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Can separate CPUE indices be developed for the two groper species, hapuku (*Polyprion oxygeneios*) and bass (*P. americanus*)?

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EXECUTIVE SUMMARY

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This study investigated whether satisfactory CPUE indices could be developed for the two groper species, hapuku (*Polyprion oxygeneios*) and bass (*P. americanus*), either separately or in combination.

Catch and landings data are recorded for bass, hapuku, and "groper". Less than 10% are recorded to species level. CPUE analyses could be undertaken only on the "groper" dataset. The answer to the main objective is thus "no".

Seven target fisheries were analysed for the decade 1989 90 to 1998 99. There were three dropline fisheries (the main targeting method for groper): northeastern North Island, Cook Strait, and Southland; three bottom longline fisheries: northeastern North Island, eastern North Island, and Cook Strait; and one setnet fishery: Cook Strait (Kaikoura).

Two thresholds were used to select vessels which seriously targeted groper, an annual landing of 10 t or 5 t. The latter provided an average of only 23 vessels per fishery; most fished only a few years, and few fished right through the 1990s.

CPUE was determined by dividing the sum of landings by all selected vessels by the sum of all days on which they reported a groper catch. Zero catch days were not included. Two vessel-selection procedures were used: vessels which had caught above the 5 t threshold at least once were included in all years; and alternatively they were included only for the years in which they reached the threshold.

In most datasets analysed, the nominated target species were groper, bluenose, ling, and school shark. In Cook Strait fisheries, the groper-only target fisheries were analysed. It was possible to compare Cook Strait line-caught groper CPUE values from the 1990s with values from 1940 to 1961.

Where sample sizes (vessels) were adequate, CPUE trends were flat, and positively correlated with landings. Single vessels entering or leaving the fishery often had a large effect. CPUE trends were similar for vessels landing above the threshold of 10 t, above the threshold of 5 t, vessels targeting groper plus associated species (bluenose, ling, school shark), and vessels targeting only groper.

During the period 1940 to 1961 Cook Strait line vessels had CPUE values (landings per day) of 200 300 kg. This is comparable to the CPUE of similar vessels during the 1990s.

The decline in Cook Strait groper landings between 1950 and the early 1980s was previously interpreted as a decrease in stock size, and the first yield estimates for the Quota Management System were cautiously low for this and adjacent regions. A closer examination of these landings data by port, in association with landings of ling and rock lobster, now suggests that at least part of this decline resulted from fishers moving effort from line fishing into more lucrative rock lobster potting. This could mean that the yield estimates were too low.

Data quality needs to be improved before more detailed CPUE analyses are attempted. These should include gear and effort parameters. Bass and hapuku should be recorded separately, and catches must be recorded as greenweight. Consideration could be given to modifying Fishstock boundaries.

1. INTRODUCTION

This report addresses Objective 2 of Project HPB1999/01: "To determine whether it is possible to use CPUE as an index of abundance for hapuku and bass separately." These are two large demersal fishes in the family Polyprionidae, hapuku (*Polyprion oxygeneios*) and bass (*P. americanus*). They are both known in New Zealand as groper.

The New Zealand groper fishery is small, landings during the 1990s being less than 1% of total national finfish landings. However, groper are valuable fishes, and in many regions they are relatively more valuable as one component of a set of seasonal fisheries than their total landed weight suggests. About half the estimated catch (and 40–50% of landings) is recorded as targeted. A few vessels catch most of this, but small targeted catches are made by a large number of vessels (Paul 2002a). The other half of the catch is taken as very small bycatches in almost all the country's fisheries for marine finfish.

The yield estimates and subsequent TACs developed in the mid 1980s were based on regional catch histories for groper fisheries around the New Zealand mainland, and trawl survey biomass values for the Chatham Rise and the Campbell Plateau (or the Stewart/Snares shelf region). Mainland fisheries included some with a long and reasonably stable catch history, and some which had expanded rapidly within only a few years. There was no useful information from which to derive the sustainable harvest level, but there was a suspicion that both groper species were long-lived and slow-growing. There were also anecdotal accounts of quite rapid depletion of fishing grounds, particularly in the newer fisheries. It was decided to reduce total landings to about 50% of their peak value, and in order to achieve this a variety of factors was taken into account when regional TACs were set. Landings from most mainland Fishstocks were initially well below the initial TACs, but have since increased to equal and occasionally exceed them. The procedure for deriving yields from trawl survey biomass values is now considered obsolete; the two TACs derived in this way had no effect on the manner these offshore Fishstocks were exploited, always being considerably higher than landings.

There has been no subsequent work on groper fisheries to evaluate whether the initial TACs (now TACCs) were reasonable, or to monitor the status of these fisheries. The use of CPUE indices has been considered a possibility, but until recently it has not been possible to access a long enough time series of catch and effort data. This study is an attempt to do this.

The main objective of this work was to determine whether separate CPUE time series could be developed for the bass and hapuku components of the groper fishery. However, an early review of data from the Ministry of Fisheries' catch-effort database showed that only about one-quarter of the estimated catch was recorded by species, and – because many vessels used all three codes (bass, hapuku, and groper) in their records – even less (4–11%) of the catch could be considered to be reasonably separated by species. Less than 10% of landings were separated by species.

A secondary objective was to develop one or more CPUE time series for the catch data from both species combined. This had two purposes: to examine the issues involved in developing CPUE indices from relatively small fisheries, and to determine whether there were any large trends in CPUE that reflected a change in abundance of at least one species.

2. METHODS

A review of the combined-species data for the total New Zealand fishery (Paul 2002a) identified seven target fisheries which might provide useful CPUE indices. There were three bottom longline fisheries, three dropline fisheries, and one setnet fishery (Figure 1). None were particularly large, particularly in the number of vessels involved.

The analysis of landings by vessel (Paul 2002a) suggested that a suitable threshold level would be at an annual landing of 10 t per vessel. This threshold was also chosen by Bradford (2001) in CPUE analyses of the school shark fishery, which is reasonably similar in size and character.

For each of the seven fisheries, vessels which had made a landing of at least 10 t of groper (coded as BAS, HAP, or HPB) in any one year of the decade 1989–90 to 1998–99 were selected. For each vessel, the following data were used: annual estimated catch, annual landing, number of days on which groper were caught, and the target species listed for each day. The vessels had been allocated to region and method (i.e., fishery) by Paul (2002a) on the basis of their predominant fishing activity during each year. Some overlaps (with other regions, other methods) are present in the data, but considered minimal (though impossible to quantify). Some data grooming was undertaken, particularly removal of high catch and landing outliers, but otherwise the data had to be accepted as correct even if considered suspect.

Annual CPUE values were calculated as the total landing of groper for all selected vessels, divided by the total number of days on which they had recorded groper. (For the Cook Strait fisheries which targeted groper, estimated catch was used instead of landing, see below.) Two procedures were used: (1) vessels with a landing of greater than 10 t in at least one year were included in all years; (2) vessels were included only if they landed over 10 t for the year in question.

Preliminary examination of the data indicated that in some fisheries there were too few vessels landing more than 10 t. Also, most vessels fished for only a few years, and very few met the threshold of a 10 t landing in each year. The threshold was lowered to an annual landing of 5 t, and similar CPUE calculations made. This increased the number of vessels from 89 (mean 13 per fishery) to 160 (mean 23 per fishery), but the number of vessels which fished consistently through the decade changed little. The same two procedures of selecting vessels as described above were used, and the paired results are presented for each fishery.

For most fisheries the category 'target species' was not included in the analysis; the data were too sparse to be subdivided to this level. However, data inspection showed a common set of target species in most fisheries: groper (any code), bluenose (*Hyperoglyphe antarctica*), ling (*Genypterus blacodes*), and school shark (*Galeorhinus galeus*). Two exceptions were made: in the northeastern North Island bottom longline fishery snapper (*Pagrus auratus*) were excluded as a target, and in the Cook Strait (Kaikoura) setnet fishery tarakihi (*Nemadactylus macropterus*) were included as a target.

In addition, for the three Cook Strait fisheries (longline, dropline, setnet) a further analysis was undertaken, determining CPUE when only groper were targeted. This analysis used estimated catch data (landings cannot be linked with target species), and required (a) identifying the vessels involved in each fishery, and (b) using the original estimated catch extracts. Estimated catch records (cf. landings) contain some records which are processed weight instead of greenweight; it was assumed that this anomaly remained constant across years.

Some early (1940–61) catch, effort, and CPUE data for part of the Cook Strait fishery (Wellington-based vessels) were given by Tunbridge (1962). They were assumed to be comparable to the catch-effort dataset from the 1990s, and are included in this account, the values being re-plotted for direct comparison.

3. RESULTS

3.1 Separation of species

The possibility of splitting the combined-species reported catch using such parameters as region, depth, fishing method, and season, was assessed. It was considered impractical. Most of the commercial catch is reported on CELR forms, which do not record depth. As far as is known, fishing methods and seasons do not usefully separate the species. There *are* some regional and depth differences in the abundance of each

species, but the possibility of splitting even part of the combined catch reliably using this information was judged impractical. When new grounds are found, the hapuku which are in shallower water are exploited first, followed by the bass from greater depths, and this is repeated as further grounds are found, or when fishing resumes on previously-worked grounds.

3.2 Sample size

Reducing the threshold for selection of vessels in each fishery, from those which landed at least 10 t per year to those which landed at least 5 t, almost doubled the total number of vessels (89 to 160). However, it had little effect on the CPUE trends in individual fisheries (Figure 2). The CPUE trends seem to be driven mainly by the landings and effort data from the few vessels with high catches.

