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The relative abundance of red gurnard, John dory, tarakihi and other inshore finfish species around northern New Zealand – the potential for a new “northern hotspot” trawl survey series

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CONTENTS

1. INTRODUCTION ... 3
2. METHODS ... 4
  2.1. Background to trawl surveys ... 4
  2.2. Catch and biological sampling ... 5
  2.3. Data grooming and restratification ... 5
  2.4. Data metrices calculated ... 11
  2.5. Data analysis ... 15
    2.5.1. Ranking of strata ... 16
    2.5.2. Allocation of stations ... 16
    2.5.3. Target coefficients of variation (c.v.s) ... 16
    2.5.4. Optimisation of stratification ... 17
    2.5.5. Biomass trajectory comparisons ... 17
  2.6. Assessment of population size frequency ... 18
  2.7. Analysis of commercial data ... 18
  2.8. Survey trawl net options ... 19
3. RESULTS ... 20
  3.1. Total Biomass survey optimisations ... 20
    3.1.1. East Northland ... 21
    3.1.2. Hauraki Gulf ... 22
    3.1.3. Bay of Plenty ... 22
    3.1.4. West Coast of North Island ... 26
  3.2. Spawning stock biomass survey optimisations ... 29
    3.2.1. East Northland ... 30
    3.2.2. Hauraki Gulf ... 32
    3.2.3. Bay of Plenty ... 32
    3.2.4. West coast North Island ... 32
  3.3. Length frequency comparison ... 36
  3.4. Commercial catch analysis ... 44
  3.5. Trawl net options for a "northern hotspot" survey ... 50
    3.5.1. The High Opening Bottom Trawl (HOBT) ... 50
    3.5.2. The east coast South Island Trawl ... 50
    3.5.3. The east coast North Island Trawl ... 51
    3.5.4. Commercial Trawl net option ... 52
    3.5.5. Estimated costs and decision summary ... 53
4. DISCUSSION ... 54
5. CONCLUSION ... 58
6. ACKNOWLEDGMENTS ... 58
7. REFERENCES ... 58
8. APPENDICES ... 63

EXECUTIVE SUMMARY

Morrison, M.A.; Bian, R.; Jones, E.G.; McKenzie, J.; Parsons, D.; Shankar, U. (2013). The relative abundance of red gurnard john dory, terakihi and other inshore species around northern New Zealand – the potential for a new "northern hotspot" trawl survey series.

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Scientific trawl surveys are a valuable fishery-independent monitoring tool, used worldwide to assess populations without potential confounding from changing fishing gear and fishing practices over time and providing the opportunity to collect a wide range of additional biological and ecological data. The major disadvantage is the relatively high expense of obtaining relatively small amounts of data. In northern New Zealand, a series of trawl surveys in four regions (west coast, WCNI; east Northland, ENLD; Hauraki Gulf, HAGU; Bay of Plenty, BPLN) were discontinued in 2000 due to the expense outweighing the perceived value of the data collected. In this study the scope for reducing the area covered and number of stations required was explored. The aim was to assess the feasibility of a combined northern survey that targeted abundance "hotspots" to produce biomass trajectories that were good proxies for the full data series existing from historical surveys encompassing 1982–2000.

Using the original time series of trawl survey data for each area, an optimization process ranked the strata from most to least important and then dropped the lowest ranking strata one by one. At each iteration the algorithm ALLOCATE was used to allocate stations across strata required to obtain particular sets of coefficient of variation (c.v.) values. Four different c.v. target levels were set, based where possible on historical target c.v.'s, each encompassing the individual target c.v.s for red gurnard (GUR), John dory (JDO), and tarakihi (TAR). New 'reduced strata' biomass trajectories were calculated and compared to the full strata (original survey) biomass trajectories. Kolmogorov-Smirnov tests were used to compare length frequency distributions from the full and "optimised" analyses.

The results of the simulation indicated that it is possible to reduce the number of strata and stations in each of the 4 survey areas and still produce biomass trends for the adult populations of the target species that, in the most part, were very similar to the original survey trajectories. However, the reduced strata survey simulations produced significantly different length frequency distributions for red gurnard and John dory in some years which suggests that the reduced survey design is less capable than the full survey of monitoring population size structure and pre-recruit biomass in some areas.

Based on the premise that a future survey is aiming to monitor spawning stock biomass, and taking into account past c.v. targets where specified and general cost-benefit considerations, a combined northern "hotspot" survey of 173 stations (ENLD 49; HAGU 41; BPLN 52; WCNI 31) is suggested. The total reduction in number of stations is nearly 40% overall and the reduction in survey area is 27%.

The timing and spatial extent of the surveys were compared to commercial red gurnard, John dory and tarakihi fisheries. The survey area covered the main commercial fishing grounds in all cases except for tarakihi in east Northland. There are fluctuations in landings for all three species, with generally higher landings during spring/summer for John dory and red gurnard and particularly clear peaks in late summer/autumn for tarakihi, that were not encompassed by historical surveys. It was concluded that the timing of some surveys could be shifted to better coincide with these known periods of higher landings. If all surveys were to be combined in a single northern survey, they would need to run from February through to early April, or could span from early spring/summer (Hauraki Gulf & west coast) to late summer and autumn (East Northland and Bay of Plenty).

The trawl net used for the original survey was designed over 30 years ago, and with a different primary target species in mind (adult and juvenile snapper). Although no single net will catch all species

optimally, a number of alternative, more modern and/or more cost effective options were reviewed and it is likely that a net design more in line with current industry practices could improve the efficiency of some or all species or size groups and may be more acceptable to industry.

The premise that led to the commissioning of this report was that the 1982–2000 RV *Kaharoa* Northern trawl survey series provided reasonable John dory, red gurnard and tarakihi abundance indices. The results provide no evidence to dispute this premise for red gurnard and John dory, but suggest that the original surveys were unlikely to have been optimal for tarakihi in their timing, and, to a lesser degree, their spatial stratification. Improved monitoring of John dory and red gurnard could be achieved using the optimized trawl survey programme, providing a valuable comparison with the historical data. However, such a survey is unlikely to effectively monitor tarakihi on the east coast. To achieve improved monitoring for this species, the timing (and possibly spatial extent) of either all or some of the historical surveys could be modified with the hope that such changes do not negatively influence abundance estimation for the other species. Initial surveys (two or three minimum) would require at least as many stations as used in the original series, but it should then be possible to optimise the new survey design. Alternatively, a completely new trawl survey programme could be initiated, with timing, spatial coverage and trawl net designed for the key species in each area, with a view to eventual optimization of the design. The results presented in this report demonstrate the utility of the simulation tool developed and provide some insight as to the likely station number differential between "initial" and "optimised" surveys. Ultimately, the choice for a given species and stock is a management question and will depend on what the trawl survey indices are to be used for, the benefits of increased precision, versus the associated increasing costs in achieving that precision.

1. INTRODUCTION

A range of stock monitoring tools is required for the effective management of fished populations. Fisheries-independent biomass surveys are especially valuable, allowing for populations to be assessed without the potential confounding issue of changing fishing gear and fishing practises over time, including 'technology creep'. Trawl surveys in particular are a well established monitoring tool, used to manage fished finfish stocks in many nations (Doubleday & Rivard 1981, Gunderson, 1993, Hilborn & Walters, 1992).

In northern New Zealand a trawl survey series was initiated in the early 1980s, using the newly commissioned fisheries research vessel *Kaharoa,* to monitor the status of snapper (SNA – *Pagrus auratus*) stocks (SNA 1 and SNA 8), with secondary target species of John dory (JDO – *Zeus faber*) and red gurnard (GUR – *Chelidonichthys kumu*). In 1982 the snapper target focus of the surveys was shifted on the east coast (SNA 1) to 1+ fish, and on the west coast (SNA 8) to 2+ and 3+ fish, the purpose being to allow year class strengths to be calculated before they fully recruited to the commercial fishery. These surveys were run as four separate geographic entities – the west coast North Island (WCNI), east Northland (ENLD), Hauraki Gulf (HAGU), and Bay of Plenty (BPLE). The east Northland survey ran for only two years (1990, 1993), before being terminated due to the presence of large areas of untrawlable ground (reefs). In 1999, Tarakihi (TAR – *Nemadactylus macropterus*) was added as a target species for the west coast and Bay of Plenty surveys. Towards the end of the 1990s the "perceived" value of trawl surveys as predictors of snapper year class strength diminished due to the belief that commercial catch sampling and tagging programmes to estimate stock biomass, were providing sufficient data for successful stock assessments. The last survey was carried out in the Hauraki Gulf in 2000, after which all the northern trawl surveys were terminated on the premise that the cost of doing them outweighed the relative value of the data gained.

Recent catch-per-unit analyses have provided information on relative abundance for North Island tarakihi, red gurnard and John Dory management areas (Fu, et al. 2008, Kendrick, 2009a, 2009b). However, without a fisheries-independent trawl survey, it cannot be determined whether CPUE is truly an effective monitoring tool for these species. Consequently, the idea of reinstating the northern trawl surveys was proposed. The combined number of stations used in the previous surveys, although variable, exceeded 300; the cost of returning to the previous design was therefore prohibitive. Adopting a survey design that sampled a sub-set of 'core' areas, while still reliably tracking the biomass trajectories over time of the different species and stocks was suggested.

This report assesses the feasibility of creating a new northern "hotspot" trawl survey series optimised to monitor the abundance and population structure of three species (John Dory, red gurnard, tarakihi). Using the historical trawl time series, the feasibility of retaining the temporal trends in estimated spawning stock biomass seen in the 'full' survey series, while using only a sub-set of the original data (i.e. through dropping strata, and/or the number of stations in any given strata) was examined. The indices of other important species (e.g. snapper, trevally, leatherjacket and school shark) were also examined under a reduced "hotspot" survey design. In addition, the effect of reducing strata and / or stations on the population structure of target species was examined by comparing the length frequencies obtained from both the full and subsetted data.

The initiation of a new trawl survey raises other questions around the optimal timing and trawl gear that might be used, particularly where the target species are different from those that the original survey was designed to sample. Traditionally, fisheries-independent trawl surveys aim to maintain the same vessel, trawl gear and methods to reduce confounding issues (e.g. Hurst et al 1992, Engås, 1994). The trawl net used for the historical surveys was designed in the early 1980s with juvenile snapper as the target species. Rebuilding such a trawl, with the same materials as used originally, is potentially a challenge, and may not be possible if the materials are no longer manufactured. A new survey starting 30 years later, with different target species, may require a different trawl net. Similarly, the timing of the original surveys may, or may not be optimised for the new target species. The spatial coverage and timing of the surveys were explored using commercial catch data for the relevant species. The potential trawl net options currently available were also reviewed and the merits and disadvantages of the choices available for a new survey discussed.

2. METHODS

2.1. Background to trawl surveys

In this and the following sections we provide a broad overview of how the trawl surveys have been structured and implemented. However, we note that there have been ongoing changes in approaches, stratification, survey design (e.g., one versus two phase), target species, and the technology available (e.g., introduction of SCANMAR, GPS, and motion-compensating scales) over the seventeen year period in which these trawl surveys were undertaken. Documenting all these changes in detail is beyond the scope of this report; the reader is directed to the trawl survey reviews for the wider region (Langley 1994a), west coast (Morrison et al. 2001c) and Bay of Plenty (Morrison et al. 2001b) for this background information. Overall, the same vessel and net configurations were used throughout each individual survey area, making data directly comparable through time.

Data were available from 27 separate trawl surveys, all carried out using R.V. *Kaharoa* (see Table 1 for details). In brief, these surveys employed a standardised trawling procedure, with tows being conducted in daylight hours between 0530 and 1700 (NZST). A high opening bottom trawl (HOBT) with cut away lower wings and a nominal 40 mm codend was used. If a given station was in an area of foul or the depth was out of range, an area within 2 n. miles (3.7 km) of the station in the same stratum was searched for suitable ground. If suitable ground was not found, the station was abandoned and the next station on the list was selected as a replacement. Standard tows were either 0.7 (1.4 km) (east coast) or 1.5 n. miles (2.8 km) (west coast) in length. Distance was estimated using GPS, and/or Satnav or radar for earlier surveys. Warp to depth ratios ranged from 16:1 at the shallowest stations to 4:1 for the deeper trawls. Depending on the year of survey, doorspread was recorded and averaged over the tow using Scanmar (later surveys), or calculated using the method of Kawahara & Tokusa (1981) (earlier surveys).

Survey regions were stratified based on depth, latitude, and catch rates from previous surveys. Random stations were allocated within each of these strata, with a minimum number of three stations per stratum. Pre-survey simulations were run to allocate additional available stations to those strata most likely to achieve the best reduction in the coefficients of variation (c.v.s) for one or more of the target species. Most of the surveys were of a two-phase design, where an initial phase of sampling (*c.* 70% of available stations) was followed by a second phase targeting those strata most likely to offer the best c.v. reductions with increased sampling effort. However, some of the earlier surveys were of a simpler one-phase design.

Table 1: Summary of survey years and associated reports.

East Northland (ENLD)

Year	No. tows	Report
1990	62	Drury & McKenzie (1992a)
1993	77	Drury & Hartill (1994)

Hauraki Gulf (HAGU)

Year	No. tows	Report
1982	80	No report
1984	83	No report
1985	80	No report
1986	124	No report
1987	83	No report
1988	69	No report
1989	78	No report
1990	73	Drury & McKenzie (1992b)
1992	73	Langley (1994b)
1993	73	Langley (1994c)
1994	70	Langley (1994d)
1997	49	Morrison & Francis (1999)
2000	48	Morrison *et al*. (2001a)

Bay of Plenty (BPLE)

Year	No. tows	Report
1983	61	No report
1985	80	No report
1990	59	Drury & McKenzie (1992d)
1992	82	Drury & Hartill (1993b)
1996	73	Morrison (1997)
1999	76	Morrison & Parkinson (2000)

West Coast North Island (WCNI)

Year	No. tows	Report
1986	66	No report
1987	56	No report
1989	84	Drury & McKenzie (1992c)
1991	81	Drury & Hartill (1993a)
1994	73	Langley (1995)
1996	122	Morrison (1998)
1999	100	Morrison & Parkinson (2001)

2.2. Catch and biological sampling

For the majority of surveys, the catch of each species from each tow was sorted, boxed, and weighed on motion-compensating 100 kg Seaway scales to the nearest 0.1 kg. However, in some of the earlier surveys (1985 and 1987 in particular), weight data were only recorded for selected species. Length, to the nearest centimetre below actual length, and sex were recorded for all QMS and some selected non-QMS species, either for the whole catch or, for larger catches, on a sub-sample of up to 200 randomly selected fish. Biological information was obtained from a random sample of up to 60 fish for snapper. One or more of the following records or samples were taken: length to the nearest centimetre below actual length, otoliths, sex and gonad stage (females only). Biological information and otolith collections were made for other species (red gurnard, John dory, tarakihi) in the later surveys. Length-weight data was collected across a range of surveys for different species, and used to generate length–weight relationships.

2.3. Data grooming and restratification

All data were initially extracted from the "*trawl*" fisheries database, from the tables 'catch' and 'station', and manipulated in an ACCESS database. Data were groomed for errors, and all stations recorded as having poor gear performance (code 3 or 4) removed from the data series. This process removed the following number of stations: ENLD, 7; HAGU, 13; BPLE, 7; and WCNI, 6.

Stratification design changed adaptively with time across different surveys, along with the overall spatial extent for some regions (e.g., west coast North Island – see Morrison et al. (2001a). In order to analyse all available data in a standardised and meaningful fashion, we used the most recent stratification to re-stratify all stations from all years. The stratifications used are shown in Figures 1 to 4, and their associated spatial extents (by strata) in Table 2. This resulted in a number of shots falling outside the stratification design, or within strata deemed to be unfishable (e.g., areas of 'foul'). Most of these instances occurred when earlier surveys covered areas from both the east and west coast, before a rationalisation of survey design, or in the case of the Bay of Plenty, when later surveys were designed to avoid known or suspected areas of foul ground. This process removed the following number of stations for being outside the survey area: ENLD, 26; HAGU, 64; BPLE, 3; and WCNI, 48; and 24 stations from the Bay of Plenty for falling inside strata areas designated more recently designated as 'foul'.

Table 2: Strata and associated areal extents (km^2) of the four trawl survey areas, as per most recent surveys for each.

Surveys							
East Northland (ENLD)		Hauraki Gulf (HAGU)		Bay of Plenty (BPLE)		West coast North Island (WCNI)	
Stratum	Area	Stratum	Area	Stratum	Area	Stratum	Area
REI1	74	c1149	65	c1096/2096	432	A25	254
REI2	119	c1219	888	c5187/5287	629	AA50	942
GEB1	191	c1268	312	c6085	740	A100	624
GEB2	225	c1284	73	c7085	1696	A200	1998
GEB3	313	c1386	68	c808CNE	1304	B25	104
GEB4	611	c1449	269	c909CNE	897	BB50	323
KAW1	209	c1518	3212	c4085	486	B100	1332
KAW2	138	c1887	270			B200	970
BOI1	124	c2229	560			C25	562
BOI2	62	c4492	2405			C50	612
KBR1	618	c9292	67			C100	1736
KBR2	1400					C200	1045
BRB1	147					D25	191
BRB2	181					DD50	462
BRB3	679					RG50	441
BRB4	2907					E25	312
						E50	487
						E100	3635
						E200	1424
						F25	329
						F50	741
						F100	2490
						F200	2722
						G25	492
No. of Strata	16		11		7		24
Total area (km^2)	8000		8189		6184		11908

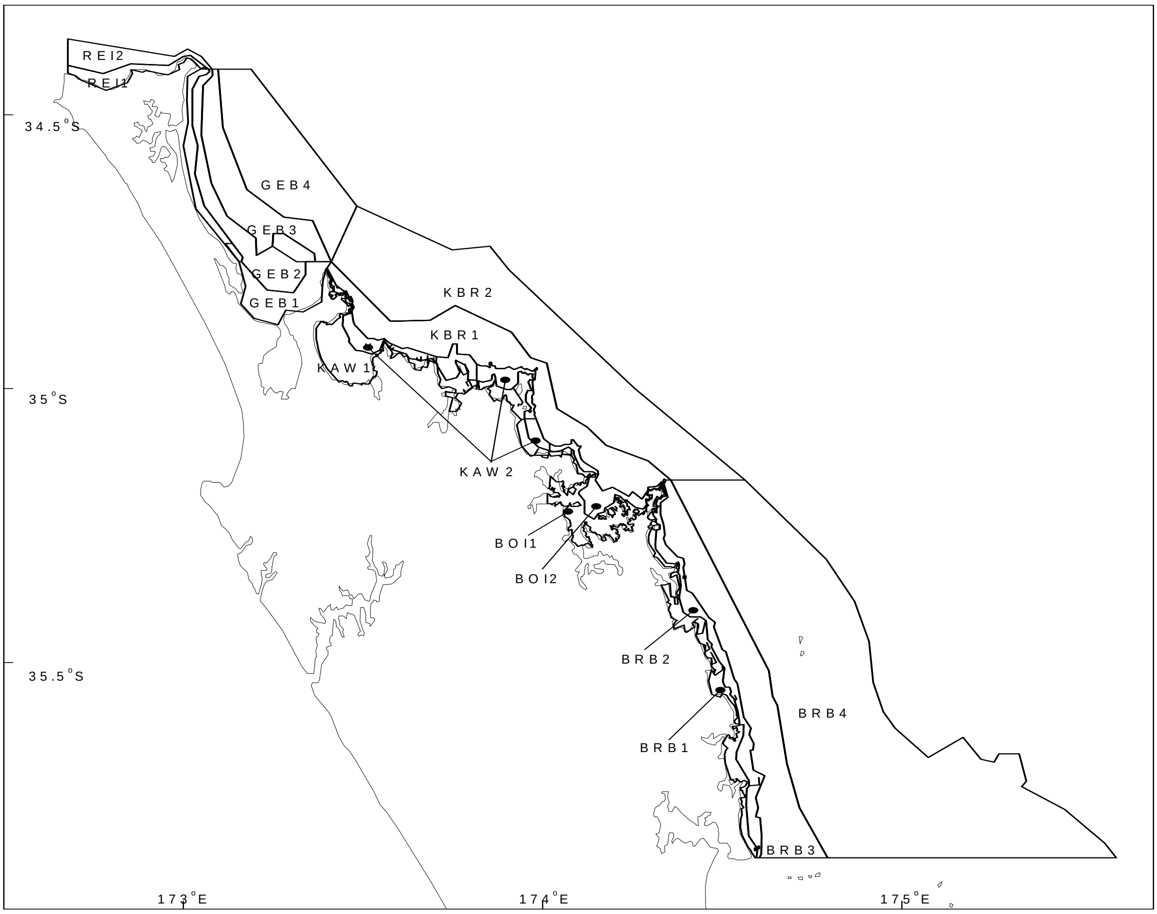

Figure 1: East Northland survey stratification.

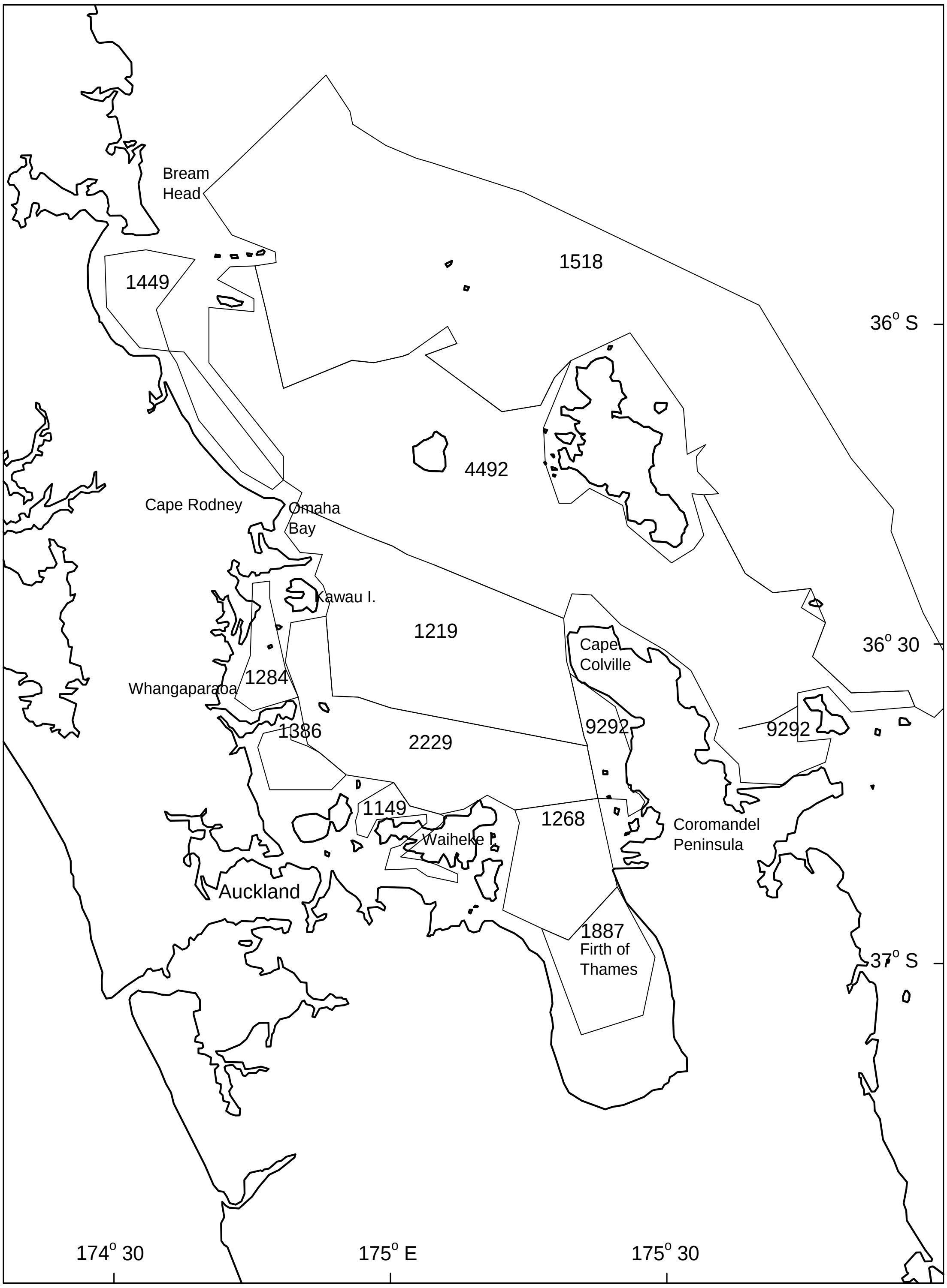

Figure 2: Hauraki Gulf survey stratification.

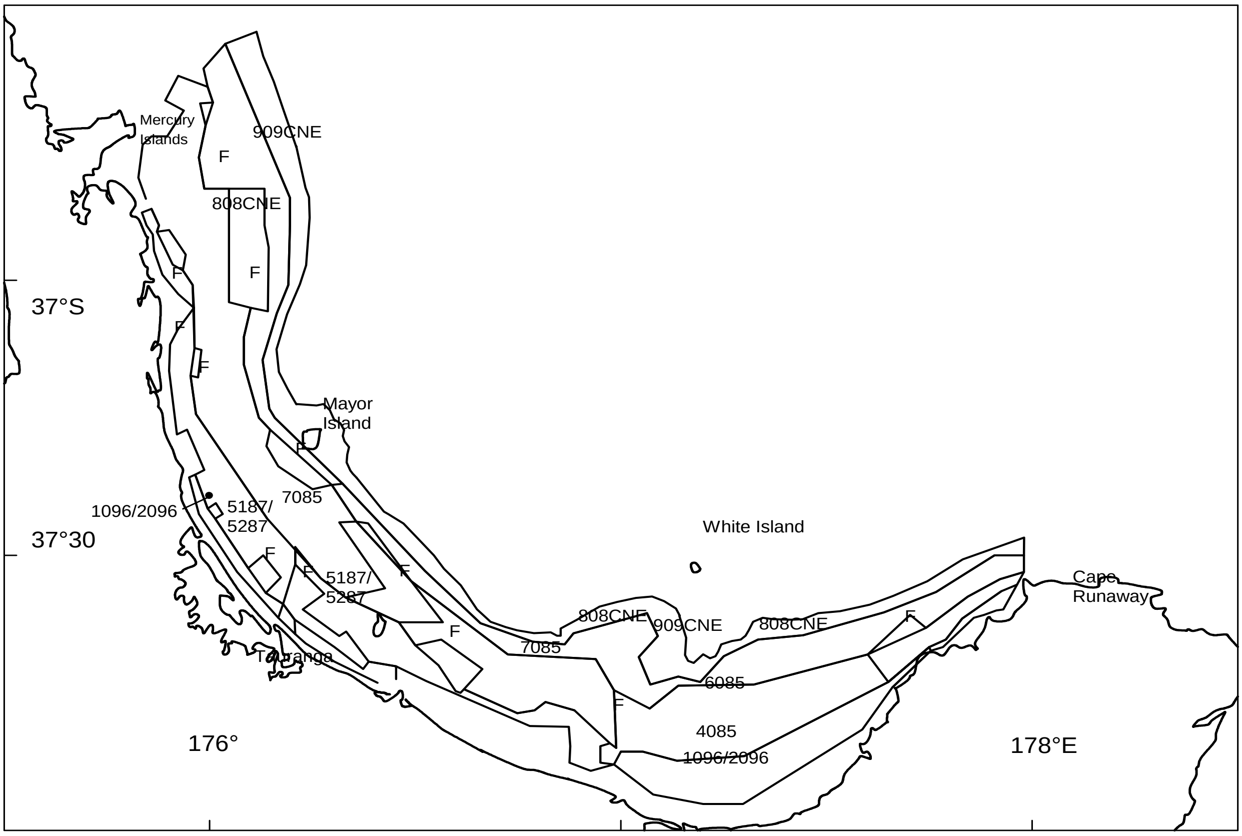

Figure 3: Bay of Plenty survey stratification.

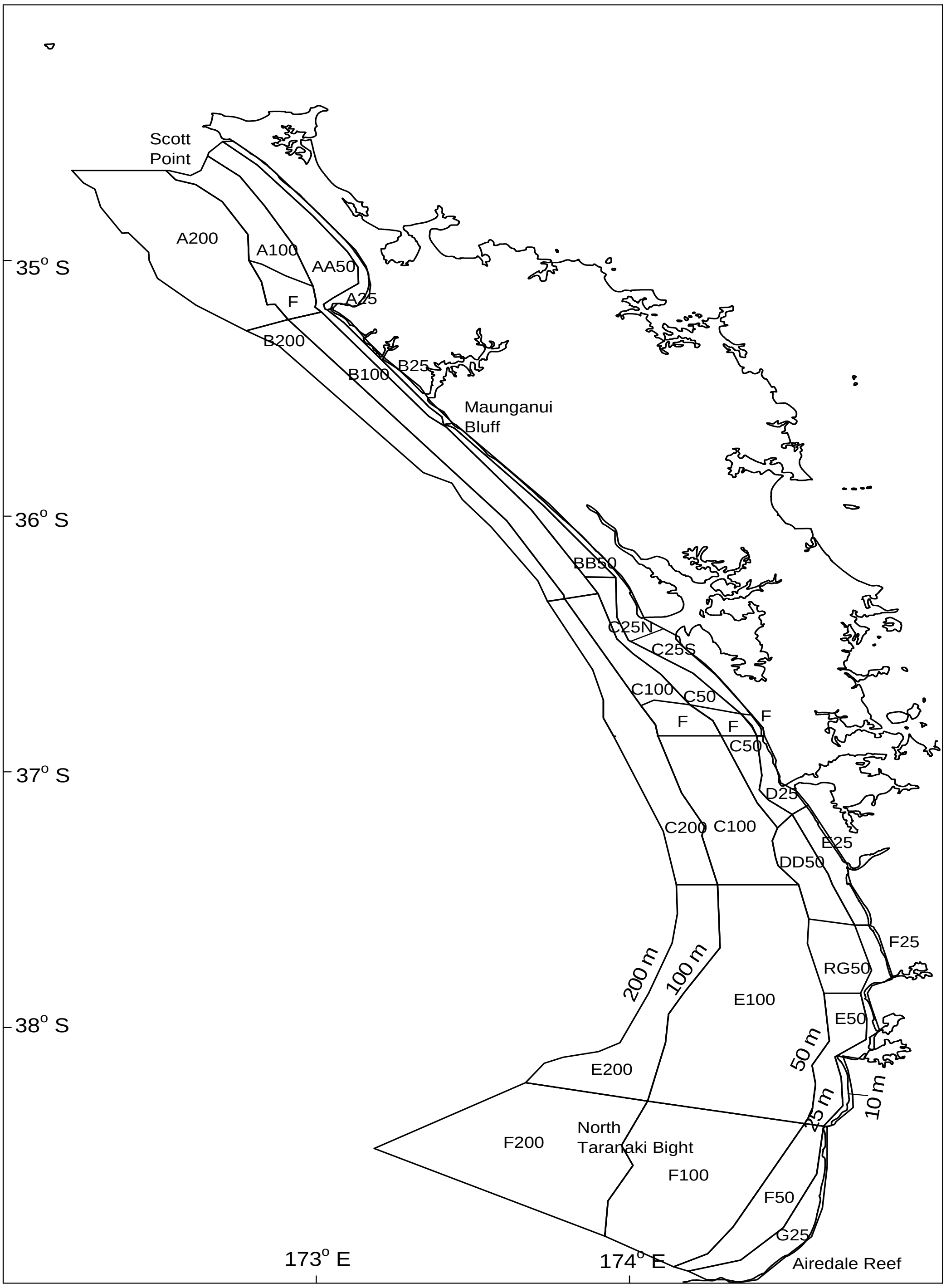

Figure 4: West Coast North Island survey stratification.

2.4. Data metrices calculated

For each tow the total swept area biomass (kg per km^2) for all target species (GUR, JDO, TAR) and selected abundant non-target species (SNA , SCH, school shark – *Galeorhinus galeus*, TRE, trevally, *Pseudocaranx dentex*, LEA – leatherjacket, *Parika scaber*) was calculated. The swept area of the trawl was estimated using the distance towed and doorspread values recorded in the database. Biomass was derived using length frequency data and established length-weight relationships obtained from literature or from the "*trawl"* fisheries database. This approach allowed the inclusion of surveys where weights were not recorded consistently for all species and also enabled total biomass to be subdivided into adult and juvenile fractions for the target species.

The validity of the length-weight relationships to estimate biomass was first tested by carrying out a correlation test between the recorded and estimated individual tow weights. Figure 5 gives the relationship between observed and calculated individual tow weight values for all species considered. Two alternative length-weight relationships were available for gurnard; Elder (1976) and Hanchet et al (2000), of which the Elder relationship was selected as most appropriate. For tarakihi, no published relationship was available and data from a previous project was used instead (McKenzie, unpublished).

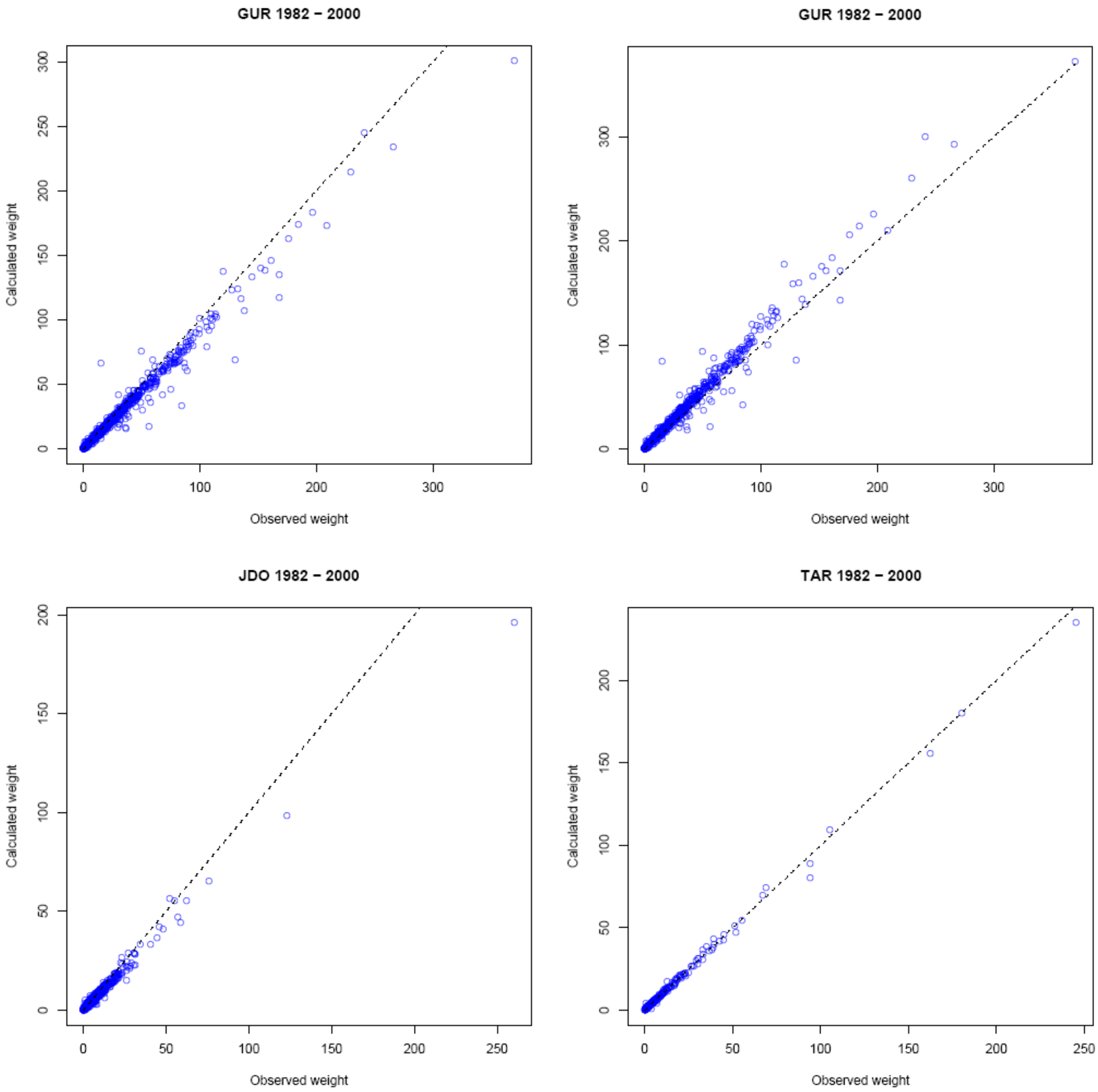

Figure 5: Correlation between observed and calculated tow weights (kg) for red gurnard using Elder length-weight relationships (left), and Hanchet et al. (right), John dory and tarakihi. Open circles represent data from individual tows.

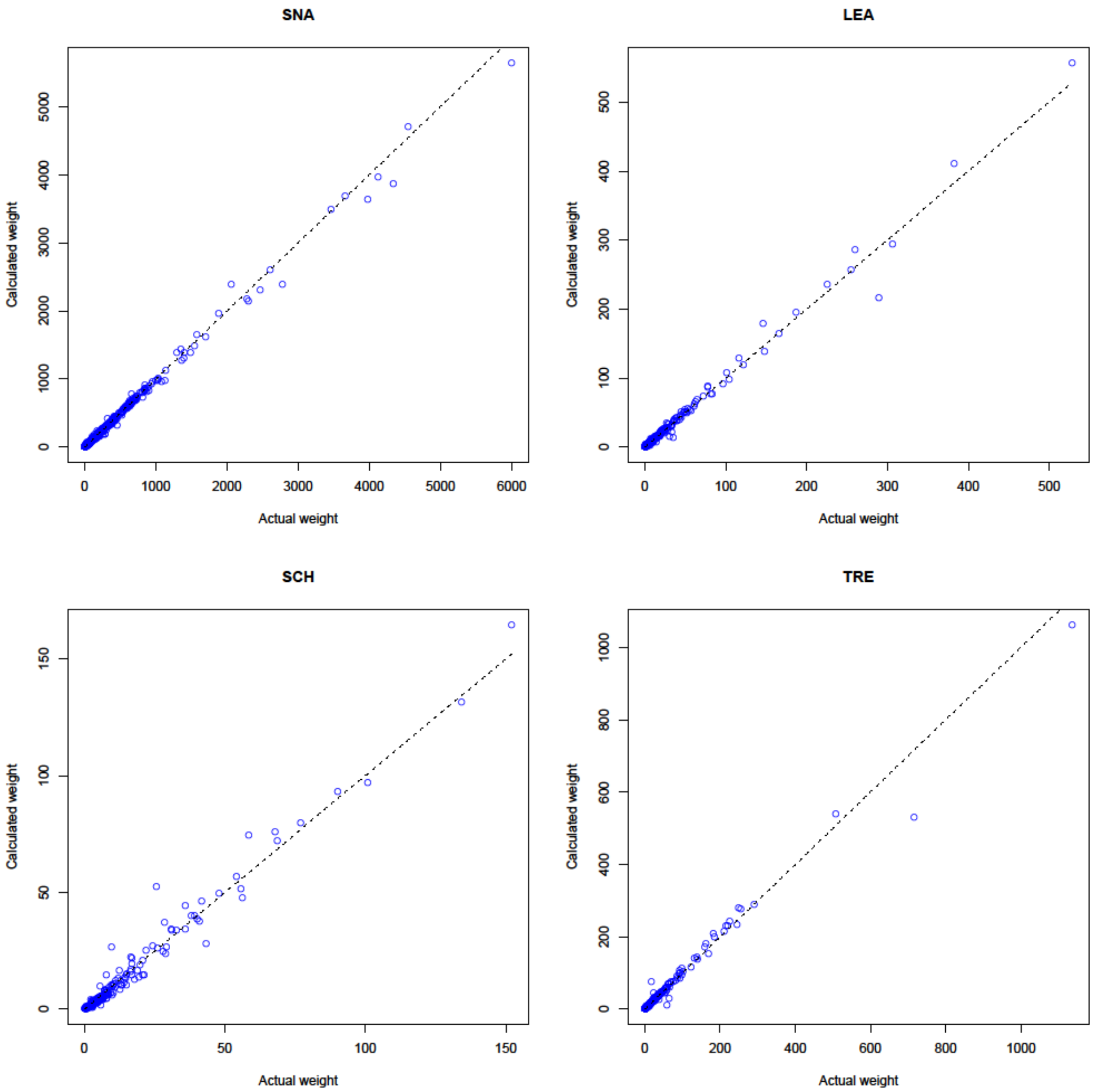

Figure 5 continued: Correlation between observed and calculated tow weights (kg) for snapper, leatherjacket, school shark and trevally. Open circles represent data from individual tows.

In order to estimate spawning stock and juvenile biomass for John dory, red gurnard and tarakihi, the length threshold for separating adult and juvenile fish was required for each species. Clear size modes were apparent in the length frequency distributions for John dory, with a separation at around 30 cm, but both red gurnard and tarakihi displayed unimodal distributions (see Appendix E). In some of the more recent surveys (1997–2000), maturity data were collected for all three species. The original cruise reports should be consulted for the species-specific maturity scales used. For this study, adults were defined as all stages showing evidence of maturing to spawn or of having spawned (stage 2 and above). Figure 6 shows the percentage of fish (male and females combined) at each length class by maturity stage. Stages 3 and above are grouped together. Based on these plots, the length at which 50% of individuals were classed as stage 2 was taken as the threshold separating adults and juveniles. For red gurnard and John dory the chosen threshold length was 20 cm and for tarakihi 25 cm was selected (Figure 6).

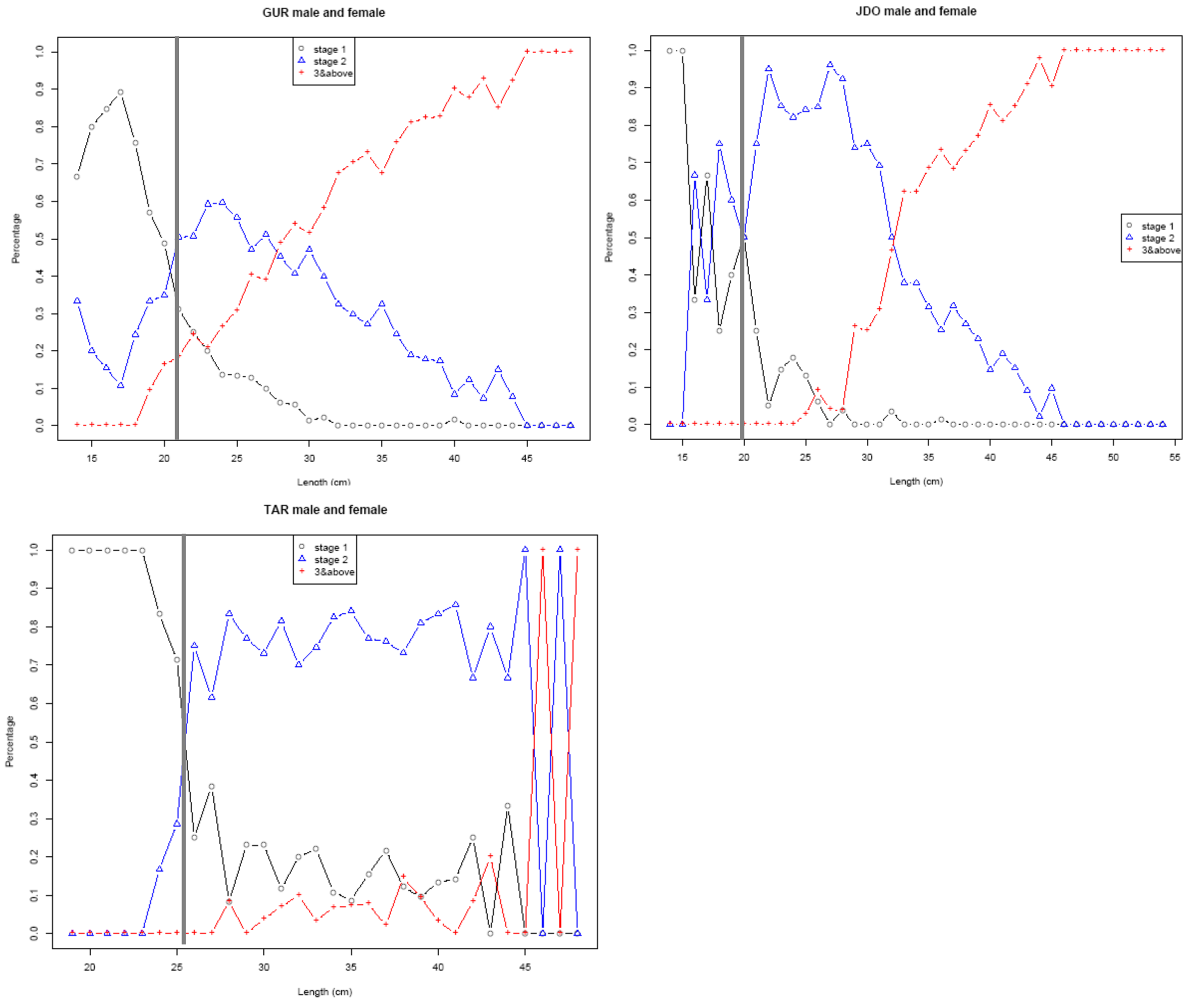

Figure 6: Proportion of different maturity stages at each length class for red gurnard (top), John dory (middle) and tarakihi (bottom), with the chosen threshold length separating adults and juveniles indicated for each species. Data from all survey areas combined.

Following separation of each tow into adult and juvenile portions, the swept area adult biomass values could be scaled up to strata and total spawning stock biomass estimates and associated c.v. s were calculated for each survey. Tables 3 and 4 present the total and spawning stock biomass estimates and associated c.v. s for each year of each survey. These estimates were taken as the "true" biomass trajectories against which the hotspot subarea biomass trajectories were compared. Some of the recalculated biomass values differed from those published in the original survey reports. These discrepancies result from stratification differences between the current and the original analyses.

Table 3: **Revised full total biomass (t) and associated c.v.s for the four survey areas, after re-stratification of all data.**

Year	Stations	GUR		JDO		LEA		SCH		SNA		TAR		TRE	
		Biomass	c.v.	Biomass	c.v.	Biomass	c.v.	Biomass	c.v.	Biomass	c.v.	Biomass	c.v.	Biomass	c.v.
ENLD															
1990	62	40.12	23.95	163.49	34.85	436.6	27.8	100.5	71.4	2050	29.4	251.42	22.37	39.8	27
1993	77	101.49	25.75	281.90	29.49	520.3	16.7	1.1	100	2610	16.3	199.20	33.27	511.5	82.8
HAGU															
1982	80	267.03	14.68	151.09	13.54	5.6	100	0	–	1120	17	7.92	69.95	0	–
1984	83	444.48	13.52	164.82	21.52	154.4	38.5	0	–	4110	23.7	23.16	45.30	98.1	79.8
1985	80	30.37	37.22	203.09	18.47	88.3	99.6	0.3	1	2120	19.6	44.87	48.12	14.2	51
1986	124	256.86	26.60	166.32	19.20	133.5	67.5	15.1	83.6	2140	18.6	1.47	1	19.7	68.6
1987	83	574.94	18.10	246.39	20.23	186.6	44.2	9	74	6410	27.1	19.98	1	7.2	87.2
1988	69	635.03	16.82	308.71	24.40	171.2	26.9	28.5	49.4	3620	15.5	112.28	48.31	10.1	61.4
1989	78	109.70	24.15	254.64	19.72	247.7	26.2	6.7	94.3	7490	17.3	76.17	51.42	119.9	79.5
1990	73	119.53	15.33	261.67	13.32	272.3	28	40.4	100	8840	22.8	37.76	70.83	44.1	41.6
1992	73	282.38	8.47	190.40	34.07	166.3	31	2.1	89.4	2720	12.8	179.76	39.38	4.7	65.2
1993	73	157.39	16.21	316.34	24.95	463.7	26.7	4.4	72.2	6740	13.1	96.44	71.86	12	60.8
1994	70	205.28	18.82	252.37	18.23	246.9	18.8	270.2	99.1	3690	9.7	136.46	60.74	9.9	76.5
1997	49	216.41	13.48	327.82	17.39	651.6	30.3	5.7	77.7	6290	17.2	242.72	54.95	5.9	73.6
2000	48	21.65	48.98	226.91	26.75	116.3	37.1	150.2	99.7	7750	27.4	726.95	87.35	21.9	56.1
BPLE															
1983	61	310.52	14.63	111.14	18.73	86	25.5	22.2	100	196.4	26.9	6.38	44.29	6.4	38.7
1985	80	40.83	16.03	109.71	12.48	5.9	55.4	0	–	692.4	14.6	151.5	88.42	95.4	26.6
1990	59	363.32	12.14	152.02	15.96	88.7	27.2	9.2	79.9	1830	16.8	12.65	65.79	82.1	23.9
1992	82	245.23	9.35	202.67	14.82	256.5	20.9	0.6	70.4	1240	11.5	103.39	28.81	64.6	36
1996	73	270.12	14.96	179.49	32.72	13.6	57.9	7.2	75	1050	16.4	33.83	40.74	35.6	29.5
1999	76	344.83	13.0	179.72	13.20	83.4	18.5	1.5	75.5	1550	18.7	48.05	28.20	264.2	26.2
WCNI															
1986	66	2885.7	12.12	188.66	18.94	81.3	39.4	64.1	30.3	574.6	7.4	318.75	5.5	552	38.9
1987	57	1554.9	17.91	139.59	20.11	80	51.1	40.1	100	549.7	31.2	14.79	44.89	61.2	70.3
1989	84	1951.1	12.75	227.18	10.89	281.4	21.8	138.1	27	1390	19	82.49	36.19	1530	28.3
1991	81	3417.9	12.98	581.97	23.55	244	36.6	1780	32.3	864.9	19.2	521.75	44.15	825.6	27.7
1994	75	3150.6	21.21	144.47	31.29	138.7	41.1	315.9	40.6	589	14.2	90.94	30.29	476.9	37.2
1996	125	3018.1	9.84	448.03	9.52	229.6	20.9	911.8	20.3	1110	18	665.78	26.34	310.7	23.7
1999	100	1937.3	13.94	337.65	11.56	119.3	20.2	400.4	24.4	1160	12.4	519.18	14.95	687.3	44.9

Table 4: Revised spawning stock biomass (t) and associated *c.v.*s for the four survey areas, after re-stratification of all data.

Year	GUR		JDO		TAR	
ENLD	Biomass	c.v.	Biomass	c.v.	Biomass	c.v.
1990	40.1	23.9	162.5	35.1	251.4	22.4
1993	101.3	25.7	281.9	29.5	199.2	33.3
BPLE						
1983	304.9	14.8	111.1	18.7	5.2	52.8
1985	40.7	16.1	109.7	12.5	151.4	88.4
1990	350.1	11.7	152.0	15.9	12.3	65.6
1992	244.1	9.4	202.1	14.8	103.1	28.9
1996	267.6	15.0	179.5	32.7	33.3	40.5
1999	342.5	13.0	179.6	13.2	46.5	29.0
HAGU						
1982	256.7	14.7	150.2	13.6	7.9	69.9
1984	432.3	13.2	158.7	21.5	23.2	45.3
1985	30.3	37.3	199.7	18.7	44.9	48.1
1986	247	27.3	162.7	19.5	1.5	100
1987	482.1	18.1	238.8	20.4	20.0	100
1988	632.6	16.9	304.6	25.8	112.3	48.3
1989	109.5	24.18	251.1	20.1	76.2	51.4
1990	119.2	15.4	257.7	13.4	37.8	70.8
1992	281	8.5	185.9	34.9	179.8	39.4
1993	157.2	16.2	307.8	25.6	96.1	72.1
1994	201.3	19.0	241.0	19.1	136.2	60.9
1997	211.6	13.8	319.6	17.5	242.7	54.9
2000	21.4	49.4	223.5	26.9	727.0	87.3
WCNI						
1986	2847.1	12.1	187.2	19.1	318.7	5.5
1987	1515.5	18.2	137.5	20.4	14.2	46.9
1989	1931	12.8	225.3	10.9	81.8	36.4
1991	3376.1	12.9	575.2	23.6	521.7	44.1
1994	3113	21.3	137.2	31.4	88.9	30.8
1996	2884.5	9.9	444.0	9.6	659.4	26.5
1999	1819.2	13.7	335.4	11.6	512.9	15.0

2.5. Data analysis

The central objective of both analyses was to determine if the same relative biomass trajectory as for the ‘full’ data series could be obtained with lesser sampling effort, by reducing the number of strata and sampling stations. To do this the relative leverage of different strata on the ‘true’ biomass trajectories (defined to be those of the full data surveys) was assessed. A C++ program was written to carry out a two phase survey simulation and biomass calculation. An R script was written that called the S+ function *allocate* (Section 1.5.2 below), which retrieved the allocations for the three target species. The process described below was the same for both the total and spawning stock biomass analyses.

2.5.1. Ranking of strata

To determine which strata drove biomass trajectories most strongly, their relative leverage within a two-phase multi-species random survey method (Manly et al. 2002) was assessed. Using a "drop-one-stratum-each-time" approach, the mean biomass of each species was calculated, dropping one stratum's catch samples each time, $m_{s,y,d}$, and then the difference, $E_{s,y,d}$, between this and the all-strata-means for that survey year, $m_{s,y}$; and the means, variances and standard deviations across survey years were estimated,

$E_{s,d} = \frac{1}{n}\sum_{y} E_{s,y,d}$, $V_{s,d} = \frac{1}{n-1}\sum_{y}[(E_{s,y,d} - E_{s,d})^2]$ and $D_{s,d} = \sqrt{V_{s,d}}$, where n is the number of survey years.

The across survey years weighted sum of the biomass difference mean and standard deviation $S_{s,d} = w_E E_{s,d} + w_D D_{s,d}$, were then calculated using a weighting based on the number of survey years available. For instance, in east Northland survey, there were only two years data, so a lower weighting was assigned, versus the Hauraki Gulf survey, with many years. The sums $S_{s,d}$ were then ranked in ascending order $R_{s,d}$, and the ranks for each dropped stratum from the three target species R_d added. The combined ranks of three species were used to decide which strata to drop (see Appendices A–D).

2.5.2. Allocation of stations

It was initially intended to use the two-phase random survey method for the allocation of stations to strata, as proposed for single species by Francis (1984), and extended to multispecies by Manly et al. (2002). However, a review by Francis (2006) of strata allocation methods, as used both here and overseas, concluded that the most efficient approach was the S+ code function '*allocate*' developed by Brian Bull in 1999, and modified by Francis in 2003. Details of this function were described in Francis (2006), section 2.3, and appendix 3. This function was used to allocate stations to strata, with a base station allocation of three per stratum. As the *allocate* function deals with only one species, it was run for each of the three future target species, and then the maximum number of stations of the three species was taken as the allocation for the multispecies allocation.

2.5.3. Target coefficients of variation (c.v.s)

Target c.v. s for the different survey areas fundamentally determine how many strata and stations are sampled. Currently, there are no national guidelines on how c.v. s are set, and these vary from species to species within a given survey, as well as between different survey series. Target values were specified for the west coast and Bay of Plenty surveys, but do not appear to have ever been set for the east Northland and Hauraki Gulf surveys. For the current analysis, the effect of reducing the precision of the c.v. s (i.e. lowering them) on the number of strata and stations required was assessed using four sets of c.v. s, which included the most recent target c.v. s for the WCNI and BPLE surveys (both from 1999). These scenarios are given in Table 5.

Table 5 The number of strata and stations required for each of four target c.v. scenarios for each of the 4 areas.* denotes previously used target c.v.s.

Survey	c.v.s scenarios	Target c.v.s (%) GUR	JDO	TAR
ENLD	1	15	20	25
	2	18	20	25
	3	18	20	30
	4	20	25	35
HAGU	1	15	20	NA
	2	18	20	NA
	3	20	25	NA
	4	25	30	NA
BPLE	1	15*	20*	30*
	2	18	20	30
	3	18	25	30
	4	20	25	35
WCNI	1	15	20	20
	2	18*	20*	25*
	3	20	25	25
	4	20	25	30

2.5.4. Optimisation of stratification

Using the rank sums, R_d , the lowest ranked stratum was dropped from the data set and the total number of stations required to achieve each of the four c.v. scenarios was estimated. The entire process was repeated with the next least important stratum removed. This process was continued until the number of stations required passed a lower inflection point, and began to increase in number again. The strata and stations for each step were plotted for each c.v. scenario and used to select the optimum combination for a "northern hot spot" survey based on either observed total biomass or estimated adult spawning stock biomass.

2.5.5. Biomass trajectory comparisons

Following the optimisation process, the historical time series data were used to compare the biomass trajectories obtained from the "original" full survey (Tables 3 and 4) with those that would have been obtained from a survey with the suggested reduced number of strata. The number of actual stations included in this sub-set of selected strata varied historically, with some years being higher and others being lower than the number of stations predicted to reach particular target c.v. levels. A bootstrap approach could have been used to select the appropriate number of stations in the reduced strata survey, but given that the once the strata were chosen, selection was from a fixed distribution, the mean value would therefore remain the same, with only the precision changing. Since the survey design used to collect the data originally was optimized for different species, it was considered more appropriate to compare like with like and therefore the trajectories compared biomass estimates from full and reduced strata surveys with the number of stations as per the original allocation. This resulted in the total number varying between years, some being more or less than those predicted for the suggested target c.v.s.

2.6. Assessment of population size frequency

To obtain an overall population size frequency distribution from both the full and reduced strata surveys, the mean count per km^2 for each size class within each stratum was calculated from the individual tow estimates. From these data a stratum population was estimated using the stratum area to scale the densities. Stratum populations were then summed together to produce an overall population estimate.

The effect of a reduction of strata and stations on the estimation of population length structure was explored by comparing the overall length frequency obtained for each species from each full survey with the distribution that would be obtained from a reduced strata survey in the same year. These plots and accompanying cumulative length frequency curves are shown in Appendix G. Kolmogorov-Smirnov tests were used to assess the significance of the differences in these cumulative curves. The maximum difference between the relative cumulative frequencies (*D*) of the two samples (full survey sample and hot spot survey sample in each year) was calculated along with the expected critical difference, *Dα,* for a pre-selected probability *(α* = 0.05)

$D_{\alpha} = \sqrt{0.5\,[-\ln(0.5\alpha)]} \cdot \sqrt{\frac{n_1 + n_2}{n_1 \cdot n_2}}$, where n_1 and n_2 are the sample sizes (number of fish caught) of the two samples

If $D\alpha - D > 0$, then the two samples are not significantly different, but if $D\alpha - D < 0$, then the two samples are significantly different from each other. In addition to testing each year individually, overall tests were carried out for each survey area, combining the data from all years

2.7. Analysis of commercial data

To assess how spatial patterns of commercial finfish catch broadly related to trawl stratifications, commercial catch data from the TCEPR and CLR reporting system were extracted via the Ministry of Fisheries database. These data spanned the period of 1 October 1989 to 27 June 2006, for all trips where red gurnard, John dory, or tarakihi were caught by at least one tow undertaken in the East Coast North Island (stat areas 002, 003), Hauraki Gulf (stat areas 005, 006, 007), Bay of Plenty (stat areas 004, 008, 009, 010), and West Coast North Island (stat areas 041, 042, 043, 044, 045, 046, 047). In this spatial analysis, data were binned into four seasonal time periods (January–March; April–June; July–September; October–December), averaged across all years, and combined by 1 degree squares, to provide an average catch by species per season. This resolution was set by the data confidentiality clauses stipulated by MFish in displaying data that refers to the magnitude of catch. These data were imported into the GIS system ARCMap, and used as a spatial data layer against which to visually assess the survey stratifications. No attempt was made to develop standardised catch rates or similar, due to the wide range of vessels and associated gear specifications used, and differences in targeted species both in time and space, driven by the influences of market and regulatory forces (i.e., not directly by species abundance).

These commercial catch levels were plotted for red gurnard, John dory and tarakihi as a backdrop against the final sub-set of selected strata proposed for a new ‘northern’ trawl survey series, and are given in Appendix H for reference. Where the time period encompasses the timing of a particular historical survey, this is indicated in the figure legends, i.e., WCNI and HAGU, October–November surveys (seasonal period 4); ENLD and BPLE, February surveys (seasonal period 1).

To investigate whether the historical timing of surveys matches the timing of peak commercial catches, the same data (updated to 30t September 2008) were subdivided into total estimated catches within and outwith the full trawl survey area using the GPS positions provided and plotted on a month by month basis for comparison.

2.8. Survey trawl net options

An overview is provided of the available scientific and commercial trawl net designs along with the advantages and disadvantages of each option. Information on currently used commercial nets was obtained via consultation with a number of net manufacturers and SEAFic. The latter provided selected data from a recent survey of inshore trawl gear and operations carried out for Seafood Innovations and SEAFic by Clement & Associates (2008). The data were collected via one-to-one interviews with 153 fishermen from all over New Zealand. For this assessment, only those individuals operating in areas encompassed by the surveys and targeting at least one of the target species were used. Data provided included the manufacturer/trawl type used, net characteristics such as ground rope,bridle length and mesh size, and operational characteristics such as headline height.

3. RESULTS

3.1. Total Biomass survey optimisations

The simulated optimisation results for each of the four survey areas are given in Figure 7. The inflection points represent the proposed optimised survey design in terms of minimum number of strata and range of stations to achieve different target c.vs. Figure 8 shows these retained strata for each area combined to produce a northern hot spot survey. In order to assess whether a reduced strata survey retained the same temporal trends as the full data series, the biomass trajectories resulting from both the full survey and the reduced survey were compared for each area in turn.

