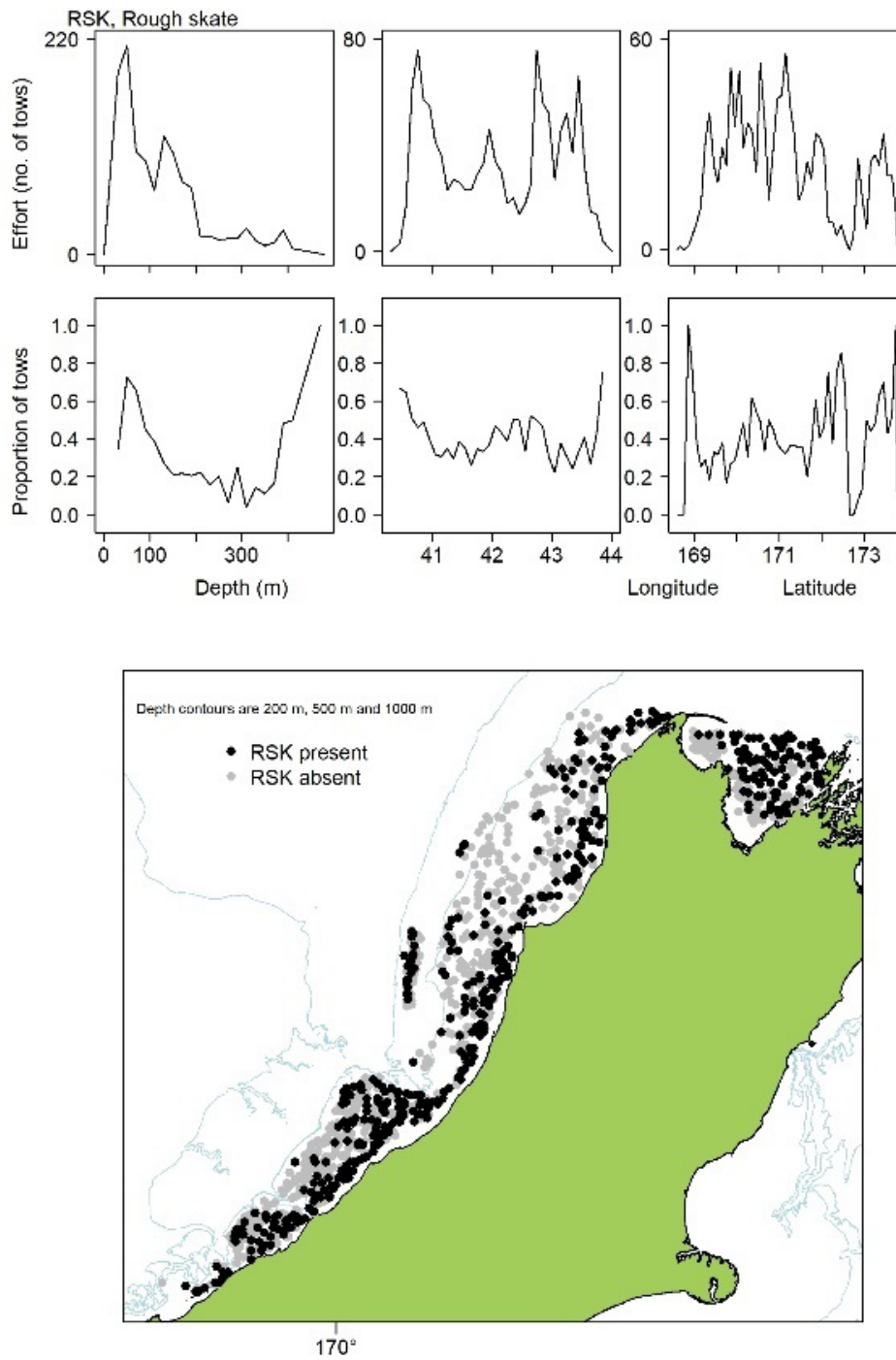
### **West coast South Island (WCSI) inshore; QMA 7**

The west coast South Island inshore trawl survey series includes Tasman Bay and Golden Bay and waters off the west coast from Cape Farewell to the Haast River Mouth. Surveys have been conducted in 1992, 1994, 1995, 1997, 2000, and then biennially from 2003 to 2021. A differentiation is made between the strata adjacent to the west coast and those located in Tasman Bay and Golden Bay (TBGB) (Figure 19). Strata have remained consistent throughout the time series covering depths of 20–400 m off the west coast and 20–70 m in the Tasman Bay and Golden Bay area. Two strata covering depths of 10–20 m were added in TBGB in 2017.

For RSK, a substantial number of fish caught in the survey came from TBGB (Figure 5a, Figure 25a) so the index formed from the combined west coast and TBGB strata was considered. Numbers caught varied from 36 in 2005 to more than 200 in later surveys, representing 17% to > 40% occurrence in tows. Relative biomass CVs for RSK are less than 30%, except for 1997 and 2003, and between-year consistency was judged as good (Table 3 and Figure 25a). The number of fish measured for length frequencies was judged as reasonable, being greater than 50 in most surveys and more than 100 in some (Table 3). It was not possible to compare length frequencies between survey and commercial data because of a lack of observer data, but the range of lengths measured during the WCSI survey was consistent with that from the ECSI survey (Figure 31 cf. Figure 28). Consistency of the length frequency data was considered very good (Figure 31). This survey was taken forward as a candidate for partial quantitative assessment.

For SSK, the index formed over the west coast strata only was considered because this species is caught in TBGB very infrequently (Figure 5b, Figure 25b). Similar to rough skate, the relative biomass estimates were relatively steady at the start of the series before dropping sharply in the early to mid-2000s, and then increasing to a peak in 2015. Relative biomass CVs for SSK were mixed, with low CVs before 2000, higher values up to nearly 80% for surveys with low biomass, and then varying values of between 25 and 43% since 2011 (Table 4). The between-year consistency was judged as good. The number of fish measured for length frequencies was variable, with < 20 per survey during the low abundance period and > 20, but less than 100, in the other surveys. Given the generally low abundance of this species, these numbers were still judged as reasonable (Table 4). It was not possible to compare length frequencies between survey and commercial data because of a lack of observer data but compared with the WCSI offshore survey, the WCSI inshore survey caught very few large, mature males and females (Figure 32, Figure 32 cf. Figure 33). Consistency of the length frequency data was considered very good (Figure 32). This survey was taken forwards as a candidate for partial quantitative assessment but with the proviso it was possibly a juvenile index.

a)



**Figure 5:** Distribution of WCSI inshore survey tows showing locations of positive catches for a) RSK and b) SSK. (Continued on next page)

b)

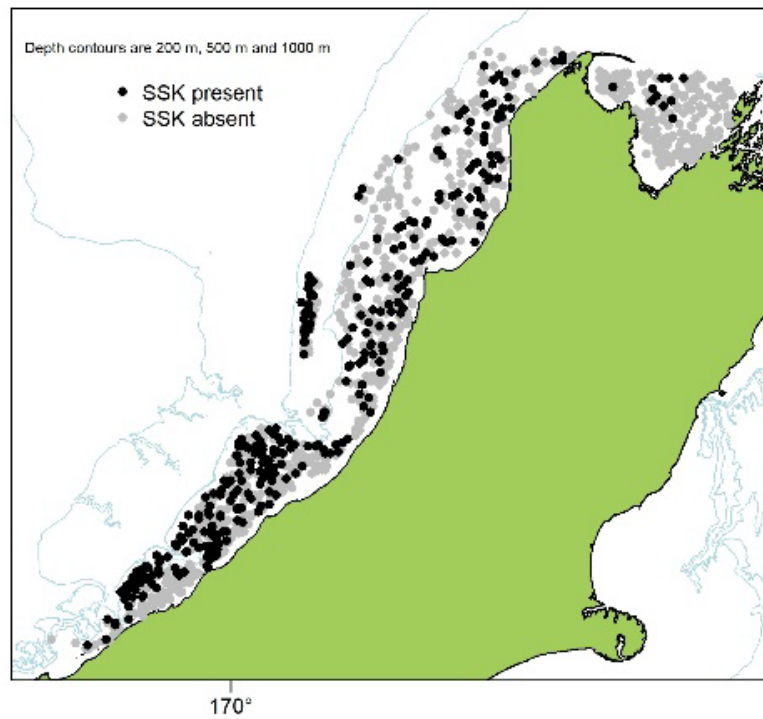
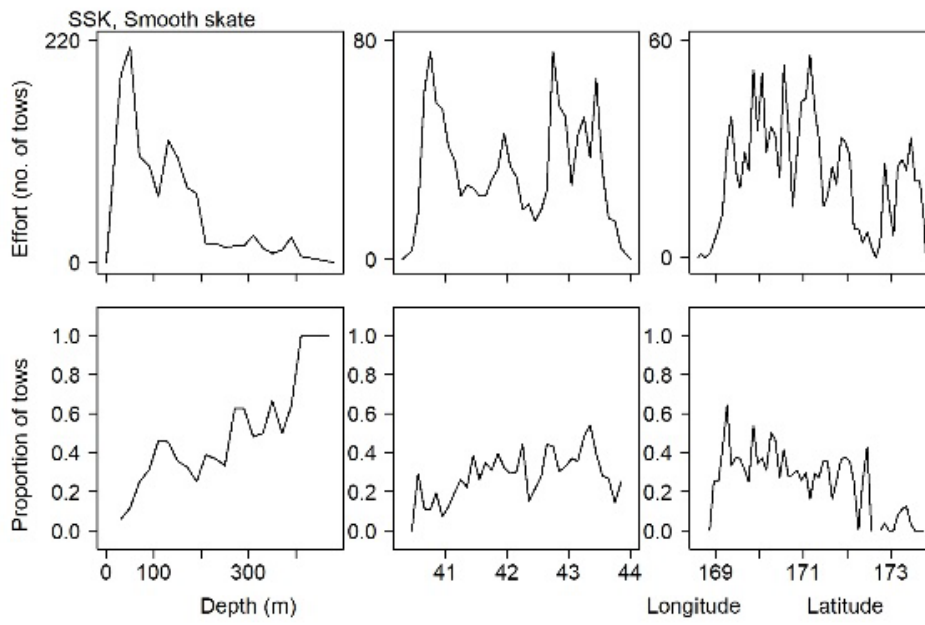


Figure 5: *continued.* b) SSK.

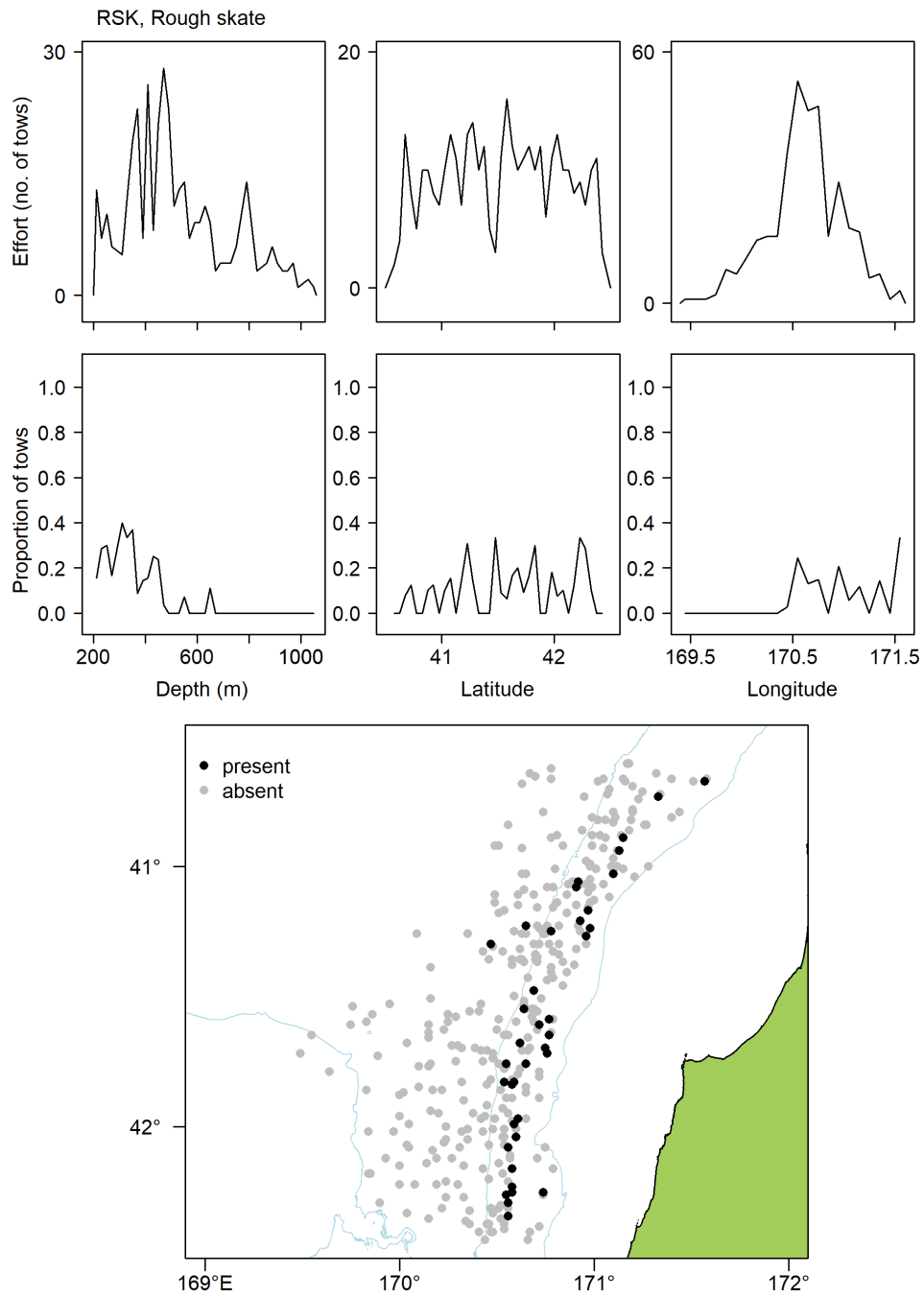
### **West coast South Island (WCSI) offshore; QMA 7**

The current WCSI offshore combined trawl and acoustic survey was first carried out in 2012, based on strata used previously in acoustic only surveys from 1988 to 2000, with the 2000 survey including a random trawl component (O’Driscoll et al. 2014). The 2012 survey added strata that covered depths of 200–300 m and 650–800 m. A further four surveys have been carried out in 2013, 2016, 2018, and 2021. The strata cover the depth range of 200–800 m to the north of Hokitika Canyon, with deeper strata down to 1000 m included from 2016. Distribution plots showed the shallow strata (200–400 m) to be important for RSK and both shallow and deep strata to be important for SSK (Figure 6a, Figure 6b), so the survey time series including the strata introduced from 2012 was selected for review.

Very few RSK were caught in this survey and the relative biomass CVs were 40% or higher. The number of fish measured for length frequencies was poor, at < 20 individuals per survey (Table 3). The occurrence was mainly at depths shallower than 400 m and represents the deeper end of the distribution off the west coast, with the survey adjoining the shallower strata of the WCSI inshore survey, where this species was more numerous. The WCSI offshore survey was judged to not provide a reliable index of RSK abundance.

Smooth skate were more widespread, mainly shallower than 600 m. The relative biomass CV was 46% in 2016 but in other years CVs have been at or below 30%. The number of fish measured for length frequencies was between 20 and 100 individuals per survey and considered reasonable for this species (Table 4). Consistency of the biomass time series was judged as good (Figure 26b). It was not possible to compare length frequencies between survey and commercial data because of a lack of observer data in this QMA, but lengths in the WCSI offshore survey ranged from 40 to 130 cm for males and up to 150 cm for females, which was comparable with lengths found in the Chatham Rise survey and included representation of mature fish (Figure 33). This survey was taken forward as a candidate for partial quantitative assessment for SSK.

a)



**Figure 6: Distribution of WCSI offshore survey tows showing locations of positive catches for a) RSK and b) SSK. (Continued on next page)**

b)

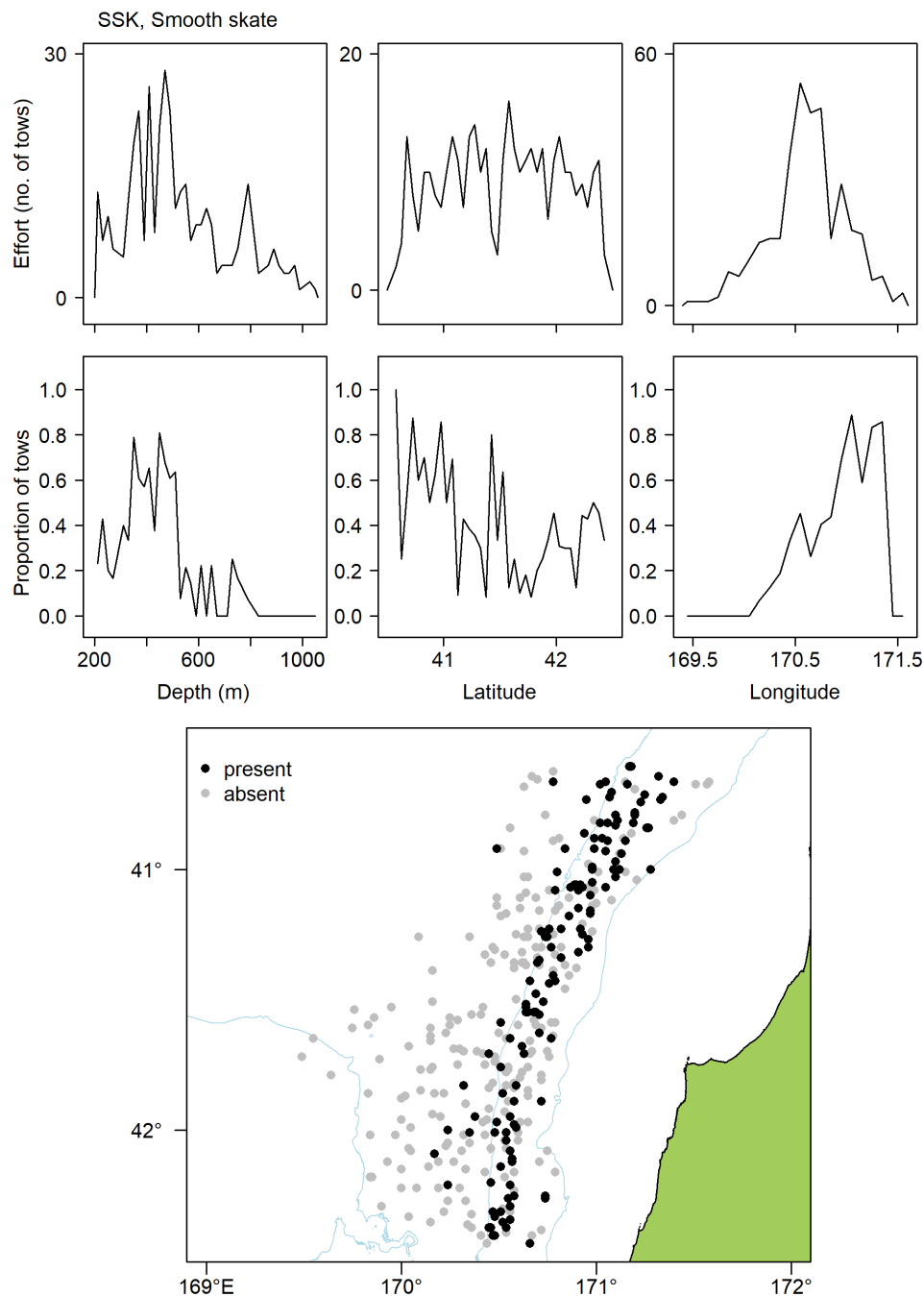


Figure 6: *continued.* b) SSK.

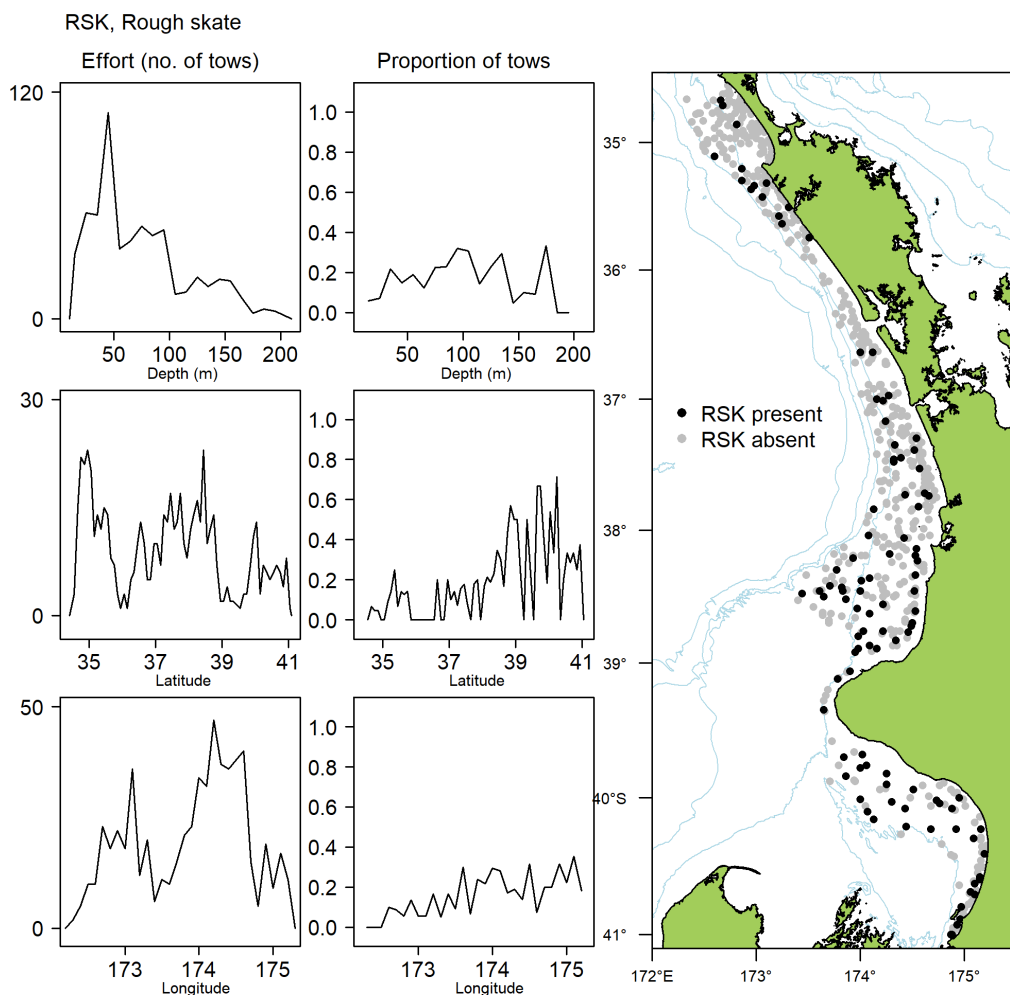
### West coast North Island (WCNI); QMA 8

Previous surveys in this region were completed in 1986, 1987, 1989, 1991, 1994, 1996, and 1999, but there have been changes in extent and strata definitions between years. The time series was re-started in 2018, with surveys also in 2019 and 2020 (Jones et al. 2022). The current series includes a core area north of New Plymouth out to 100 m surveyed since 1989, and an extended area (out to 200 m) sampled in some of those years. The ‘southern strata’, located south of New Plymouth and around to the south Taranaki Bight (Figure 21), were included in 1991 and all surveys in 2018–2020. Skate were not identified to species in 1989, and identification was variable in 1991 (separate species codes were used in the southern strata only) but considered reasonable from 1994 onwards when both codes were used.

Rough skate occurred throughout the survey area, but were less common further north, with the south Taranaki Bight having significant occurrences of fish (Figure 7a). Abundance was low, with occurrence generally less than 20% of tows across the depth range. For the ‘whole survey’ series (just four surveys), relative biomass CVs have been less than 40% for the three most recent surveys. The number of fish measured was low (15–36), but enough to form scaled length frequencies, but the resulting length frequency distributions were judged as no better than reasonable. The size caught ranged from 31 to 62 cm encompassing juveniles, mature males, but few mature females. The Inshore Working Group concluded there were insufficient data points available from surveys including the southern strata (four surveys) to form a biomass index for RSK. However, it was noted that the time series should be re-visited once more data points are available.