At this lower threshold, a moderate number of vessels participated in each fishery and landed at least 5 t of groper at some time during the decade (Table 1). However, only small numbers fished in any one year, particularly when vessels were chosen which caught at least 5 t in a particular year. In order to work with reasonable sample sizes, the lower threshold of a 5 t landing of groper was used in subsequent analyses.

Table 1: Number of fishing vessels in the main target fisheries for groper, landing at least 5 t in any one year, from which the landings (or catch) and fishing effort data were derived.

Region	Method	All vessels[1]	Vessels nos.[2] by year[3]									
			1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Northeast	Longline	41	6	19	16	18	19	19	19	19	19	20
North I			3	14	11	10	7	10	9	11	11	12
	Dropline	36	11	8	13	12	12	16	15	16	18	13
			6	6	8	9	5	8	8	10	11	10
Eastern	Longline	23	5	4	8	6	9	9	10	7	9	7
North I			3	2	5	5	8	4	6	3	6	4
Cook	Longline	19	6	8	6	8	3	7	3	4	4	7
Strait			3	5	4	6	2	4	3	2	3	4
	Dropline	19	10	10	11	10	10	13	11	9	9	11
			6	8	9	8	8	6	6	7	6	9
	Setnet	15	10	9	9	10	10	9	8	9	8	7
			6	7	7	8	9	8	8	8	7	7
Southland	Dropline	13	2	2	3	3	5	6	6	4	4	3
			2	2	2	2	5	5	4	3	2	2

Notes:
1. Number of individual vessels which fished at some time during the decade.
2. Number of vessels which fished each year. The first row tallies vessels which landed > 5 t groper in any year during the decade and fished in the year concerned (but may not have landed > 5 t). The second row tallies only vessels which landed > 5 t in the year concerned.
3. Years are fishing years, i.e., 1990 is fishing year 1989–90.

3.3 Target fisheries

Landings in each of the target fisheries are shown in Table 2.

Table 2: Landings (t) in the seven target fisheries, by region and method, taken by vessels which landed > 5 t of groper in the listed year.

Region	Method	Mean landing[1]	Landings[2] (t) by year[3]									
			1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Northeast	Longline	113	23	132	131	115	80	119	115	143	125	142
North I		98	21	124	121	97	57	102	99	124	112	126
	Dropline	145	156	129	133	127	113	129	145	167	172	182
		136	145	126	123	124	96	119	131	157	168	176
Eastern	Longline	61	19	28	60	89	121	49	99	30	67	45
North I		54	18	25	54	87	119	31	93	18	58	37
Cook	Longline	67	26	40	27	84	27	131	111	61	55	104
Strait		63	23	33	24	83	23	125	111	59	53	98
	Dropline	123	102	131	143	98	119	116	134	108	122	155
		117	97	127	135	92	113	100	128	108	119	150
	Setnet	121	112	121	105	109	115	113	118	120	184	115
		118	100	116	100	106	111	112	118	119	184	115
Southland	Dropline	32	15	21	30	19	44	50	58	38	19	26
		30	15	21	27	19	44	48	55	36	15	24
Target fishery totals		661	453	602	629	641	619	707	780	667	744	769
		617	419	572	584	608	563	637	735	621	709	726
Total N.Z. landing			947	1 214	1 291	1 463	1 585	1 573	1 643	1 561	1 577	1 647

Notes:
1. Mean annual landing for the decade.
2. Landing (t) by fishing year. The first row is landings from those vessels which landed > 5 t of groper in any year during the decade and which fished in the year concerned (but may not have landed > 5 t). The second row is landings only from vessels which landed > 5 t in the year concerned.
3. Years are fishing years, i.e., 1990 is fishing year 1989–90.

3.4 CPUE by method and region

CPUE trends for the seven target fisheries during the decade 1989–90 are shown in Figure 3, arranged by region and method. "Target fishery" in this section means vessels targeting not only groper but the main species associated with them: bluenose, ling, school shark, and (for one setnet fishery) tarakihi. Two options were used to select vessels: (1) those which landed 5 t or more of groper in a year were used for that year, and (2) those which landed at 5 t or more of groper in any year of the decade were included in all years. The CPUE trends are very similar.

Bottom longlines are not the favoured line method for groper fishing, but a moderate catch is reported taken by longlining, with groper and associated species (see above) listed as target species. In their usual configuration, bottom longlines are deployed across relatively open seafloor. It is possible that some variants of this, closer to the dropline style fishing more typically used for groper (with gear set across or near foul ground), were recorded as bottom lining, but this could not be determined from the catch-effort data.

The longline CPUE for the northeast of the North Island (QMA 1) was essentially stable, with variations generally matching trends in landings. The longline CPUE for the east coast of the North Island (part QMA 2) is erratic, but matches the landing trends even more clearly. The longline CPUE trend for Cook

Strait partly matches landing trends. It has two features: reasonable stability at 250–350 kg/day; and a CPUE two to three times this level in three years (1994–95 to 1996–97). When data from these three years were examined, it was clear that the rise resulted from the entry of one high-catching vessel into a small fleet of only 2–4 vessels in these years. In addition, the set of species targeted by this vessel suggested that it may have been using a form of dropline.

Dropline fisheries showed more stable CPUE trends through the 1990s. The CPUE trends sometimes matched trends in landings. For the northeast of the North Island, and in Cook Strait, the dropline CPUE trends were essentially flat. For Southland, the trend was also flat except for one year (1991–92) when a change of vessel occurred in a fleet of only two.

The only setnet fishery, in the Kaikoura region of Cook Strait, was stable through most of the 1990s in the number of vessels (generally the same ones), in the level of landings, and in CPUE. From 1997–98 there was less stability in the composition of the fleet, but CPUE remained level or (in 1997–98) increased. This increase results from higher catches by all the vessels which fished above the 5 t threshold that year.

3.5 CPUE by method and target species, Cook Strait

Cook Strait was the only region with moderate groper catches taken by all three main methods, and CPUE indices were developed for the catch taken when groper was the listed target, as well as when the target was either groper, bluenose, ling, or school shark.

The longline fishery results are considered unreliable; too few (1–5) vessels were involved, catches were variable, and it seems likely (based on listed target species) that some of the lines were a form of dropline rather than true bottom longlines.

In the dropline fishery the CPUE values and trends were similar for the effort which targeted only groper, and which targeted groper and the associated species.

In the Kaikoura setnet fishery there was moderate agreement between the two CPUE trends, but the CPUE values were considerably higher when groper was recorded as the target species. The setnet fishery was the most stable during the 1990s in terms of vessel continuity and catch level. It targeted the same species: groper, bluenose, ling, and school shark, plus tarakihi. These (tarakihi in particular) are presumably taken at different depths, and CPUE values differ when different combinations of target species are considered. The trends, however, are essentially similar: essentially flat, and matching fluctuations in the annual estimated catch values.

3.6 CPUE by region and method, northeast North Island, Cook Strait, Southland

To detect any common pattern in CPUE trends, values for six of the target fisheries are replotted by region in Figure 4. (The east coast North Island longline fishery is omitted because bottom longlining is considered a less relevant fishing method for targeting groper.)

The two CPUE trends for the northeastern North Island are essentially flat from 1990–91 onwards, with the dropline values always higher. There is a small inverse relationship between them in some years, which may result from vessels which use both methods having to be defined by a single method, or from vessels using gear which is intermediate between a dropline and longline.

The three CPUE trends for Cook Strait are essentially flat. There are three anomalous years for bottom longliners, which occurred when a new and successful vessel (possibly also using droplines) began fishing.

The single CPUE trend for Southland is essentially flat. The sample size of vessels is small, and the high CPUE value in 1991–92 occurred when the two vessels fishing in the previous years were replaced by two others.

3.7 Cook Strait line CPUE since 1940

It is worth examining catch and effort in the Cook Strait region in greater detail, because the original yield estimates for this and adjacent regions were influenced by the observation that landings in this large and long-established groper fishery showed a fluctuating downward trend from 1950 to the mid 1970s (see figure 5 in Paul 2002a). There was an apparent recovery in the late 1970s, but this was almost entirely due to the development of a new setnet fishery at Kaikoura.

Some early (1940–61) CPUE values for line-fishing vessels working out of Wellington were calculated by Tunbridge (1962). He named the lines "set lines" and described them as having 60 hooks per line, which makes it probable that these were the droplines normally used by Cook Strait groper fishermen, rather than longlines. He calculated CPUE as landings (lbs) per 10 days fishing. These values have been converted to kg/day for comparison with the more recent data (Figure 5, lower panel). In general, CPUE values for the period 1940 to 1961 are very similar to values in the 1990s, in most years being 200–300 kg/day. However, catch per day is unlikely to be a good measure of CPUE (see Discussion).

It is not possible to obtain comparable values for the intervening years, in order to determine whether the decline in groper landings into Wellington (Figure 5, top panel) from the late 1950s to the early 1980s reflects a CPUE decline, or a change in fishing activities at this port or the Cook Strait region. Some indirect information can be obtained on vessel numbers, and on the relationship between the groper and rock lobster fisheries, but they cannot fully explain the complexity of Cook Strait fisheries (Appendix 1).

In summary, the fluctuating downward trend in groper landings from the Cook Strait region (i.e., into Cook Strait ports) from 1950 to the mid 1970s cannot be simply attributed to a decline in the stock of groper. Landings of ling showed similar trends; they declined in parallel with Wellington groper landings, and they fluctuated in parallel with Kaikoura landings. Where groper and ling landings declined, they did so as a more lucrative rock lobster fishery developed. However, the converse argument also cannot be ruled out: that the groper and ling stocks were both being overfished and were declining, and as a consequence fishers shifted to lobster fishing, or diversified within the fishing industry.