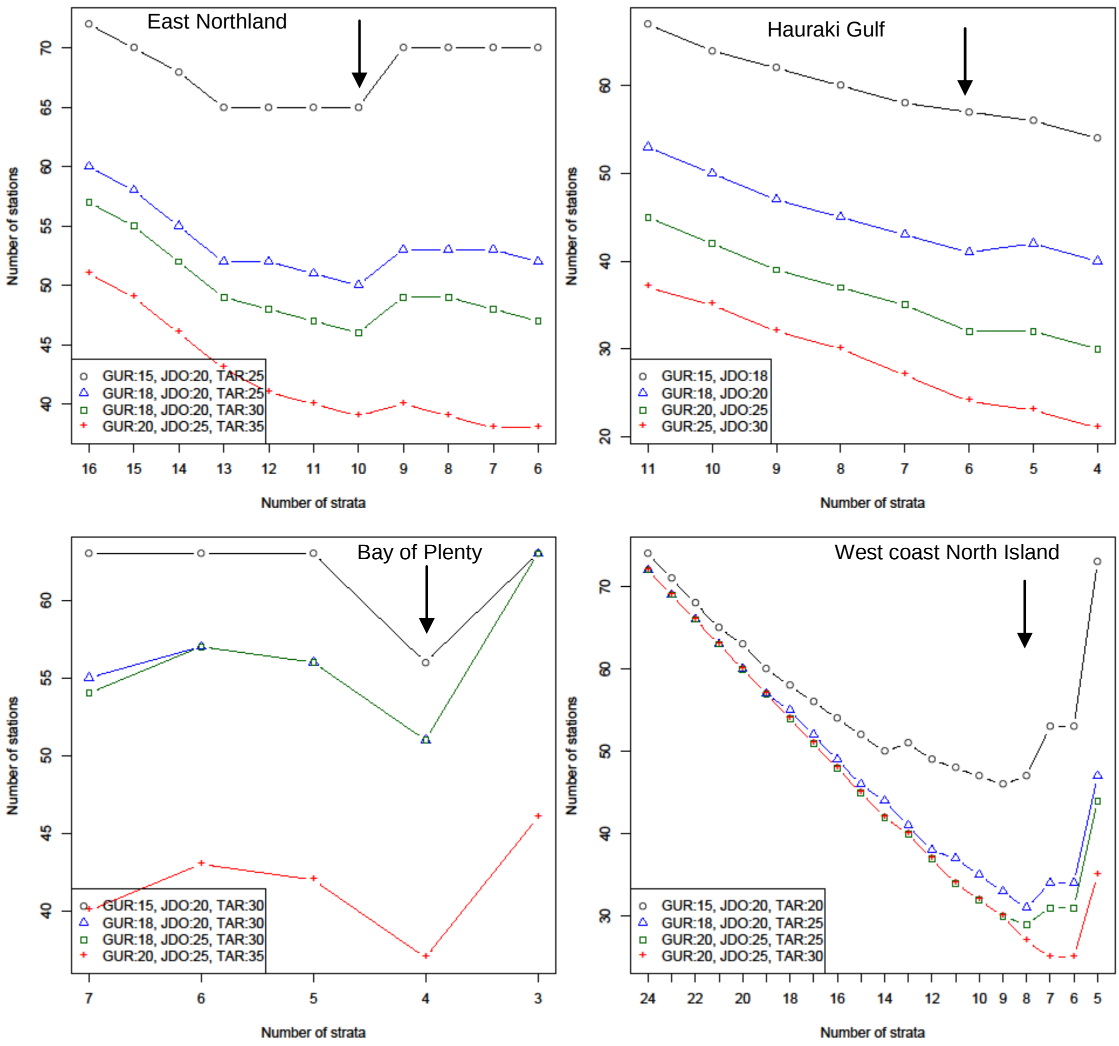

Figure 7: Simulation results for the four survey areas, given different target c.v. scenarios. Inflection points, and/or the strata level chosen for all subsequent reduced strata biomass trajectories, are indicated with a downward arrow. The blue line represents the selected sampling level chosen for comparison with the full time series.

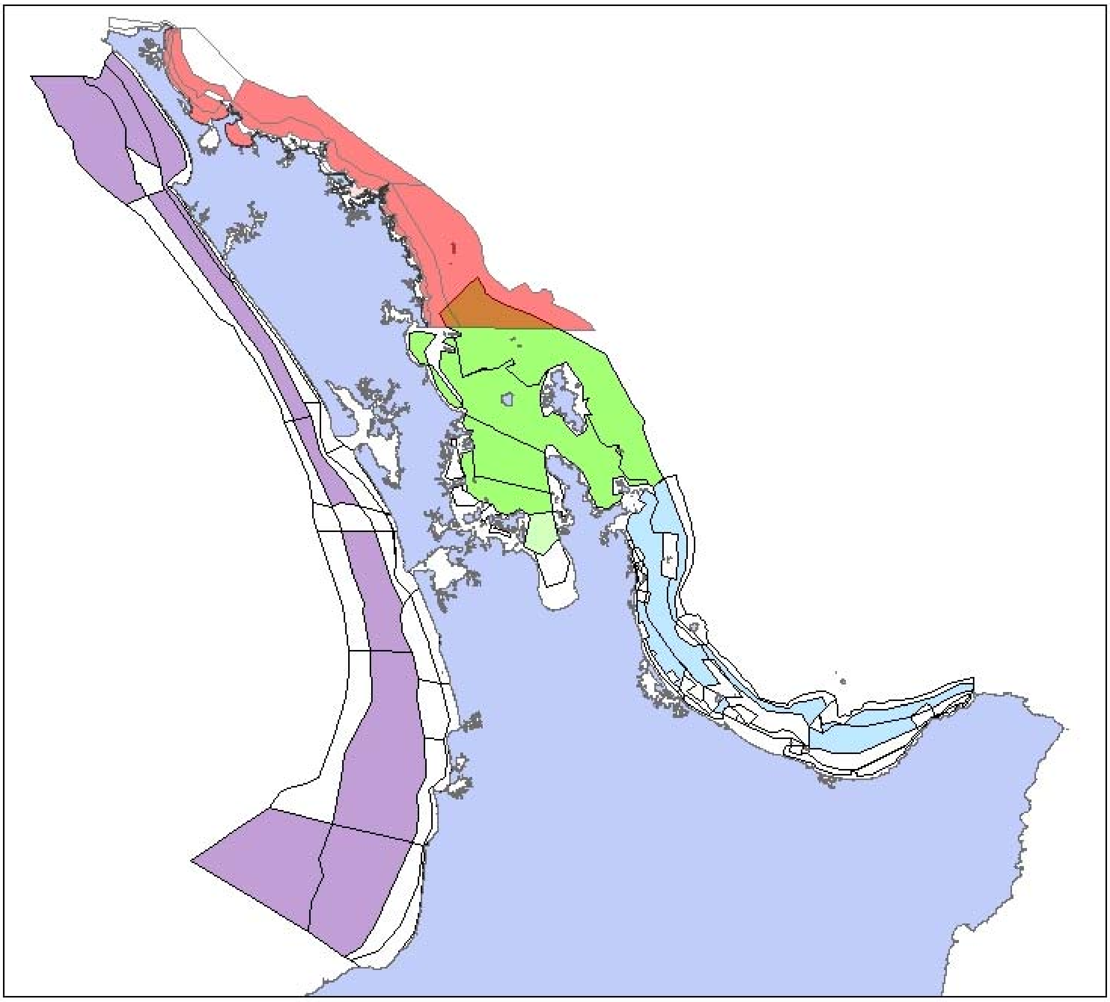

Figure 8: Strata retained for a new 'northern' trawl survey time series. Each survey area's strata are shown in a different colour, while all discarded strata are blank. Note that there is some spatial overlap between the most southern ENLD stratum and the most northern HAGU stratum. Strata in a paler are not included in both total and adult biomass optimisations (East Northland, Bay of Islands and inner Hauraki Gulf)

3.1.1. East Northland

There were 16 strata in the East Northland surveys with a total of 77 stations (see Table 2). Based on R_d, stratum REI2 was dropped first and a station allocation undertaken; then REI1 was dropped, a new station allocation produced, and so forth (see Appendix C). Where two or more strata had an identical rank, the one with the smaller rank for gurnard was dropped first. Using this process, many of the shallow strata were discarded, due to snapper no longer being a target species, the retained strata being mainly the larger, deeper water ones, with the exception of GEB4 and RE12 (Figure 8). A minimum inflection point was reached at 10 strata, with a range of 39–65 stations (see Figure 7). No c.v. s were specified in the previous surveys and the target c.v.s selected (GUR 18%, JDO 20% and TAR 25%) required an estimated 50 stations. Increasing the simulated sampling effort above this level produced only a modest gain in red gurnard c.v., while sampling at a lesser level reduced the precision of the tarakihi estimates to 30% for one level down, and 35% for two levels down (as well as reducing John dory to 25%).

To assess whether reducing the area sampled produced values still approximating the full data series, the biomass trajectories resulting from the reduced strata survey, are compared with the all-strata biomass trajectories (Figure 9). The actual number of stations within the 10 strata were 36 in 1990 and 50 in 1993. The trends (in this case the slope between two survey points) were similar for red gurnard, John dory, and tarakihi, although for the latter, the increase in biomass indicated by the reduced strata trajectory was less than in the full survey trajectory (approximately 2-fold increase compared to 3-fold increase). The plots of abundant non-target species showed similar trajectories for trevally, school shark and snapper, although the estimated biomass for snapper was considerably lower (500 t). For leatherjacket, the slopes diverged with the reduced strata survey suggesting a slight decline as opposed to slight increase in the full survey.

3.1.2. Hauraki Gulf

In the Hauraki Gulf surveys there were originally 11 strata and 48 stations (see Table 2). Using the same iterative process as described above, the relationship between the number of strata and the number of stations was assessed. No clear minimum inflection point was apparent, with the number of stations continuing to decrease down to four strata. However, for tarakihi, 3 of the 11strata were ranked as '1' (R_d). Examination of these strata's catch showed their tarakihi catch to be zero, so that when these strata were iteratively dropped, $E_{s,y,d}$ for all these strata was zero. Tarakihi is a deeper water species, and has never been a target species for the Hauraki Gulf trawl survey series, where the strata are relatively shallow. The above process was repeated without tarakihi, resulting in a minimum inflection point at 6 strata (Figure 8), with an associated 25–60 stations depending on the target c.v.'s. The 6strata retained were all the larger strata, while the shallower strata on the western and eastern side of the Hauraki Gulf were dropped (Figure 8).

No target c.v. s were specified for red gurnard or John dory in the last Hauraki Gulf survey, with achieved levels of 46% and 26%. The suggested sampling effort from the optimisation process (41 stations) is similar to that of the last survey but concentrated in fewer strata with the predicted level of c.v.s (GUR 18% and JDO 20%) well below those previously estimated. To achieve even higher precision would require another 20 stations for relatively modest gains. Comparison of the all-strata biomass series with the reduced 6-strata series is shown in Figure 10. The total number of stations sampled historically within the chosen 6 strata varied widely between years from 27 to 72. The plots show effectively no difference between the two trajectories for red gurnard and tarakihi or three of the four abundant non-target species. For both John dory and snapper, there were some differences in trajectories between particular years but similar patterns overall. The lower biomass estimates for snapper, particularly over the more recent surveys, is likely due to many of the shallower high density strata being dropped.

3.1.3. Bay of Plenty

The more recent surveys in the Bay of Plenty included 7 strata and 78 stations (Table 2). As the number of strata were reduced down to three, there was a minimum at four (Figure 8). The strata dropped included the deep offshore strata (909CNE) added specifically to target tarakihi. The remaining dropped strata (1096/2096, 4085) were in the shallow (< 50 m) eastern side of the survey area, where red gurnard and John dory catches tended to be low. The suggested number of stations ranged from 37 to 56. Choosing 51 stations was predicted to give c.v. levels of GUR 18%, JDO 20–25% and TAR 30%. Increasing sampling effort to 56 stations lowers the GUR c.v. levels from 18% to 15%.

Comparison of the full biomass trajectories versus the reduced strata trajectories are shown in Figure 11. The actual number of stations in the selected strata varied from 25–43 overall. Trajectories for John dory and leatherjacket were generally similar and also for tarakihi, although there seemed to be a slight divergence over the two most recent surveys. Trajectories for red gurnard followed an overall similar pattern, although biomass estimates were considerably lower in the reduced strata survey, in particular the 1983 and 1990 surveys, which resulted in a different overall trajectories; no trend for the full biomass and an apparent increase with the reduced strata survey over the course of the time series. For snapper, the overall pattern was similar, with biomass peaks in 1990 and 1999, but the estimated abundances from the reduced strata survey were about two thirds lower than the full strata estimates and the relative increase between 1983 and 1990 was higher (18 fold from the reduced strata compared to 9 fold from the full survey). For trevally, the reduced strata estimates diverged from the full strata estimates in some years and did not always capture the same pattern in abundance, and school shark largely disappeared from the reduced strata trajectory, although even in the full strata survey their biomass was very low (tens of tonnes).

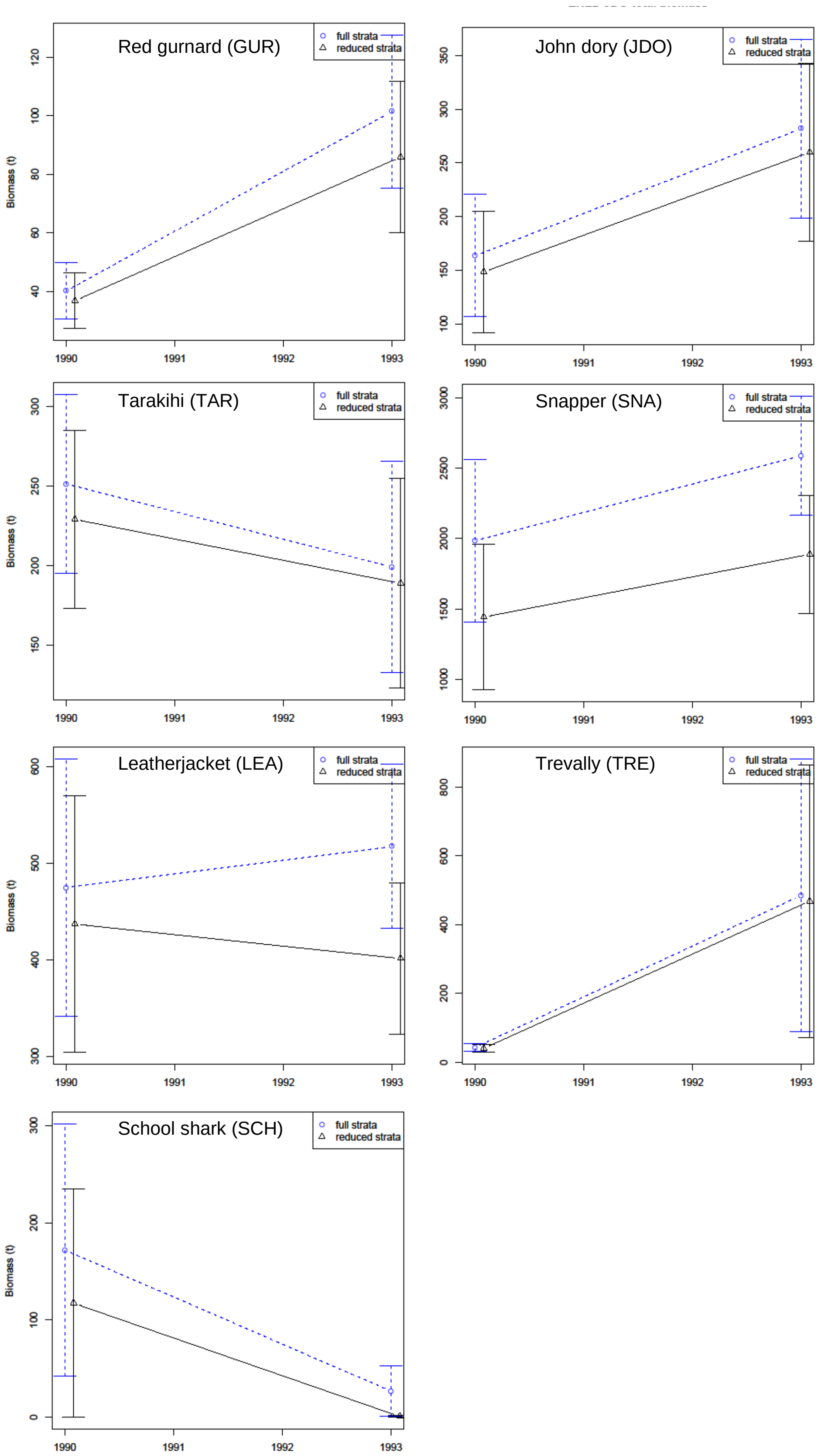

Figure 9: East Northland full survey biomass trajectories (hashed lines), and reduced strata (solid lines) biomass trajectories (the second scenarios specified in Table 5 and Figure 7) for the target species GUR, JDO, TAR and other non-target QMS species occurring in some abundance. Dates are slightly offset to facilitate comparisons.

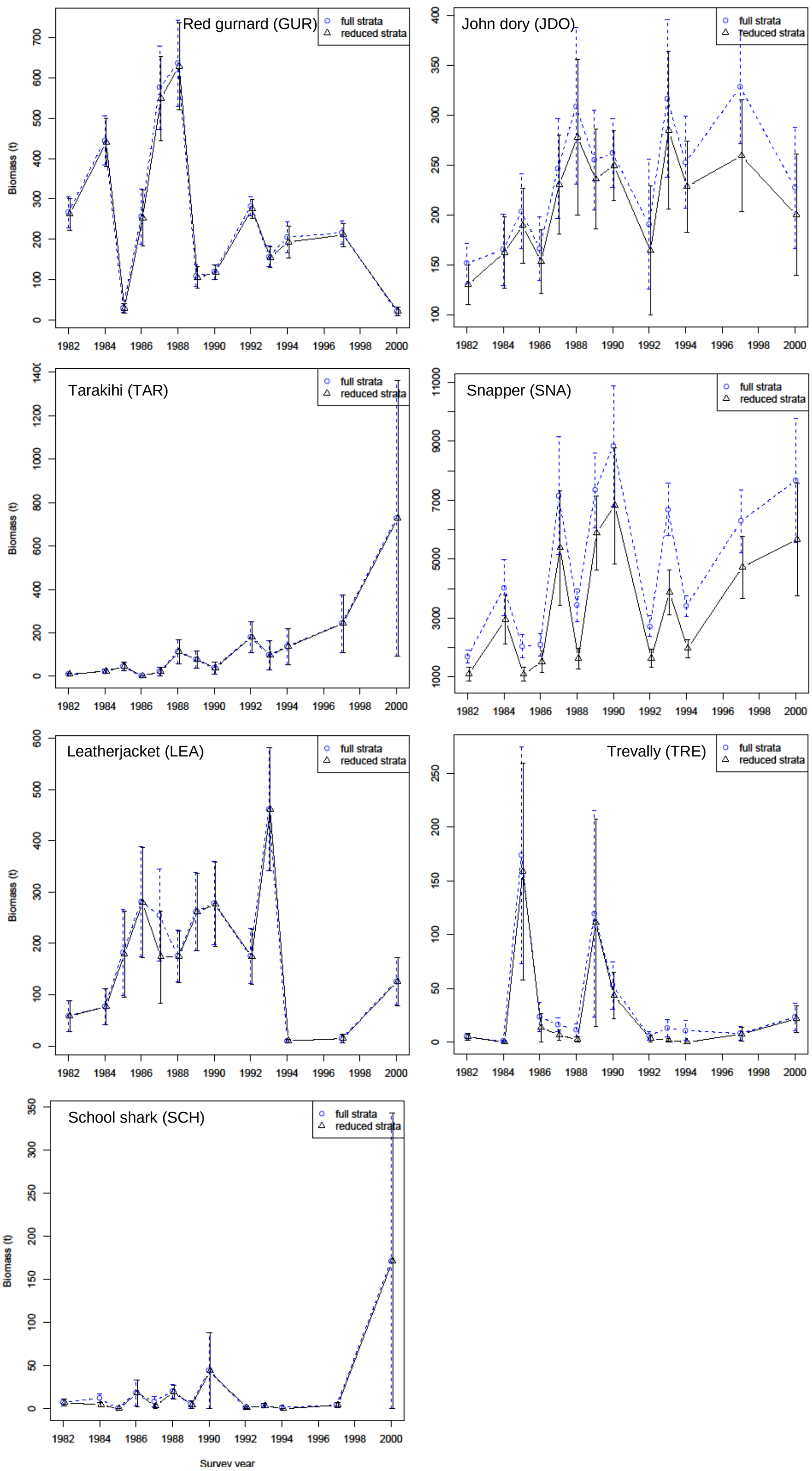

Figure 10: Hauraki Gulf full survey biomass trajectories (hashed lines), and reduced strata (solid lines) biomass trajectories (the second scenarios specified in Table 5 and Figure 7) for the target species GUR, and JDO and other non-target QMS species occurring in some abundance. Dates are slightly offset to facilitate comparisons.

3.1.4. West Coast of North Island

The more recent surveys of the west coast North Island were stratified into 24 areas with 100 stations (see Table 2). A minimum inflection point was reached at 8 strata (Figure 8) with a range of 27–47 stations. This was the most dramatic reduction of all the surveys. All of the 50–100 m water depth strata were retained, along with one deeper 100–200 m stratum off the northern Taranaki Bight, and the 25–50, and 100–200 m strata off Ninety Mile Beach (see Figure 8).

The specified c.v.s in the 1999 survey were; SNA 20%, GUR 20%, JDO 20%, and TAR 20–25%. Selecting similar c.v. levels of 18, 20 and 25% for the new target species allowed the number of stations to be dropped to just 31.

Comparison of the full biomass trajectories versus the reduced strata trajectories are shown in Figure 12. The actual number of stations from the selected strata ranged from 22–41. Patterns were broadly similar for red gurnard and John dory, although there were different trajectories between individual surveys (e.g. increase in red gurnard biomass from 1987 to 1991 was about 2 fold in the full survey, but over 3 fold in the reduced strata survey). For tarakihi, the full survey strata produced very different biomass estimates in the first survey and again in 1991 and 1996 when relative increases were greater in the full strata compared to the reduced strata survey. For the abundant non-target species, trajectories for leatherjacket, school shark and trevally were broadly similar. However, snapper estimates from the full survey were markedly higher than for the reduced strata, and overall trajectories were very different; one suggesting a decline in abundance of nearly 50% compared to a near doubling in population according to the other.

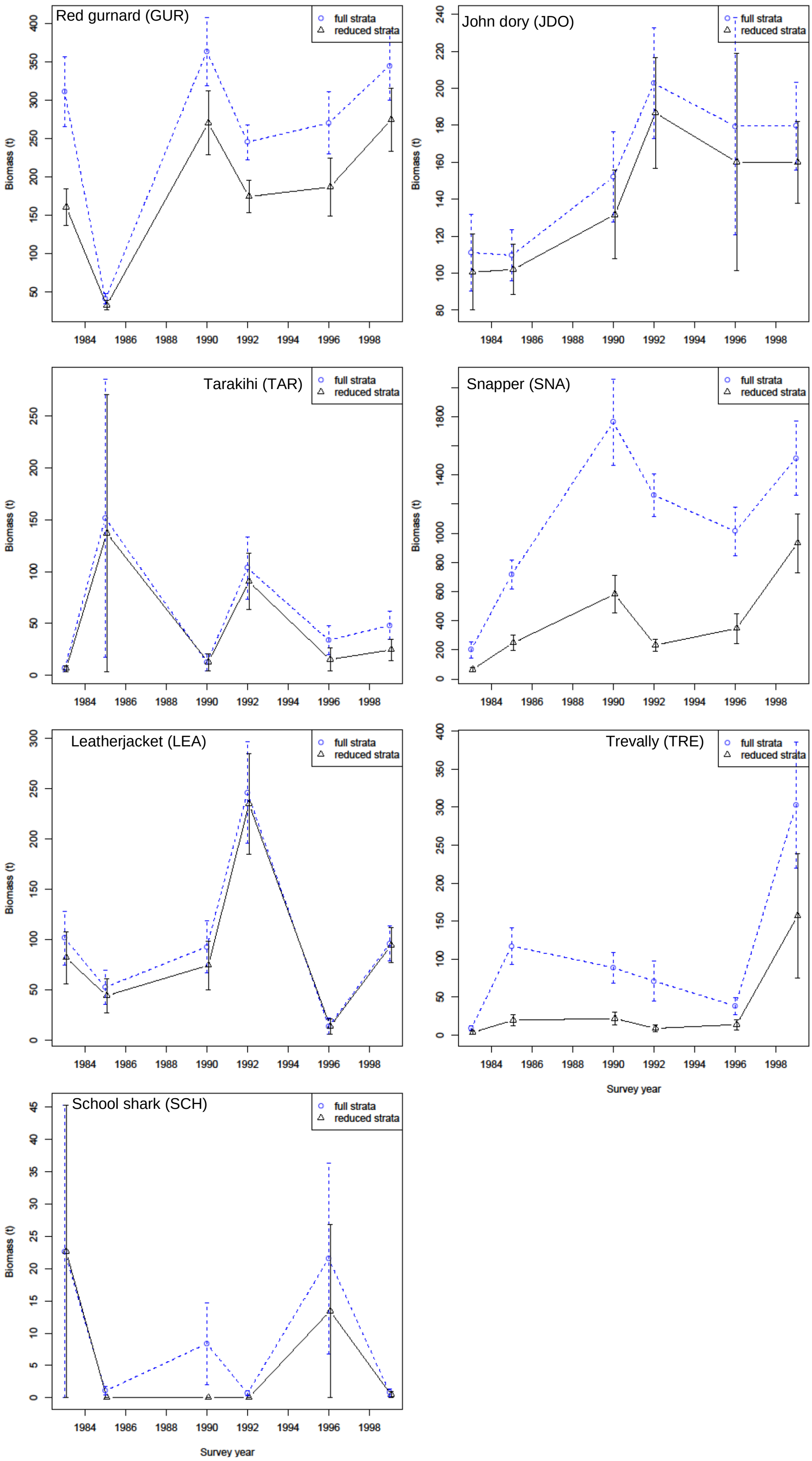

Figure 11: Bay of Plenty full survey biomass trajectories (hashed lines), and reduced strata (solid lines) biomass trajectories (the second scenarios specified in Table 5 and Figure 7) for the target species GUR, JDO and TAR and other non-target QMS species occurring in some abundance. Dates are slightly offset to facilitate comparisons.

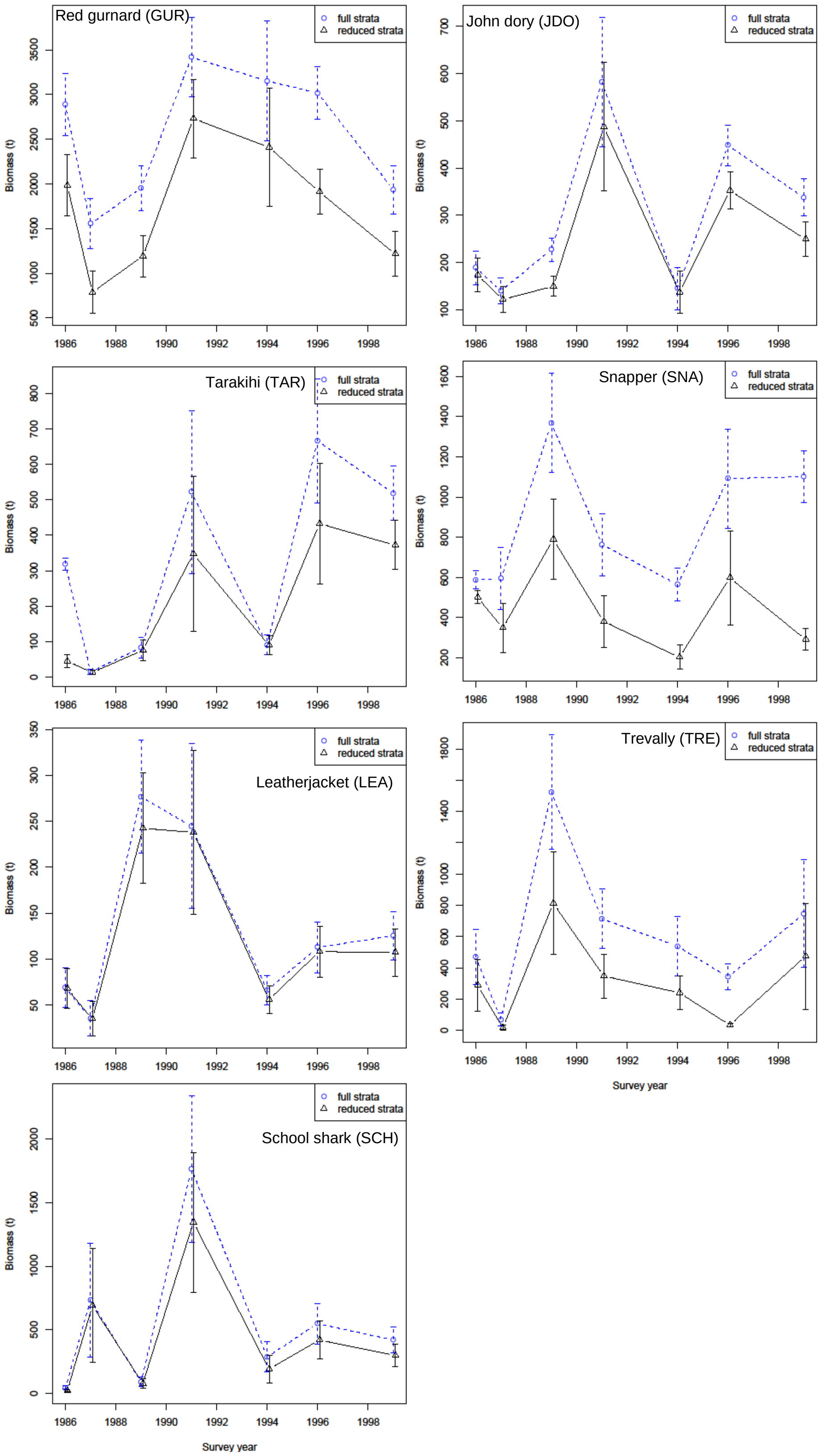

Figure 12: West coast North Island full survey biomass trajectories (hashed lines), and reduced strata (solid lines) biomass trajectories (the second scenarios specified in Table 5 and Figure 7) for the target species GUR, JDO and TAR and other non-target QMS species occurring in some abundance. Dates are slightly offset to facilitate comparisons.

3.2. Spawning stock biomass survey optimisations

For the spawning stock biomass analyses, for each survey and each target species, strata were ranked separately for adult and juvenile estimated biomass. These rankings are given in Appendices A toD. For the adult part of the population, the plots showing the optimised strata-station combination are given in Figure 13 with the selected number of strata indicated by a downward pointing arrow. The chosen number of strata based on the optimisation simulation along with the number of predicted stations to reach selected target c.v. s are given in Table 6 for each survey. The numbers of strata and stations from the total biomass simulations are also given for comparison.

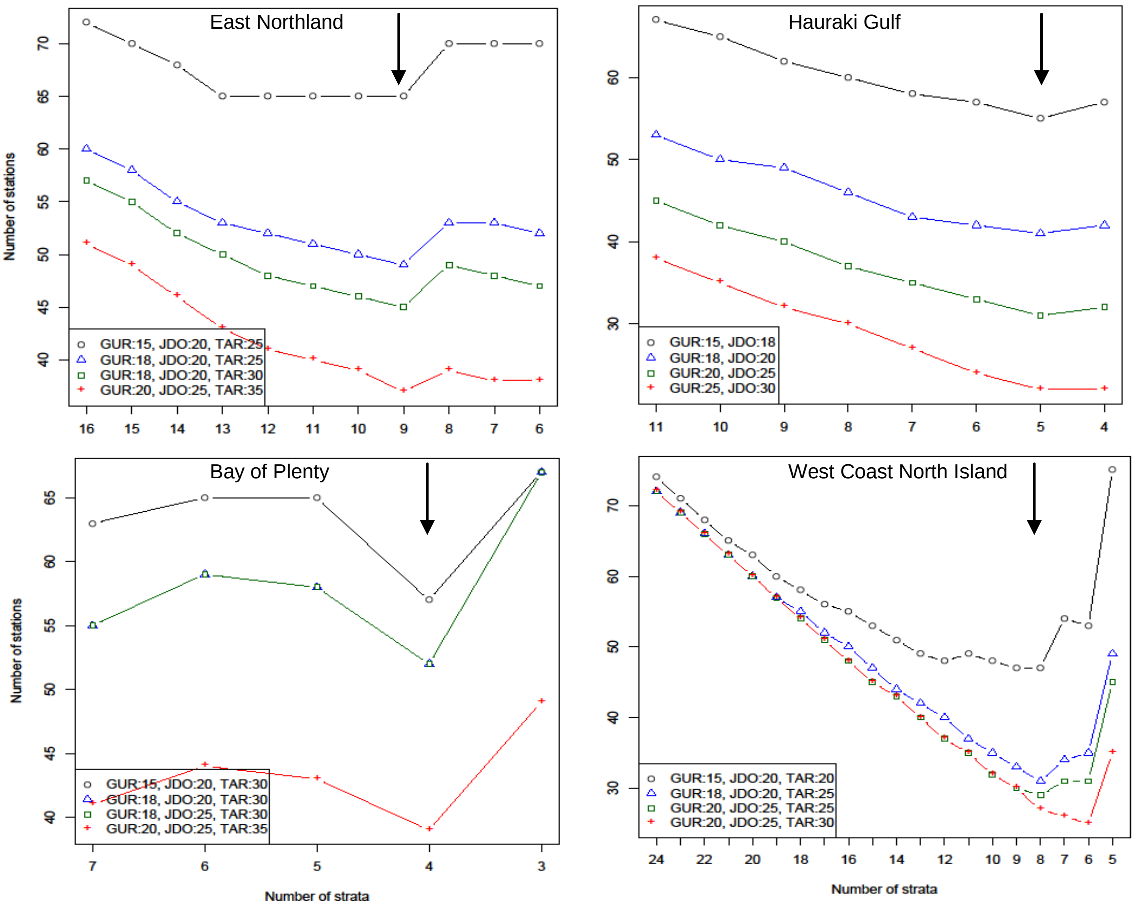

Figure 13: Simulation results for the four survey areas, given different target c.v. scenarios. Inflection points and/or the strata level chosen for all subsequent reduced strata spawning biomass trajectories are indicated with a downward arrow.

Table 6: The number of strata and stations required for each of four target c.v. scenarios for each of the 4 areas for both total and spawning stock biomass. The selected station design chosen for comparison of trajectories is given in red.

Survey	c.v scenarios	Target c.v.s (%)			Spawning stock biomass		Total biomass	
		GUR	JDO	TAR	No of strata	No. of stations	No of strata	No. of stations
ENLD	1	15	20	25	9	65	10	65
	2	**18**	**20**	**25**	**9**	**49**	**10**	**50**
	3	18	20	30	9	45	10	46
	4	20	25	35	9	37	10	39
HAGU	1	15	18	NA	5	55	6	57
	2	**18**	**20**	NA	**5**	**41**	**6**	**41**
	3	20	25	NA	5	31	6	32
	4	25	30	NA	5	22	6	24
BPLE	1	15*	20*	30*	4	57	4	56
	2	**18**	**20**	**30**	**4**	**52**	**4**	**51**
	3	18	25	30	4	52	4	51
	4	20	25	35	4	39	4	37
WCNI	1	15	20	20	8	47	8	47
	2	**18***	**20***	**25***	**8**	**31**	**8**	**31**
	3	20	25	25	8	29	8	29
	4	20	25	30	8	27	8	27

3.2.1. East Northland

Figure 13 shows the minimum inflection point in the number of required stations was reached at nine strata; one less than was recommended for the total biomass (see Figure 7). The stratum dropped was the outer Bay of Islands (50-100 m). However, the overall number of stations predicted to achieve the same c.v. levels was effectively the same.

For the proposed target species, a comparison of the biomass trajectories for estimates of spawning stock biomass and the number of juveniles predicated from the reduced strata survey were compared with those estimates from a full set of strata in Figure 14. For both the adult and juvenile parts of the stock, the reduced strata survey gave lower, but similar trajectories to the full survey although the gradients were slightly diverging for gurnard. No juvenile tarakihi were caught in either of these surveys. Separation of the adult and juvenile portions of the population highlighted a decline in the number of juvenile John dory caught in the second survey that was not apparent in the total biomass surveys. Overall, removing the juvenile biomass from the simulations made little difference to the trajectories (c.f. Figure 9 and Figure 14).

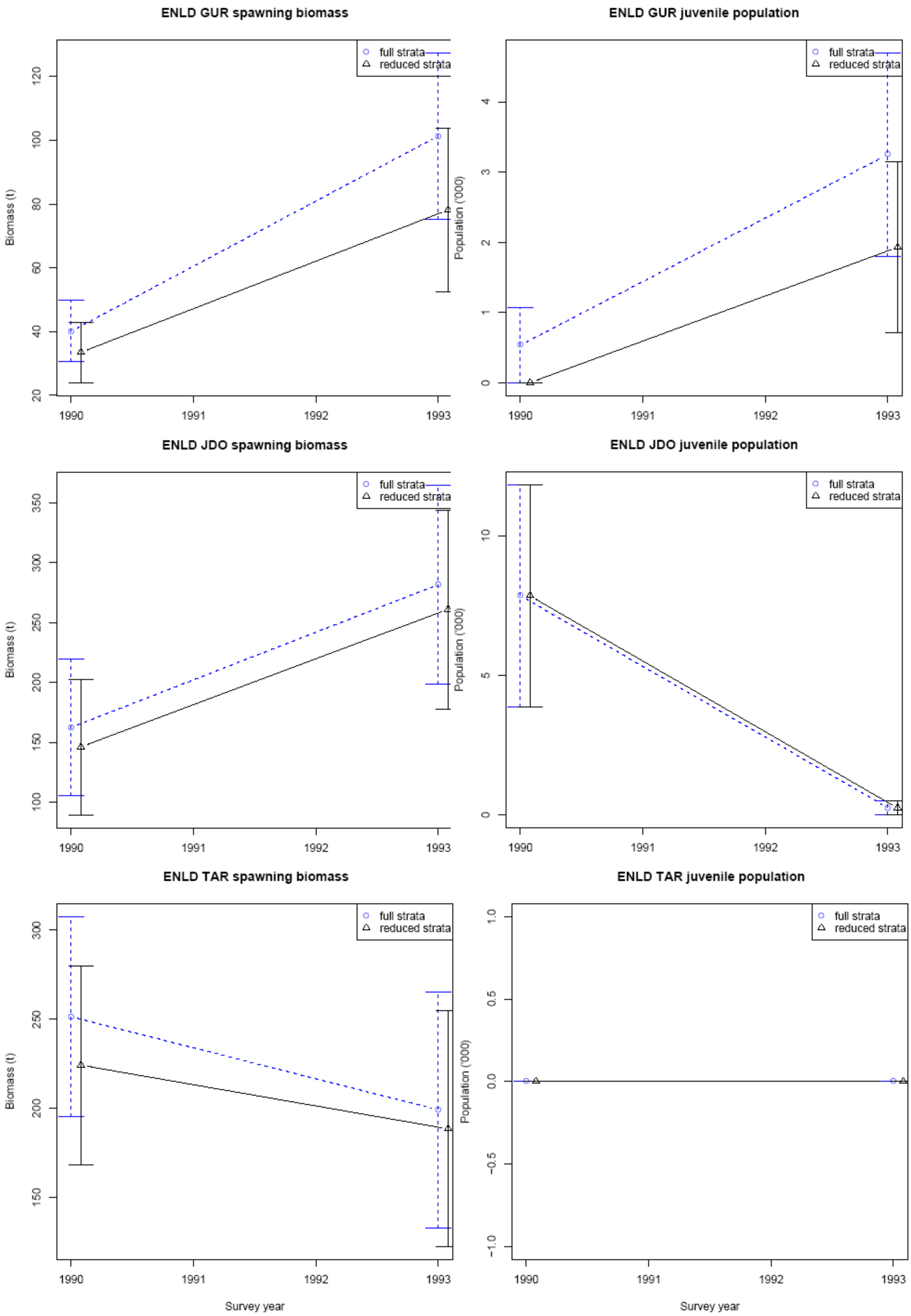

Figure 14: East Northland full survey (hashed line) and reduced strata (solid line) trajectories for adult biomass and juvenile abundance for the target species and selected c.v. scenario.

3.2.2. Hauraki Gulf

Figure 13 shows the minimum inflection point in the number of required stations was reached at five strata; (c.f. six for the full biomass estimation). The additional stratum dropped in the spawning stock optimisation was 1268 (inner Gulf between Waiheke Island and Coromandel). The number of stations needed to achieve the target c.v.s (GUR 18%, JDO 20%) was similar to that required for the total biomass optimisation (Table 6). Increasing the number of stations to 55 only lowered the c.v. level for red gurnard and indicated that a significant increase in sampling effort and costs would be needed to improve precision for this and the other species.

Similar to the total biomass comparisons, the reduced survey trends for adult red gurnard and tarakihi followed the full survey biomass and population trends very closely, whilst biomass estimates were lower and trajectories between certain years slightly diverging for John dory (Figure 15). Patterns of juvenile abundance were very different to the adult populations with a dramatic increase in red gurnard numbers in 1987, and juvenile tarakihi recorded in only very low numbers in two surveys.

3.2.3. Bay of Plenty

For the Bay of Plenty surveys, the minimum inflection point using the estimated spawning stock biomass was at four strata with 52 stations required for the selected c.v. levels. This was the same number of strata as the previous optimisation, except that the c.v. level for John dory spawning stock biomass only was 20% instead of 25% for total biomass. Reduced survey trajectories for both adult and juvenile tarakihi followed the full survey trajectories relatively closely in most instances (see Figure 16). Biomass estimates for adult gurnard in the reduced strata survey were lower in most years apart from 1985, with the full survey biomass trajectory showing only a slight increase over the time series, compared to a more marked increase in the reduced strata survey trajectory. Once more, very different abundance patterns were observed for the juvenile populations, with mainly low values and large “spikes” in particular years for gurnard (1990) and John dory (1992).

3.2.4. West coast North Island

Using the estimated adult spawning stock biomass, the optimisation suggested the same eight strata and 31 stations as the total biomass analysis, giving the same c.v. levels. The reduced strata adult spawning stock biomass trajectories of the three key species were similar to the full biomass apart from the 1986 estimates for tarakihi, which were less than a quarter of the full survey estimates (see Figure 17). Trajectories for juvenile population estimates were similar, although for red gurnard the increase in population numbers over the last four surveys was greater for the full survey (around a 5- fold increase) than in the reduced strata survey (around a 3-fold increase).

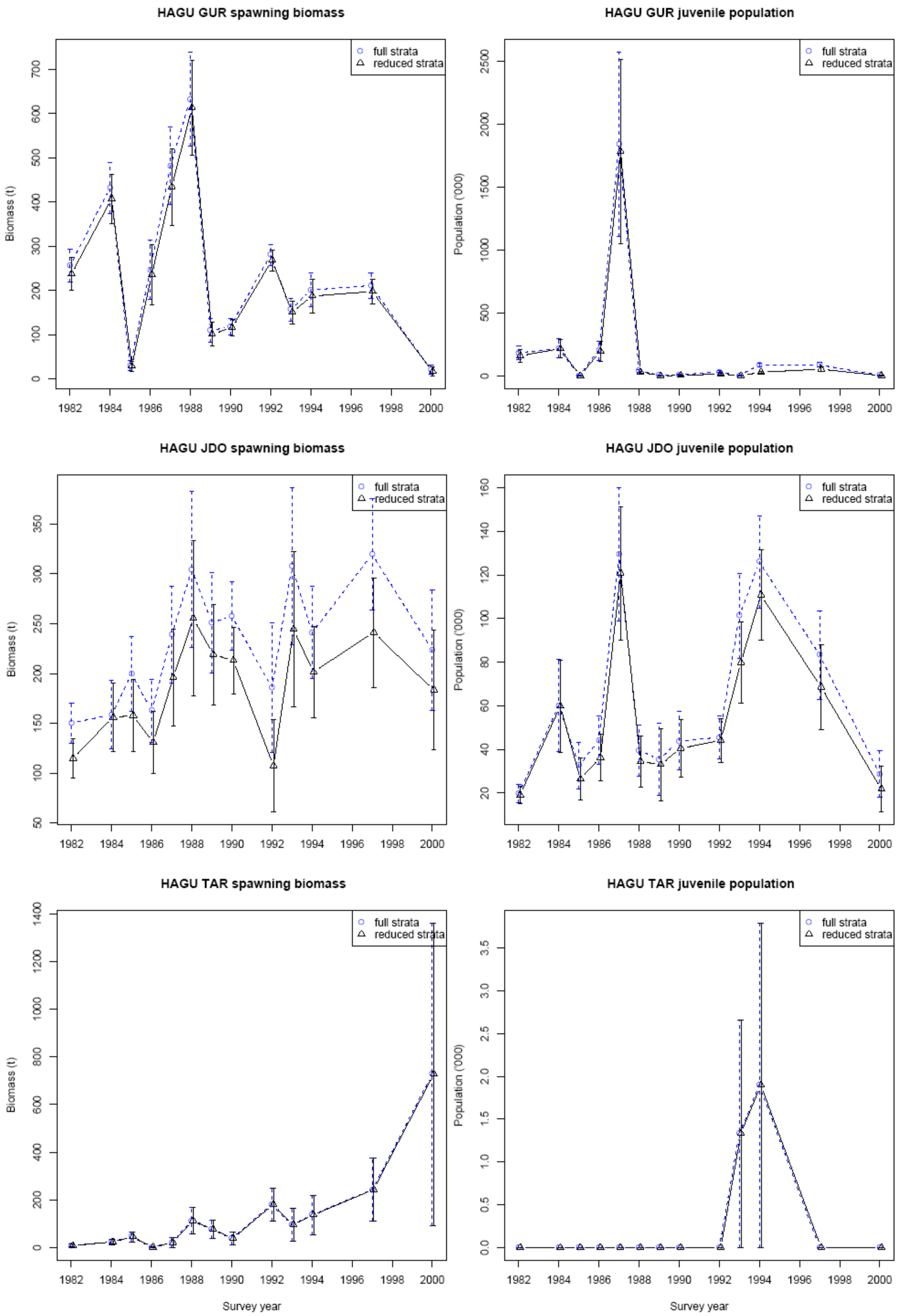

Figure 15: Hauraki Gulf full survey (hashed line) and reduced strata (solid line) trajectories for adult biomass and juvenile abundance for the target species and selected c.v. scenario.

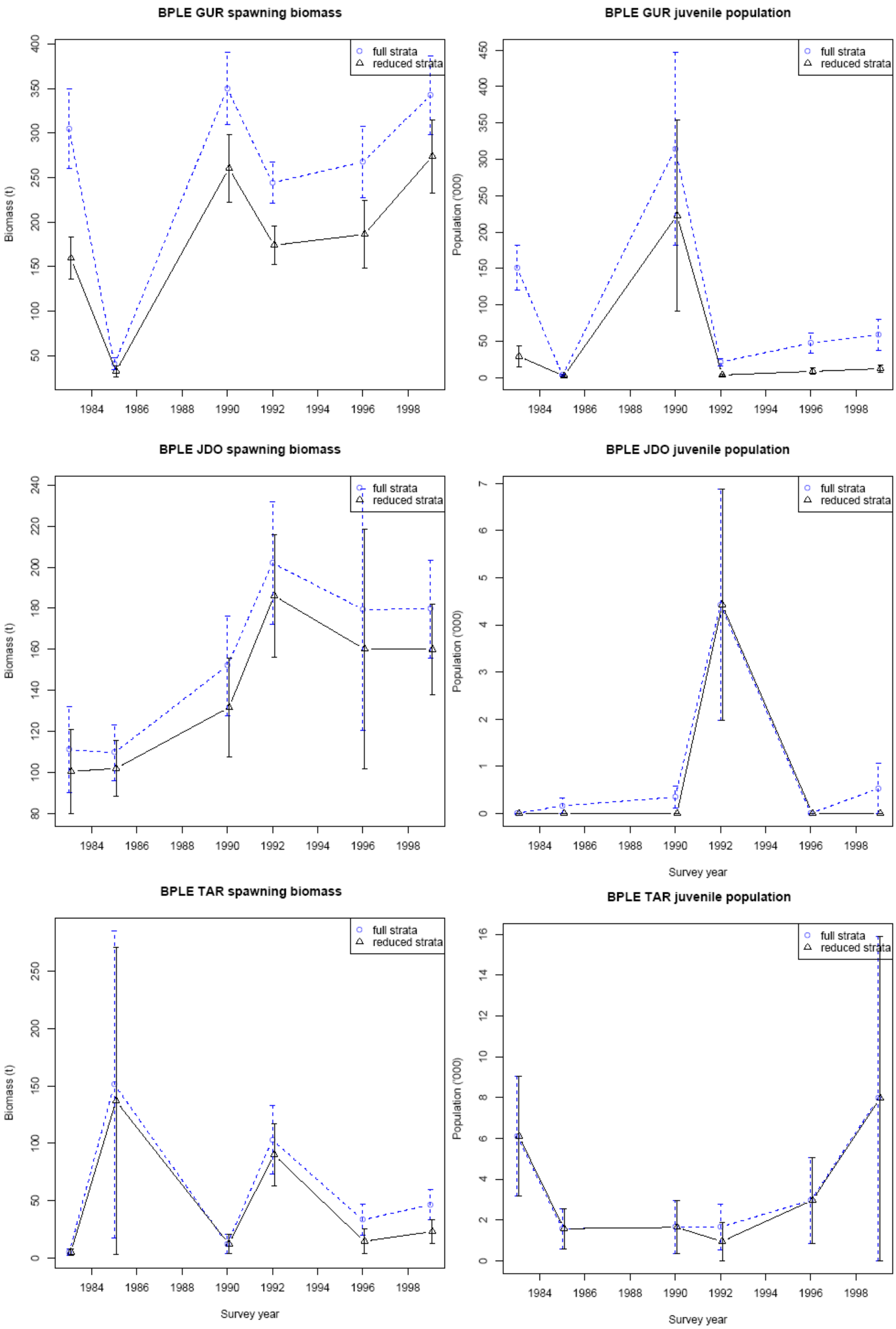

Figure 16: Bay of Plenty full survey (hashed line) and reduced strata (solid line) trajectories for adult biomass and juvenile abundance trajectories for the target species and selected c.v. scenario.

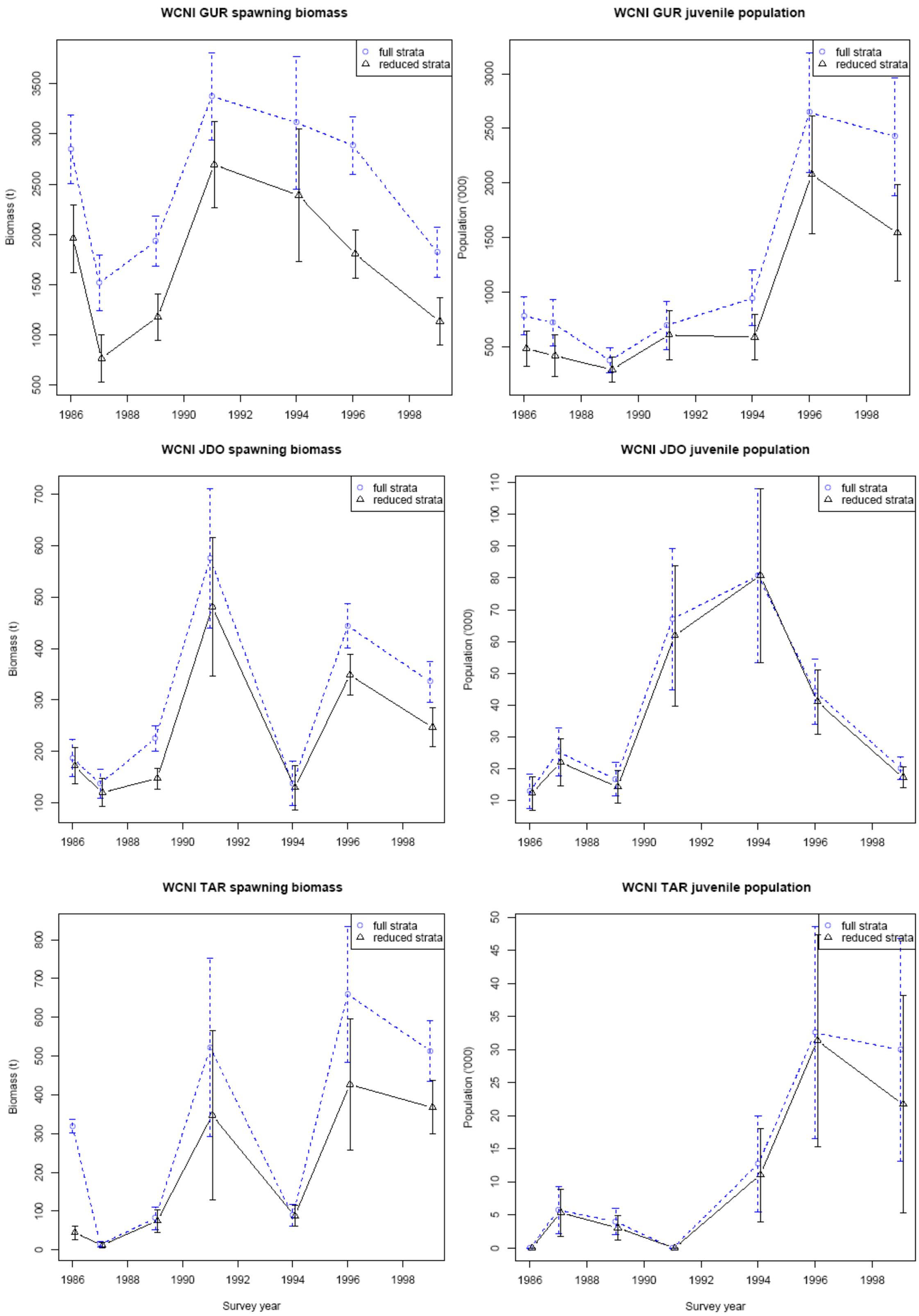

Figure 17: West coast North Island full survey (solid line) and reduced strata (hashed line) trajectories for adult biomass and juvenile abundance trajectories for the target species and selected c.v. scenario.

3.3. Length frequency comparison

A population size frequency distribution, scaled to survey area, was estimated for both the full and the chosen reduced strata surveys for each target species in each survey (Figures 18–21). The unscaled length frequency samples (for all surveys combined) are given in Appendix E. Whilst the reduced strata surveys produce lower population frequencies for some length classes (e.g., East Northland gurnard, John dory in the Hauraki Gulf, and all three species in the Bay of Plenty), in most cases the patterns and the cumulative length frequency curves appeared similar. In order to assess whether these length distributions differed significantly, two-tailed Kolmogorov-Smirnov tests were conducted for each species in each survey, using all fish measured over the time series as the sample. Table 7 gives the overall results for all years combined for each species in each survey area. No significant differences were detected within the smallest data set from the east Northland surveys however, significant differences were found in some of the other regions for red gurnard and John dory. The same tests were also carried out on an individual survey basis. All the individual length frequency plots, and cumulative frequencies for each of the three target species in each year, of each survey are given in Appendix G and the K-S test results for each of these datasets are given in Appendix F.

Table 7: Kolmogorov-Smirnov tests comparing the overall survey length frequency distributions obtained from full and reduced strata surveys. N_1 and N_2 are the number of fish sampled; D maximum difference between relative cumulative frequencies; Dα expected critical difference for a probability of 0.05 and decision to accept or reject the null hypothesis.

Survey/ Species	N_1	N_2	D	Dα	Decision
ENLD					
GUR	636	1054	0.028	0.068	Accept H_0
JDO	437	610	0.023	0.085	Accept H_0
TAR	274	325	0.012	0.111	Accept H_0
HAGU					
GUR	12141	15768	0.014	0.016	Accept H_0
JDO	2649	5026	0.069	0.033	**Reject H_0**
TAR	726	726	0	0.071	Accept H_0
BPLE					
GUR	6113	15158	0.035	0.021	**Reject H_0**
JDO	1349	2008	0.039	0.048	Accept H_0
TAR	427	707	0.023	0.083	Accept H_0
WCNI					
GUR	34745	84480	0.08	0.009	**Reject H_0**
JDO	1255	1893	0.054	0.049	**Reject H_0**
TAR	1341	1880	0.029	0.049	Accept H_0

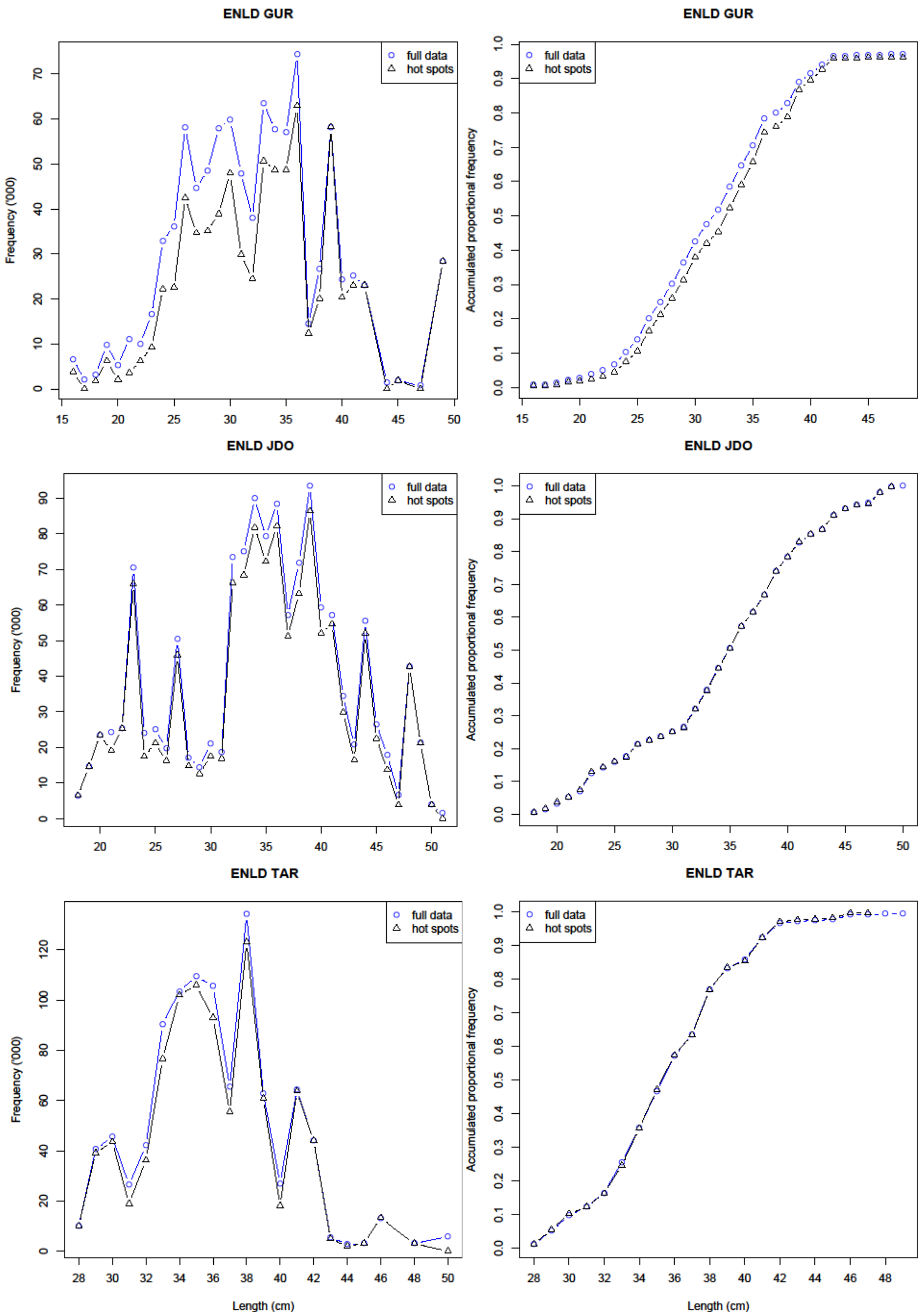

Figure 18: Population length frequencies and cumulative frequency curves for the three target species in the East Northland survey for full (circle) and reduced (triangle) strata surveys.

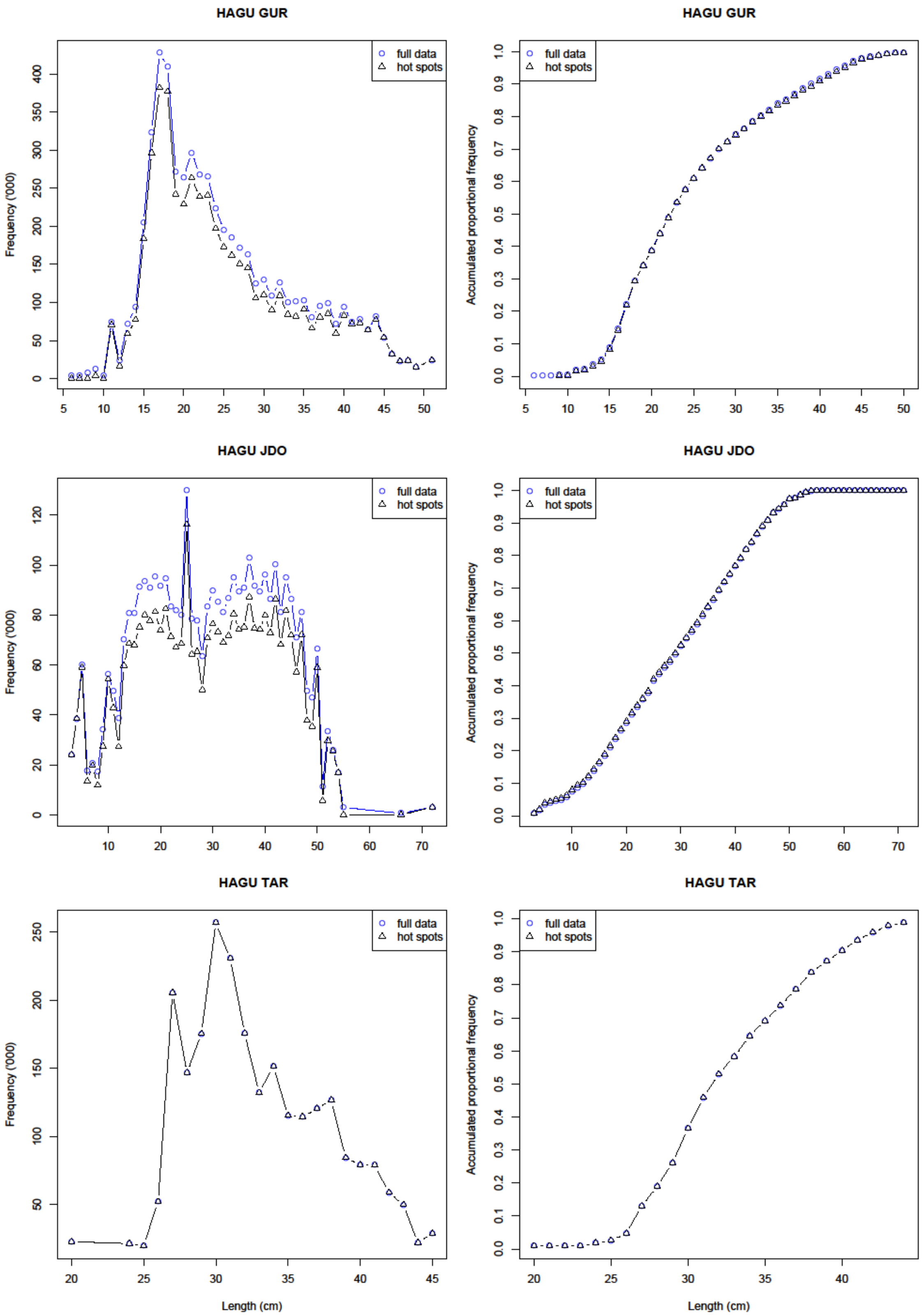

Figure 19: Population length frequencies and cumulative length frequency curves for the three target species in the Hauraki Gulf survey for full (circle line) and reduced (triangle line) strata surveys.