Numbers of smooth skate were variable between surveys, with 20–61 recorded between 1994 and 1999, but lower numbers (< 20) in years when the whole survey was covered (Figure 24), and few caught in the southern strata. The relative biomass CVs for the whole survey series have been at or above 40% (Table 4 and Figure 7b). The WCNI survey was not considered suitable for providing indices of abundance for SSK.

a)



**Figure 7: Distribution of WCNI survey tows showing locations of positive catches for a) RSK and b) SSK. (Continued on next page)**

b)

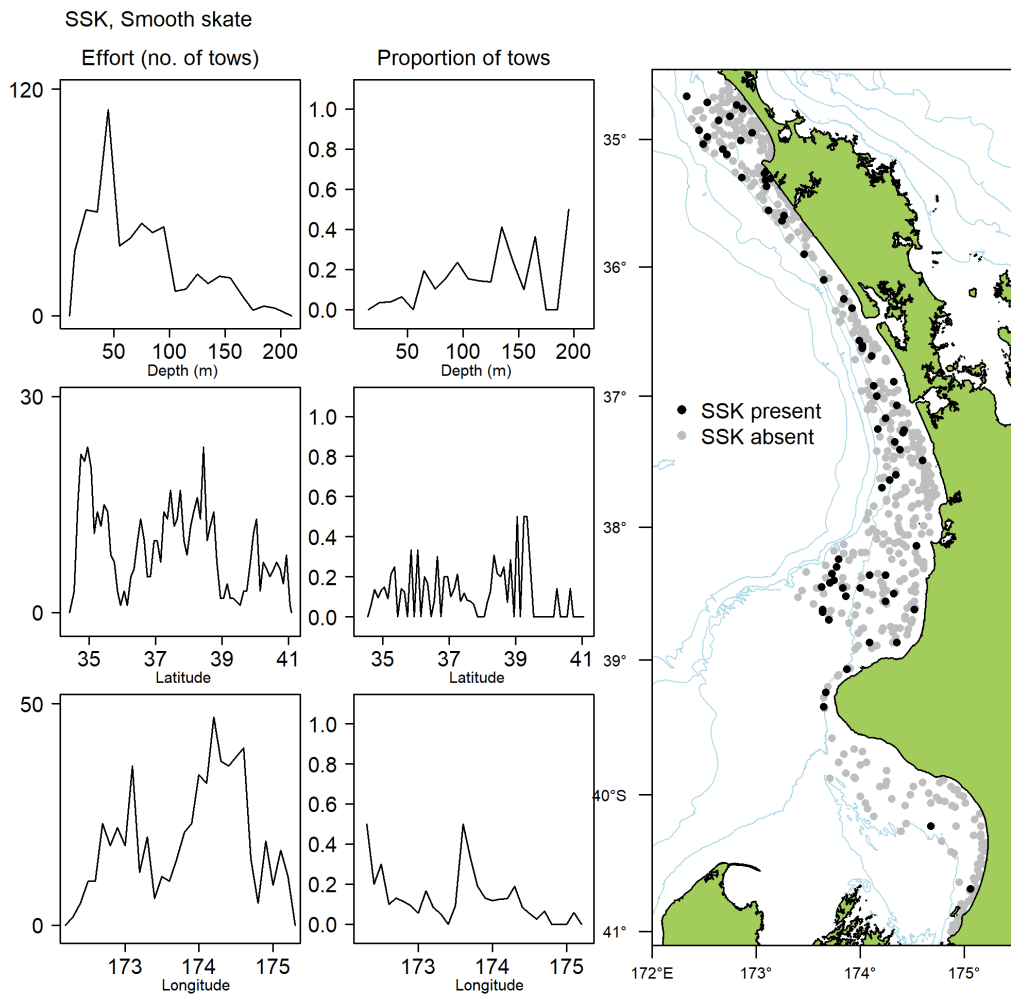


Figure 7: *continued.* b) SSK.

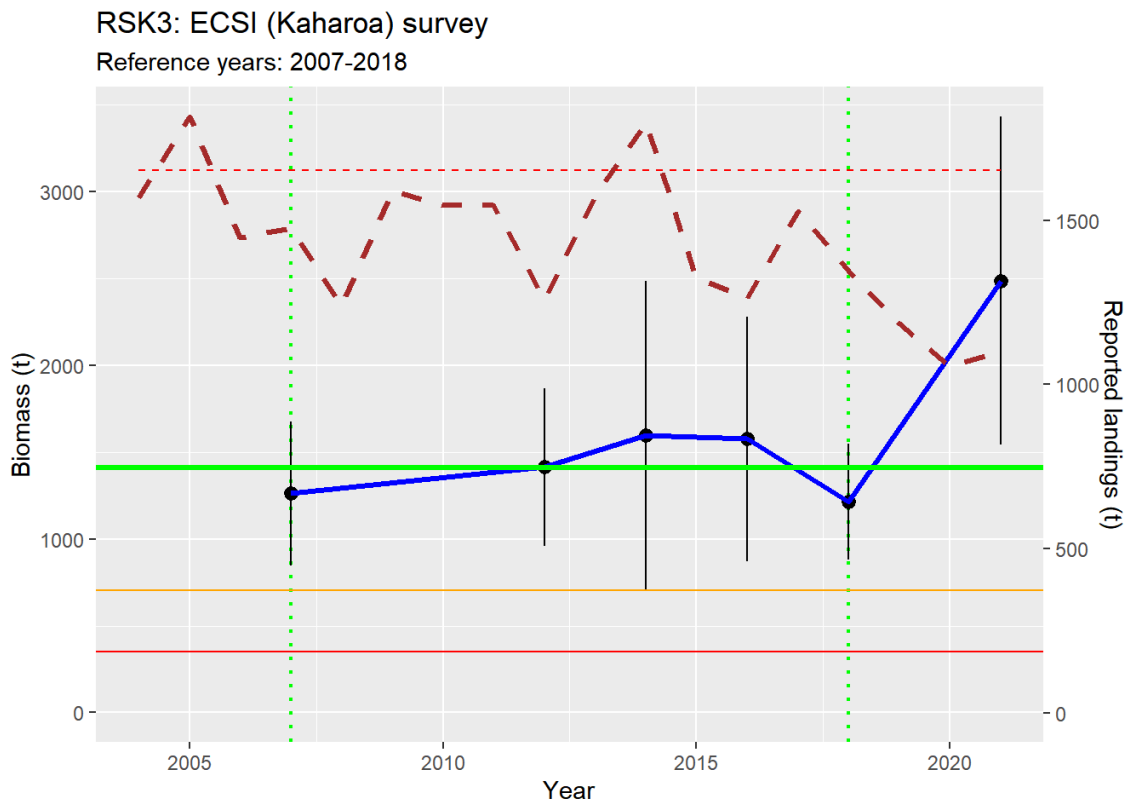
### 3.2 Partial quantitative assessments

Partial quantitative assessments were attempted for rough skate from two survey areas (ECSI and WCSI inshore), and four surveys for smooth skate (ECSI, the Chatham Rise, WCSI inshore, and WCSI offshore). All were presented to the working group (31 March 2022) for review. Only two were accepted for management advice: the ECSI for rough skate and the WCSI offshore survey for smooth skate.

#### 3.2.1 Assessments accepted as a basis for management advice

##### **RSK: East coast South Island (ECSI); RSK 3; RV *Kaharoa***

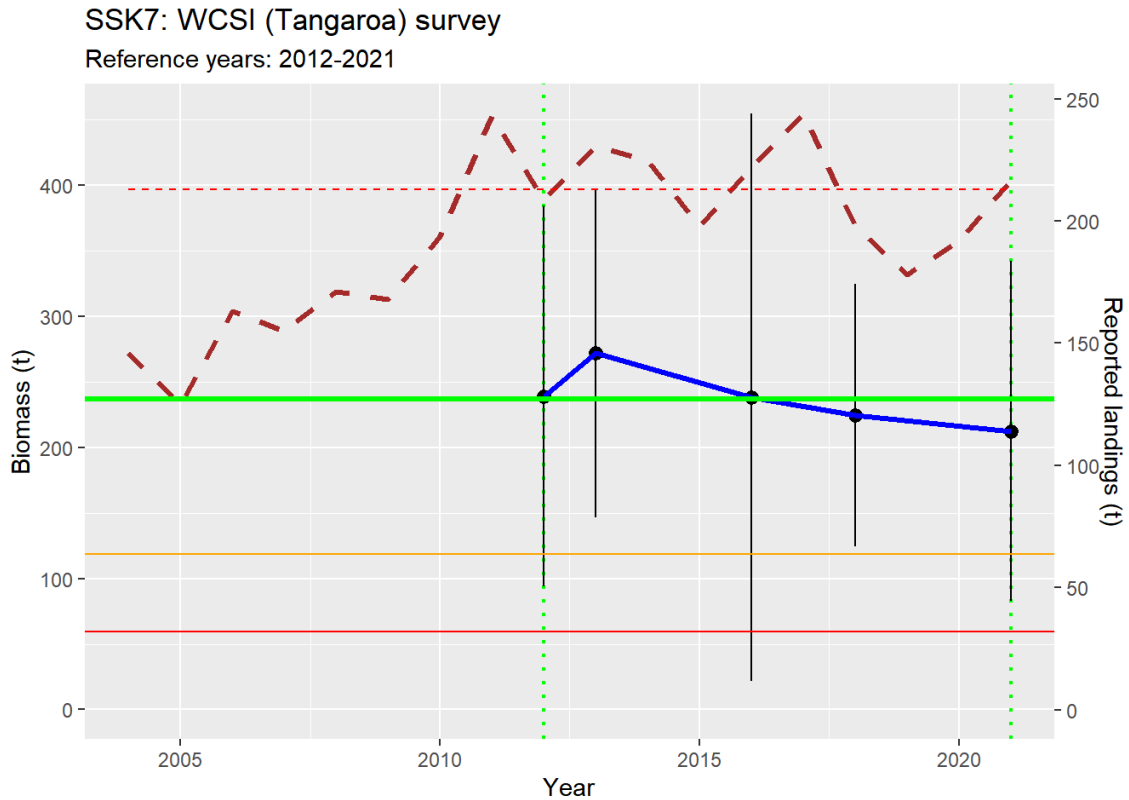
A reference period between 2007 and 2018 was identified where the biomass index was stable and where landings were relatively stable (Figure 8). The survey time series relative biomass, based on core strata, was greater from 2007 onwards compared with the 1990s (Figure 22a). Assuming the proportion of biomass in the core area to be constant over time, this implied that biomass was greater in the 2000s than in the 1990s and that the reference period was not over a period of reduced biomass. The increase in biomass was correlated with a reduction in fishing effort in the mixed species inshore trawl fishery for FMA 3 (Starr et al. in prep.).



**Figure 8:** RSK 3 relative biomass from ECSI *Kaharoa* trawl survey (blue line plus vertical lines showing  $\pm 2$  s.d. (left axis)), reported Quota Management Report/Monthly Harvest Return landings (brown dashed line), and Total Allowable Commercial Catch for RSK 3 (red dotted line (right axis)). Green line represents the  $B_{MSY}$  proxy calculated as the arithmetic mean of abundance series results from 2007 to 2018. Orange line shows soft limit (50%  $B_{MSY}$  proxy), and red line shows hard limit (25%  $B_{MSY}$  proxy).

### SSK: West coast South Island (WCSI) offshore; SSK 7; RV *Tangaroa*

A reference period between 2012 and 2021 was identified where the biomass index was stable and where landings were relatively stable. Landings were also higher in the reference period than previously (Figure 9). The survey time series biomass based on core strata was greater from 2012 compared with the estimate from 2000 (Figure 26b). Assuming the proportion of biomass in the core area to be constant over time there was no indication the reference period was taken over a period of reduced biomass.



**Figure 9:** SSK 7 relative biomass from WCSI offshore *Tangaroa* trawl survey (blue line plus vertical lines showing  $\pm 2$  s.d. (left axis)) and reported Quota Management Report/Monthly Harvest Return landings (brown dashed line) and Total Allowable Commercial Catch for SSK 7 (red dotted line) (right axis). Green line represents the  $B_{MSY}$  proxy calculated as the arithmetic mean of abundance series results from 2012 to 2021. The orange line shows soft limit (50%  $B_{MSY}$  proxy) and the red line shows hard limit (25%  $B_{MSY}$  proxy).

To test for sensitivity to the type of mean calculated over the reference period for the two accepted partial quantitative assessments, the geometric mean and variance weighted mean were calculated in addition to the arithmetic mean. Little difference was found between the means (Table 5).

**Table 5:** Reference biomass levels using alternative methods for calculating the mean of survey results from the reference period chosen for the partial quantitative assessment.

Stock	Survey	Arithmetic mean	Geometric mean	Variance weighted mean
RSK 3	ECSI ( <i>Kaharoa</i> )	237.3	236.5	235.9
SSK 7	WCSI offshore ( <i>Tangaroa</i> )	1412.2	1403.4	1320.7

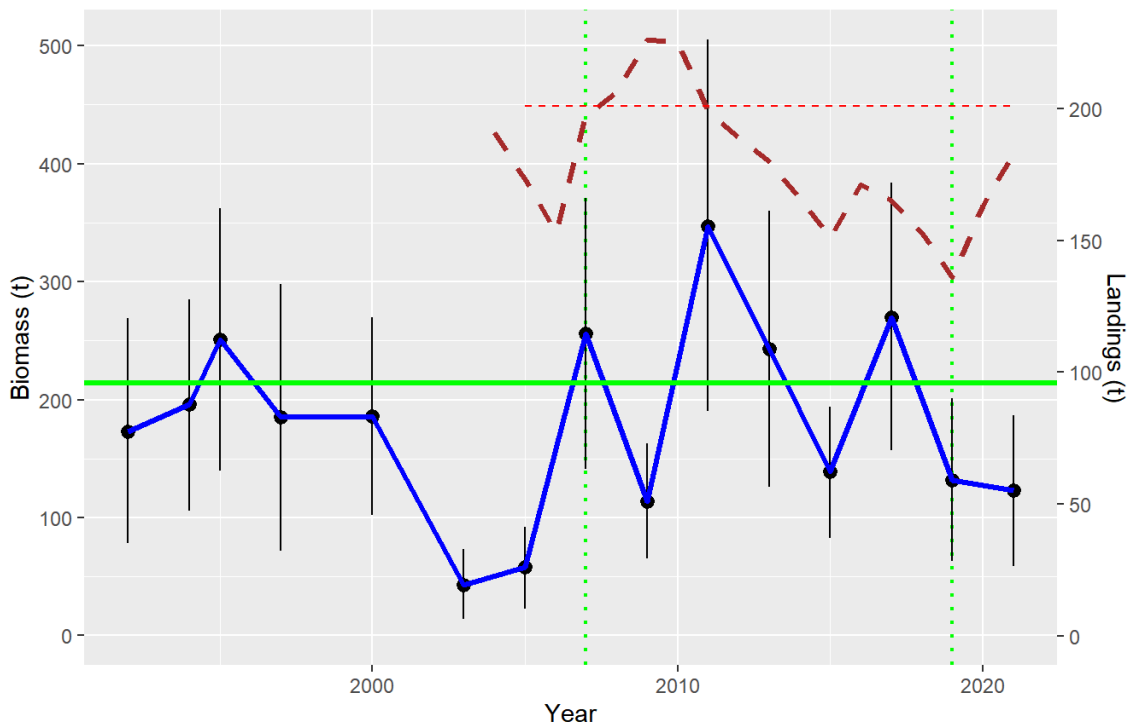
### 3.2.2 Assessments rejected as a basis for management advice

#### RSK: West coast South Island (WCSI) inshore; RSK 7; RV *Kaharoa*

In the period since introduction of RSK into the QMS there was considerable inter-annual fluctuations in relative biomass estimates. The years proposed for the reference period (2007–2019) resulted in relative biomass estimates more than 2 standard deviations away from the mean value (Figure 10). Landings in this period were also not considered stable. The INSWG did not consider any period after introduction of RSK into the QMS when landings were considered stable and in any short period that could be chosen based on relative stability of landings (e.g., 2007–2011) for the reference period, the inter-annual variability in biomass index was considered too great.

### RSK7: WCSI (Kaharoa) survey

Reference years: 2007-2019



**Figure 10:** RSK 7 relative biomass from WCSI inshore *Kaharoa* trawl survey (blue line plus vertical lines showing  $\pm 2$  s.d. (left axis)), reported Quota Management Report/Monthly Harvest Return landings (brown dashed line), and Total Allowable Commercial Catch for RSK 7 (red dotted line (right axis)). Green line represents the  $B_{MSY}$  proxy calculated as the arithmetic mean of abundance series results from 2007 to 2019.

### SSK: East coast South Island (ECSI); SSK 3; RV *Kaharoa*

For this stock, a reference period between 2009 and 2018 was proposed, but landings have not been considered stable in this or any other period since SSK entered the QMS (Figure 11).

SSK3: ECSI (Kaharoa) survey

Reference years: 2009-2018

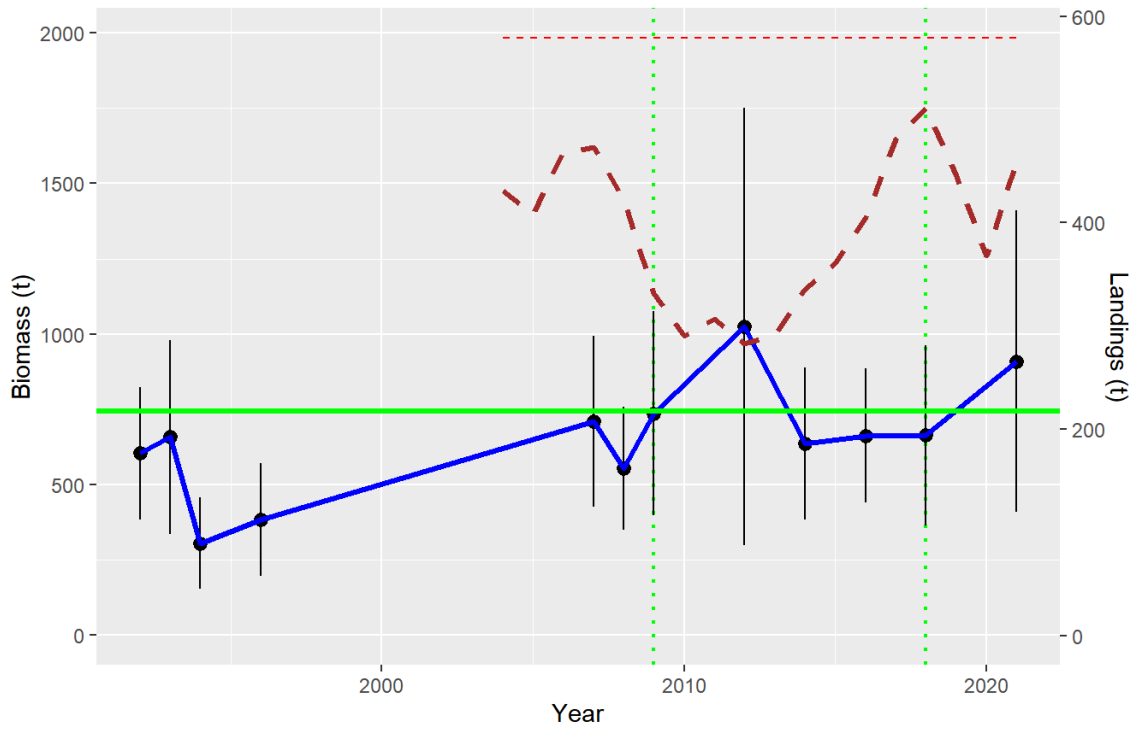
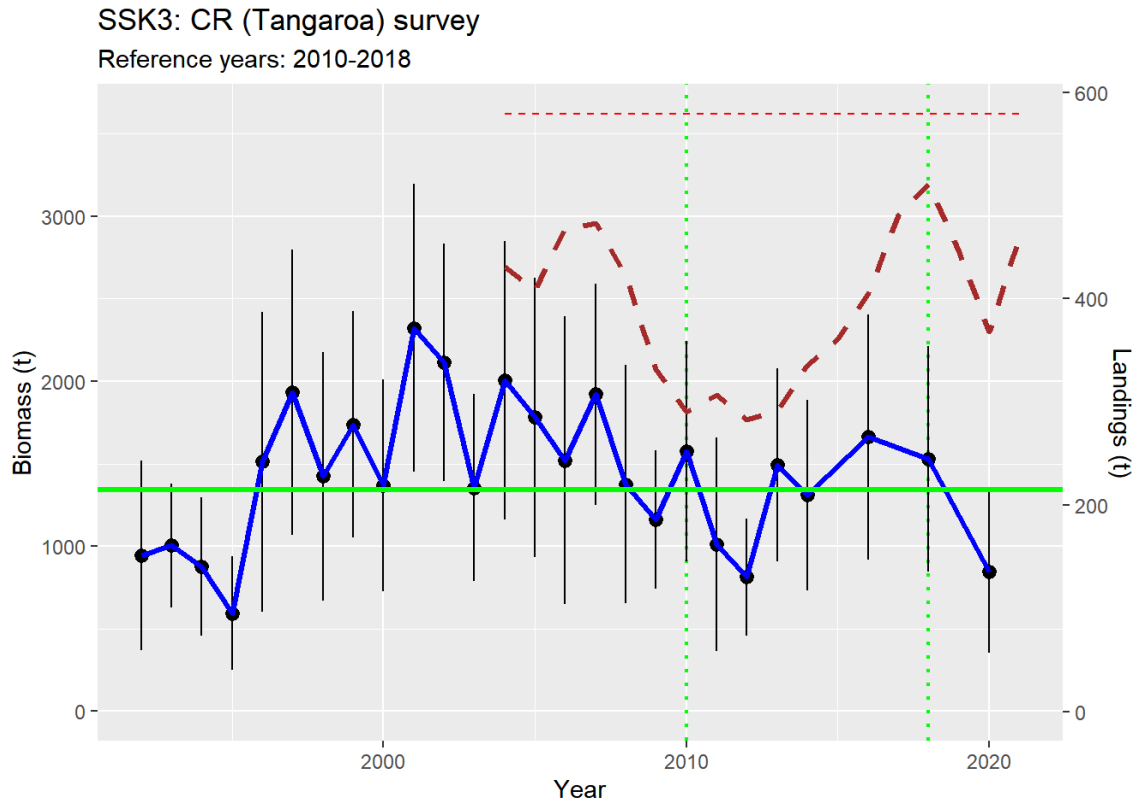


Figure 11: SSK 3 relative biomass from ECSI *Kaharoa* trawl survey (blue line plus vertical lines showing  $\pm 2$  s.d. (left axis)), reported Quota Management Report/Monthly Harvest Return landings (brown dashed line), and Total Allowable Commercial Catch for SSK 3 (red dotted line (right axis)). Green line represents the  $B_{MSY}$  proxy calculated as the arithmetic mean of abundance series results from 2009 to 2018.

### SSK: Chatham Rise; SSK 3; RV *Tangaroa*

There has been no period since SSK entered the QMS with stable landings (Figure 12). For the putative reference period selected from the survey, although most confidence intervals overlap the mean relative biomass calculated, there is suggestion from the survey results that SSK experienced a decline in biomass from 2001 to 2012 followed by a recovery. If true this would mean there was also no period of stable biomass index, and the putative reference period was in a period of stock increase.



**Figure 12:** SSK 3 relative biomass from Chatham Rise *Tangaroa* trawl survey (blue line plus vertical lines showing  $\pm 2$  s.d. (left axis)), reported Quota Management Report/Monthly Harvest Return landings (brown dashed line), and Total Allowable Commercial Catch for SSK 3 (red dotted line (right axis)). Green line represents the  $B_{MSY}$  proxy calculated as the arithmetic mean of abundance series results from 2010 to 2018.

## SSK: West coast South Island (WCSI) inshore; SSK 7; RV *Kaharoa*

Landings were relatively stable over the period 2011–2021. However, during this period the inter-annual variability of the survey index was large (Figure 13).

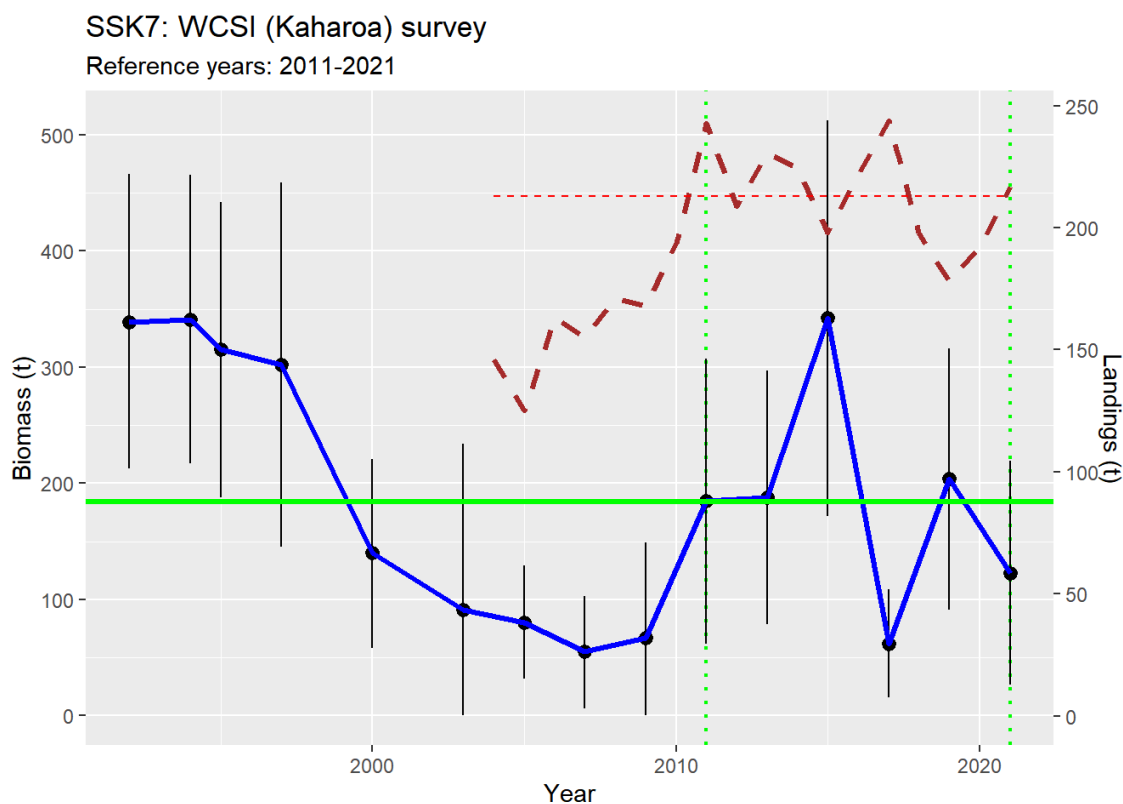


Figure 13: SSK 7 relative biomass from WCSI inshore *Kaharoa* trawl survey (blue line plus vertical lines showing  $\pm 2$  s.d. (left axis)), reported Quota Management Report/Monthly Harvest Return landings (brown dashed line), and Total Allowable Commercial Catch for SSK 7 (red dotted line (right axis)). Green line represents the  $B_{MSY}$  proxy calculated as the arithmetic mean of abundance series results from 2011 to 2021.

## 4. DISCUSSION

Relative biomass indices from a total of 10 trawl survey series covering 8 stocks (4 of each species) were reviewed, from which 6 trawl survey time series, 2 for rough skate (ECSI and WCSI inshore) and 4 for smooth skate (ECSI, Chatham Rise, and WCSI inshore and offshore), covering RSK 3 and 7 and SSK 3 and 7, were considered to provide sufficiently reliable indices of abundance to be potentially useful. Partial quantitative assessments were attempted for these 6 survey series and presented to a meeting of the INSWG for review. Two of these assessments, for RSK3 and SSK7, were accepted.