In Wellington, the decline was relatively greater because a number of the first-generation dropline fishers left the fishery and were not replaced; the younger generation of established fishing families tended to take shore jobs within the fishing industry, and newcomers to fishing diversified into a number of less arduous, more profitable fisheries.

4. DISCUSSION

In this study the "target fisheries" used in the derivation of regional CPUE trends during the 1990s were the main line (and in one instance setnet) fisheries which targeted bluenose, ling, and school shark *in addition to* groper. In the Cook Strait (Kaikoura) setnet fishery it was shown that the CPUE trend when only groper were targeted was a little different, and perhaps (in theory at least) more reliable. It would have been preferable to use targeted-groper CPUE data for the other fisheries but for three reasons this was impractical, at least in this study. (1) It was not easy to link groper landing values (more reliable than catch values, see Paul 2002a) to target species; the data from the small number of vessels in the Kaikoura fishery had to be extracted individually from datasets. (2) There are few vessels in each fishery which meet the 5 t annual groper landing threshold for the set of target species. The number – or at least the number of fishing days – would be even fewer if groper-only data were used. (3) There is unlikely to be a major, or at least consistent, distinction between the nominated targeting of groper and the targeting

of bluenose and ling. The position is complex. (a) Only one target species can be nominated for each fishing event, even when there is a high probability that two or more species are equally likely to be caught. While it did subjectively appear during data analyses that relatively higher quantities of groper were caught when they were nominated as the target, this was not always so. (b) It is possible that because catch-effort forms are completed after the event, some fishers record the most abundant species caught as their target. (c) It is also possible that some fishers are cautious when nominating their target when they are approaching their quota limits for one or more species, as there are rules within the Quota Management System which then limit their selling and trading options.

Alternative analyses could be undertaken which used "most abundant species caught" in place of "nominated target species", or which used the groper catch and associated fishing effort when groper were one of the top two (perhaps three) species taken. This would resolve some of the above difficulties in defining appropriate target fisheries, but still has problems. The necessary catch-effort extracts would be considerably more complex, requiring the listing of the top five species for each daily record in which groper were either targeted or caught. Their analysis would require the development of new procedures, and – at least initially – the analysis could only be done on estimated catches, which have the unfortunate problem of comprising a mixture of greenweight and processed weight values.

The CPUE indices through the 1990s for the seven target fisheries used in this study showed either no trend, or – where sample size was small – apparently random fluctuations, particularly in the bottom longline fisheries which target groper less efficiently. These are unstandardised CPUE indices, with the unit of effort set at one day's fishing. It can be argued that this ignores the possibility that fishers have an optimal level of catch for one day, large enough to be profitable, but small enough to be handled by the vessel's size and crew. In this event, the measure of effort should not be a day's fishing, but the amount of gear used. This can certainly be investigated in subsequent studies, although there will still be drawbacks: small numbers of vessels in each fishery; known ambiguities in the manner in which finer-scale effort variables (line numbers, hook numbers, soak time) have been recorded; and between-fisher variation in fishing skill, particularly the ability to place their lines or nets in optimal localities in relation to tide times and the run of the current. In a previous study (NIWA, unpublished data) of the catch rates (as catch per hook) of just one vessel operated by two skippers over the period 1983–95, it became clear that catch rates changed with skipper, and with assumed target species (the main species taken). Although the details of a single-vessel study cannot be reported here, it can perhaps be noted that after making some allowance for skipper and target-species differences, catch-per-hook increased during this time period, but with high within-year and between-year variability.

An earlier study of groper CPUE in the Cook Strait line fishery, although also based only on the broad measure of catch per day, showed no decline over the period 1940–61 (Tunbridge 1962), when the Cook Strait groper fishery was at its peak. The catch per day values from that period were similar to the values from the 1990s in this study. The steady decline in groper catches from the Cook Strait region, as landings into Cook Strait ports from 1950 to about 1980, may have resulted from decreased target fishing for groper as well as a decline in fish abundance (see Appendix 1). Several changes in effort from about 1950 onwards make comparisons difficult: mechanical line haulers were introduced in the mid 1950s; hemp lines with canvas floats were replaced by nylon lines and rubber floats about 1960; improved echo-sounders, and subsequently GPS equipment, assisted the exploration of new grounds; the number of lines, their length (and number of hooks), and the manner in which they were worked, changed; and there was a generational change in the fishers. There are two related factors which have probably undergone less change, but still influence CPUE (towards a stable value of catch per day): vessel size (hence carrying capacity), and the processing capacity of the sheds which receive the groper catch. In combination, vessel and shed size may define an optimum day's landing, and fishing strategies are varied to achieve this. Catch per hook is more likely to be a useful measure of CPUE than catch per day in the main line fisheries, if other effort variables can be standardised.

A study of groper CPUE during the peak years of the Kaikoura setnet fishery, 1979 to 1986, has also been undertaken (G.A. McGregor in Paul 1988). The effort parameter was 100 m net/trip. CPUE showed no trend.

Although no studies have clearly demonstrated a CPUE decline in the Cook Strait region, it must be remembered that the hapuku can undergo long distance migrations (Beentjes & Francis 1999), and the bass or wreckfish is also considered to be migratory (Sedberry et al. 1999, Peres 2000 and pers. comm). It appears likely that Cook Strait is a central location for fish moving from north to south and also east to west; if so, the fishery is operating on a stock that is larger than one which simply resides in the region, and on a stock that is regularly renewed by both recruitment and immigration.

The main objective of this study, developing CPUE indices for the two groper species separately, could not be achieved because only a small part of the catch and landings data was separated by species. Some unstandardised CPUE indices were developed for the combined groper catch in the main groper fisheries. Catch per day values showed either no trend, or varied apparently randomly because of the small sample sizes (vessels per fishery).

A further requirement of this study was to provide recommendations for future data collection and analyses. These can be summarised as follows.

Data collection

- Insist that groper catches and landings be recorded by species, codes BAS and/or HAP. Although this is an existing requirement, it is not enforced.
- Insist that groper estimated catch values be recorded as greenweight, not processed weight. Although this is an existing requirement, it is not enforced.
- Consider revising groper Fishstock boundaries to simplify and more easily monitor the main fisheries (Paul 2002a, 2002b).
- Consider asking a selected number of the main groper fishers to answer a questionnaire directed at clarifying those aspects of their fishing strategies likely to influence CPUE analyses of their catch and effort data.

Analyses

- Although full standardised CPUE analyses may not be required (or appropriate) for groper, the value of effort parameters on a finer scale than "number of fishing days" should be investigated. For line fisheries these should at least include number of lines, number of hooks, and perhaps number of sets or some measure of soak time. For the setnet fishery these should include number of nets, length of (each) net), and perhaps number of sets or some measure of soak time. The value of the soak time parameter needs careful investigation.
- Analyses should investigate the issue of target species, by considering the catch when (a) groper is the nominated target, (b) either groper, ling, or bluenose is the nominated target, (c) groper is either the main species, or one of the top two or three species, caught. In this context, groper is either hapuku or bass; however, when catch by species data become available, the issue of whether hapuku or bass are targeted separately requires investigation.

5. ACKNOWLEDGMENTS

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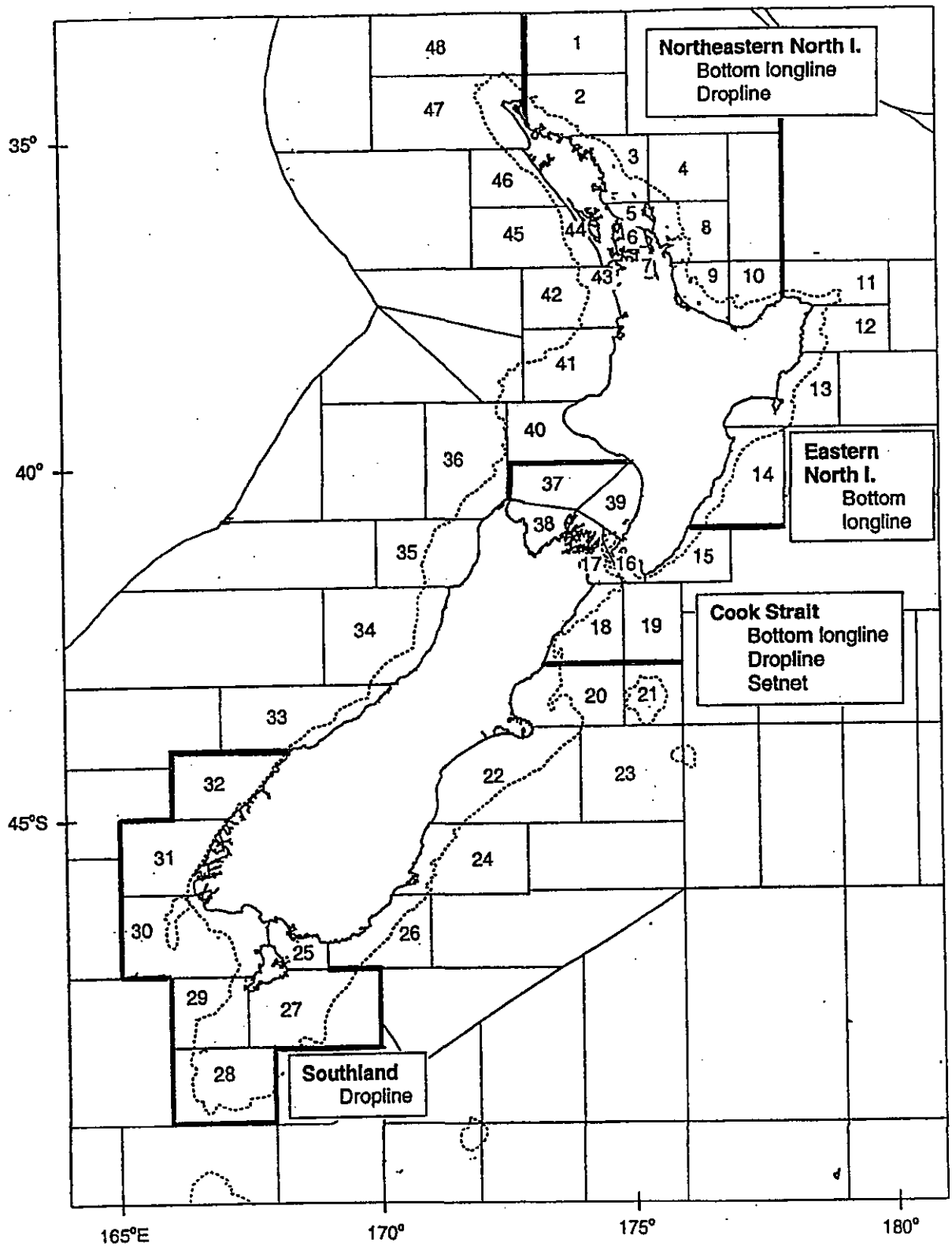