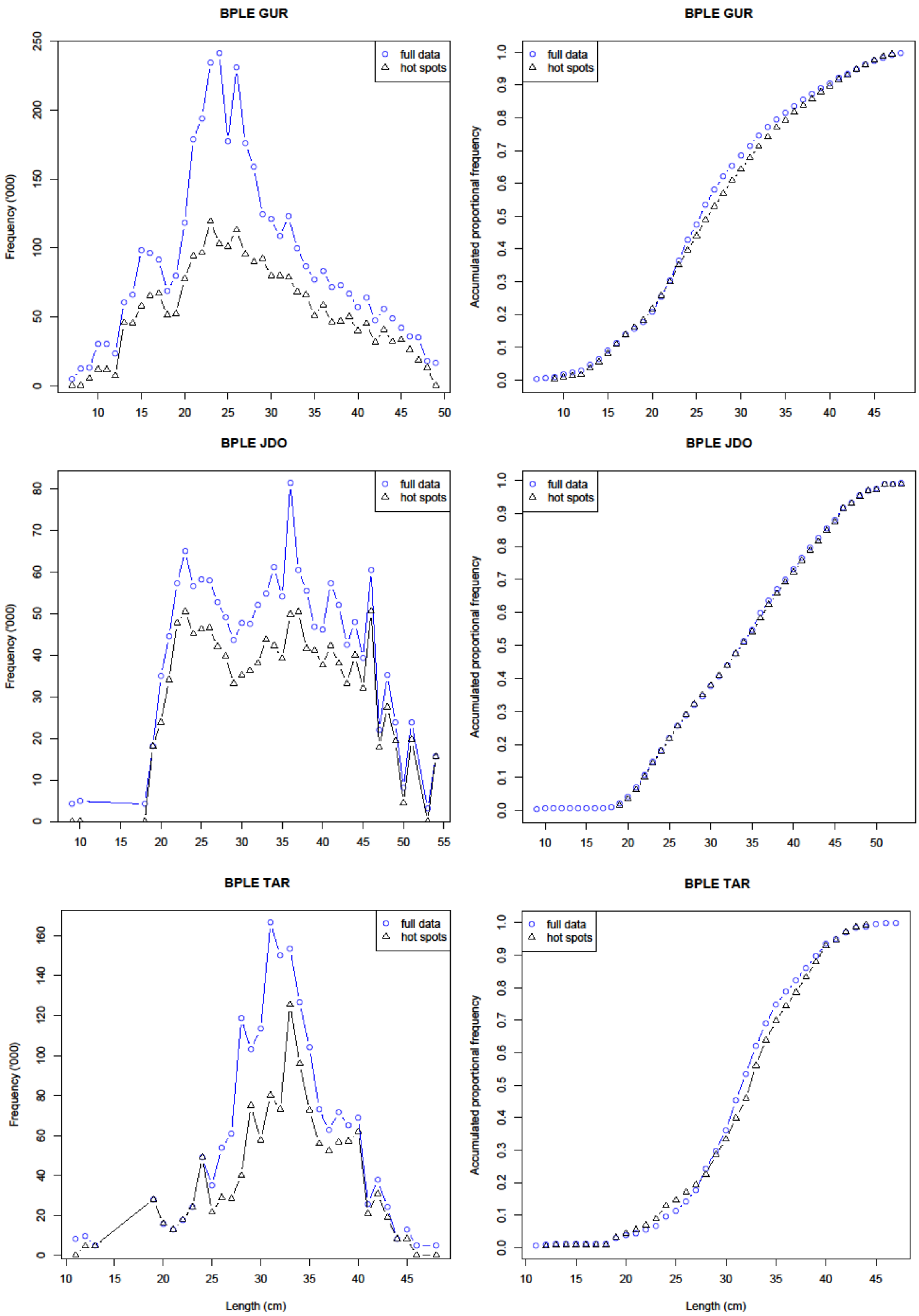

Figure 20: Population length frequencies and cumulative length frequency curves for the three target species in the Bay of Plenty survey for full (circle line) and reduced (triangle line) strata surveys.

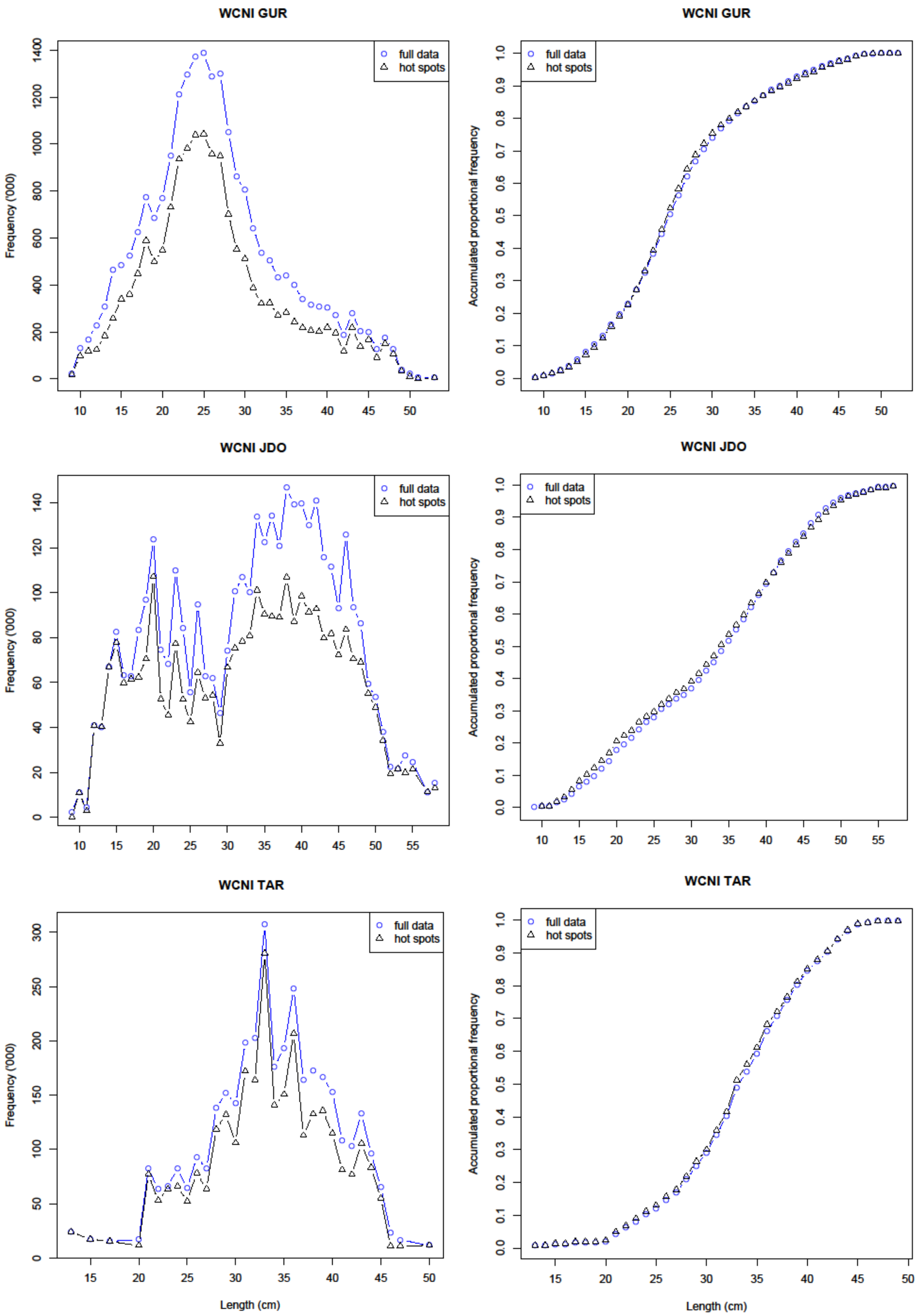

Figure 21: Population length frequencies and cumulative length frequency curves for the three target species in the West Coast survey for full (circle line) and reduced (triangle line) strata surveys.

Within the Hauraki Gulf, gurnard length frequencies were significantly different in 5 of the 13 years, although when the overall population was tested, the difference was not significant. An example of two of the years where a simulated reduced strata survey produced a significantly different length frequency is given in Figure 22. In both 1994 and 1997, the reduced strata surveys appeared to under-sample the juvenile portion of the population less than 20 cm. Only 2 out of the 13 survey years were significantly different for John dory, but the overall difference for this species was also significantly different. Figure 23 shows the two years (1990 and 1992) where the population structure as estimated from the reduced strata survey differed markedly in the larger size classes compared to that estimated from a full strata survey.

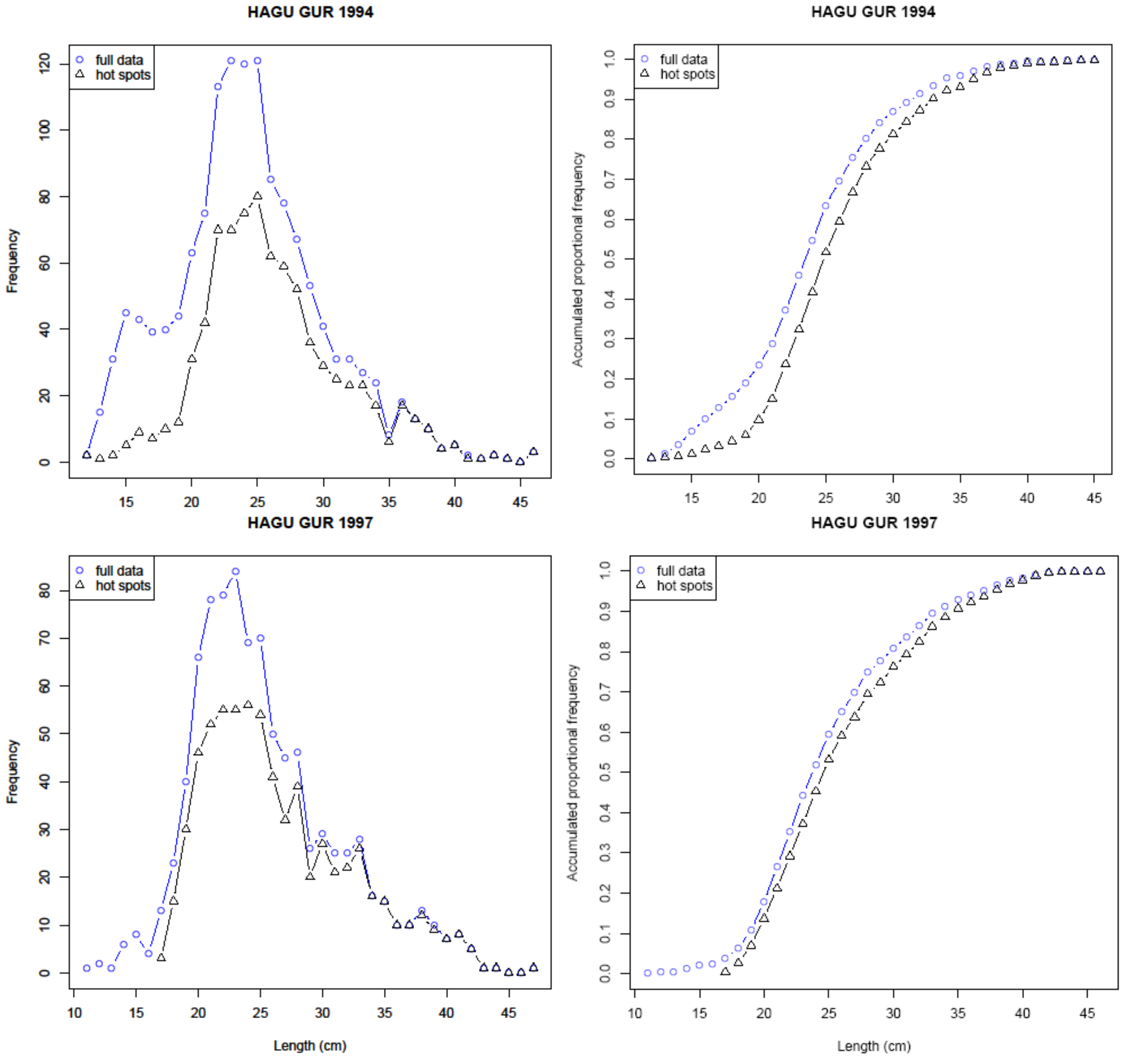

Figure 22: Length frequency distributions and cumulative frequency curves for red gurnard in the Hauraki Gulf 1994 and 1997 surveys.

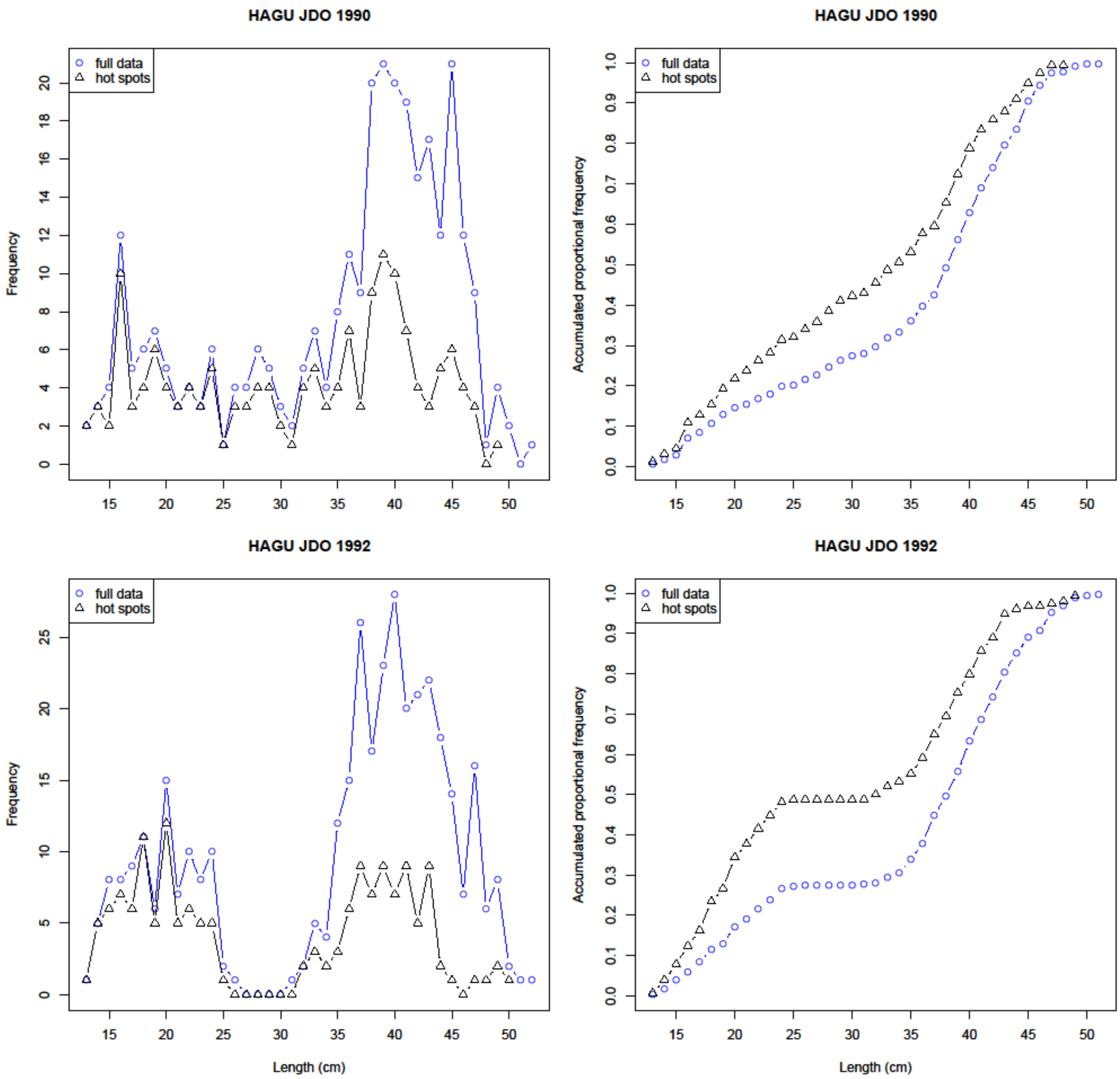

Figure 23: Length frequency distributions and cumulative frequency curves for John dory in the Hauraki Gulf 1990 and 1992 surveys.

In the Bay of Plenty surveys, the simulated reduced strata surveys produced significant differences in length frequency for John dory in 1 year, but not overall and in 4 out of 6 years for red gurnard. Three of the four years are shown in Figure 24. In 1998 and 1992 the difference was greatest between the smaller size classes but in 1990, some of the larger size classes were under sampled in the reduced strata survey.

In the west coast surveys, in 6 out of 7 years, the reduced strata survey results were significantly different for red gurnard. Although no single year produced a significant difference for John dory, the comparison of all years summed together was. Figure 25 gives a selection of individual survey years for red gurnard on the west coast.

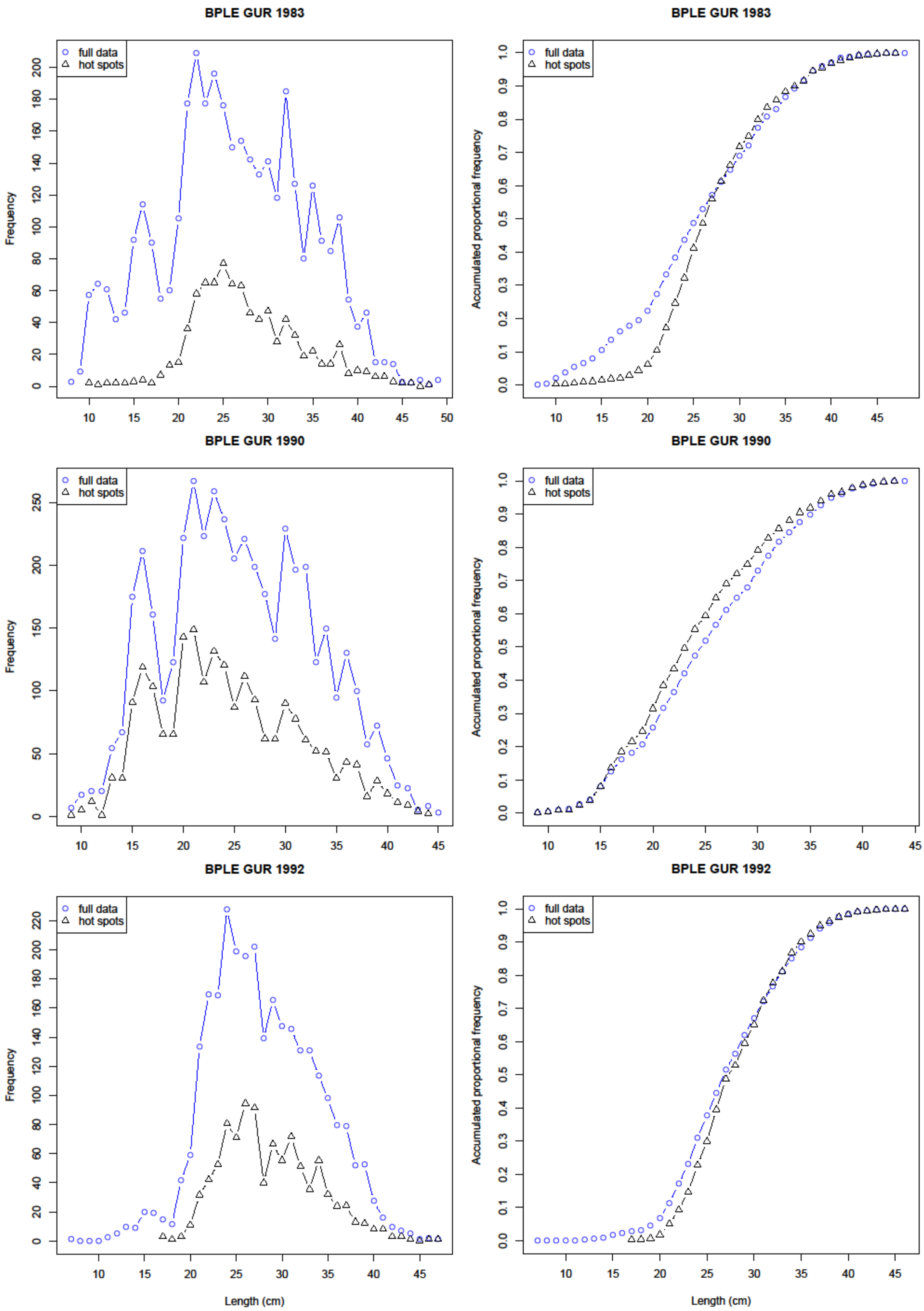

Figure 24: Length frequency distributions and cumulative frequency curves for red gurnard in the Bay of Plenty 1983, 1990 and 1992 surveys.

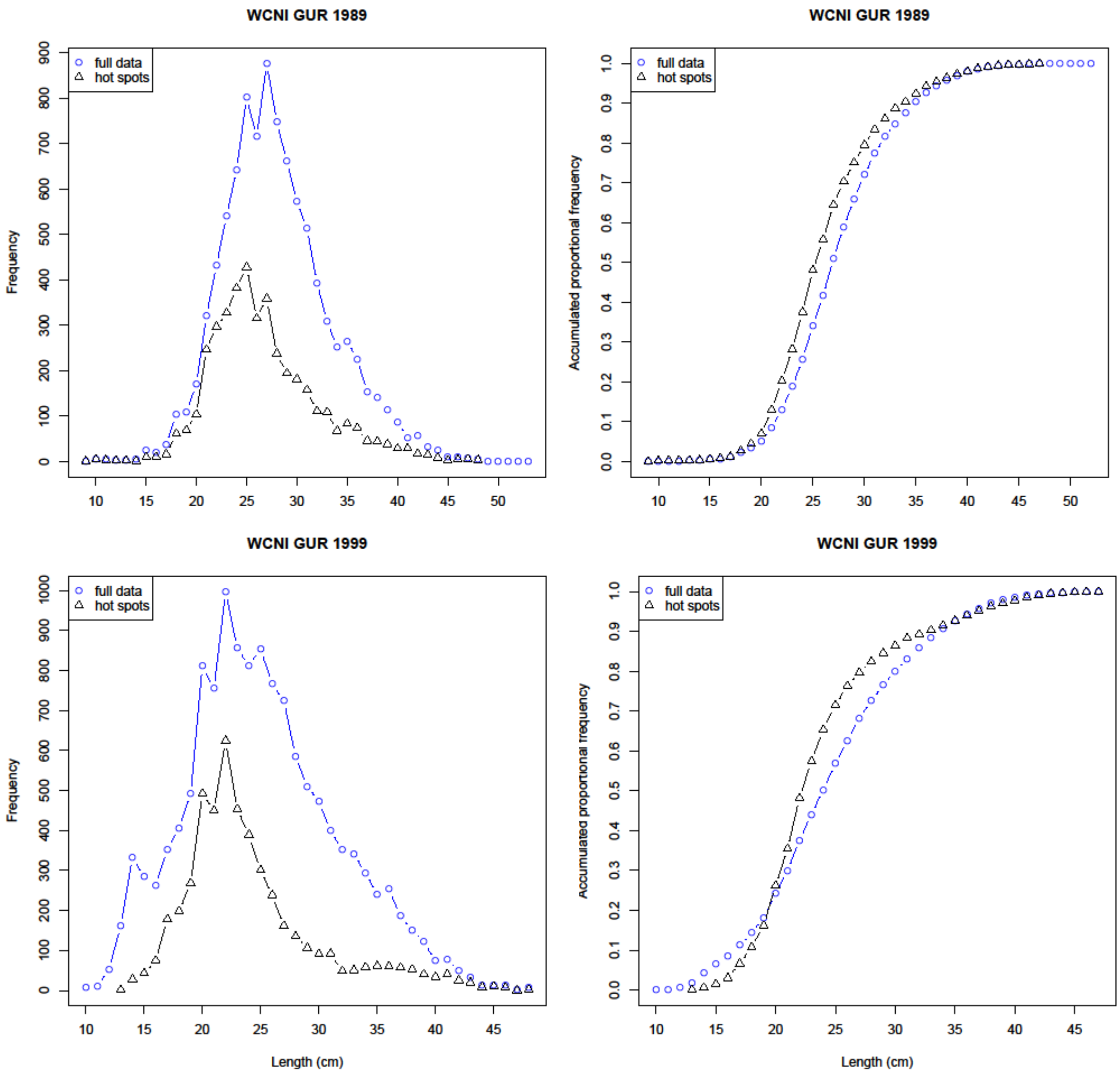

Figure 25: Length frequency distributions and cumulative frequency curves for red gurnard in the west coast 1983, 1989 and 1999 surveys.

3.4. Commercial catch analysis

The maps showing the commercial catch by 1 degree squares, overlaid with the survey strata are given in Appendix H. These figures show that the sub-sets of strata selected for a new 'northern hot spot' trawl survey series do encompass the areas of highest commercial catch in an acceptable fashion, within the unavoidable constraint that the survey depth range may not fully encompass the commercial fishing areas, which are likely to extend deeper than 200–250 m (the maximum depths included for any survey area). Figures 26 to29 show quantitatively how the commercial catch for each species in each full survey area relate to the total commercial catch from that region on a month by month basis (total estimated catch 1989–2008). For the most part, the catch from the area encompassed by the historical survey represented over 70% of the total estimated catch. For instance, in the Hauraki Gulf the commercial catches from the survey area were between 85–99% of the total catch on a month by month basis (Figure 27). However, for some species, in some areas, the survey area catch was lower. In east Northland, tarakihi catches from the survey represented only 20–50% of the total catches at the most, with the catches from the survey area being particularly low between July and October (Figure 26). In the Bay of Plenty, commercial catches from within the survey area for all three species ranged between 60and 76% (Figure 28).

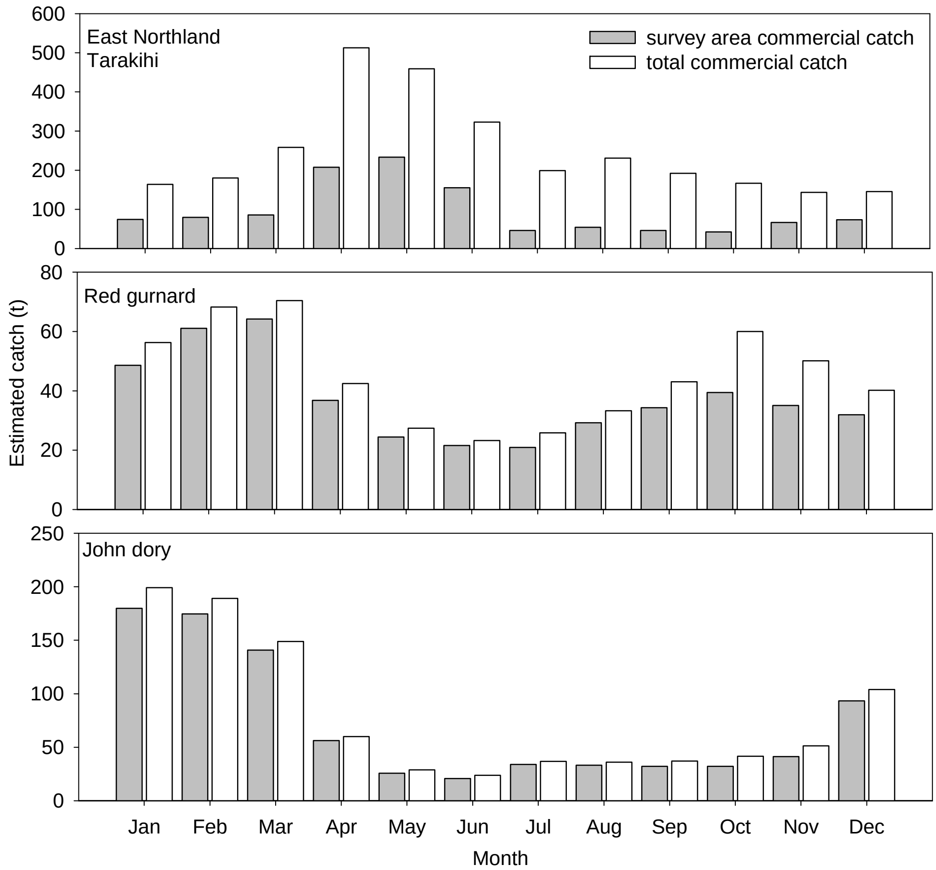

Figure 26: Estimated commercial catch (1989–2008) from the east Northland area showing both the total catch and that from the area encompassed by the survey (all strata).

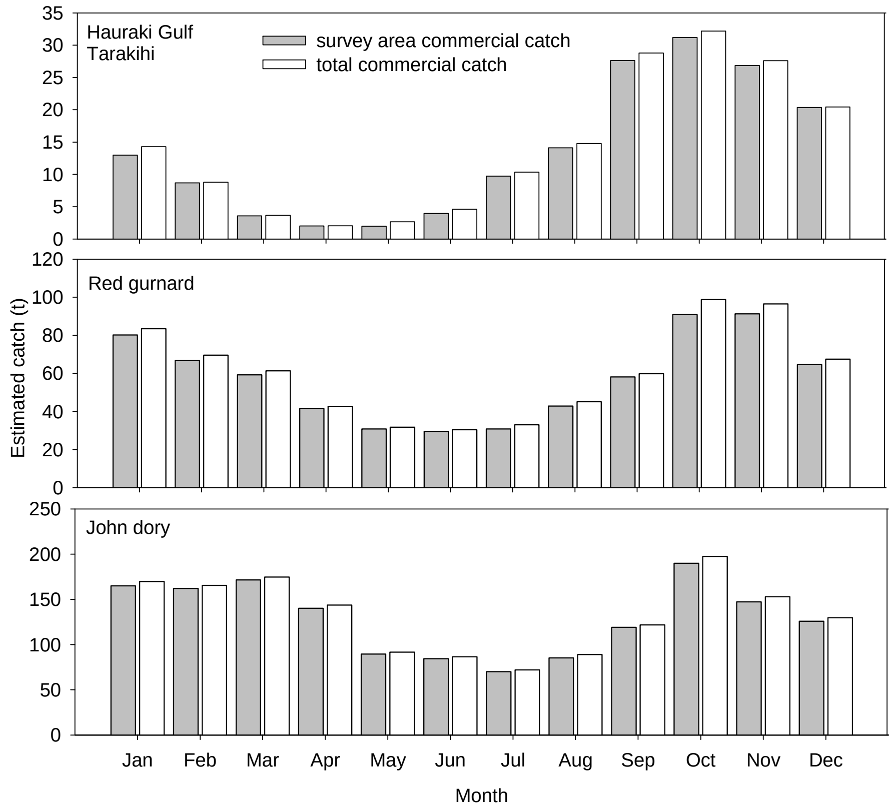

Figure 27: Estimated commercial catch (1989–2008) from the Hauraki Gulf region showing both the total catch and that from the area encompassed by the survey (all strata).

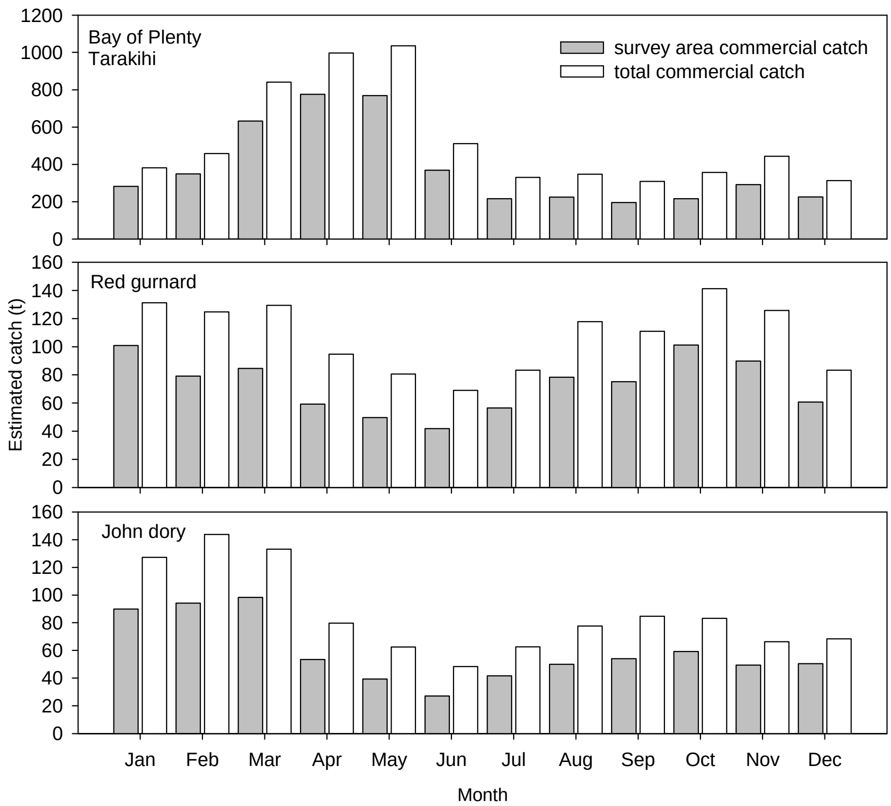

Figure 28: Estimated commercial catch (1989–2008) from the Bay of Plenty region showing both the total catch and that from the area encompassed by the survey (all strata).

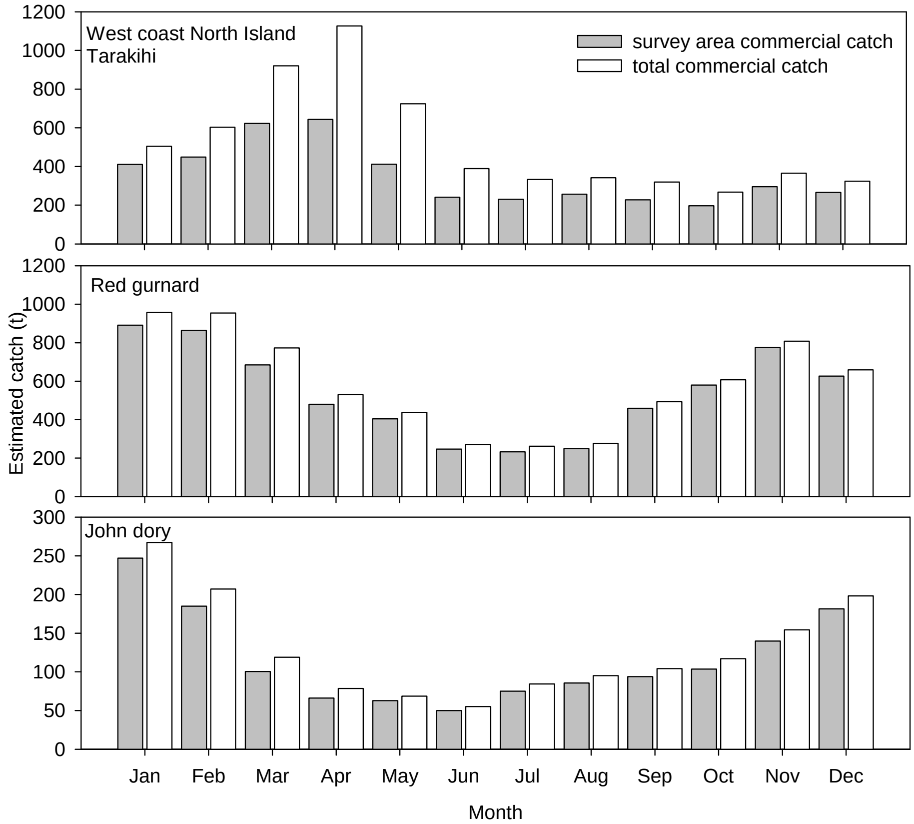

Figure 29: Estimated commercial catch (1989–2008) from the North Island west coast region showing both the total catch and that from the area encompassed by the survey (all strata).

In all cases, the temporal trends in catches from the area covered by the surveys were very similar to those from the total area from which commercial catches were landed, as shown by the high correlation coefficients in Table 8. Therefore, despite not encompassing the full spatial extent of the commercial fishery for these species, the survey strata still capture the same temporal trends.

Table 8: Pearson correlation coefficients for the relationship between survey area and total monthly commercial catches for the three target species in all four survey areas.

Survey area	Red gurnard	John dory	Tarakihi
East Northland	0.9976	0.9989	0.9653
Hauraki Gulf	0.9479	0.9989	0.9266
Bay of Plenty	0.9990	0.9996	0.9994
West coast North island	0.9687	0.9851	0.9967

As well as assessing the spatial coverage of the survey, the monthly catches allowed the historical timing of the surveys to be compared to the timing of peak commercial catches. Figure 30 shows the proportion of the total estimated commercial catch (from the years 1989–90 to 2008–09) for each species in each area by month and overlays the timing of historical surveys (grey bars). There are variations in commercial catch for all three species that likely reflect a combination of abundance/availability, but also variations in species targeted. Both John dory and red gurnard catches are higher over the spring (Hauraki Gulf) and summer months, (east northland and west coast in particular). The timing of the historical surveys matches these patterns reasonably well with the Hauraki Gulf surveys being carried out in November–December, a little earlier on the west coast and in February for the Bay of Plenty and the second east Northland survey. However, these timings clearly miss the peak period for tarakihi landings which occur between April and May along the east coast (east Northland and Bay of Plenty) and in March–April on the west coast. The higher proportion of landings of tarakihi in the Hauraki Gulf should be viewed with caution as the total landings from this area are very low (see Figure 27) and could reflect a shift of fishing in deeper waters where tarakihi is more likely to be caught as a bycatch. Table 9 summarises the problems with previous survey timings and suggests some alternatives. With a view to one continuous North Island survey, the suggested timing would run from January–February in the Hauraki Gulf, through to March–April time in the Bay of Plenty and east Northland.

Table 9: Summary of alternative survey times for trawl surveys in the four North island regions.

Region	Period of peak commercial landings			Previous survey		Proposed survey	
	GUR	JDO	TAR	Timing	Problem	Timing	Problem
East Northland	Jan – Mar	Dec– Mar	Apr– Jun	Feb & Nov– Dec	TAR – low catch	March– Apr Apr– May	TAR – migrating? GUR & JDO – low catch?
Hauraki Gulf	Oct– Mar	Oct– Mar	Sept– Dec	Nov– Dec	TAR – low catch – too shallow	Nov– Dec Jan– Feb	Temporally separate from other surveys SNA – high catches
Bay of Plenty	Oct– Jan	Jan– Mar	Mar– May	Feb	TAR – low catch	Mar– Apr	TAR – migrating? GUR & JDO – low catch?
West Coast	Nov– Feb	Nov– Feb	Jan – April	Oct– Nov	TAR – low catch	Feb	None

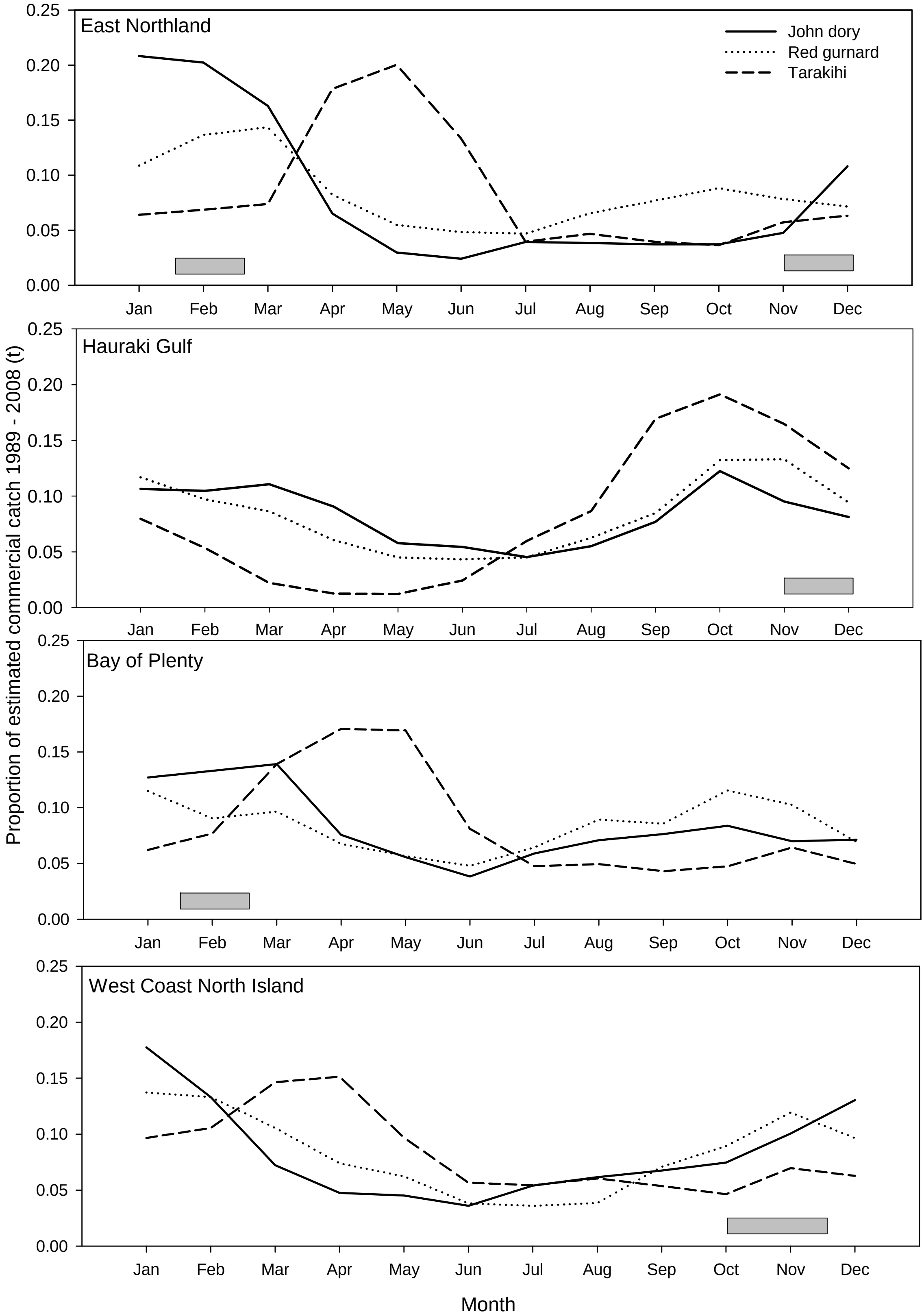

Figure 30: Monthly commercial catch trends for the three target species in each survey area with the timing of the historical surveys indicated by the grey shaded area.

3.5. Trawl net options for a "northern hotspot" survey

The NIWA research vessel *Kaharoa* currently has three demersal trawl gears that have been used in current and previous inshore bottom trawl surveys. Historically these trawls have been used successfully to target two of the key species in the proposed new northern hot spot survey. Red gurnard were/are target species for the northern North Island and South Island surveys; tarakihi were a target on both the North Island surveys and are a target in current South Island surveys. John dory is/was not a target for the South Island or east coast North Island surveys due to the species northerly distribution. The following sections provide details about each trawl net and the advantages and disadvantages of its use in a new northern hotspot survey.

3.5.1. The High Opening Bottom Trawl (HOBT)

Historically this trawl net has been used for all surveys aboard *Kaharoa* from Kapiti Island north around to East Cape. Originally designed in the early 1980s for use on pre-recruit snapper, it is based on a mini orange roughy style trawl, but other target species included red gurnard, John dory, trevally and tarakihi.

Trawl and rigging

As the name suggests, the HOBT has a high headline height with cut away lower wings with 14.15 m chain extensions. It has 300 mm mesh in the fore part of the trawl and a 40 mm codend. The trawl was rigged with 0.7 m lay back, the standard *Kaharoa* rectangular V doors (3.4 m^2), 55 m sweeps and 55 m bridles. The ground rope construction was a combination of rubber discs/cookies and steel cannon balls hung from chain droppers (see Appendix I for a net plan). The gear was rigged to attain a headline height of around 5–6 m and a door spread of around 70–80 m. The cut away lower wings were designed to minimize damage on rougher ground.. Towing speeds and distances for this trawl varied slightly depending on the area of the survey; 0.7–1 n. mile and 3–3.2 knots for Bay of Plenty; 1.5n. mile and 3-3.5 knots for west Coast North Island and 0.7 n. miles and 3 – 3.5 knots for Hauraki Gulf.

Advantages of using this trawl

- Direct comparison with earlier results possible as the same vessel and trawl net will have been used and there should be no changes in catchabilities of the key species.
- The trawl design is more suited to rougher bottom (a known issue in some areas such as east Northland), having no lower wings.

Disadvantages of using this trawl

- The net is of an old design and may come under scrutiny from both fishers and researchers.
- As this net is not currently in serviceable condition, the original nets will have to be re-constructed with materials that may be difficult and / or costly to source (likely minimum 6 month lead in time required).
- The net is difficult to set and get fishing correctly
- There have been some bottom contact concerns with this trawl
  The cut away lower wings may reduce efficiency of the net for bottom-orientated species.

3.5.2.

3.5.3. The east coast South Island Trawl

his trawl, constructed in 1991, was based on a commercial 2 seam "Alfredo" trawl design, specifically for use on South Island trawl surveys on *Kaharoa* which still run on a biennial basis. The target species for these surveys currently include red cod, giant stargazer, spiny dogfish, tarakihi and, on the west coast, red gurnard, and on the east coast, dark ghost shark and sea perch.

Trawl and rigging

The *Kaharoa* South Island trawl is a full wing trawl and uses the standard *Kaharoa* rectangular V doors (3.4 m^2), 55 m sweeps, 55 m bridles. The fore meshes are 150 mm. A 60 mm codend is used with the option to use a 28 mm codend if required. The ground rope construction is a combination of rubber disc and steel cannon ball hung from chain droppers. The net is fished hard down with a headline height of between 4–5m. Distance and towing speed have been standardized to 1 hour duration at 3 knots (about 3 n. miles). See Appendix I for a net plan.

Advantages of using this trawl

- The trawl is successfully used in the South Island for two of the proposed target species (GUR, TAR), and more recently has been successfully been used to monitor John dory in JDO7.
- Future North and South Island surveys could potentially be comparable.
- The trawls are currently maintained and therefore start-up trawl net costs for a new survey would be minimal and knowledge on how to rig and fish the nets properly is well established.

Disadvantages of using this trawl

- Direct comparisons with earlier northern New Zealand survey results will not be possible due to the potential changes in catchability of species in the two nets.
- Any proposed new survey design is based on analysis of data collected using the HOBT and as above, a change in trawl may render these results inapplicable
- The design is not suited to rougher bottom, having lower wings.
- The net is of a relatively old design and may come under scrutiny from both fishers and researchers.

3.5.4.

3.5.5. The east coast North Island Trawl

This trawl was specifically designed for surveying between East Cape and Kaikoura. The surveys ran from 1993 to 1996. The target species were initially snapper, tarakihi, trevally and gemfish, but by the final survey, only tarakihi and pre-recruit gemfish were considered adequately sampled. See Appendix I for a net plan.

Trawl and rigging

The trawl was based on a commercial design used in the area with input from those local fishers and net sheds into the design. It is a large, high-lift, full wing trawl using the standard *Kaharoa* rectangular V trawl doors, 55 m sweeps (with plastic covers to stop the wires digging into the soft sediment) and 55 m bridles and a ground rope consisting of 14 mm wire rope. This trawl attains the largest headline height of between 6–9m. Tows were 1 hour long at 3.5 knots. See Appendix I for a net plan.

Advantages of using this trawl

- This trawl was successfully used for one of the proposed target species (TAR).
- The full wings and high headline height may be more efficient for other target species (SNA, JDO)

Disadvantages of using this trawl

- Direct comparisons with earlier northern New Zealand survey results will not be possible due to the potential changes in catchability of species in the two nets.
- Any proposed new survey design is based on analysis of data collected using the HOBT and as above, a change in trawl may render these results inapplicable
- The design is not suited to rougher bottom, having lower wings.
- The net is of a relatively old design and may come under scrutiny from both fishers and researchers.

The above sections provide an overview of the scientific trawl net options available and table 10 summarises the characteristics of all three trawls. From the point of view of continuing a time series of surveys, the original HOBT net would be the optimal choice, but re-construction with identical materials and regaining the requisite knowledge on how to rig and fish this net would be an expensive exercise. The remaining nets offer alternative options that present fewer logistical problems. However, using either of these nets makes direct historical comparison of data impossible without inter-calibration, and brings the risk that the optimisation analysis carried out using historical data will not be directly applicable.

Table 10: Summary details of the scientific trawl net options available for a new northern hotspot survey.

Net	HOBT	ECSI	ECNI
Type	Cut away lower wing	Full wing	Full wing
No of seams	4	2	2
Backstrop	6.6	7.5	6.6
Sweeps	55 (16mm)	55 (16mm)	55 (16mm)
Bridles (top)	55 (12mm)	55 (12mm)	55
Bridles (bottom)	55 (16mm)	55 (16mm)	55 (16mm plastic coated)
Headline length (m)	34.5	25	29.75
Floatation (kg)	217	220–230	210–220
V lines (m)	n/a	6.4	9.75
Ground rope length (m)	18.66	32.37	not available
Ground rope weight	120 + 40	243 + 37	170–270
Layback	0.7	1.5	1.03
Headline height (m)	5–6	~5	6–9
Door spread (m)	70 - 90	~82 (60–90)	70–110
Optimum wing spread	17	12.35	14.88
Fore meshes (mm)	300	150	300
Codend size (mm)	40	60 or 28	80 (knotless)
Towing speed (knots)	3–3.5	3.0	3.5

3.5.6.

3.5.7. Commercial Trawl net option

3.5.8.

A new trawl design could be selected if the future survey is considered to be the start of a new time series. The most appropriate design would likely be based on a current commercial net. A previously published questionnaire survey collected information from inshore fishers on the type and typical operational parameters of their trawls (Clement & Associates 2008). From the North, Central and Hawke's Bay region over 70 fishers were interviewed. The average size and horse power of commercially operating vessels is smaller than RV *Kaharoa* (28 m and 700 hp). Some details by area and trawl type are given in Table 11. Depending on the main target species, the trawl net characteristics vary slightly. Those targeting mainly gurnard and flatfish used smaller two panel nets with a chain or rope-bound ground rope, often less than 20 m in length (range: 15–35 m) with mainly 20–30 m bridles (range: 6–50 m) and sweeps usually between 60–80 m in length (range: 40–150 m). Largest meshes were usually 152 mm (6 inches). A typical headline height was about 3 m (range: 0.9–3.7 m), towed for about 3 hours at around 2.8 knots (range: 2.2–3.2 knots). Those targeting mainly tarakihi and/or snapper tended to use larger two or four panel nets. For tarakihi, the most common groundrope length was about 27 m (range: 21–50 m) with bridle lengths varying from 13.5 to 50 m, but usually between 30–40 m in length and sweeps varying from 40 to140 m, but most commonly 100–110 m in length. Headline heights were usually 2.5–3.5 m high (range: 1.5–4.6 m), towed at around 3 knots for 3-4 hours. For those targeting snapper, headline heights were more likely to be greater than 4 m (range: 1.1–4.9 m) and towing speed more likely to be greater than 3 knots. A number of respondents were classed as "mixed" based on their catch being a mixture of all species. These trawls had a groundrope length of about 33m, a headline height ranging from 2 to7 m, mainly with 50 m bridles and sweeps ranging in length from 70 to 300 m.

In the survey results, trawl nets were classified as "low" (3–6 ft), "medium" (6–12 ft) or "high" (> 12 ft) opening trawls (Clement & Associates 2008). Given the target species for the northern hotspot survey, a medium or high headline trawl would be most appropriate. Milligan trawl manufacturers made 16% and 50% of medium and high opening trawls respectively. Gourocks made 33 and 15%. As an example of a possible commercial option, a net plan for a generic Milligan trawl is included in Appendix I. This is a four panel trawl with 12" (305 mm) mesh in the wings and 4" (100 mm) mesh in the codends. These nets have a larger, "squarer" mouth than the survey trawls and are designed to attain headline heights of 6–6.5 m to better catch John dory and tarakihi. The ground gear used with the net is generally wire with rope and sometimes chain wrapped around it or small tightly packed cookies.

Table 11: Summary details of commercial trawlers operating in the North Island taken from Clement & Associates (2008).

Parameter		North	Central	Hawke's Bay
Average vessel size (m)		19	15	14
Average vessel age		36	33	34
Average horse power (Hp)		390	270	251
Average tow speed (knots)	SNA	3.1	3.2	3.1
	GUR	3.0	2.9	2.8
	TAR	2.9	3.0	3.0
Average headline height (m)	"Low"	1	2	2
	"Medium"	3	3	3
	"High"	5	5	5
Size of largest meshes (mm)	"Low"	152	229	305
	"Medium"	457	305	229
	"High"	457	457	305
Predominant ground type		Hard	Soft	Soft
Ground gear type		Rope bound	Chain	Rope bound

Advantages of using this trawl

- A design based on current commercial trawls may improve catching efficiency for some or all target species.
- The results may be more readily accepted by both fishers and researchers.

Disadvantages of a new trawl design

- Direct comparisons with earlier northern New Zealand survey results will not be possible due to the potential changes in catchability of species in the two nets.
- Any proposed new survey design is based on analysis of data collected using the HOBT and, as above, a change in trawl may render these results inapplicable.
- The construction of a new trawl (minimum of two nets, codends and spares) will be expensive and may require the purchase of new trawl doors.
- Added cost due to gear trials that will be required to fully test the new trawl and establish optimised, standard rigging.

3.5.9. Estimated costs and decision summary

3.5.10.

Both the HOBT and the east coast North Island trawls would need considerable refurbishment, or to be completely rebuilt. A rough estimate of $12,000 per net would need to be confirmed depending on availability of the correct materials. Gear trials would also be recommended to allow for crew familiarization, rigging optimisation and ground contact trials. The South Island survey trawl is currently used on a regular basis and the cost of this option would be restricted to ongoing maintenance, although the increased usage may require an additional trawl net to be purchased. Gear trials would not be required although some modification of ground gear for harder conditions might be recommended. If a new trawl net was commissioned, a workshop/meeting with selected net maker and commercial fishers is recommended to finalize the design. The cost of two complete new trawls is estimated at about $50,000 (including new doors) and this option would also require thorough gear trials well in advance of a survey.

PRORITY	RECOMMENDED TRAWL	LIMITATIONS	COST LEVEL
CONTINUATION OF TIME SERIES →	HOBT	Likely lower efficiency for bottom-orientated species (GUR) compared to other trawls	HIGH
A NEW TIME SERIES WITH OPTIMUM GEAR & TIMING →	COMMERCIAL-STYLE TRAWL	Unlikely to design a trawl that can catch all target species with equal efficiency on all ground types. Will still be a compromise	HIGHEST
MOST COST EFFECTIVE OPTION →	SOUTH ISLAND SURVEY TRAWL	Headline height is lowest of all options, may be less optimal for TAR. More prone to damage on hard ground	LOWEST

4. DISCUSSION

The aim of this study was to assess the potential for a “northern hotspot” trawl survey that combined four historical surveys into one. The approach was to use an optimisation process that ranked the strata in each individual survey from most to least important and then drop the lowest ranking strata one by one, estimating the total number of stations required each time to obtain particular c.v. values. Figures 8 and 13 allow the selection of an optimised survey design by choosing the inflection point with the lowest number of strata and stations, the number depending on the desired target c.v.s. The historical trawl data were then used to compare the total and spawning stock biomass values that would have been obtained from such a reduced strata survey with the full survey values over the course of each survey time series.

This process was first carried out using total biomass estimated from length frequency data and length weight relationships. The analysis was then repeated with adult biomass and juvenile numbers estimated separately. Using this method allowed inclusion of earlier surveys where actual weight information was not collected consistently for all species in the catch. The most recent stratification for each survey was used to re-stratify earlier surveys and allow the use of all data in a standardized way. As a result, some of the revised full survey estimates were different from the original estimates calculated at the time based on actual recorded weights.

Both sets of results indicated potential for reductions in area and sampling effort in all surveys, some more than others; only a 7–11% reduction in area and a 15% reduction in stations in the Hauraki Gulf, compared to a 36% reduction in area and a 70% reduction in stations on the west coast. Where large areas were removed from the survey, such as the west coast, the scaled biomass totals were lower, but the simulated trajectories were generally similar to those obtained using the original number of strata. However, in some instances, the relative changes between years and/or over the full time series apparent from the reduced strata survey were not the same as the full survey, with potentially very different management implications, for example, the different overall trends for red gurnard in the Bay of Plenty and for snapper on the west coast. In these cases, the reduced strata surveys gave considerably lower estimates in some years which resulted in different between-year and overall time series trends. In the Bay of Plenty, the different overall trajectory was essentially due to a single exceptionally large catch of red gurnard taken in one of the discarded inshore strata. Removal of the stratum resulted in a significantly lower biomass estimate in this year. The west coast snapper biomass estimates were markedly lower in all years but followed a similar pattern as the full survey until the final year, where they diverged.

When the population size structure was assessed for the three target species, the reduced strata survey simulations produced significantly different length frequency distributions for red gurnard and John dory in some years, due to an absence of either smaller or larger size classes or both. In some instances, differences in the length structure were subtle and not immediately apparent from the cumulative curves but caused the null hypothesis to be rejected. It should be noted that the Kolmogorov-Smirnov test is highly sensitive to sample size and this varied widely between species and surveys.

Many of the strata discarded were shallow areas included when juvenile snapper was a target species. Such areas may also be important for other juvenile species. For red gurnard in particular, the removal of these shallow strata reduced numbers of fish under 20 cm in the Bay of Plenty and west coast surveys. Being able to monitor pre-recruit biomass is a valuable aspect of fishery-independent data, but only the west coast and Hauraki Gulf were ever optimized for pre-recruit snapper and were not especially effective for other species; tarakihi less than 25 cm were rarely caught anywhere apart from on the west coast. Therefore, if proportion-at-age and pre-recruitment biomass are considered important for these species, then neither the historic nor the reduced strata surveys are probably optimal.

Based on the assumption that it is the spawning stock biomass being monitored, the results of the simulation indicate that it is possible to reduce the number of strata and stations in each of the four survey areas and still produce biomass trends for the adult populations of the target species that, in the most part, are very similar to those of the original survey. Taking into account past c.v. targets where specified, a combined northern "hotspot" survey of 173 stations (ENLD 49; HAGU 41; BPLN 52; WCNI 31) could be carried out. The total reduction in number of stations is nearly 40% overall and the reduction in survey area is 27%. Given the large area still to be surveyed, the term "hot spot" is perhaps not appropriate, but the analysis has demonstrated scope for reducing costs significantly. Further reductions could be made by reducing the number of stations at the expense of changing the target c.v.s. No national standards for target c.v.s for individual species exist, nor guidelines on what acceptable c.v.s should be, based either on a species life-history (age and growth dynamics) and/or management considerations for different stocks.

How well either the original or a reduced survey tracks the true abundance of the three target species remains in question. The analysis of the commercial landings certainly indicates that catches from within the area covered by the surveys made up a large proportion of the total catch in all cases apart from east Northland tarakihi, and the temporal patterns were also highly correlated. On the basis of consistent length frequencies, biomass estimates and comparisons with fishery-dependent indices, recent reviews and CPUE characterizations also concluded that the previous surveys covered the distribution and adequately sampled the populations, with the exception of tarakihi in the east coast surveys (Hanchet et al. 2000, Hanchet & Field, 2001, Fu et al. 2008, Morrison et al. 2001b & 2001c). The poor sampling of tarakihi on the east coast appears to be a combination of inadequate spatial coverage and possibly timing. In east Northland, the survey coverage is much lower compared to other areas with more than half the commercial catch coming from outside the survey area. In a recent analysis of catch and effort data Kendrick (2009b) noted that whilst historically, most tarakihi has been caught in statistical area 002, more recently, areas 003 and 004 were equally important. It is likely therefore that a significant amount of commercial fishing takes place further offshore in deeper waters not covered by the survey. This species is rarely caught in the Hauraki Gulf surveys due to the shallower depth range of this survey. In the Bay of Plenty, whilst commercial landings from the survey area appear to represent a high proportion of the total landings, the biomass estimates from the survey were low (under 50t), even when additional strata out to 250 m depth were added to target this species in 1996 and 1999. Morrison et al. (2001b) noted that the maximum percentage of commercial catch is taken in about 250 m, so the additional strata may not fully encompass stock boundaries.

The comparison of temporal trends in commercial catches and historical survey timing also indicates a reasonable match for red gurnard and John dory, but a poor match for east coast tarakihi. While the variations in landings most likely reflect a number of factors other than simply changes in abundance and/or availability of the fish, such as vessels changing the species targeted for economic reasons (see Dunn et al. 2000), they are still useful indicators for alternative survey timing. Both red gurnard and John dory are major bycatch species in a number of fisheries (principally snapper and trevally) as well as being targeted themselves. Highest catches were recorded in spring summer, but strong seasonal patterns were not observed in the catch and effort data for the targeted fisheries of either species (Fu et al. 2008, Kendrick, 2009a). Given that these are sedentary (red gurnard) and weak swimmers (John dory), it seems likely that populations are relatively localized. In contrast, tarakihi fisheries are targeted and highly seasonal with greatest catches in summer/late autumn. In the Bay of Plenty, these fisheries coincide with known spawning migrations, reaching the east Cape in February and Motiti Island within the Bay of Plenty in April (Tong & Vooren 1972, Vooren & Tong, 1973). Highest catches for this species also occur around the same time in Northland and on the west coast of the North Island, although evidence for spawning aggregations has not been reported at these sites in the literature. Shifting the timing could improve the ability of the Bay of Plenty and East Northland surveys to sample tarakihi. The surveys should be timed to coincide with the middle of the season to avoid missing any movements in or out of the area, but, as such, will run the risk of problems associated with highly aggregated patterns of occurrence. A late summer/autumn survey does not coincide with highest commercial catches for the other two species. Whilst such a change may not necessarily impact on the overall power of the surveys to sample these species, this cannot be known for sure and the distribution within the area may be markedly different; for example, John dory in the Hauraki Gulf undergo seasonal summer movements into deeper water (Annala et al. 2004).

