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Data on discards of fish species were extracted from the Ministry of Fisheries Scientific Observer Programme databases for the fishing years 1994–95 and 1995–96 covering target fisheries for southern blue whiting (*Micromesistius australis*), orange roughy (*Hoplostethus atlanticus*), hoki (*Macruronus novaezelandiae*), and oreos (*Allocyttus niger*, *Pseudocyttus maculatus*). Data were checked, edited, and summarised into two separate datafiles: one covered the full tow-by-tow data (with estimated catch data) from the observer database, and the second was a subset of this where detailed processed figures were available for each tow. Data were summarised into three categories: target species, other commercial species, and non-commercial species

The effect of specific factors on the level of discards was examined using multivariate step-wise linear regression. Catch weight, and catch rate, of the discard categories were log transformed and included as dependent variables in the analysis. The independent variables differed slightly between fisheries, but covered season, area, depth, gear type, catch size, and vessel characteristics. The main factors which appeared to influence discards were catch size for southern blue whiting and orange roughy and vessel nationality for hoki. No factors stood out in the oreo fishery. However, there were often insufficient data to enable confident interpretation of the effect of some of these factors separately, and in general linear modelling gave a poor fit to the data.

Discard ratios were calculated for each of the discard groups as the weight of the species discarded over the weight of the target species which was retained. This ratio was then used to estimate the level of discards in the fishery by applying it to the reported landed catch of the target species. For southern blue whiting and hoki, catch totals were simply taken from the Quota Management Reports for each fishery, and the discard ratio applied. For orange roughy and oreos, where the fisheries are mixed in several areas, the total discards were estimated from the sum of the discards in the target fishery and the discards in the bycatch fishery. Total discards were relatively low for each of the fisheries examined. For the 1994–95 and 1995–96 fishing years, averaged annual discards of all species amounted to 300 t in the southern blue whiting fishery, 1200 t in orange roughy, 10 400 t in hoki, and 600 t in oreo fisheries. Variances of the discard estimates were derived from bootstrap analyses. Discards of other non-target commercial species were low.

Introduction

Concern about the composition and extent of discards in marine fisheries is not new, and with an increasing number of the world's major commercial fisheries becoming overexploited, the impact on associated species has become of greater concern. A number of scientific workshops have focused on bycatch and discard issues over the last decade (e.g., Sissenwine & Daan 1991, Boddeke 1992, Murawski 1992, Weber 1995, Mace 1996): the emphasis has been on prawn and gill-net fisheries which have been widely publicised, but the same problems exist with finfish trawling.

On a global scale, discards have been estimated at millions of metric tonnes. Saila (1983) prepared the first detailed report on world bycatch and discard levels and estimated a minimum discard of fish and shellfish of about 7 million tonnes. A more comprehensive assessment by Alverson *et al.* (1994) suggested annual discards in commercial fisheries throughout the 1980s–early 1990s of 27 million tonnes (range 18–40 million t) out of a total harvest of about 80 million tonnes. Most of this was attributed to Northern Hemisphere fisheries, particularly shrimp fisheries. Bottom trawls (together

with longline and pot fisheries) ranked second, then drift-net and seine fisheries. Pelagic trawl and targeted purse-seine fisheries had the lowest ratios of discard to target catch.

Successful stock assessment requires good data on the true catch and mortality of fish species. Estimates are needed of the total catch, and not just that which is landed or reported, so information on fish discards is important. This applies to both target species and bycatch, where the latter comprise other commercial species or non-commercial ones. Such data can also contribute to an improved understanding of fish communities, and the possible impact of fishing on the long-term sustainability of exploited ecosystems.

It is important to clarify the terms "bycatch" and "discards", as they have a range of overlapping and confusing definitions. *Discarded catch* (discards) is all the fish, both target and non-target species, returned to the sea as a result of economic, legal, or personal considerations (*after* McCaughran (1992). It does not include *incidental catch* (retained catch of non-target species) and is less than the level of *bycatch* (discarded catch plus incidental catch).

This study, funded by the Ministry of Fisheries (project ENV9703) aimed to estimate discards in the New Zealand trawl fisheries for southern blue whiting, orange roughy, hoki, and oreos: These fisheries are amongst New Zealand's largest and most valuable. Catches in 1995–96 were about 20 000 t for southern blue whiting, 35 000 t for orange roughy, 180 000 t for hoki, and 25 000 t for oreos (both black oreo and smooth oreo) (Annala *et al.* 1998). Fisheries of this scale have considerable potential to catch large amounts of non-target species, or of the target species that are damaged or of unwanted size. The former is particularly relevant because all these fisheries involve targeting spawning aggregations, with high catch rates and large catches per trawl.

There have been few major studies on the level of discards over entire New Zealand trawl fisheries, although individual fisheries, or aspects of discards, have been examined. Ballara & Hurst (1997) examined bycatch of hoki fishing. They used Scientific Observer Programme data to adjust the levels of reported catch for hake, ling, and silver warehou in the fishery off the west coast of the South Island. Estimated catches of these species were often much greater than reported catch, although it is unclear whether discarding was the cause.

Sources of error in reported catch for orange roughy fisheries have been examined by Clark (1991) for the Challenger Plateau, and Robertson (1986) and Francis *et al.* (1992, 1993) for the Chatham Rise. Discards of small and/or damaged fish were estimated by Clark (1991) and Francis *et al.* (1993) at between 1 and 10% of the total catch. It was noted that this aspect of catch overrun had declined over time with improved fishing practices.