Figure 1: Location of the target fisheries used for CPUE analyses. The regions are those defined in the general account of the groper fishery (Paul 2002a).

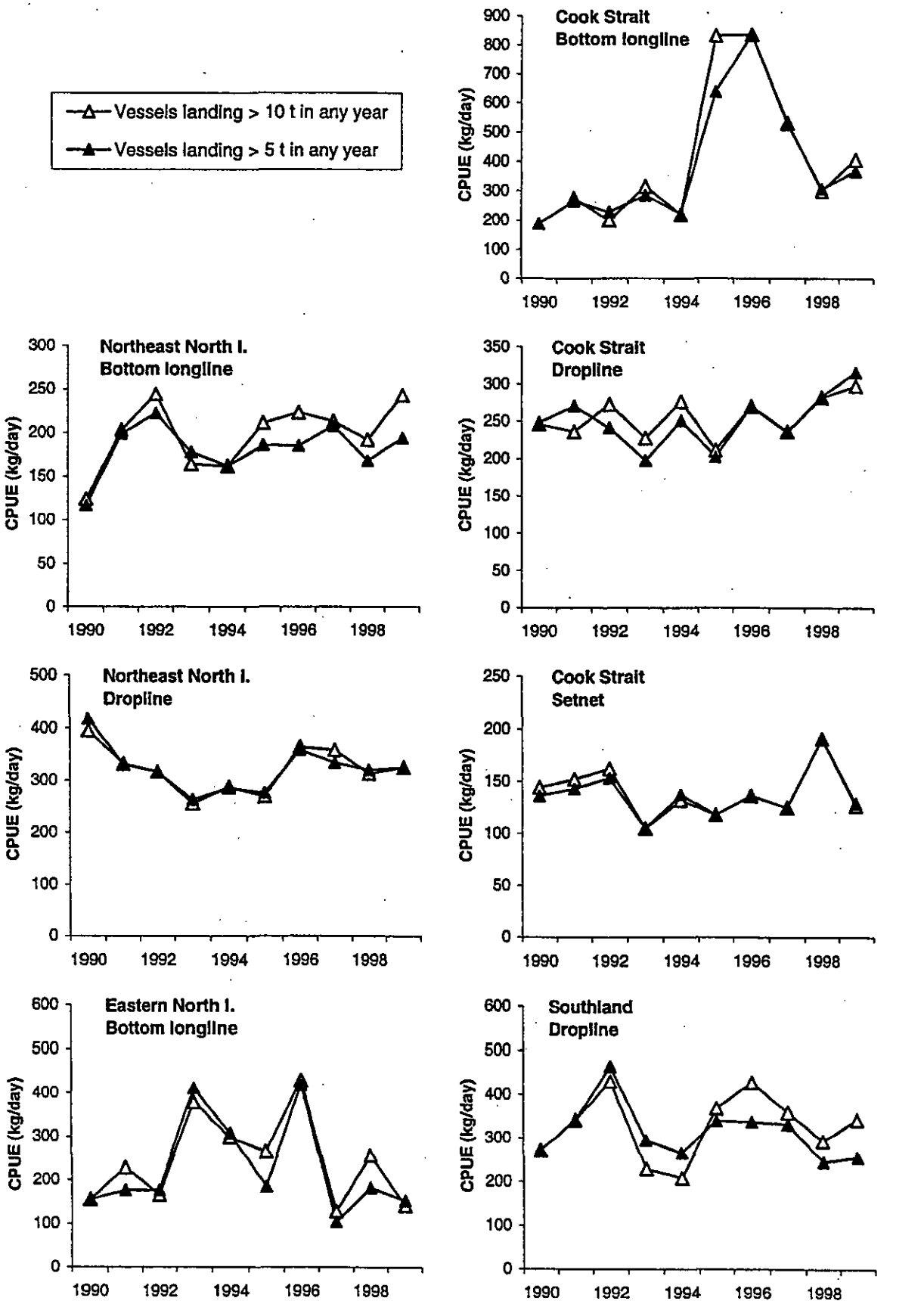

Figure 2: Effect of landing threshold (5 t or 10 per year) and consequently sample size (number of vessels) on CPUE trends in the main target fisheries. The fisheries are presented by region and method, for vessels which targeted the set of species: groper (BAS, HAP, HPB), bluenose (BNS), ling (LIN), and school shark (SCH). The two trends are: (1) for vessels which landed at least 10 t of groper in one or more years of the decade 1990–99; (2) for vessels which landed at least 5 t of groper in any year of the decade. If a vessel met the threshold in one year it was retained for the decade. CPUE values are summed landings divided by summed days when groper were caught.

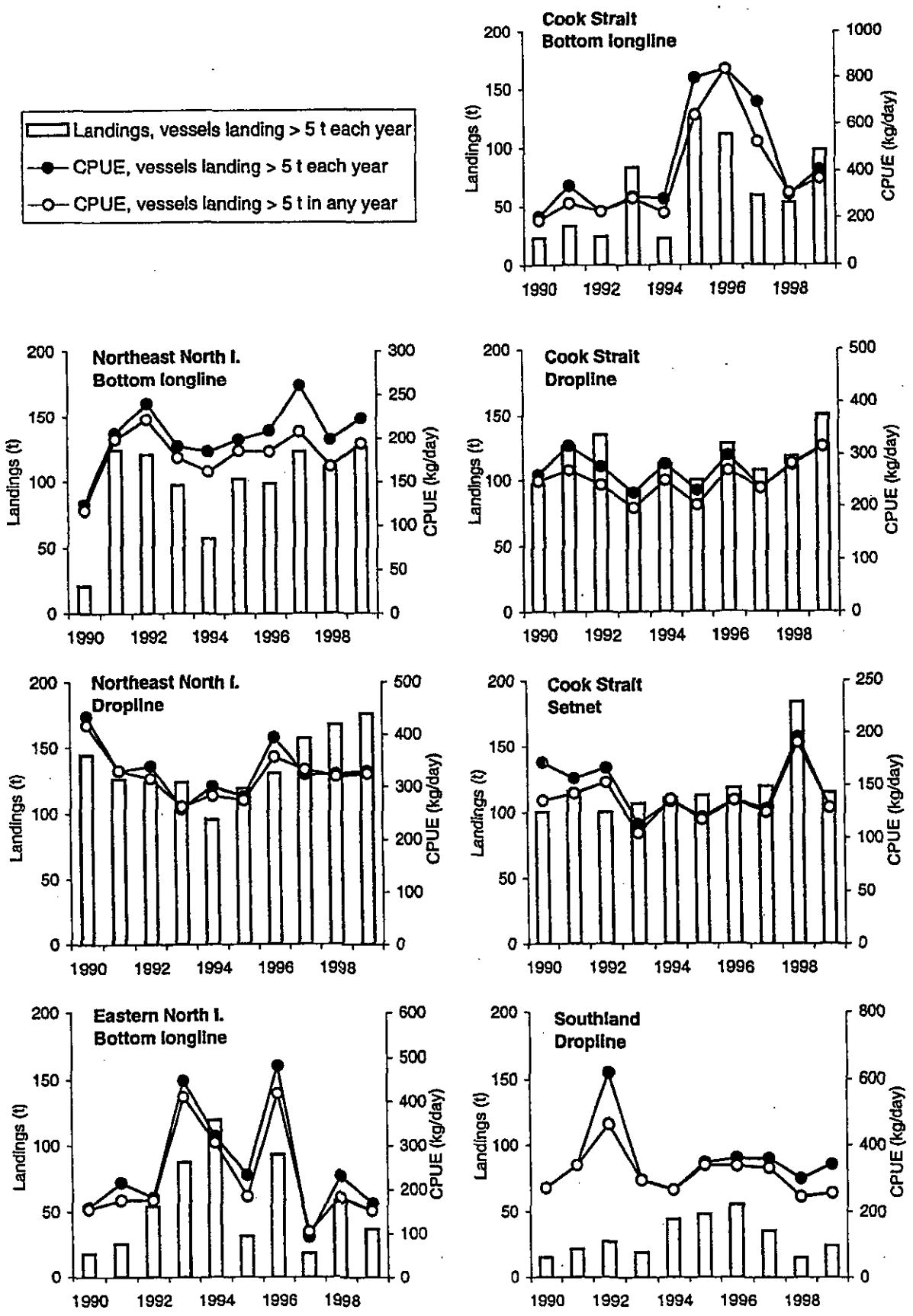

Figure 3: Effect of vessel selection options on CPUE trends in the main target fisheries. The fisheries are presented by region and method, for vessels which targeted the set of species: groper (BAS, HAP, HPB), bluenose (BNS), ling (LIN), and school shark (SCH). The two selection options are (1) vessels landing > 5 t of groper were included for that year only; (2) vessels landing > 5 t of groper in any year of the decade were included for all years. The landings shown are shown for vessels in option 1.