If a new survey was considered to be the start of a new time series, there is the potential to update the trawl gear used to one more in line with the current fishing industry and potentially more efficient for the new target species. Whilst absolute abundance is not the target, and the biomass estimates for red gurnard and John dory were considered to be consistent and representative of the population (Hanchet et al. 2000, Fu et al. 2008,), length-dependent selectivity may result in smaller size classes being under-sampled (Engås & Godø 1989, Walsh 1992, Munro et al. 1997) and changing trawl design may improve sampling of smaller size classes. The three species present a challenge in terms of their differing morphology, ecology, behaviour and subsequent relative catchabilities in a net. Red gurnard is the most benthic and commercial fishers targeting this species use lower headlines and lower towing speeds. The ground contact in the wings will likely affect the efficiency for this species and the trawl used historically did not have lower wings. Both John dory and tarakihi generally occur just above the seabed. Commercial fishers targeting these species use trawls with higher headlines and faster and/or longer tow durations, not that dissimilar to the original HOBT trawl. Whilst no single net will catch all species optimally, it is likely that a net design more in line with current industry practice could improve efficiency of some or all species or particular size groups and may be more acceptable to the industry. In relation to catchability, the effect of water clarity on net avoidance by tarakihi may be important. This has also been shown to impact on catch rates of larger snapper in the Hauraki Gulf region (Francis & Williams 1995) and is one of the reasons trawl surveys were not considered an optimal method for monitoring adult snapper abundance. Such environmental influences cannot be avoided but should be measured as part of the survey protocol for inclusion as an explanatory variable in any modelled abundance index.

The information presented in this report is given as a guide to the options available, but the final choice will depend on the priorities and cost limitations. Continuation of the historical time series could provide a very powerful tool for tracking the relative biomass trends of species such as red gurnard and John dory. If this is the priority, then the timing of the surveys and the trawl used should remain the same and the reduced strata survey design could be adopted. The key limitation will be the ineffectiveness of the east coast surveys for monitoring tarakihi, as well as reduced ability to sample pre-recruit numbers for all species and less abundant non-target species. If tarakihi is the priority species, then starting a new trawl series, with the timing (and possibly the trawl net design) optimised for this species will likely improve abundance estimates, but may or may not impact on estimates for the other species. This option will not have the benefit of an immediate result (in terms of historical comparison) and will not be able to utilize the optimization analysis, requiring a minimum of 3 years of higher sampling effort before results can be assessed and the design optimized. If pre-recruit biomass is an important consideration, then, again, both survey design and trawl net may need to be reconsidered and exploratory sampling carried out in the first instance. A compromise may be to change the survey design for the Bay of Plenty and east Northland, whilst retaining the historical survey design for the Hauraki Gulf (where tarakihi is not found at the depths sampled) and west coast (which had better catch rates of tarakihi compared to the east coast surveys). The different timing required means that a combined "all-in-one" survey cannot be carried out, but does allow some immediate results in key areas whilst improving the value of problem surveys. Table 13 summarises these options.

Table 12: Summary of North Island survey options.

Option	Advantages	Disadvantages / Difficulties
Retain original trawl survey & employ optimised design	Immediate benefit of long term comparison with historical data.	Historical data may not reflect true abundance.
	Reasonable confidence in abundance estimates for GUR and JDO.	Poor estimates of TAR, on the east coast in particular.
	Reduced cost through optimization & fewer stations.	Reduced power to detect changes in abundance and length frequency.
	Trawl net suited for rougher areas	Rebuild of original trawl may pose difficulties and will require gear trials & catchability issues remain
Modify timing and/or trawl net		Starting a new survey, no historical comparison Optimization may not be applicable – will require high effort and cost in first few years.
	Better abundance estimates for TAR	Unknown effect on estimates for GUR and JDO
	Better catchability for some or all species and Industry confidence	Will require extensive gear trials
Modify some surveys and retain others	This will allow surveys to be optimized to the important species in each area – e.g., TAR in Bay of Plenty	Effort and cost will be high in areas where a new survey started
	Will gain immediate benefit in areas left unchanged – e.g., Hauraki Gulf	Timing likely to be spread throughout the year so surveys cannot be combined .

The original northern trawl surveys were terminated on the premise that, at the time, the cost of doing them outweighed the relative value of the data gained. Whilst catch sampling and CPUE analyses are far cheaper and easier to collect, such fishery-dependent data are potentially vulnerable to bias (Doubleday & Rivard 1981, Hilborn & Walters 1992) and need to be interpreted with great care and a good understanding of the fishery dynamics (Dunn et al. 2000). Whilst more costly to collect and often with lower precision, fishery-independent indices are considered less vulnerable to bias and, worldwide, there is an increasing reliance on such data to provide both relative and absolute (e.g., Reid et al. 2007) abundance indices for tuning stock assessments (e.g., Beare et al. 2005, Mesnil et al. 2009). Trawl surveys also provide an opportunity to collect additional biological data on maturity, fecundity, condition, length-weight relationships etc, all of which may change over time and reflect the overall health of the populations sampled (e.g. Rätz & Lloret 2003, Sandeman et al. 2008). In addition, with a move towards ecosystem approaches to management, encompassing biodiversity, climate impacts and the use of ecosystem models such as Ecopath (e.g., Mackinson et al. 2009) and multispecies stock assessment (e.g., Gaichas et al. 2009, Howell & Bogstad 2010 and see ICES 2010 for more examples), the full catch composition of scientific trawl surveys is increasingly being utilized. Such approaches generally require an increase in sampling effort rather than a decrease and whilst there are currently many issues associated with interpreting the data (e.g., Fraser et al. 2007, Trenkel & Cotter 2009), this is the likely future direction in which fisheries management elsewhere is headed.

5. CONCLUSION

The premise that led to the commissioning of this report was that the 1982-2000 RV *Kaharoa* northern trawl survey series provided reasonable John dory, red gurnard and tarakihi abundance indices. The results provide no evidence to dispute this premise for red gurnard and John dory, but suggest that the original trawl surveys were unlikely to have been optimal for tarakihi in their timing, and, to a lesser degree, their spatial stratification. Improved monitoring of John dory and red gurnard could be achieved using the optimized trawl survey programme, providing a valuable comparison with the historical data. However, such a survey is unlikely to effectively monitor tarakihi on the east coast. To achieve improved monitoring for this species, the timing (and possibly spatial extent) of either all or some of the historical surveys could be modified with the hope that such changes do not negatively influence abundance estimation for the other species. Initial surveys (two to three minimum) would require at least as many stations as used in the original series, but it should then be possible to optimise the new survey design. Alternatively, a completely new trawl survey programme could be initiated, with timing, spatial coverage and trawl net designed for the key species in each area, with a view to eventual optimization of the design. The results presented in this report demonstrate the utility of the simulation tool developed and provide some insight as to the likely station number differential between "initial" and "optimised" surveys. Ultimately, the choice for a given species and stock is a management question and will depend on what the trawl survey indices are to be used for, the benefits of increased precision, versus the associated increasing costs in achieving that precision.

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8. APPENDICES

8.1. APPENDIX A: Strata ranking for East Northland surveys for estimated total, adult and juvenile populations

Table A1: Estimated east Northland total biomass calculated with one stratum dropped each time. The dropped stratum is given in the first column.

Stratum	Year	GUR	GUR c.v.	JDO	JDO c.v.	TAR	TAR c.v.
BRB2	1990	39483	0.243137	159928	0.356117	250697	0.224323
BRB2	1993	92428.7	0.280776	273604	0.303603	198854	0.33326
BRB1	1990	39828.1	0.241243	159801	0.356199	248599	0.225992
BRB1	1993	100777	0.259393	279127	0.29788	197896	0.334812
BRB3	1990	35771.6	0.258431	155742	0.364859	164457	0.192685
BRB3	1993	98163.4	0.26579	226996	0.363665	149891	0.361497
BRB4	1990	35978.5	0.240983	95095.7	0.18918	206168	0.270187
BRB4	1993	78227	0.152351	201001	0.095676	93248.5	0.510813
BOI1	1990	40123.7	0.239513	157383	0.361851	251420	0.223685
BOI1	1993	94569.5	0.274884	268329	0.309709	199201	0.332683
BOI2	1990	39967.6	0.240447	160849	0.354227	248738	0.22584
BOI2	1993	97683	0.267448	275736	0.301573	198825	0.333312
KAW2	1990	39187	0.24492	160681	0.354567	251420	0.223685
KAW2	1993	96712.3	0.269862	277396	0.299751	199201	0.332683
KBR1	1990	30761.8	0.304335	127837	0.436236	240045	0.233508
KBR1	1993	95466.7	0.272336	224405	0.367554	199201	0.332683
KAW1	1990	36924.3	0.254067	161186	0.353401	245259	0.22908
KAW1	1993	86314	0.293872	275959	0.301277	199201	0.332683
KBR2	1990	32655.1	0.185201	152513	0.366622	209081	0.249096
KBR2	1993	95647.8	0.266389	268228	0.308973	194976	0.339201
GEB4	1990	39439.2	0.243051	160919	0.353744	231953	0.240902
GEB4	1993	101494	0.257569	281903	0.294984	190250	0.34725
GEB1	1990	38459.9	0.24888	160110	0.355749	231716	0.227322
GEB1	1993	97764.6	0.265881	274946	0.302336	198123	0.334449
GEB2	1990	37000	0.259701	158833	0.358341	249264	0.225454
GEB2	1993	90702.2	0.283635	275888	0.30123	199201	0.332683
REI1	1990	40123.7	0.239513	163491	0.348533	251420	0.223685
REI1	1993	98894.2	0.263029	281364	0.295548	199201	0.332683
REI2	1990	38620.4	0.246837	163491	0.348533	251420	0.223685
REI2	1993	100911	0.258992	281146	0.295766	199201	0.332683
GEB3	1990	37531.3	0.25569	154508	0.368031	239647	0.23395
GEB3	1993	96653.1	0.270312	262522	0.315241	171546	0.351071

Table A2: estimated adult biomasses calculated with one stratum dropped each time. The dropped stratum is given in the first column.

Stratum	Year	GUR	GUR c.v.	JDO	JDO c.v.	TAR	TAR c.v.
BRB2	1990	39447.4	0.243348	159087	0.358214	250697	0.224323
BRB2	1993	92270.1	0.281215	273571	0.303641	198854	0.33326
BRB1	1990	39792.5	0.241451	158773	0.358689	248599	0.225992
BRB1	1993	100665	0.25965	279094	0.297916	197896	0.334812
BRB3	1990	35735.9	0.258679	155554	0.365266	164457	0.192685
BRB3	1993	97991.1	0.266222	226963	0.363719	149891	0.361497
BRB4	1990	35942.8	0.241211	94067.1	0.19222	206168	0.270187
BRB4	1993	78054.8	0.152591	200967	0.095696	93248.5	0.510813
BOI1	1990	40088	0.239717	156354	0.364416	251420	0.223685
BOI1	1993	94452.6	0.275227	268329	0.309709	199201	0.332683
BOI2	1990	39931.9	0.240653	159820	0.356688	248738	0.22584
BOI2	1993	97516.5	0.26787	275703	0.30161	198825	0.333312
KAW2	1990	39151.3	0.245135	159653	0.357033	251420	0.223685
KAW2	1993	96540	0.270308	277363	0.299788	199201	0.332683
KBR1	1990	30726.1	0.304676	126809	0.440007	240045	0.233508
KBR1	1993	95294.4	0.272792	224372	0.36761	199201	0.332683
KAW1	1990	36888.6	0.254303	160157	0.355851	245259	0.22908
KAW1	1993	86179.1	0.294291	275926	0.301314	199201	0.332683
KBR2	1990	32619.5	0.185387	151484	0.369306	209081	0.249096
KBR2	1993	95475.5	0.266833	268195	0.309012	194976	0.339201
GEB4	1990	39403.5	0.243262	159890	0.3562	231953	0.240902
GEB4	1993	101322	0.257973	281870	0.29502	190250	0.34725
GEB1	1990	38424.2	0.249102	159081	0.358231	231716	0.227322
GEB1	1993	97592.3	0.266316	274913	0.302373	198123	0.334449
GEB2	1990	37000	0.259701	157805	0.36086	249264	0.225454
GEB2	1993	90529.9	0.284136	275855	0.301267	199201	0.332683
REI1	1990	40088	0.239717	162463	0.350918	251420	0.223685
REI1	1993	98722	0.263453	281331	0.295584	199201	0.332683
REI2	1990	38584.7	0.247056	162463	0.350918	251420	0.223685
REI2	1993	100739	0.259401	281113	0.295802	199201	0.332683
GEB3	1990	37495.6	0.255924	153480	0.370687	239647	0.23395
GEB3	1993	96480.9	0.270759	262489	0.315281	171546	0.351071

Table A3: Rankings of strata in the ENLD survey for adult, all and juvenile portions of the population. Strata retained in the selected reduced strata survey are in bold.

	GUR	JDO	TAR	rank	stratum	no
Adult	**GUR**	**JDO**	**TAR**	**rank**	**stratum**	**no**
	16	**16**	**16**	**48.0**	**BRB4**	**1**
	12	**14**	**10**	**34.0**	**KBR1**	**2**
	10	**11**	**14**	**32.9**	**KBR2**	**3**
	7	**15**	**15**	**32.4**	**BRB3**	**4**
	8	**13**	**13**	**31.1**	**GEB3**	**5**
	15	**7**	**9**	**26.8**	**KAW1**	**6**
	13	**10**	**5**	**24.0**	**BRB2**	**7**
	5	**9**	**12**	**22.5**	**GEB1**	**8**
	14	**6**	**6**	**21.4**	**GEB2**	**9**
	6	8	8	20.8	BOI2	10
	11	12	2.5	20.3	BOI1	11
	9	5	2.5	13.2	KAW2	12
	2	3	11	11.1	GEB4	13
	1	4	7	9.0	BRB1	14
	3	2	2.5	7.0	REI2	15
	4	1	2.5	6.0	REI1	16
Total	**GUR**	**JDO**	**TAR**	**rank**	**stratum**	**no**
	16	**16**	**16**	**48.0**	**BRB4**	**1**
	12	**14**	**10**	**34.0**	**KBR1**	**2**
	10	**11**	**14**	**32.9**	**KBR2**	**3**
	8	**13**	**13**	**31.1**	**GEB3**	**4**
	6	**15**	**15**	**30.8**	**BRB3**	**5**
	15	**7**	**9**	**26.8**	**KAW1**	**6**
	13	**10**	**5**	**24.0**	**BRB2**	**7**
	5	**9**	**12**	**22.5**	**GEB1**	**8**
	7	**8**	**8**	**22.4**	**BOI2**	**9**
	14	**6**	**6**	**21.4**	**GEB2**	**10**
	11	12	2.5	20.3	BOI1	11
	9	5	2.5	13.2	KAW2	12
	2	3	11	11.1	GEB4	13
	1	4	7	9.0	BRB1	14
	3	2	2.5	7.0	REI2	15
	4	1	2.5	6.0	REI1	16
Juvenile	**GUR**	**JDO**	**TAR**	**rank**	**stratum**	**no**
	15	14	8.5	34.0	BOI1	1
	12	15	8.5	32.2	BRB2	2
	16	7	8.5	26.7	BRB1	3
	14	7	8.5	25.8	KAW1	4
	13	7	8.5	25.4	GEB2	5
	5.5	16	8.5	24.6	BRB3	6
	11	7	8.5	24.5	BOI2	7
	5.5	7	8.5	19.5	BRB4	8
	5.5	7	8.5	19.5	GEB1	9
	5.5	7	8.5	19.5	GEB3	10
	5.5	7	8.5	19.5	GEB4	11
	5.5	7	8.5	19.5	KAW2	12
	5.5	7	8.5	19.5	KBR1	13
	5.5	7	8.5	19.5	KBR2	14
	5.5	7	8.5	19.5	REI1	15
	5.5	7	8.5	19.5	REI2	16

8.2. APPENDIX B: Strata ranking for Hauraki Gulf survey for estimated total, adult and juvenile populations

Table B1: Estimated Hauraki Gulf total biomass calculated with one stratum dropped each time. The dropped stratum is given in the first column.

Stratum	Year	GUR	GUR c.v.	JDO	JDO c.v.	TAR	TAR c.v.
c1149	2000	21646.6	0.489811	223785	0.271299	726952	0.873526
c1149	1982	267032	0.146839	151095	0.135427	7924.95	0.699595
c1149	1984	444479	0.135174	164816	0.215227	23156.1	0.45306
c1149	1985	30370.7	0.372237	200805	0.186786	44869.7	0.481242
c1149	1986	256506	0.266361	164403	0.194266	1476.43	1
c1149	1987	573050	0.181591	243718	0.204527	19979.1	1
c1149	1988	634222	0.16845	304100	0.257857	112282	0.483109
c1149	1989	109409	0.242122	252856	0.198628	76172.1	0.514276
c1149	1990	119514	0.153377	259356	0.134394	37766.5	0.708308
c1149	1992	281705	0.084889	183104	0.353984	179765	0.393799
c1149	1993	157386	0.162139	310056	0.254368	96445.7	0.718633
c1149	1994	205091	0.188424	250091	0.183963	136461	0.607421
c1149	1997	215766	0.135224	325040	0.175349	242716	0.549516
c1268	2000	19883.8	0.527777	203244	0.297682	726952	0.873526
c1268	1982	263042	0.148821	142540	0.141363	7924.95	0.699595
c1268	1984	436176	0.136995	130665	0.24425	23156.1	0.45306
c1268	1985	30115	0.375354	181814	0.20386	44869.7	0.481242
c1268	1986	251520	0.271563	145467	0.215399	1476.43	1
c1268	1987	566009	0.183777	227682	0.216878	19979.1	1
c1268	1988	625811	0.170668	294628	0.265968	112282	0.483109
c1268	1989	106195	0.249092	212654	0.201576	76172.1	0.514276
c1268	1990	117549	0.155727	246250	0.140067	37766.5	0.708308
c1268	1992	277074	0.086101	178196	0.36384	179765	0.393799
c1268	1993	155180	0.164378	275659	0.273145	96445.7	0.718633
c1268	1994	200457	0.192567	229301	0.193979	136461	0.607421
c1268	1997	211970	0.137344	272249	0.143586	242716	0.549516
c1887	2000	21264.3	0.498293	208956	0.290418	726952	0.873526
c1887	1982	267032	0.146839	151095	0.135427	7924.95	0.699595
c1887	1984	444479	0.135174	164816	0.215227	23156.1	0.45306
c1887	1985	29836.6	0.378805	200349	0.187133	44869.7	0.481242
c1887	1986	255672	0.267225	161008	0.197903	1476.43	1
c1887	1987	569815	0.18254	240218	0.207306	19979.1	1
c1887	1988	631893	0.169067	290204	0.269357	112282	0.483109
c1887	1989	106634	0.248152	245081	0.204605	76172.1	0.514276
c1887	1990	118829	0.154217	258759	0.134499	37766.5	0.708308
c1887	1992	280797	0.085159	187235	0.346302	179765	0.393799
c1887	1993	156652	0.162887	308225	0.25581	96445.7	0.718633
c1887	1994	199768	0.193384	245898	0.18692	136461	0.607421
c1887	1997	214549	0.135995	285784	0.198081	242716	0.549516
c9292	2000	21594.3	0.490991	225260	0.269496	726952	0.873526
c9292	1982	265626	0.147592	151095	0.135427	7924.95	0.699595
c9292	1984	440678	0.136216	164628	0.215469	23156.1	0.45306
c9292	1985	30209.5	0.374209	202112	0.185587	44869.7	0.481242
c9292	1986	256059	0.266812	165711	0.192725	1476.43	1
c9292	1987	560315	0.185722	245830	0.202788	19979.1	1

Stratum	Year	GUR	GUR c.v.	JDO	JDO c.v.	TAR	TAR c.v.
c9292	1988	635033	0.168236	308712	0.254031	112282	0.483109
c9292	1989	109696	0.24149	254644	0.197241	76172.1	0.514276
c9292	1990	119434	0.153478	256965	0.135649	37766.5	0.708308
c9292	1992	280915	0.085139	187908	0.345159	179765	0.393799
c9292	1993	156857	0.162676	314039	0.251287	96445.7	0.718633
c9292	1994	202872	0.190483	250675	0.183549	136461	0.607421
c9292	1997	216286	0.134905	323641	0.175726	242716	0.549516
c1219	2000	14951.7	0.573365	217812	0.278603	726952	0.873526
c1219	1982	198222	0.179288	143482	0.141412	7924.95	0.699595
c1219	1984	365137	0.156246	138901	0.242449	23156.1	0.45306
c1219	1985	28400.9	0.391965	188330	0.1966	44869.7	0.481242
c1219	1986	184223	0.348797	158360	0.200507	1476.43	1
c1219	1987	562736	0.183647	238187	0.206439	19979.1	1
c1219	1988	596294	0.178496	292694	0.267476	112282	0.483109
c1219	1989	99497.8	0.261105	203358	0.240546	76172.1	0.514276
c1219	1990	117053	0.156282	231566	0.12833	37766.5	0.708308
c1219	1992	235680	0.089625	181411	0.356509	179765	0.393799
c1219	1993	137371	0.185273	295003	0.265922	96445.7	0.718633
c1219	1994	156501	0.236515	206647	0.218205	136461	0.607421
c1219	1997	196408	0.142264	301695	0.185661	242716	0.549516
c2229	2000	18266.4	0.565671	213172	0.284526	726952	0.873526
c2229	1982	251576	0.154316	136989	0.147986	7924.95	0.699595
c2229	1984	424113	0.139347	164816	0.215227	23156.1	0.45306
c2229	1985	30337.5	0.372643	174677	0.206468	44869.7	0.481242
c2229	1986	249393	0.273744	147017	0.211768	1476.43	1
c2229	1987	551184	0.188243	218935	0.226664	19979.1	1
c2229	1988	622219	0.171488	289900	0.270222	112282	0.483109
c2229	1989	105774	0.249482	241368	0.207825	76172.1	0.514276
c2229	1990	117441	0.155701	229116	0.147247	37766.5	0.708308
c2229	1992	276767	0.086068	138202	0.334937	179765	0.393799
c2229	1993	153098	0.166163	283002	0.276919	96445.7	0.718633
c2229	1994	201187	0.191559	235797	0.194192	136461	0.607421
c2229	1997	206827	0.136325	317010	0.179363	242716	0.549516
c1386	2000	21646.6	0.489811	225184	0.269538	726952	0.873526
c1386	1982	266236	0.147261	142809	0.139515	7924.95	0.699595
c1386	1984	444479	0.135174	164461	0.215679	23156.1	0.45306
c1386	1985	30190.2	0.374415	200457	0.187106	44869.7	0.481242
c1386	1986	256597	0.266266	163492	0.195332	1476.43	1
c1386	1987	574260	0.181211	243112	0.205026	19979.1	1
c1386	1988	633747	0.168576	306383	0.255954	112282	0.483109
c1386	1989	109558	0.241794	251571	0.199623	76172.1	0.514276
c1386	1990	119497	0.153397	260667	0.133719	37766.5	0.708308
c1386	1992	281857	0.084864	184824	0.350905	179765	0.393799
c1386	1993	157386	0.162139	306825	0.256998	96445.7	0.718633
c1386	1994	204780	0.188709	244969	0.187591	136461	0.607421
c1386	1997	216049	0.135054	321506	0.177177	242716	0.549516
c1518	2000	21646.6	0.489811	164489	0.277944	650467	0.971008
c1518	1982	218107	0.151034	104411	0.154305	0	0
c1518	1984	338373	0.131866	126204	0.214634	13380.8	0.683152
c1518	1985	19960.2	0.509541	128159	0.126782	0	0
c1518	1986	188032	0.204712	98560.7	0.131425	1476.43	1
c1518	1987	548238	0.188726	165044	0.263324	0	0
c1518	1988	495065	0.16832	208243	0.243966	923.81	1

Stratum	Year	GUR	GUR c.v.	JDO	JDO c.v.	TAR	TAR c.v.
c1518	1989	75922	0.305829	188445	0.19598	0	0
c1518	1990	84923.1	0.176715	149307	0.192361	24175.7	0.953048
c1518	1992	246072	0.076545	146374	0.325453	28480.2	0.908148
c1518	1993	122472	0.145971	276328	0.277667	29865.2	0.644758
c1518	1994	178445	0.203763	197083	0.133645	72090.3	0.956658
c1518	1997	191694	0.146678	252472	0.191824	35961.4	0.469917
c4492	2000	12272.6	0.558712	137346	0.294984	76484.5	0.858335
c4492	1982	185774	0.188179	106952	0.139701	7924.95	0.699595
c4492	1984	287867	0.166985	101438	0.294091	9775.29	0.526647
c4492	1985	13600.5	0.391743	155558	0.234269	44869.7	0.481242
c4492	1986	169260	0.363353	130140	0.238125	0	0
c4492	1987	193619	0.138812	158866	0.173121	19979.1	1
c4492	1988	339030	0.207899	184390	0.32853	112282	0.483109
c4492	1989	64932.5	0.255831	194947	0.229267	76172.1	0.514276
c4492	1990	61105	0.191439	206331	0.139844	13590.8	1
c4492	1992	140295	0.14189	147294	0.432606	151284	0.435584
c4492	1993	72954.3	0.253637	174553	0.18954	66580.5	1
c4492	1994	122007	0.197707	173264	0.237384	64370.5	0.714333
c4492	1997	105283	0.218957	245527	0.218265	206754	0.639896
c1449	2000	21646.6	0.489811	225486	0.269237	726952	0.873526
c1449	1982	223483	0.146942	142376	0.141133	7924.95	0.699595
c1449	1984	375388	0.156163	164816	0.215227	23156.1	0.45306
c1449	1985	30370.7	0.372237	200987	0.186595	44869.7	0.481242
c1449	1986	245525	0.276903	165218	0.193228	1476.43	1
c1449	1987	479421	0.213377	239543	0.207419	19979.1	1
c1449	1988	503952	0.208466	304738	0.257232	111358	0.487046
c1449	1989	100393	0.248873	251458	0.199486	76172.1	0.514276
c1449	1990	100608	0.176157	258265	0.13484	37766.5	0.708308
c1449	1992	243357	0.094459	186922	0.346966	179765	0.393799
c1449	1993	148014	0.172068	309160	0.255237	96445.7	0.718633
c1449	1994	179694	0.194348	244034	0.188182	136461	0.607421
c1449	1997	175328	0.129126	319042	0.178261	242716	0.549516
c1284	2000	21646.6	0.489811	224347	0.27058	726952	0.873526
c1284	1982	264187	0.14842	138103	0.148167	7924.95	0.699595
c1284	1984	443621	0.135433	162596	0.218055	23156.1	0.45306
c1284	1985	30315.4	0.372912	197714	0.189401	44869.7	0.481242
c1284	1986	255863	0.267024	163845	0.194917	1476.43	1
c1284	1987	570749	0.182308	242800	0.205301	19979.1	1
c1284	1988	633059	0.168759	303128	0.2585	112282	0.483109
c1284	1989	108949	0.243133	250056	0.200778	76172.1	0.514276
c1284	1990	119328	0.153613	260113	0.134005	37766.5	0.708308
c1284	1992	279240	0.085616	182517	0.354753	179765	0.393799
c1284	1993	156487	0.163055	310515	0.254141	96445.7	0.718633
c1284	1994	202049	0.191192	245981	0.186917	136461	0.607421
c1284	1997	213967	0.136302	314210	0.180135	242716	0.549516

Table B2: Estimated adult biomasses calculated with one stratum dropped each time. Dropped stratum is given in the first column.

Stratum	Year	GUR	GUR c.v.	JDO	JDO c.v.	TAR	TAR c.v.
c1149	2000	21411.3	0.494386	220536	0.272759	726952	0.873526
c1149	1982	256660	0.147299	150194	0.136278	7924.95	0.699595
c1149	1984	432258	0.132589	158709	0.215154	23156.1	0.45306
c1149	1985	30317.3	0.372895	197372	0.189685	44869.7	0.481242
c1149	1986	246625	0.273378	160825	0.197639	1476.43	1
c1149	1987	480251	0.181197	236224	0.206682	19979.1	1
c1149	1988	631850	0.169254	299961	0.26164	112282	0.483109
c1149	1989	109284	0.242396	249332	0.20222	76172.1	0.514276
c1149	1990	119150	0.153744	255426	0.134883	37766.5	0.708308
c1149	1992	280396	0.085175	178591	0.363182	179765	0.393799
c1149	1993	157245	0.162262	301558	0.261571	96118.6	0.721035
c1149	1994	201196	0.190561	238806	0.193045	136194	0.60876
c1149	1997	210996	0.138402	316803	0.176945	242716	0.549516
c1268	2000	19758	0.531016	199882	0.29988	726952	0.873526
c1268	1982	252767	0.149323	141664	0.142266	7924.95	0.699595
c1268	1984	425154	0.134263	124758	0.244184	23156.1	0.45306
c1268	1985	30061.6	0.376023	178370	0.207404	44869.7	0.481242
c1268	1986	242087	0.27843	142162	0.219511	1476.43	1
c1268	1987	474288	0.1834	220259	0.219496	19979.1	1
c1268	1988	623926	0.171357	290576	0.26991	112282	0.483109
c1268	1989	106080	0.249361	209168	0.205987	76172.1	0.514276
c1268	1990	117253	0.156027	242892	0.140407	37766.5	0.708308
c1268	1992	276035	0.086307	174063	0.372733	179765	0.393799
c1268	1993	155052	0.164491	267397	0.281676	96118.6	0.721035
c1268	1994	196796	0.194601	218120	0.204401	136194	0.60876
c1268	1997	208417	0.139913	264001	0.142837	242716	0.549516
c1887	2000	21132.4	0.500737	205726	0.292253	726952	0.873526
c1887	1982	256660	0.147299	150194	0.136278	7924.95	0.699595
c1887	1984	432258	0.132589	158709	0.215154	23156.1	0.45306
c1887	1985	29803.4	0.379225	196999	0.18996	44869.7	0.481242
c1887	1986	245837	0.27425	157490	0.201369	1476.43	1
c1887	1987	477176	0.182255	233054	0.20931	19979.1	1
c1887	1988	629617	0.169849	286531	0.273056	112282	0.483109
c1887	1989	106504	0.248451	241600	0.208379	76172.1	0.514276
c1887	1990	118609	0.154416	254959	0.134934	37766.5	0.708308
c1887	1992	279769	0.08536	182816	0.354926	179765	0.393799
c1887	1993	156576	0.162944	299795	0.263046	96118.6	0.721035
c1887	1994	197647	0.193922	234883	0.196087	136194	0.60876
c1887	1997	210749	0.138567	277768	0.200377	242716	0.549516
c9292	2000	21359	0.49559	221897	0.271058	726952	0.873526
c9292	1982	255296	0.148057	150194	0.136278	7924.95	0.699595
c9292	1984	428469	0.133628	158521	0.215405	23156.1	0.45306
c9292	1985	30156.1	0.374873	198693	0.188434	44869.7	0.481242
c9292	1986	246176	0.273863	162088	0.19609	1476.43	1
c9292	1987	467445	0.186166	238247	0.204945	19979.1	1
c9292	1988	632654	0.16904	304558	0.257717	112282	0.483109
c9292	1989	109553	0.241804	251086	0.200815	76172.1	0.514276
c9292	1990	119070	0.153846	253024	0.136168	37766.5	0.708308
c9292	1992	279572	0.085433	183414	0.353862	179765	0.393799
c9292	1993	156716	0.1628	305525	0.258322	96118.6	0.721035
c9292	1994	199061	0.192602	239343	0.192623	136194	0.60876

Stratum	Year	GUR	GUR c.v.	JDO	JDO c.v.	TAR	TAR c.v.
c9292	1997	211445	0.138113	315393	0.177338	242716	0.549516
c1219	2000	14716.4	0.581079	215079	0.279582	726952	0.873526
c1219	1982	191927	0.179794	142698	0.142226	7924.95	0.699595
c1219	1984	355548	0.153486	134332	0.24231	23156.1	0.45306
c1219	1985	28347.5	0.392706	185633	0.199466	44869.7	0.481242
c1219	1986	177230	0.357296	155960	0.202897	1476.43	1
c1219	1987	477007	0.182125	232164	0.208358	19979.1	1
c1219	1988	594299	0.179305	290266	0.270103	112282	0.483109
c1219	1989	99354.5	0.261479	201322	0.243891	76172.1	0.514276
c1219	1990	116689	0.156666	228132	0.128198	37766.5	0.708308
c1219	1992	234342	0.08993	177237	0.365127	179765	0.393799
c1219	1993	137230	0.185438	287570	0.272905	96118.6	0.721035
c1219	1994	153378	0.23941	198103	0.228099	136194	0.60876
c1219	1997	191955	0.145466	293903	0.187431	242716	0.549516
c2229	2000	18053.5	0.571312	210403	0.285594	726952	0.873526
c2229	1982	242518	0.154709	136095	0.149005	7924.95	0.699595
c2229	1984	412128	0.136627	158709	0.215154	23156.1	0.45306
c2229	1985	30317.3	0.372895	171813	0.210355	44869.7	0.481242
c2229	1986	239668	0.281101	143637	0.215564	1476.43	1
c2229	1987	460763	0.188223	211606	0.229682	19979.1	1
c2229	1988	620361	0.172162	285747	0.274386	112282	0.483109
c2229	1989	105708	0.249636	237942	0.211645	76172.1	0.514276
c2229	1990	117078	0.156081	225355	0.14787	37766.5	0.708308
c2229	1992	275429	0.086377	133689	0.346715	179765	0.393799
c2229	1993	152957	0.166293	275923	0.283955	96118.6	0.721035
c2229	1994	197415	0.193745	225115	0.203901	136194	0.60876
c2229	1997	202279	0.139901	309764	0.180543	242716	0.549516
c1386	2000	21411.3	0.494386	221821	0.2711	726952	0.873526
c1386	1982	255865	0.147739	141909	0.140443	7924.95	0.699595
c1386	1984	432258	0.132589	158377	0.215594	23156.1	0.45306
c1386	1985	30136.7	0.375081	197013	0.190026	44869.7	0.481242
c1386	1986	246737	0.273254	159925	0.198733	1476.43	1
c1386	1987	481474	0.180741	235564	0.20725	19979.1	1
c1386	1988	631377	0.16938	302246	0.25968	112282	0.483109
c1386	1989	109414	0.242108	248034	0.203257	76172.1	0.514276
c1386	1990	119134	0.153765	256727	0.134201	37766.5	0.708308
c1386	1992	280470	0.08517	180336	0.359887	179765	0.393799
c1386	1993	157245	0.162262	298577	0.264129	96118.6	0.721035
c1386	1994	200861	0.190877	233694	0.197045	136194	0.60876
c1386	1997	211195	0.138277	313329	0.178803	242716	0.549516
c1518	2000	21411.3	0.494386	162042	0.282116	650467	0.971008
c1518	1982	207942	0.150955	103665	0.1558	0	0
c1518	1984	329888	0.132035	120667	0.212289	13380.8	0.683152
c1518	1985	19906.8	0.510911	126408	0.124897	0	0
c1518	1986	178149	0.206957	94923	0.132444	1476.43	1
c1518	1987	455368	0.189536	157917	0.267313	0	0
c1518	1988	492686	0.169414	204089	0.249441	923.81	1
c1518	1989	75778.7	0.306403	184887	0.201188	0	0
c1518	1990	84559.7	0.177301	146018	0.194785	24175.7	0.953048
c1518	1992	244664	0.076819	141861	0.336239	28480.2	0.908148
c1518	1993	122331	0.146098	268423	0.286178	29538.1	0.651382
c1518	1994	174473	0.206549	185732	0.142677	71823.9	0.96055
c1518	1997	186840	0.150628	247584	0.195563	35961.4	0.469917

Stratum	Year	GUR	GUR c.v.	JDO	JDO c.v.	TAR	TAR c.v.
c4492	2000	12037.3	0.567411	134867	0.294112	76484.5	0.858335
c4492	1982	179712	0.189839	106650	0.139795	7924.95	0.699595
c4492	1984	278204	0.161604	99108.8	0.295152	9775.29	0.526647
c4492	1985	13547.1	0.393297	152357	0.238614	44869.7	0.481242
c4492	1986	165425	0.371523	127991	0.241621	0	0
c4492	1987	175735	0.131983	155766	0.174407	19979.1	1
c4492	1988	337453	0.208855	181925	0.332619	112282	0.483109
c4492	1989	64789.3	0.256391	192938	0.23174	76172.1	0.514276
c4492	1990	60741.6	0.192275	204068	0.140185	13590.8	1
c4492	1992	139013	0.14292	146246	0.435742	151284	0.435584
c4492	1993	72813.6	0.254061	170578	0.192762	66580.5	1
c4492	1994	118394	0.203235	167536	0.244918	64370.5	0.714333
c4492	1997	101402	0.229487	239941	0.219133	206754	0.639896
c1449	2000	21411.3	0.494386	222206	0.270695	726952	0.873526
c1449	1982	213439	0.146294	141475	0.142073	7924.95	0.699595
c1449	1984	365017	0.152657	158709	0.215154	23156.1	0.45306
c1449	1985	30317.3	0.372895	197543	0.189498	44869.7	0.481242
c1449	1986	235890	0.284409	161580	0.196632	1476.43	1
c1449	1987	393233	0.216595	232043	0.209686	19979.1	1
c1449	1988	501618	0.209646	300664	0.260945	111358	0.487046
c1449	1989	100249	0.249226	248015	0.203068	76172.1	0.514276
c1449	1990	100397	0.1765	254499	0.135255	37766.5	0.708308
c1449	1992	242101	0.094978	182599	0.355426	179765	0.393799
c1449	1993	147930	0.172164	300754	0.262397	96118.6	0.721035
c1449	1994	175722	0.196824	234195	0.196709	136194	0.60876
c1449	1997	171131	0.130763	311221	0.179675	242716	0.549516
c1284	2000	21411.3	0.494386	220997	0.272148	726952	0.873526
c1284	1982	253816	0.14895	137202	0.149182	7924.95	0.699595
c1284	1984	431400	0.13285	156489	0.218088	23156.1	0.45306
c1284	1985	30261.9	0.373572	194324	0.192351	44869.7	0.481242
c1284	1986	245994	0.274073	160262	0.198322	1476.43	1
c1284	1987	477954	0.182048	235267	0.207523	19979.1	1
c1284	1988	630695	0.169563	299018	0.262282	112282	0.483109
c1284	1989	108811	0.243439	246537	0.204439	76172.1	0.514276
c1284	1990	118965	0.153981	256190	0.134483	37766.5	0.708308
c1284	1992	277885	0.085919	178004	0.364	179765	0.393799
c1284	1993	156353	0.163172	302126	0.261231	96118.6	0.721035
c1284	1994	198185	0.193387	234704	0.196291	136194	0.60876
c1284	1997	209183	0.139541	305990	0.181895	242716	0.549516

Table B3: Rankings of strata in the Hauraki Gulf survey for adult, total and juvenile portions of the population. Strata retained in the selected reduced strata survey are in bold.

Adult	**GUR**	**JDO**	**TAR**	**rank**	**stratum**	**no**
	11	**11**	**11**	**33.0**	**c4492**	**1**
	10	**10**	**10**	**30.0**	**c1518**	**2**
	9	**4**	**9**	**19.1**	**c1449**	**3**
	8	**7**	**4.5**	**17.7**	**c1219**	**4**
	7	**8**	**4.5**	**17.7**	**c2229**	**5**
	6	9	4.5	17.2	c1268	6
	4	6	4.5	13.5	c1887	7
	3	5	4.5	11.5	c1284	8
	5	1	4.5	8.3	c9292	9
	2	2	4.5	7.1	c1149	10
	1	3	4.5	6.7	c1386	11
All	**GUR**	**JDO**	**TAR**	**rank**	**stratum**	**no**
	11	**11**	**11**	**33.0**	**c4492**	**1**
	10	**10**	**10**	**30.0**	**c1518**	**2**
	9	**4**	**9**	**19.1**	**c1449**	**3**
	8	**8**	**4.5**	**18.5**	**c1219**	**4**
	6	**9**	**4.5**	**17.2**	**c1268**	**5**
	7	**7**	**4.5**	**17.1**	**c2229**	**6**
	4	6	4.5	13.5	c1887	7
	3	5	4.5	11.5	c1284	8
	5	1	4.5	8.3	c9292	9
	2	2	4.5	7.1	c1149	10
	1	3	4.5	6.7	c1386	11
Juvenile	**GUR**	**JDO**	**TAR**	**rank**	**stratum**	**no**
	11	11	11	33.0	c4492	1
	10	10	5.5	22.9	c1219	2
	8	9	5.5	20.7	c1518	3
	9	7	5.5	19.7	c1449	4
	7	8	5.5	19.2	c2229	5
	6	6	5.5	17.2	c1268	6
	5	5	5.5	15.2	c1887	7
	3	2	5.5	8.7	c1149	8
	2	3	5.5	8.7	c1284	9
	1	4	5.5	8.2	c1386	10
	4	1	5.5	8.2	c9292	11

8.3. APPENDIX C: Strata ranking for the Bay of Plenty survey for estimated total, adult and juvenile populations.

Table C1: Estimated total biomasses calculated with one stratum dropped each time. The dropped stratum is given in the first column

Stratum	Year	GUR	GUR c.v.	JDO	JDO c.v.	TAR	TAR c.v.
c808CNE	1983	303948	0.148771	101186	0.196229	6090.62	0.461803
c808CNE	1985	29494.2	0.144255	91949.1	0.146984	17561.3	0.097797
c808CNE	1990	356307	0.123774	126083	0.174245	12651.4	0.657893
c808CNE	1992	235095	0.092762	194417	0.153494	90845.7	0.31331
c808CNE	1996	259572	0.153809	169739	0.345705	29606.6	0.459289
c808CNE	1999	315665	0.138874	160478	0.144592	36639.9	0.330594
c7085	1983	253114	0.16817	44569.2	0.21844	3854.41	0.47607
c7085	1985	30091	0.199606	42461	0.145751	150774	0.888432
c7085	1990	267478	0.136365	90968.7	0.180911	10760.8	0.753261
c7085	1992	169311	0.103649	88451.1	0.121652	88445.8	0.307656
c7085	1996	199836	0.163168	74379.3	0.224098	23066.8	0.373065
c7085	1999	216924	0.168148	69472.1	0.240326	38442.5	0.279129
c1096/2096	1983	227095	0.117666	101464	0.202185	6384.87	0.442925
c1096/2096	1985	33353.9	0.188324	102229	0.133004	151505	0.88416
c1096/2096	1990	304849	0.139488	137618	0.174882	12651.4	0.657893
c1096/2096	1992	216600	0.103872	189698	0.15744	103393	0.288119
c1096/2096	1996	234245	0.168256	164843	0.355404	30490.1	0.438557
c1096/2096	1999	302355	0.144173	169251	0.134856	48052.5	0.282027
c5187/5287	1983	242858	0.175446	99020	0.206464	5734.75	0.47993
c5187/5287	1985	34313.2	0.181833	103110	0.13232	151505	0.88416
c5187/5287	1990	254845	0.126378	130087	0.17484	9246.42	0.82139
c5187/5287	1992	195350	0.107853	168303	0.170326	81982.6	0.319594
c5187/5287	1996	221882	0.174607	167863	0.349506	33638.4	0.409711
c5187/5287	1999	285698	0.138396	172177	0.13782	48052.5	0.282027
c6085	1983	281643	0.159377	99206.2	0.203328	3474.82	0.652441
c6085	1985	36807.3	0.169838	99331	0.126812	149118	0.898252
c6085	1990	304729	0.13695	129331	0.174667	5295.51	0.735453
c6085	1992	206893	0.09898	172774	0.172577	61989.9	0.389018
c6085	1996	212594	0.142657	145800	0.388653	33833.8	0.407385
c6085	1999	286929	0.1381	156806	0.124911	44604.6	0.303535
c4085	1983	243949	0.179768	110240	0.188686	6384.87	0.442925
c4085	1985	40099.2	0.162798	109465	0.12512	151505	0.88416
c4085	1990	328401	0.131522	146030	0.165474	12651.4	0.657893
c4085	1992	202880	0.107233	199720	0.150299	90325.7	0.299331
c4085	1996	223077	0.17579	175248	0.33496	33833.8	0.407385
c4085	1999	322401	0.131095	172974	0.133666	48052.5	0.282027
c909CNE	1983	310522	0.146336	111137	0.187337	6384.87	0.442925
c909CNE	1985	40831.8	0.160319	109709	0.124861	137061	0.977335
c909CNE	1990	363322	0.121404	152024	0.159621	12651.4	0.657893
c909CNE	1992	245226	0.093459	202672	0.148189	103396	0.288108
c909CNE	1996	269516	0.149966	179061	0.328037	18533.3	0.620441
c909CNE	1999	339029	0.131601	177140	0.133525	24470.5	0.420352

Table C2: Estimated adult biomasses calculated with one stratum dropped each time. The dropped stratum is given in the first column.

Stratum	Year	GUR	GUR c.v.	JDO	JDO c.v.	TAR	TAR c.v.
c808CNE	1983	298356	0.150399	101186	0.196229	5170.7	0.528225
c808CNE	1985	29356.4	0.144975	91945.3	0.146991	17508.8	0.097869
c808CNE	1990	343051	0.119173	126076	0.174252	12351	0.656206
c808CNE	1992	233986	0.092997	193814	0.153487	90596.1	0.314378
c808CNE	1996	257021	0.154545	169739	0.345705	29162.7	0.456276
c808CNE	1999	313316	0.13907	160416	0.144624	36639.9	0.330594
c7085	1983	247651	0.170532	44569.2	0.21844	3013.81	0.555987
c7085	1985	30019.3	0.200073	42457.1	0.145767	150722	0.888741
c7085	1990	254629	0.127664	90961.4	0.180919	10460.5	0.75343
c7085	1992	168202	0.103978	88059.6	0.122661	88196.3	0.308746
c7085	1996	197551	0.16465	74379.3	0.224098	22914.5	0.375633
c7085	1999	214994	0.168468	69409.9	0.240464	36929.7	0.288841
c1096/2096	1983	224856	0.116734	101464	0.202185	5170.7	0.528225
c1096/2096	1985	33249.3	0.188985	102229	0.133004	151452	0.884467
c1096/2096	1990	292968	0.13397	137618	0.174882	12351	0.656206
c1096/2096	1992	215850	0.104066	189095	0.157446	103147	0.288977
c1096/2096	1996	232169	0.168968	164843	0.355404	29968.1	0.436368
c1096/2096	1999	301050	0.144134	169251	0.134856	46539.7	0.290113
c5187/5287	1983	238096	0.177939	99020	0.206464	4520.59	0.586825
c5187/5287	1985	34214.1	0.182353	103106	0.132326	151452	0.884467
c5187/5287	1990	250295	0.127132	130080	0.174846	9044.75	0.818129
c5187/5287	1992	194383	0.108167	167700	0.170356	81733.1	0.320816
c5187/5287	1996	219549	0.17558	167863	0.349506	33190.5	0.406661
c5187/5287	1999	283493	0.138415	172115	0.137848	46539.7	0.290113
c6085	1983	276401	0.161196	99206.2	0.203328	2807.01	0.802541
c6085	1985	36669.6	0.1705	99327.2	0.126818	149118	0.898252
c6085	1990	291992	0.131607	129323	0.174673	5196.86	0.732875
c6085	1992	205847	0.09926	172563	0.172157	61973.3	0.389015
c6085	1996	210043	0.143113	145800	0.388653	33311.8	0.405197
c6085	1999	284579	0.13821	156744	0.124932	43091.9	0.313023
c4085	1983	239285	0.182261	110240	0.188686	5170.7	0.528225
c4085	1985	39961.4	0.16338	109461	0.125125	151452	0.884467
c4085	1990	317392	0.126116	146023	0.165479	12351	0.656206
c4085	1992	202315	0.107426	199118	0.150285	90088.9	0.3004
c4085	1996	222117	0.175748	175248	0.33496	33311.8	0.405197
c4085	1999	320778	0.131391	172912	0.133691	46539.7	0.290113
c909CNE	1983	304929	0.14789	111137	0.187337	5170.7	0.528225
c909CNE	1985	40694	0.160882	109705	0.124866	137009	0.977709
c909CNE	1990	350065	0.116808	152016	0.159626	12351	0.656206
c909CNE	1992	244117	0.093697	202070	0.148169	103147	0.288977
c909CNE	1996	266964	0.150646	179061	0.328037	18011.3	0.619332
c909CNE	1999	336693	0.131745	177078	0.133551	22957.7	0.445159

Table C3: Rankings of strata in the Bay of Plenty survey for adult, all and juvenile potions of the population. Strata retained in the selected reduced strata survey are in bold.

Adult	**GUR**	**JDO**	**TAR**	**rank**	**stratum**	**no**
	4	**6**	**6**	**14.8**	**c6085**	**1**
	7	**7**	**3**	**14.7**	**c7085**	**2**
	6	**5**	**4**	**14.0**	**c5187/5287**	**3**
	2	**4**	**7**	**10.5**	**c808CNE**	**4**
	5	3	1	7.0	c1096/2096	5
	3	2	2	6.4	c4085	6
	1	1	5	4.7	c909CNE	7
All	**GUR**	**JDO**	**TAR**	**rank**	**stratum**	**no**
	4	**6**	**6**	**14.8**	**c6085**	**1**
	7	**7**	**3**	**14.7**	**c7085**	**2**
	6	**5**	**4**	**14.0**	**c5187/5287**	**3**
	2	**4**	**7**	**10.5**	**c808CNE**	**4**
	5	3	1	7.0	c1096/2096	5
	3	2	2	6.4	c4085	6
	1	1	5	4.7	c909CNE	7
Juvenile	**GUR**	**JDO**	**TAR**	**rank**	**stratum**	**no**
	4	6	5	14.0	c7085	1
	3	7	6	13.9	c6085	2
	7	2.5	4	11.2	c5187/5287	3
	6	5	2	10.9	c1096/2096	4
	5	2.5	3	9.2	c4085	5
	1	2.5	7	7.4	c808CNE	6
	2	2.5	1	4.7	c909CNE	7

8.4. APPENDIX D: Strata ranking for the West Coast North Island survey for adult and estimated juvenile populations

Table D1: Estimated adult biomasses calculated with one stratum dropped each time. The dropped stratum is given in the first column.

Stratum	Year	GUR	GUR c.v.	JDO	JDO c.v.	TAR	TAR c.v.
E100	1986	2277170	0.078404	109815	0.130418	318755	0.055092
E100	1987	1206180	0.213406	80412.2	0.187196	3678.73	0.609182
E100	1989	1528060	0.131073	168625	0.121275	75149.3	0.391951
E100	1991	2609810	0.126926	430373	0.27947	513751	0.448109
E100	1994	2066180	0.089245	82019.4	0.246086	63722.5	0.380573
E100	1996	2487240	0.088635	407028	0.102325	650225	0.269007
E100	1999	1718040	0.13715	299254	0.110031	510481	0.151119
E50	1986	2705770	0.128409	186503	0.191596	318755	0.055092
E50	1987	1345120	0.18102	139590	0.201097	14796.6	0.448963
E50	1989	1860010	0.132867	211423	0.112444	82240.9	0.36296
E50	1991	3367720	0.131614	580369	0.236153	521753	0.441503
E50	1994	3078240	0.216415	144467	0.312945	90943.3	0.302919
E50	1996	2991050	0.099223	448033	0.095194	665779	0.263495
E50	1999	1916400	0.140885	334857	0.116367	519184	0.149528
RG50	1986	2808230	0.124517	183305	0.193073	318755	0.055092
RG50	1987	1516640	0.182627	130000	0.211475	14300.3	0.463246
RG50	1989	1898060	0.131118	223175	0.110663	81014.3	0.36828
RG50	1991	3417970	0.12989	581968	0.235511	521753	0.441503
RG50	1994	3073100	0.217423	144467	0.312945	90943.3	0.302919
RG50	1996	2969620	0.099947	446598	0.095478	665779	0.263495
RG50	1999	1853580	0.143629	334817	0.116585	518373	0.149758
F25	1986	2807970	0.1246	188661	0.189433	318755	0.055092
F25	1987	1511720	0.184056	137348	0.204144	14796.6	0.448963
F25	1989	1907000	0.130413	226759	0.109092	82493.8	0.361861
F25	1991	3400390	0.130555	581968	0.235511	521753	0.441503
F25	1994	3131300	0.21341	144467	0.312945	90943.3	0.302919
F25	1996	2988530	0.099237	447572	0.095286	665779	0.263495
F25	1999	1919640	0.140648	336391	0.116027	519184	0.149528
E25	1986	2830950	0.123467	187228	0.19073	318755	0.055092
E25	1987	1554990	0.179193	139590	0.201097	14796.6	0.448963
E25	1989	1927300	0.128989	222749	0.110826	82493.8	0.361861
E25	1991	3397540	0.130669	581053	0.23588	521753	0.441503
E25	1994	3146480	0.212385	144467	0.312945	90943.3	0.302919
E25	1996	2997350	0.099069	444665	0.09583	665779	0.263495
E25	1999	1910480	0.141189	333864	0.116913	519184	0.149528
C100	1986	2741130	0.127215	157854	0.217379	317668	0.055175
C100	1987	1296420	0.143015	103433	0.250953	13176.9	0.488935
C100	1989	1833960	0.133933	216467	0.112828	78747.1	0.377858
C100	1991	3132450	0.130831	572324	0.239371	308981	0.28568
C100	1994	2707290	0.246384	127721	0.346123	72469.4	0.326557
C100	1996	2661580	0.103562	401972	0.10043	660600	0.265542
C100	1999	1590930	0.140829	326544	0.119097	517572	0.149962
DD50	1986	2834680	0.123427	188661	0.189433	318755	0.055092
DD50	1987	1489370	0.187087	139590	0.201097	14796.6	0.448963
DD50	1989	1858540	0.133644	212562	0.11124	82310.6	0.362659
DD50	1991	3377910	0.131406	580505	0.236099	521753	0.441503

Stratum	Year	GUR	GUR c.v.	JDO	JDO c.v.	TAR	TAR c.v.
DD50	1994	3126600	0.213725	144467	0.312945	90943.3	0.302919
DD50	1996	2936390	0.100697	448033	0.095194	665779	0.263495
DD50	1999	1774560	0.147569	335339	0.116392	518554	0.149705
C50	1986	2679420	0.129105	188418	0.189673	318755	0.055092
C50	1987	1388000	0.198779	135614	0.206506	14796.6	0.448963
C50	1989	1827740	0.132398	223456	0.110374	82287.7	0.362758
C50	1991	3387030	0.13107	581968	0.235511	521753	0.441503
C50	1994	2995270	0.222884	144370	0.313153	90943.3	0.302919
C50	1996	2899210	0.102115	447175	0.09537	665779	0.263495
C50	1999	1844240	0.14608	337175	0.115809	519184	0.149528
C25	1986	2815930	0.124174	188661	0.189433	318755	0.055092
C25	1987	1427690	0.194639	139590	0.201097	14796.6	0.448963
C25	1989	1892550	0.131269	223087	0.110601	82493.8	0.361861
C25	1991	3343410	0.132414	580204	0.236207	521753	0.441503
C25	1994	3077150	0.217005	144467	0.312945	90943.3	0.302919
C25	1996	2890160	0.102215	445738	0.095658	665779	0.263495
C25	1999	1897920	0.142231	336143	0.116138	519184	0.149528
D25	1986	2856470	0.122413	188661	0.189433	318755	0.055092
D25	1987	1505470	0.185004	139590	0.201097	14796.6	0.448963
D25	1989	1932610	0.128546	223866	0.110333	79790.4	0.372584
D25	1991	3404250	0.1304	581753	0.235598	521753	0.441503
D25	1994	3146090	0.212411	144467	0.312945	90943.3	0.302919
D25	1996	2984750	0.099492	448033	0.095194	665779	0.263495
D25	1999	1887470	0.143008	337038	0.11585	519184	0.149528
A100	1986	2802850	0.12469	166646	0.21294	277441	0.008455
A100	1987	1554990	0.179193	139590	0.201097	14796.6	0.448963
A100	1989	1865910	0.129942	210616	0.112939	32927.4	0.372903
A100	1991	3068800	0.1255	513946	0.247271	498519	0.459723
A100	1994	3150620	0.212106	144467	0.312945	90943.3	0.302919
A100	1996	2873210	0.101435	406130	0.093913	644058	0.271791
A100	1999	1897310	0.141914	315565	0.11992	505219	0.153537
A25	1986	2830110	0.123454	188661	0.189433	318755	0.055092
A25	1987	1554990	0.179193	139590	0.201097	14796.6	0.448963
A25	1989	1942150	0.128148	218615	0.107242	82493.8	0.361861
A25	1991	3341180	0.132238	578836	0.236775	521753	0.441503
A25	1994	3150620	0.212106	144467	0.312945	90943.3	0.302919
A25	1996	2917500	0.10146	441567	0.096315	665419	0.263637
A25	1999	1879980	0.143618	330952	0.11777	519184	0.149528
AA50	1986	2468360	0.129951	166721	0.212939	318755	0.055092
AA50	1987	1554990	0.179193	139590	0.201097	14796.6	0.448963
AA50	1989	1871660	0.13182	215468	0.112944	71883.1	0.390589
AA50	1991	3055050	0.139584	560834	0.244106	511939	0.449558
AA50	1994	2933500	0.227403	128132	0.352223	75610	0.302696
AA50	1996	2799500	0.105254	431158	0.097627	660919	0.265398
AA50	1999	1725680	0.154436	310244	0.122817	503143	0.153132
A200	1986	2369840	0.147637	178968	0.199693	318755	0.055092
A200	1987	1554990	0.179193	139590	0.201097	14796.6	0.448963
A200	1989	1951100	0.127574	227176	0.108896	82493.8	0.361861
A200	1991	3412150	0.130101	581968	0.235511	472907	0.480532
A200	1994	3150620	0.212106	144467	0.312945	90943.3	0.302919
A200	1996	3006330	0.098769	432309	0.09386	629458	0.277551
A200	1999	1924370	0.14034	325204	0.119589	267271	0.189498
B100	1986	2672820	0.127831	178682	0.19664	316676	0.055064

Stratum	Year	GUR	GUR c.v.	JDO	JDO c.v.	TAR	TAR c.v.
B100	1987	1375850	0.200702	113266	0.236329	14796.6	0.448963
B100	1989	1804360	0.131002	195811	0.123741	78607.2	0.378887
B100	1991	3126410	0.139331	565359	0.240643	518439	0.44431
B100	1994	2909700	0.228181	127629	0.341508	75180.6	0.362586
B100	1996	2561710	0.113354	396994	0.100707	494035	0.142592
B100	1999	1743010	0.153137	318088	0.121738	517234	0.150045
B200	1986	2818000	0.124158	185131	0.193046	44479.3	0.394813
B200	1987	1554990	0.179193	139590	0.201097	14796.6	0.448963
B200	1989	1951100	0.127574	227176	0.108896	82493.8	0.361861
B200	1991	3413090	0.130073	575187	0.23812	491901	0.467084
B200	1994	3150620	0.212106	144467	0.312945	90943.3	0.302919
B200	1996	2998010	0.099022	432770	0.097905	597979	0.287185
B200	1999	1933550	0.139678	334751	0.116611	511307	0.151604
BB50	1986	2851840	0.122622	185999	0.192108	318755	0.055092
BB50	1987	1487400	0.187227	137470	0.203792	13233.9	0.489584
BB50	1989	1908010	0.130449	220429	0.112119	79979.8	0.371909
BB50	1991	3274310	0.135589	581550	0.23568	520675	0.442417
BB50	1994	3059280	0.218252	141435	0.319488	89810.7	0.306585
BB50	1996	2915340	0.101434	444807	0.095867	664826	0.26387
BB50	1999	1896520	0.142347	336509	0.116034	519184	0.149528
G25	1986	2885720	0.121244	188661	0.189433	318755	0.055092
G25	1987	1554990	0.179193	139590	0.201097	14796.6	0.448963
G25	1989	1912400	0.130075	225475	0.109689	82493.8	0.361861
G25	1991	3332700	0.133099	579058	0.236676	521753	0.441503
G25	1994	3136530	0.213055	143841	0.314275	90943.3	0.302919
G25	1996	2772540	0.094614	442865	0.095598	665779	0.263495
G25	1999	1889410	0.142876	334222	0.116835	519184	0.149528
F50	1986	2885720	0.121244	188661	0.189433	318755	0.055092
F50	1987	1554990	0.179193	139590	0.201097	14796.6	0.448963
F50	1989	1788100	0.136652	216540	0.113522	82493.8	0.361861
F50	1991	3332840	0.13315	581415	0.235733	521753	0.441503
F50	1994	2968250	0.224731	141064	0.320378	90541.2	0.304232
F50	1996	2939780	0.100571	443518	0.095873	665779	0.263495
F50	1999	1887400	0.142481	332923	0.117013	519184	0.149528
F100	1986	2885720	0.121244	188661	0.189433	318755	0.055092
F100	1987	1554990	0.179193	139590	0.201097	14796.6	0.448963
F100	1989	1610310	0.126423	206872	0.106452	82493.8	0.361861
F100	1991	2827480	0.15532	477315	0.254241	520104	0.442891
F100	1994	2725380	0.240193	120096	0.361198	78325.2	0.318297
F100	1996	2846090	0.102447	380724	0.101532	631376	0.274776
F100	1999	1753580	0.130428	301616	0.128835	509021	0.152108
C200	1986	2885720	0.121244	188661	0.189433	318755	0.055092
C200	1987	1554990	0.179193	139590	0.201097	14796.6	0.448963
C200	1989	1951100	0.127574	227176	0.108896	82493.8	0.361861
C200	1991	3412300	0.130104	560209	0.244575	461715	0.494528
C200	1994	3150620	0.212106	144467	0.312945	90943.3	0.302919
C200	1996	2994740	0.099128	433149	0.098187	634797	0.275996
C200	1999	1931380	0.139832	310046	0.125238	465796	0.15426
E200	1986	2885720	0.121244	188661	0.189433	318755	0.055092
E200	1987	1554990	0.179193	139590	0.201097	14796.6	0.448963
E200	1989	1951100	0.127574	227176	0.108896	82493.8	0.361861
E200	1991	3401120	0.130496	529530	0.257685	438349	0.505186
E200	1994	3150620	0.212106	144467	0.312945	90943.3	0.302919

Stratum	Year	GUR	GUR c.v.	JDO	JDO c.v.	TAR	TAR c.v.
E200	1996	3010990	0.098623	413618	0.098834	532733	0.325899
E200	1999	1934320	0.139615	313119	0.120684	434830	0.173857
F200	1986	2885720	0.121244	188661	0.189433	318755	0.055092
F200	1987	1554990	0.179193	139590	0.201097	14796.6	0.448963
F200	1989	1951100	0.127574	227176	0.108896	82493.8	0.361861
F200	1991	3380690	0.131157	466507	0.230522	482009	0.475944
F200	1994	3150620	0.212106	144467	0.312945	90943.3	0.302919
F200	1996	2998190	0.09896	375568	0.107862	522924	0.326027
F200	1999	1927190	0.140138	255600	0.111768	451410	0.154602
B25	1986	2885720	0.121244	188661	0.189433	318755	0.055092
B25	1987	1554990	0.179193	139590	0.201097	14796.6	0.448963
B25	1989	1951100	0.127574	227176	0.108896	82493.8	0.361861
B25	1991	3396640	0.130705	581068	0.235874	521753	0.441503
B25	1994	3129600	0.213528	143892	0.314187	90943.3	0.302919
B25	1996	2977010	0.099724	444740	0.09585	665779	0.263495
B25	1999	1919890	0.140625	335743	0.116273	519184	0.149528

Table D2: Estimated adult biomasses calculated with one stratum dropped each time. The dropped stratum is given in the first column.