Discards of small fish and less preferred species (black oreo) were studied for oreo fisheries (A. Hart, NIWA, unpub. data). However, data examined in the early 1990s were inadequate to draw conclusions about this.

Objectives

To estimate the total quantity of target and non-target fish species discarded in the trawl fisheries for southern blue whiting, orange roughy, hoki, and oreos during the fishing years 1994–95 and 1995–96.

To determine the effects of specific factors on total discards, including season, area, depth, gear type, vessel type and size.

Methods

Data sources

Trawl and catch information from observer records was extracted from the MFish database *'obs'* for each of the four fisheries for fishing years 1994–95 and 1995–96. The recorded target species was used to define each fishery: SBW for southern blue whiting; ORH for orange roughy; HOK for hoki; and OEO (all species combined, i.e., OEO, BOE, SSO) for oreos.

Data were processed into three types of spreadsheets for analysis: estimated catch records, tow-by-tow (database 1); processed catch records, full data (database 2); and processed catch records, subset data (database 3).

Estimated catch records, tow-by-tow data

Tow-by-tow data covering vessel details, fishing gear, location, date and time, environmental variables, and estimated catch by target species were extracted from the tables *new_observer_trip, new_observer_station*, and *new_observer_greenweight*. Details of vessel type (factory or ice boat) and overall length were obtained from MFish records. Length of tow was calculated from start and finish positions, and duration of tow was calculated from start and finish times.

The number of tows available for each fishery was 384 for SBW, 2550 for ORH, 3697 for HOK, and 332 for OEO. Many species codes were used by observers in each fishery, so for practicality these codes were combined into groups according to taxonomic family. This reduced the number of associated catch groups in each fishery from 49 to 39 for SBW, 163 to 91 for ORH, 204 to 138 for HOK, and from 61 to 47 for OEO.

The tow-by-tow data were inserted into spreadsheets, one for each fishery. The spreadsheets include tow-by-tow catch weights for each species group. Checks were made to ensure that the sum of catches for these species groups was equal to the total catch recorded for each tow. For some tows this was not so because of invalid species codes in the database. Where this occurred the weights for these codes was added to the UNI (unidentified) catch for that tow. These invalid codes were rare and usually amounted to only a few kilograms.

Net type, as recorded by observers, was simplified in the spreadsheet to MW (midwater) or BT (bottom), and the path of the net simplified to four categories: 1, bottom throughout; 2, midwater throughout at a relatively constant depth; 3, midwater throughout over a broad range of depths; 4, a mixture of bottom and midwater. For category 2 tows, the height of the net above the seabed was calculated as the mean of the difference between the groundrope depth and seabed depth at the beginning and end of the tow.

Each fishery was divided into a number of areas based on geography or known stock divisions and all tows were assigned to one of these areas.

SBW	OEO	ORH	HOK
Bounty Platform (BNTY)	Louisville Ridge (LOUI)	NW Challenger Plateau (NWCHAL)	Bay of Plenty (BOP)
Auckland Is. (AUCK)	NW Chatham R ise (NWCHAT)	SW Challenger Plateau (SWCHAL)	Cook Strait (COOK)
Campbell Plateau (CAMP)	SW Chatham Rise (SCRW)	Bay of Plenty (BOP)	West Coast South I. (WCSI)
Pukaki Rise (PUKA)	SE Chatham Rise (SCRE)	East Coast North I. (ECNI)	Chatham Rise (CHAT)
	Otago coast (OTAGO)	North Chatham Rise (NCHAT)	Campbell Plateau (SUBA)
	Bounty Platform (BNTY)	South Chatham Rise (SCHAT)	Puysegur Bank (PUYS)
	Puysegur Bank (PUYS)	Bounty Platform (BNTY)	
		Puysegur Bank (PUYS)	
		Louisville Ridge (LOUI)	

The distribution of all the observed trawls of each target fishery, by month and by area, is given in Appendix 1.

Processed catch records, full data

The database table *new_observer_processed* was examined to determine the species that were retained, discarded, or partially retained. Useful fields in this table included the processed weight, weight of fish discarded (greenweight), and the calculated greenweight (calculated from the processed weight and a recorded conversion factor). Because this table is structured on a processing 'groupnumber' rather than on the station number, stations were frequently combined or split. The estimates of catch and of fish discards were summed over all records for all species. The proportion discarded for each species was then applied to the catch for each tow in database 1 to give an estimated weight of fish kept and of fish discarded for each tow.

Initially it was thought the tow-by-tow data would be the most complete for species composition, and would therefore be the most useful for estimating individual species discards. However, as the characteristics of the various data became evident, the full processed dataset was subsequently used as the main source of information on discards. It contained the most accurate data on retained/discarded weights of target and bycatch commercial species. It was used to estimate discard ratios of commercial species, and for bootstrap analyses to estimate variance of the discard ratios.