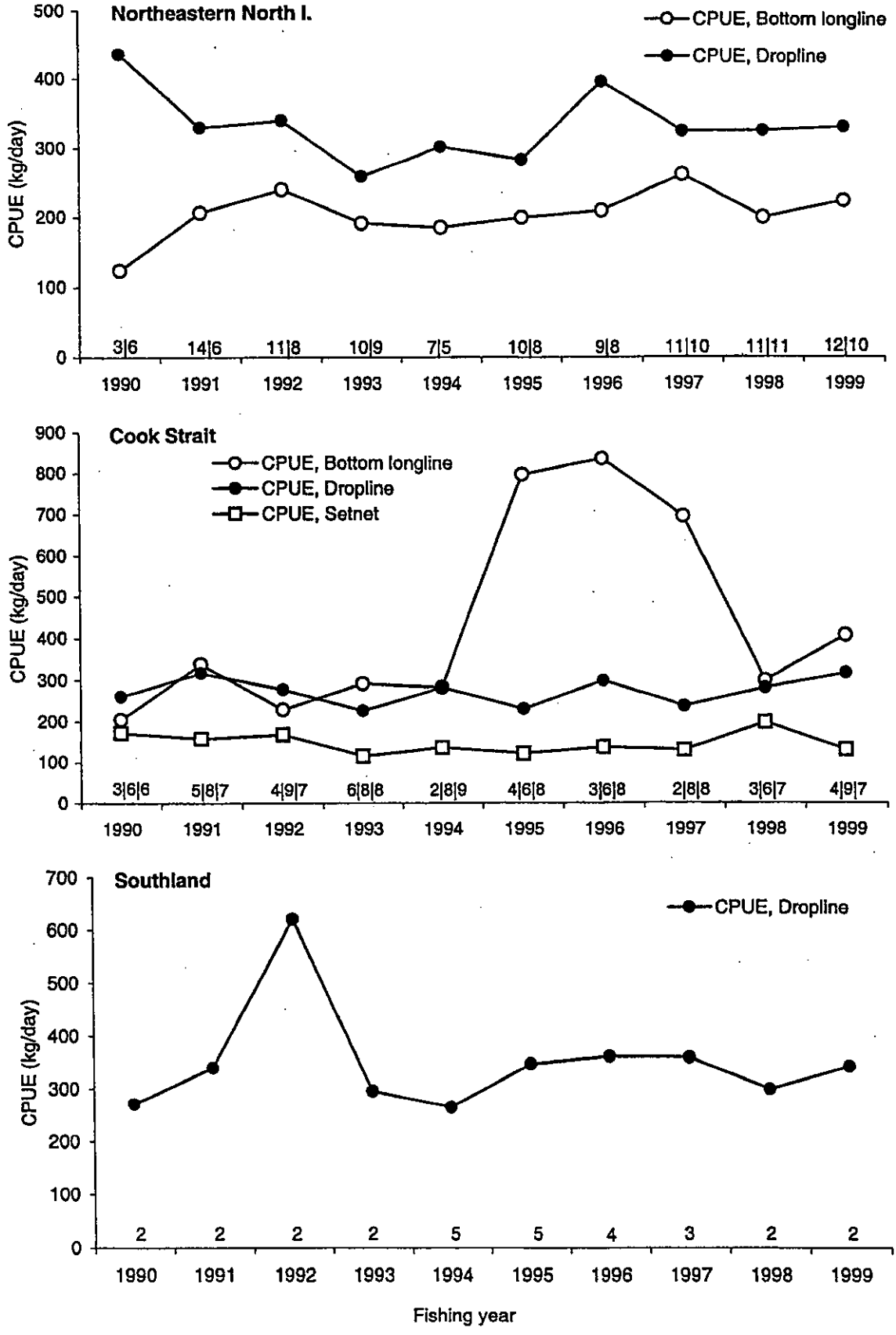

Figure 4: CPUE trends in the main target fisheries for groper, by region and method. The values are for vessels which landed > 5 t of groper in each year, when effort was targeted at several species (BNS, LIN, SCH) in addition to groper. Numbers of vessels are listed along the x axis, in the sequence: bottom longline, dropline (northeastern North Island); bottom longline, dropline, setnet (Cook Strait); dropline (Southland).

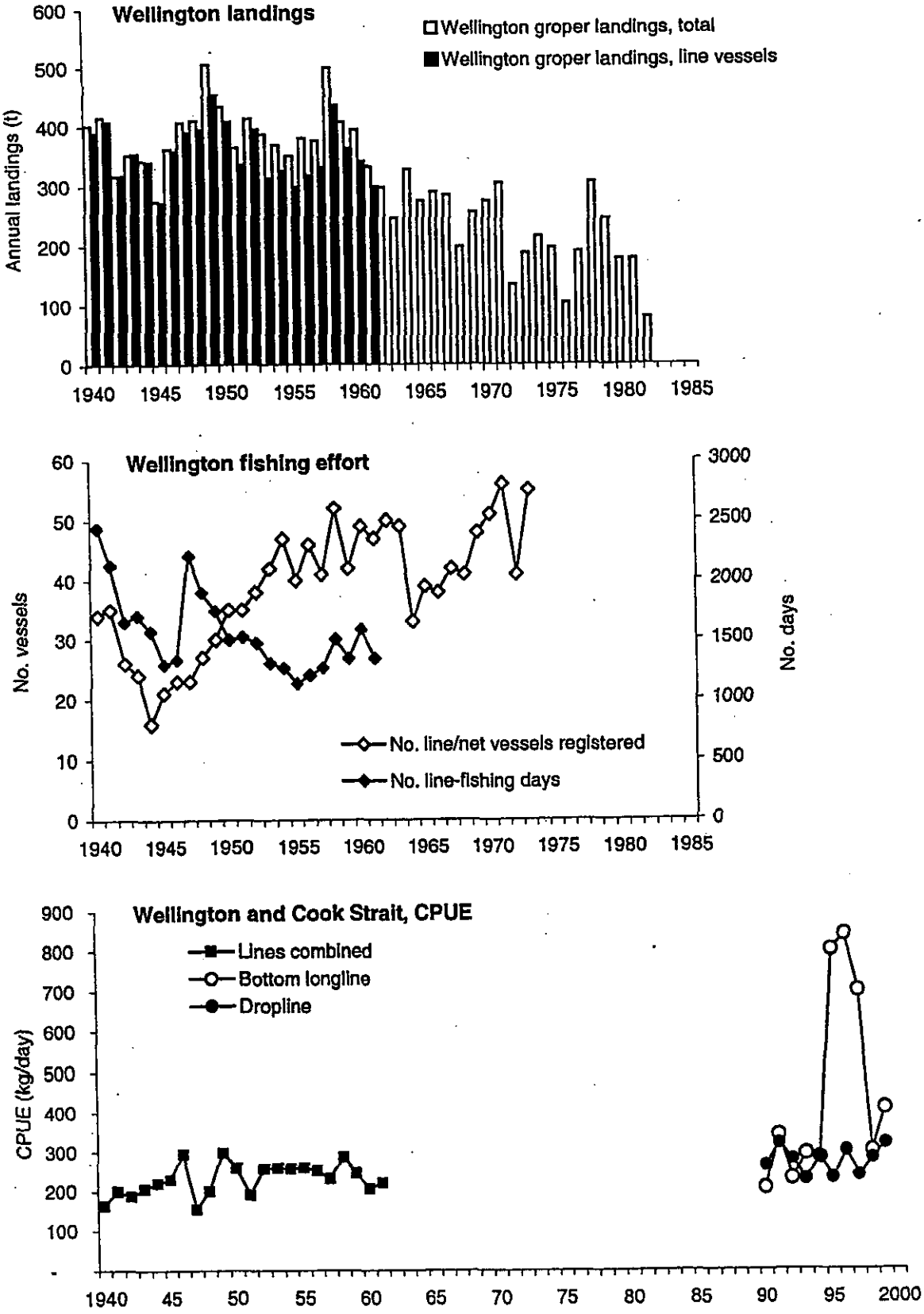

Figure 5: Landings (t), effort, and CPUE trends in the Cook Strait line fishery for groper, 1941–61 and 1990–99. Top: Wellington groper landings, total (from Annual Reports on Fisheries), and line vessels only (from Tunbridge 1962). Centre: Wellington line-fishing effort, as registered line/net vessels (Annual Reports on Fisheries), and line-fishing days (Tunbridge 1962); for discussion, see Appendix 1. Bottom: CPUE. The 1940–61 values are re-plotted from Tunbridge (1962); they are not defined, but assumed to be the mean of line vessel (longline and dropline) landings divided by fishing days (most trips being of one day) when groper or associated species were targeted. The 1990s CPUE values are for vessels landing > 5 t of groper in each year, when line fishing (bottom longline and dropline) was targeted at groper, bluenose, ling, and school shark; for explanation of the three high bottom longline values see text.