Stratum	Year	GUR	GUR c.v.	JDO	JDO c.v.	TAR	TAR c.v.
E100	1986	2256210	0.078928	108870	0.131779	318755	0.055092
E100	1987	1183410	0.215801	79464.6	0.187488	3597.22	0.625563
E100	1989	1514400	0.13061	167049	0.120608	74422.8	0.394895
E100	1991	2580490	0.126421	427543	0.280768	513751	0.448109
E100	1994	2042210	0.089223	78205.3	0.242261	62615.5	0.385663
E100	1996	2361200	0.088599	403594	0.103139	643903	0.270993
E100	1999	1634160	0.135061	296963	0.110524	507670	0.151728
E50	1986	2671960	0.128183	185080	0.193342	318755	0.055092
E50	1987	1306320	0.183661	137480	0.204296	14178.4	0.469164
E50	1989	1840690	0.133025	209624	0.112077	81514.5	0.3654
E50	1991	3326080	0.130407	573632	0.236924	521753	0.441503
E50	1994	3046830	0.216918	137249	0.314053	88920.4	0.308211
E50	1996	2858020	0.100107	444042	0.095934	659457	0.265383
E50	1999	1798580	0.138578	332657	0.116886	512877	0.15053
RG50	1986	2771480	0.124349	181882	0.194864	318755	0.055092
RG50	1987	1477120	0.185631	128220	0.214722	13682.1	0.484827
RG50	1989	1878160	0.131279	221324	0.110381	80519.2	0.369821
RG50	1991	3376090	0.128694	575231	0.236272	521753	0.441503
RG50	1994	3037520	0.218099	137249	0.314053	88920.4	0.308211
RG50	1996	2837020	0.100859	442607	0.096223	659457	0.265383
RG50	1999	1753840	0.140716	332526	0.117121	512065	0.150765
F25	1986	2772850	0.124355	187238	0.191142	318755	0.055092
F25	1987	1473060	0.18703	135238	0.207443	14178.4	0.469164
F25	1989	1887030	0.130573	224939	0.10879	81767.3	0.364283
F25	1991	3358640	0.129356	575231	0.236272	521753	0.441503
F25	1994	3094470	0.214105	137249	0.314053	88920.4	0.308211
F25	1996	2855020	0.100131	443581	0.096028	659457	0.265383
F25	1999	1801610	0.138343	334100	0.116556	512877	0.15053
E25	1986	2792550	0.123355	185805	0.192462	318755	0.055092
E25	1987	1515470	0.182043	137480	0.204296	14178.4	0.469164
E25	1989	1907420	0.129127	220898	0.110545	81767.3	0.364283
E25	1991	3355780	0.129471	574316	0.236646	521753	0.441503
E25	1994	3108880	0.213117	137249	0.314053	88920.4	0.308211
E25	1996	2863790	0.099959	440674	0.096582	659457	0.265383
E25	1999	1792940	0.138866	331573	0.117452	512877	0.15053
C100	1986	2705010	0.127051	156773	0.219218	317668	0.055175
C100	1987	1259730	0.145981	101443	0.256211	12558.6	0.513732
C100	1989	1816160	0.134018	214784	0.112389	78222.1	0.37951
C100	1991	3104320	0.13003	566944	0.239603	308981	0.28568
C100	1994	2675170	0.247175	121986	0.346084	70446.5	0.333583
C100	1996	2540090	0.104673	398758	0.100801	654913	0.267201
C100	1999	1498420	0.138851	324381	0.119611	511264	0.150972
DD50	1986	2796100	0.123324	187238	0.191142	318755	0.055092
DD50	1987	1450080	0.190251	137480	0.204296	14178.4	0.469164
DD50	1989	1838600	0.133841	210802	0.110973	81584.2	0.365094
DD50	1991	3336410	0.1302	573768	0.236868	521753	0.441503
DD50	1994	3089040	0.214476	137249	0.314053	88920.4	0.308211
DD50	1996	2807190	0.101569	444042	0.095934	659457	0.265383
DD50	1999	1662180	0.144933	333048	0.116925	512246	0.150711
C50	1986	2644180	0.128944	187093	0.191289	318755	0.055092

Stratum	Year	GUR	GUR c.v.	JDO	JDO c.v.	TAR	TAR c.v.
C50	1987	1360520	0.200873	133503	0.209886	14178.4	0.469164
C50	1989	1807940	0.132554	221606	0.110089	81561.2	0.365195
C50	1991	3345150	0.129878	575231	0.236272	521753	0.441503
C50	1994	2960560	0.223569	137153	0.314273	88920.4	0.308211
C50	1996	2770590	0.103003	443223	0.096105	659457	0.265383
C50	1999	1729000	0.143843	334949	0.116315	512877	0.15053
C25	1986	2777360	0.124079	187238	0.191142	318755	0.055092
C25	1987	1388720	0.198107	137480	0.204296	14178.4	0.469164
C25	1989	1872930	0.13141	221236	0.110317	81767.3	0.364283
C25	1991	3301820	0.131208	573468	0.236979	521753	0.441503
C25	1994	3040820	0.217722	137249	0.314053	88920.4	0.308211
C25	1996	2762140	0.103113	441747	0.096406	659457	0.265383
C25	1999	1780180	0.139977	333852	0.116668	512877	0.15053
D25	1986	2818250	0.122282	187238	0.191142	318755	0.055092
D25	1987	1466500	0.188038	137480	0.204296	14178.4	0.469164
D25	1989	1912570	0.128686	222039	0.110044	79064	0.375184
D25	1991	3362570	0.129199	575016	0.23636	521753	0.441503
D25	1994	3108570	0.213139	137249	0.314053	88920.4	0.308211
D25	1996	2851590	0.100391	444042	0.095934	659457	0.265383
D25	1999	1771390	0.140667	334747	0.116377	512877	0.15053
A100	1986	2764590	0.124588	165549	0.214659	277441	0.008455
A100	1987	1515470	0.182043	137480	0.204296	14178.4	0.469164
A100	1989	1846020	0.130083	208766	0.112611	32446.4	0.37703
A100	1991	3027060	0.123592	507209	0.24811	498519	0.459723
A100	1994	3113020	0.212834	137249	0.314053	88920.4	0.308211
A100	1996	2754800	0.102546	402959	0.09487	637737	0.273824
A100	1999	1780880	0.139579	313689	0.120577	498911	0.154618
A25	1986	2791530	0.123349	187238	0.191142	318755	0.055092
A25	1987	1515470	0.182043	137480	0.204296	14178.4	0.469164
A25	1989	1922080	0.128287	216765	0.106859	81767.3	0.364283
A25	1991	3299320	0.131029	572175	0.237524	521753	0.441503
A25	1994	3113020	0.212834	137249	0.314053	88920.4	0.308211
A25	1996	2786960	0.102413	437576	0.097076	659097	0.265527
A25	1999	1763260	0.141362	328661	0.11832	512877	0.15053
AA50	1986	2429780	0.129743	165298	0.215079	318755	0.055092
AA50	1987	1515470	0.182043	137480	0.204296	14178.4	0.469164
AA50	1989	1851810	0.13198	213878	0.1126	71204.7	0.393586
AA50	1991	3013870	0.138185	554424	0.244854	511939	0.449558
AA50	1994	2897340	0.228275	121357	0.354548	73587.1	0.308689
AA50	1996	2679270	0.106061	427440	0.098339	654598	0.267319
AA50	1999	1612310	0.15241	308064	0.123406	496836	0.154206
A200	1986	2331750	0.147883	177544	0.201578	318755	0.055092
A200	1987	1515470	0.182043	137480	0.204296	14178.4	0.469164
A200	1989	1931030	0.127707	225326	0.108607	81767.3	0.364283
A200	1991	3370270	0.128905	575231	0.236272	472907	0.480532
A200	1994	3113020	0.212834	137249	0.314053	88920.4	0.308211
A200	1996	2872690	0.099644	428318	0.094609	623136	0.27969
A200	1999	1806280	0.138029	323112	0.120099	262216	0.191145
B100	1986	2637080	0.127572	177436	0.198242	316676	0.055064
B100	1987	1340200	0.204163	111548	0.240449	14178.4	0.469164
B100	1989	1785410	0.131058	194112	0.123565	77880.7	0.381588
B100	1991	3087560	0.13805	558622	0.241473	518439	0.44431
B100	1994	2872750	0.229108	121611	0.343082	73739	0.368207

Stratum	Year	GUR	GUR c.v.	JDO	JDO c.v.	TAR	TAR c.v.
B100	1996	2485220	0.114113	393651	0.101592	487714	0.14228
B100	1999	1636840	0.150323	315797	0.122337	510926	0.151057
B200	1986	2780140	0.124032	183707	0.194816	44479.3	0.394813
B200	1987	1515470	0.182043	137480	0.204296	14178.4	0.469164
B200	1989	1931030	0.127707	225326	0.108607	81767.3	0.364283
B200	1991	3371210	0.128878	568450	0.23892	491901	0.467084
B200	1994	3113020	0.212834	137249	0.314053	88920.4	0.308211
B200	1996	2864370	0.09991	428985	0.098633	591658	0.289527
B200	1999	1815450	0.137336	332631	0.117096	505309	0.152524
BB50	1986	2813520	0.122495	184576	0.193862	318755	0.055092
BB50	1987	1449000	0.190277	135462	0.206972	12697.2	0.510742
BB50	1989	1888020	0.13061	218635	0.11183	79253.3	0.374498
BB50	1991	3235910	0.13427	574952	0.236386	520675	0.442417
BB50	1994	3022130	0.219045	134218	0.320964	87787.8	0.312029
BB50	1996	2784550	0.102395	440859	0.096608	658504	0.265764
BB50	1999	1779160	0.140078	334218	0.116563	512877	0.15053
G25	1986	2847150	0.121113	187238	0.191142	318755	0.055092
G25	1987	1515470	0.182043	137480	0.204296	14178.4	0.469164
G25	1989	1892400	0.130233	223625	0.109404	81767.3	0.364283
G25	1991	3290850	0.131909	572321	0.237455	521753	0.441503
G25	1994	3099080	0.213788	136624	0.315457	88920.4	0.308211
G25	1996	2640840	0.09465	438881	0.096347	659457	0.265383
G25	1999	1771540	0.140664	331931	0.117373	512877	0.15053
F50	1986	2847150	0.121113	187238	0.191142	318755	0.055092
F50	1987	1515470	0.182043	137480	0.204296	14178.4	0.469164
F50	1989	1770170	0.136822	214689	0.113251	81767.3	0.364283
F50	1991	3291240	0.131953	574678	0.236497	521753	0.441503
F50	1994	2932080	0.22556	133846	0.321909	88920.4	0.308211
F50	1996	2806580	0.101527	439527	0.096626	659457	0.265383
F50	1999	1771100	0.140136	330632	0.117554	512877	0.15053
F100	1986	2847150	0.121113	187238	0.191142	318755	0.055092
F100	1987	1515470	0.182043	137480	0.204296	14178.4	0.469164
F100	1989	1595730	0.126994	205768	0.106613	81767.3	0.364283
F100	1991	2792120	0.153789	471084	0.255404	520104	0.442891
F100	1994	2688740	0.241356	113567	0.363307	76425.9	0.324909
F100	1996	2712450	0.10348	376909	0.102369	629036	0.275804
F100	1999	1640740	0.126413	300435	0.129048	502714	0.15316
C200	1986	2847150	0.121113	187238	0.191142	318755	0.055092
C200	1987	1515470	0.182043	137480	0.204296	14178.4	0.469164
C200	1989	1931030	0.127707	225326	0.108607	81767.3	0.364283
C200	1991	3370420	0.128908	553667	0.245396	461715	0.494528
C200	1994	3113020	0.212834	137249	0.314053	88920.4	0.308211
C200	1996	2861100	0.100022	429158	0.098981	628698	0.278013
C200	1999	1813280	0.137497	307755	0.125879	459821	0.155139
E200	1986	2847150	0.121113	187238	0.191142	318755	0.055092
E200	1987	1515470	0.182043	137480	0.204296	14178.4	0.469164
E200	1989	1931030	0.127707	225326	0.108607	81767.3	0.364283
E200	1991	3359240	0.1293	523022	0.258643	438349	0.505186
E200	1994	3113020	0.212834	137249	0.314053	88920.4	0.308211
E200	1996	2877350	0.09949	409627	0.099667	526412	0.329006
E200	1999	1816230	0.13727	310828	0.121278	429438	0.175234
F200	1986	2847150	0.121113	187238	0.191142	318755	0.055092
F200	1987	1515470	0.182043	137480	0.204296	14178.4	0.469164

Stratum	Year	GUR	GUR c.v.	JDO	JDO c.v.	TAR	TAR c.v.
F200	1989	1931030	0.127707	225326	0.108607	81767.3	0.364283
F200	1991	3338810	0.12996	459770	0.230707	482009	0.475944
F200	1994	3113020	0.212834	137249	0.314053	88920.4	0.308211
F200	1996	2864550	0.099844	372020	0.108666	518085	0.328223
F200	1999	1809090	0.137818	253309	0.112298	445103	0.15572
B25	1986	2847150	0.121113	187238	0.191142	318755	0.055092
B25	1987	1515470	0.182043	137480	0.204296	14178.4	0.469164
B25	1989	1931030	0.127707	225326	0.108607	81767.3	0.364283
B25	1991	3354800	0.12951	574331	0.23664	521753	0.441503
B25	1994	3092180	0.214266	136675	0.315364	88920.4	0.308211
B25	1996	2845720	0.100572	440749	0.096601	659457	0.265383
B25	1999	1802120	0.1383	333452	0.116804	512877	0.15053

Table D3: Rankings of strata in the west coast North Island survey for adult, all and juvenile portions of the population. Strata retained in the selected reduced strata survey are in bold.

	GUR	JDO	TAR	rank	stratum	no
Adult						
	20	**20**	**20**	**60.0**	**B100**	**1**
	22	**18**	**22**	**59.7**	**C100**	**2**
	24	**24**	**15**	**57.8**	**E100**	**3**
	23	**22**	**16**	**57.2**	**F100**	**4**
	18	**21**	**17**	**53.9**	**A100**	**5**
	19	**15**	**23**	**53.0**	**A200**	**6**
	21	**17**	**14**	**48.5**	**AA50**	**7**
	3	**23**	**19**	**34.4**	**F200**	**8**
	5	14	24	33.5	B200	9
	13	12	10	33.5	DD50	10
	16	13	8	33.0	E50	11
	1	19	21	30.0	E200	12
	11	8	13	29.5	BB50	13
	10	11	9	29.0	A25	14
	9	9	11	27.8	RG50	15
	2	16	18	27.3	C200	16
	15	10	3.5	22.7	F50	17
	17	5	7	22.6	C50	18
	14	7	3.5	19.2	G25	19
	7	2	12	16.0	D25	20
	12	4	3.5	14.7	C25	21
	6	6	3.5	14.1	E25	22
	4	3	3.5	10.0	B25	23
	8	1	3.5	9.0	F25	24
All	**GUR**	**JDO**	**TAR**	**rank**	**stratum**	**no**
	22	**19**	**22**	**61.3**	**C100**	**1**
	20	**20**	**20**	**60.0**	**B100**	**2**
	24	**24**	**15**	**57.8**	**E100**	**3**
	23	**22**	**16**	**57.2**	**F100**	**4**
	18	**21**	**17**	**53.9**	**A100**	**5**
	19	**15**	**23**	**53.0**	**A200**	**6**
	21	**17**	**14**	**48.5**	**AA50**	**7**
	3	**23**	**19**	**34.4**	**F200**	**8**
	5	14	24	33.5	B200	9
	13	12	10	33.5	DD50	10
	16	13	7	31.4	E50	11
	15	10	9	30.8	F50	12
	11	8	13	29.5	BB50	13
	1	18	21	29.2	E200	14
	10	9	11	29.0	RG50	15
	2	16	18	27.3	C200	16
	9	11	8	26.5	A25	17
	17	5	6	21.3	C50	18
	14	7	3	18.4	G25	19
	7	2	12	16.0	D25	20
	12	4	3	14.1	C25	21
	6	6	3	13.3	E25	22
	4	3	3	9.4	B25	23
	8	1	3	8.4	F25	24

Juvenile	GUR	JDO	TAR	rank	stratum	no
	23	24	23	69.4	E100	1
	22	23	19	61.9	C100	2
	24	21	18	60.0	B100	3
	17	22	24	59.4	F100	4
	20	20	14	50.5	A100	5
	21	17	13	47.0	RG50	6
	19	19	11	44.4	AA50	7
	13	14	12	38.0	BB50	8
	6	16	15	31.5	B200	9
	2	18	22	31.4	F200	10
	4	13	21	29.5	A200	11
	18	11	5.5	28.2	C50	12
	2	15	20	27.7	E200	13
	16	10	5.5	26.2	E50	14
	15	9	5.5	24.7	DD50	15
	2	12	17	23.4	C200	16
	11	8	5.5	21.7	A25	17
	10	2.5	16	21.7	F50	18
	12	7	5.5	21.1	F25	19
	8	6	5.5	18.2	D25	20
	7	5	5.5	16.5	G25	21
	14	2.5	5.5	16.0	C25	22
	9	2.5	5.5	13.7	B25	23
	5	2.5	5.5	11.4	E25	24

8.5. APPENDIX E: Unscaled length frequency distributions and cumulative proportional frequency plots from all survey catches summed together

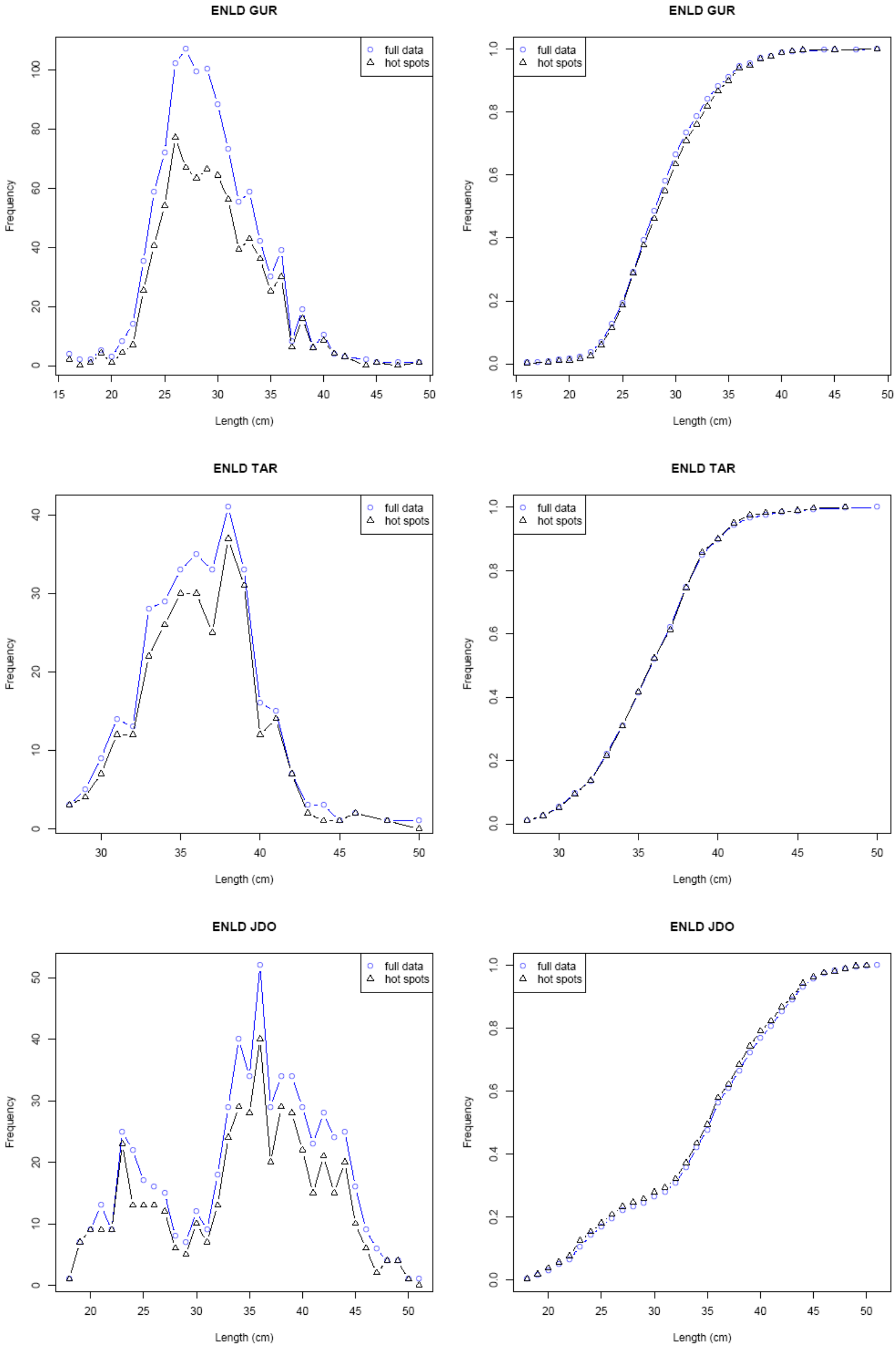


Figure E1: East Northland total unscaled length frequency distributions and cumulative curves for GUR, JDO and TAR

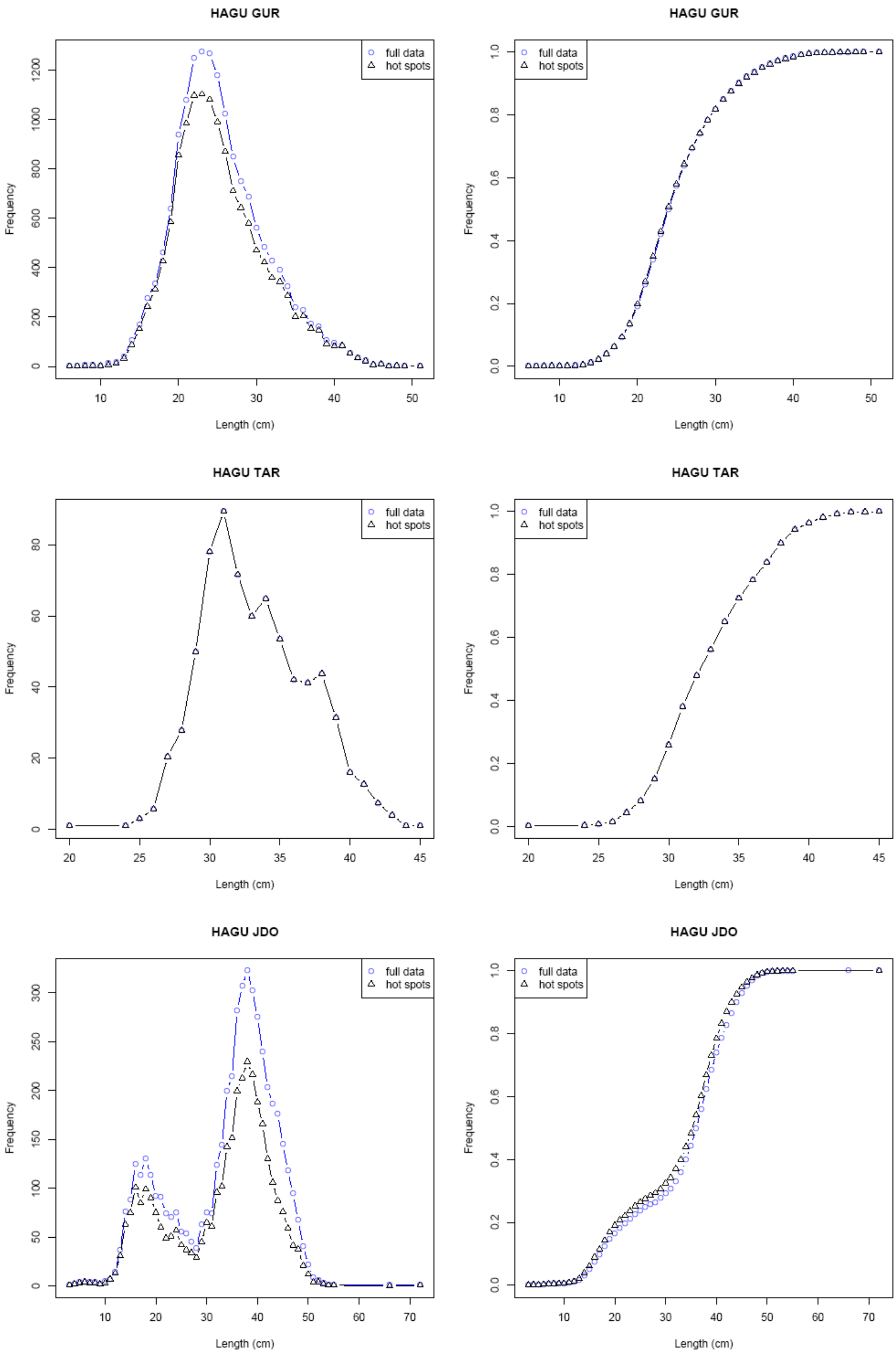


Figure E2: Hauraki Gulf total unscaled length frequency distributions and cumulative curves for GUR, JDO and TAR

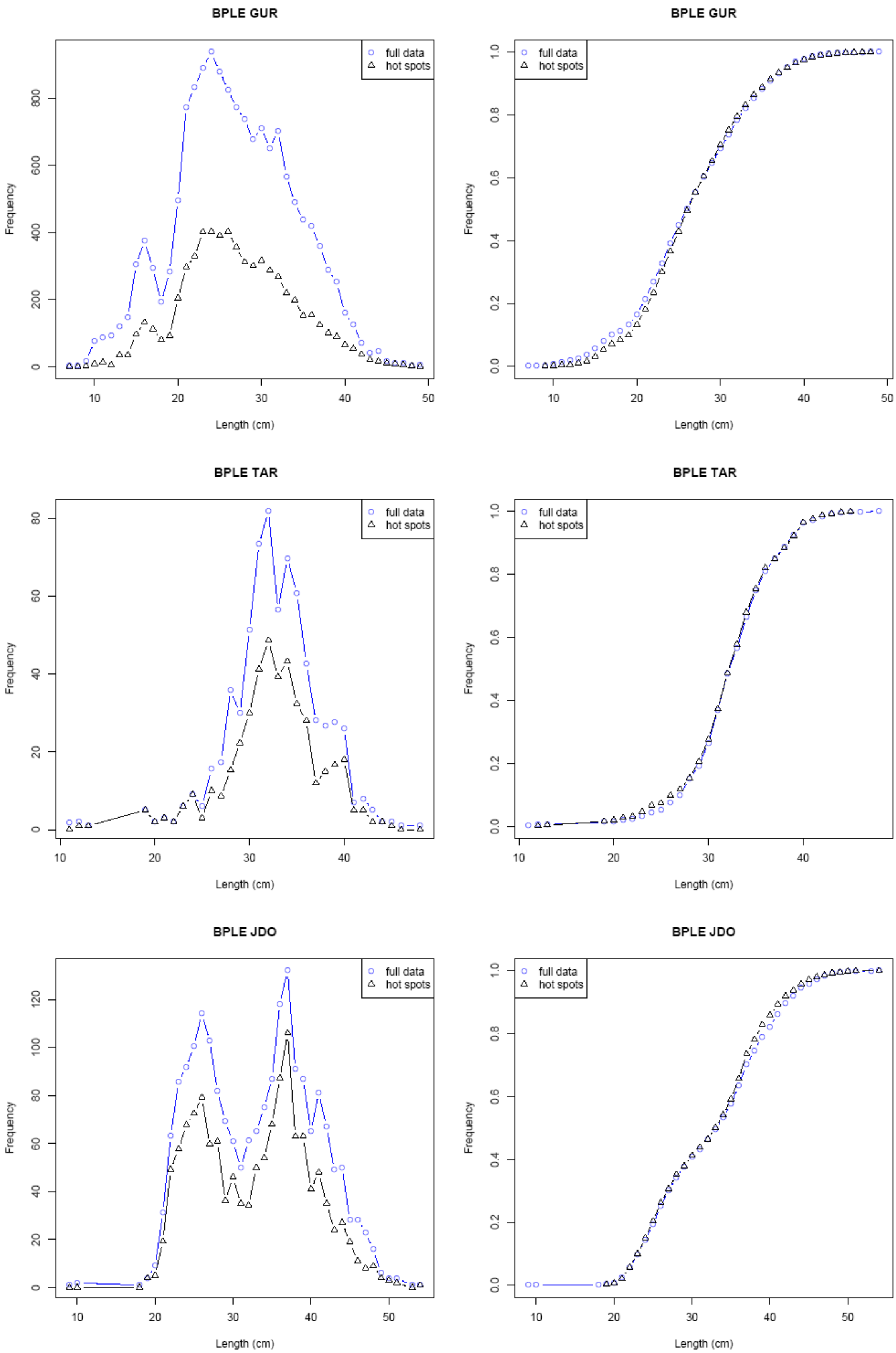
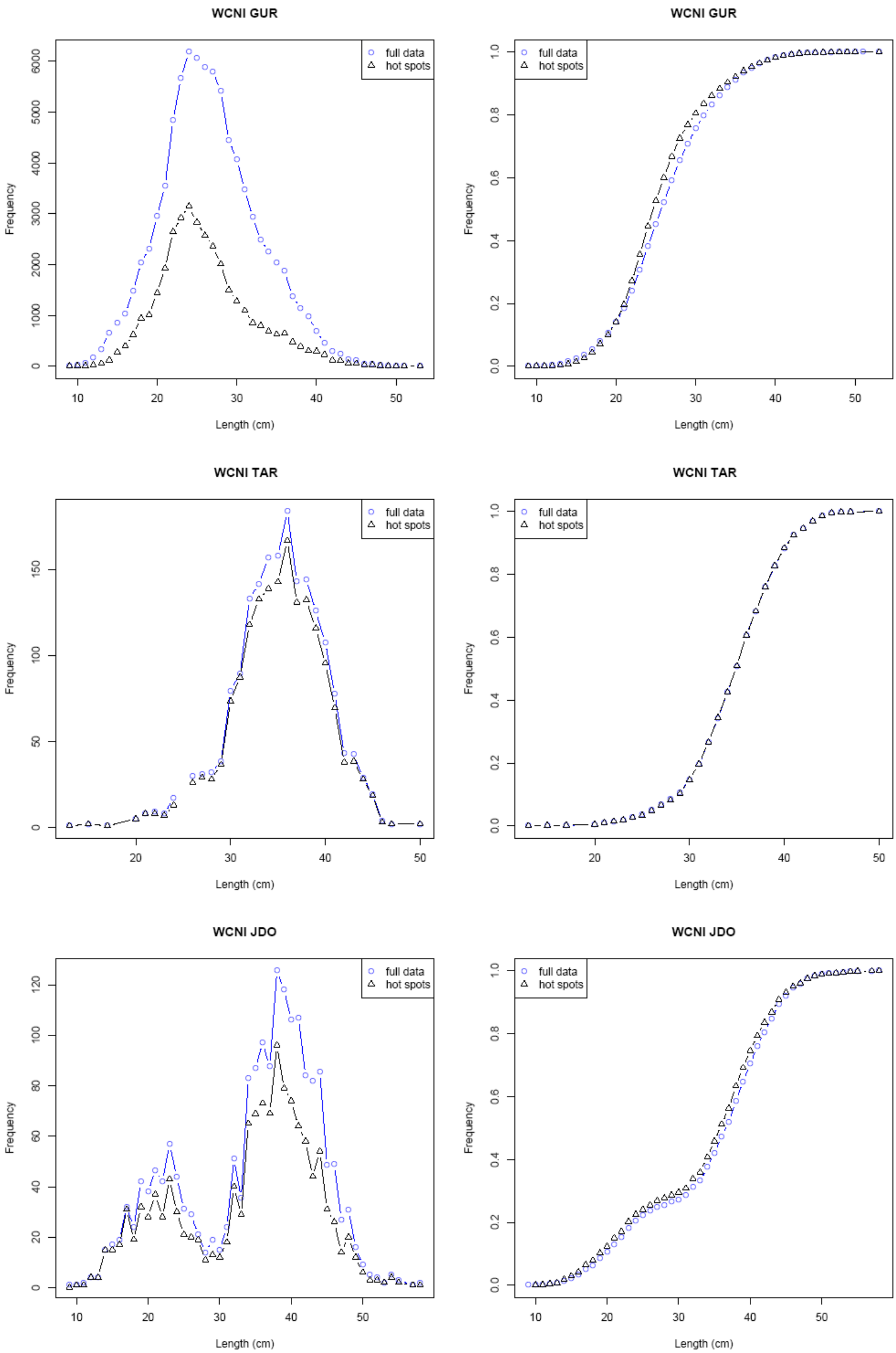


Figure E3: Bay of Plenty total unscaled length frequency distributions and cumulative curves for GUR, JDO and TAR



Appendix E4: West coast total unscaled length frequency distributions and cumulative curves for GUR, JDO and TAR

8.6. APPENDIX F: Results of Kolmogorov-Smirnov tests for individual survey years

Each table provides the values for $D\alpha$ - D and the outcome of each test.

East Northland

Species	1990	1993	All years
GUR	0.184 - 0.089	0.073 - 0.019	0.068 - 0.028
	nonsig	nonsig	nonsig
JDO	0.166 - 0.056	0.099 - 0.015	0.085 - 0.023
	nonsig	nonsig	nonsig
TAR	0.146 - 0.016	0.172 - 0.021	0.111 - 0.012
	nonsig	nonsig	nonsig

Hauraki Gulf

Species	1982	1984	1985	1986	1987	1988	1989	1990	1992	1993	1994	1997	2000	All years
GUR	0.039 - 0.014	0.041 - 0.042	0.339 - 0.112	0.056 - 0.044	0.04 - 0.08	0.049 - 0.02	0.132 - 0.099	0.103 - 0.019	0.058 - 0.085	0.088 - 0.039	0.06 - 0.138	0.069 - 0.071	0.219 - 0.179	0.016 - 0.014
	nonsig	**sig**	nonsig	nonsig	**sig**	nonsig	nonsig	nonsig	**sig**	nonsig	**sig**	**sig**	nonsig	nonsig
JDO	0.12 - 0.065	0.11 - 0.013	0.145 - 0.085	0.108 - 0.08	0.125 - 0.075	0.149 - 0.087	0.128 - 0.086	0.134 - 0.181	0.13 - 0.227	0.086 - 0.047	0.1 - 0.044	0.12 - 0.117	0.15 - 0.054	0.033 - 0.069
	nonsig	nonsig	nonsig	nonsig	nonsig	nonsig	nonsig	**sig**	**sig**	nonsig	nonsig	nonsig	nonsig	**sig**
TAR	0.533 - 0	0.377 - 0	0.679 - 0	1.921 - 0	1.109 - 0	0.429 - 0	0.466 - 0	0.419 - 0	0.286 - 0	0.312 - 0	0.244 - 0	0.233 - 0	0.096 - 0	0.071 - 0
	nonsig	nonsig	nonsig	nonsig	nonsig	nonsig	nonsig	nonsig	nonsig	nonsig	nonsig	nonsig	nonsig	nonsig

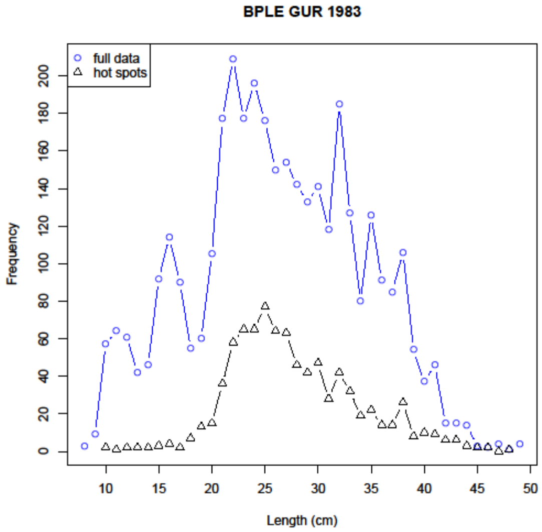
Bay of Plenty

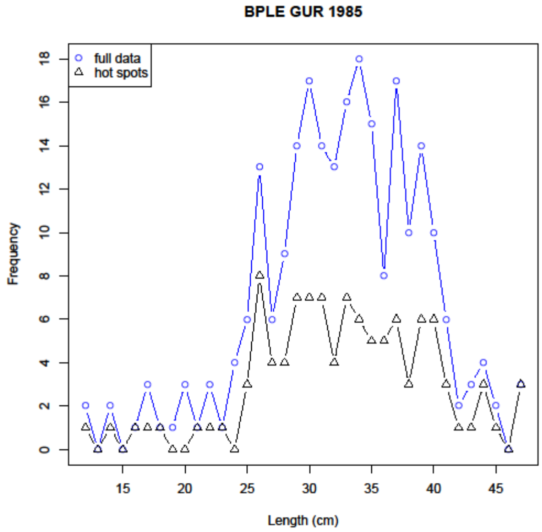
Species	1983	1985	1990	1992	1996	1999	All years
GUR	0.052 - 0.17	0.157 - 0.043	0.036 - 0.081	0.05 - 0.084	0.053 - 0.075	0.053 - 0.052	0.021 - 0.035
	significant	nonsig	**significant**	**significant**	**significant**	nonsig	**significant**
JDO	0.144 - 0.146	0.139 - 0.065	0.127 - 0.094	0.087 - 0.064	0.145 - 0.05	0.104 - 0.014	0.048 - 0.039
	significant	nonsig	nonsig	nonsig	nonsig	nonsig	nonsig
TAR	0.419 - 0	0.181 - 0.015	0.345 - 0	0.129 - 0.077	0.346 - 0.176	0.212 - 0.165	0.083 - 0.023
	nonsig	nonsig	nonsig	nonsig	nonsig	nonsig	nonsig

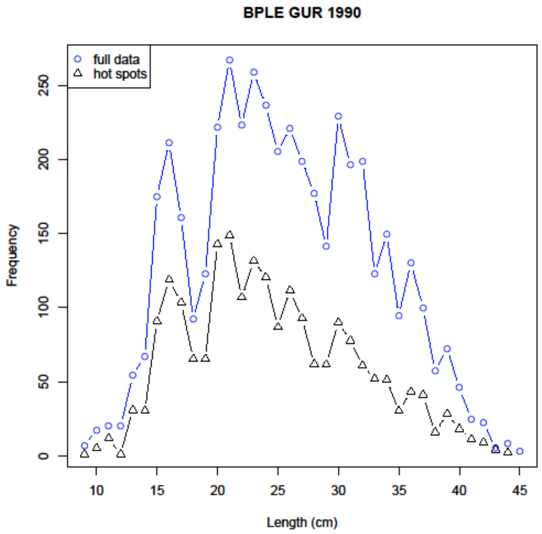
West coast of North Island

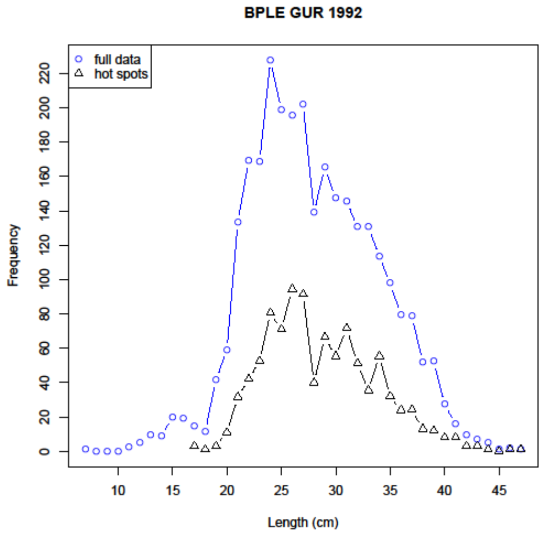
Species	1986	1987	1989	1991	1994	1996	1999	All years
GUR	0.028 - 0.02	0.033 - 0.112	0.025 - 0.141	0.021 - 0.084	0.022 - 0.048	0.018 - 0.127	0.023 - 0.151	0.009 - 0.08
	nonsig	**significant**	**significant**	**significant**	**significant**	**significant**	**significant**	**significant**
JDO	0.152 - 0.022	0.201 - 0.039	0.14 - 0.082	0.11 - 0.053	0.16 - 0.055	0.101 - 0.04	0.121 - 0.091	0.049 - 0.054
	nonsig	nonsig	nonsig	nonsig	nonsig	nonsig	nonsig	**significant**
TAR	0.179 - 0.04	0.573 - 0.111	0.201 - 0.068	0.13 - 0.08	0.238 - 0.037	0.093 - 0.057	0.077 - 0.037	0.049 - 0.029
	nonsig	nonsig	nonsig	nonsig	nonsig	nonsig	nonsig	nonsig

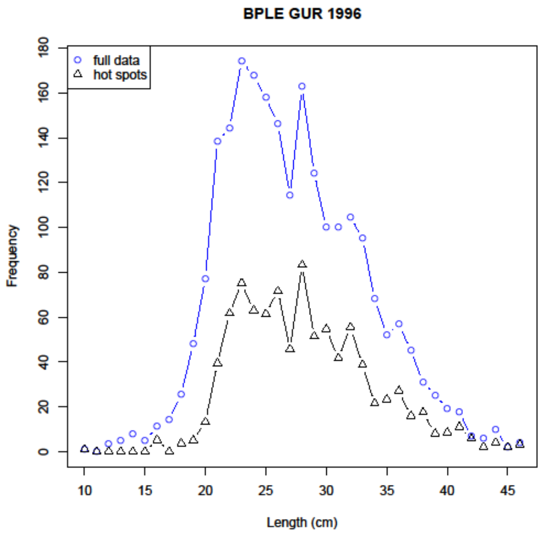
8.7. APPENDIX G: Length frequency distributions and cumulative frequency curves for each year

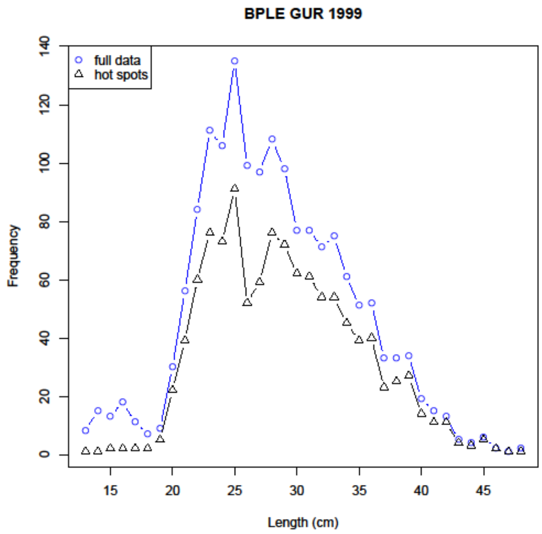


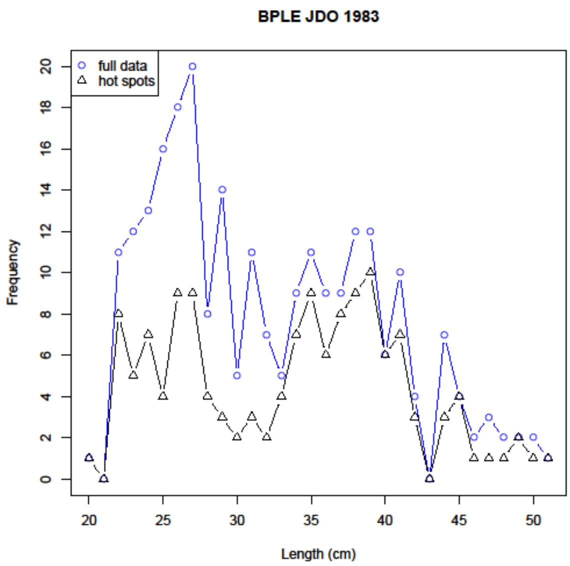


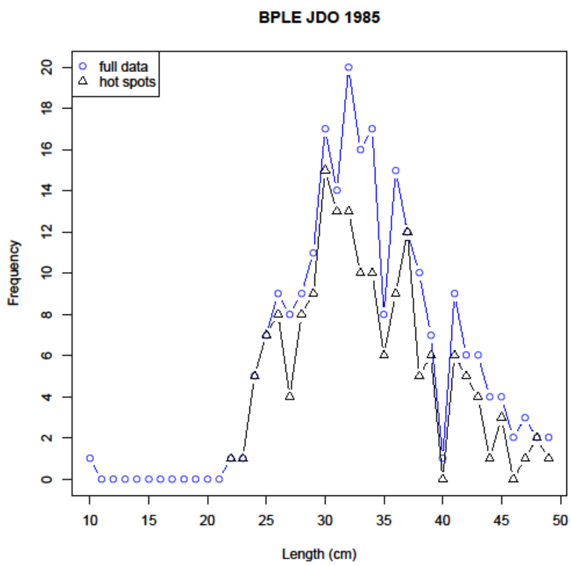


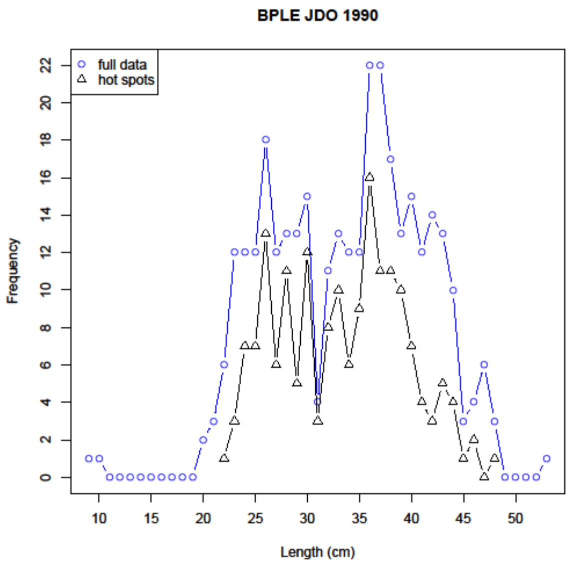


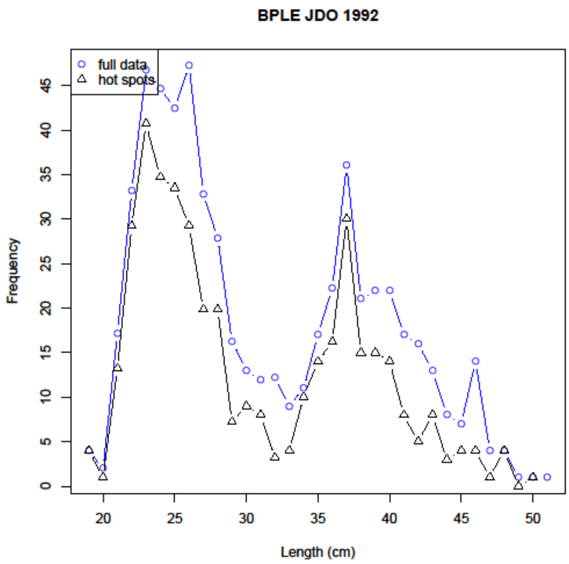


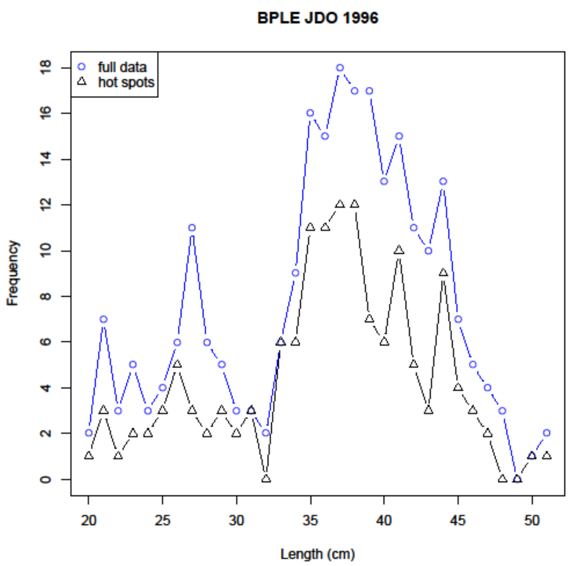


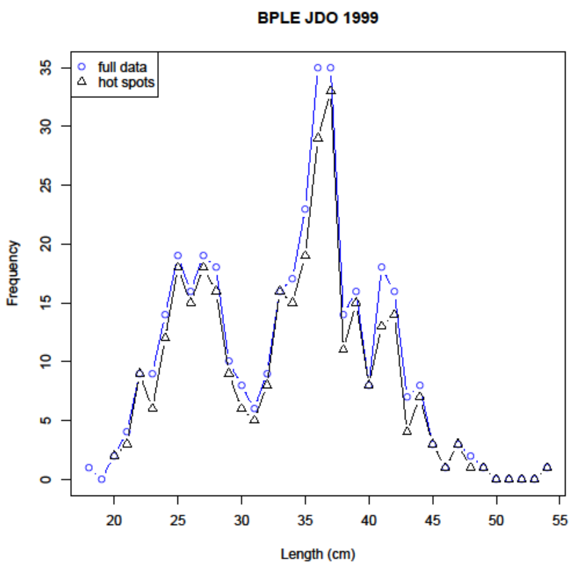

BPLE JDO 1983
full data
hot spots
Frequency
Length (cm)

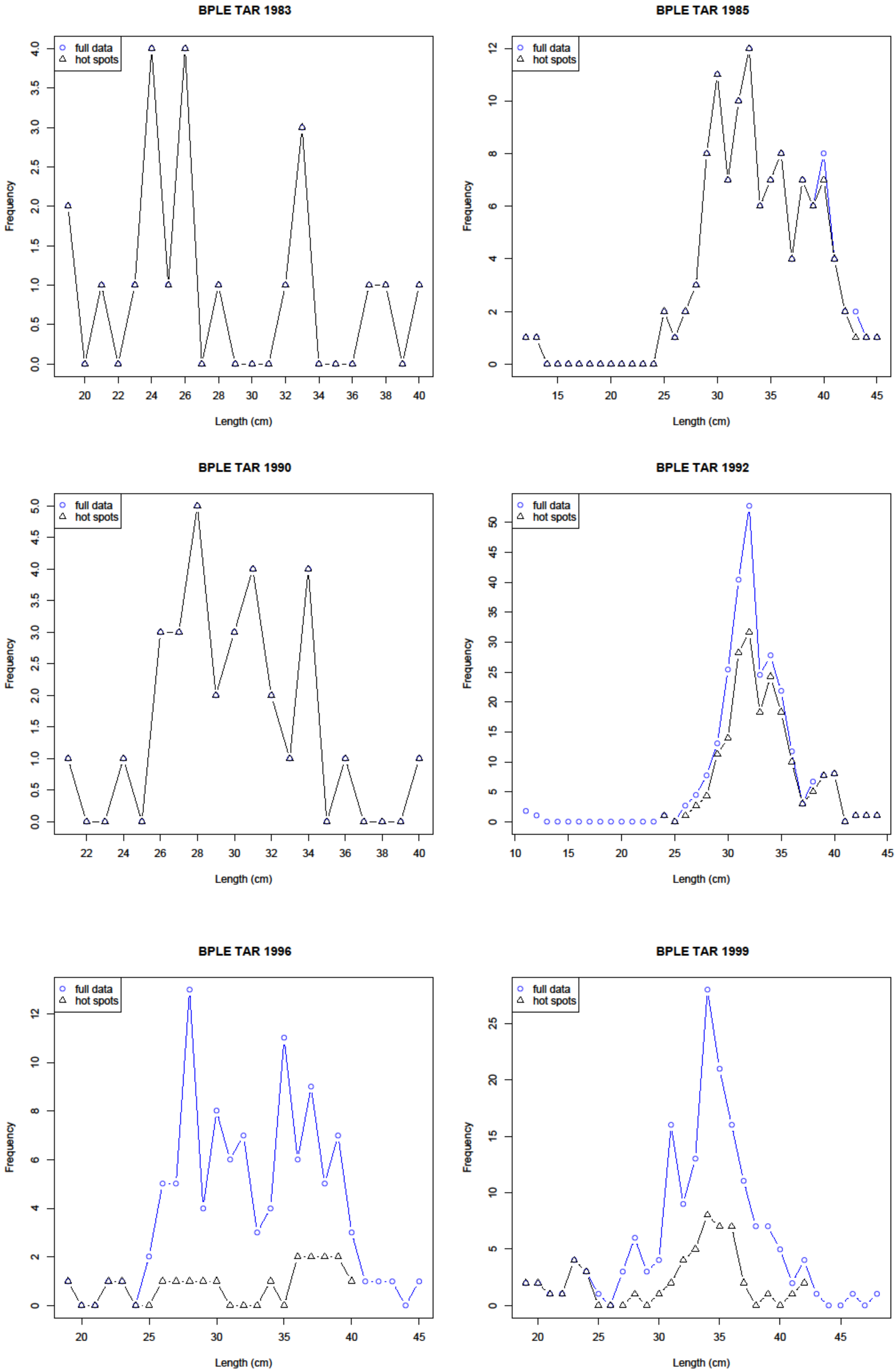

BPLE JDO 1985
full data
hot spots
Frequency
Length (cm)

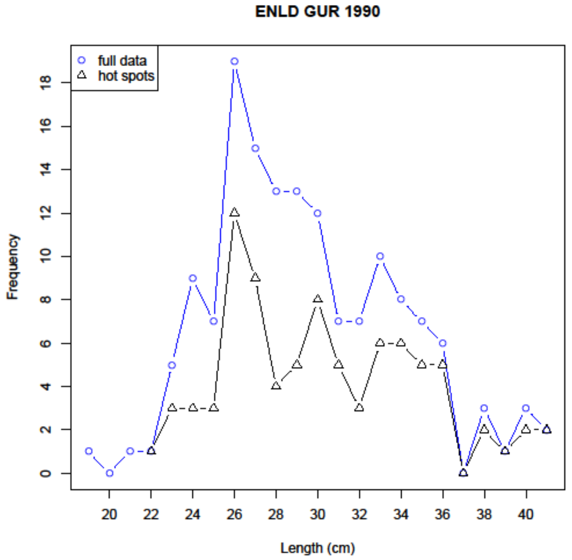

BPLE JDO 1990
full data
hot spots
Frequency
Length (cm)

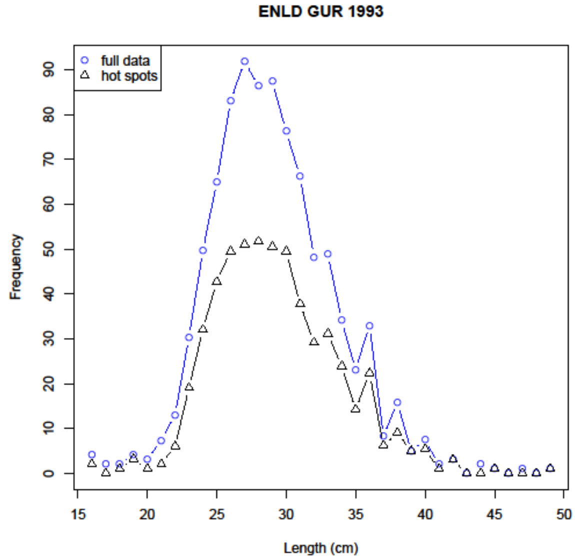

BPLE JDO 1992
full data
hot spots
Frequency
Length (cm)


BPLE JDO 1996
full data
hot spots
Frequency
Length (cm)


BPLE JDO 1999
full data
hot spots
Frequency
Length (cm)


BPLE TAR 1983
BPLE TAR 1985
BPLE TAR 1990
BPLE TAR 1992
BPLE TAR 1996
BPLE TAR 1999
full data
hot spots
Frequency
Length (cm)


ENLD GUR 1990
full data
hot spots
Frequency
Length (cm)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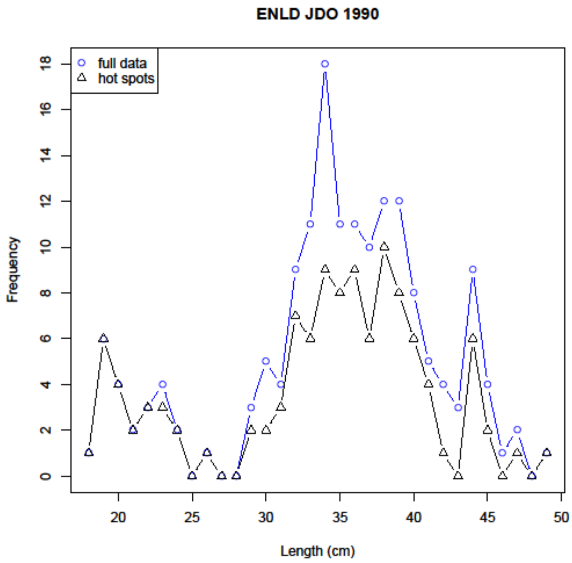
full data
hot spots
Frequency
Length (cm)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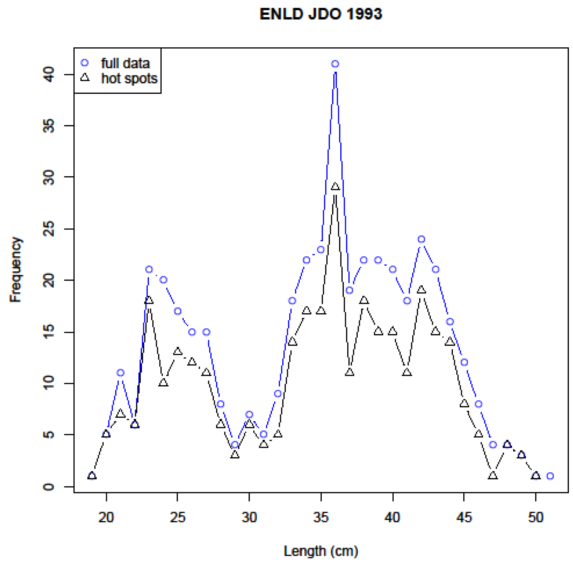
hot spots
Frequency
Length (cm)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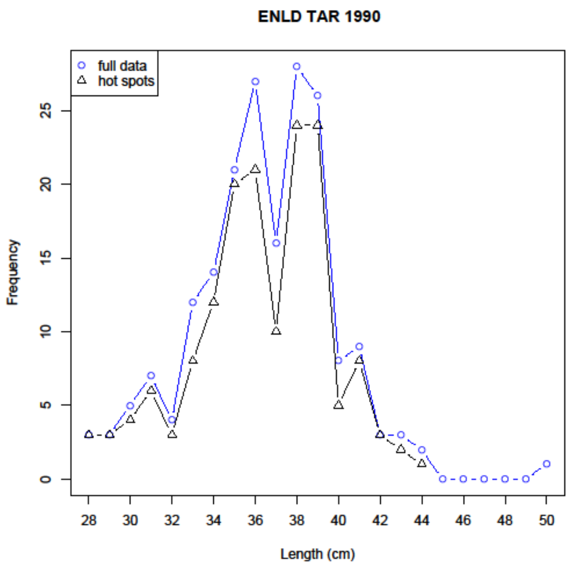
hot spots
Frequency
Length (cm)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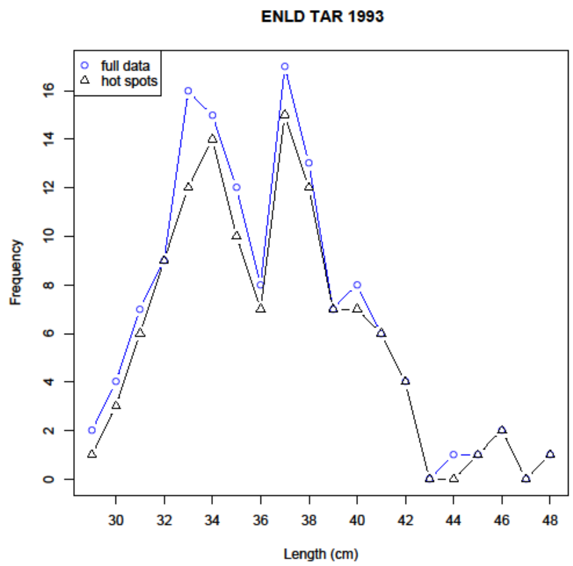
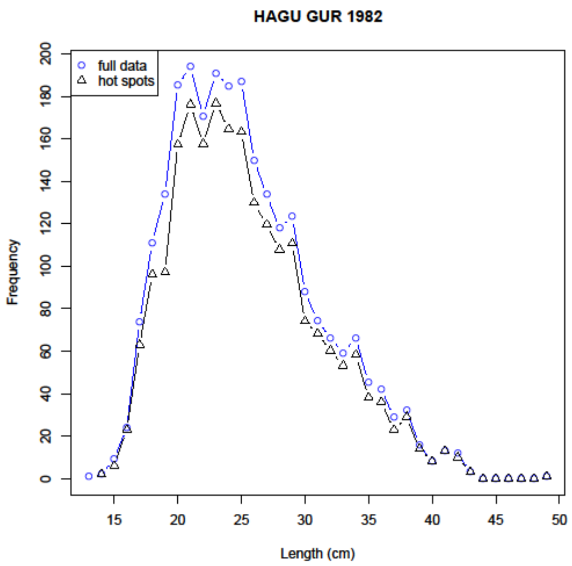
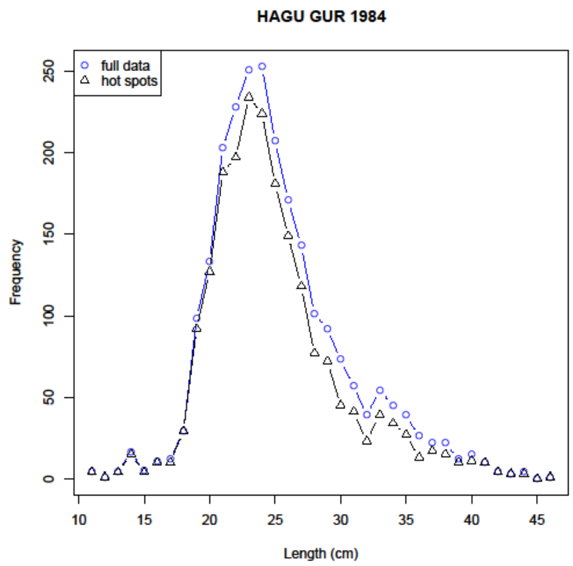
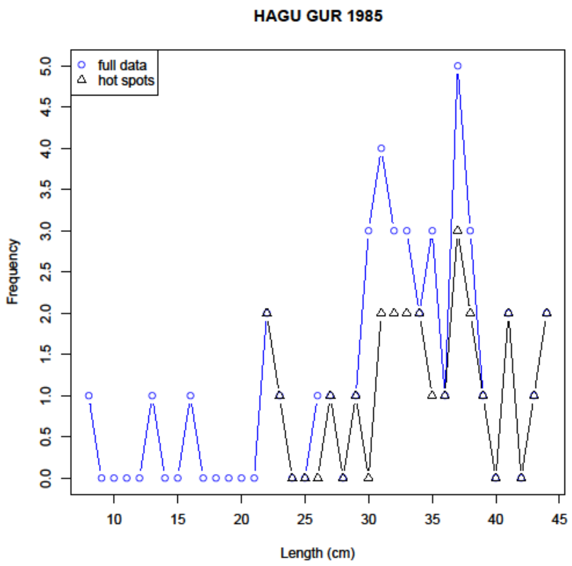
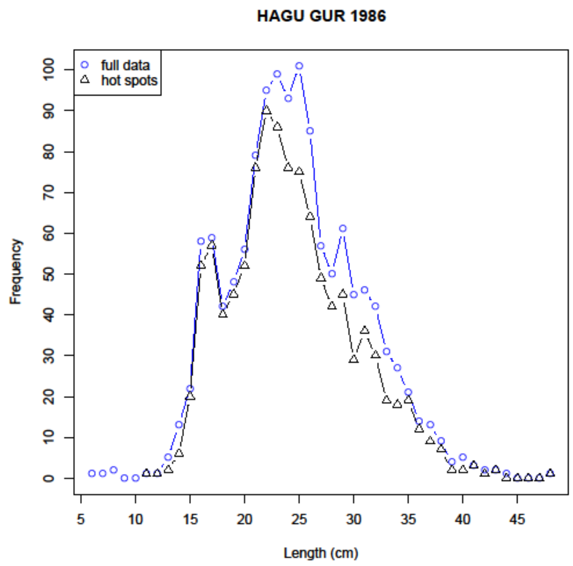
full data
hot spots
Frequency
Length (cm)