The WCSI inshore survey series was not accepted to form the basis for partial quantitative assessment for RSK because the inter-annual variability in biomass indices was considered too great in the period when landings were relatively stable. It was suggested by the INSWG that alternative combinations of strata could be considered to see if a more consistent time series would be possible. A possible solution is to exclude TBGB strata. The west coast indices, although still variable, are less so than the combined west coast TBGB time series (Figure 25a). It is not known, however, how connected or distinct RSK are between the west coast and TBGB. An alternative possible explanation for the variability in indices could be the minimum depth surveyed along the west coast. Except for the northern-most inshore strata, minimum depth is 25 m. The ECSI survey showed the importance of depths 10–30 m for RSK. The

depth distribution of RSK is potentially shifting between years making a larger or smaller proportion too shallow to be surveyed.

The design of ECSI and WCSI research trawl surveys are not ideally suited to the depth range of SSK and these surveys indicated geographic stratification of SSK fish sizes. Large, mature SSK are under-represented in both the ECSI and WCSI inshore surveys. The Chatham Rise survey does not catch smaller SSK at lengths recorded from commercial catch. An earlier review of the Chatham Rise series considered the core area and depth range appropriate for SSK, and the biomass to be well estimated, with CVs between 20–30% (O’Driscoll et al. 2011) and rejection for use in a partial quantitative assessment was primarily because no period of stable landings could be identified. However, both the ECSI survey and observer data include smaller size SSK under-represented in Chatham Rise catches and it is not known if SSK are a single stock, or separate stocks, over the shelf and Chatham Rise areas. Combining results of ECSI and Chatham Rise surveys is not considered feasible because the two surveys use different ground gear with potentially quite different catching efficiencies of skates.

There is only one current trawl survey series covering the RSK and SSK 8 stocks. This survey has recently been re-instated after a gap of almost 20 years, but only 3 surveys have so far been completed. The INSWG concluded that the WCNI survey should be re-visited once more data points are available because it is potentially suitable as an abundance index for RSK in this area. From the WCSI inshore and ECSI surveys it is known that RSK can be caught to depths of 400 m, whereas the deepest strata of the WCNI survey are only to 200 m. However, the WCNI survey catches RSK up to 60 cm in length which is consistent with maximum lengths from length frequency data from the WCSI inshore survey.

In this project, potential partial quantitative assessments were assessed after using an arithmetic mean for the reference period mean survey index. Other work on partial quantitative assessments have made use of arithmetic means, geometric means, and means weighted by survey point uncertainty (Fisheries New Zealand 2022a). The INSWG suggested Fisheries New Zealand make clear which type of mean was expected prior to any future assessments. For the two stocks for which partial quantitative assessments were accepted, the choice of calculation for the mean biomass made little difference (Table 5).

## **5. POTENTIAL RESEARCH**

The WCSI inshore survey was initially accepted as providing a reliable index of abundance for RSK, but inter-annual variability of the abundance indices was later judged as too high. As discussed above, surveying west coast waters between 10 m and the current minimum survey depth could potentially lead to a more consistent survey time series. If the additional hauls did prove important there would, of course, be a considerable time lag before enough data points were available to form a revised index.

To know if the WCSI inshore survey, restricted to west coast strata, is suitable for tracking RSK abundance it is also important to know the level of connection between the west coast South Island and the Golden Bay and Tasman Bay areas with respect to RSK. The tagging of RSK by inshore trawl surveys has been discontinued and to date returns have not been analysed (Fisheries New Zealand 2022a). Even though returns were low they may shed some light on the connectedness of west coast and Golden Bay and Tasman Bay areas.

## **6. ACKNOWLEDGEMENTS**

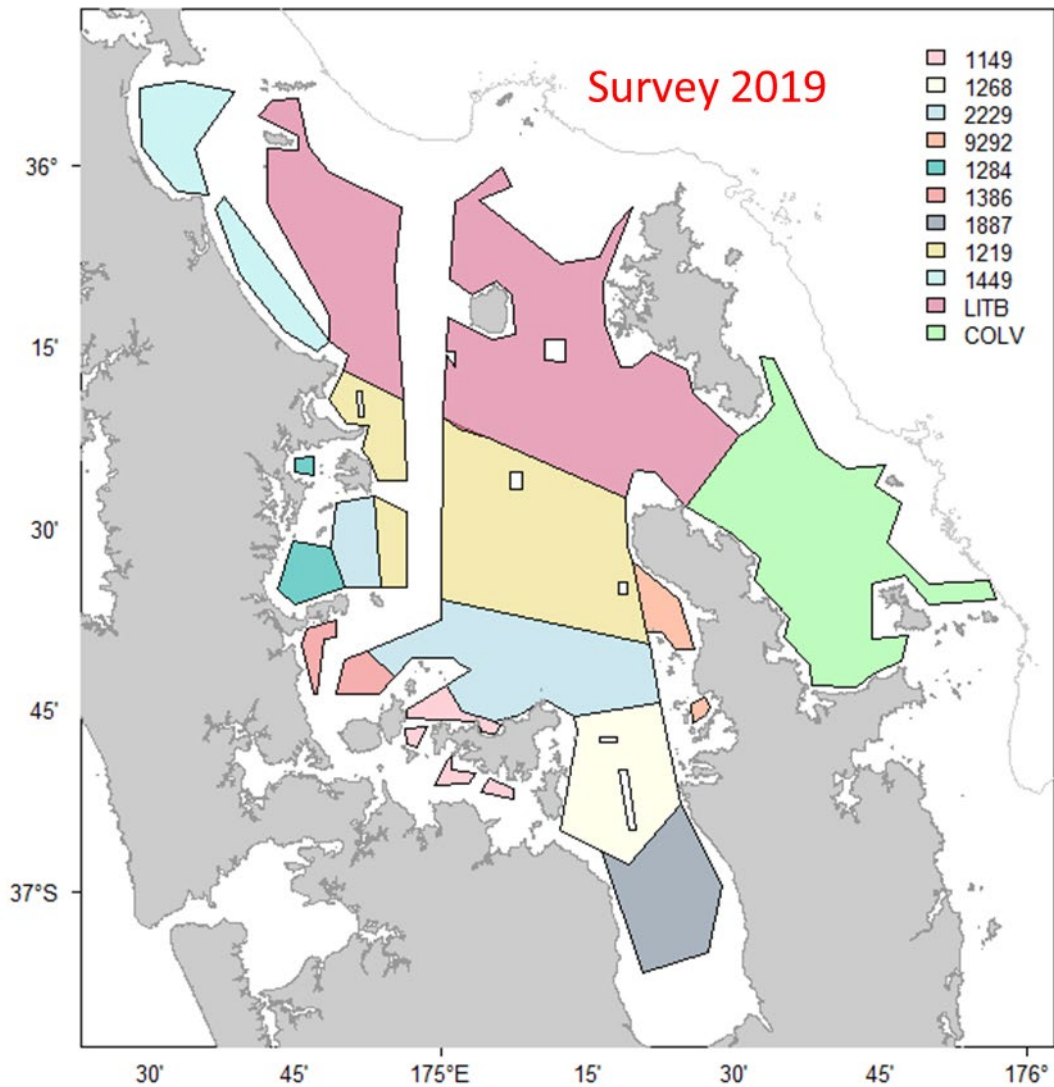
This research was carried out by NIWA under contract to Fisheries New Zealand, Project INS2021-02. We thank the members of the Inshore Working Group, in particular industry representatives who helped to add context and aid our understanding of survey findings. We also thank Anthony Charsley for comments and suggestions on the initial draft of this report.

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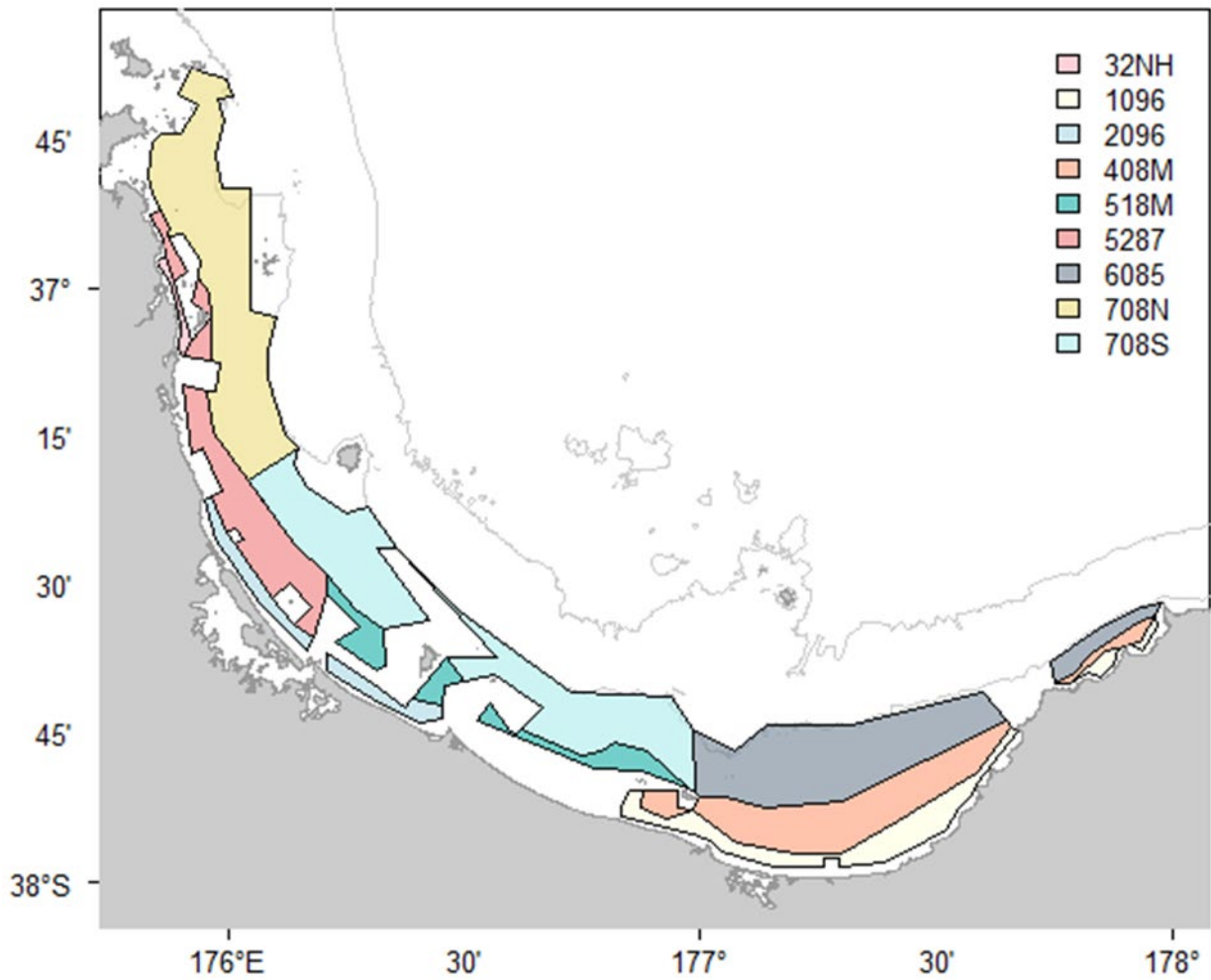
**APPENDIX 1: SURVEY STRATA AND STRATA DEPTH RANGES**



10–25 m strata: 1149,1284,1386,1887,9292  
 10–50 m stratum: 1449  
 25–45 m strata: 1268, 2229

25–50 m strata: 1219, 1449  
 15–75 m stratum: COLV  
 45–75 m stratum: LITB

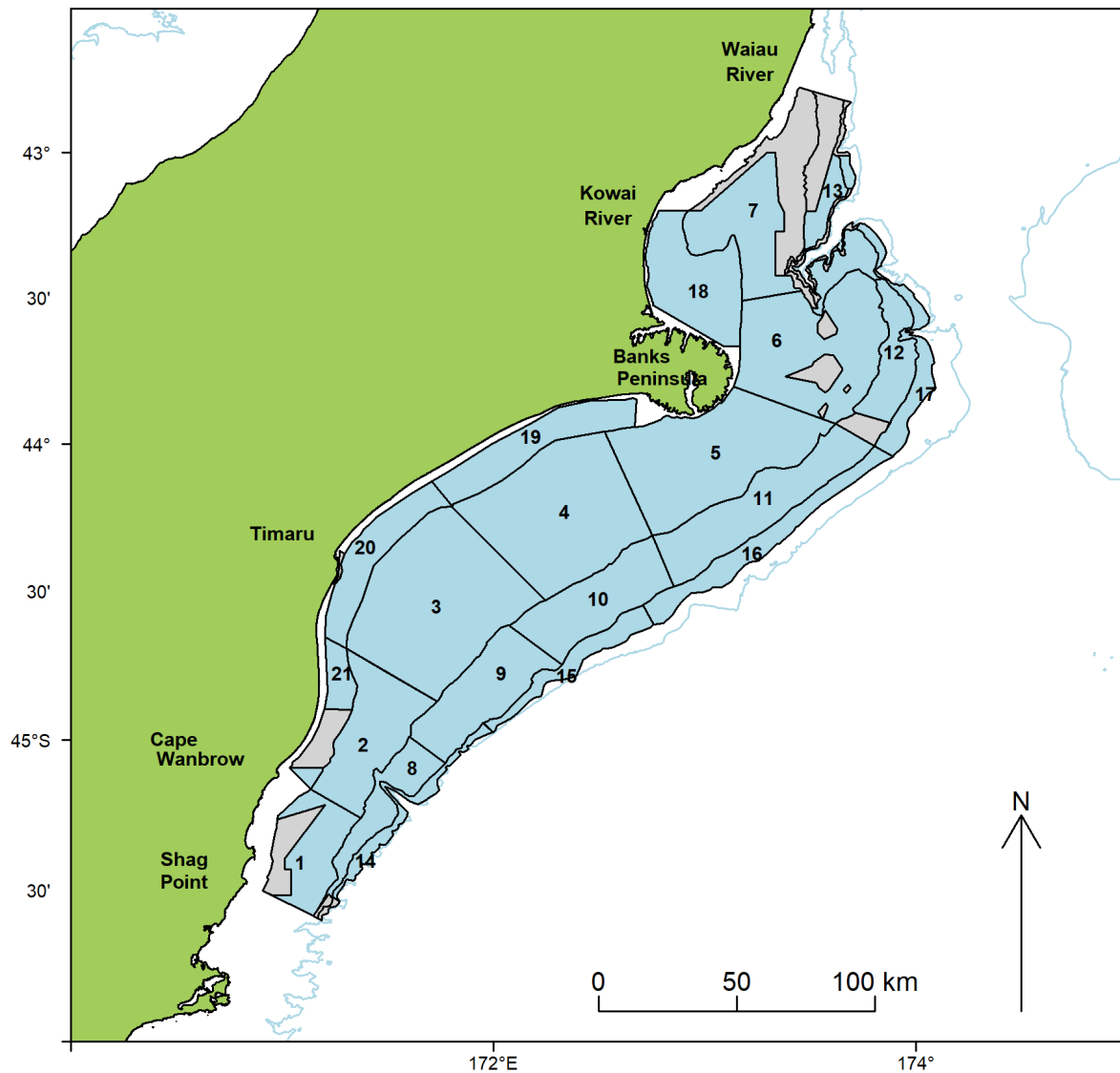
**Figure 14: Hauraki Gulf (HAGU) survey strata and strata depth ranges.**



10–25 m strata: 1096, 2096, 32NH  
 25–50 m strata: 408M, 518M, 5287

50–100 m strata: 6085, 708N, 708S

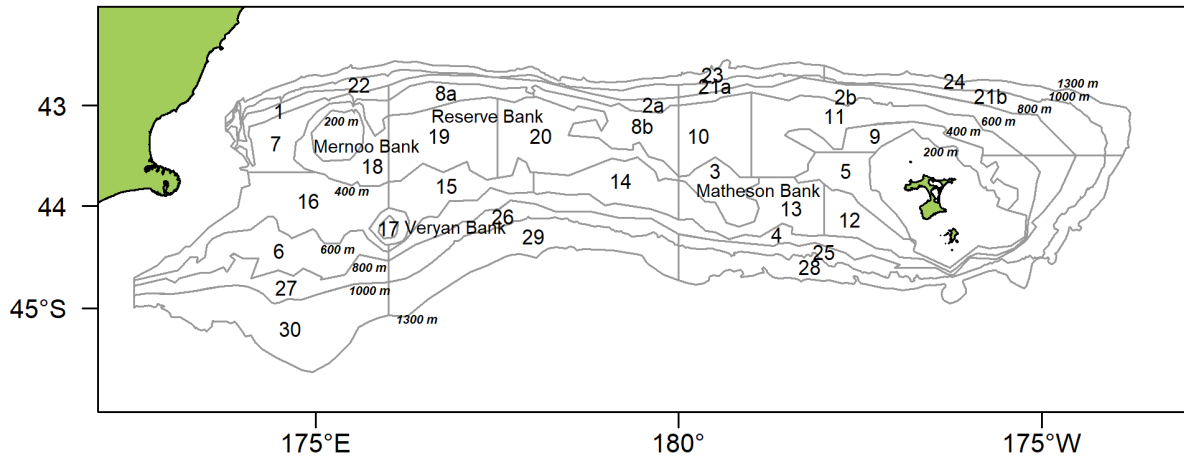
**Figure 15: Bay of Plenty (BPLe) survey strata and strata depth ranges.**



10–30 m strata: 18, 19, 20, 21  
 30–100 m strata: 1, 2, 3, 4, 5, 6, 7

100–200 m strata: 8, 9, 10, 11, 12, 13  
 200–400 m strata: 14, 15, 16, 17

**Figure 16: East coast South Island (ECSI) survey strata and strata depth ranges. Grey areas indicate rough ground.**



Core strata

200–400 m strata: 3, 5, 9, 17–20

400–600 m strata: 7, 8A, 8B, 10–16

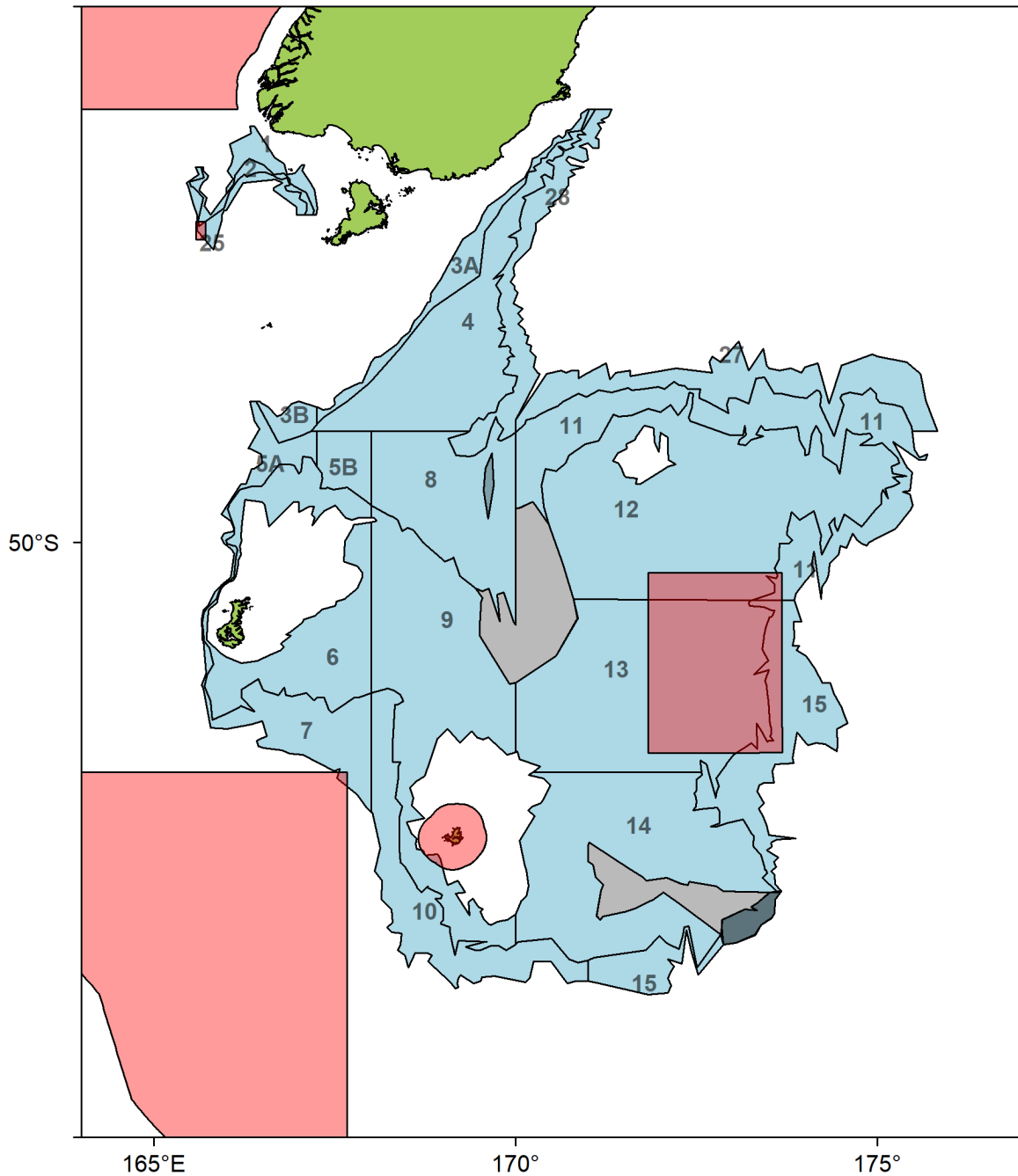
600–800 m strata: 1, 2A, 2B, 4, 6

Deep strata

800–1000 m strata: 21A, 21B, 22, 25–27

1000–1300 m strata: 23, 24, 28–30

**Figure 17: Chatham Rise survey strata and strata depth ranges. Colour of text indicates strata used for the alternative relative biomass time series depicted in Figure 23.**



Core strata

300–600 m strata: 1, 3A, 3B, 6, 9, 12–14

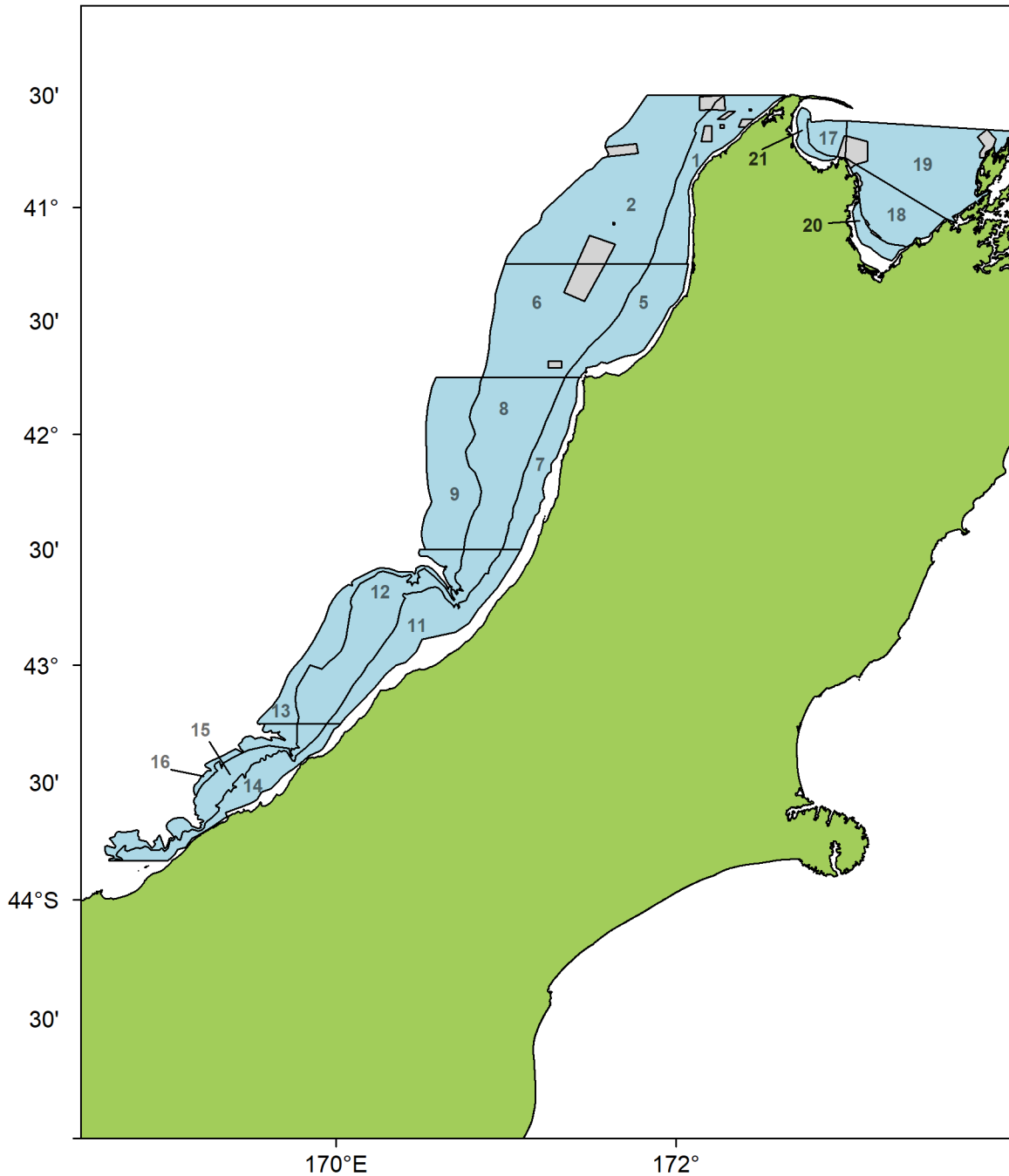
600–800 m strata: 2, 4, 5A, 5B, 7, 8, 10, 11, 15

\* Stratum 26 was removed in 2012.