Processed catch records, subset data

Tow-by-tow information is necessary to examine factors affecting the level of discards. The estimated catch dataset (database 1) contained only pro-rata discard estimates per tow, and the full processed data (database 2) were grouped over several tows. As a solution, only records from the *new_observer_processed* table where the groupnumber represented a single station were selected. These records were matched to the corresponding subset of the tow-by-tow spreadsheet data. These data were entered into the 'subset' data spreadsheets (database 3). The number of trawls used in the analysis were as follows:

Fishery	Whole dataset	Subset	Percentage
SBW	384	135	35
OEO	332	171	52
ORH	2 550	987	39
HOK	3 697	1 846	50

A possible bias is risked by using this subset. Some checking revealed that where a groupnumber was made up of two or more stations, those stations had on average a smaller total catch than stations used in our subsets. The following data are for orange roughy.

No. stns	Mean catch/stn(kg)	S.D.	N
1	5 748.4	10 826.3	987
2	4 593.8	8 855.5	100
3	4 322.7	7 103.1	38
4	4 004.3	4 990.9	37
5	2 909.3	3 512.2	40
6	3 007.2	4 484.6	21
7	1 473.8	1 152.7	19
8	2 336.2	3 404.2	25
9	1 657.1	1 677.1	16
10	2 135.6	1 211.5	5

(No. stns, number of trawls per group-number; N, number of group-numbers)

Initially, this dataset had two records of catch by species by tow, one from the *new_observer_greenweight* table and one from the *new_observer_processed* table. Usually these values matched exactly, but there was often more detail in the *greenweight* table for species not usually processed, and more precision in the *processed* table for species that usually were processed. Sometimes catches from more than one station were lumped in the *processed* table. Discrepancies appeared to vary from trip to trip. For the hoki spreadsheet, *processed* weights were used exclusively as there was too much data to check manually. In the smaller orange roughy, southern blue whiting, and oreo spreadsheets, however, discrepancies with an obvious source (mostly lumped catches) were corrected for the main species.

Weights of fish retained and fish discarded were calculated in each fishery for three groups: the target species (SBW, ORH, OEO, HOK); other main commercial species (combined, COM); and all other species combined (OTH). Species included in COM were those which appeared in more than 1% of tows and either had over 75% of the catch by weight overall retained or were quota species.

Fishery	Commercial species
SBW	ghost shark, hake, hoki, ling, red cod, scampi, stargazer, silver warehou, white warehou
OEO	hake, hoki, ribaldo, orange roughy
ORH	bluenose, black oreo, smooth oreo, spiky oreo, alfonsino, cardinalfish, hake, hoki, ribaldo, oilfish
HOK	barracouta, bluenose, black oreo, alfonsino, ghost shark, hake, jack mackerel, lookdown dory, ling, smooth oreo, orange roughy, Ray's bream, red cod, ribaldo, southern blue whiting, school shark, scampi, gemfish, spiky oreo, sea perch, arrow squid, stargazer, silver warehou, blue warehou, white warehou

Weights of discarded fish were estimated as the difference between the weight of fish caught and the weight of fish retained plus the estimated proportion of any fish lost at the surface in that group.

Analyses of total discards

For estimation of total discards in each fishery, data from database 1 (for non-commercial species) and database 2 (for commercial species) were used to calculate discard ratios. The total catch retained and total catch discarded were calculated for each of the three main categories, target, COM, and OTH.

The discard ratio, R, was defined as the ratio of discarded catch to retained catch

$$\hat{R} = \frac{\sum_{i=1}^{m} d_i}{\sum_{i=1}^{m} l_i}$$

where m trips are sampled from a stratum, d_i is the weight of the species discarded from the ith trip sampled, and l_i is the weight of the species retained from the ith trip sampled.

Assumptions are made that all trips are sampled with equal probability, and that all shots in the trip are observed. Both assumptions are reasonable.

Many of the non-target commercial species taken as bycatch in a particular target fishery (e.g., hoki, hake, ling in the SBW fishery) are target species in other fisheries. This means that to apply the discard ratio calculated for the species grouping, the catch of these species in solely the southern blue whiting fishery would need to be estimated — the catch from the target fisheries would need to be separated. To do this would require substantial effort and time in identifying just southern blue whiting trips, or parts of a trip, to use Catch Landing Returns (CLRs) to breakdown the other species catch. Alternatively, using tow-by-tow records (Trawl Catch Effort Processing Returns (TCEPR)), where the quantities of these other species are low, might be inaccurate as estimated catch (often eye-ball estimates from the bridge) would need to be used. Therefore, l_i was taken as the retained catch of the target species. All the ratios then relate to the landed catch of the target species in the fishery. This was thought to be acceptable as the fisheries considered here generally target a single species.

For each species-grouping the discard ratio is then multiplied by the known landed catch (L) of the target species in the stratum to estimate total discards:

$$\hat{D} = \hat{R} \times L$$

Estimates of R were derived from two data sources. For the target species, and other commercial species, processing catch records were thought to be complete and reliable. Because tow by tow information was not necessary for this procedure, the full processed dataset (database 2) was used. This applied to SBW, ORH, HOK, OEO (and BOE/SSO), and COM categories. For the OTH grouping, the species composition and catch from the estimated catch records (database 1) were more comprehensive as many minor species were not recorded on the processing summary. Therefore, R for OTH was calculated from the estimated tow by tow database.

Variance of the estimates of discards was derived from bootstrap analyses. Data from all database 2 records were used for this, with the discard ratio being bootstrapped. This involved sampling at random (with replacement) a large number of sets of pairs (500 or 1000 depending on the size of the dataset) of ratio values from database 2. Each of the sets was the same length as the base data set, and usually produced a distribution of ratios that was close to normally distributed. Variances and coefficients of variation were then calculated from these distributions and applied to the estimates of R.