Appendix 1: Fisheries for groper, ling, and rock lobster in the Cook Strait region

An account of the line fisheries for groper and ling, and the pot fishery for rock lobster, serves to demonstrate the complexity of these fisheries in the Cook Strait region, but does not directly provide information on CPUE trends.

The only measure of fishing effort for the period 1940 to 1975 which is accessible and potentially useful is the number of line (and net) vessels registered at the port of Wellington recorded in the Annual Reports on Fisheries (see text Figure 5, centre panel). It can be directly compared with Tunbridge's CPUE series for the years 1940–61. For the first eight years the agreement was good, both series recording a steep wartime drop and post-war increase. For the next seven years the series go in opposite directions. From the mid 1950s there is general agreement again, but little trend. From 1962 onwards no comparison can be made, but the sharp drop in registered line/net vessels in 1964 is almost certainly an artefact in terms of fishing effort. The fishing industry was de-licensed in 1963; consequently it was no longer necessary for fishers who had not been using their licenses to retain them, as replacements could be acquired relatively easily if needed. The 1964 drop suggests that up to one-third of the "licensed vessels" in previous years were not actually fishing, but were inactive licences. The increase in registered vessels from 1965 onwards represents a different feature: new entrants into the line and net fisheries. In summary, (1) it is not possible to separate line and net vessels, although the registered number of line/net vessels were probably the same vessels, at least until 1950; (2) an unknown proportion of registered vessels did not actually fish; and (3) from 1965 the composition of the registered fleet changed as inactive vessels dropped out and new entrants, many of whom were part-time fishers, replaced them. The number of vessels registered at Wellington cannot be used as a proxy for fishing effort.

A possible reason for the decline in Wellington groper landings is a decline in the number of skilled line fishermen, mostly of Italian and Shetland descent, working out of Island Bay. This fishing community was established around the turn of the twentieth century, and for several decades landed large quantities of groper into Wellington for distribution through the lower North Island. They also lined ling, gemfish, and school shark, as well as netting butterfish and (seasonally) blue warehou and blue moki. This was arduous and not particularly profitable work, particularly during the 1930s depression and then the war years. When war restrictions were lifted there was an increase in fishing activity, but many of the pioneering generation eventually gave up fishing and moved into shore-based fish wholesale and retail businesses, their fish supplies coming mainly from the large trawlers which commenced working post-war. Relatively few of the younger generation took up active fishing (Makarios 1996). The Fishing Co-operative that was formed in 1930 to co-ordinate fishing and trading became less relevant and was wound up in 1963.

If the decline in groper landings from Cook Strait fishing grounds was due only to a less active Wellington fishing community, the landings at other Cook Strait ports would not necessarily show the same trend. In fact, groper landings at other ports close to Cook Strait showed almost exactly the same fluctuating pattern of decline to about 1975, with most of the decrease occurring between 1950 and 1965 (Figure A1). Landings into Paremata rose quickly after the war, peaked in 1949, then dropped to a low level from 1956 onwards. Landing into ports in or near the Marlborough Sounds (Picton, Pelorus, Blenheim) rose similarly to a higher peak in 1949, declined slowly to the mid 1950s, then dropped rapidly to 1960 after which they fluctuated around a lower level. Vessels from these ports would have worked similar grounds to those from Wellington, but with more emphasis on those in the western strait. Kaikoura has been included within the Cook Strait region in this study, though the main fishing grounds worked from there are south of the strait itself. Groper landings here do differ from those from the other ports, being relatively small (usually 50–100 t) and with fluctuations but no trend between 1936 and 1970, then climbing rapidly from 1975 as a setnet fishery developed.

Although most of these Cook Strait landings represent targeted catches by line vessels, the same vessels also targeted other species. The groper fishery can be more clearly understood if these alternative fisheries are reviewed for the same time period.

Two other fish species are targeted by the same line vessels that fish for groper, using similar gear in similar areas. Bluenose (until about 1980 listed as 'bonita') are taken as both target and bycatch. They were sometimes grouped within the category 'groper'; the distortion this introduced to the groper landing values is unknown, but considered small. However, it is not possible to review bluenose landings for the years in question (late 1950s to early 1980s). Ling has also been an important target and bycatch species taken by the same Cook Strait line fishers working for groper. Landings into Wellington reached a post-war peak in 1947, and then there was a steady decline to low landings in the mid 1960s (Figure A2). The pattern at other Cook Strait ports is less consistent, but in general shows a much slower rate of decline over this period.

Another fishery that became important in the Cook Strait region from about 1950 is rock lobster potting (Annual Reports on Fisheries). Early records are incomplete, but suggest landings into Wellington and adjacent small ports of 100 t by 1930, dropping to 30 t in the depression years. By 1940 Wellington lobster landings were about 150 t (Figure A3), rising to 400 t in 1951, and fluctuating considerably (90–475 t) until the mid 1970s. Not all the early lobster catch was targeted; some was a bycatch in setnets for butterfish, warehou, and moki, and because of the relatively low market value was seen as a nuisance rather than a windfall (Makarios 1996). In the late 1940s an export market developed for frozen lobster tails (Annala 1983), which stimulated increased fishing on existing grounds and a search for new grounds. In the early 1950s some of the Wellington fishers involved in the groper fishery began exploring the rich lobster grounds in eastern Cook Strait, along the southeast coast of the North Island (Makarios 1996). Landings peaked not only at Wellington around 1950, but at surrounding ports, the Marlborough Sounds (1948–51), Kaikoura (1950), Paremata (1952), and Castlepoint (1952–54). Although lobster landings declined from the mid 1950s, the unit value (dollars per tonne) of lobster increased more rapidly than did that of groper and ling (Figure A4), particularly after 1965.

The clearest way to show the relationship between these three main fisheries (groper, ling, rock lobster) in Cook Strait is to group their landings by port (Figure A5).

- At Wellington the groper and ling landings trended downwards together. The decline began as the landings of rock lobster rose, about 1950. After 1951 lobster landings also began to decline, but with fluctuations. It can be observed that as both groper and lobster landings declined over three decades (1950s through the 1970s) there was some reciprocal relationship between them, slight rises in groper matching slight falls in lobster. It seems probable that there were close links between the two fisheries. There may have been a progressive shift away from groper fishing to lobster potting, particularly when the lobster became considerably more valuable, but the situation is almost certainly more complex. However, it is possible that lobster catches (with their higher value) became the driving force in this Wellington fishery of alternate target species, and that in years when lobster catches declined a little more effort returned to groper fishing.

- At Marlborough Sounds ports the groper and lobster fisheries developed at about the same time, and their landings almost trend together between 1940 and the early 1980s. The decline in groper landings, which at their early peak were about half the level of Wellington's, was less pronounced. There is a slight reciprocal relationship between groper and lobster landings.

- At Paremata the groper landings declined from 1950 as the lobster landings increased, but then both declined to a low level, possibly from diminished effort, after 1954. Vessels from this port would have worked northern Cook Strait, where ling are less common.

- At Kaikoura groper and ling landings trend closely together from 1940 to 1970; the dissimilar trends in the 1970s and 1980s, although both increased, probably result from the development of a new setnet fishery. There was only a slight decline in both groper and ling landings around 1950, when the lobster fishery first peaked.

It is unlikely that the decline in landings of groper into Cook Strait ports is due only to a decline in stock size. There have been changes in fishing effort that are difficult to quantify.