Deep strata\*

800–1000 m strata: 25, 27, 28

**Figure 18: Sub-Antarctic (SUBA) summer survey strata and strata depth ranges. Colour of text indicates strata used for the alternative relative biomass time series depicted in Figure 24. Grey areas indicate rough ground. Red areas indicate benthic protection areas.**



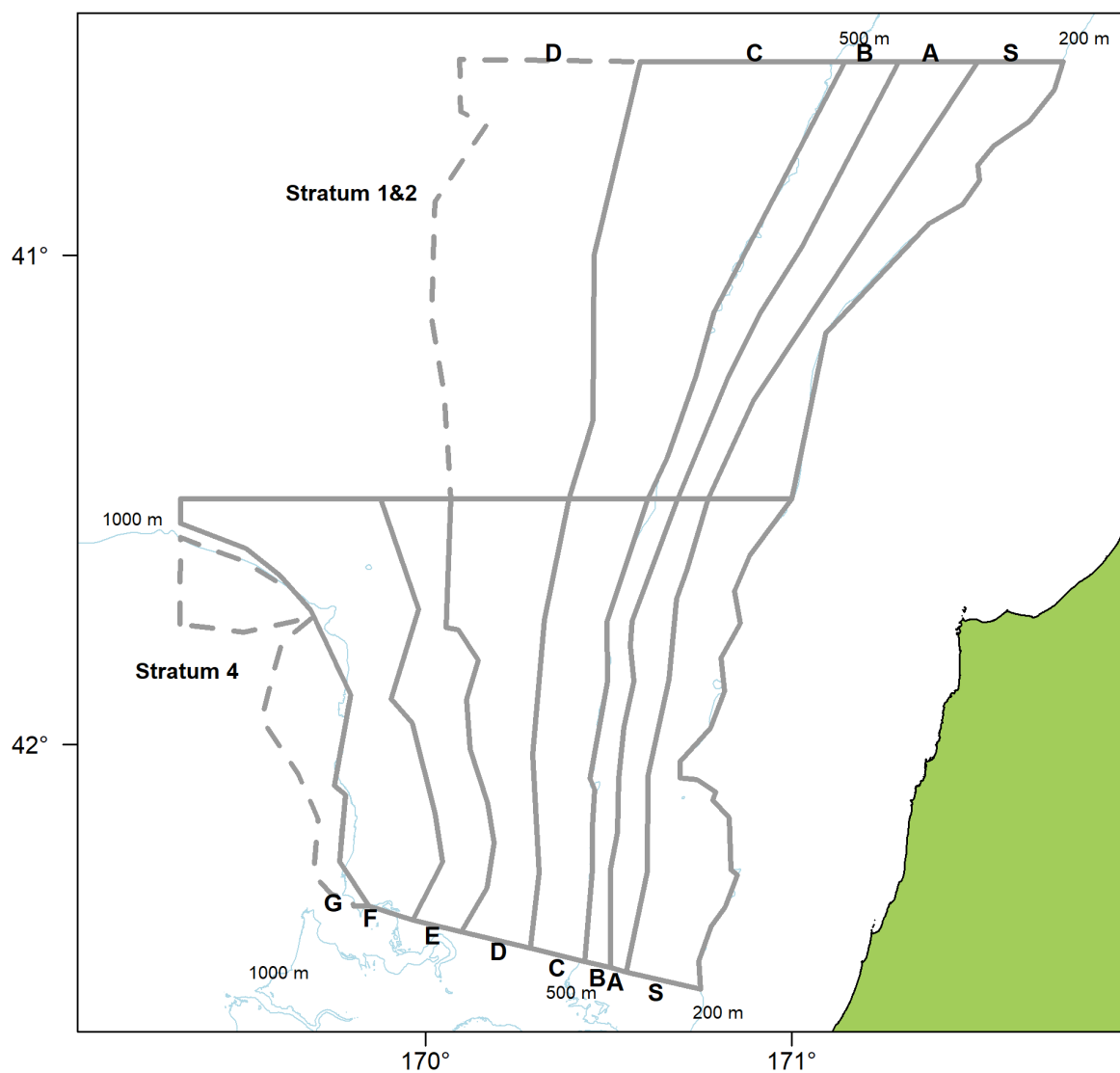
**West coast strata**

- 20–100 m stratum: 1
- 25–100 m strata: 5, 7, 11, 14
- 100–200 m strata: 2, 6, 8, 12, 15
- 200–400 m strata: 9, 13, 16

**Tasman Bay, Golden Bay (TBGB) strata**

- 10–20 m strata: 20, 21
- 20–33 m stratum: 17
- 20–42 m stratum: 18
- 20–70 m stratum: 19

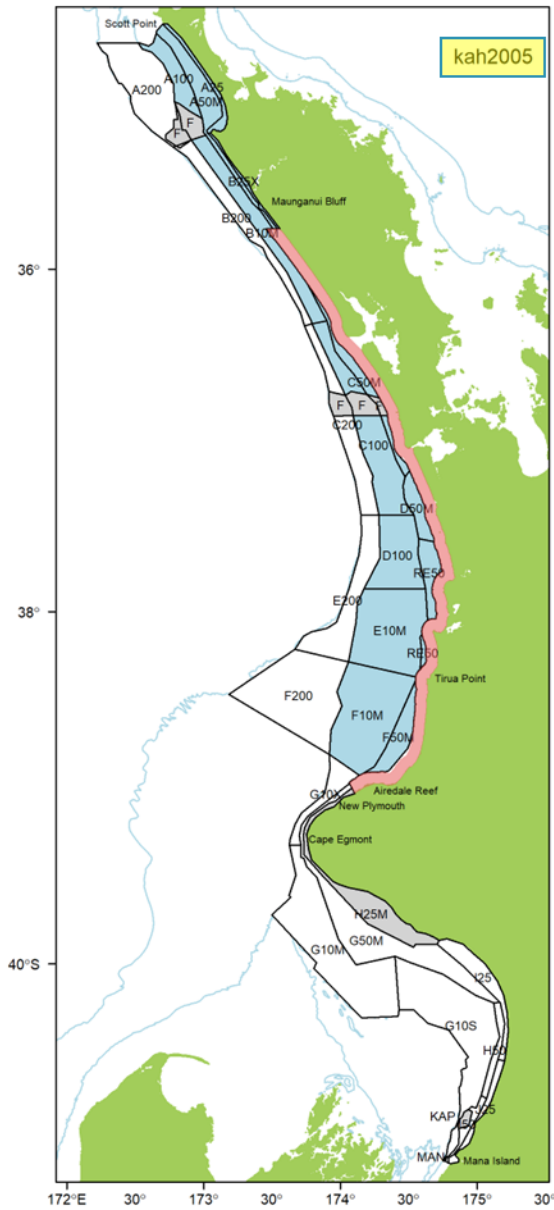
**Figure 19: West coast South Island (WCSI) inshore survey strata and strata depth ranges. Grey areas indicate rough ground.**



200–300 m strata: 1S, 2S, 4S  
 300–430 m strata: 1A, 2A, 4A  
 430–500 m strata: 1B, 2B, 4B  
 500–650 m strata: 1C, 2C, 4C

650–800 m strata: 1D, 2D, 4D  
 800–900 m stratum: 4E  
 900–1000 m stratum: 4F  
 1000–1050 m stratum: 4G

**Figure 20: West coast South Island (WCSI) offshore survey strata and strata depth ranges. Colour of text indicates strata used for the alternative relative biomass time series depicted in Figure 26.**



**Core strata**

A25, A50M, A100, B10M, B25X, B200, C50M, C100, D60M, D100, E10M, F10M, F50M, RE50

**Deep strata**

A200, B200, C200, E200, F200

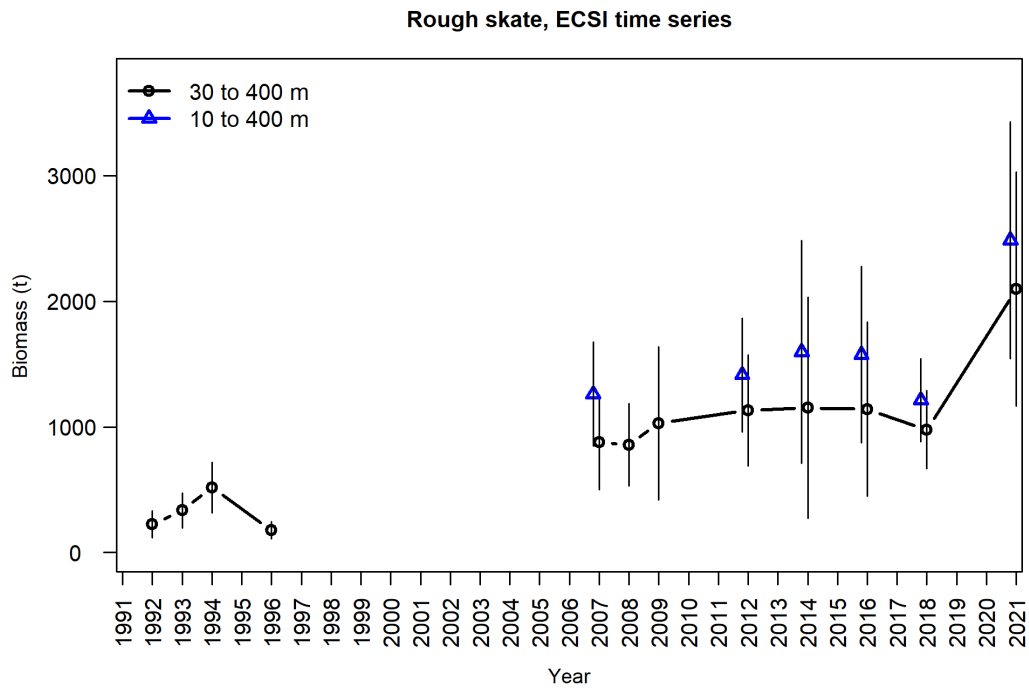
**South strata**

G10X, G10M, G10S, G50M, H50, I25, I50, J25

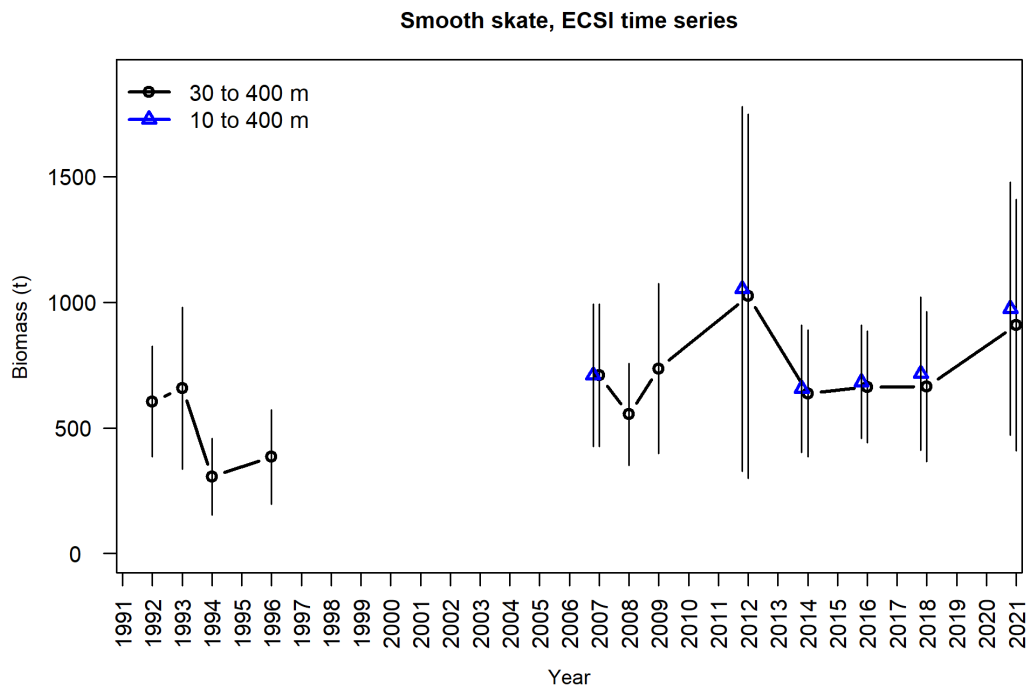
**Figure 21: West coast North Island (WCNI) survey strata. Grey areas indicate rough ground, cableways. Red area indicates Maui dolphin trawl exclusion area.**

## APPENDIX 2: TIME SERIES OF RELATIVE BIOMASS

a)

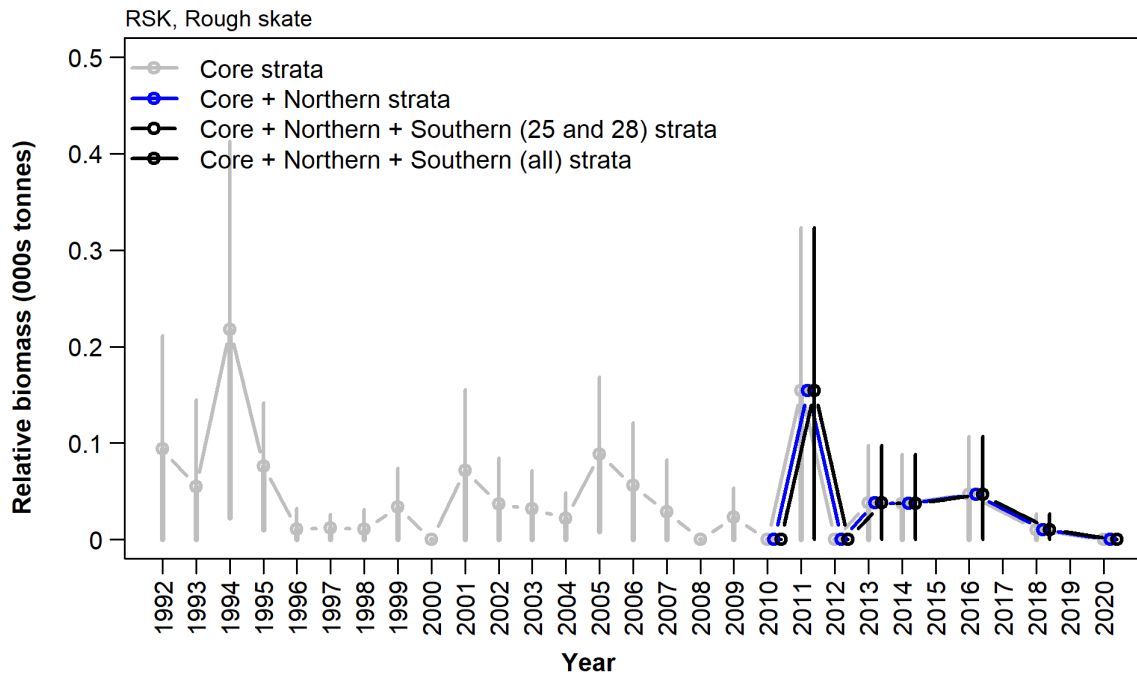


b)



**Figure 22: ECSI survey relative biomass time series for a) RSK and b) SSK.**

a)



b)

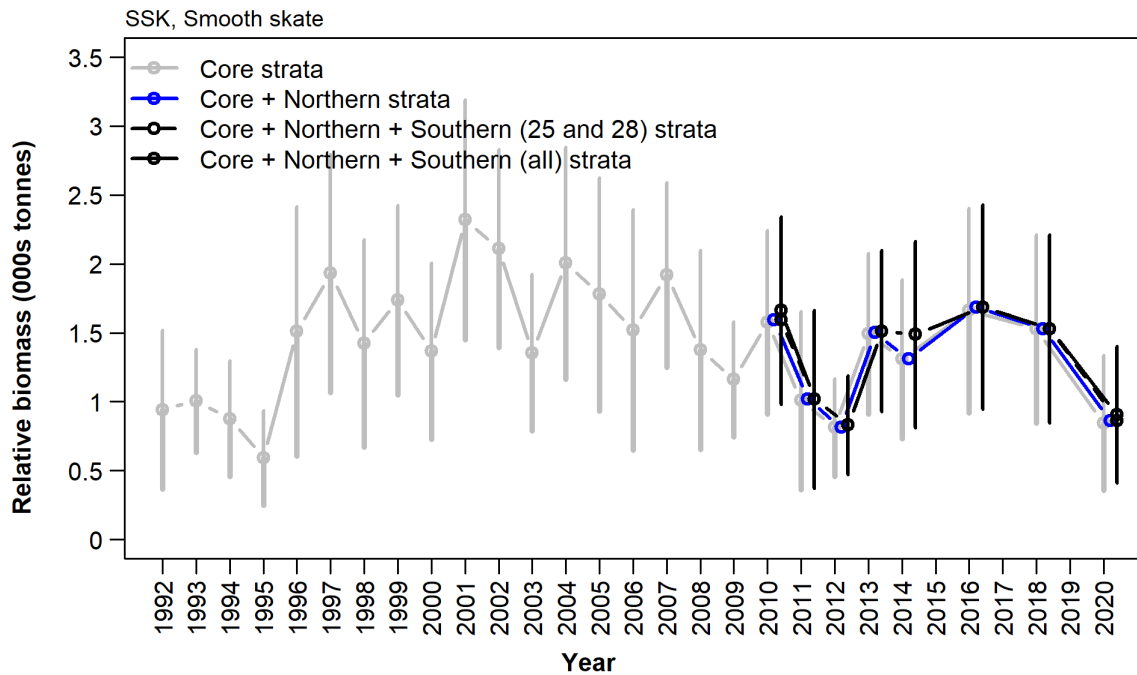
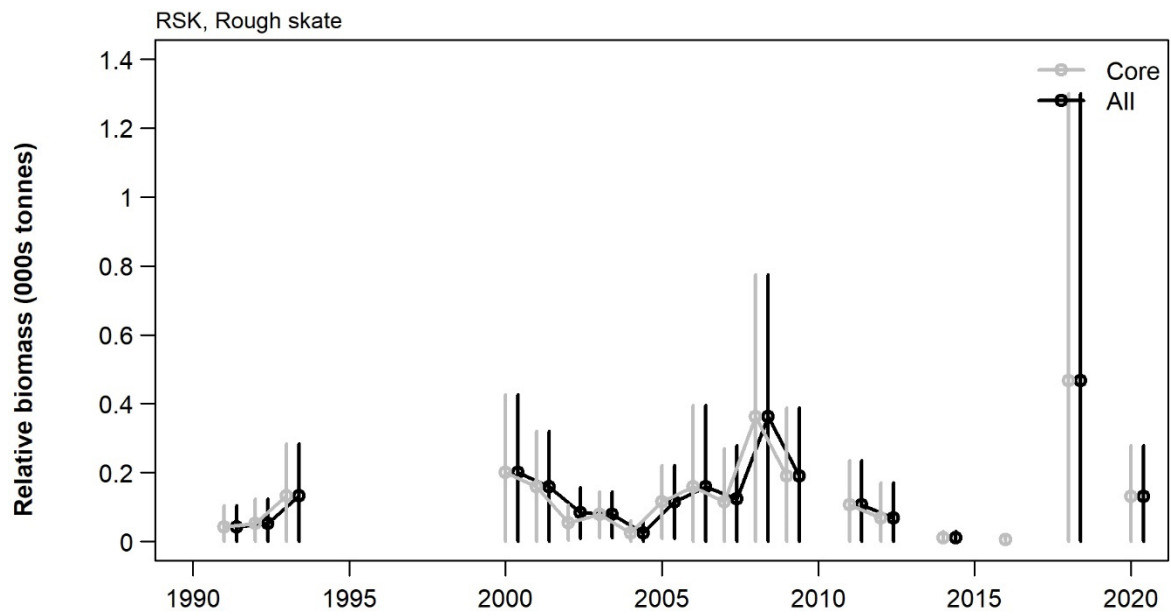


Figure 23: Chatham Rise survey relative biomass time series for a) RSK and b) SSK.

a)



b)

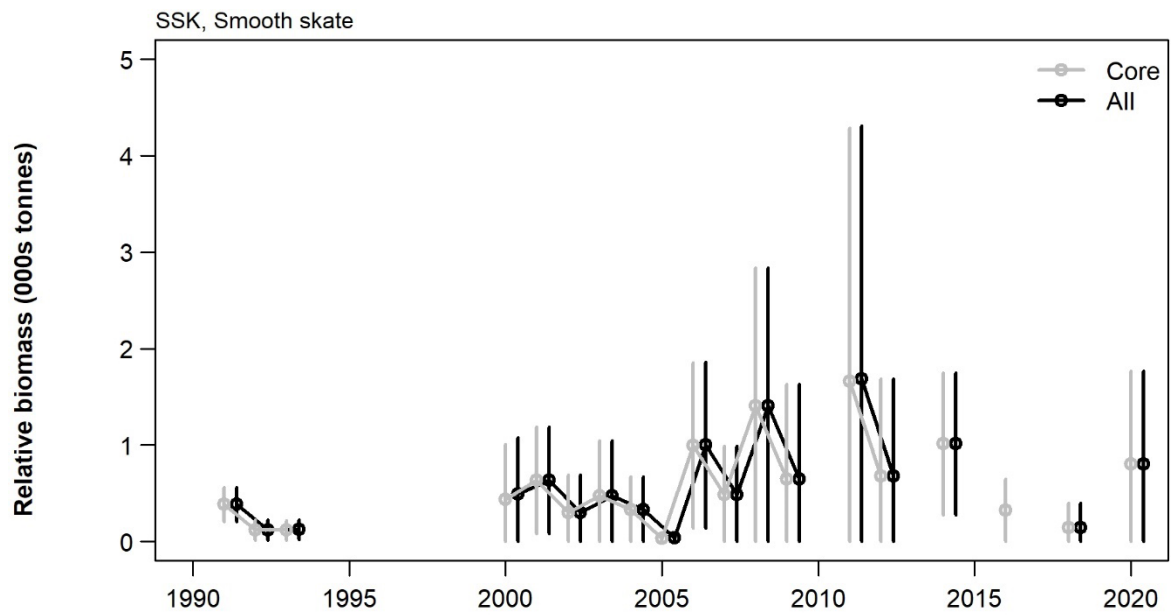
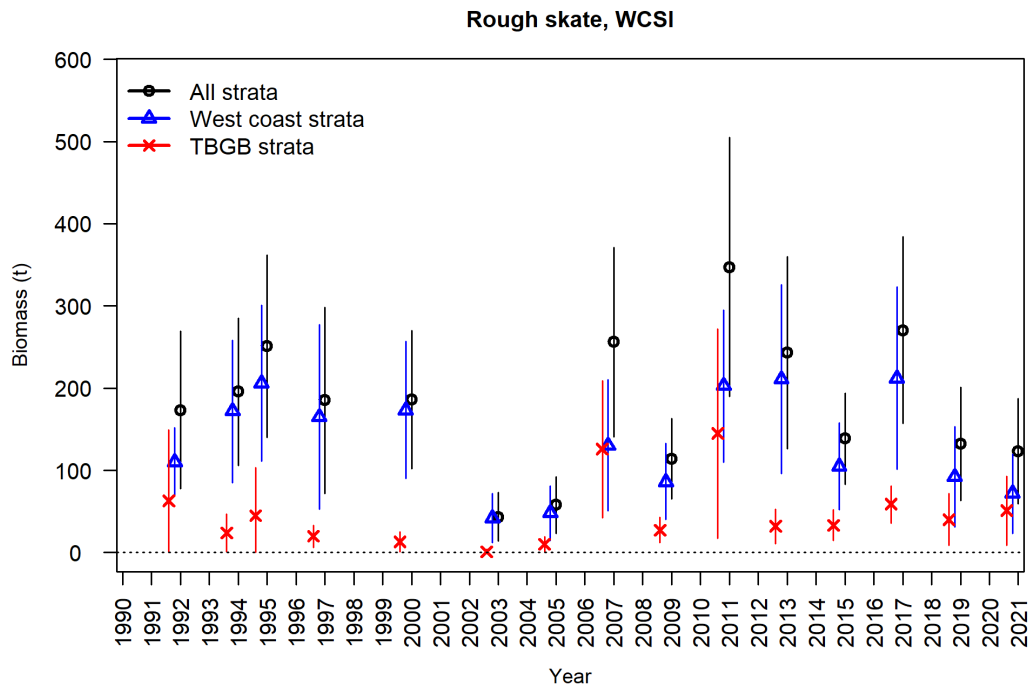


Figure 24: Sub-Antarctic (SUBA) survey relative biomass time series for a) RSK and b) SSK.

a)



b)