For southern blue whiting, a further correction was needed. The proportion of the fishery observed during the two years was over 60%, which means the assumption that the sample is taken from a near infinite population is invalid. The variances were calculated as follows;

$$V_F = V_A\left(1 - \frac{w}{W}\right)$$

where V_F is the finite sample variance, V_A the variance for all years, w is the weight of SBW catch observed, and W the weight of all SBW catch.

These additional *finite sample* variances apply to the ratios estimated for these two years only, whereas all other variances calculated apply to any year.

Bootstrapping was carried out using procedures in "New S" (Becker *et al.* 1988).

Analyses of specific factors affecting discards

Database 3 was used to carry out analyses to determine the effects of specific factors on total discards. Discards were plotted against a range of variables to identify any obvious trends in the data, and to see what data and variables were appropriate to include in subsequent analyses. These plots were also important later in interpreting the results from the multivariate analyses.

A General Linear Model (GLM) approach was used. Catch weights and catch rates of the discard categories were log-transformed and included as dependent variables in multiple step-wise regression analyses. GLM procedures were undertaken using SYSTAT (SYSTAT 1997).

The independent variables included in the analyses varied between fisheries, depending on the type of fishery (e.g., net type and height above the bottom were relevant to combined midwater and bottom trawl fisheries for hoki and southern blue whiting, but not for the bottom fisheries for orange roughy and oreo). Variables examined, and whether categorical (cat) or continuous (cont) were as follows.

Variable	cat/cont
Vessel length	cont
Nationality	cat
Area	cat
Month	cat
Net type	cat
Time of tow	cat
Net depth	cont
Net height above bottom	cont
Headline height	cont
Distance towed	cont
Total catch	cont

Checks were made on the quantity of data in each cell of the regression matrix, so that variables which were correlated could be identified and considered in the GLM procedure. Usually the automatic step-wise procedure under SYSTAT was run initially, and then the model results examined, and re-run interactively if necessary to add or exclude variables on the basis of other knowledge.

With backwards stepping, the analysis starts with all candidate variables in the equation, removes the least "significant" predictor at the first step, and continues deleting variables until no "insignificant" variables remain. The level of "significance" applied was generally whether a variable improved the fit to the model (r^2) by 1%. For ease of interpreting results from this analysis, the F-statistic, a measure of the significance of the variable in the model, has been given an arbitrary rank to allow a quick evaluation of which variables had a significant effect in the linear model.

A further term in a SYSTAT GLM was considered: "tolerance". This is a measure of the extent of correlation among the independent variables (which can make estimates of the regression coefficients unstable). Tolerance therefore gives information on whether the significance of one variable may in part be caused by the effect of another.

Tows where fish were lost at the surface were not included in these analyses as they were random events that were not thought to represent any systematic trend of discards. Because they were large (although poorly estimated) they would have a substantial and erroneous influence on results.

The general model structure was of the form:

DISCARDcatch = constant + var1 +var2 +var3.....etc.

Catch and catch rate values on both sides of the equation were log-transformed. A small amount (1kg) was added to tows with zero discards to enable the natural log transformation.

Results

Southern blue whiting

Distribution of data

The distribution of observed tows, and the size of catch of these tows, is shown in Figure 1. Most tows were on the Campbell Island Rise and the Bounty Platform: fewer trawls were sampled on the Pukaki Rise and Auckland Islands Shelf. The vessels with observers covered the same areas as the full fleet (Figure 2), and the geographical spread of the data can be considered representative of the fishery. There are only a few discrepancies in tow position between observer programme and TCEPR data.

The total reported catch of southern blue whiting in the 1994–95 and 1995–96 years was 39 756 t (Annala *et al.* 1998). The reported catch of southern blue whiting by the observed vessels totalled 23 836 t, which was 60% of the entire fishery.

Factors affecting discards

A series of plots was examined to compare discard catch from observed tows against a number of variables. Discard catch rates were also examined, but were similar in pattern to the catch results so only the catch plots are given here.

Southern blue whiting catch (Figure 3a): Two tows had considerable discards, but generally discards were small. There is a slight trend of increase in discards as catch size increases. There was no apparent pattern with other commercial species, nor with other non-commercial species.

Total catch (Figure 3b): SBW discards increased with larger catch size, but COM and OTH groups showed little response to total catch size.

Area (Figure 4a): The two large discards of SBW occurred on the Bounty Platform, but generally most tows in that area had low discard levels. More tows in the Campbell area had discards of SBW. Commercial species were also discarded more on the Campbell Rise, but catch sizes were small, and most tows in all areas had relatively low levels of discards.

Month (Figure 4b): The vessels with observers started fishing in mid August (day 225–230) and continued to early October. The two fishing years of data are combined here, but there is no apparent effect of month on discards of any of the groups.

Time of day (Figure 5a): Fishing occurred throughout the day and night, with no obvious trend in discards of any of the species groups.

Net depth (Figure 5b): Trawl depth ranged from about 200 m to 600 m, with most tows clustered between 300 and 500 m. There was no effect of net depth on SBW discards, but most other commercial species were discarded when from deeper than 500 m (ling), and the non-commercial discards peaked around 400 m.