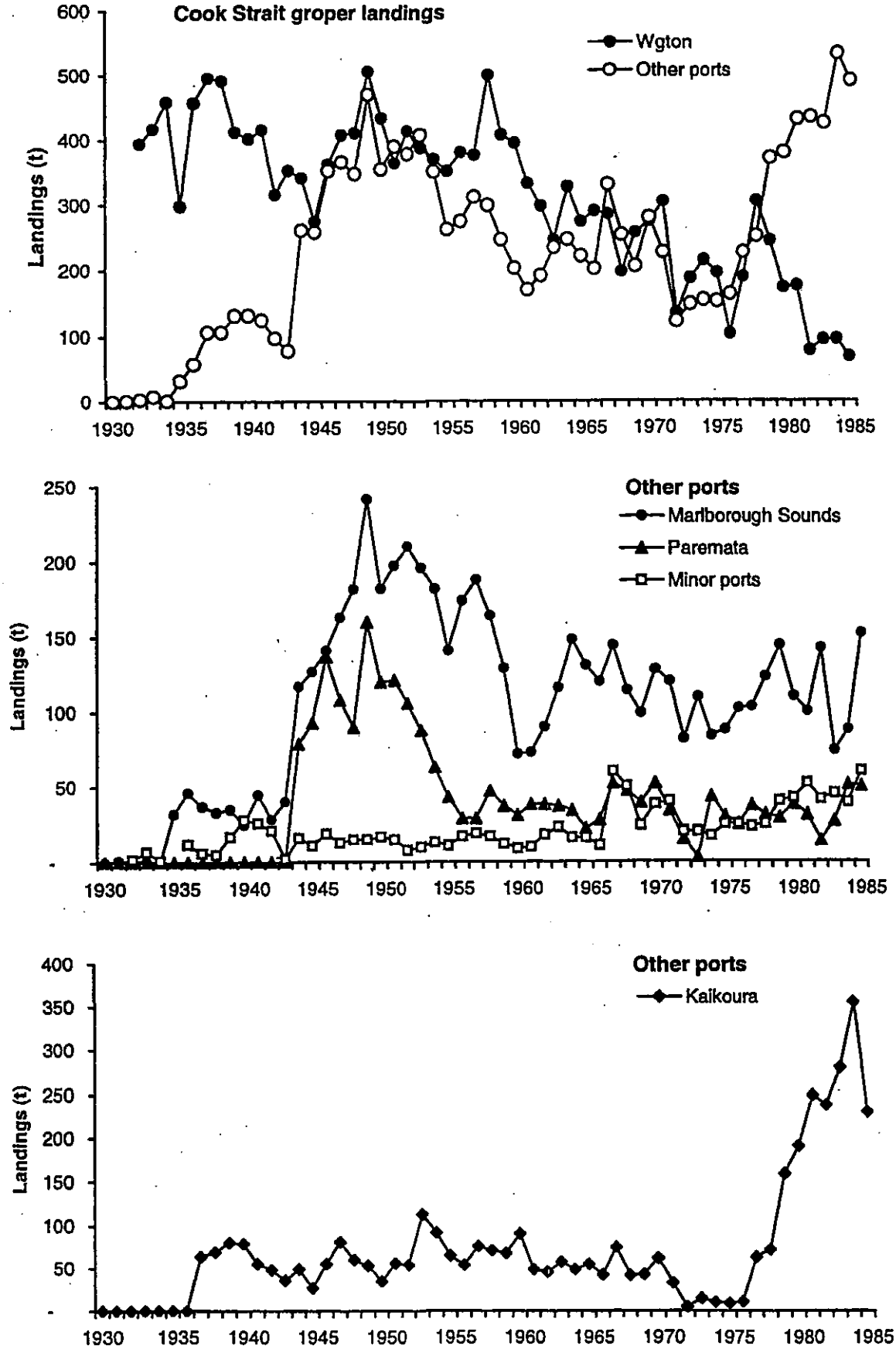

Figure A1: Landings of groper (t) into ports in the Cook Strait region. Top panel, landings subdivided into Wellington and "other ports". Centre panel, landings into other Cook Strait ports: Marlborough Sounds (Picton, Pelorus, Blenheim), Paremata, and minor ports (Castlepoint, Makara, Nelson, Wanganui). Lower panel, landings at Kaikoura, a relatively minor port with no trend in landings until the setnet fishery developed in 1976.

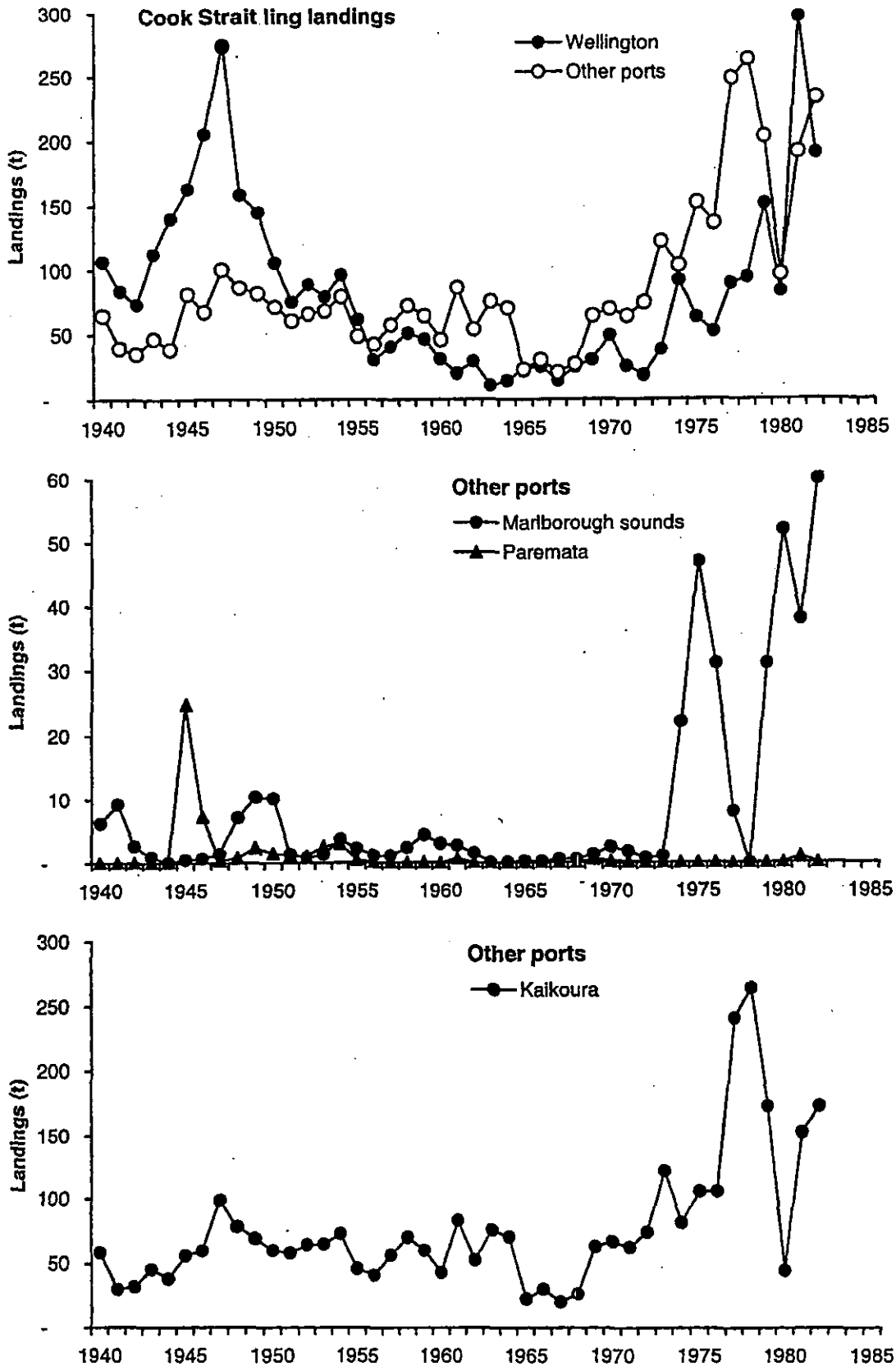

Figure A2: Landings of ling (t) into ports in the Cook Strait region. Top panel, landings subdivided into Wellington and "other ports". Centre panel, landings into other Cook Strait ports: Marlborough Sounds (Picton, Pelorus, Blenheim), and Paremata; landings at the minor ports (Castlepoint, Makara, Nelson, Wanganui) are too small to present. Lower panel, landings at Kaikoura, a relatively minor port with no trend in landings until the setnet fishery which sometimes targeted ling developed in 1976.

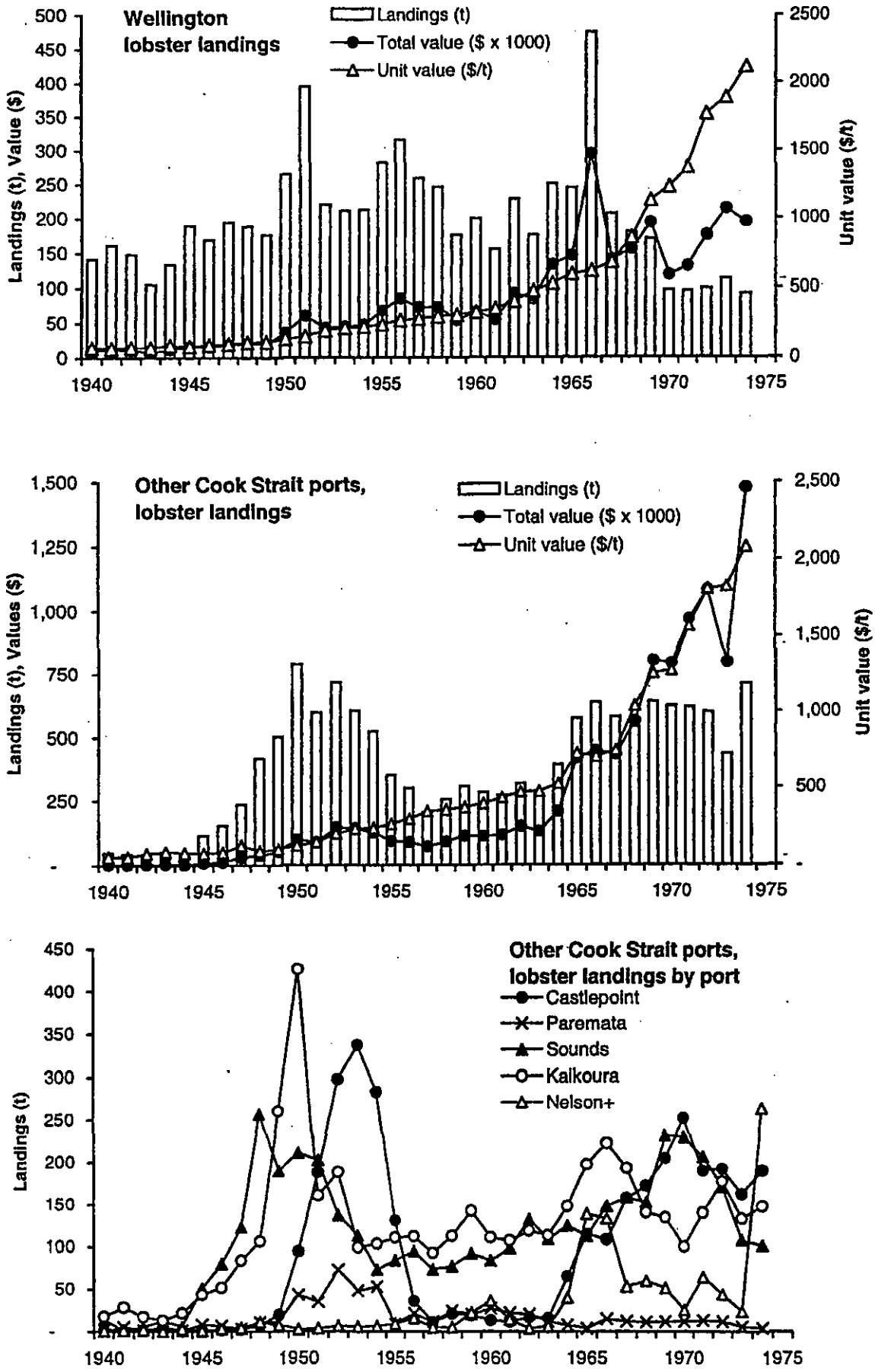

Figure A3: Landings of rock lobster (t, $) and their unit value ($/t) into Wellington and other Cook Strait ports. Top panel, Wellington. Centre panel, other Cook Strait ports (Castlepoint, Makara, Picton, Pelorus, Blenheim, Paremata, Wanganui, Nelson, Kaikoura). Lower panel, landings at the other Cook Strait ports, by port: 'Sounds' combine Picton, Pelorus, Blenheim; 'Nelson+' includes Motueka and Golden Bay; small landings at Makara not shown.