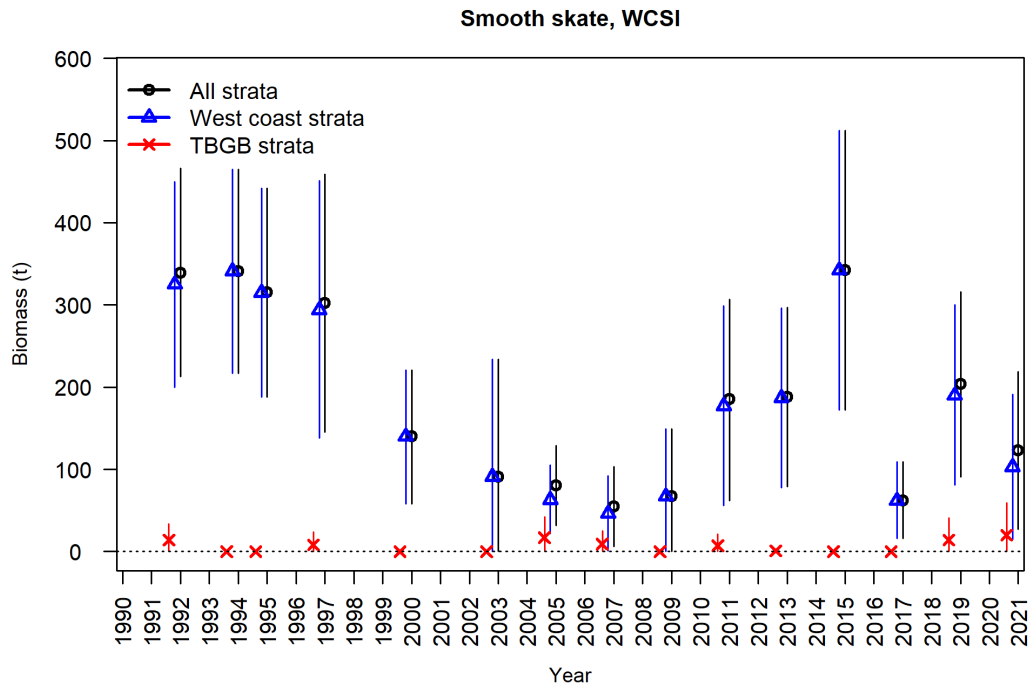
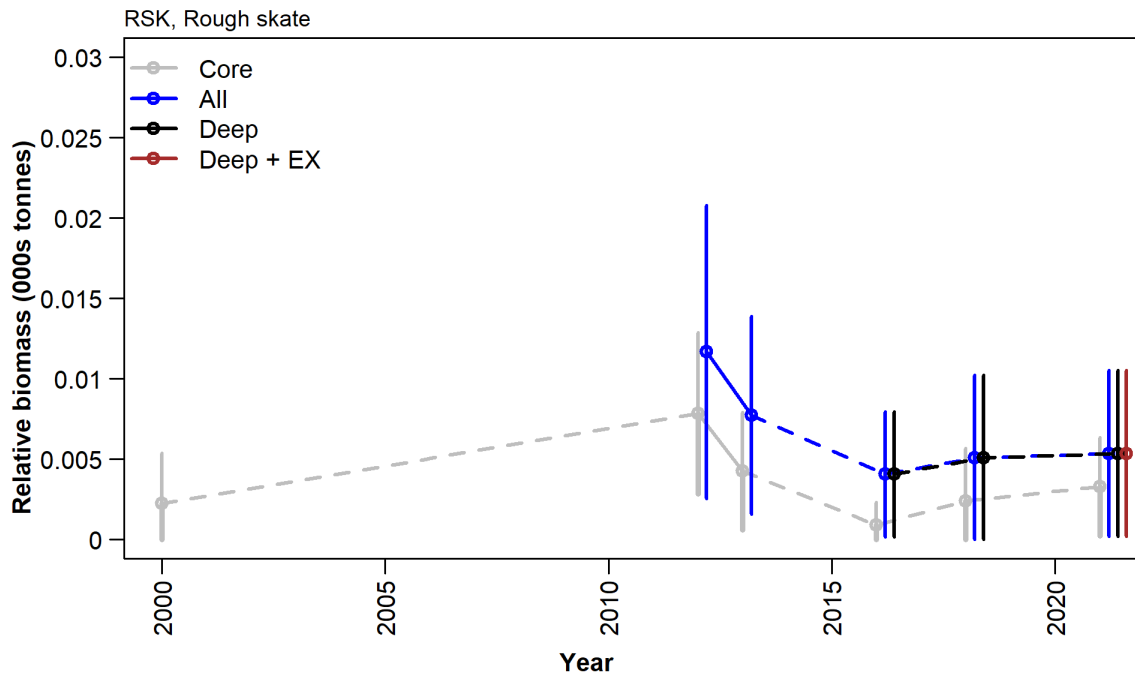


Figure 25: WCSI (inshore) survey relative biomass time series for a) RSK and b) SSK.

a)



b)

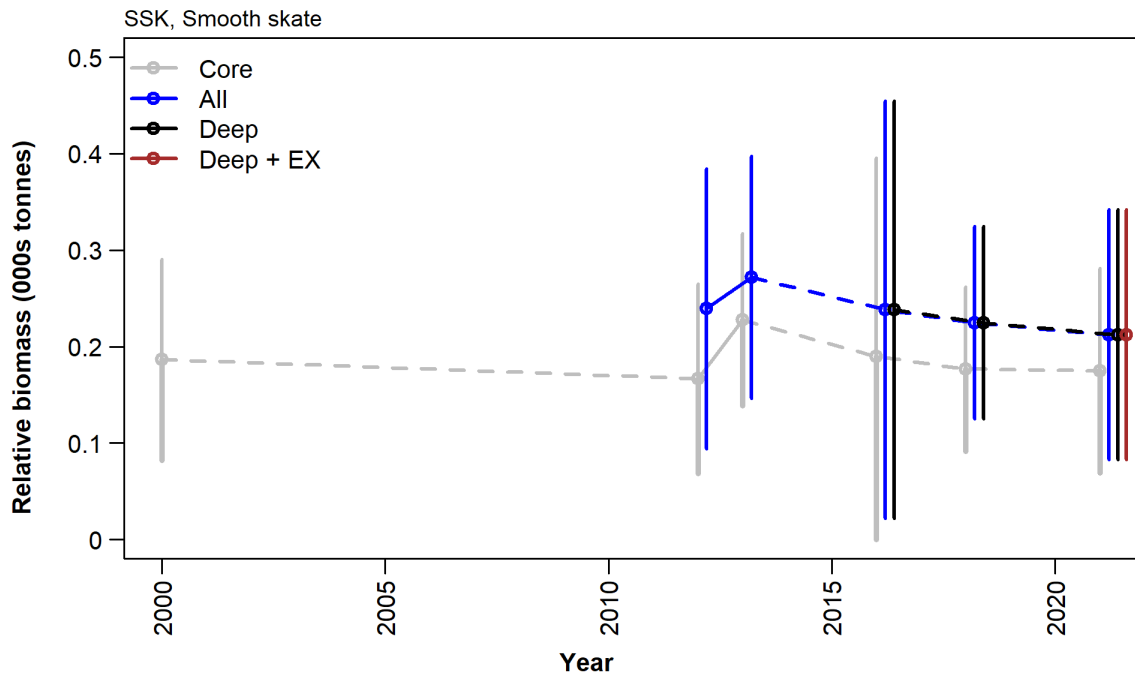
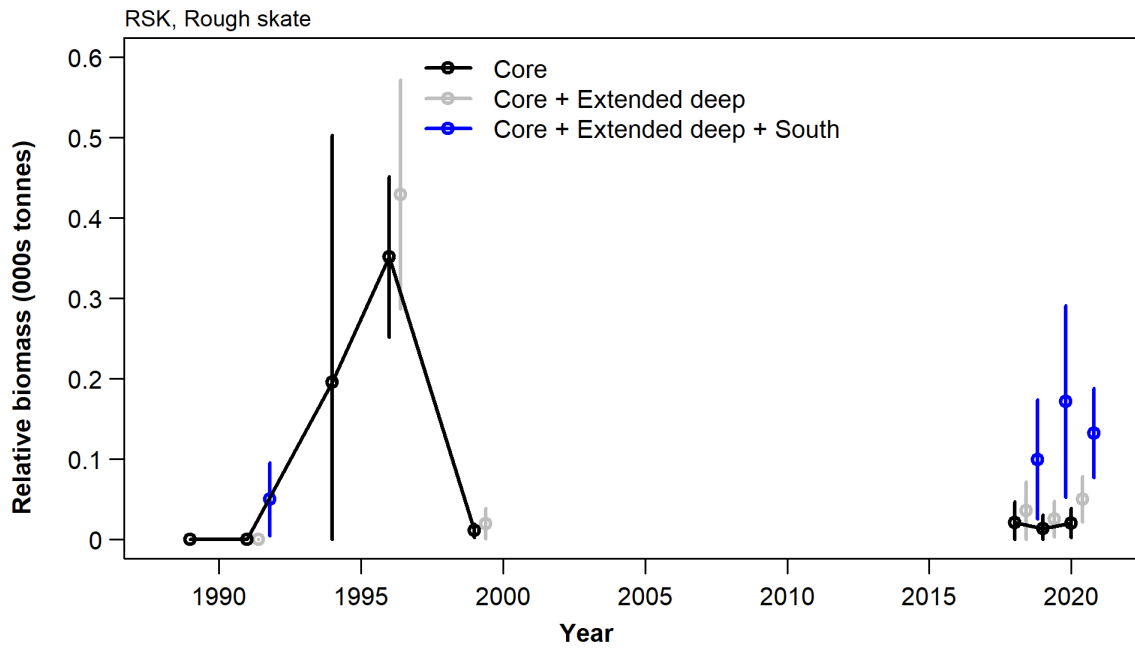


Figure 26: WCSI (offshore) survey relative biomass time series for a) RSK and b) SSK.

a)



b)

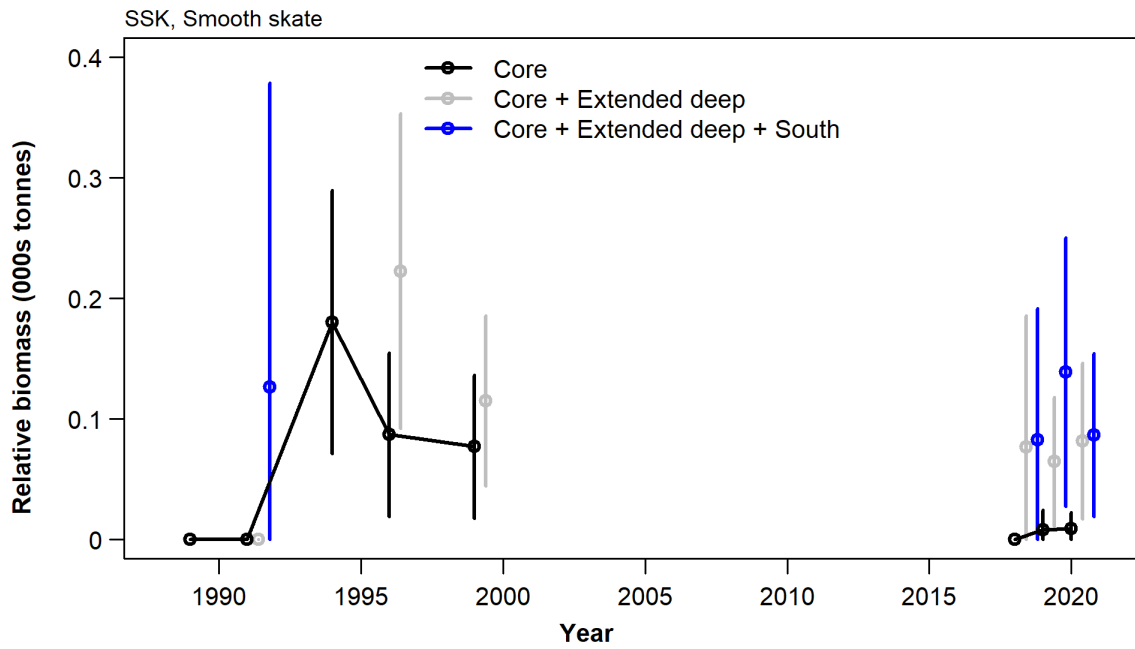


Figure 27: WCNI survey relative biomass time series for a) RSK and b) SSK. This study has only considered the years where the whole survey was sampled (Core+extended deep+ South).

### APPENDIX 3: SURVEY LENGTH FREQUENCIES

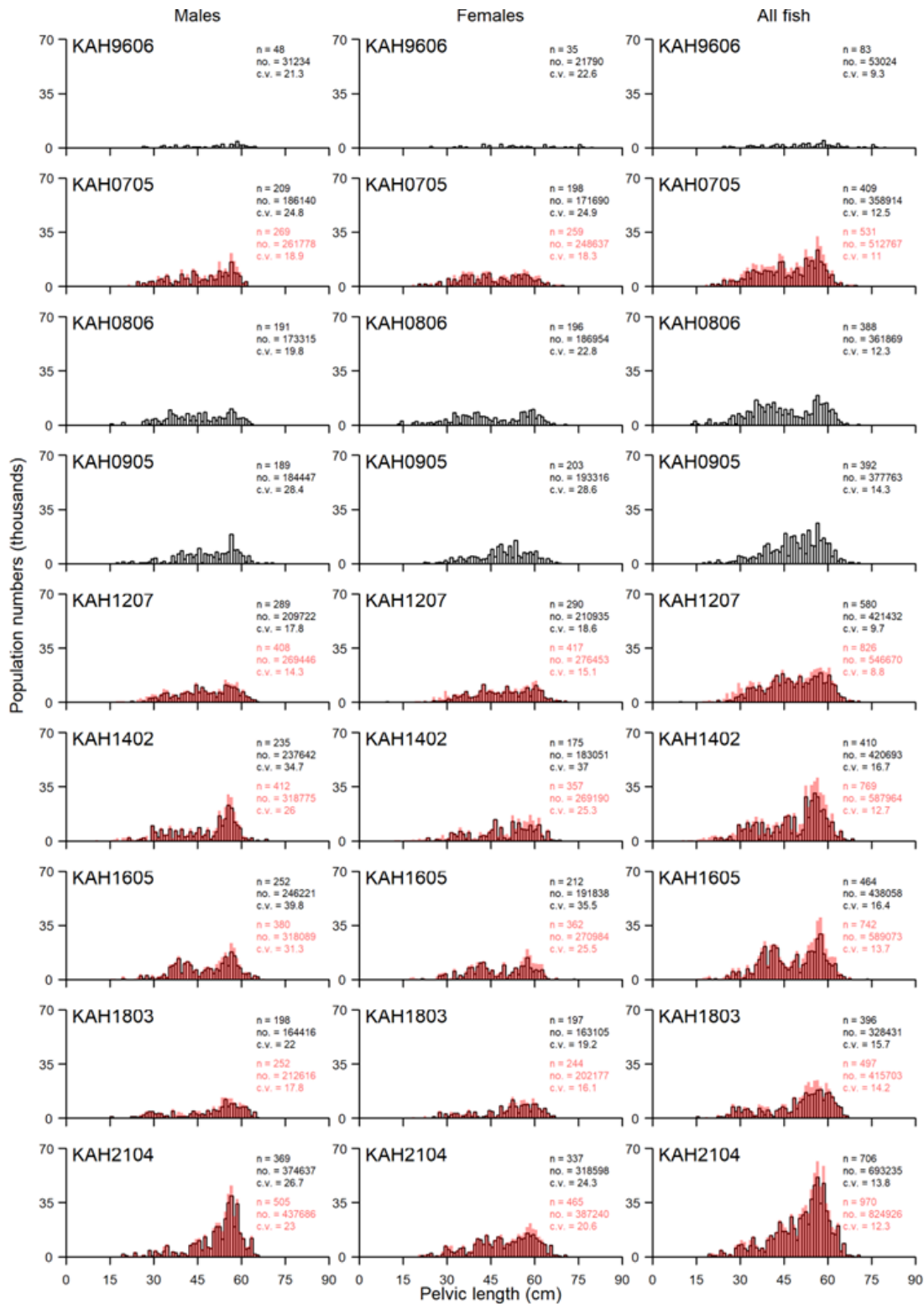


Figure 28: RSK: Scaled length frequency distributions from ECSI survey. Grey bars: using core 30–400 m strata. Red bars: Addition of 10–30 m strata to core strata.

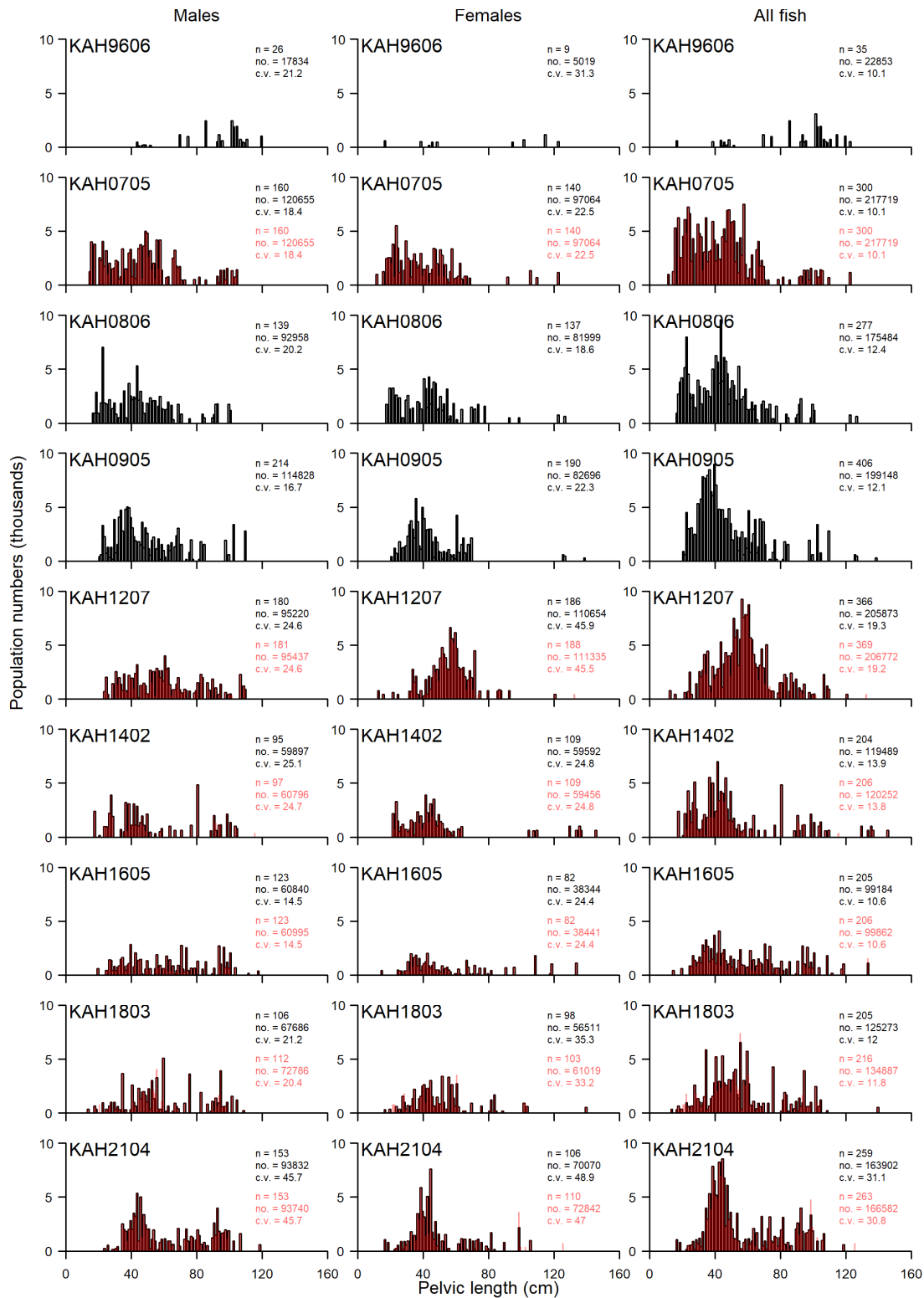
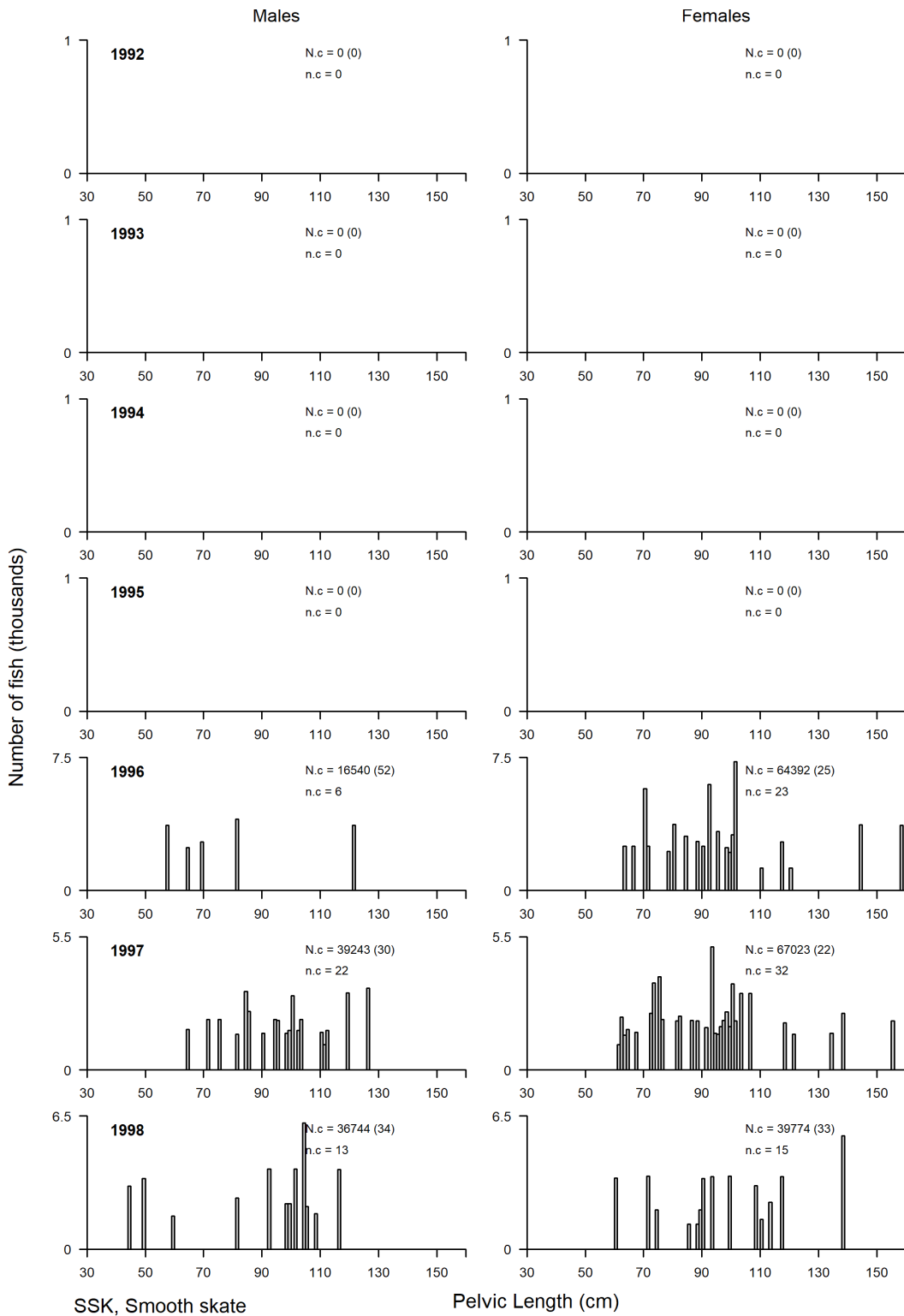
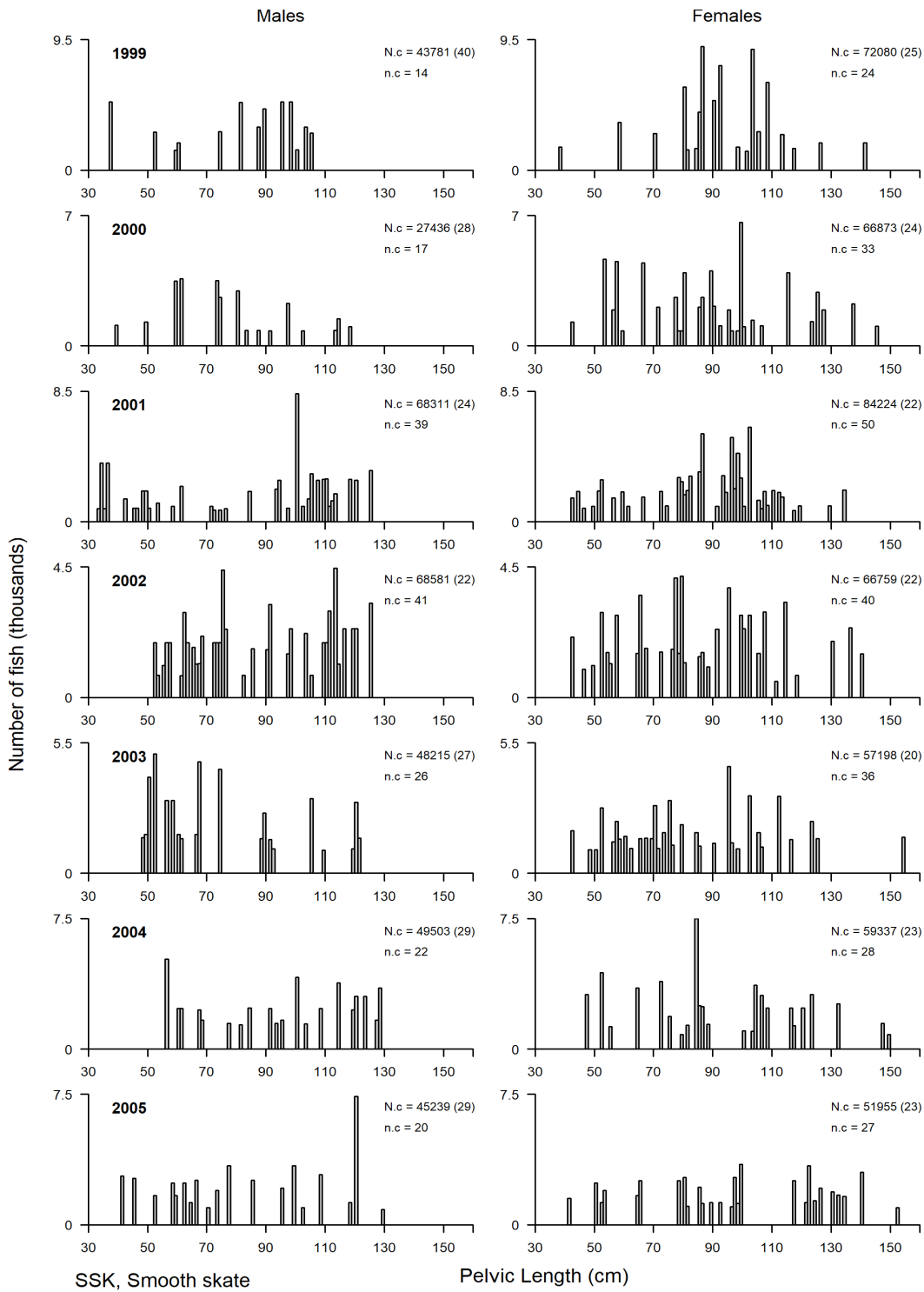


Figure 29: SSK: Scaled length frequency distributions from ECSI survey. Grey bars: using core 30–400 m strata. Red bars: Addition of 10–30 m strata to core strata.