Net height above bottom (Figure 6a): Midwater trawling took place up to 300 m above the bottom. The two large SBW discards occurred well above the bottom, but there is no trend. Other commercial and non-commercial species discards were highest close to the bottom, which reflects the species composition of these groups (primarily demersal species such as ling, rattails).

Headline height (Figure 6b): Very large nets are used in this fishery, with headline heights up to 100 m. This appeared to have little bearing on the level of discards.

Tow distance (Figure 7a): Length of tow appeared to have no effect on discards of SBW or COM groups. With non-commercial species, shorter tows sometimes had more discards.

Vessel length (Figure 7b): Size of vessel had no obvious effect on the level of discards.

The total subset sample size for southern blue whiting was only 135 trawls which means that data are not widely or evenly spread between the factors that could influence discards. Nation was not included in analyses, because 134 of the 135 tows were by Japanese vessels, and 1 by a Ukrainian trawler. Some confounding of variable effects may also occur, as shown by unbalanced spread of data (number of observed tows) between area and month:

	Auckland	Bounty	Campbell	Pukaki
August	0	31	0	0
September	2	7	87	5
October	1	0	0	2

All trawls in August were from the Bounty Platform and all in the Campbell area were in September. The sparse data in some cells means care was required when examining the effects of factors by multivariate regression.

Linear regression

Stepwise linear regression analyses were performed on log-transformed discard-catch data. However, the data showed no clear linear trends for any of the factors, with the possible exception of catch size. Hence, a linear model would not be expected to perform well given the characteristics of the plots in Figures 3 to 7, but no other simple model would fit well with the patterns of the exploratory data plots.

Results of the regression analyses are summarised in Table 1.

***Table 1*: Results of GLM linear regression on catch of discards (NA, not applicable; - , not significant; +, low F (≤ 10); ++, medium F (10–20); +++ = high F (> 20); actual F values are given in parentheses)**

Factors	SBW		COM		OTH	
Vessel length	-		-		-	
Month	-		-		-	
Area	-		+	(3)	-	
Net type	NA		-		-	
Distance	-		-		-	
Net depth	-		-		+	(2)
Start time	-		-		-	
Net height	-		-		+	(2)
Total catch	+++	(43)	-		-	
r^2	0.25		0.07		0.05	

For SBW discards, the only significant factor was the total catch: there was a positive relationship between discard level and size of catch. This variable explained about 25% of the variance. The automatic analysis also kept in vessel length, month, and net height, but these were discounted for reasons of correlated variables, or where results were driven by a small sample, and the two isolated large discard events. The two large SBW discard tows appeared to be random events, but were sometimes together at one end of the range of a variable. Thus they were initially significant in the analysis, but when they were excluded the factor was not retained.

The GLM analysis found that no variables had a major effect on discards of other species. The r^2 values for COM and OTH groupings were very low.

Discard estimation

Summary data from which discard ratios were derived are summarised in Table 2.

Table 2: **Summary of data used to calculate discard ratios in the southern blue whiting fishery**

	Retained (t)	Discard (t)	Total (t)	% discard	Discard ratio
SBW	22 767.1	354.1	23 121.2	1.5	0.0155
COM	67.8	2.3	70.1	3.3	0.0001
OTH	1.0	6.5	7.5	86.7	0.0003
TOT	22 835.9	362.9	23 198.8	1.6	0.0159

Discard ratios and their coefficients of variation are summarised in Table 3.

Table 3: **Discard ratios (*R*) and *c.v.*s by species category for the two fishing years combined and separately. (The *c.v.*s in parentheses are those adjusted for the relatively large sample size for this fishery–the finite sample values, which apply to just the two years; note that there were few discards of COM species in 1995–96, the distribution was very skewed, and a reliable ratio could not be estimated.)**

	All data	*c.v.*	1994–95	*c.v.*	1995–96	*c.v.*
SBW *R*	0.0155	35.5 (23.0)	0.0091	22.1	0.0268	56.1
COM *R*	0.0001	41.7 (27.1)	0.0005	42.1	–	–
OTH *R*	0.0003	19.1 (12.4)	0.0003	24.4	0.0002	32.5
TOT *R*	0.0159	34.5 (22.4)	0.0099	20.4	0.0272	55.7

The distributions of discard ratios for the four categories derived from the bootstrap analyses are given in Figure 8.

For southern blue whiting, it was assumed that the non-target-fishery catch was negligible, and that consequently the Quota Management Report (QMR) totals are a fairly accurate record of the retained target fishery. These catches of southern blue whiting totalled 17 477 t in 1994–95 and 22 279 t in 1995–96 (Annala *et al.* 1998). The discard ratios from Table 2 were applied to these catch figures for southern blue whiting to estimate total discards in the fishery (Table 4). Confidence intervals for the estimates from bootstrap analyses are given in parentheses.

Table 4: **Estimates of discards in the SBW trawl fishery for 1994–95 and 1995–96 (rounded to the nearest tonne), with 95% confidence intervals in parentheses**

	1994–95	1995–96	Total
SBW	271	345	616 (295–1 145)
COM	2	2	4 (1–8)
OTH	5	7	12 (10–23)
TOT	278	354	632 (314–1 169)

More detailed information on the species in the above groupings, and the proportion discarded by species, is given in Appendix 2.