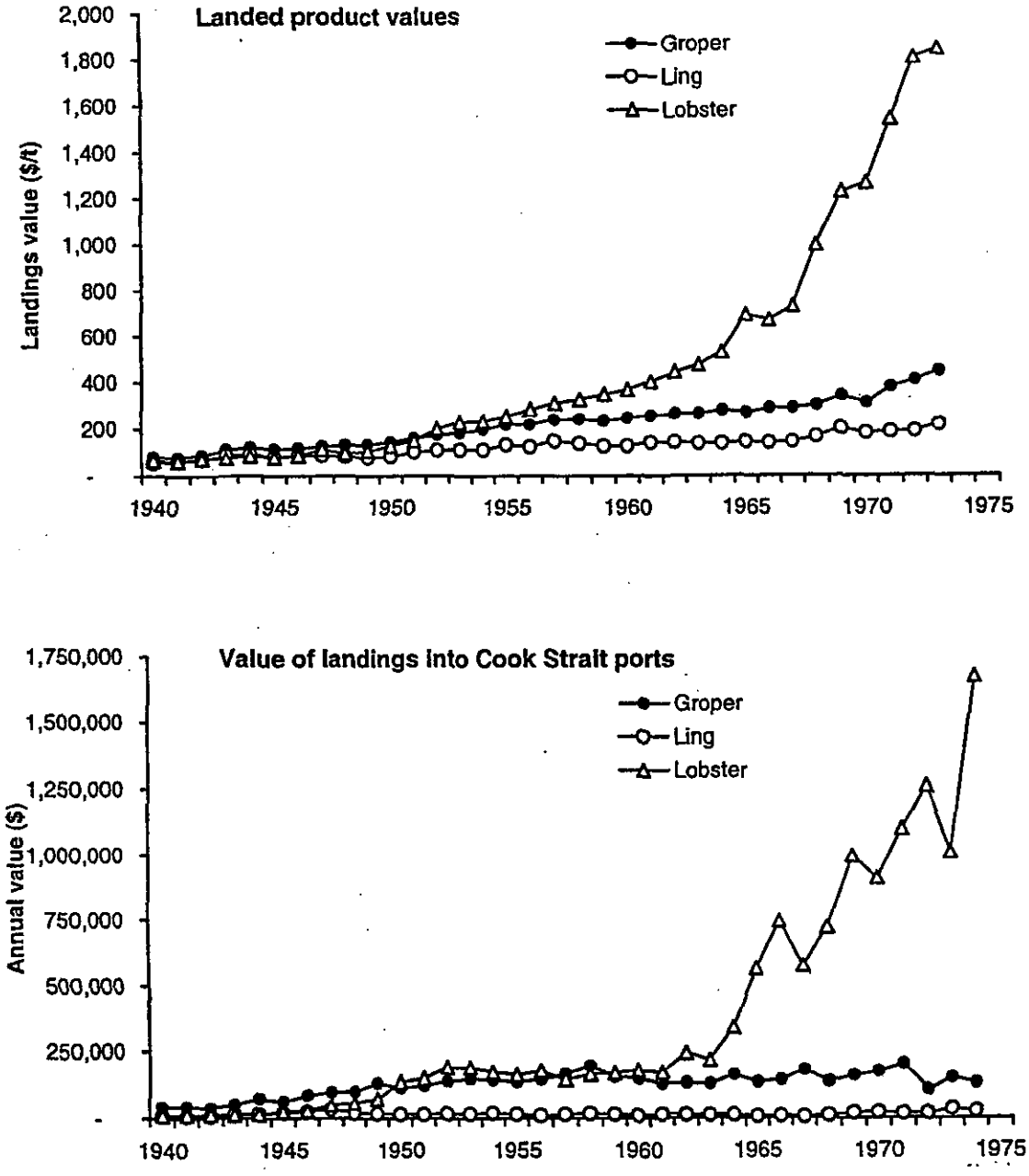

Figure A4: Relative values of groper, ling, and lobster in the Cook Strait region. Top panel, landed value ($/t) of groper, ling, and rock lobster, 1940 to 1973. The groper and ling values are calculated from the total New Zealand tonnage and monetary values, as listed in Annual Reports on Fisheries (Marine Department and Ministry of Agriculture of Fisheries). The rock lobster values are calculated from the tonnage and monetary values of landings into Cook Strait ports (Annual Reports on Fisheries). Monetary values of finfish species are not available by port. Lower panel, landed value ($), calculated from the listed monetary value and the landed tonnage.

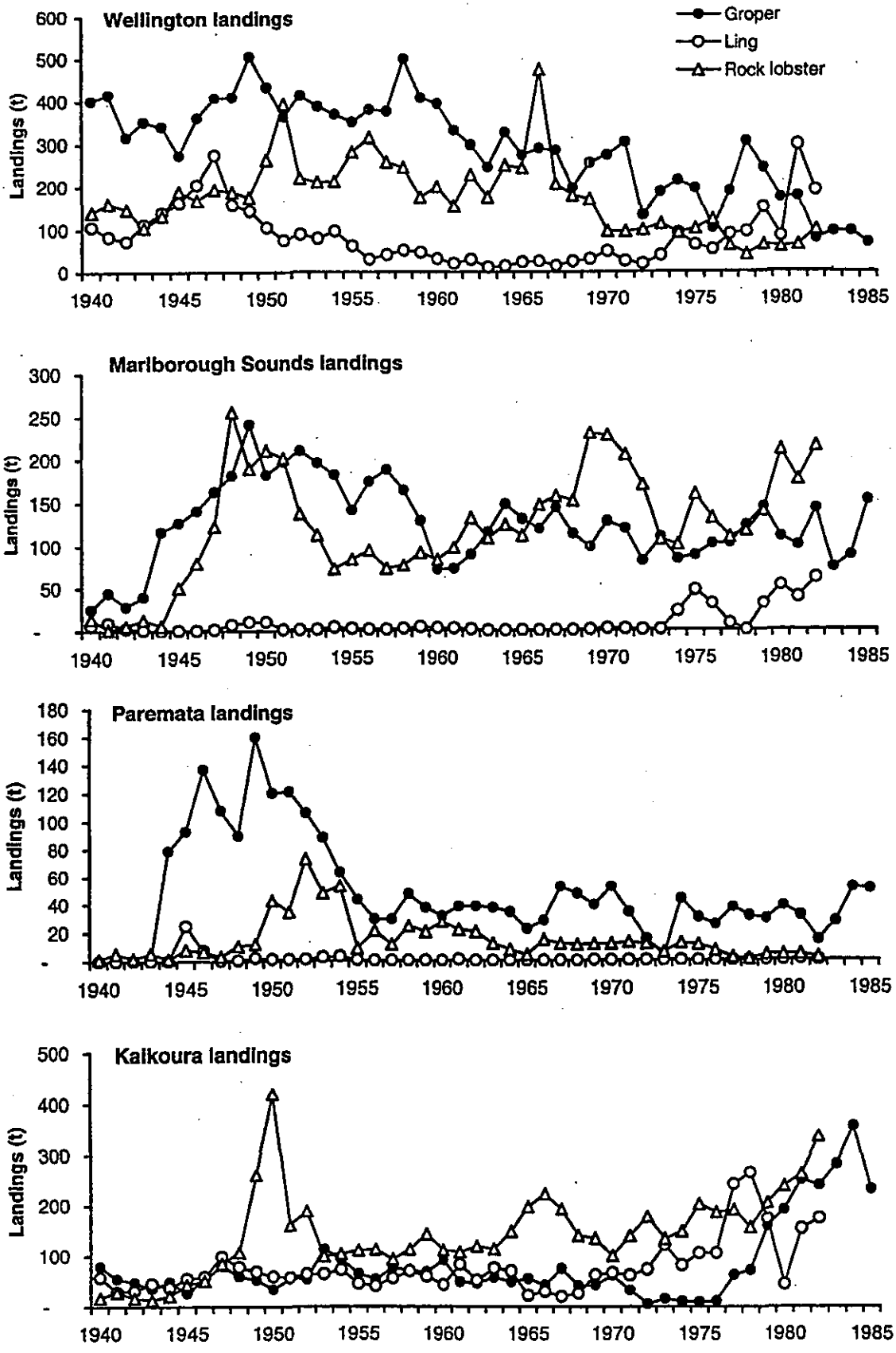

Figure A5: Landings (t) of groper, ling, and rock lobster into the main Cook Strait ports. Marlborough Sounds combine Picton, Pelorus, and Blenheim. Groper landing figures are available to 1985, ling and rock lobster landings to 1982, from various sources.