**Figure 30: SSK: Scaled length frequency distributions from Chatham Rise survey. (Continued on next three pages)**



**Figure 30: continued.** SSK: Scaled length frequency distributions from Chatham Rise survey.

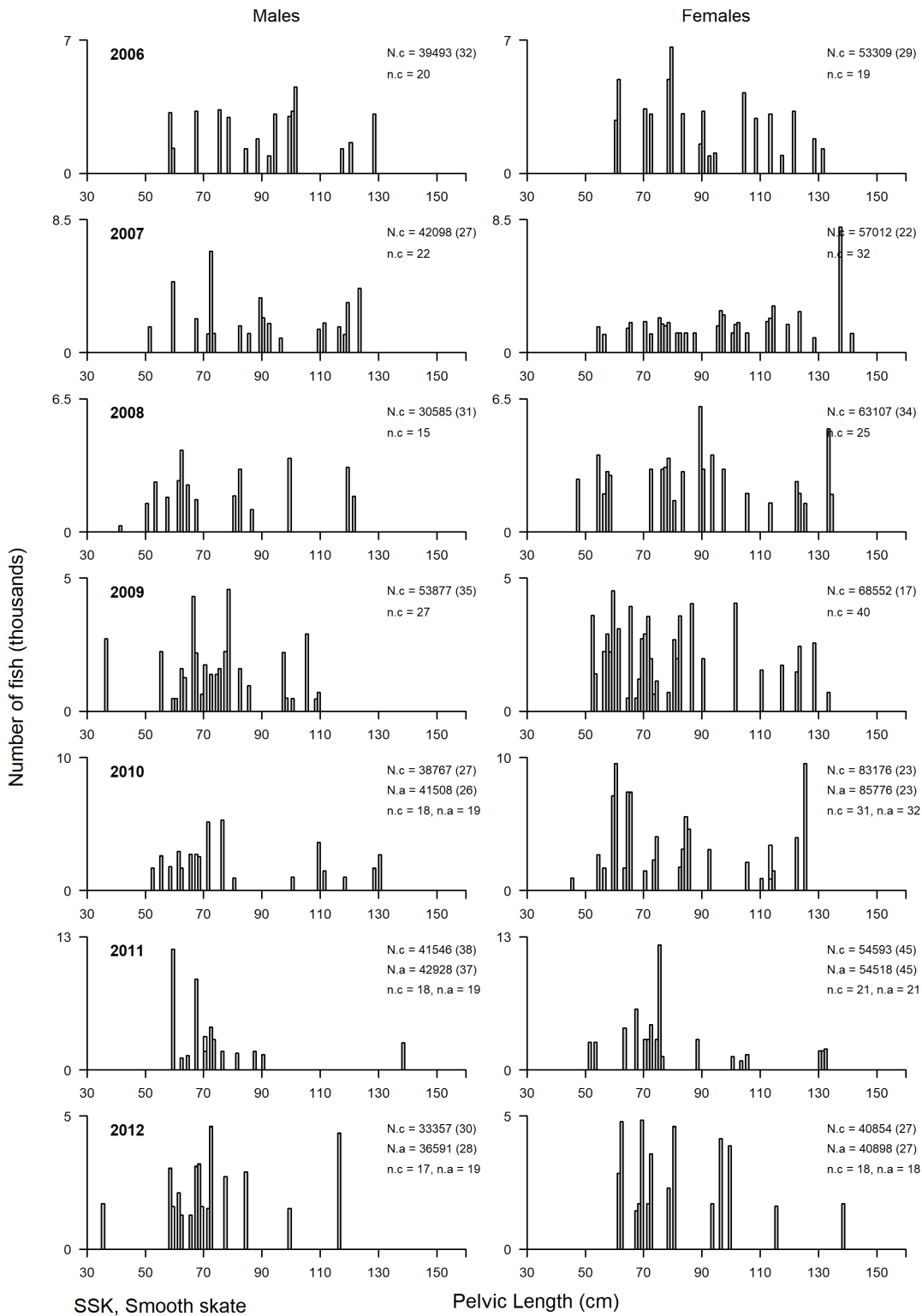
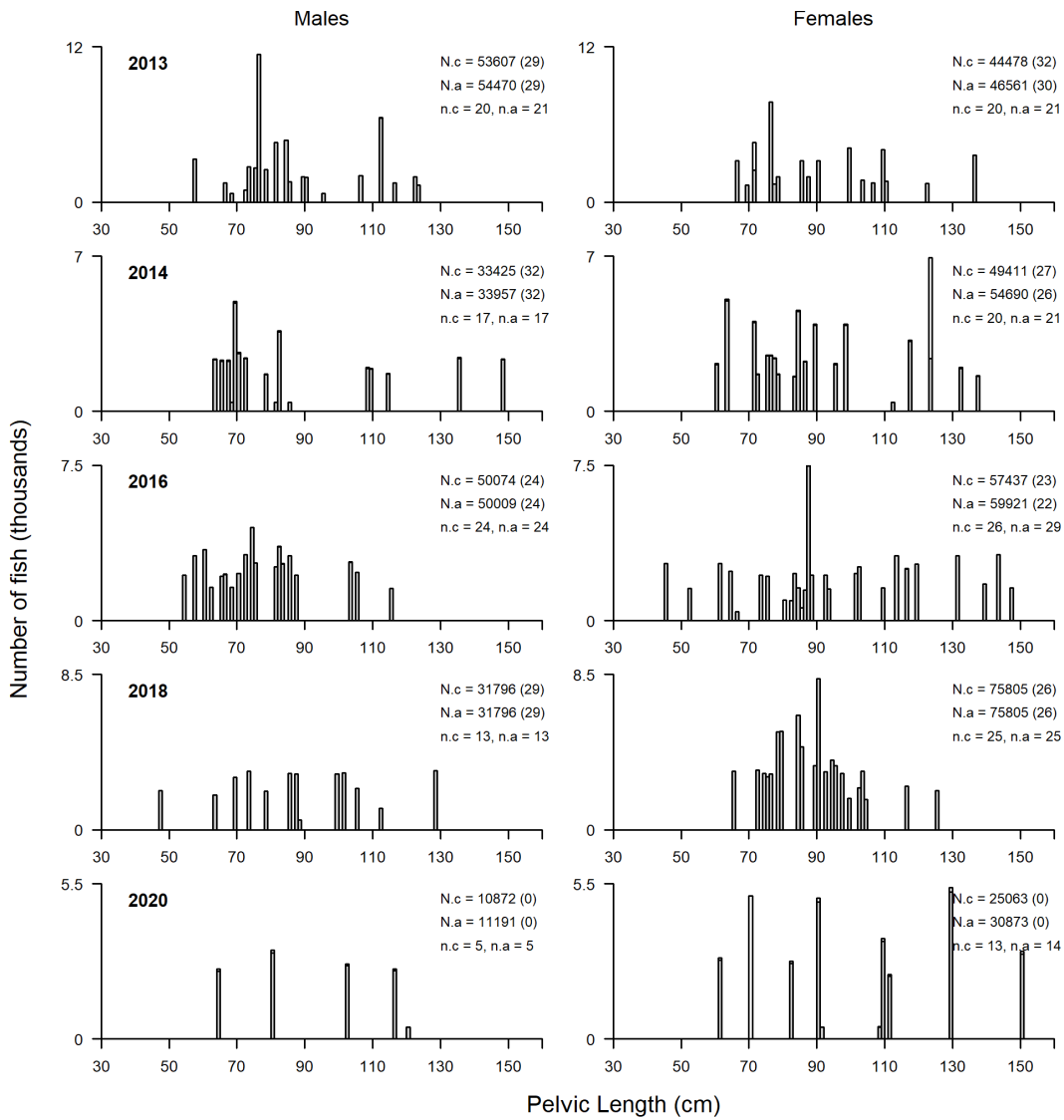


Figure 30: *continued.* SSK: Scaled length frequency distributions from Chatham Rise survey.



SSK, Smooth skate

**Figure 30: continued.** SSK: Scaled length frequency distributions from Chatham Rise survey.

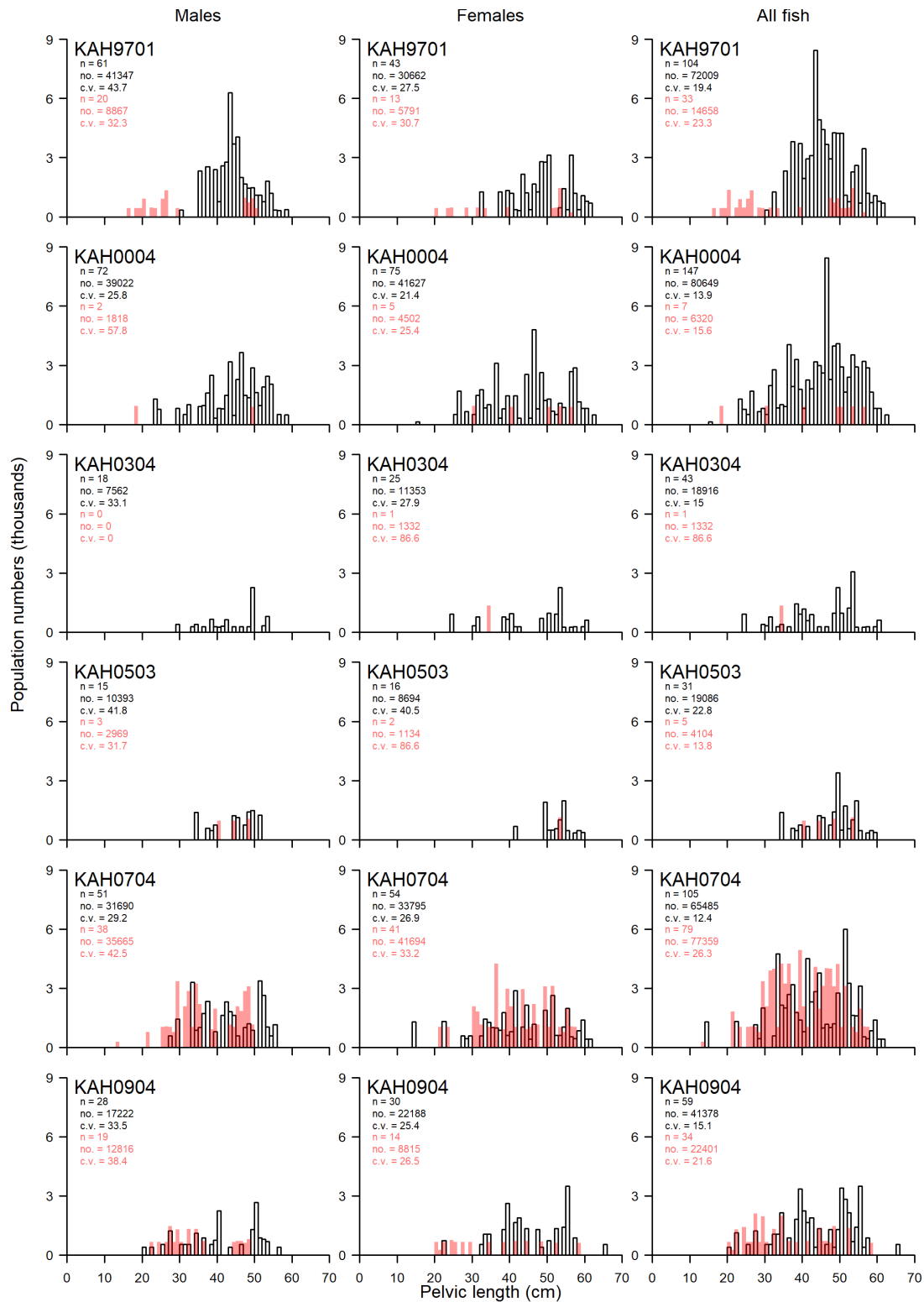


Figure 31: RSK: Scaled length frequency distributions from WCSI inshore survey. Grey bars: west coast strata. Red bars: Tasman Bay, Golden Bay strata. (Continued on next page)

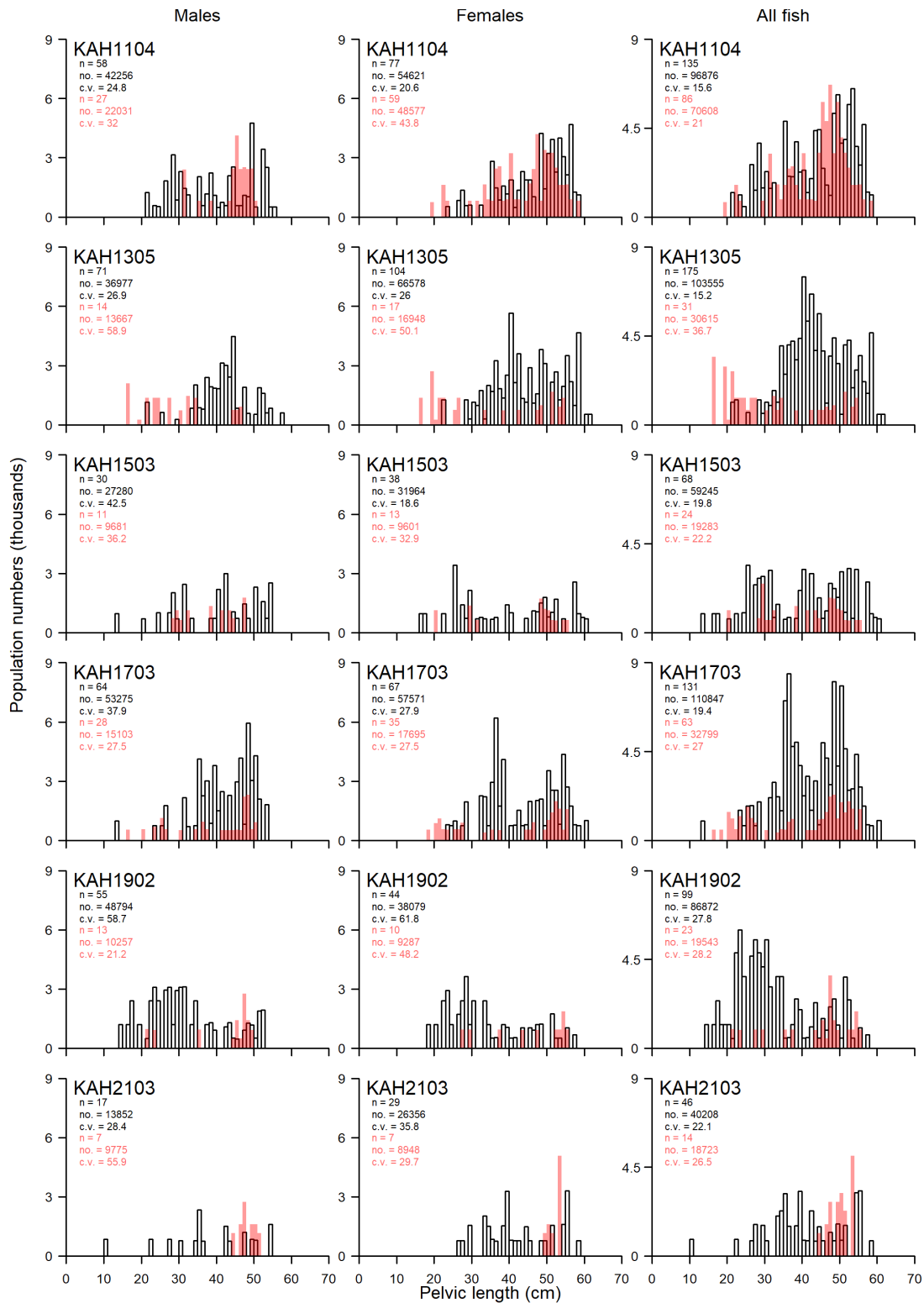


Figure 31: *continued.* RSK: Scaled length frequency distributions from WCSI inshore survey. Grey bars: west coast strata. Red bars: Tasman Bay, Golden Bay strata.

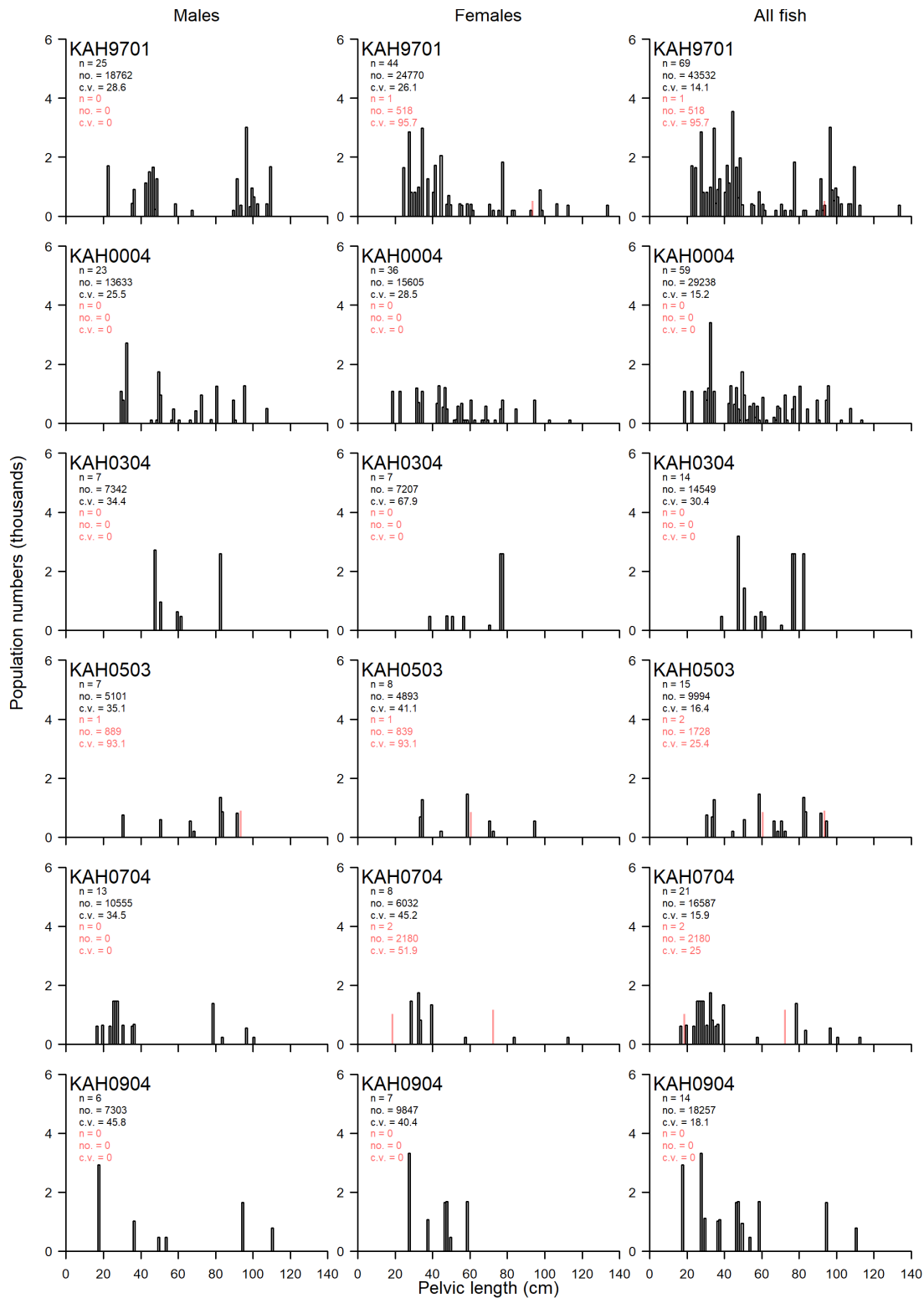


Figure 32: SSK: Scaled length frequency distributions from WCSI inshore survey. Grey bars: west coast strata. Red bars: Tasman Bay, Golden Bay strata. (Continued on next page)

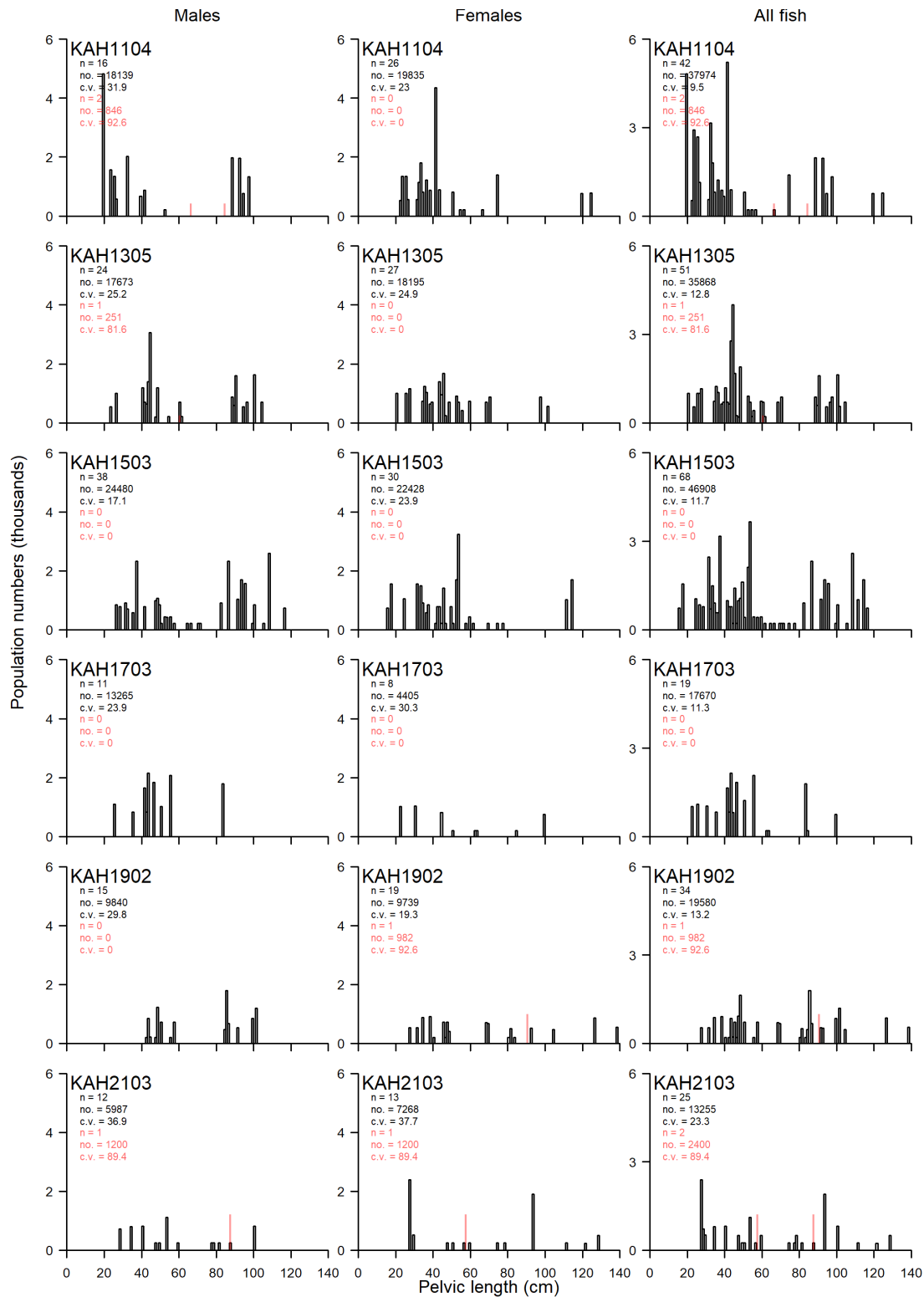
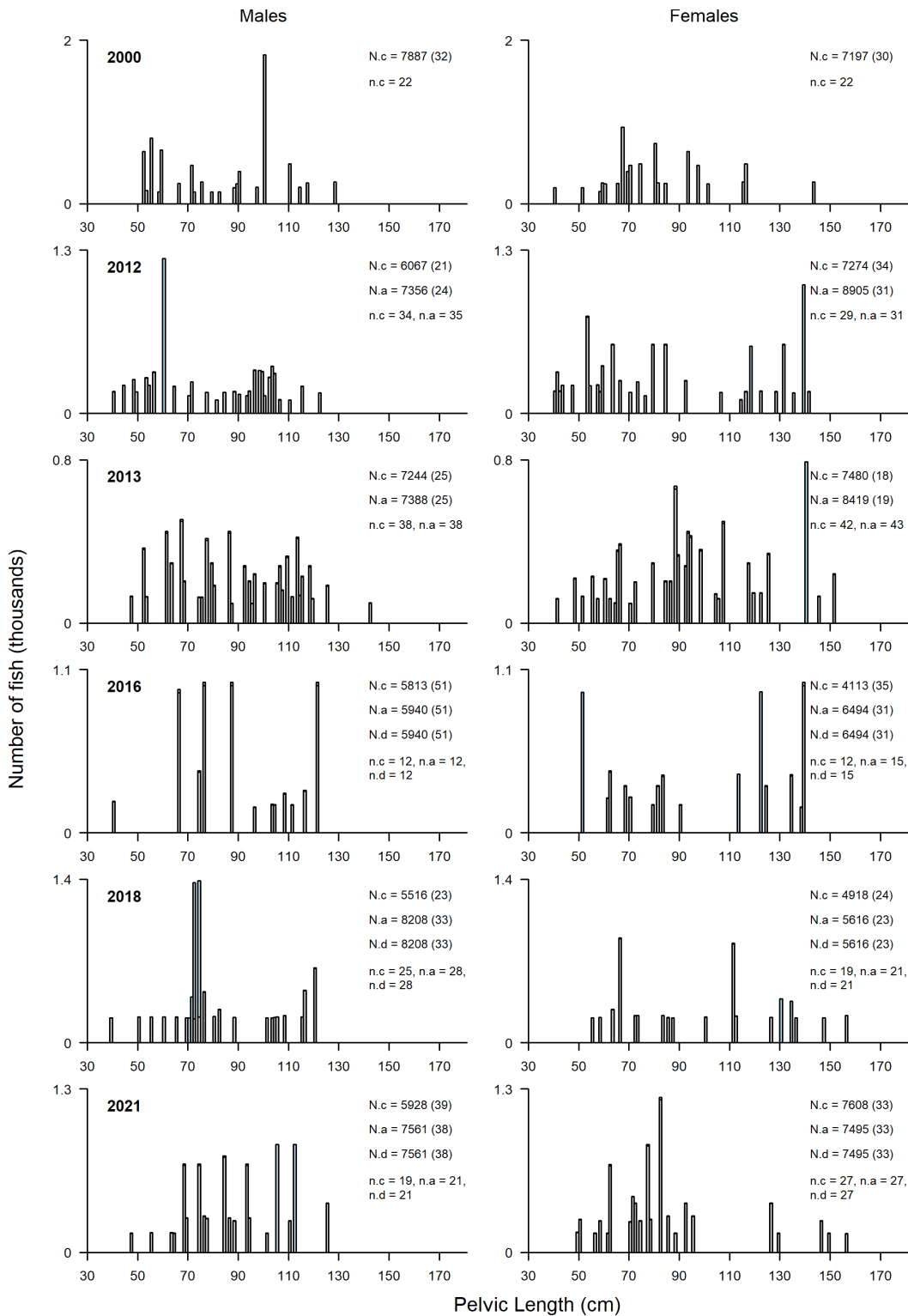