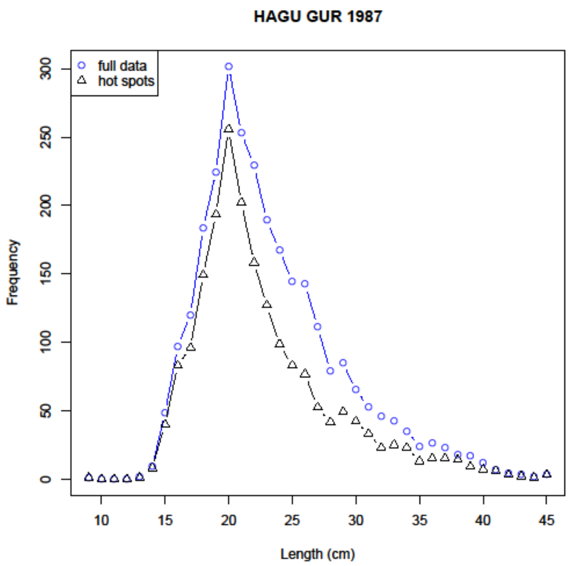

ENLD TAR 1993
full data
hot spots
Frequency
Length (cm)


HAGU GUR 1982
full data
hot spots
Frequency
Length (cm)


HAGU GUR 1984
full data
hot spots
Frequency
Length (cm)


HAGU GUR 1985
full data
hot spots
Frequency
Length (cm)


HAGU GUR 1986
full data
hot spots
Frequency
Length (cm)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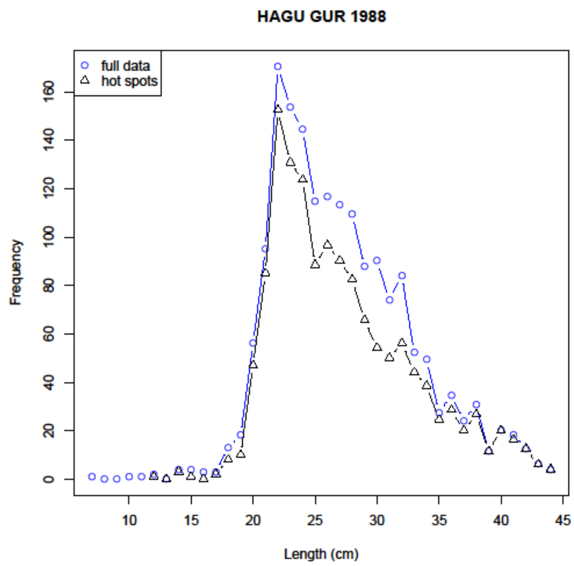
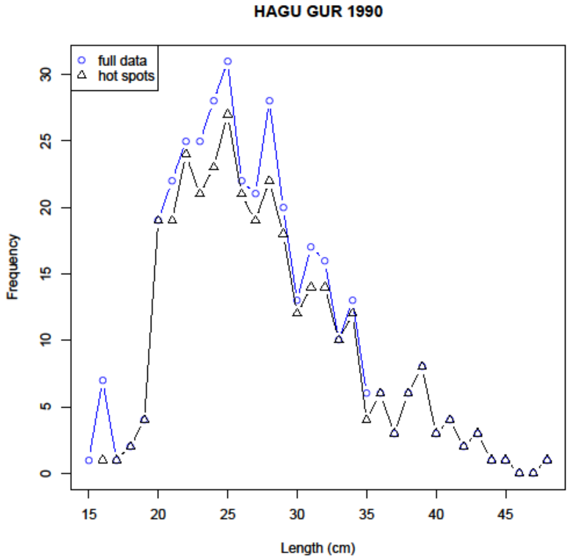
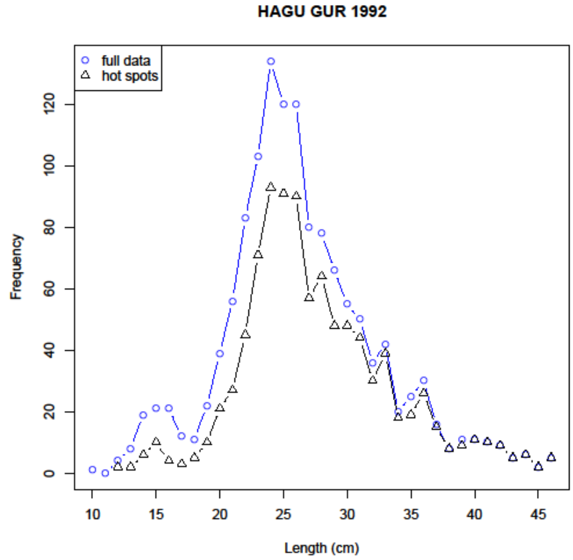
hot spots
Frequency
Length (cm)


HAGU GUR 1988
full data
hot spots
Frequency
Length (cm)


HAGU GUR 1990
full data
hot spots
Frequency
Length (cm)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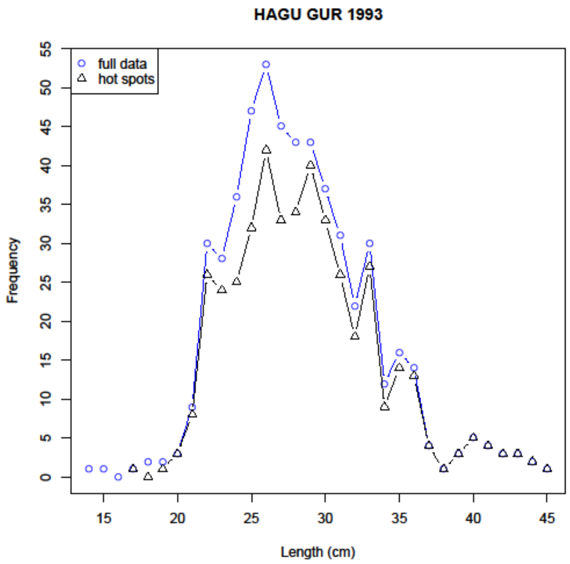
hot spots
Frequency
Length (cm)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Frequency
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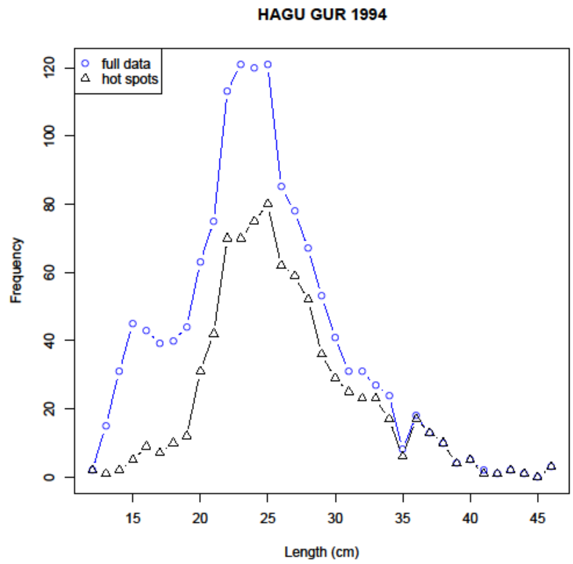
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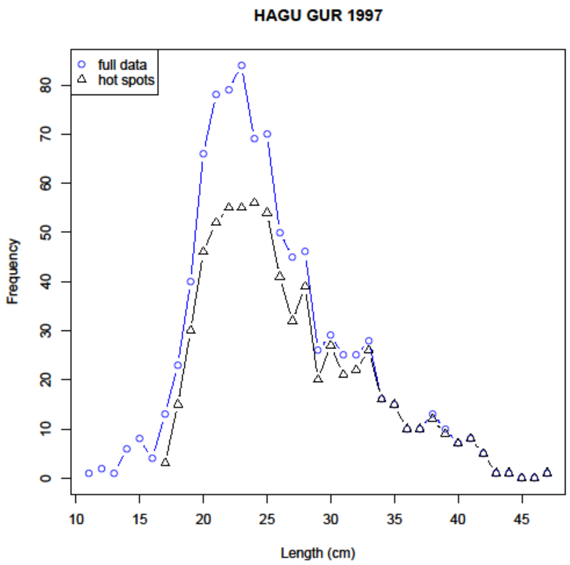
Length (cm)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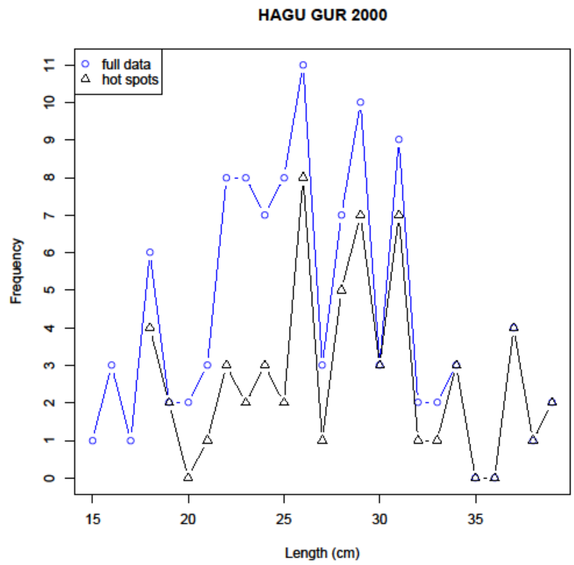
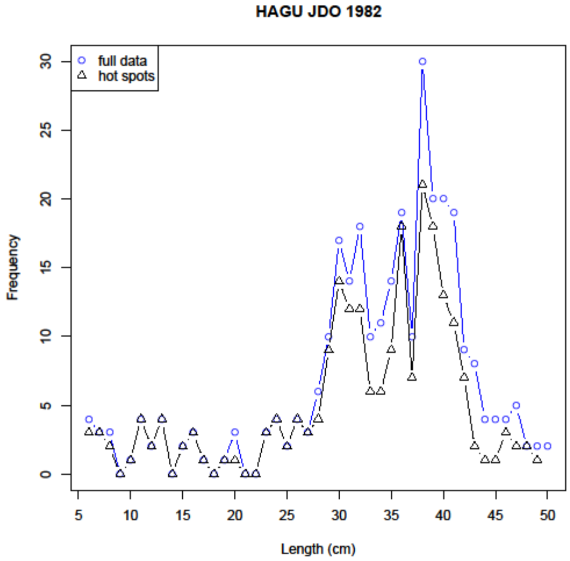
full data
hot spots
Frequency
Length (cm)


HAGU GUR 2000
full data
hot spots
Frequency
Length (cm)


HAGU JDO 1982
full data
hot spots
Frequency
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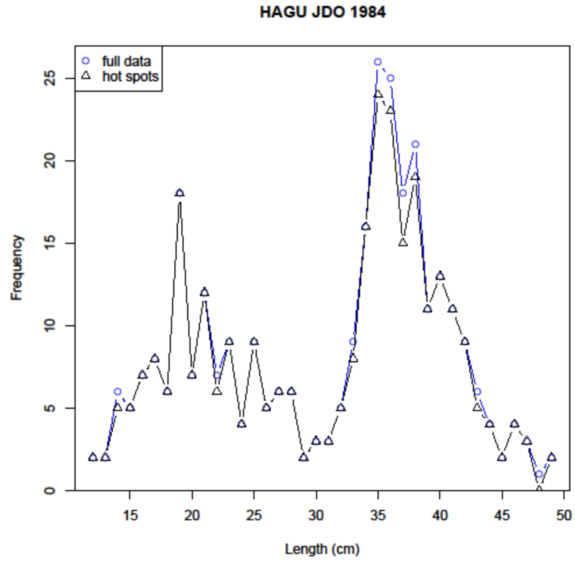
5 10 15 20 25 30 35 40 45 50
Length (cm)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hot spots
Frequency
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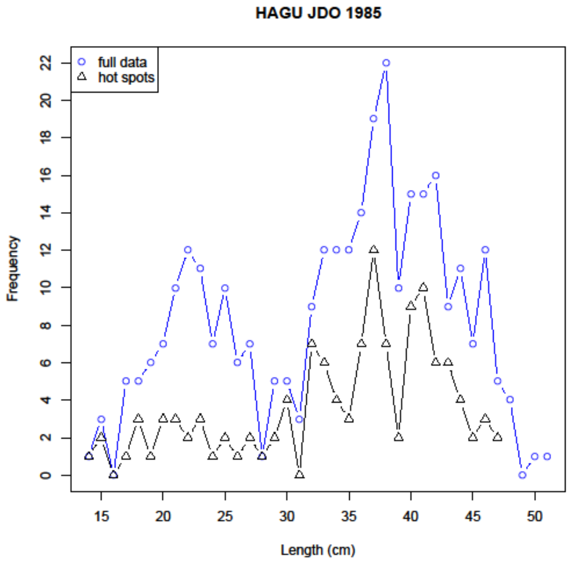
Length (cm)


HAGU JDO 1985
full data
hot spots
Frequency
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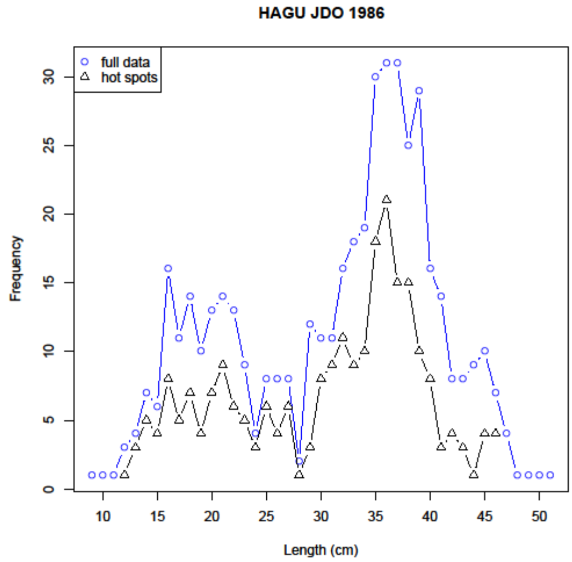
15 20 25 30 35 40 45 50
Length (cm)


HAGU JDO 1986
full data
hot spots
Frequency
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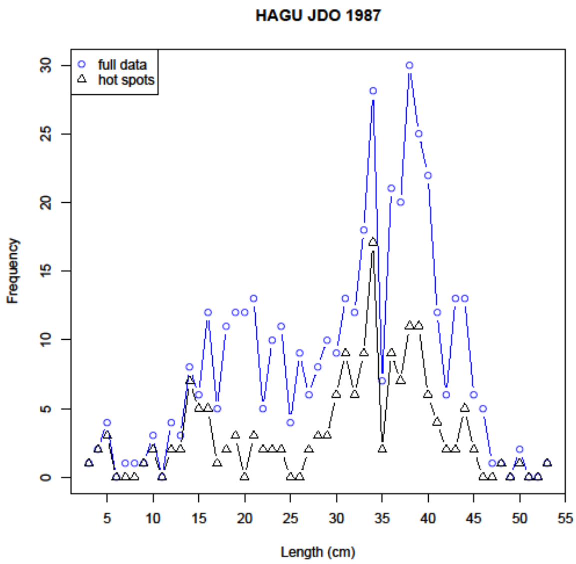
10 15 20 25 30 35 40 45 50
Length (cm)


HAGU JDO 1987
full data
hot spots
Frequency
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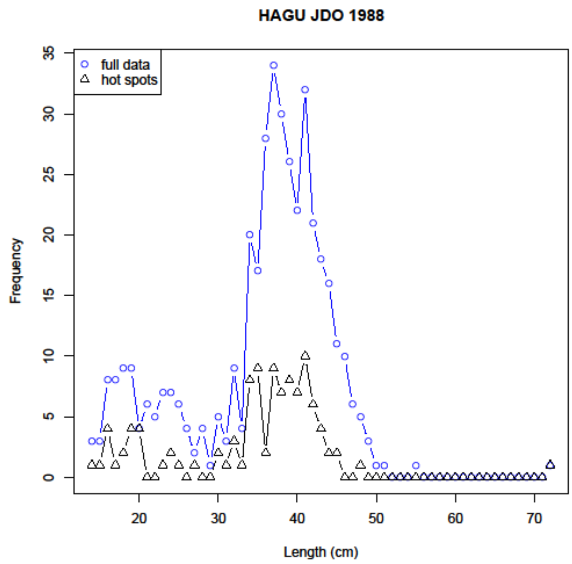
5 10 15 20 25 30 35 40 45 50 55
Length (cm)


HAGU JDO 1988
full data
hot spots
Frequency
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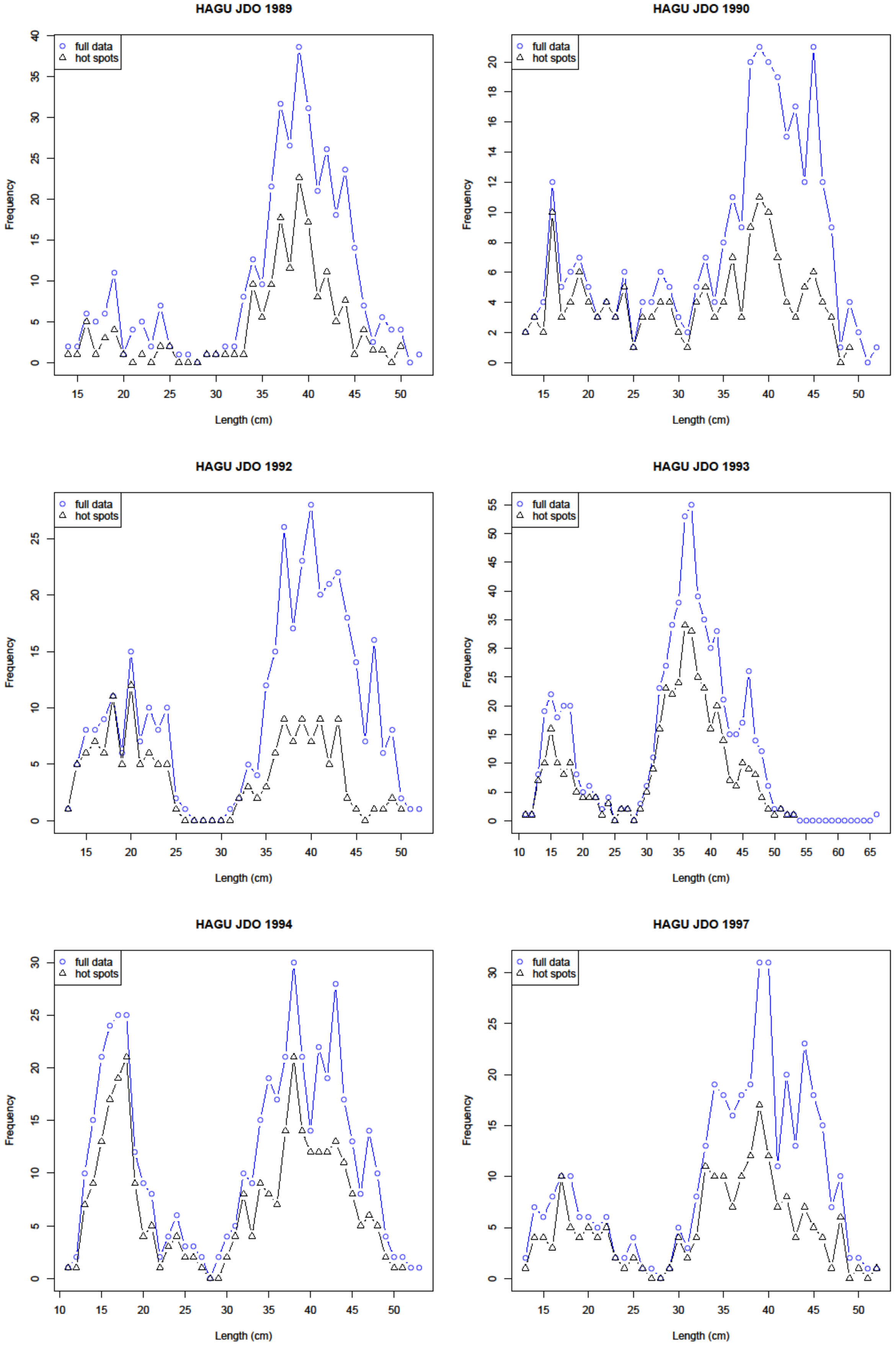
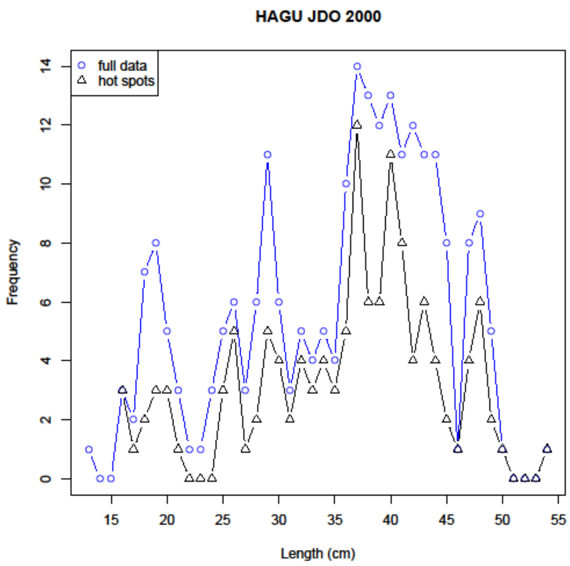
20 30 40 50 60 70
Length (cm)


HAGU JDO 1989
HAGU JDO 1990
HAGU JDO 1992
HAGU JDO 1993
HAGU JDO 1994
HAGU JDO 1997
full data
hot spots
Frequency
Length (cm)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hot spots
Frequency
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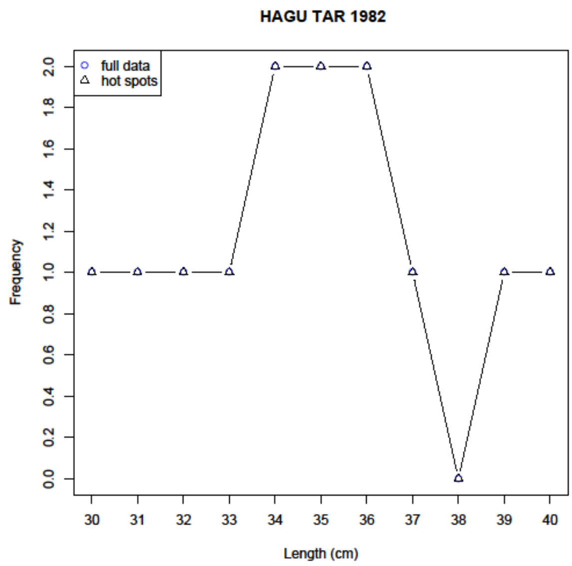
Length (cm)


HAGU TAR 1982
full data
hot spots
Frequency
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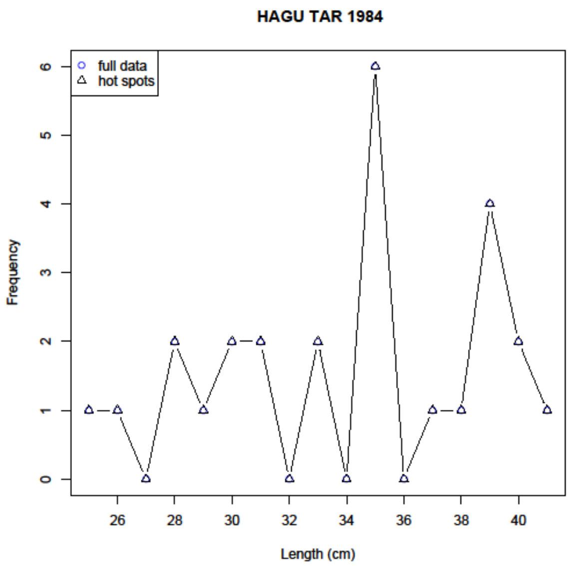
Length (cm)


HAGU TAR 1984
full data
hot spots
Frequency
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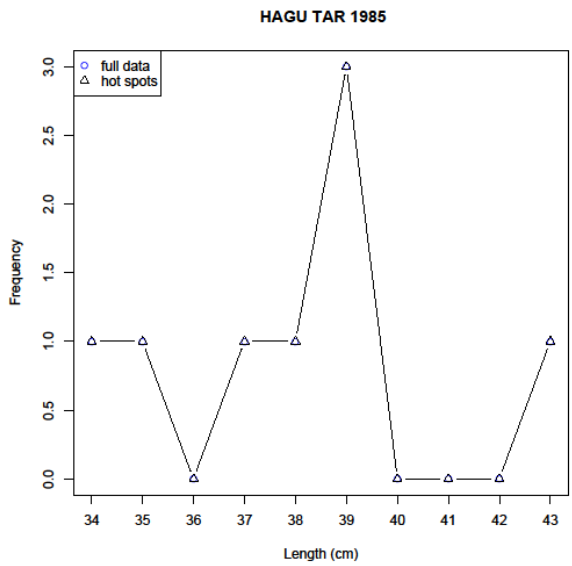
Length (cm)


HAGU TAR 1985
full data
hot spots
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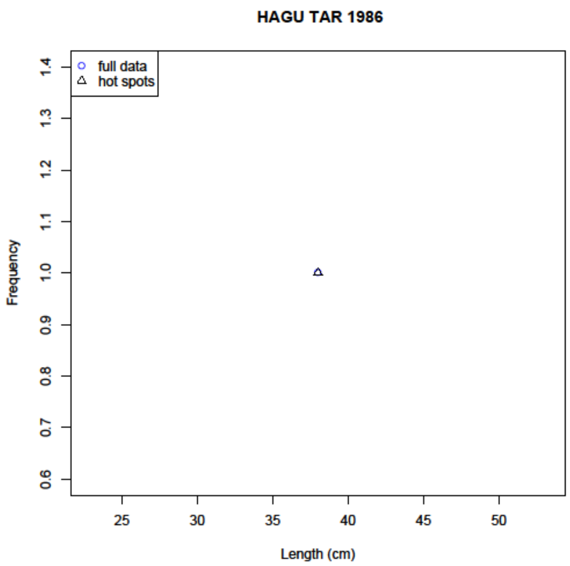
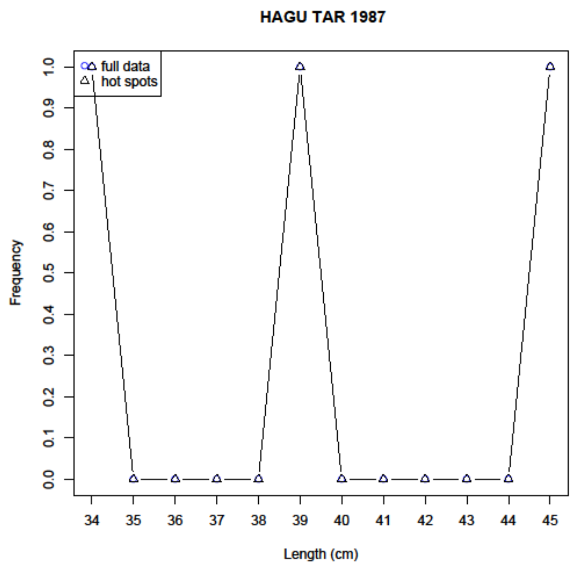
Length (cm)


HAGU TAR 1986
full data
hot spots
Frequency
0.6 0.7 0.8 0.9 1.0 1.1 1.2 1.3 1.4
25 30 35 40 45 50
Length (cm)


HAGU TAR 1987
full data
hot spots
Frequency
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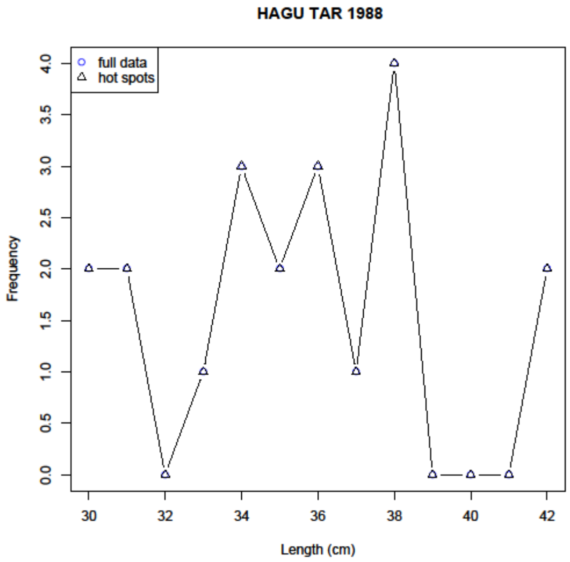
Length (cm)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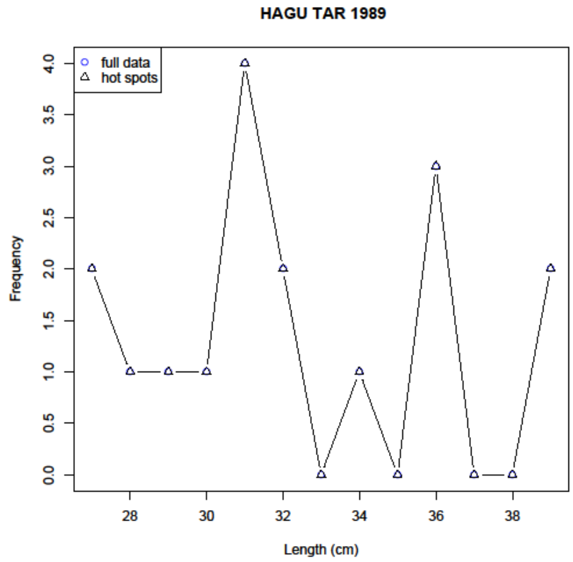
hot spots
Frequency
Length (cm)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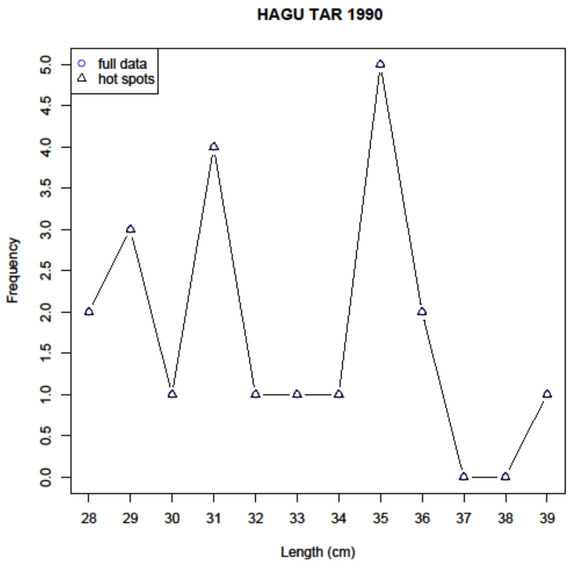
hot spots
Frequency
Length (cm)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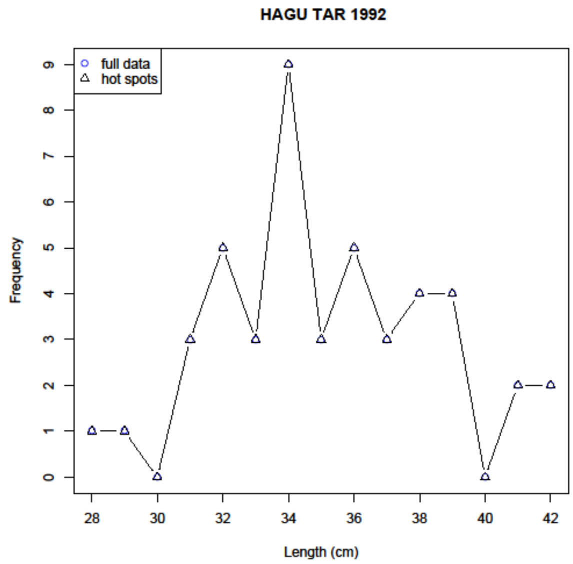
hot spots
Frequency
Length (cm)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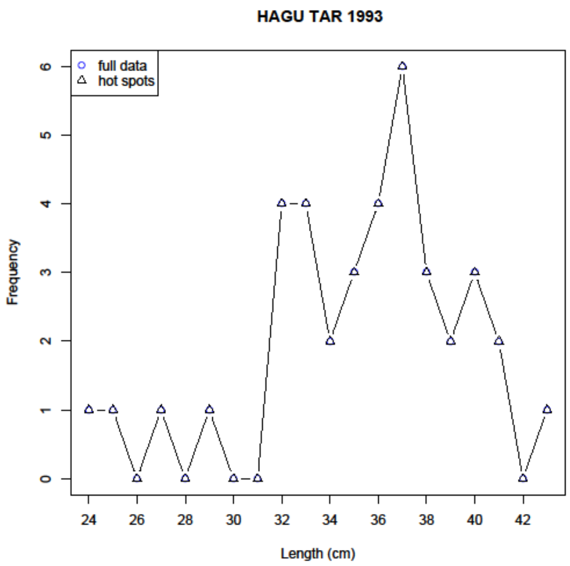
full data
hot spots
Frequency
Length (cm)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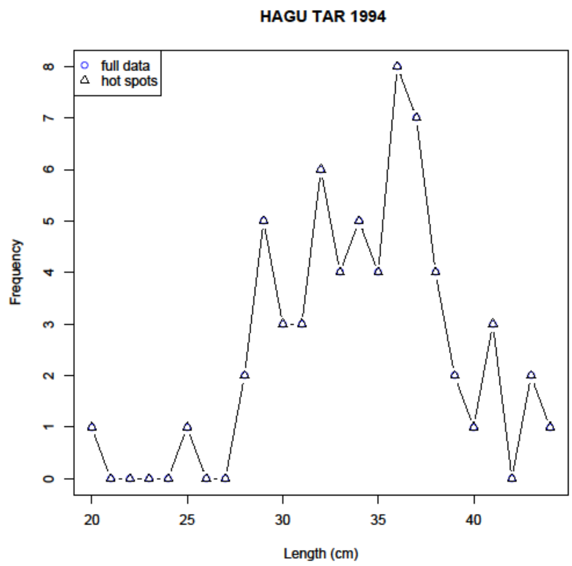
full data
hot spots
Frequency
Length (cm)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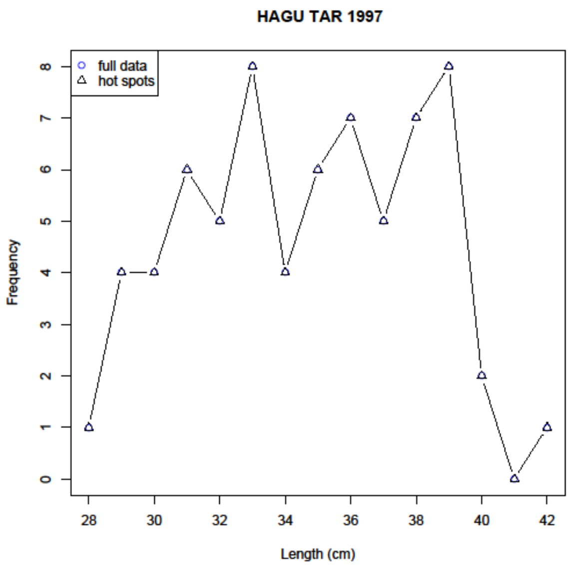
Length (cm)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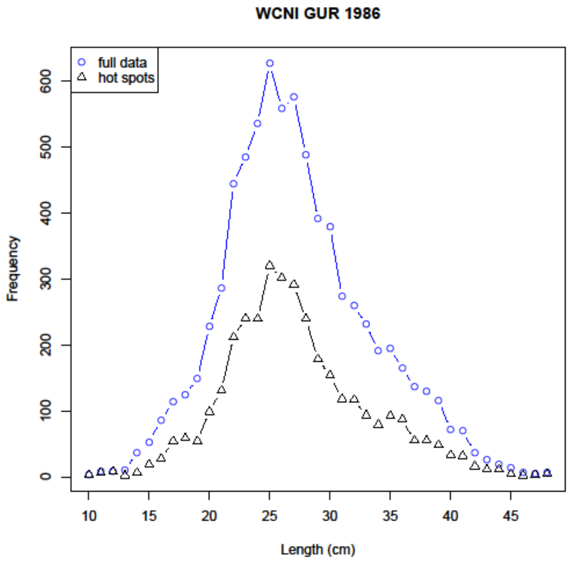
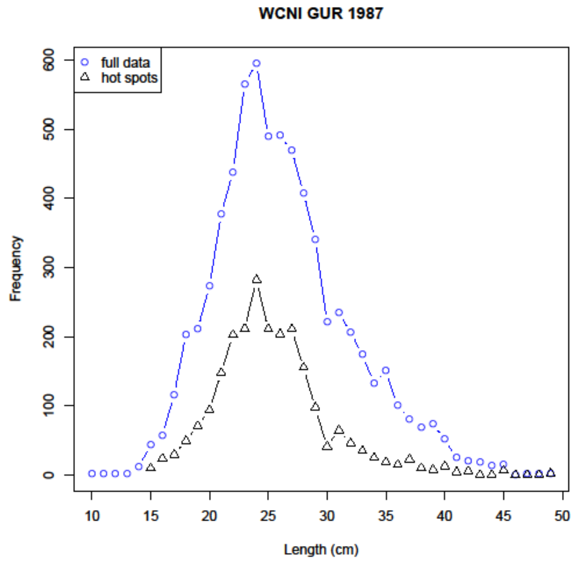
hot spots
Frequency
Length (cm)


WCNI GUR 1986
full data
hot spots
Frequency
Length (cm)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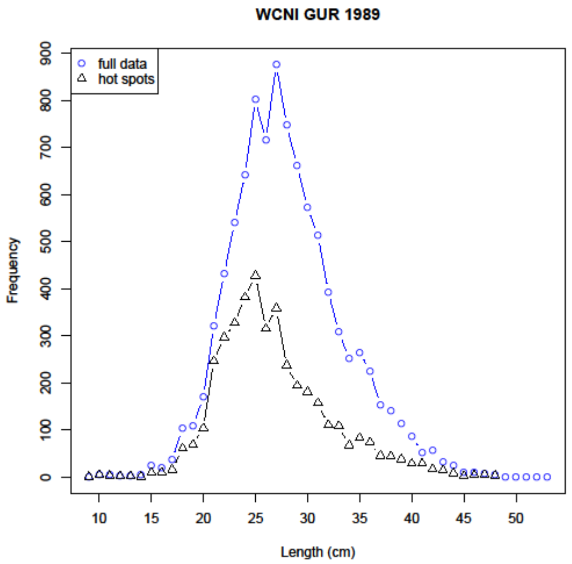
hot spots
Frequency
Length (cm)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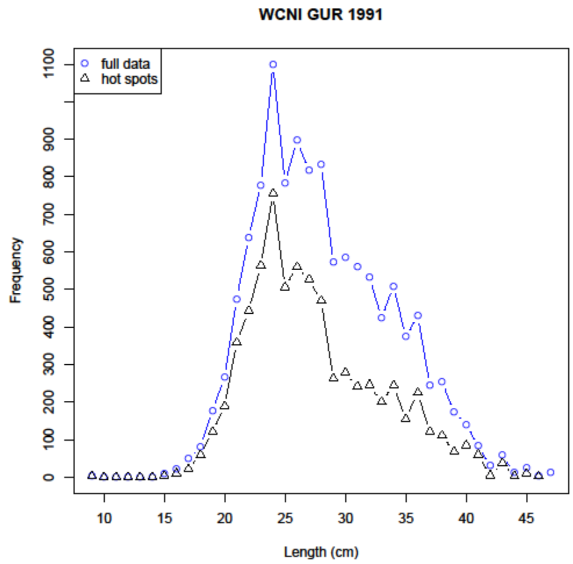
hot spots
Frequency
Length (cm)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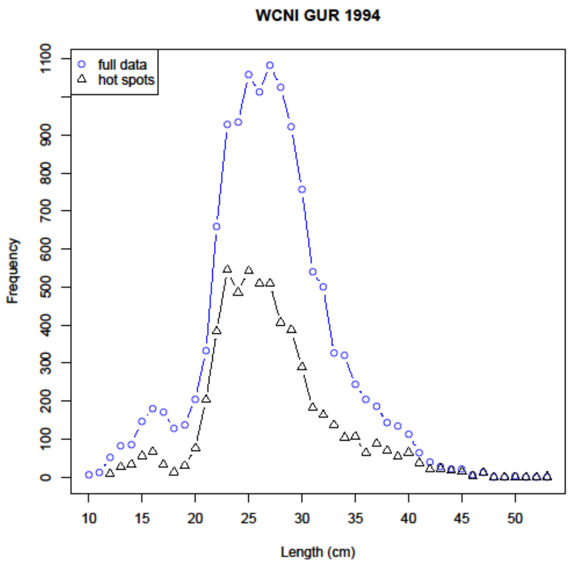
hot spots
Frequency
Length (cm)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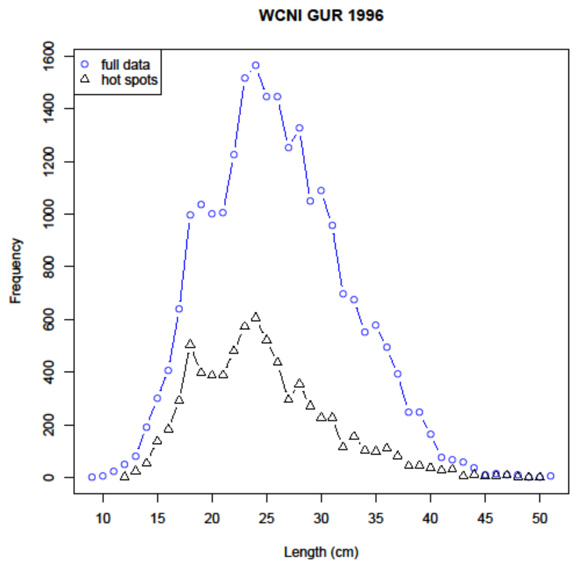
full data
hot spots
Frequency
Length (cm)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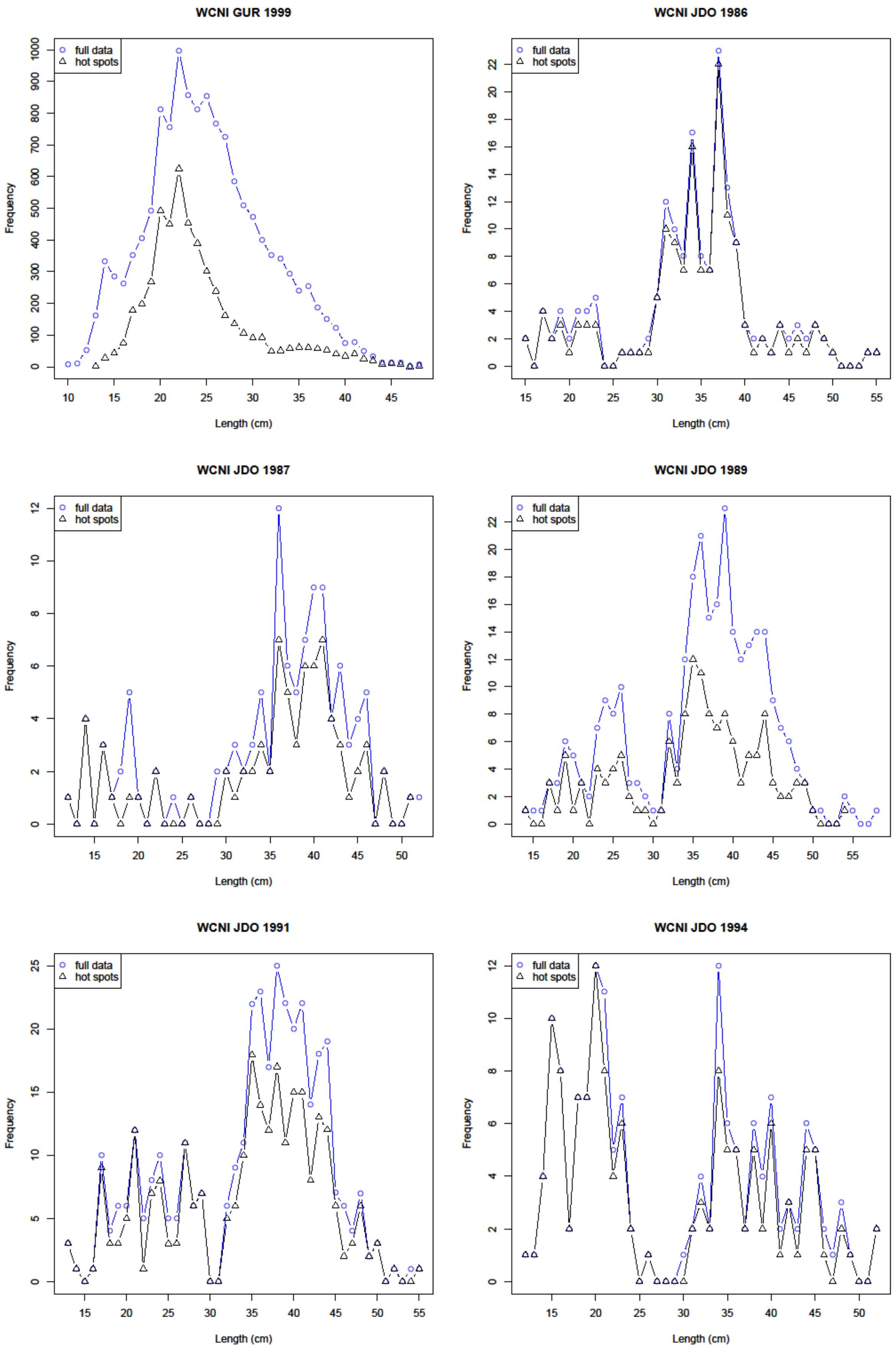
full data
hot spots
Frequency
Length (cm)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WCNI JDO 1994
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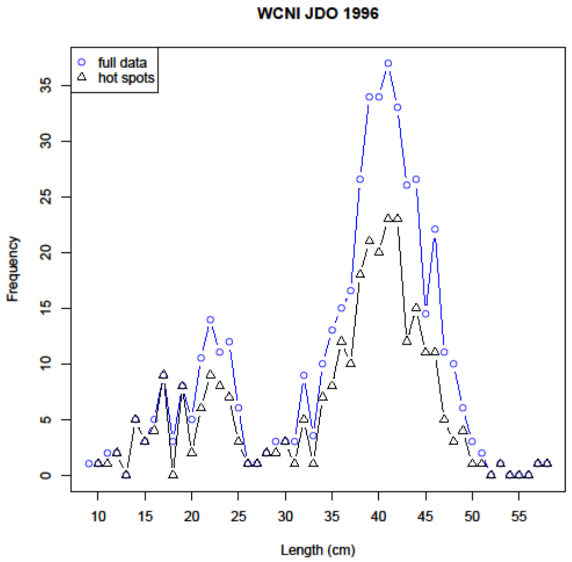
hot spots
Frequency
Length (cm)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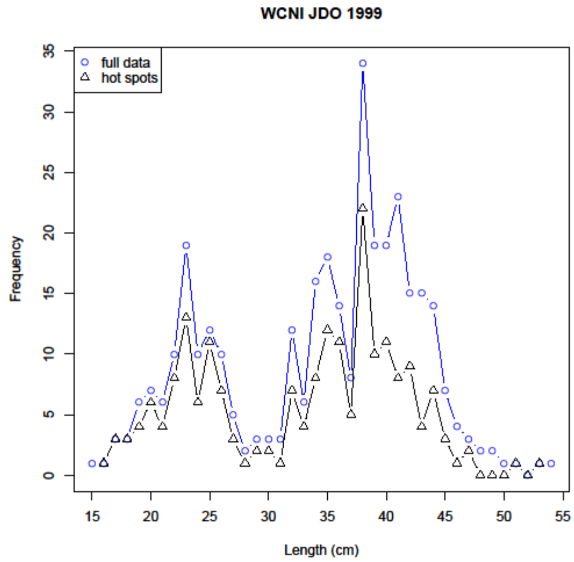
Frequency
Length (cm)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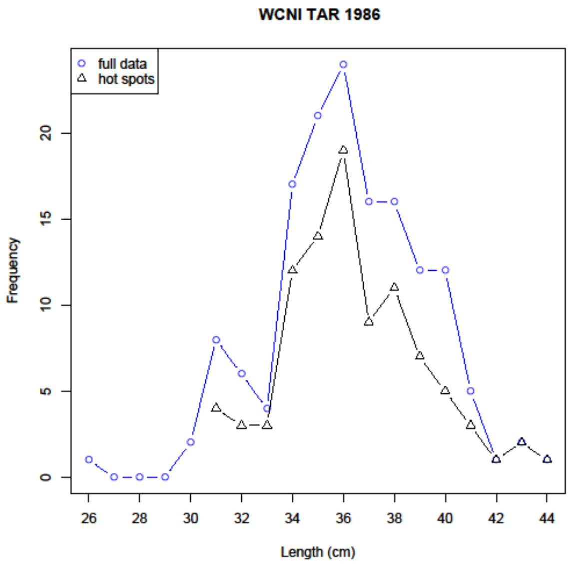
Length (cm)


WCNI TAR 1986
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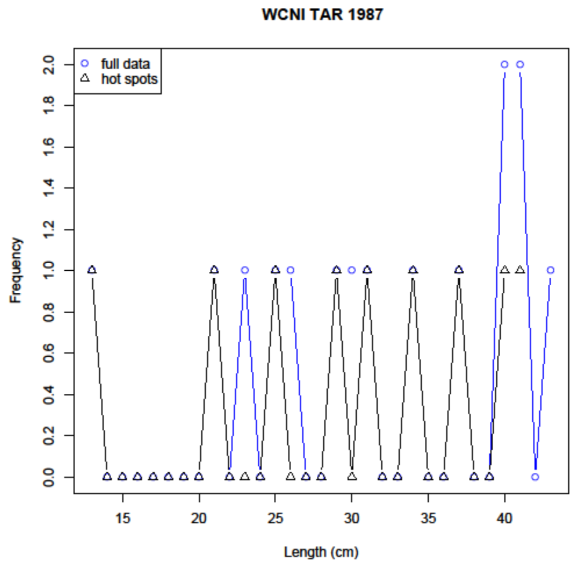
hot spots
Frequency
Length (cm)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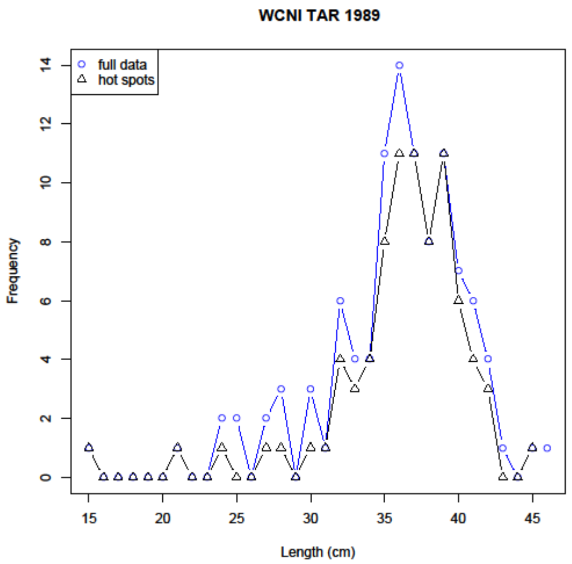
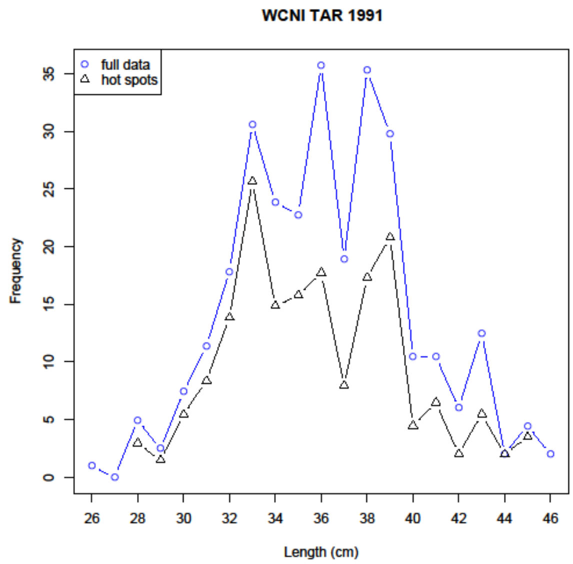
full data
hot spots
Frequency
Length (cm)


WCNI TAR 1989
full data
hot spots
Frequency
Length (cm)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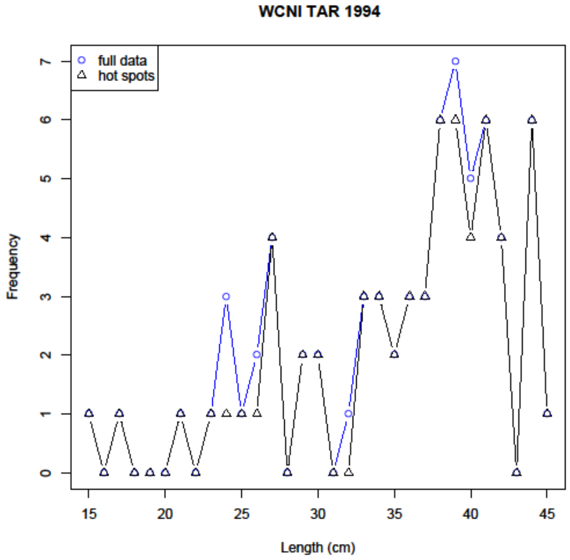
Frequency
Length (cm)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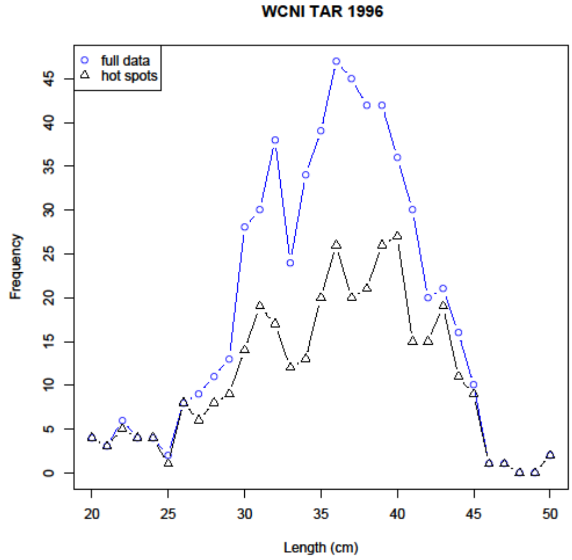
Length (cm)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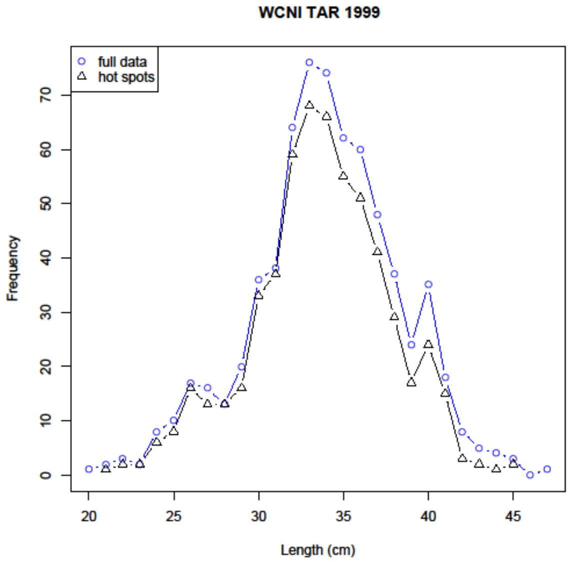
hot spots
Frequency
Length (cm)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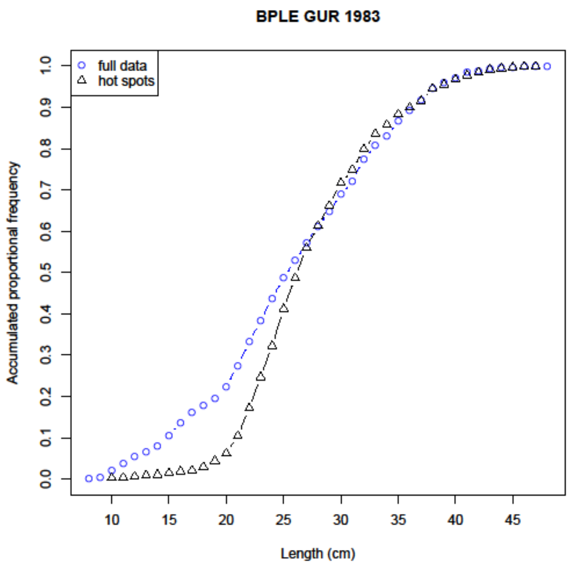
full data
hot spots
Frequency
Length (cm)


BPLE GUR 1983
full data
hot spots
Accumulated proportional frequency
Length (cm)
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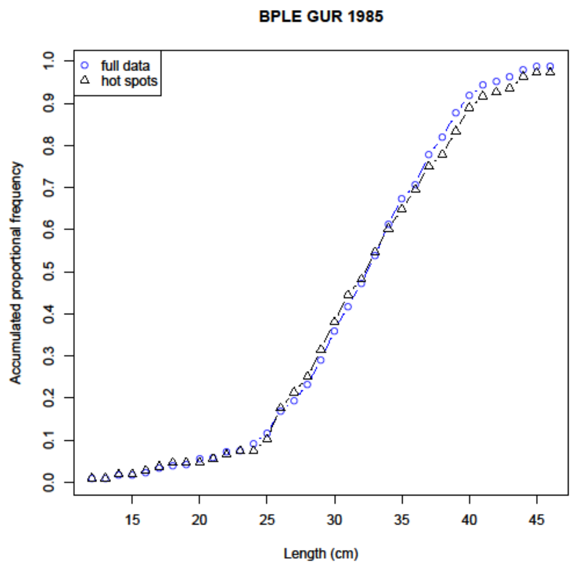
BPLE GUR 1985
full data
hot spots
Accumulated proportional frequency
Length (cm)
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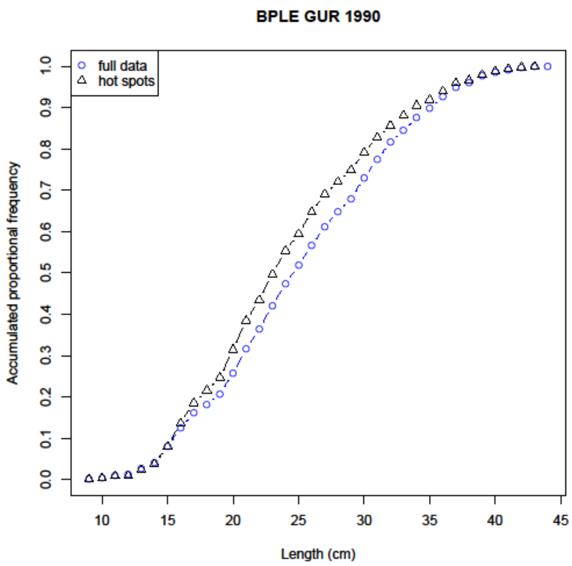
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Accumulated proportional frequency
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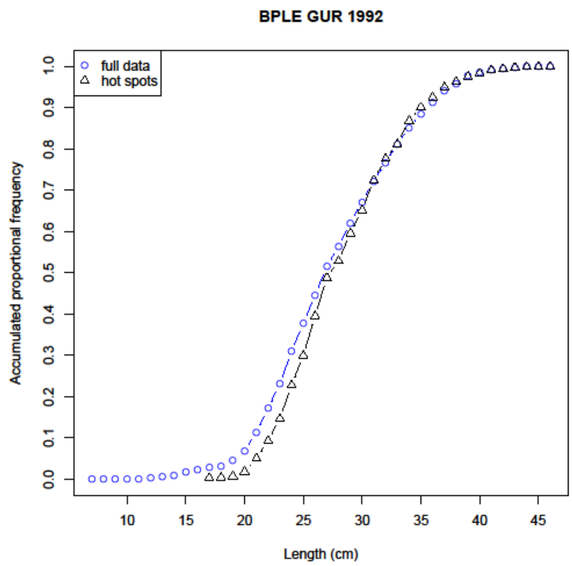
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Accumulated proportional frequency
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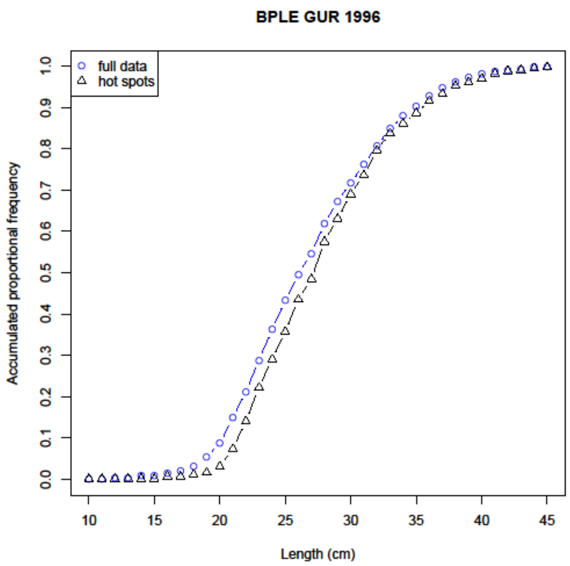
BPLE GUR 1996
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Accumulated proportional frequency
Length (cm)
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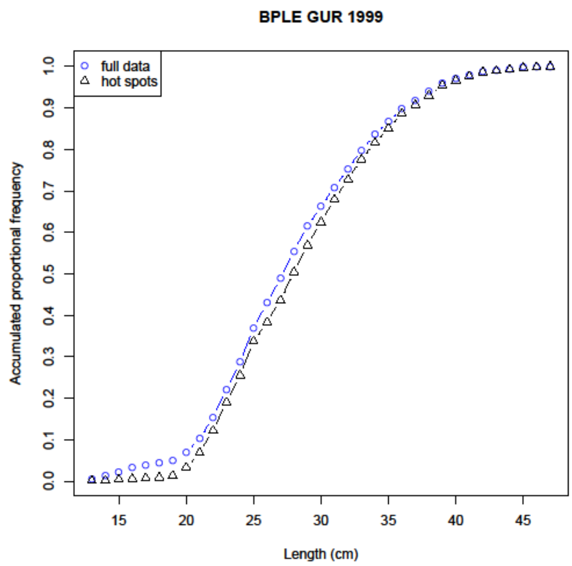
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Accumulated proportional frequency
Length (cm)
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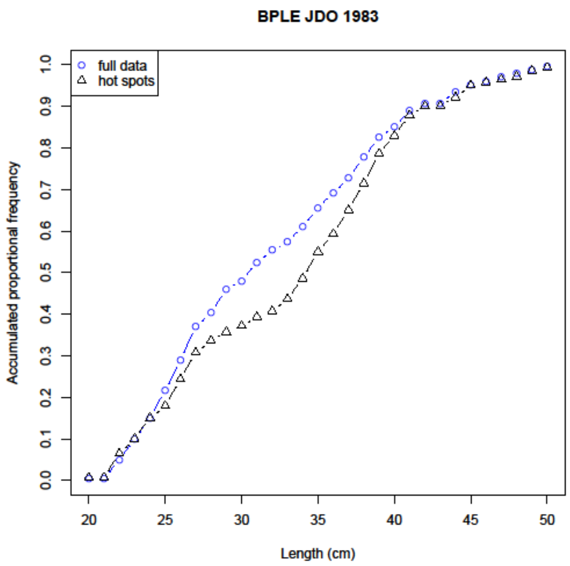
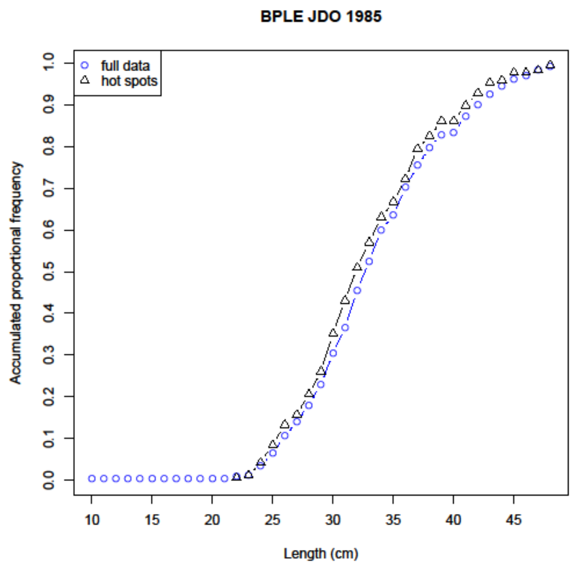