Orange roughy fishery

Distribution of data

The distribution of observed tows, and the size of catch of these tows, is shown in Figure 9. The distribution of catch from the entire commercial fishery in 1994–95 and 1995–96 is given in Figure 10. Most areas were represented by observer effort, except for the Cook Canyon fishery (off the west coast of the South Island) and a recent fishery west of the Antipodes Islands on the eastern margin of the Campbell Plateau. The best coverage was on the Chatham Rise, the Louisville Ridge, off the east coast of the North Island, and Challenger Plateau.

The total reported catch of orange roughy in the 1994–95 and 1995–96 fishing years was 64 218 t (including outside the EEZ). The reported catch of orange roughy by observed vessels in the same period was 7018 t, which was 11% of the entire fishery.

Factors affecting discards

A series of plots was examined, comparing discard catch against a number of variables. Discard catch rates were also examined but, as for the southern blue whiting data, provided no extra information.

Orange roughy catch (Figure 11a): There was some indication of higher discard levels of COM and OTH with small orange roughy catches, but this was not a strong trend. Small catches of ORH are not from an aggregation of the species, and may therefore contain more bycatch, but any effect is relatively weak.

Total catch (Figure 11b): Discards of ORH were rare. Those that did occur were associated with two vessels. The largest discards came from tows with catches between 20 and 50 t, but no trend was evident. Discards were dominated by other non-commercial species, which suggested a trend of decreasing discards with increasing catch size. No trend was evident with other commercial species.

Area (Figure 12a): Most ORH discards were from the east coast North Island, with one relatively large discard from both the Bounty Platform and Northwest Challenger Plateau. Discards of ORH from other areas were negligible. There were high levels of COM discards on the South Chatham Rise from the oreo fishery. The South Chatham Rise also had high levels of OTH discards as did the North Chatham Rise and Puysegur Bank. Discards of OTH were highly variable between areas.

Month (Figure 12b): For 1994–95 and 1995–96 there were 43–168 observed tows in each month, except for December and February in which there were less than 10 tows. Discards of ORH were more prevalent in June. Discards of COM were highest in September (linked to oreo bycatch on the Chatham Rise), and OTH were regularly discarded in most months.

Time of day (Figure 13a): Discards were evenly spread over the day with no suggestion of a day/night effect.

Bottom depth (Figure 13b): Substantial discards of ORH were confined to depths of 750–950 m and within this range showed no trend. No trend is apparent either for commercial species with substantial discards occurring with the same depth range as ORH discards. Discards of OTH appear to be highest at 900–1100 m and then decrease with greater depth of tow. Discards of TOT show this declining trend a little more clearly.

Headline height (Figure 14a): Spikes in the plots probably reflect the most commonly recorded headline heights rather than a strong relationship between these variables. Most trawl gear used by orange roughy vessels is a small rough-bottom net, which has a standard headline height of 6–7 m.

Vessel length (Figure 14b): Spikes in these plots indicate single vessels and illustrate the effect one active vessel can have. The larger vessels appear to have discarded more COM and OTH, with a trend of increasing discards with increasing vessel length most apparent for total discards.

Nation (Figure 15a): There was little data from other nations (Australia, Norway), as the fishery is dominated by New Zealand vessels. Consequently, New Zealand vessels recorded some higher discard catches than the few Norwegian vessels.

Tow distance (Figure 15b): All substantial discards of ORH came from tows of less than 4 km: discards from tows longer than this were very rare. Commercial and other species discards showed a similar pattern, with decreasing discards with tow distance.

The total subset sample size for orange roughy was 987 trawls, large enough to provide data over a wider range of variables than for southern blue whiting. There were still limitations, however. Only two foreign nations were represented, Australia and Norway, and they provided data from 1 and 44 trawls respectively. Data were available for 20 vessels, with lengths ranging from 24.9 to 74.4 m. As for southern blue whiting there was a strong correlation between month and area as the following table shows.

Month	ECNI	BNTY	CHAL	LOUIS	NCHAT	NWCHAL	BOP	OTHER	PUYS	SCHAT	Total
Jan	0	0	0	1	18	0	24	0	0	0	43
Feb	0	0	0	0	0	0	7	0	0	0	7
Mar	0	0	0	49	3	0	2	0	0	0	54
Apr	0	0	0	0	31	0	1	0	0	16	48
May	15	0	0	1	39	0	19	0	0	18	92
Jun	72	2	0	0	13	2	29	2	6	20	146
Jul	19	0	111	0	21	1	6	0	0	10	168
Aug	2	0	0	42	22	0	0	0	0	0	66
Sep	0	0	17	2	23	12	0	0	24	79	157
Oct	0	9	0	0	29	0	8	0	0	66	112
Nov	0	0	0	0	3	0	6	0	33	44	86
Dec	0	0	0	0	0	0	0	0	0	8	8
Total	108	11	128	95	202	15	102	2	63	261	987

Observed data were spread throughout the year on the Chatham Rise, but in other areas, particularly off the east coast North Island and the Challenger Plateau, trawls were made almost exclusively in two or three months only. Interpretation of analyses involving these variables requires care.

Linear regression

Stepwise linear regression analyses were performed on log-transformed discard catch data. Nation was included in the regressions, but not considered in the final models due to poor spread of the data. Results of the regression analyses are summarised in Table 5.