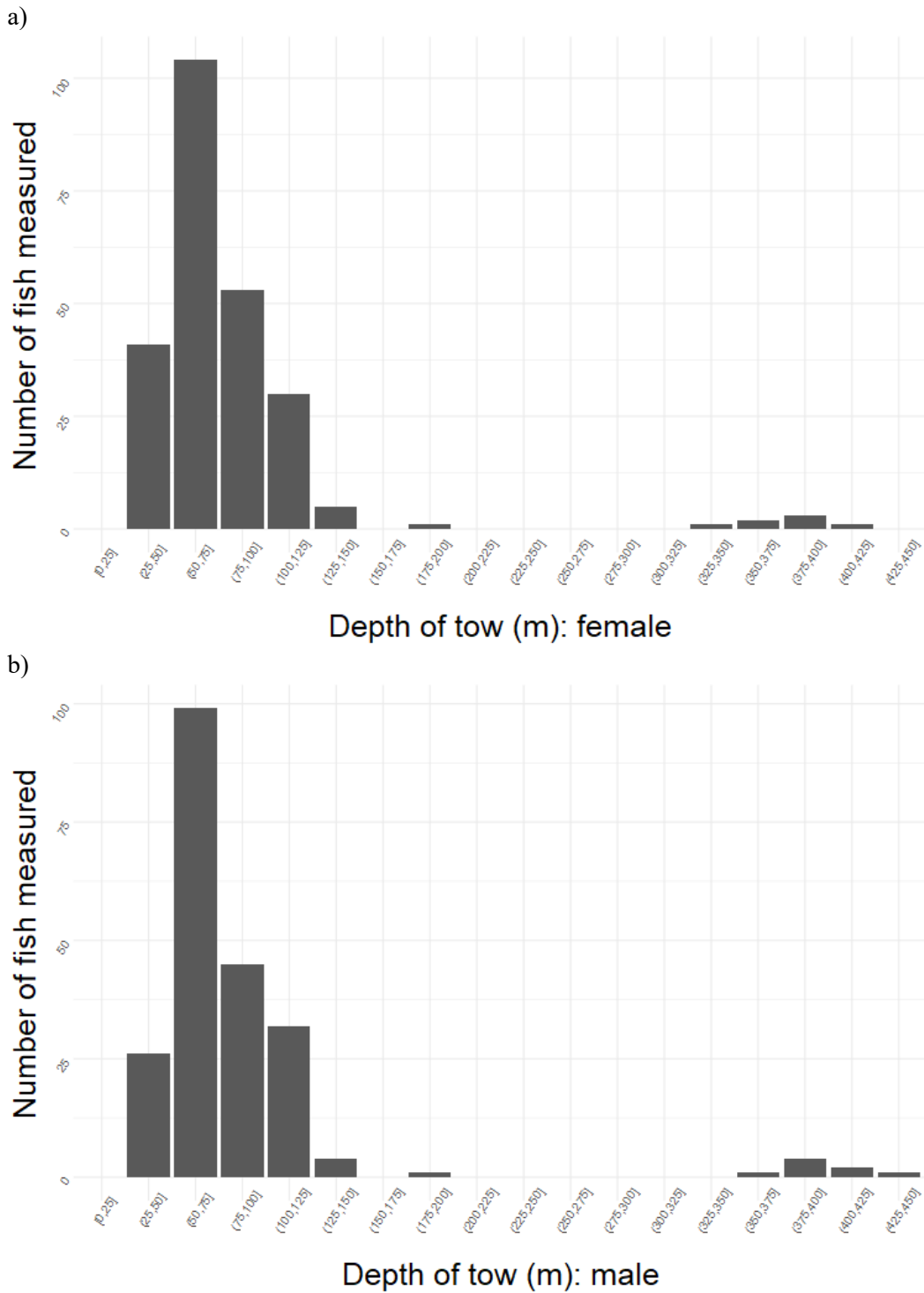
Figure 32: *continued.* SSK: Scaled length frequency distributions from WCSI inshore survey. Grey bars: west coast strata. Red bars: Tasman Bay, Golden Bay strata.



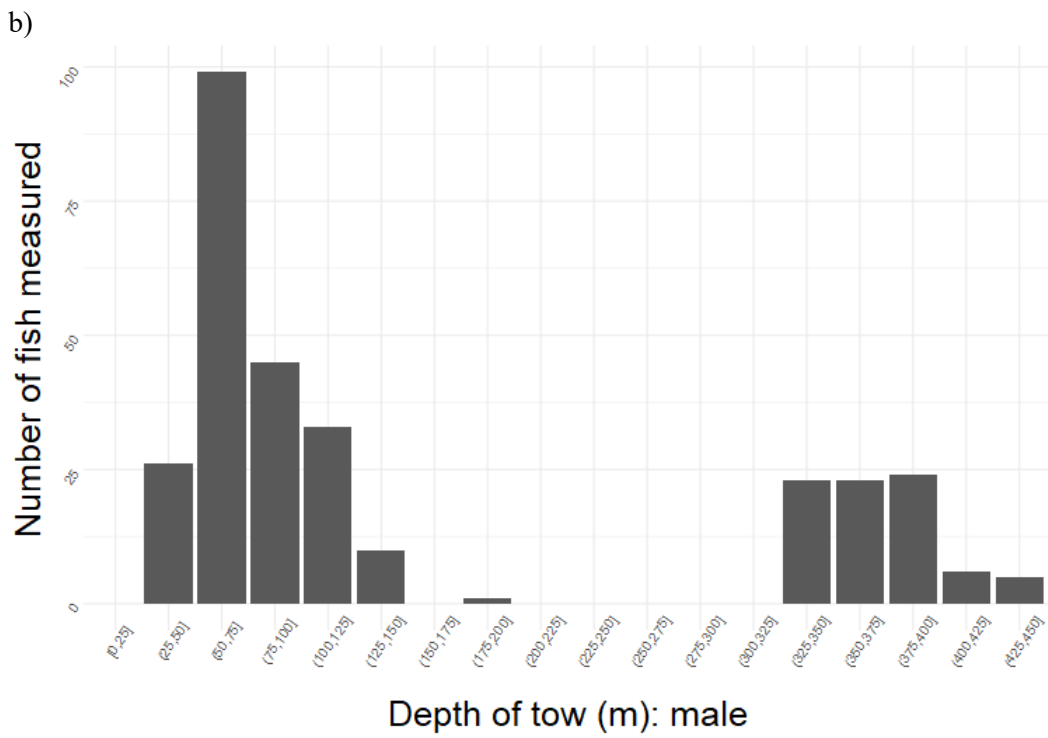
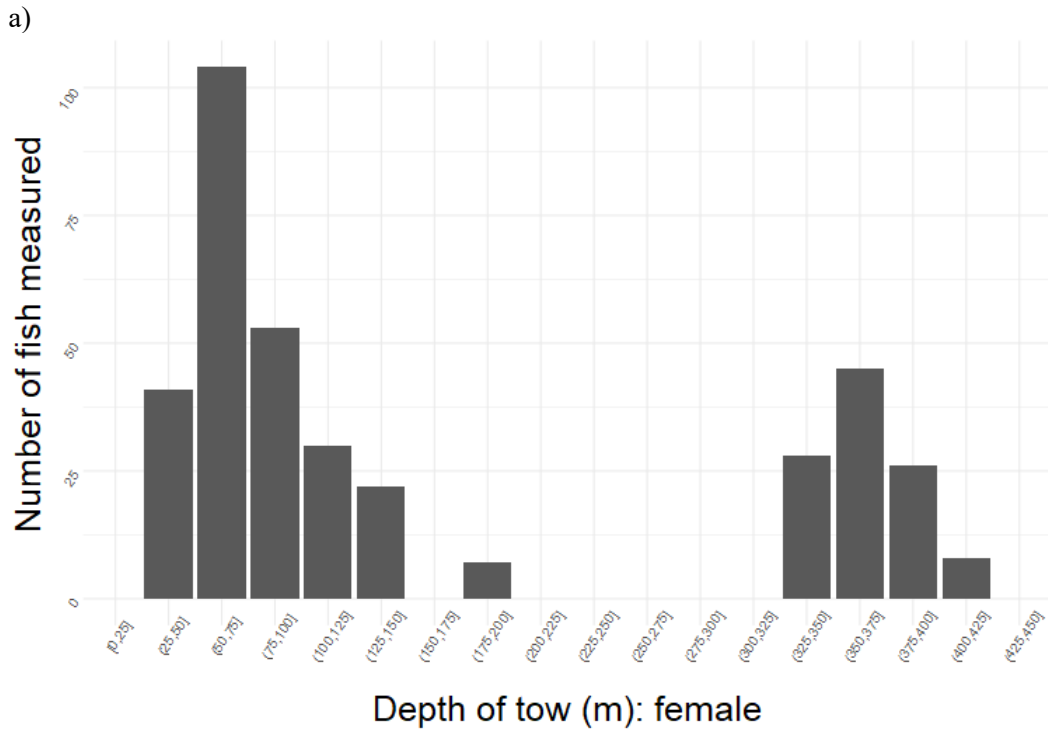
SSK, Smooth skate

**Figure 33: SSK: Scaled length frequency distributions from WCSI offshore survey.**

**APPENDIX 4: OBSERVER DATA**

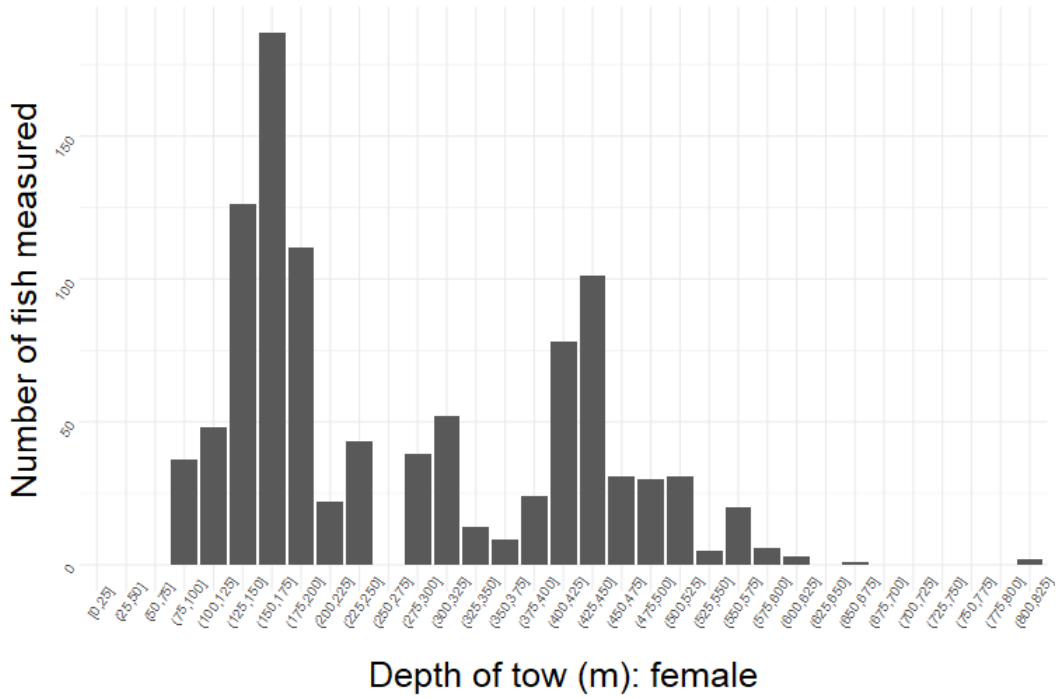


**Figure 34: RSK: Depths of all fish measured by observers in RSK 1 (FMAs 1–2) for a) females and b) males.**



**Figure 35: SSK: Depths of all fish measured by observers in SSK 1 (FMAs 1–2) for a) females and b) males.**

a)



b)

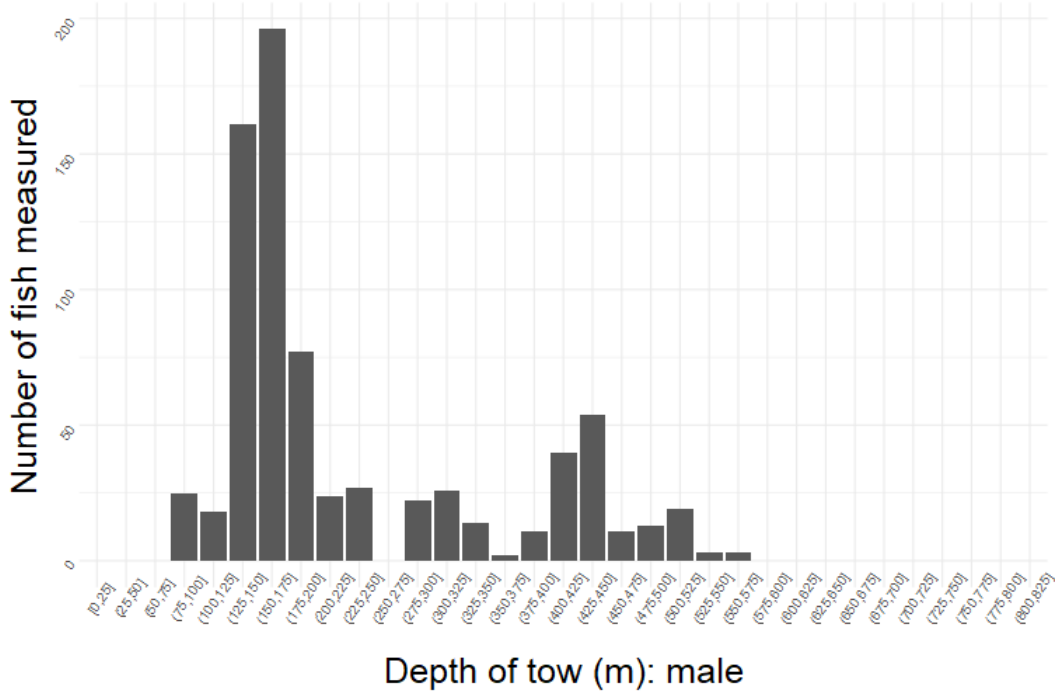
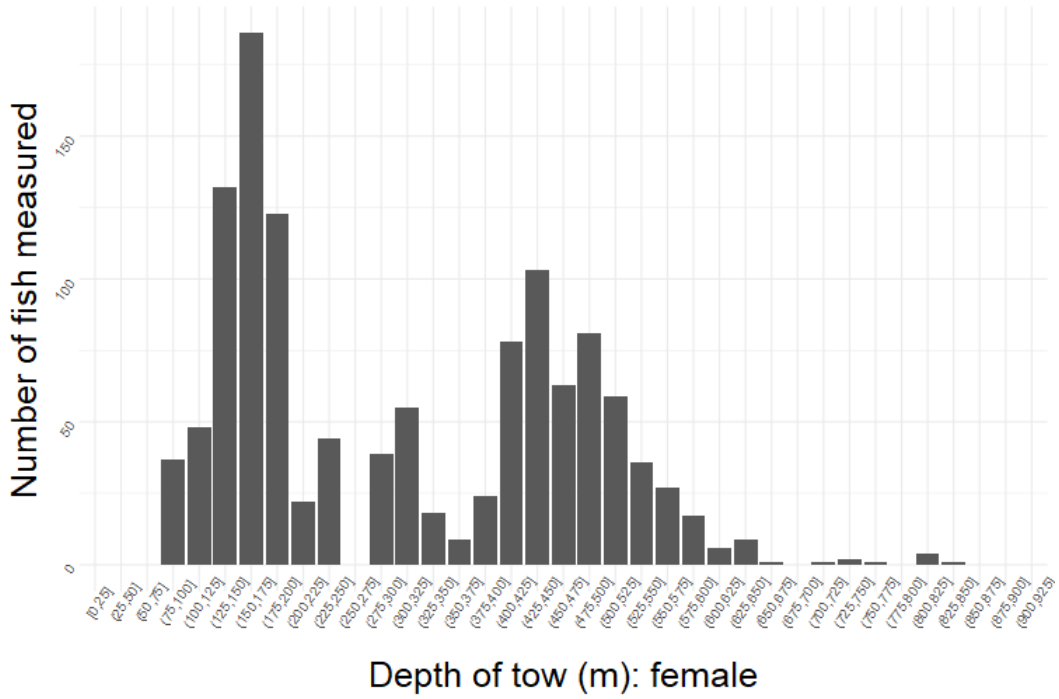


Figure 36: RSK: Depths of all fish measured by observers in RSK 3 (FMAs 3–6) for a) females and b) males.

a)



b)

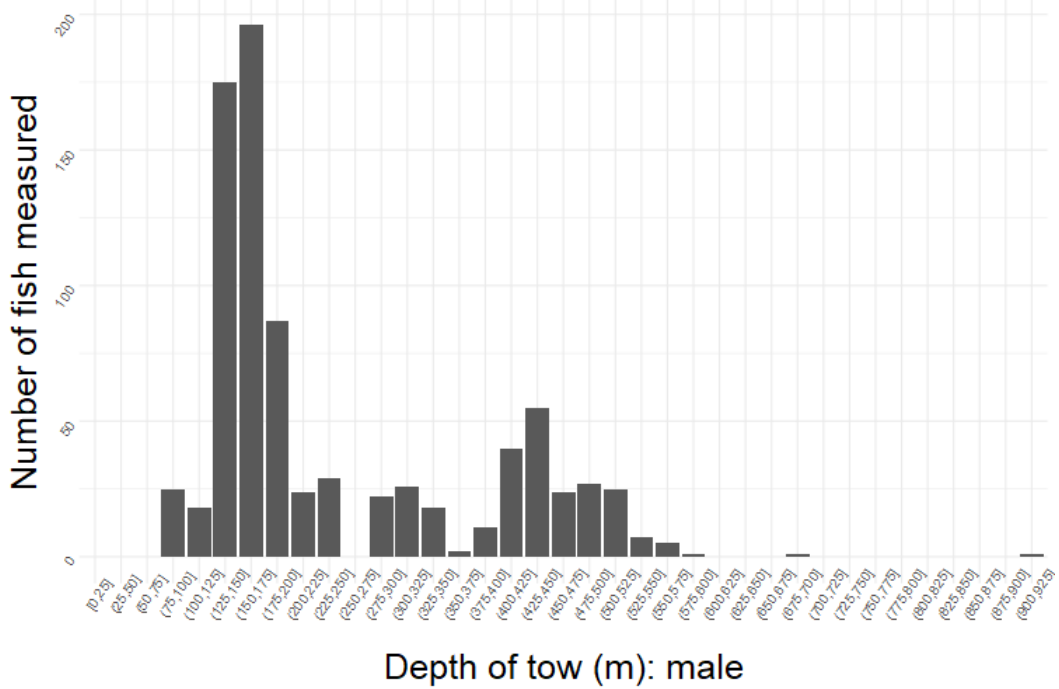
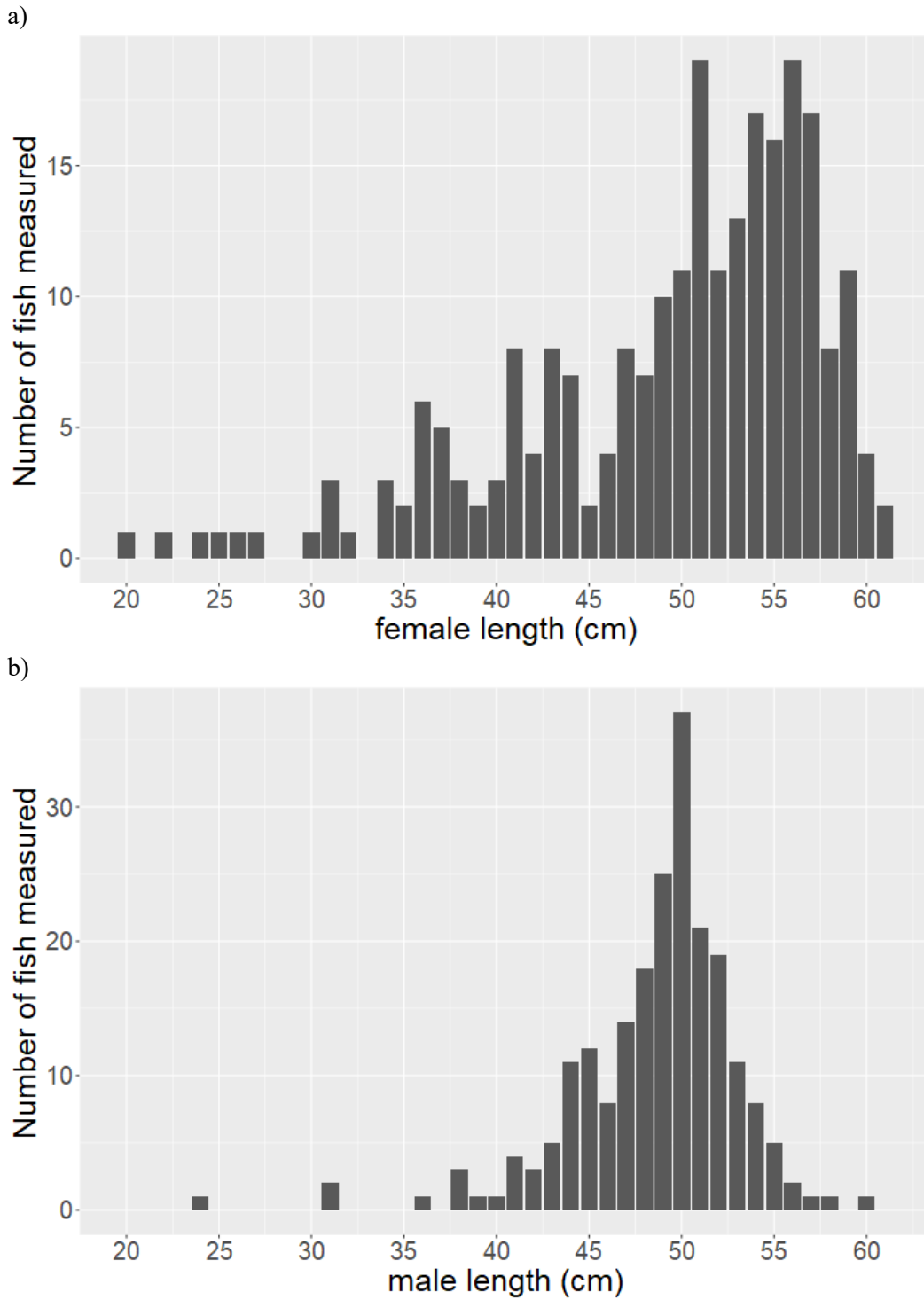


Figure 37: SSK: Depths of all fish measured by observers in SSK 3 (FMAs 3–6) for a) females and b) males.