BPLE JDO 1983
full data
hot spots
Accumulated proportional frequency
Length (cm)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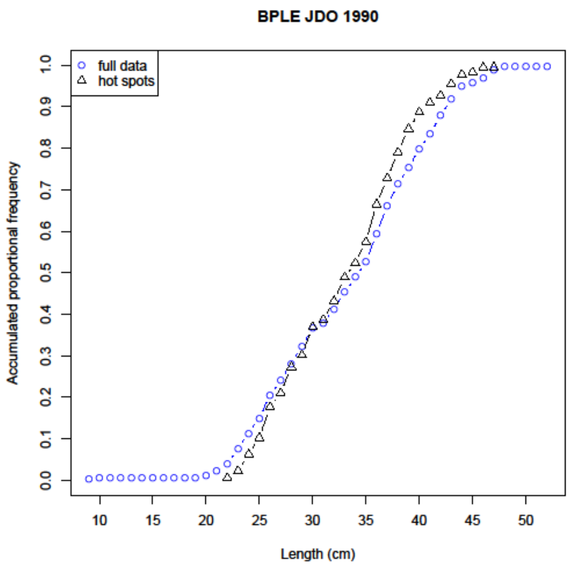
Accumulated proportional frequency
Length (cm)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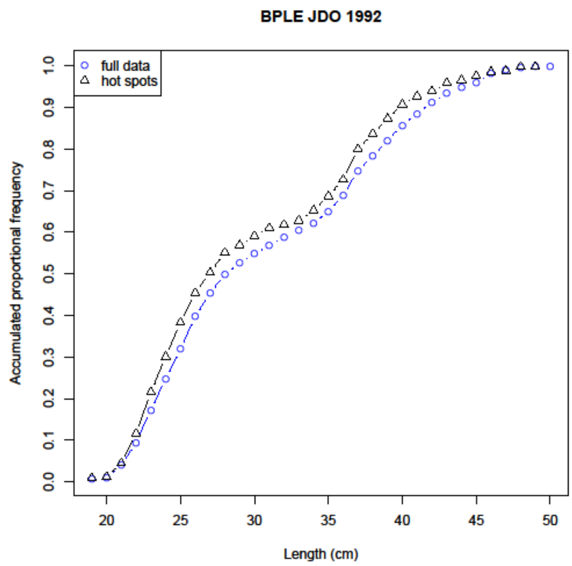
Accumulated proportional frequency
Length (cm)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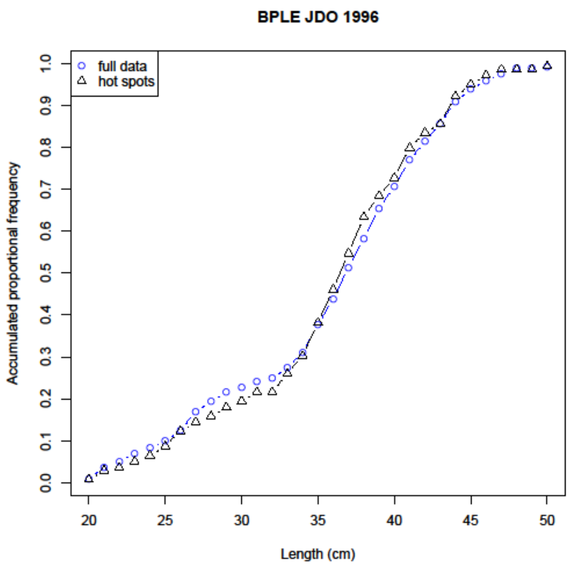
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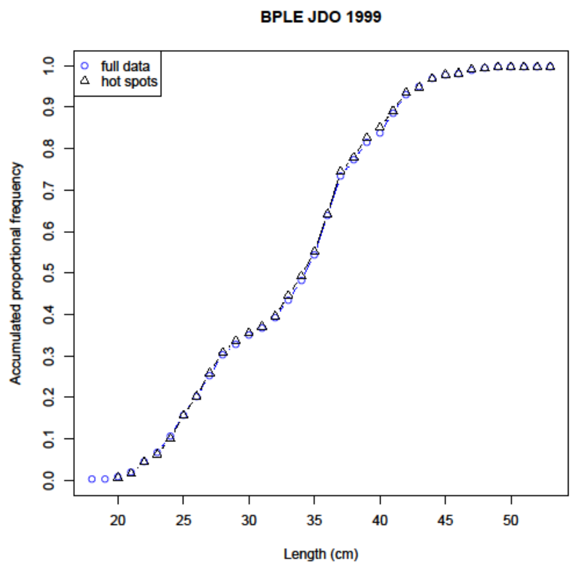
Accumulated proportional frequency
Length (cm)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full data
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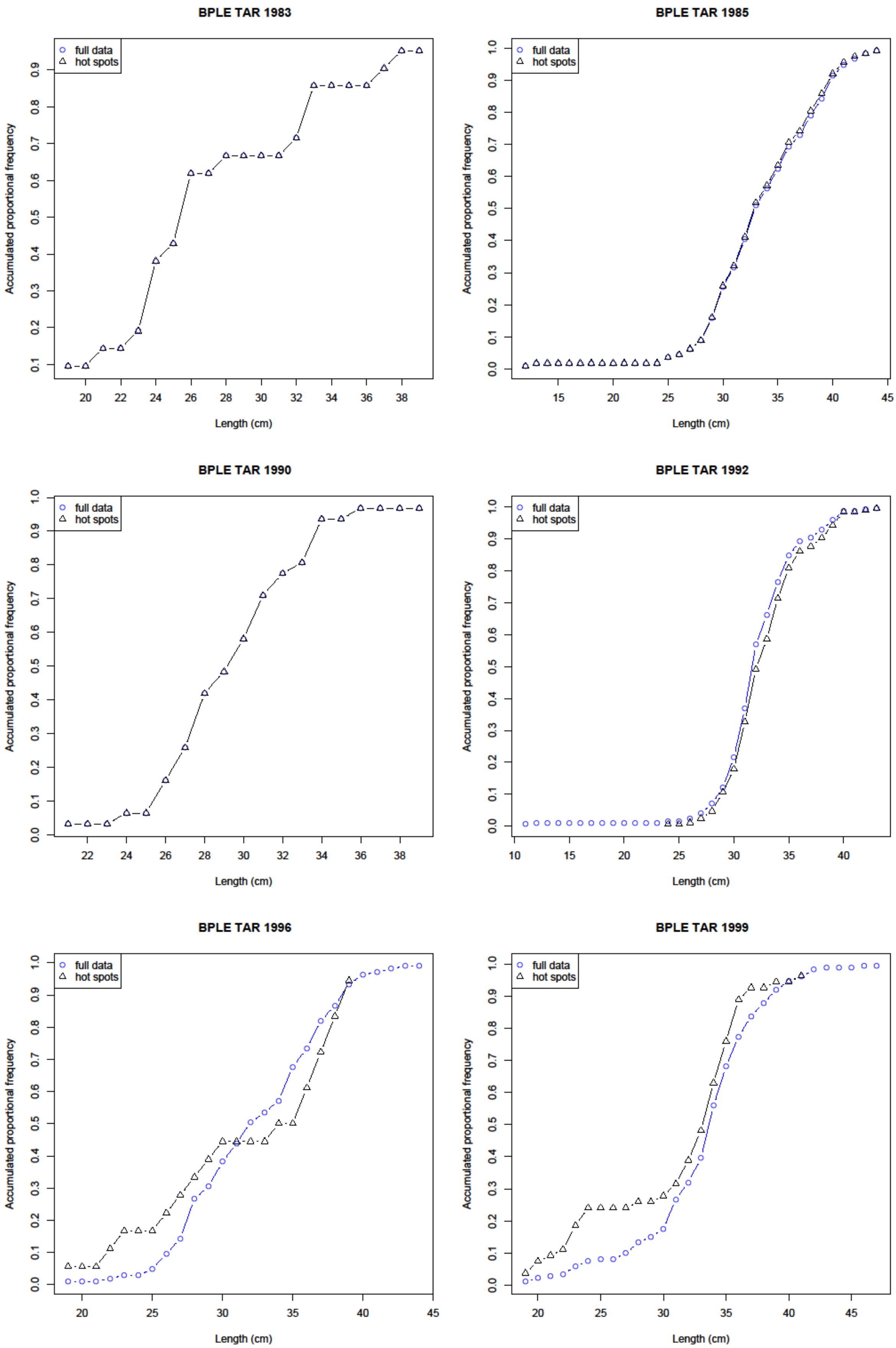
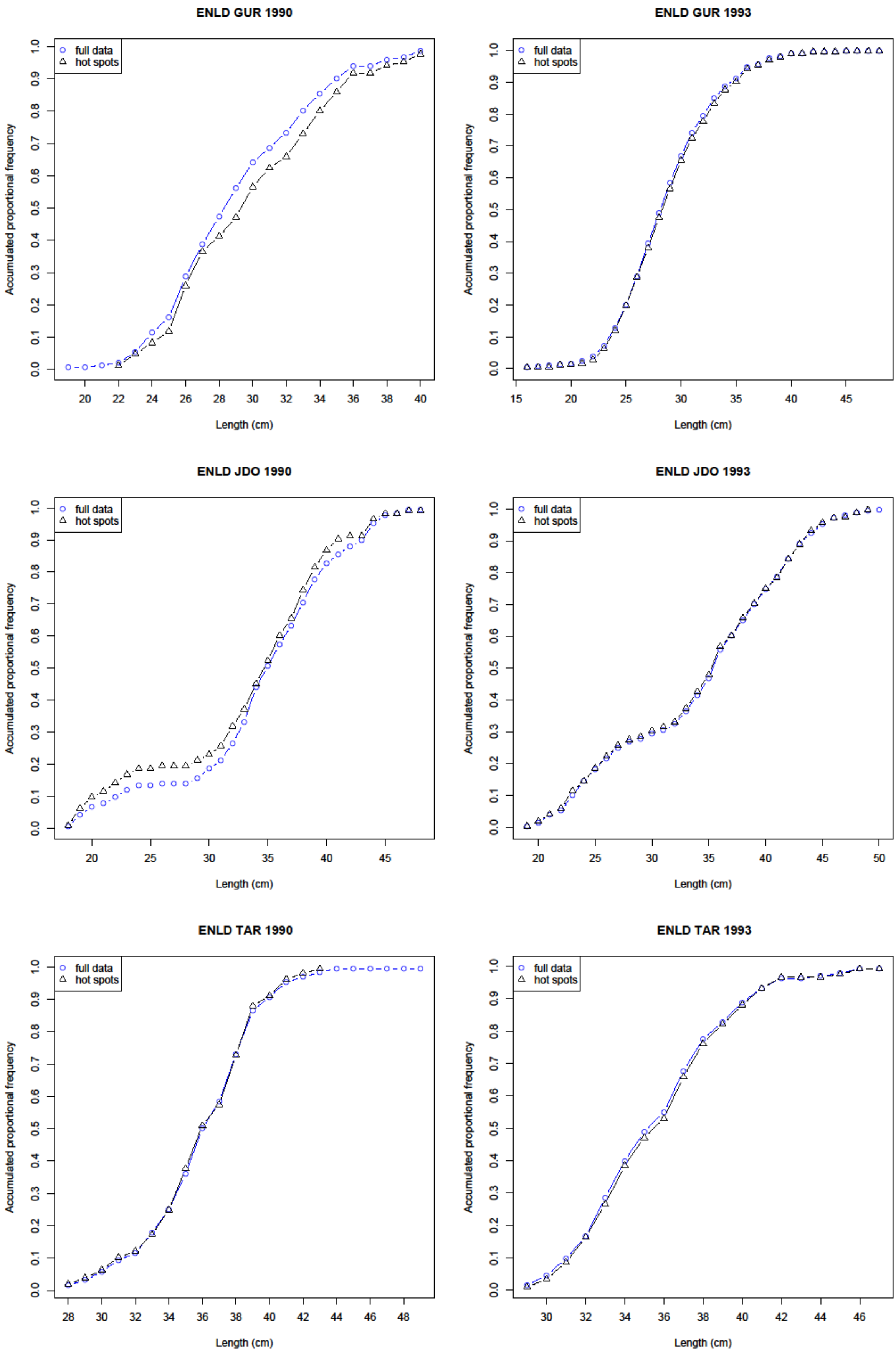
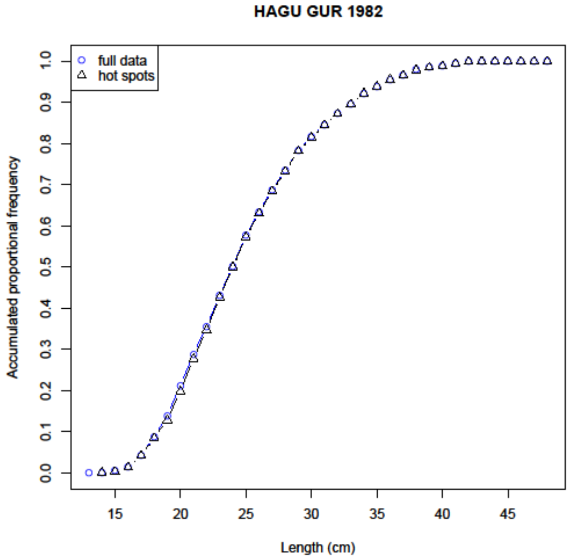

BPLE TAR 1983
BPLE TAR 1985
BPLE TAR 1990
BPLE TAR 1992
BPLE TAR 1996
BPLE TAR 1999
full data
hot spots
Accumulated proportional frequency
Length (cm)


ENLD GUR 1990
ENLD GUR 1993
ENLD JDO 1990
ENLD JDO 1993
ENLD TAR 1990
ENLD TAR 1993
full data
hot spots
Accumulated proportional frequency
Length (cm)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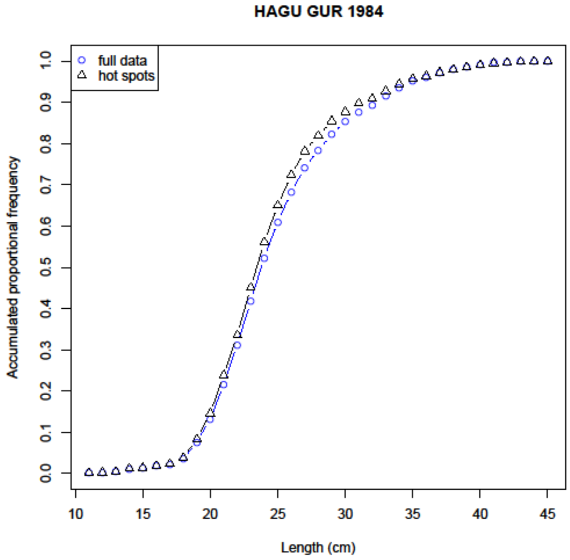
hot spots
Accumulated proportional frequency
Length (cm)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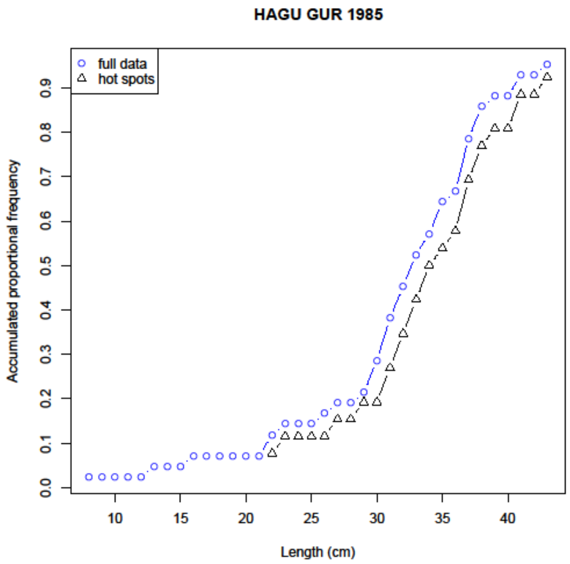
Length (cm)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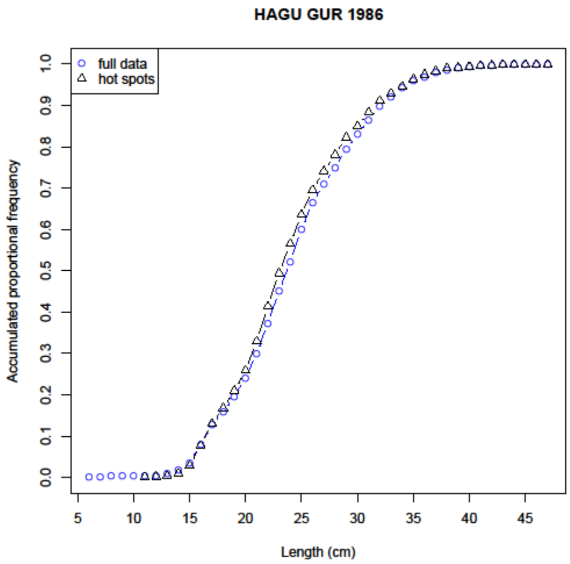
Length (cm)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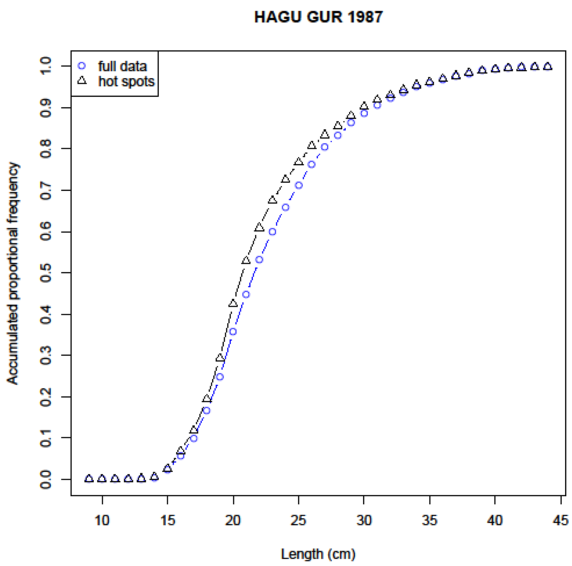
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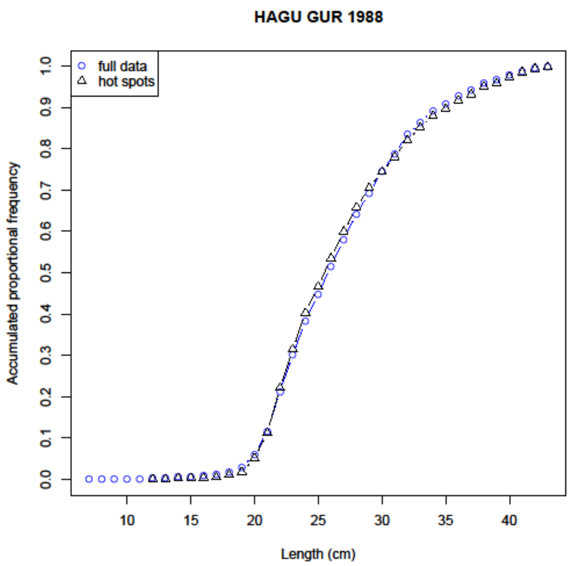
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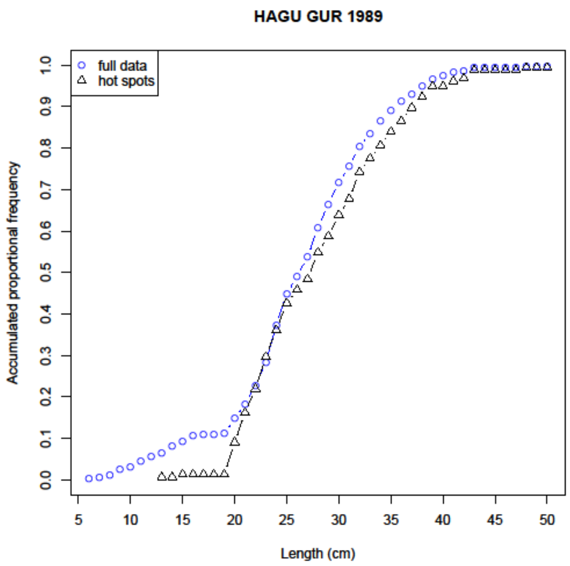
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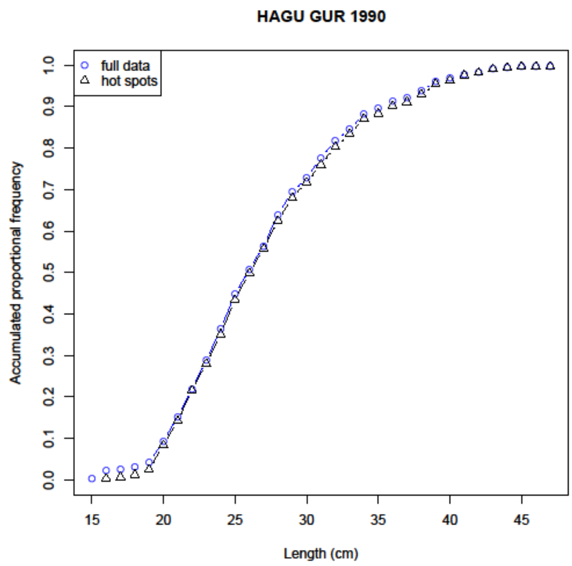
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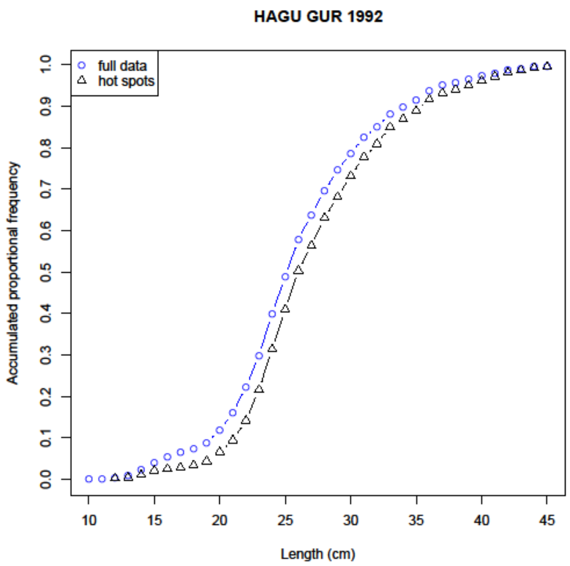
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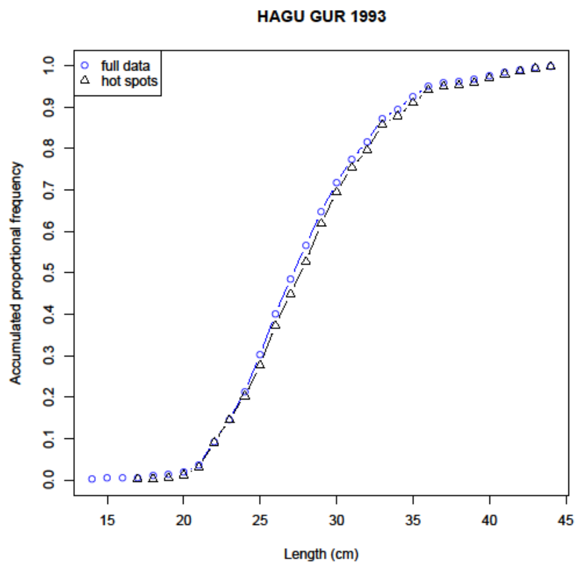
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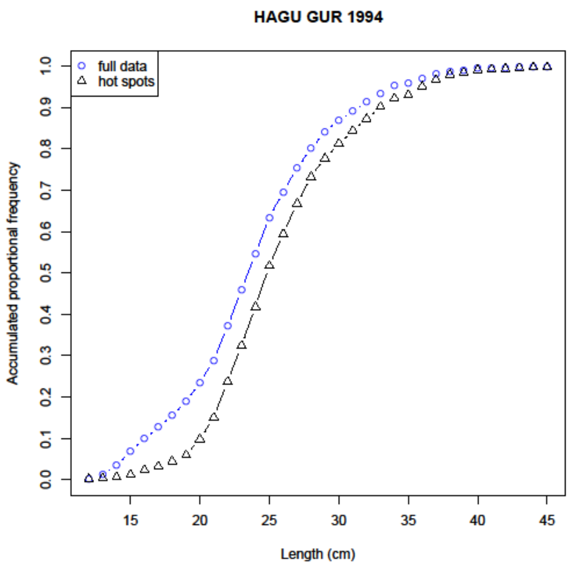
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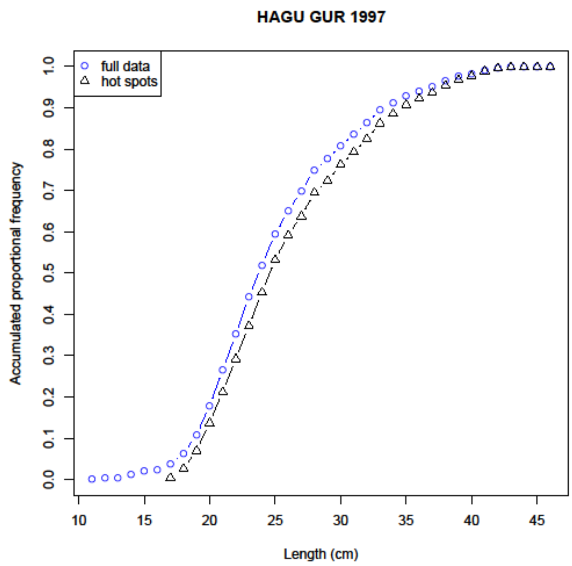
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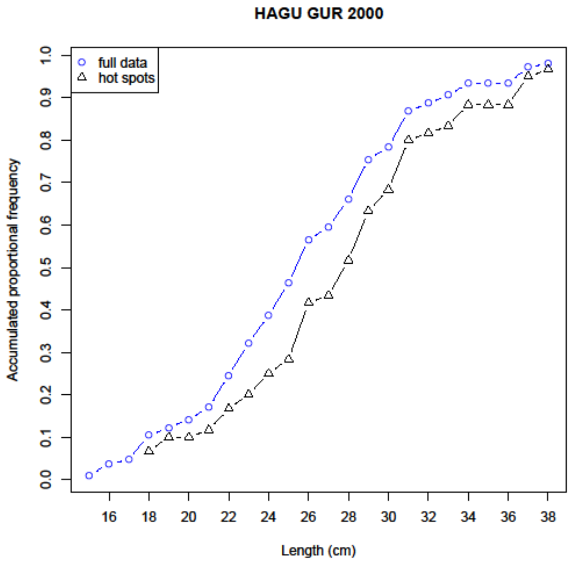
HAGU GUR 2000
full data
hot spots
Accumulated proportional frequency
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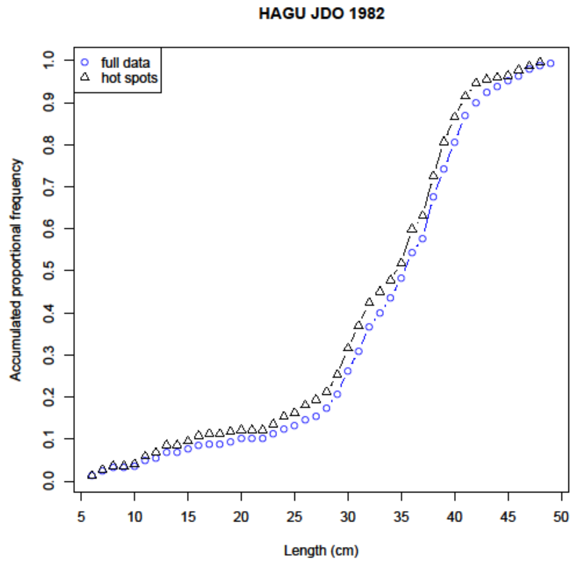
Length (cm)


HAGU JDO 1982
full data
hot spots
Accumulated proportional frequency
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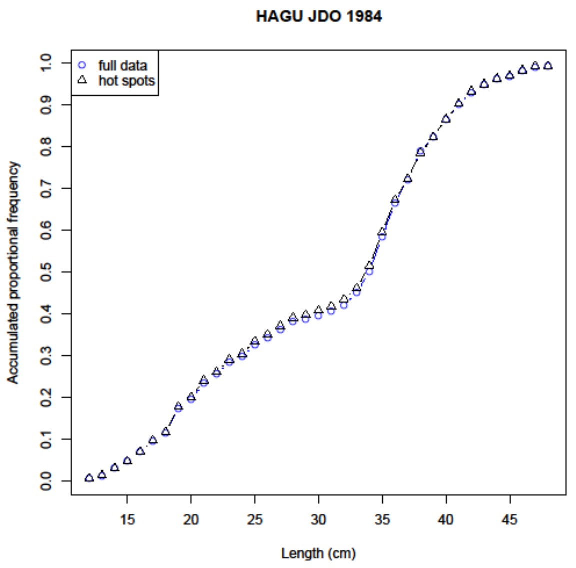
Length (cm)


HAGU JDO 1984
full data
hot spots
Accumulated proportional frequency
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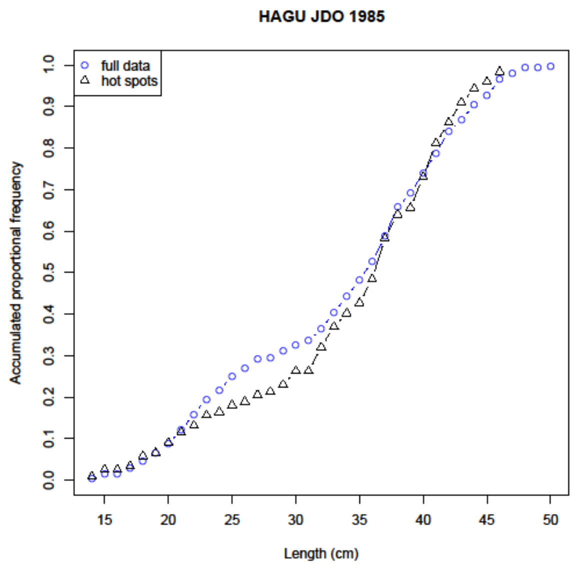
15 20 25 30 35 40 45
Length (cm)


HAGU JDO 1985
full data
hot spots
Accumulated proportional frequency
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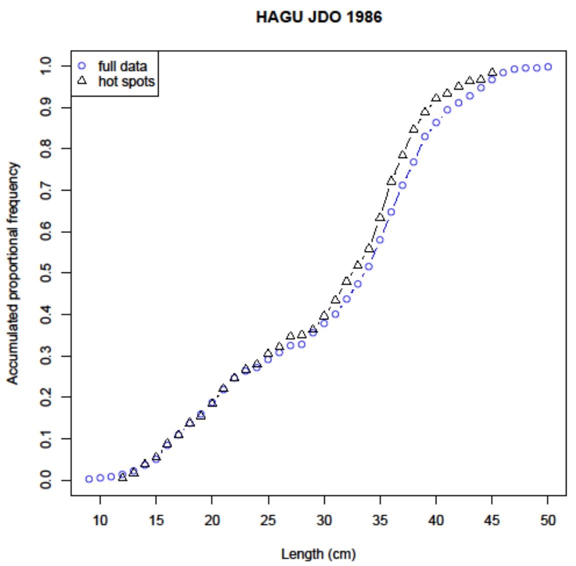
Length (cm)


HAGU JDO 1986
full data
hot spots
Accumulated proportional frequency
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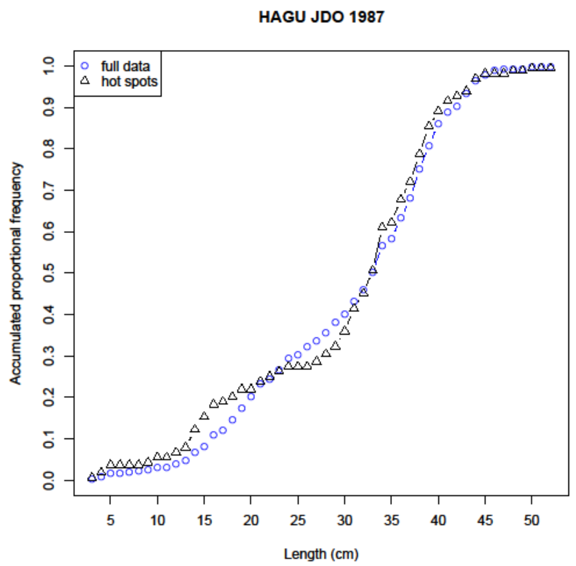
Length (cm)


HAGU JDO 1987
full data
hot spots
Accumulated proportional frequency
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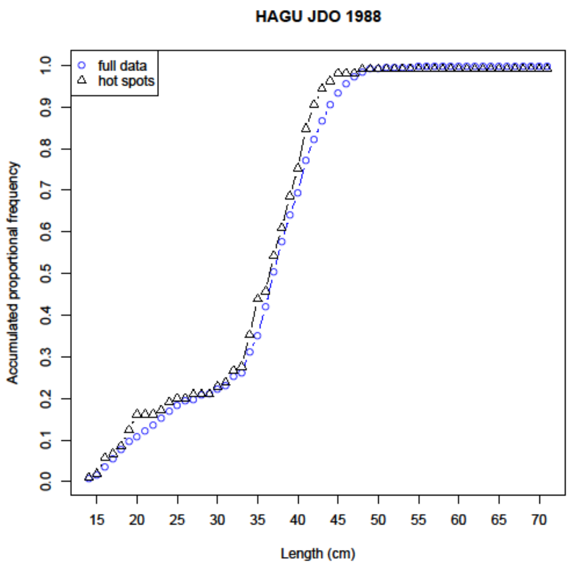
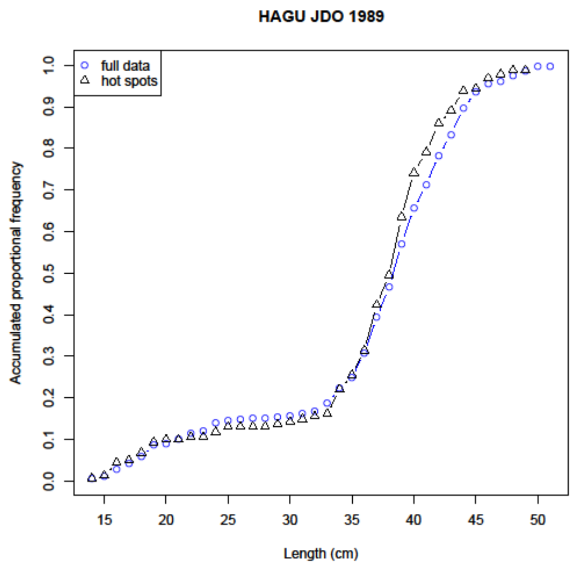
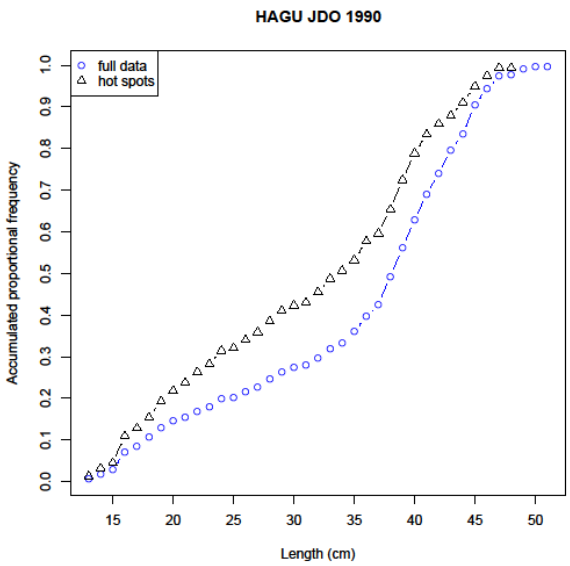
Length (cm)


HAGU JDO 1988
full data
hot spots
Accumulated proportional frequency
Length (cm)


HAGU JDO 1989
full data
hot spots
Accumulated proportional frequency
Length (cm)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hot spots
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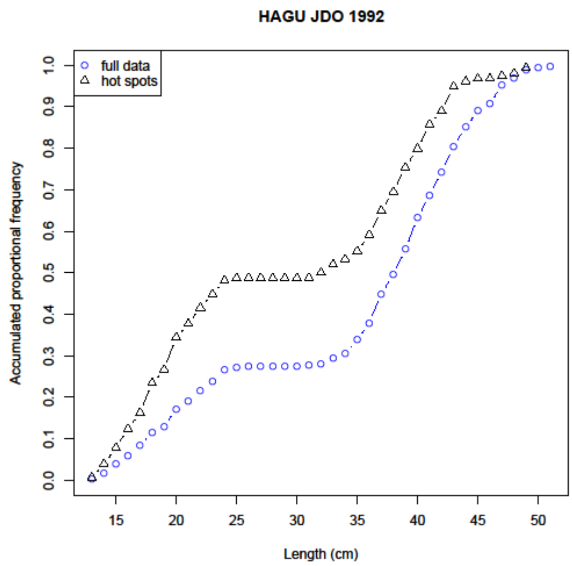
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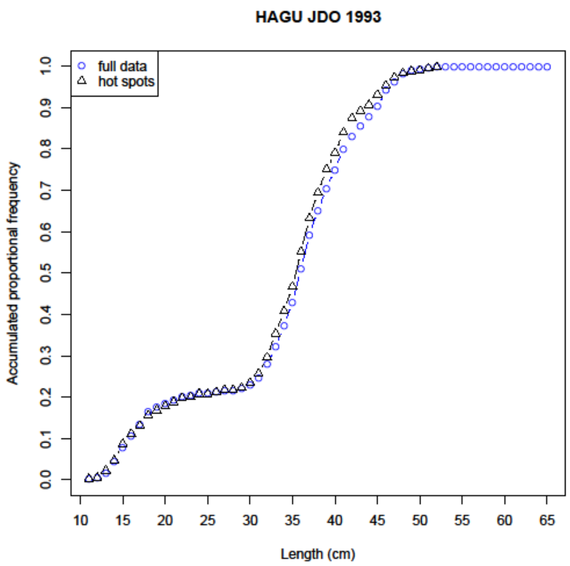
hot spots
Accumulated proportional frequency
Length (cm)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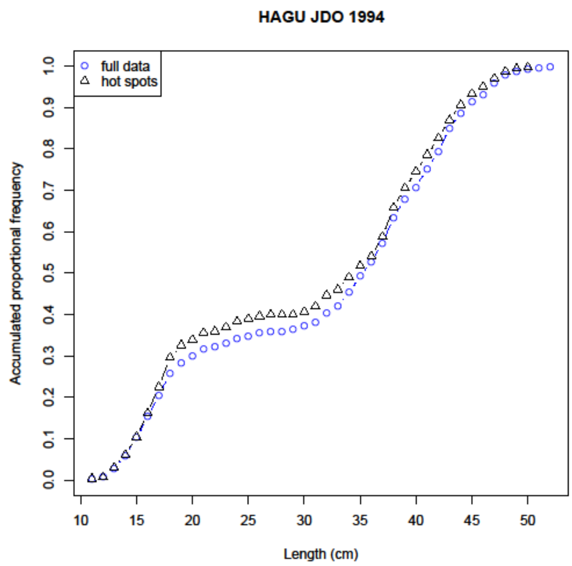
hot spots
Accumulated proportional frequency
Length (cm)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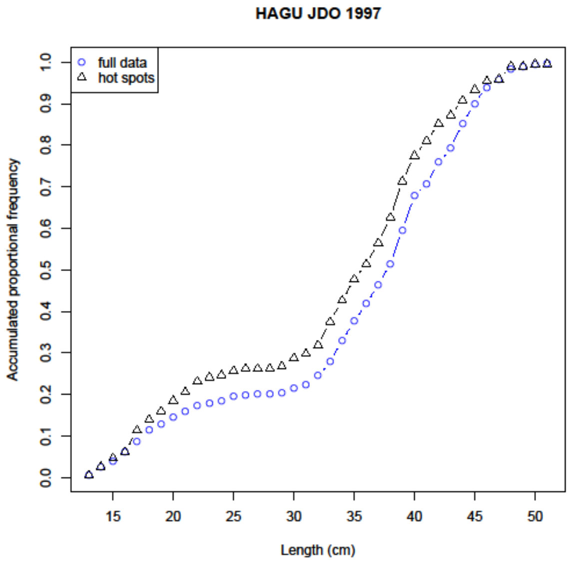
full data
hot spots
Accumulated proportional frequency
Length (cm)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hot spots
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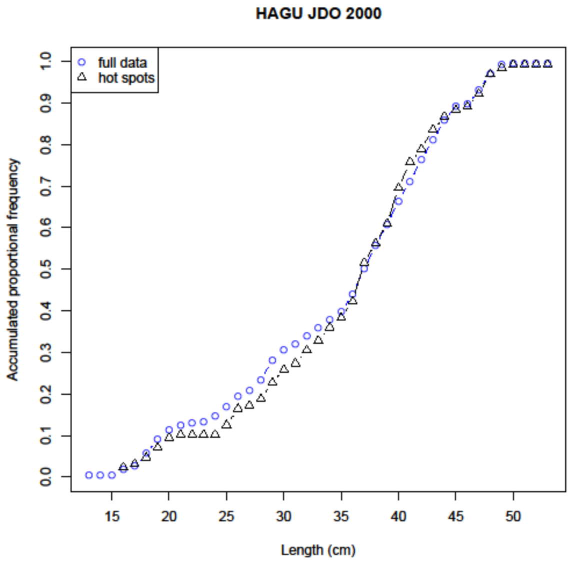
Length (cm)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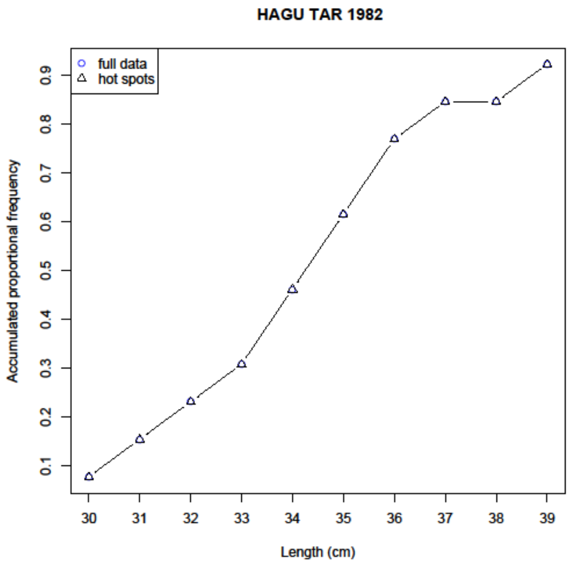
hot spots
Accumulated proportional frequency
Length (cm)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hot spots
Accumulated proportional frequency
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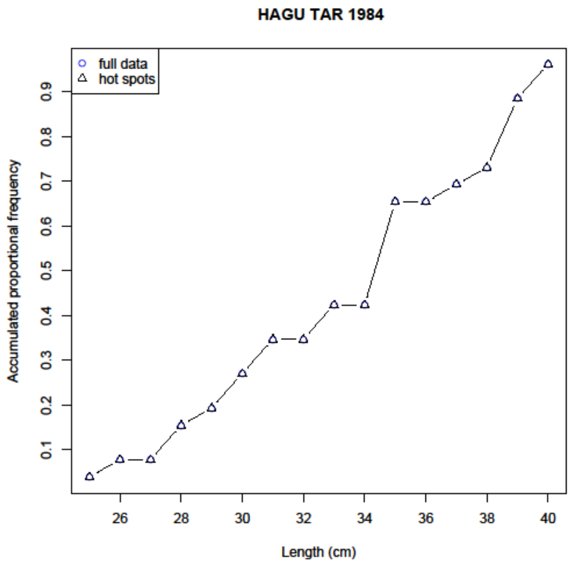
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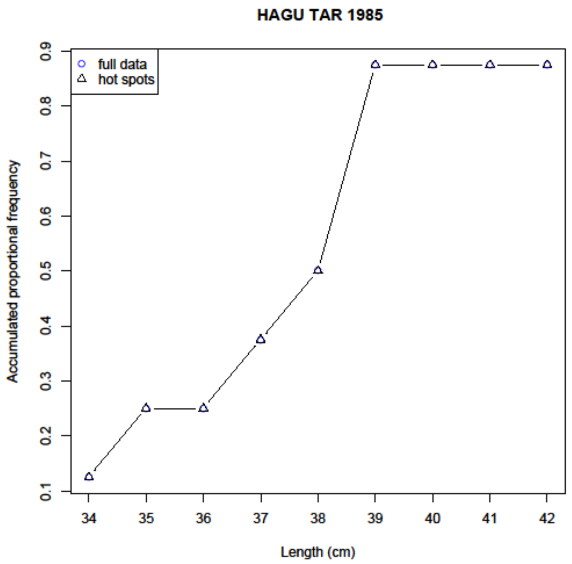
hot spots
Accumulated proportional frequency
Length (cm)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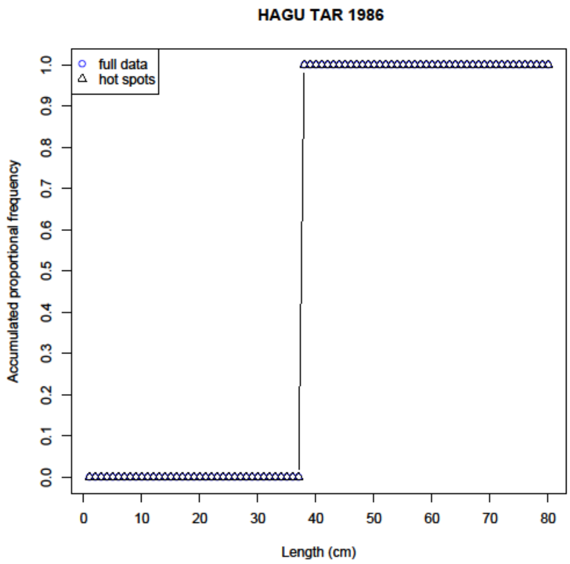
hot spots
Accumulated proportional frequency
Length (cm)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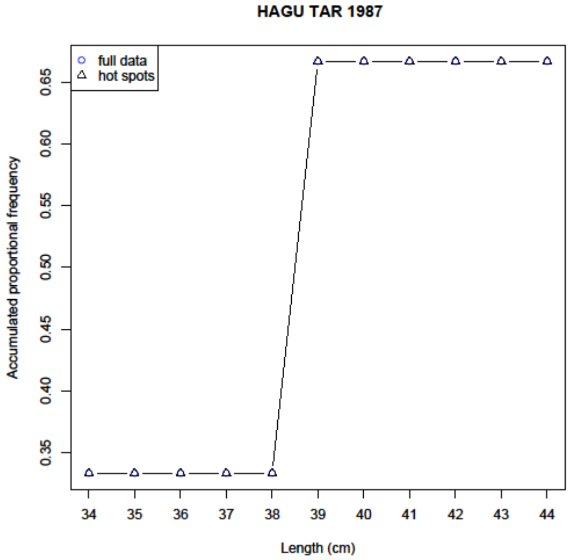
hot spots
Accumulated proportional frequency
Length (cm)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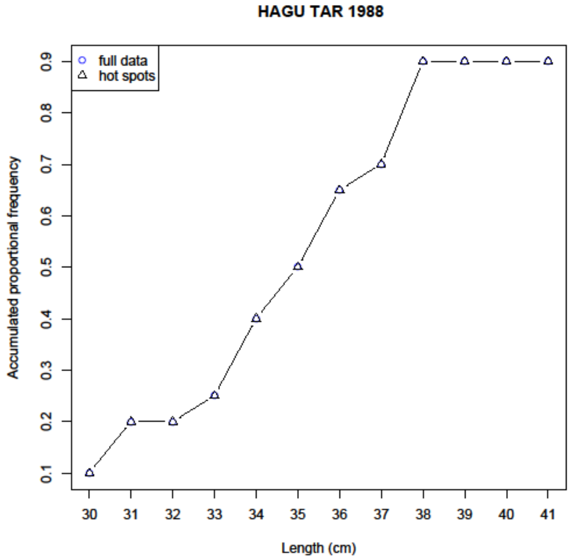
full data
hot spots
Accumulated proportional frequency
Length (cm)


HAGU TAR 1988
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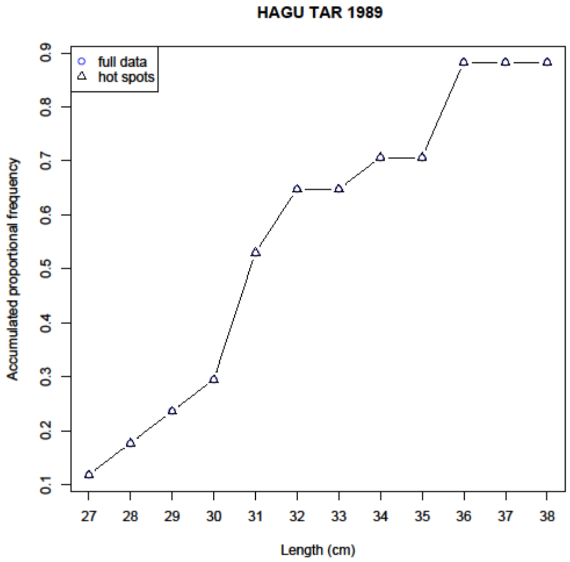
hot spots
Accumulated proportional frequency
Length (cm)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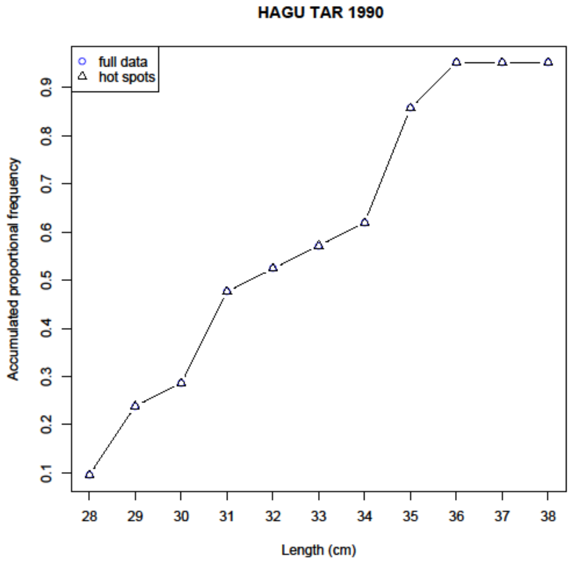
hot spots
Accumulated proportional frequency
Length (cm)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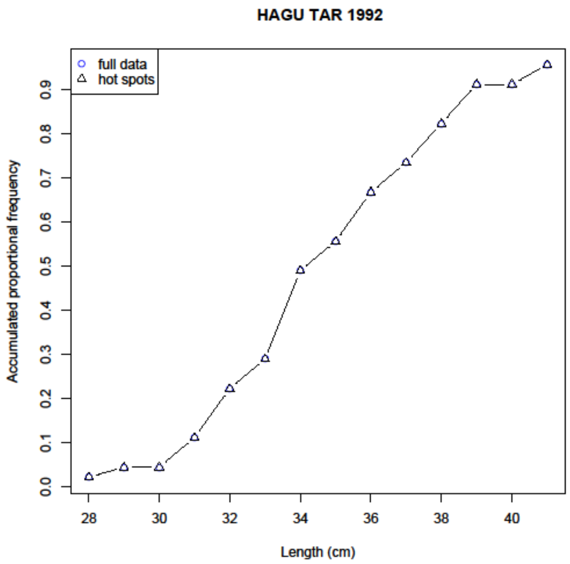
hot spots
Accumulated proportional frequency
Length (cm)


HAGU TAR 1992
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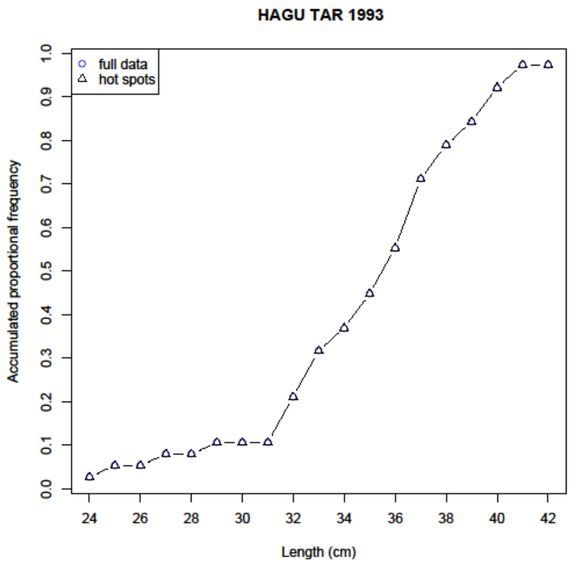
Length (cm)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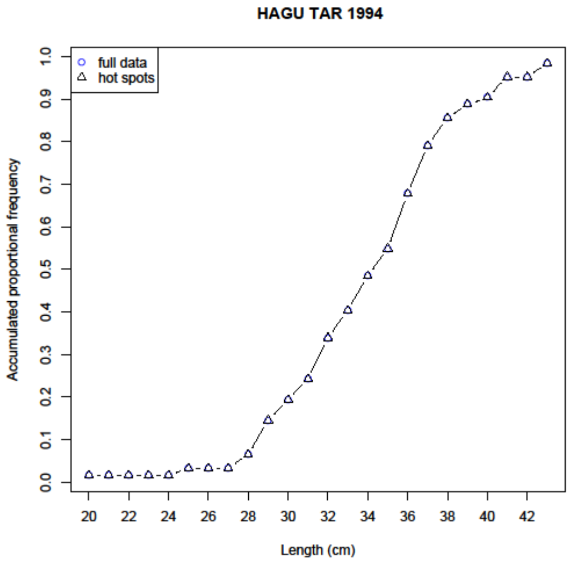
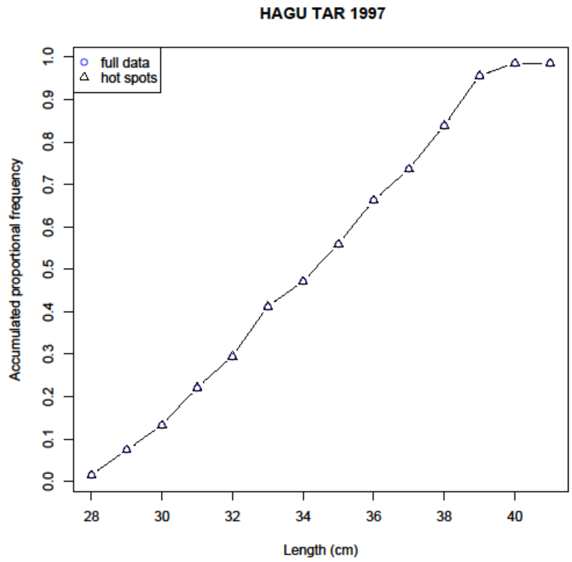
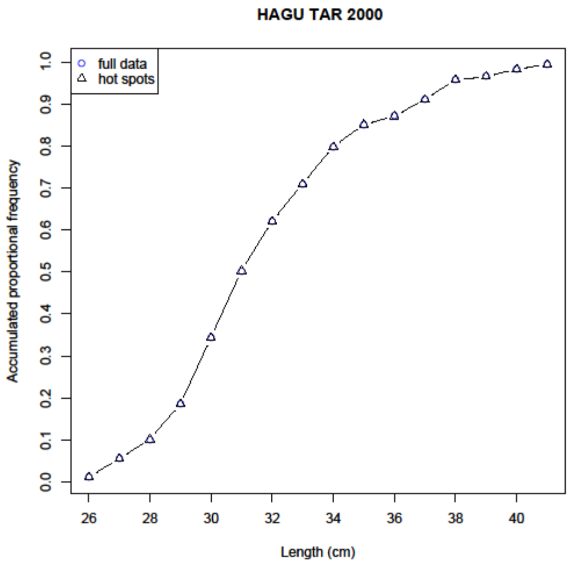
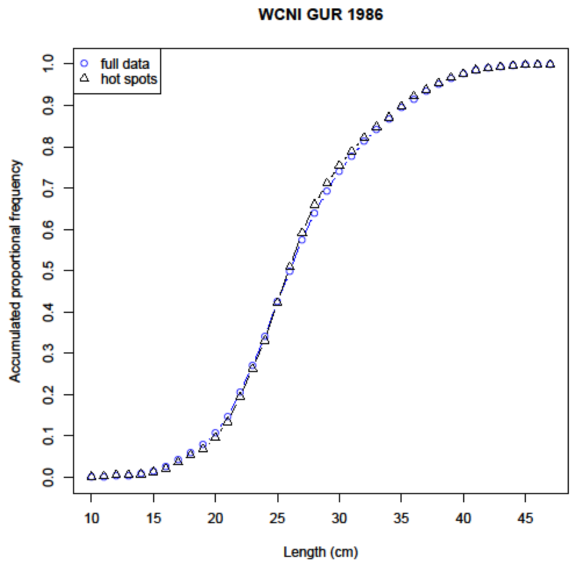
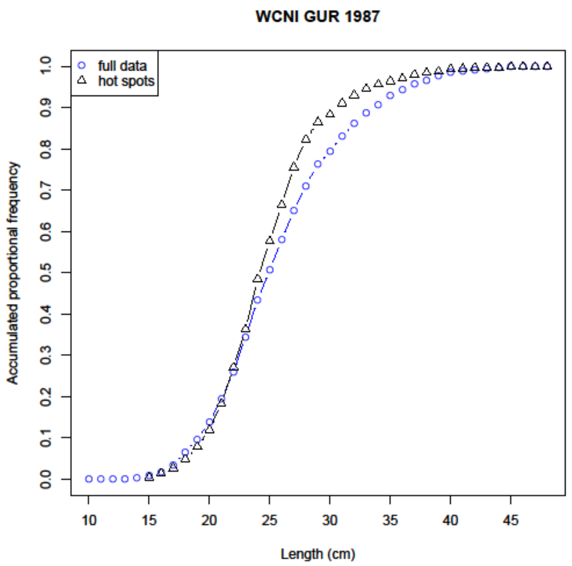
full data
hot spots
Accumulated proportional frequency
Length (cm)


HAGU TAR 1994
full data
hot spots
Accumulated proportional frequency
Length (cm)


HAGU TAR 1997
full data
hot spots
Accumulated proportional frequency
Length (cm)


HAGU TAR 2000
full data
hot spots
Accumulated proportional frequency
Length (cm)