Table 5: **Results of GLM linear regression on catch of discards (symbols as in Table 1)**

Factors	ORH		COM		OTH	
Vessel length	-		+++	(169)	+++	(141)
Headline height	-		+	(4)	-	
Month	-		+	(5)	+++	(26)
Area	+	(7)	+	(6)	+++	(22)
Distance	+	(3)	-		+++	(49)
Net depth (bottom)	++	(11)	+++	(60)	-	
Total catch	+++	(25)	++	(19)	+	(5)
Nation	-		++	(17)	-	
r^2	0.102		0.392		0.40	

For ORH discards, area, distance, depth, and total catch were significant factors, but when combined explained only 10% of the variability in the data. The inclusion of area as a significant factor is driven partly by the high incidence of discards in ORH 2A/2B and can be linked to two vessels which fished exclusively in that area. The few tows with ORH discards make it difficult to accept a linear relationship between discards and tow distance or depth. Size of catch explained the most variability and is intuitively the most sensible variable. However, when the model includes total catch as the sole variable, only 2% of the variability is explained. It is concluded that none of the variables examined are of any practical use in explaining ORH discards.

Only tow distance was automatically removed from the GLM for COM discards, with the other seven factors explaining about 39% of the variability in the data. There was a strong positive relationship between vessel length and discard level. Two large vessels with generally high discard levels clearly influenced this result, but the effect may be real. Bottom depth showed a negative relationship with COM discards and was strongest for this species grouping. COM discards were positively associated with total catch, the third best variable for this GLM. Area was a significant factor, although not strong, due mainly to the influence of the South Chatham Rise where vessels targeting orange roughy often made large catches of oreos. Month was significant also, but closer examination revealed September to have a large influence due to oreo catches on the South Chatham Rise. The GLM indicated a high correlation between these two categorical variables. A weak negative association between headline height and COM discards may be influenced by one vessel with relatively high discards which consistently had a recorded headline height of 4 or 5 m. A sensible model seems to be one that includes the variables vessel length, bottom depth, and total catch. These variables are highly independent, have high 'F' values, and, for the loss of three further variables, reduce the explanatory power of the model by only 10%.

For discards of OTH species, bottom depth was discounted as a useful variable by the GLM and the others were retained. Vessel length was again the variable with the most explanatory power, showing a strong positive relationship with discard level. In contrast to COM, tow distance was a strongly significant variable, reflecting higher catches of non commercial species with longer tows. The inclusion of month and area as factors reflects higher discards in July and on the Chatham Rise (north and south), but again there is a high degree of correlation between these variables. Headline height is again negatively correlated with discard level, but total catch is a much weaker explanatory variable for this species grouping. We retained only vessel length, tow distance, and area in the model, which while retaining only the most reliable variables, reduces r^2 from 0.41 to 0.22. Most of this reduction however, is due to month, removed from the model as its influence was unreliable because of its correlation with area.

Discard estimation

Data from which discard ratios were derived are summarised in Table 6.

***Table 6*: Summary of data used to calculate discard ratios in the orange roughy fishery**

	Retained (t)	Discard (t)	Total (t)	% discard	Discard ratio
ORH	7 098.0	26.8	7 124.8	0.4	0.0038
COM	2 881.0	29.9	2 910.9	1.0	0.0042
OTH	6.2	203.0	209.2	97.1	0.0289
TOT	9 985.2	259.7	10 244.9	3.6	0.0366

Discard ratios and their coefficients of variation are summarised in Table 7.

***Table 7*: Discard ratios and *c.v.s* by species category for the two fishing years combined and separately**

	All data	*c.v.*	1994–95	*c.v.*	1995–96	*c.v.*
ORH *R*	0.0038	70.9	0.0050	70.4	0.0011	39.0
COM *R*	0.0042	21.6	0.0040	16.7	0.0023	43.7
OTH *R*	0.0289	8.8	0.0327	10.3	0.0203	17.4
TOT *R*	0.0366	10.4	0.0421	11.3	0.0237	19.8

The distributions of discard ratios for the four categories derived from the bootstrap analyses are given in Figure 16.

Discard estimation is complicated by orange roughy being taken as a bycatch in the oreo trawl fishery. In certain areas, such as the South Chatham Rise and Macquarie Ridge, discard ratios based on the targeted orange roughy trawl data may not be appropriate. However, experience with deepwater commercial catch and effort fishing returns suggests that the target species is often not reflected in the catch composition, i.e., ORH may be the stated target species, although the catch is primarily oreos. Therefore, it was not worthwhile trying to separate the orange roughy target and orange roughy bycatch components of the total reported catch. It is assumed that the mix of species in the observed trawls is broadly representative of the overall orange roughy fishery, and that consequently the QMR totals are a fairly accurate record of the retained target fishery. These catches totalled 35 180 t in 1994–95, and 29 040 t in 1995–96 (Annala *et al.* 1998).

The discard ratios from Table 6 were applied to these catch figures for orange roughy to estimate total discards in the fishery (Table 8). Confidence intervals for the estimates from bootstrap analyses are given in parentheses.

***Table 8*: Estimates of discards in the targeted ORH trawl fishery for 1994–95 and 1995–96 (t). 95% confidence intervals are given in parentheses for the total level of discards**

	1994–95	1995–96	Total
ORH	134	110	244 (32–646)
COM	148	122	270 (172–402)
OTH	1 016	839	1 855 (1 335–1 909)
TOT	1 298	1 071	2 369 (1 539–2 957)

More detailed information on the species in the above groupings, and the proportion discarded by species, is given in Appendix 3.