**Figure 38: RSK: Lengths of all fish measured by observers in RSK 1 (FMAs 1–2) for a) females and b) males.**

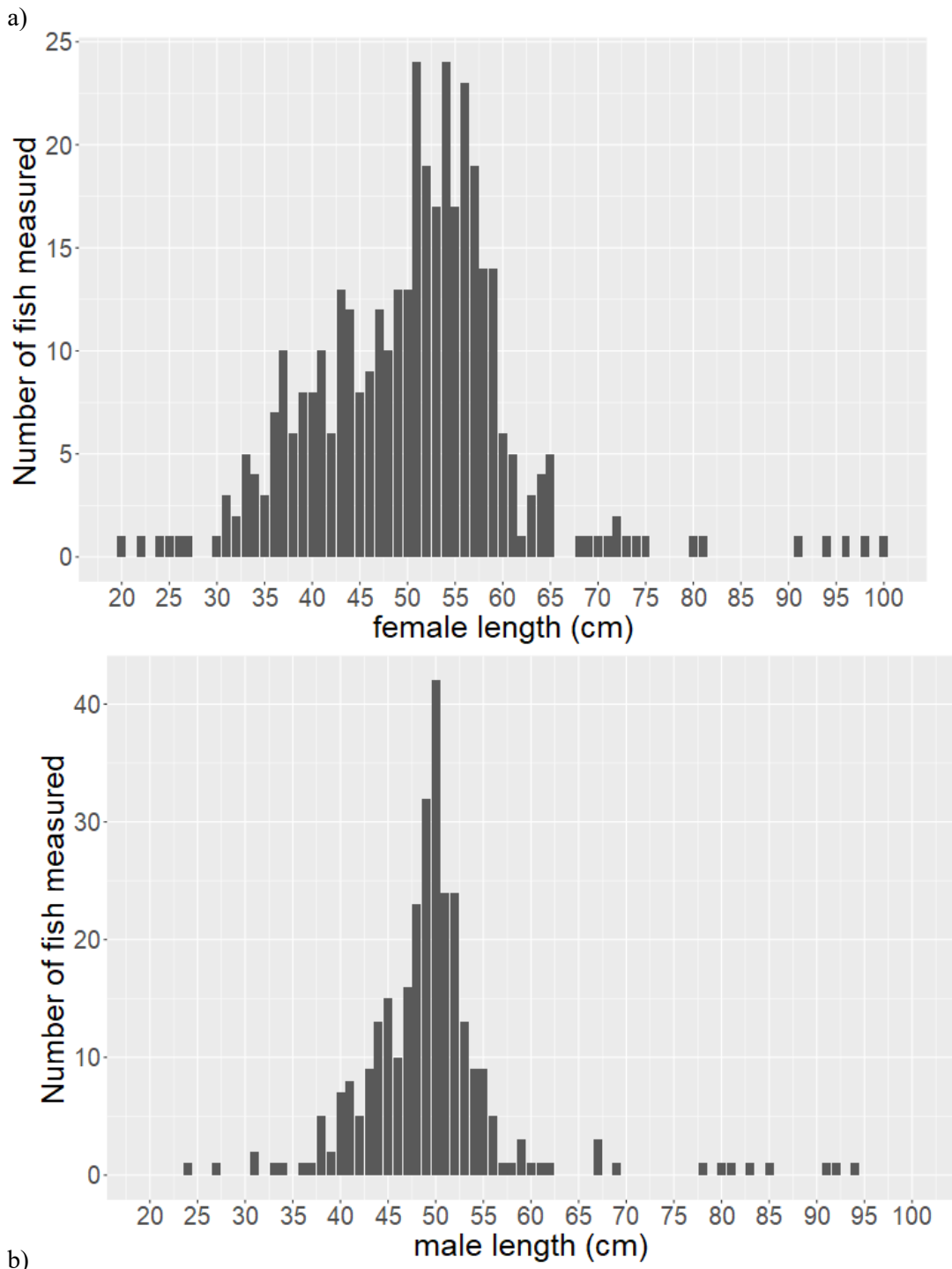
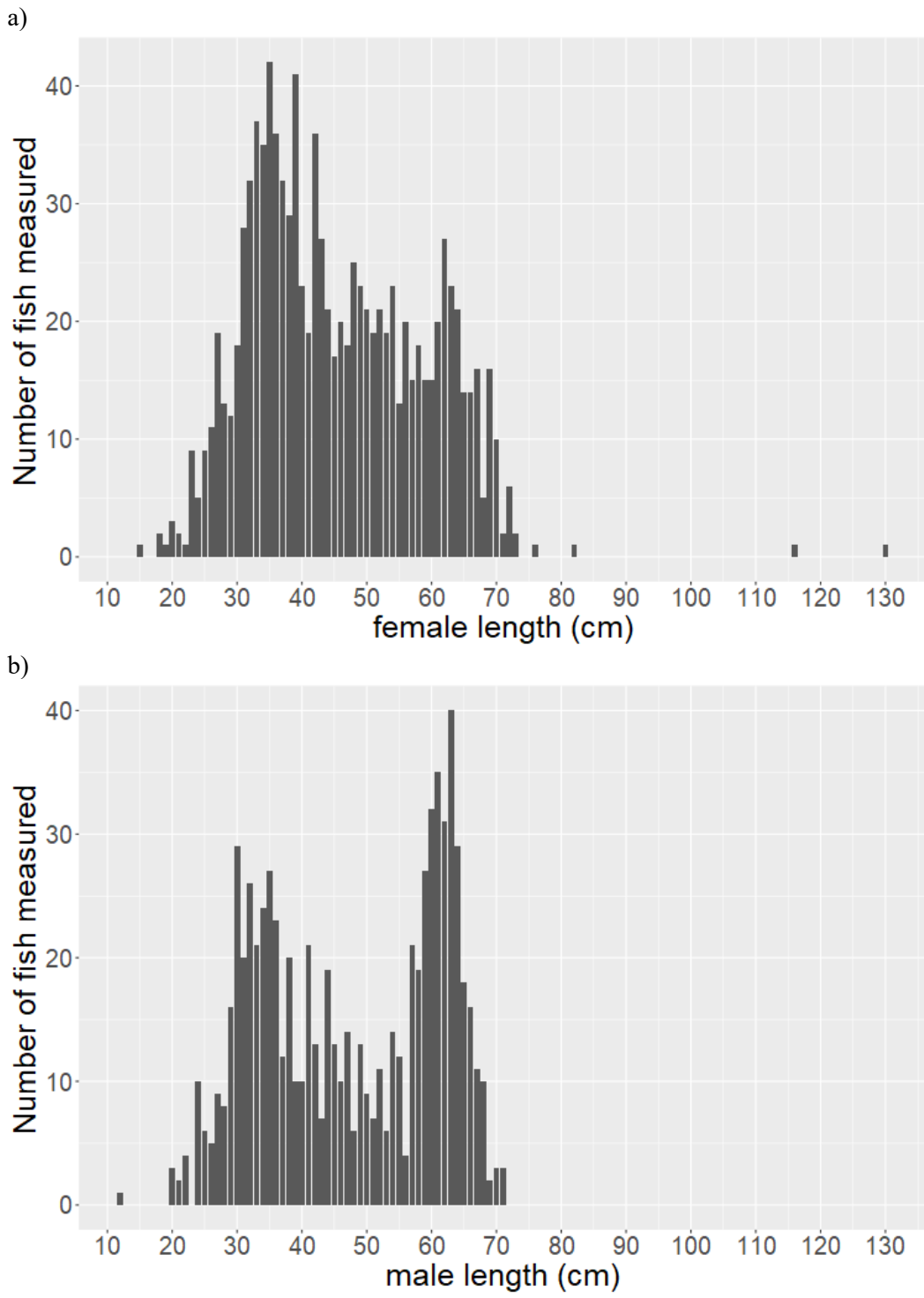
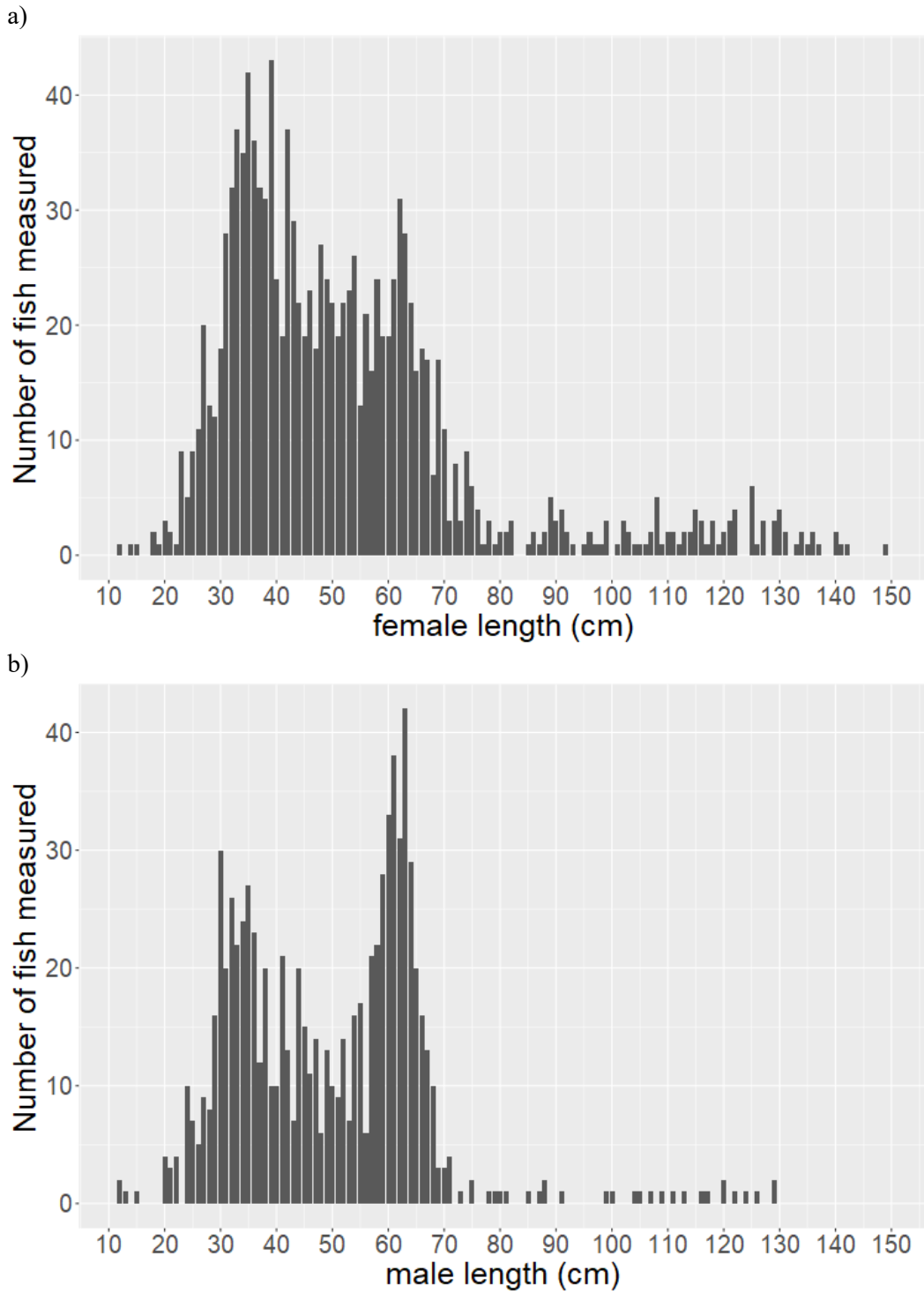


Figure 39: SSK: Lengths of all fish measured by observers in SSK 1 (FMAs 1–2) for a) females and b) males.



**Figure 40: RSK: Lengths of all fish measured by observers in RSK 3 (FMAs 3–6) for a) females and b) males.**



**Figure 41: SSK: Lengths of all fish measured by observers in SSK 3 (FMAs 3–6) for a) females and b) males.**

## APPENDIX 5: POSITIVE SURVEY CATCHES BY FISH LENGTH CLASS

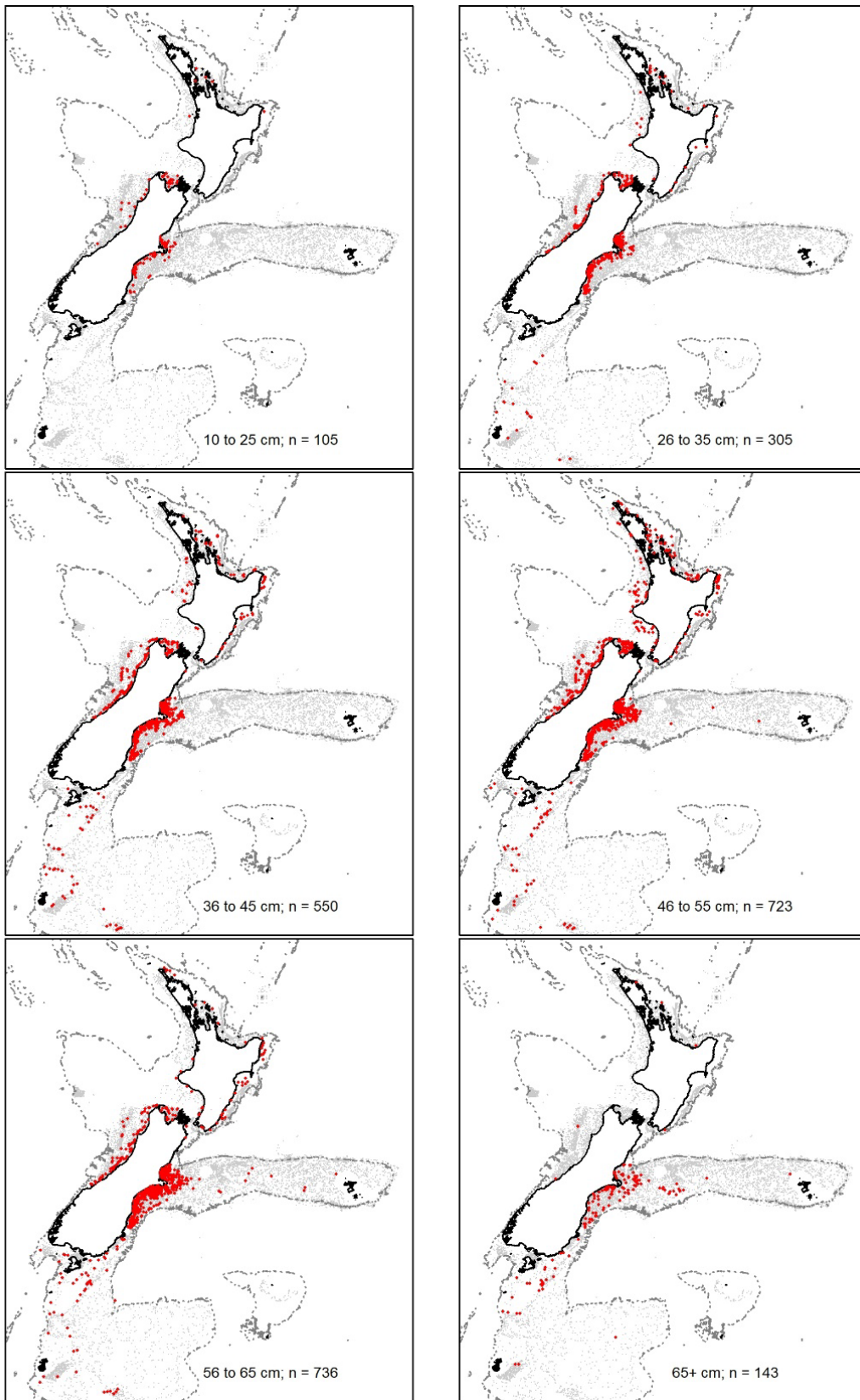
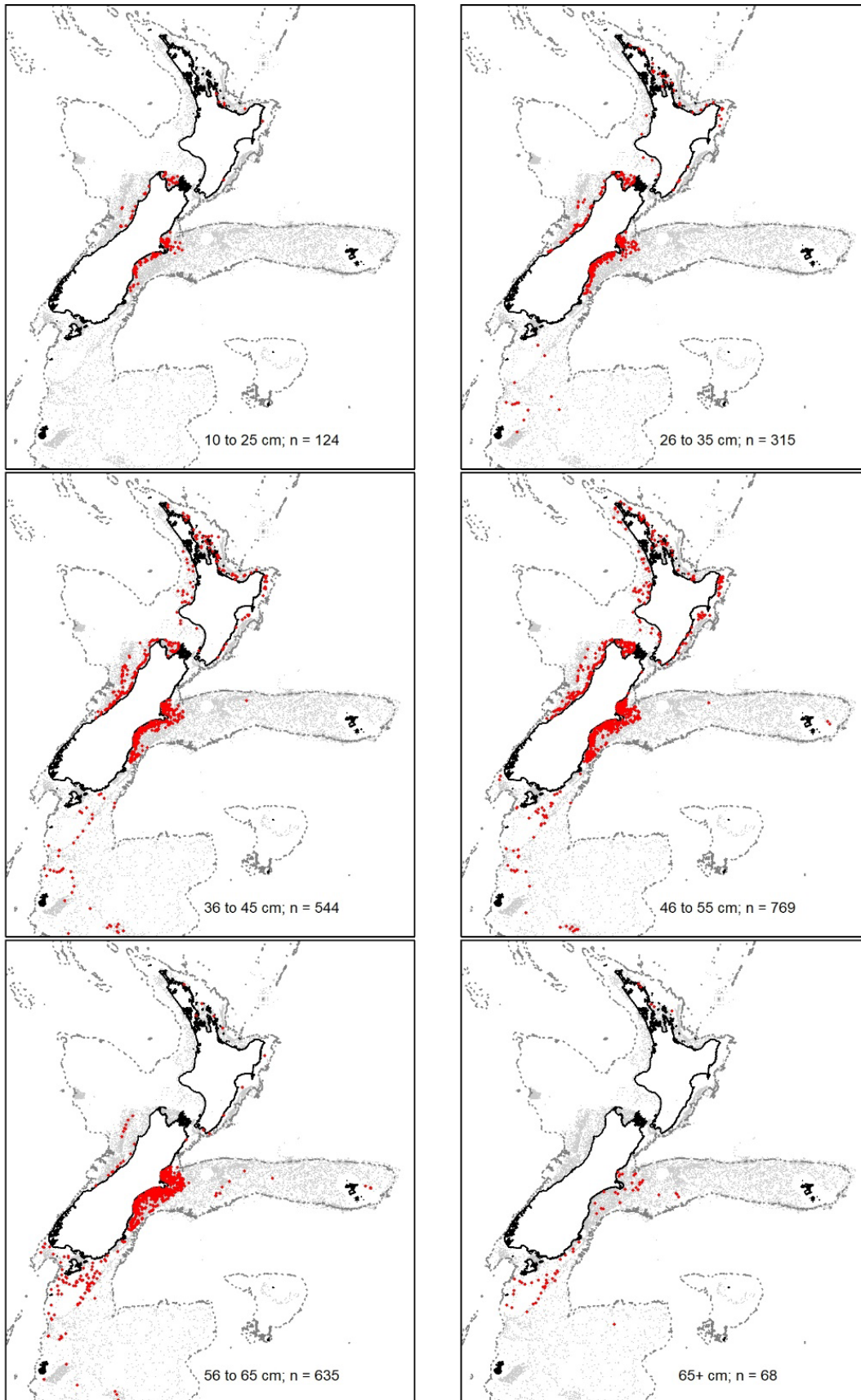
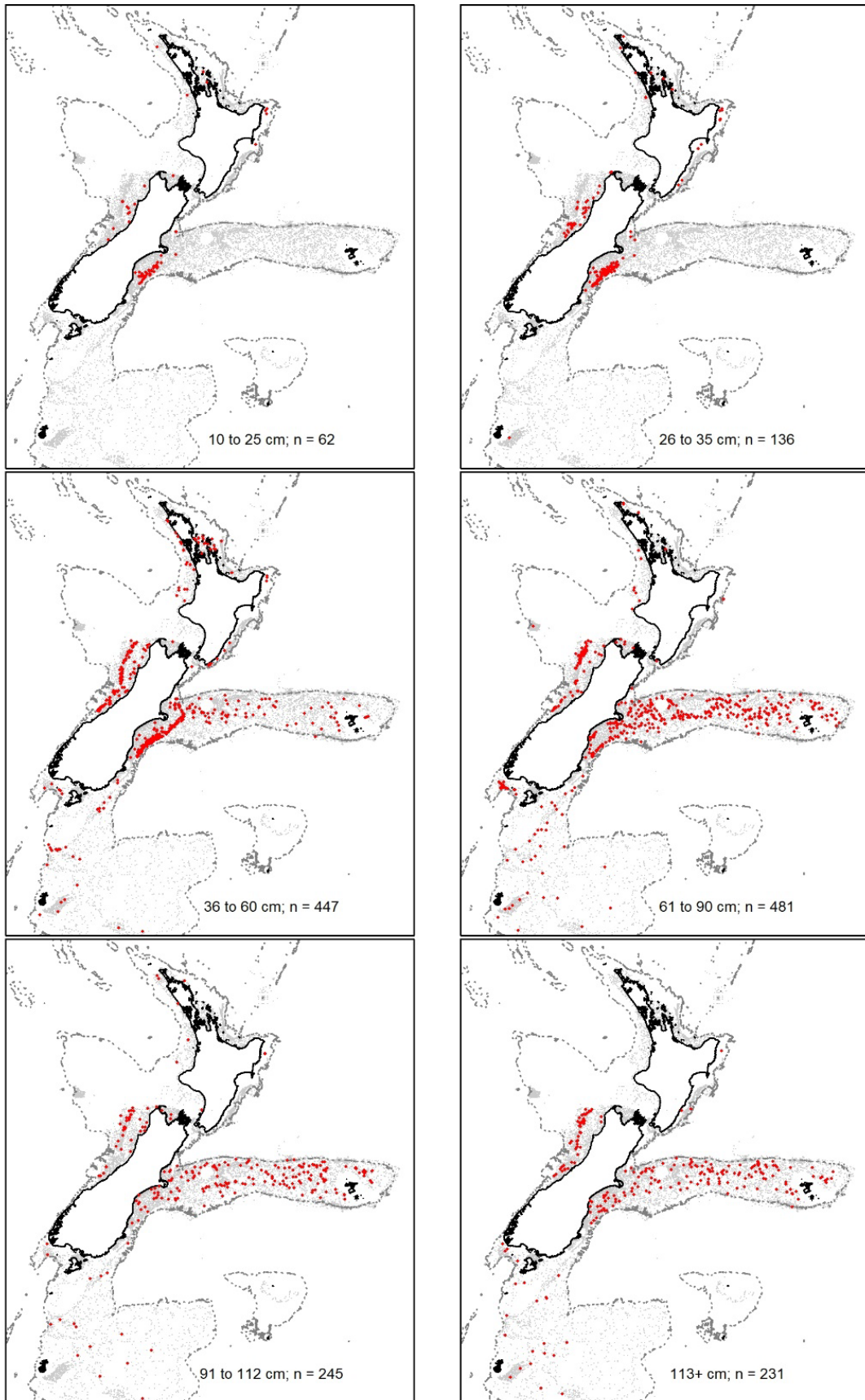


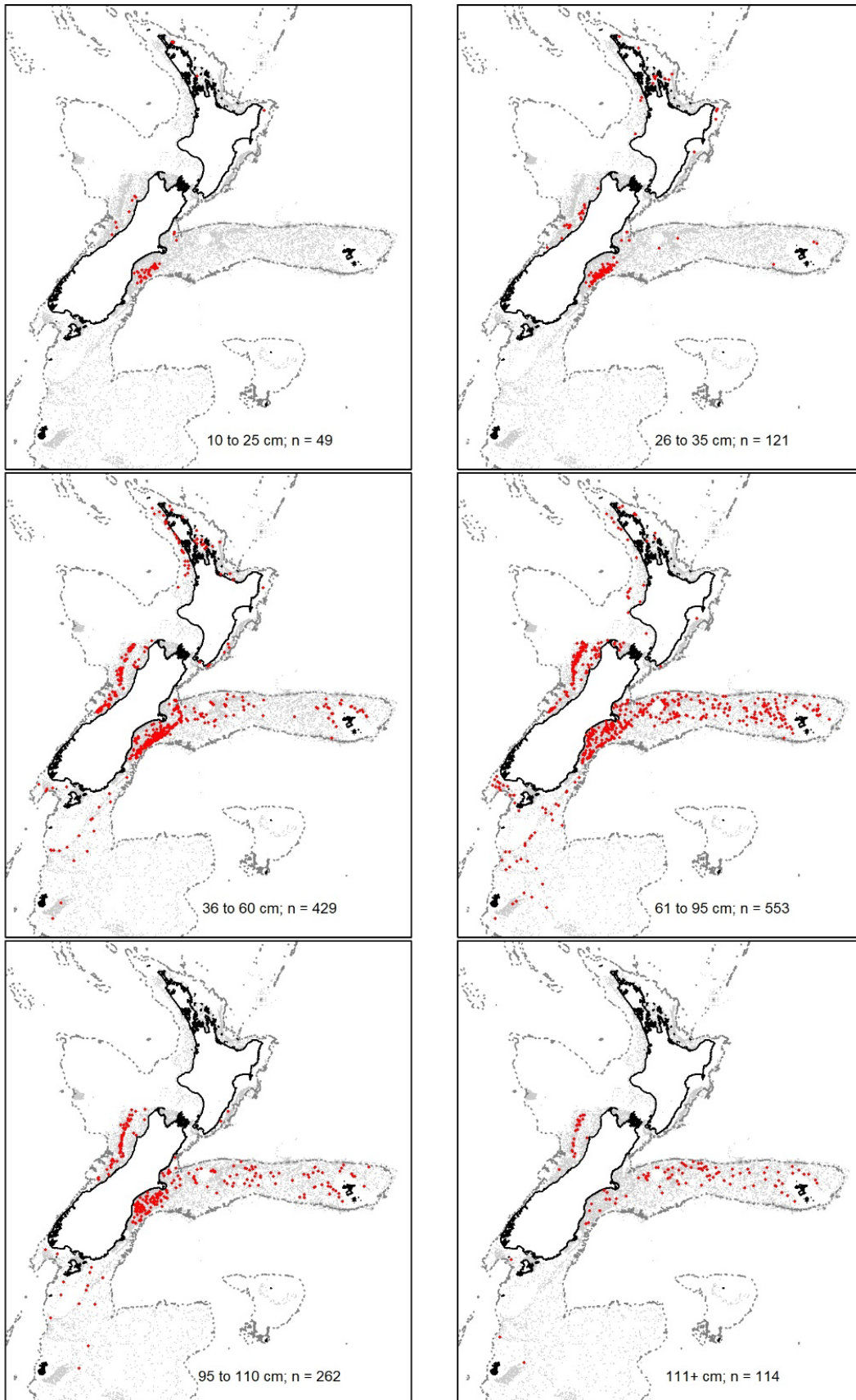
Figure 42: RSK: occurrence of females in research survey trawls by length categories. 50% maturity for female RSK = 59 cm (Fisheries New Zealand 2022a).



**Figure 43: RSK: occurrence of males in research survey trawls by length categories. 50% maturity for male RSK = 52 cm (Fisheries New Zealand 2022a).**



**Figure 44: SSK: occurrence of females in research survey trawls by length categories. 50% maturity for female SSK = 112 cm (Fisheries New Zealand 2022a).**



**Figure 45: SSK: occurrence of males in research survey trawls by length categories. 50% maturity for male SSK = 93 cm (Fisheries New Zealand 2022a).**