WCNI GUR 1986
full data
hot spots
Accumulated proportional frequency
Length (cm)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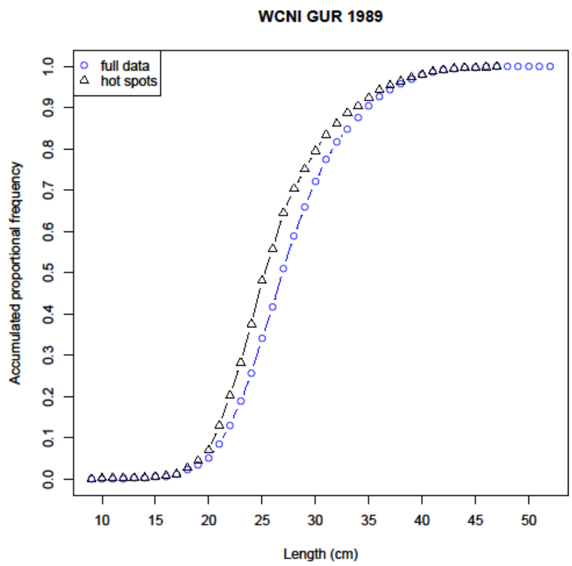
Length (cm)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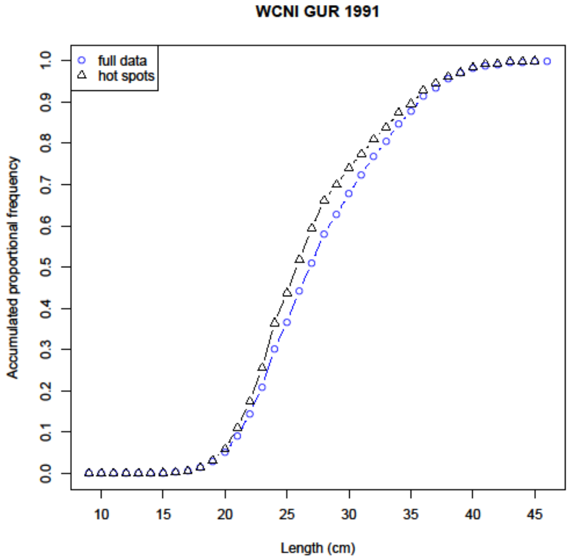
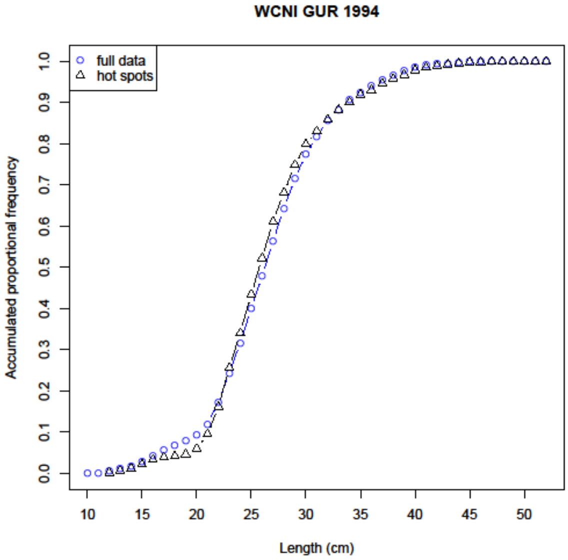
full data
hot spots
Accumulated proportional frequency
Length (cm)


WCNI GUR 1991
full data
hot spots
Accumulated proportional frequency
Length (cm)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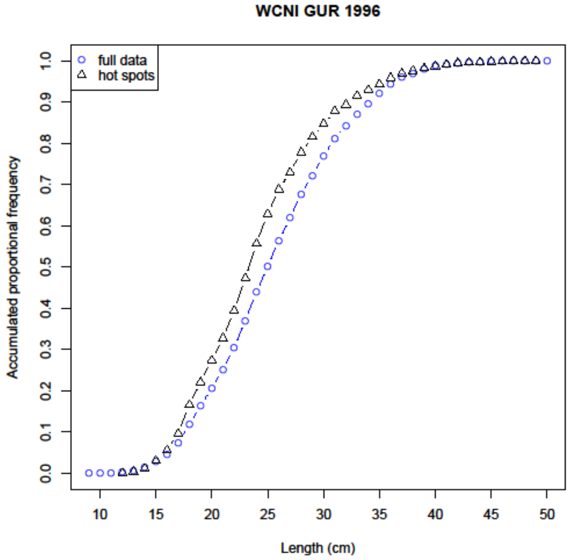
WCNI GUR 1996
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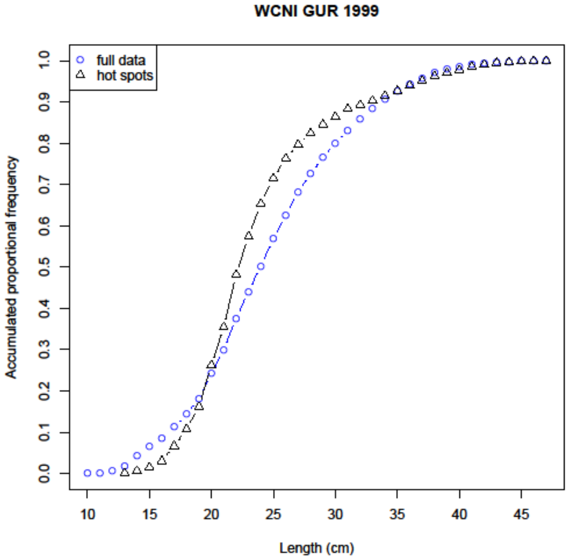
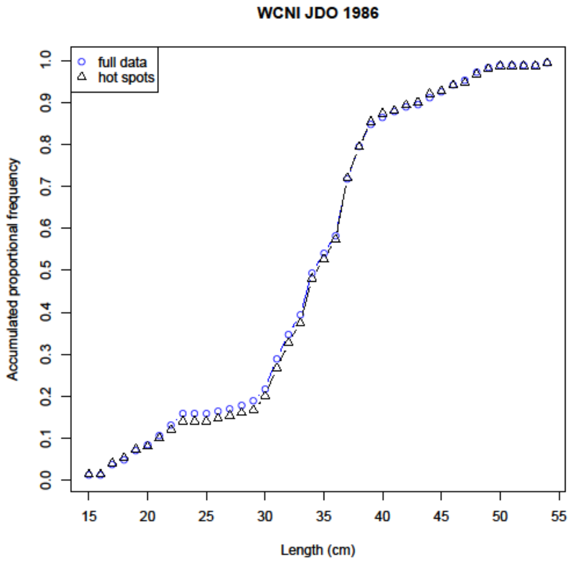
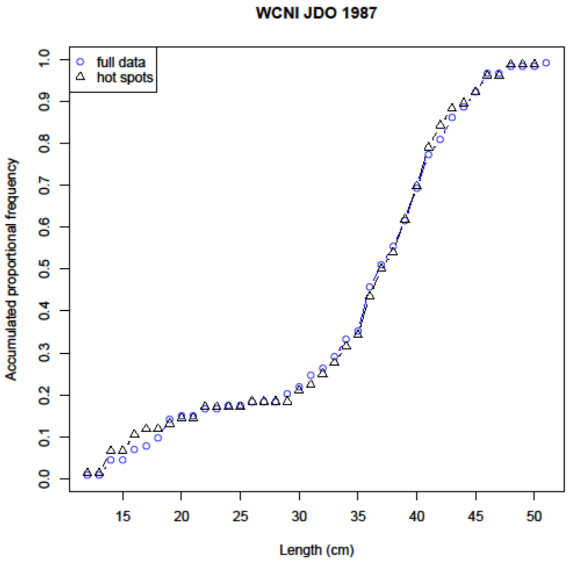
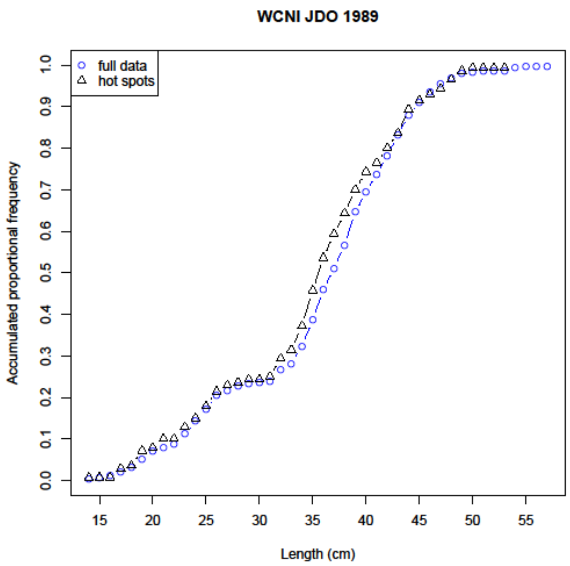
hot spots
Accumulated proportional frequency
Length (cm)


WCNI GUR 1999
full data
hot spots
Accumulated proportional frequency
Length (cm)


WCNI JDO 1986
full data
hot spots
Accumulated proportional frequency
Length (cm)


WCNI JDO 1987
full data
hot spots
Accumulated proportional frequency
Length (cm)


WCNI JDO 1989
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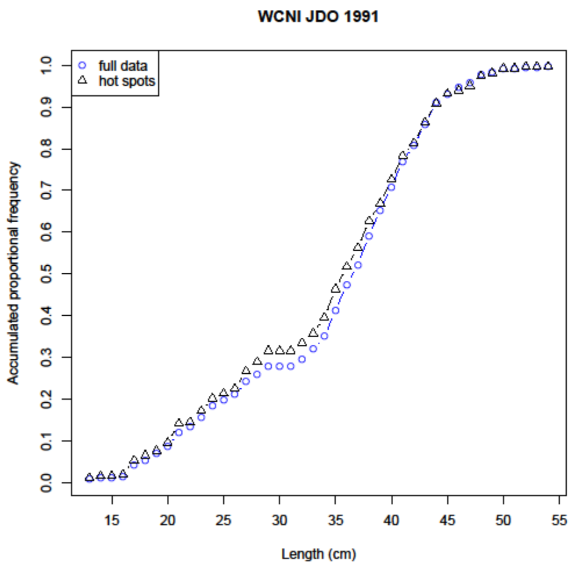
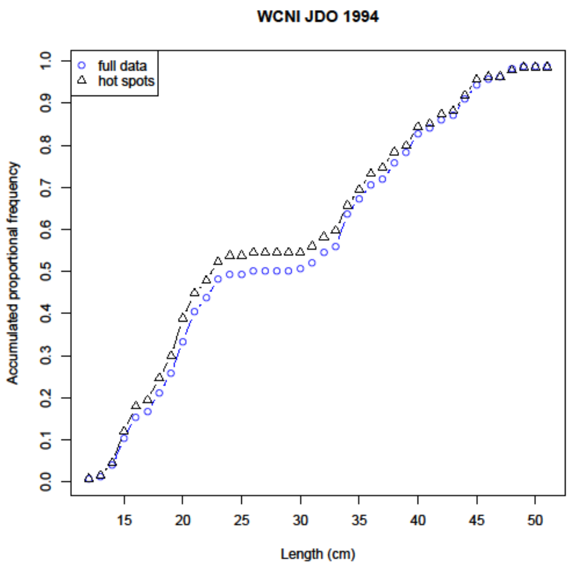
hot spots
Accumulated proportional frequency
Length (cm)


WCNI JDO 1991
full data
hot spots
Accumulated proportional frequency
Length (cm)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hot spots
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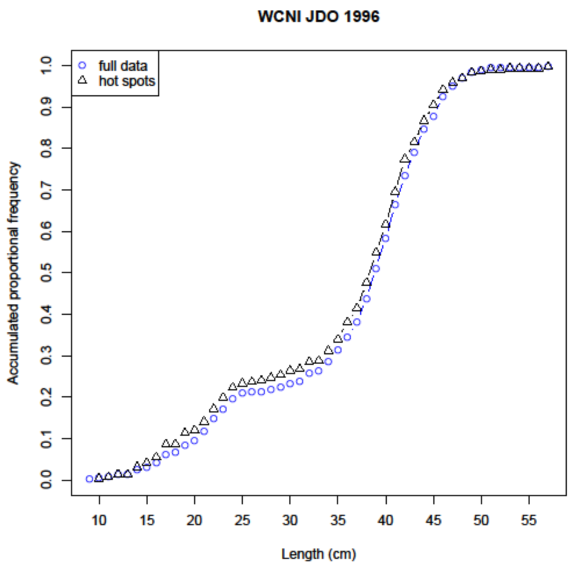
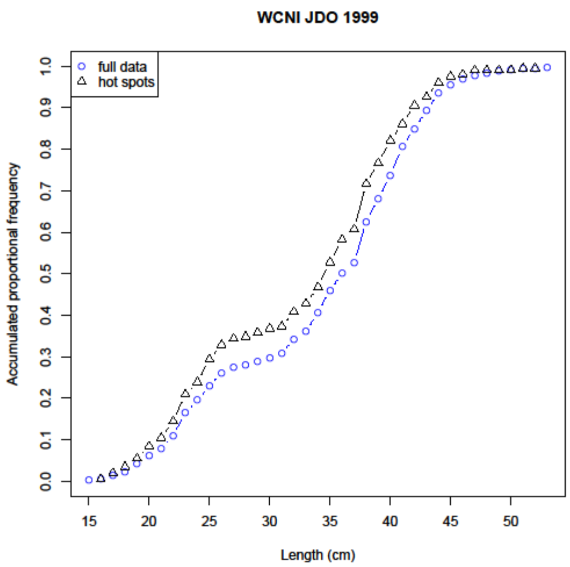
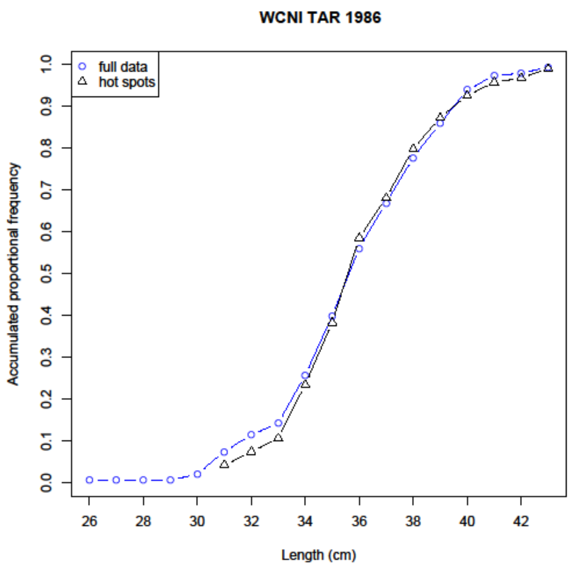
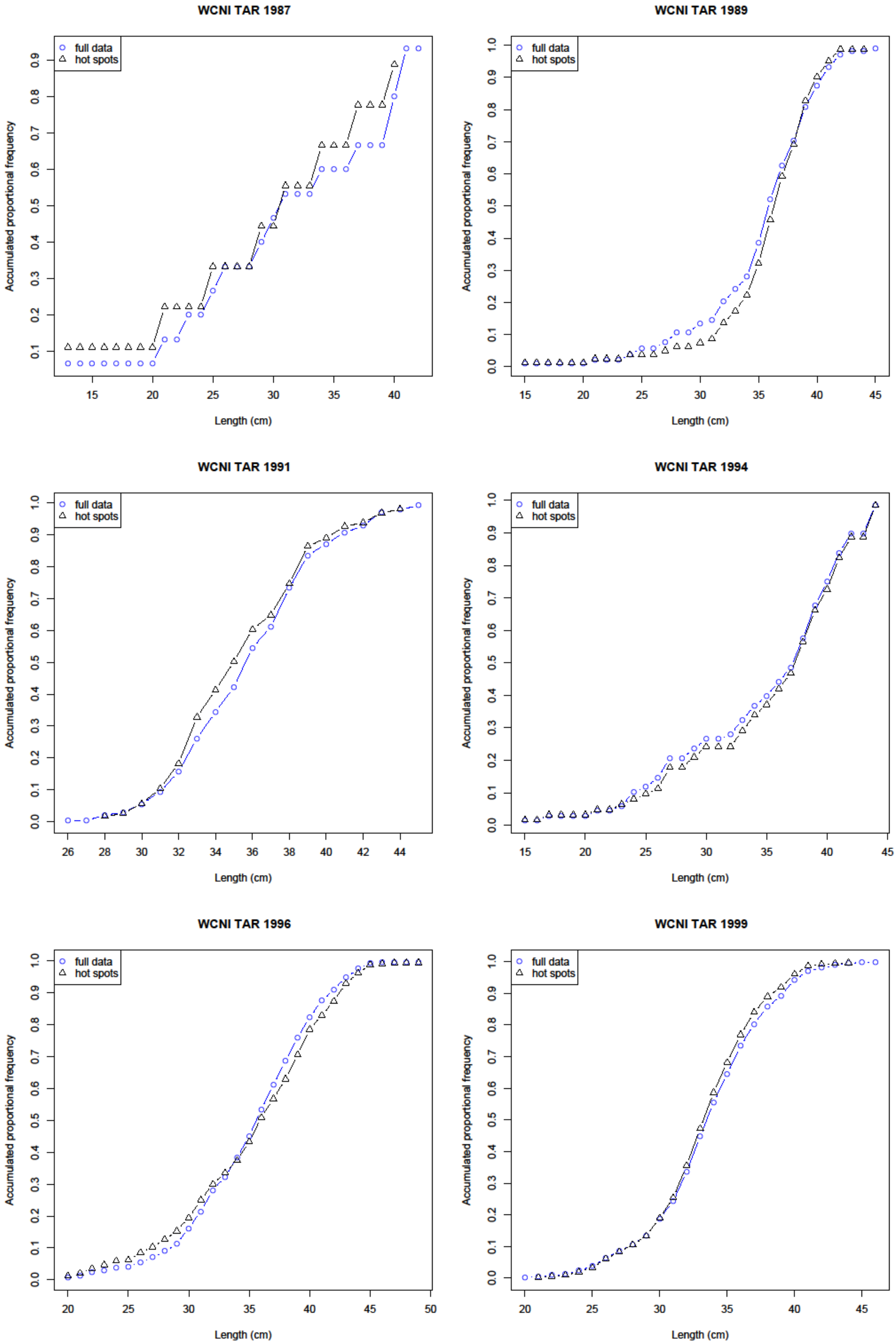
Length (cm)

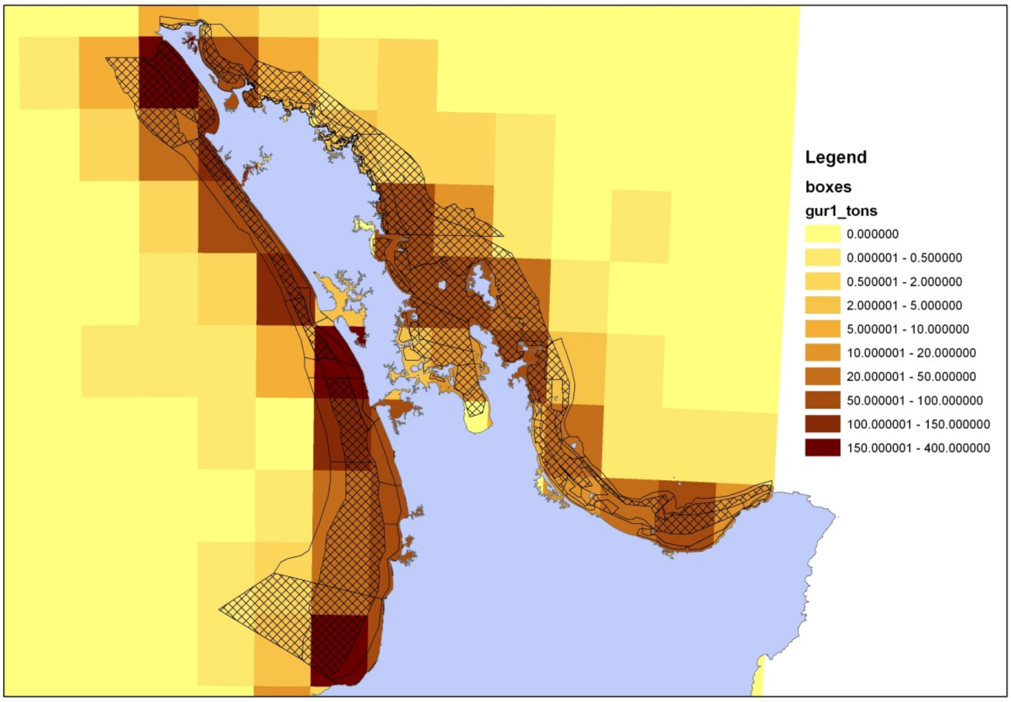

WCNI JDO 1996
full data
hot spots
Accumulated proportional frequency
Length (cm)


WCNI JDO 1999
full data
hot spots
Accumulated proportional frequency
Length (cm)

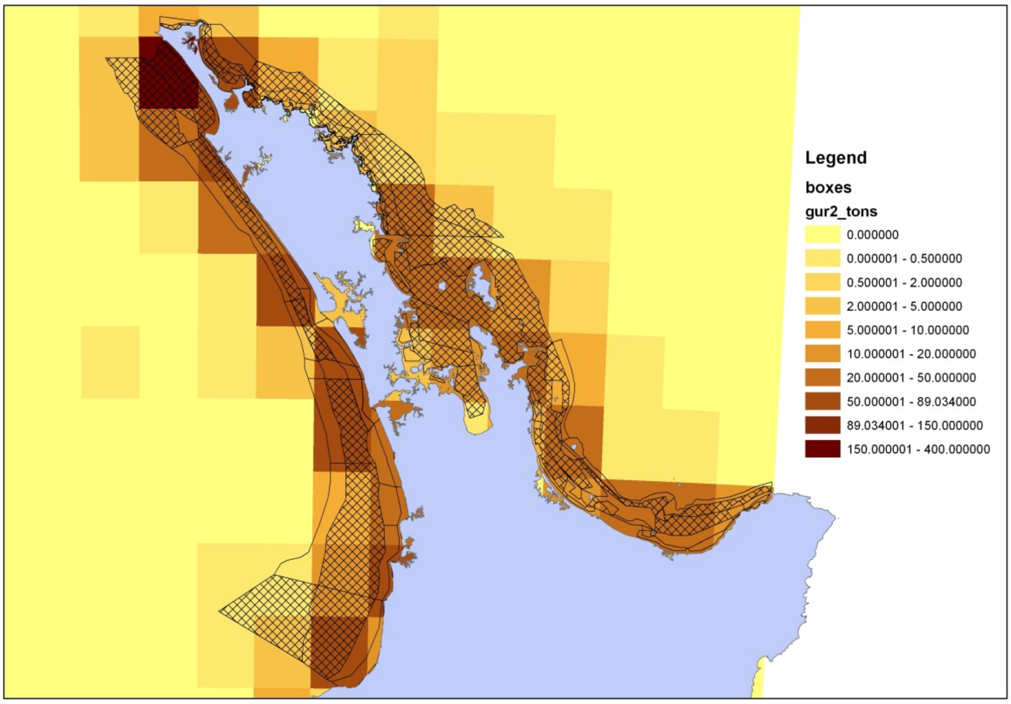

WCNI TAR 1986
full data
hot spots
Accumulated proportional frequency
Length (cm)


WCNI TAR 1987
WCNI TAR 1989
WCNI TAR 1991
WCNI TAR 1994
WCNI TAR 1996
WCNI TAR 1999
full data
hot spots
Accumulated proportional frequency
Length (cm)

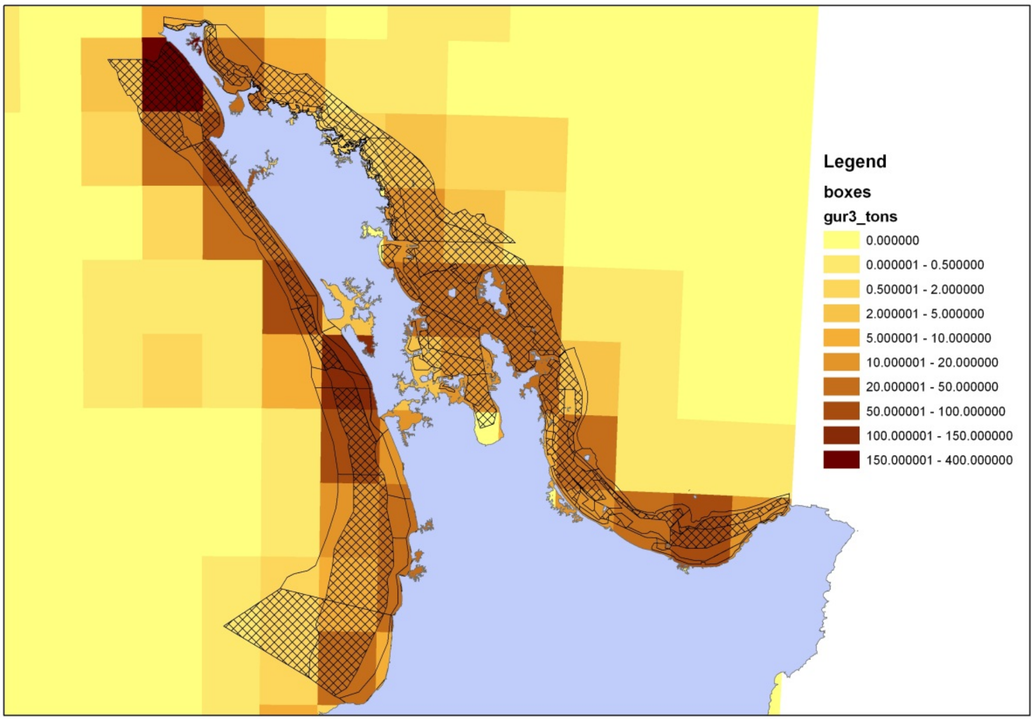
8.8. APPENDIX H: Commercial catch summed to 1 degree squares, relative to the subset of strata retained for the proposed new 'northern' trawl survey time series.



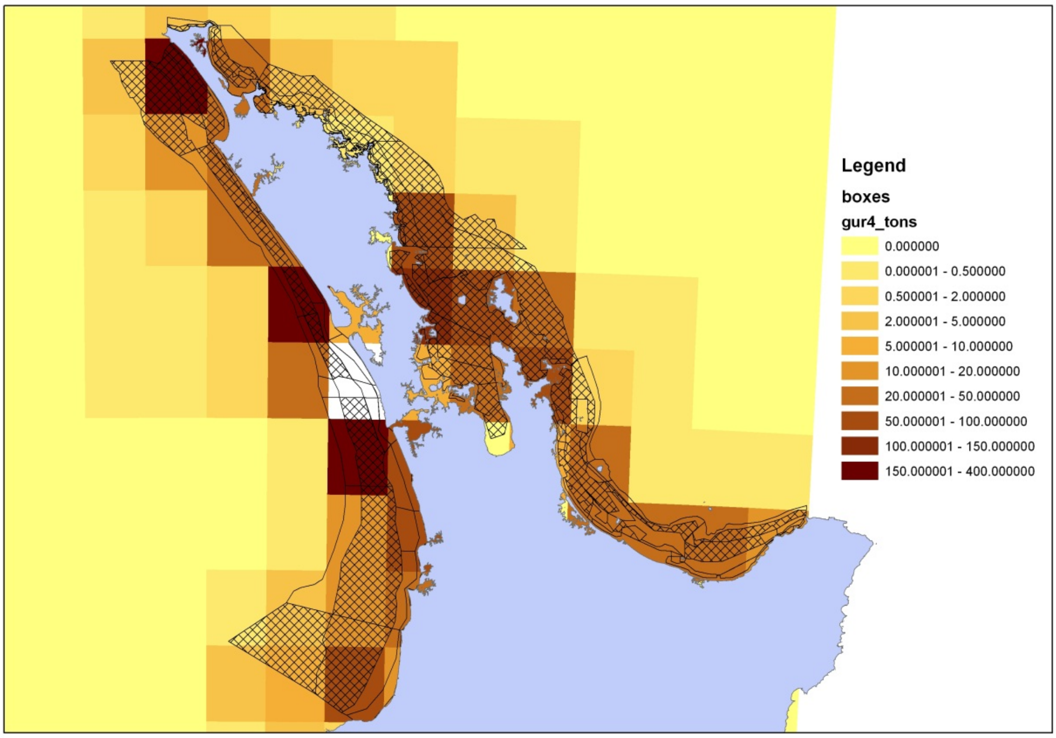
Appendix H1: Gurnard, total seasonal average catch (tonnes) (Jan–March*), by 1 degree squares.
*** time period inclusive of ENLD and BPLN surveys.**



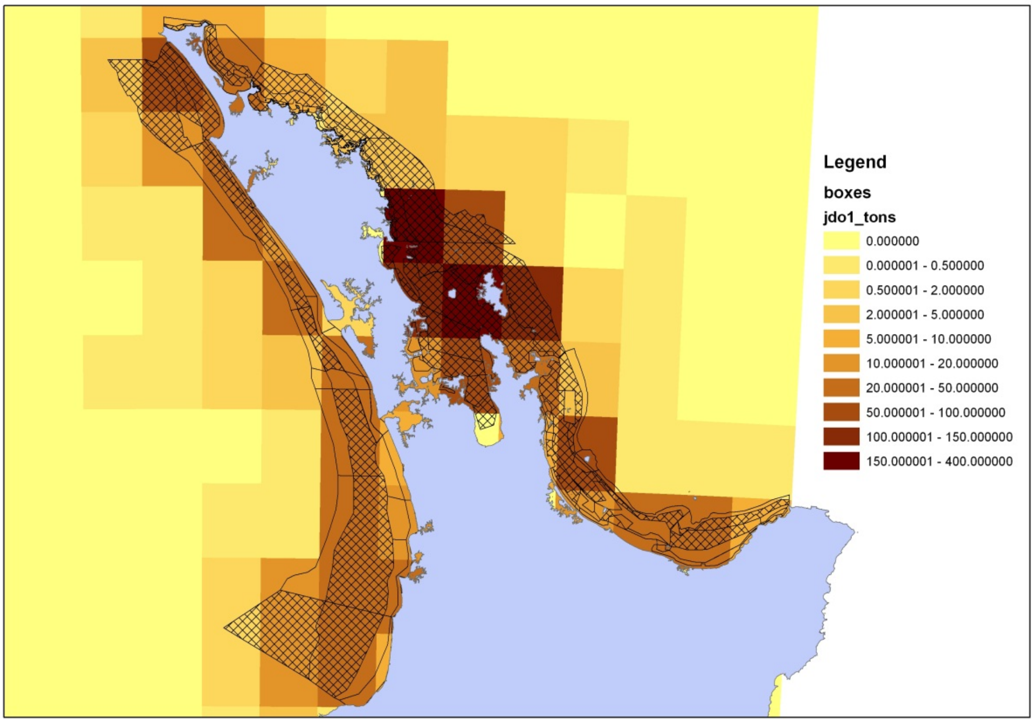
Appendix H2: Gurnard, total seasonal average catch (tonnes) (April–June), by 1 degree squares.



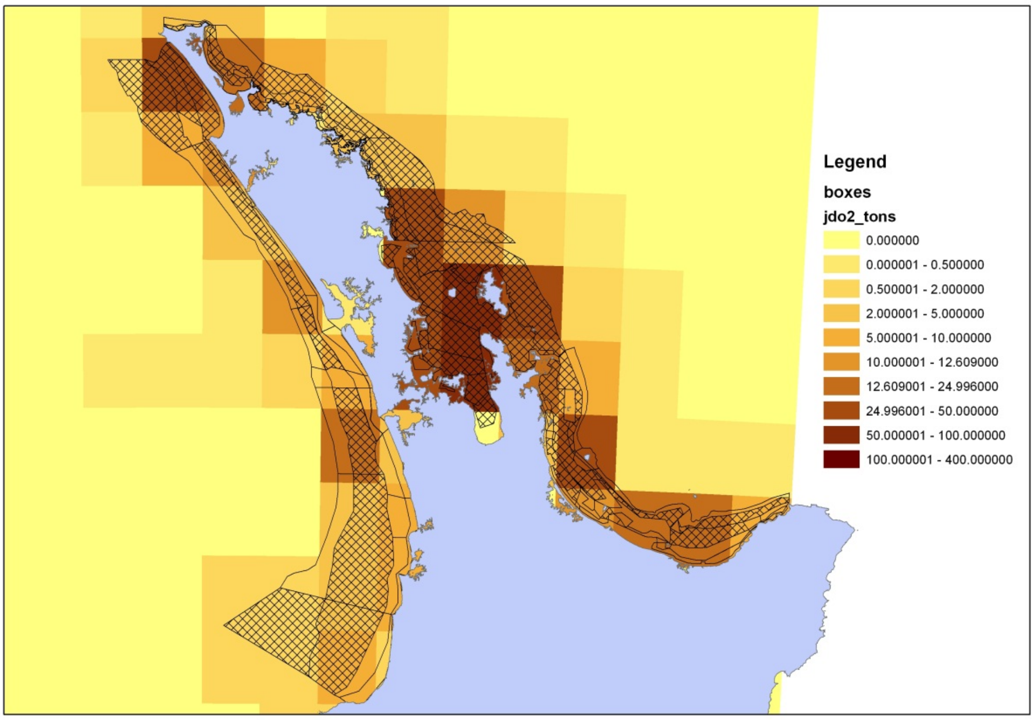
Appendix H3: Gurnard, total seasonal average catch (tonnes) (July–September), by 1 degree squares.



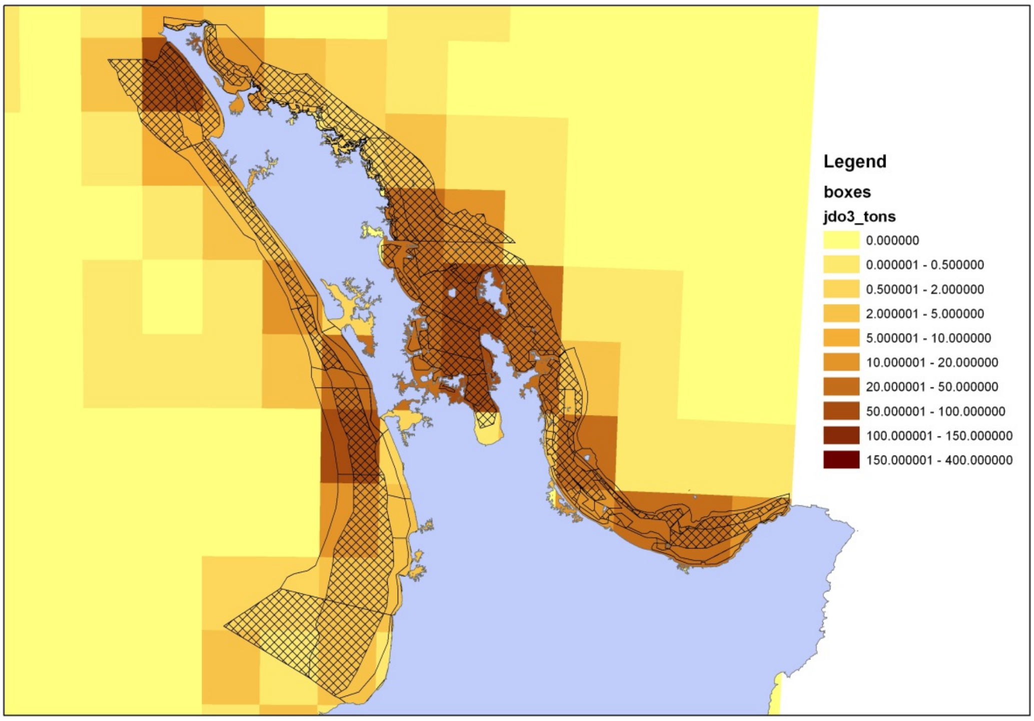
Appendix H4: Gurnard, total seasonal average catch (tonnes) (October–December*), by 1 degree squares.
*** time period inclusive of WCNI and HAGU surveys.**



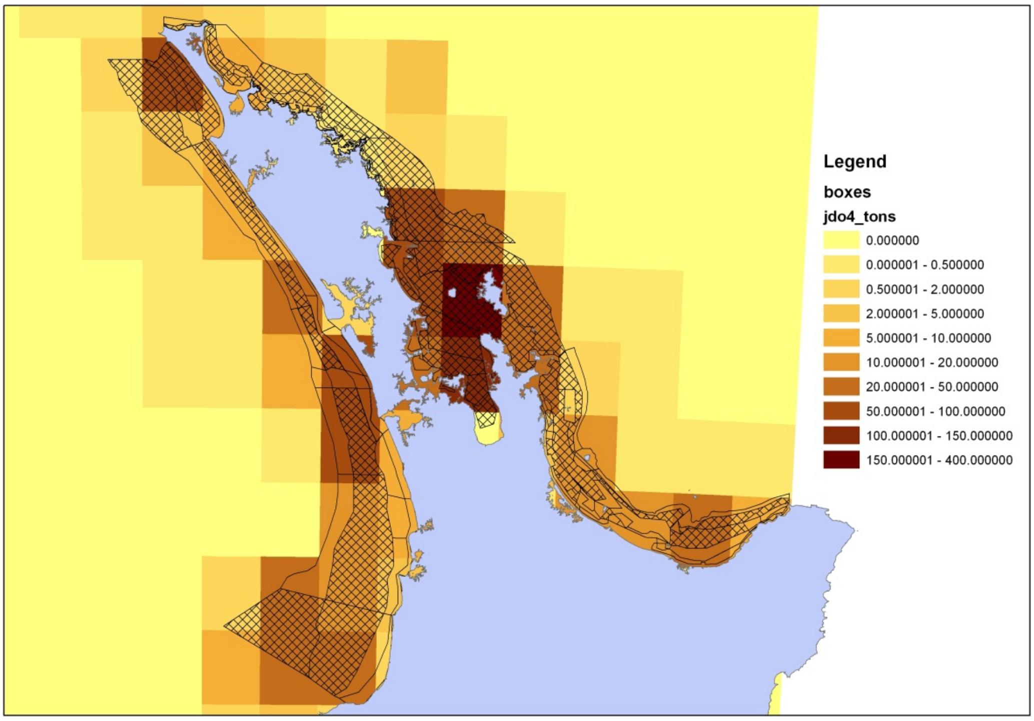
Appendix H5: John dory, total seasonal average catch (tonnes) (January–March*), by 1 degree squares.
*** time period inclusive of ENLD and BPLN surveys.**



Appendix H6: John dory, total seasonal average catch (tonnes) (April–June), by 1 degree squares.

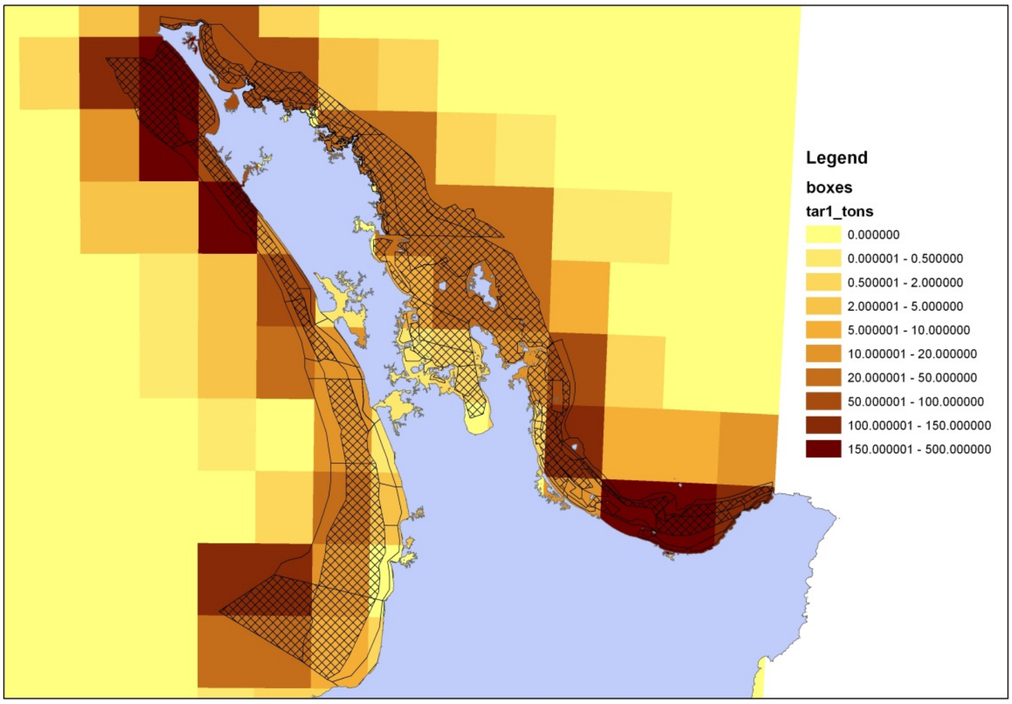


Appendix H7: John dory, total seasonal average catch (tonnes) (July–September), by 1 degree squares.

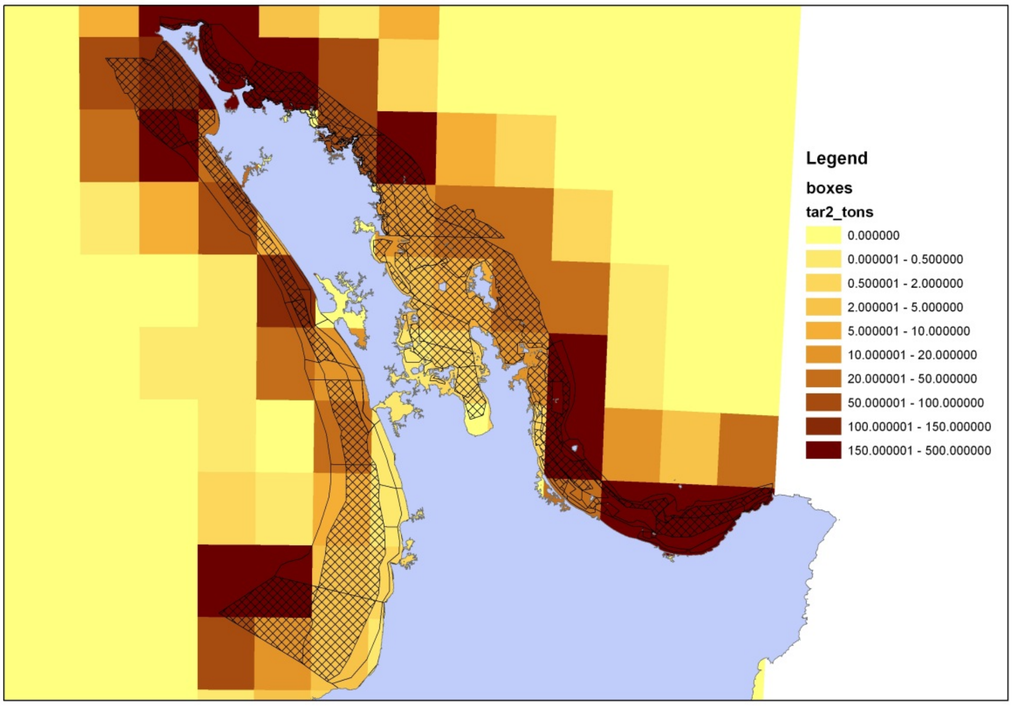


Appendix H8: John dory, total seasonal average catch (tonnes) (October–December*), by 1 degree squares.

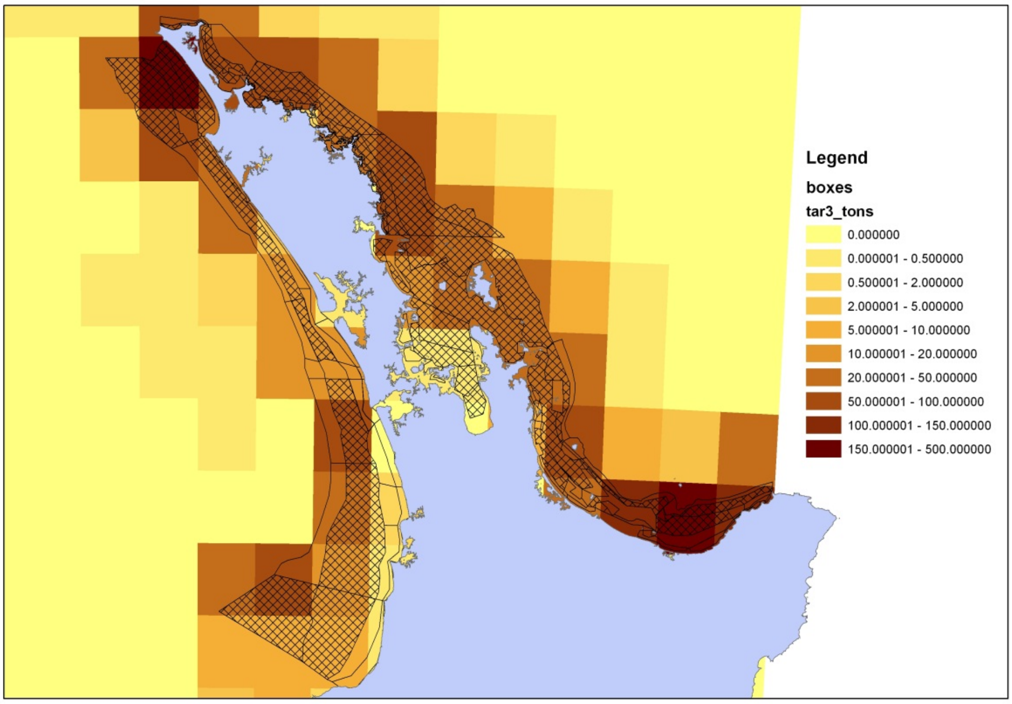
*** time period inclusive of WCNI and HAGU surveys.**



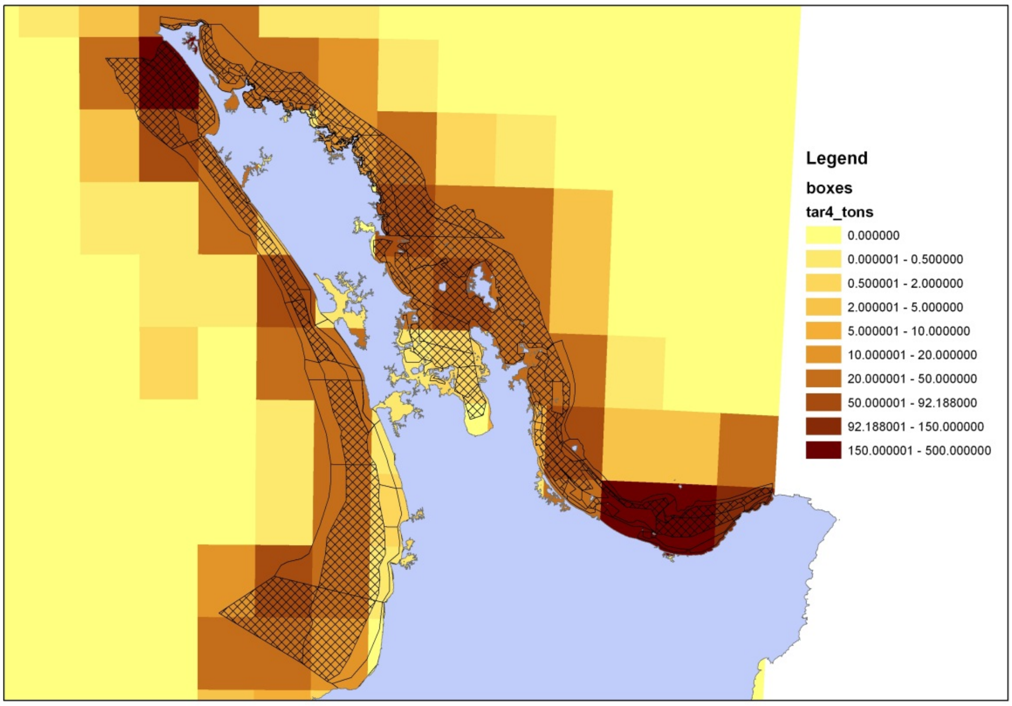
Appendix H9: Tarakihi, total seasonal average catch (tonnes) (January–March*), by 1 degree squares.
*** time period inclusive of ENLD and BPLN surveys.**



Appendix H10: Tarakihi, total seasonal average catch (tonnes) (April–June), by 1 degree squares.

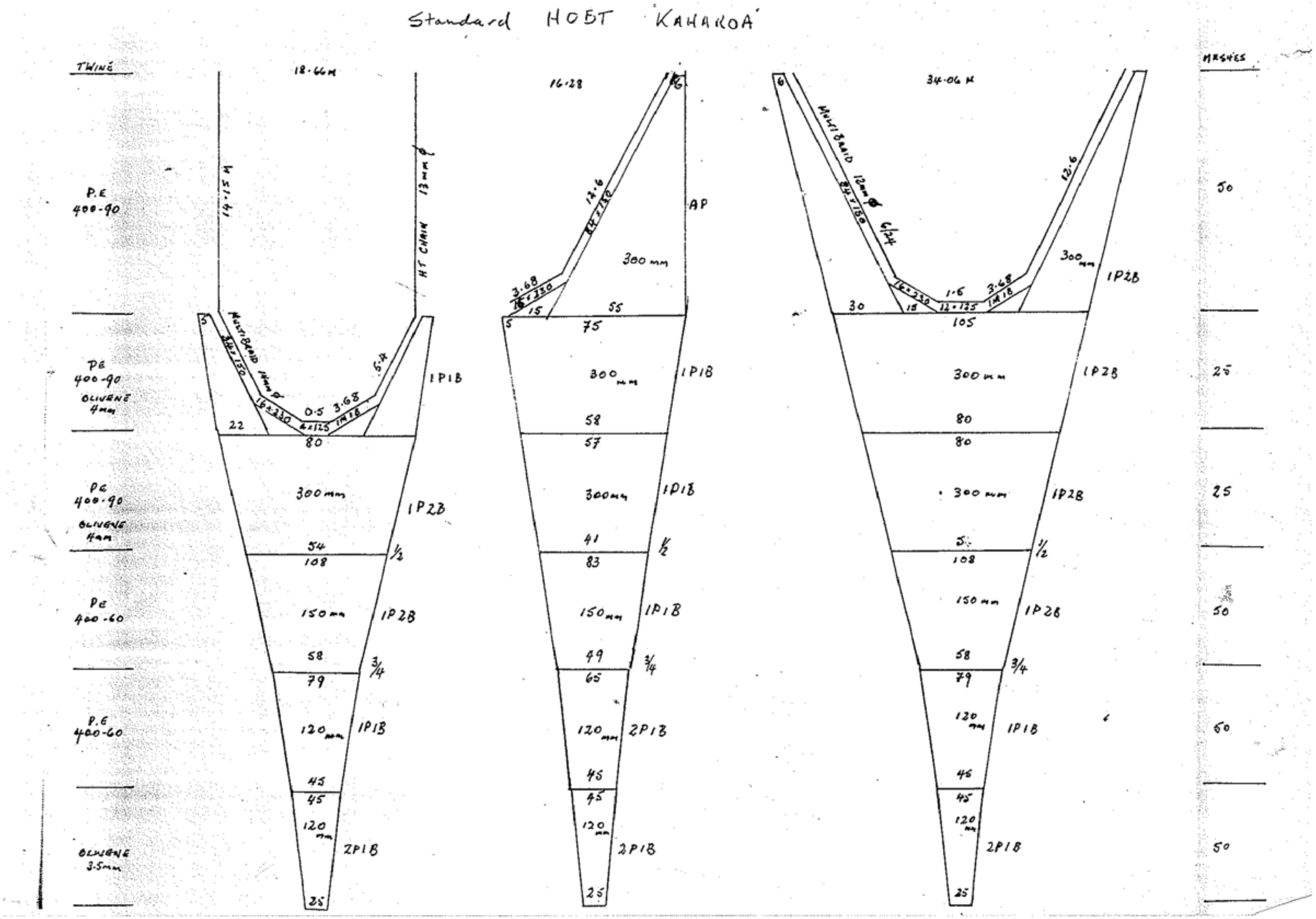


Appendix H11: Tarakihi, total seasonal average catch (tonnes) (July–September), by 1 degree squares.



Appendix H12: Tarakihi, total seasonal average catch (tonnes) (October–December*), by 1 degree squares.
*** time period inclusive of WCNI and HAGU surveys.**

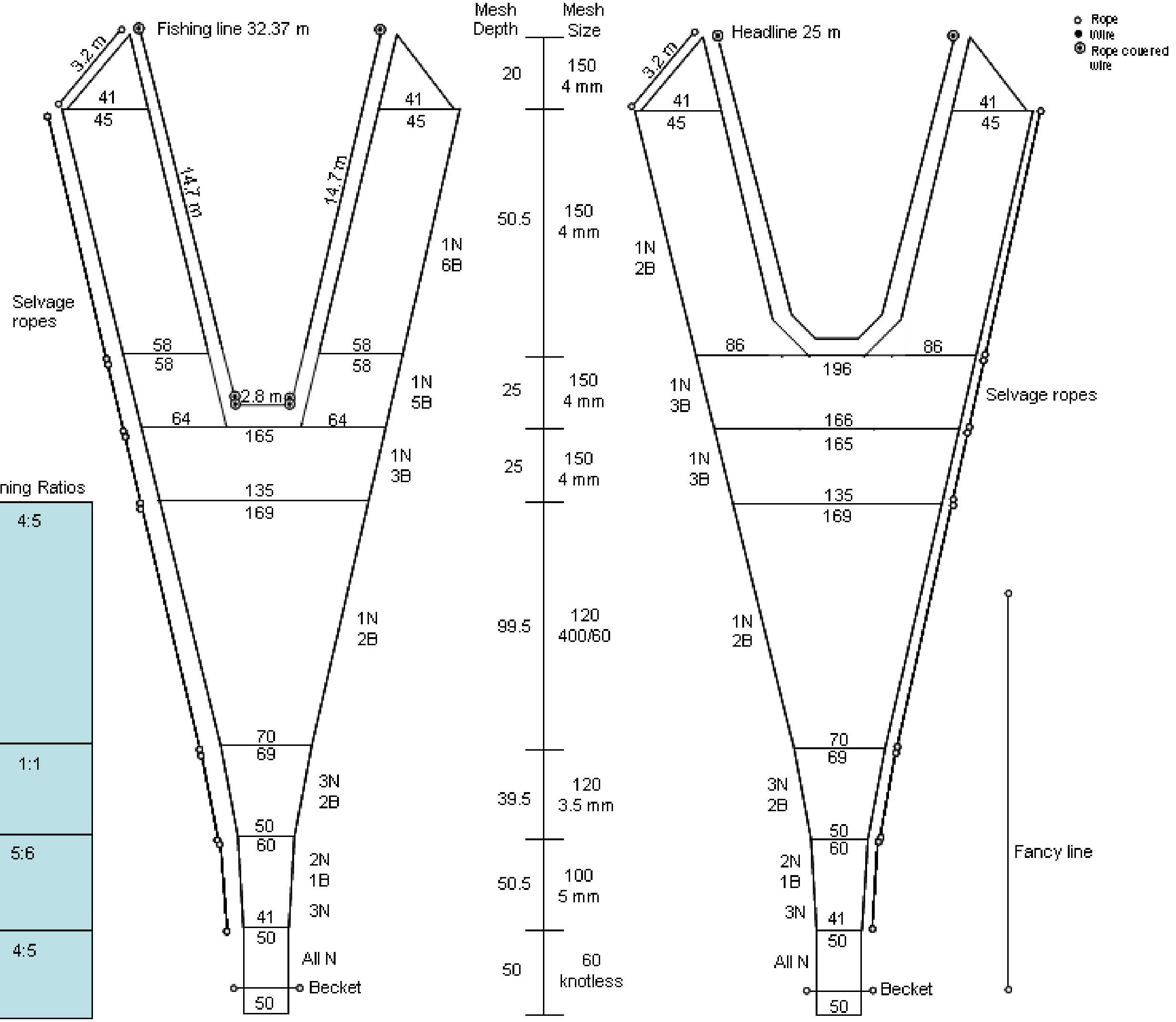
8.9. Appendix I: Net Drawings



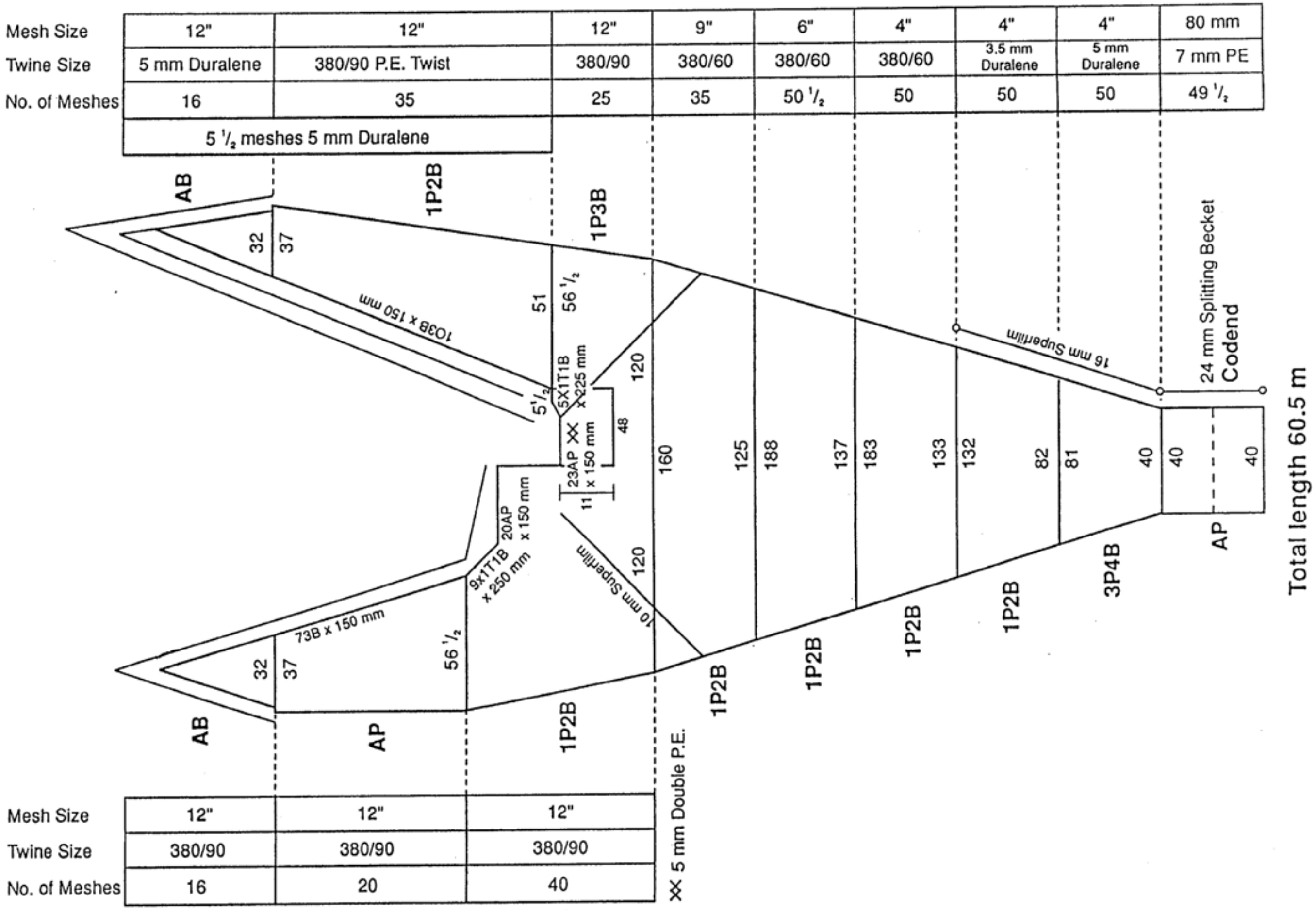
Appendix I1: Net drawing for HOBT

Net Plan: R.V. *Kaharoa* Bottom Trawl

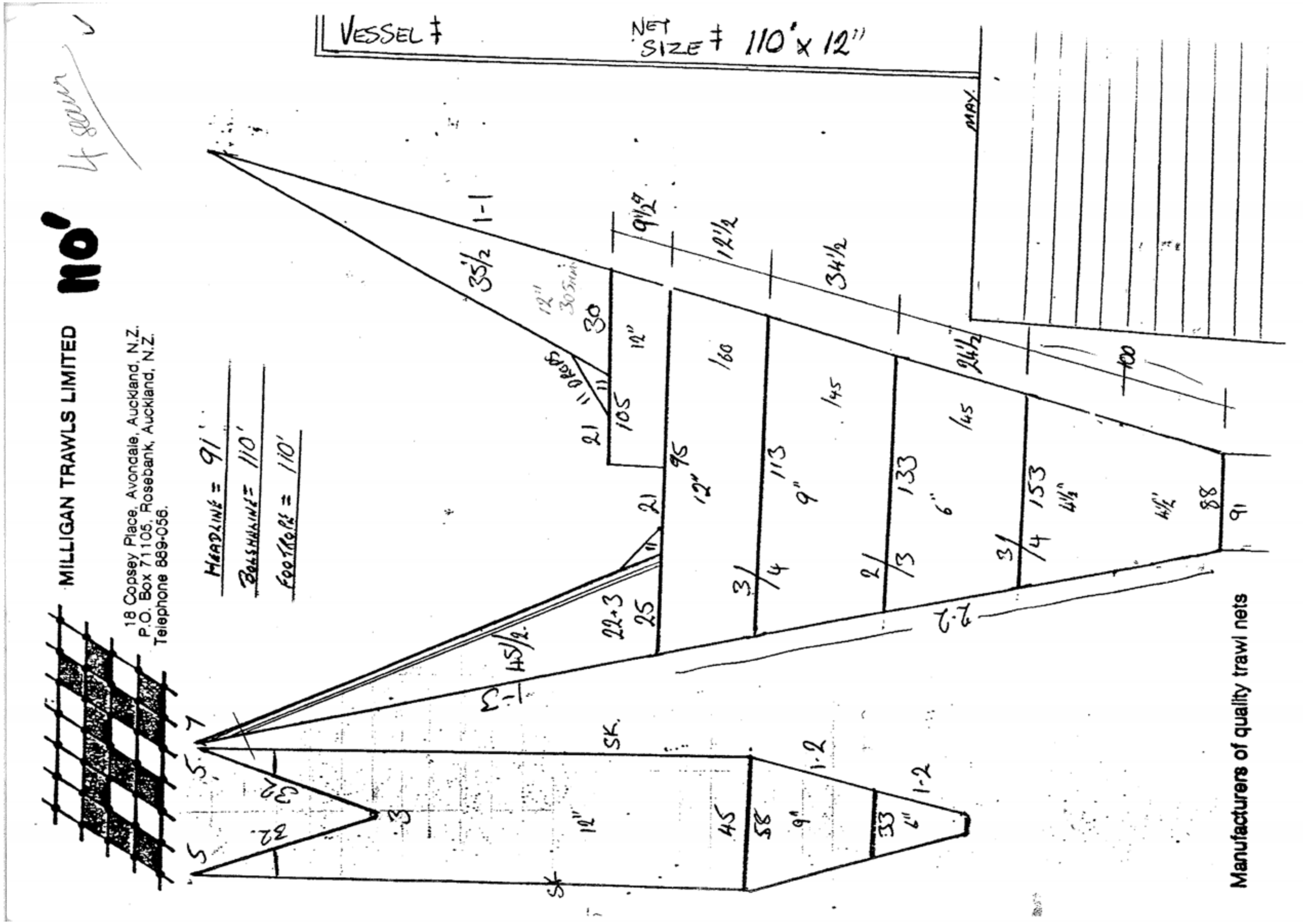
Mesh and twine size	No. meshes deep	Selvage ropes nylon 26 mm	Joining Ratios
150 mm 4 mm (Olivene)	20	V-lines 24 mm Hi-man superline 6.4 m	
150 mm 4 mm (Olivene)	50.5	6.3 m	
150 mm 4 mm (Olivene)	25	3.3 m	
150 mm 4 mm (Olivene)	25	3.3 m	
120 mm 400/60 (pe)	99.5	10.8 m	4:5
120 mm 3.5 mm (Olivene)	39.5	4.0 m	1:1
100 mm 5 mm (Olivene)	50.5	4.2 m	5:6
60 mm knotless (type)	50	-	4:5



Appendix I2: Net drawling and details for the South Island Survey trawl



Appendix I3: Net drawling for the east coast North Island survey trawl.



Appendix I4: Net drawing for a generic commercial trawl from Milligans