Hoki fishery

Distribution of data

The distribution of observed tows, and the size of catch of these tows, is shown in Figure 17, and those from the commercial fishery are given in Figure 18. Most of the observed tows were carried out in one of the three main fisheries, the Chatham Rise, west coast South Island, and the Sub-Antarctic. The Puysegur Bank area had reasonable observer coverage and a few tows were covered in Cook Strait and the Bay of Plenty.

The total reported catch of hoki in the 1994–95 and 1995–96 years was 384 000 t (Annala *et al.* 1998). The reported catch of hoki by the observed vessels for these years amounted to 54 574 t, which represented 14% of the entire fishery.

Factors affecting discards

A series of plots was examined to compare discarded catch against a number of possible explanatory variables.

Hoki catch (Figure 19a): Hoki were often discarded in quantities of less than 5 t. There was a smattering of discards between 10 and 25 t, with no strong correlation with catch size. Other commercial species were hardly discarded at all.

Total catch (Figure 19b): Discards did not appear to be related to catch size, with HOK and OTH discards occurring across a wide band of total catch size.

Area (Figure 20a): Most reports of discards of HOK and OTH came from the WCSI area, the area most extensively covered by observers. Large HOK discards were also reported from the Chatham Rise and Puysegur Bank fisheries, with some large OTH discards also on the Chatham Rise.

Month (Figure 20b): The level of discards was highest in winter, when the main WCSI fishery was operating. HOK discards were low in most months leading up to winter, and increased through July to August, before dropping back in September. Discards of OTH were also greatest throughout July–September.

Time of day (Figure 21a): This appeared to have little effect on discard level, which with both HOK and OTH was scattered throughout the 24 hour period.

Net depth (Figure 21b): Peak discards of HOK occurred around 350–450 m, the main depth band where hoki are caught in large quantities, so it is to be expected that discards would be greatest at these depths. OTH discards were mainly from around 350–450 m.

Net height above bottom (Figure 22a): The hoki fishery uses both bottom and midwater trawl gear, although most observed trawls took place within 200 m of the bottom. Discards of HOK and OTH tend to be higher close to the bottom, and low above 200 m off the bottom.

Headline height (Figure 22b): A wide range of nets with different headline openings are used in the hoki fisheries. Discards of HOK were greatest with large midwater trawls, which had headline heights of between 50 and 90 m. Other commercial species were often discarded from bottom trawls with headline heights of less than 10 m. OTH discards were highest with midwater nets of 60—80 m headline height.

Tow distance (Figure 23a): Discards of HOK and OTH occurred over a wide range of trawl distance. There appeared to be slightly higher levels of discards of HOK when tows were less than 30 km. Discards of COM were generally reported from short tows of less than 10–15 km. Discards of OTH showed no clear trend.

Vessel length (Figure 23b): Most observed vessels were large factory trawlers of 65—105 m in length. This variable is somewhat confused with nation, with certain countries having vessels of a certain size. HOK discards occurred across the range of vessel size, with low levels reported from vessels less than 65 m long, but little obvious trend with size. OTH discards were highest by vessels of 65–85 m.

Nation (Figure 24): Discard patterns differed between nations. HOK discards were more frequent on Japanese vessels, although all nations had scattered high-discard tows. Chinese boats reported low HOK discards, but relatively high dumping of OTH species.

Linear regression

Stepwise linear regression analyses were performed on log-transformed discard-catch data. However, again the data showed no clear linear trends for any of the factors. Results of the regression analyses are summarised in Table 9.

***Table 9*: Results of GLM linear regression on catch of discards (symbols as in Table 1)**

Factors	HOK		COM		OTH	
Vessel length	-		-		+++	(22)
Month	+	(8)	+	(2)	+	(6)
Area	+	(4)	-		-	
Net type	-		-		-	
Headline height	-		-		+	(4)
Distance	-		+	(4)	+	(7)
Net depth	+	(8)	-		+++	(70)
Start time	-		-		+	(2)
Net height	-		-		+++	(30)
Total catch	+	(8)	-		++	(18)
Nation	+++	(130)	+	(4)	+	(6)
r^2	0.82		0.18		0.48	

For HOK discards, the most significant factor was the vessel's nationality. There was also a positive relationship between discard level and size of catch. These variables explained about 80% of the variance. The analysis indicated that Japanese, Chinese, Korean, and Ukrainian vessels tended to discard more hoki than New Zealand, Polish, and Russian vessels. However, some care is needed with interpretation of these results, as the distribution of effort by different nationality vessels varied with month and area. Most observed fishing concentrated on the WCSI in winter, but even within this subset the spread of data was uneven. This is shown in the table below summarising numbers of trawls by month by nation.

Month		China		Japan	Korea		N.Z.	Poland	Russia
		Ukraine							
Jun	1	8	9	21	0	0	0		
Jul	1	101	86	15	0	28	2		
Aug	25	110	34	111	54	134	10		
Sep	47	1	0	106	57	225	116		
Oct	0	0	0	0	64	0	25		

The GLM analysis found nation, area, and trawl distance had a weak effect on discards of other commercial species, and the r^2 for COM was only 0.18. Depth of the trawl, total catch size, vessel length, and height above the bottom were significant explanatory variables for the OTH discards, with an r^2 of 0.48. There is a considerable species mix in the OTH classification, and so it is to be expected that a number of factors could influence the catch level of this category.

Discard estimation

Data from which discard ratios were derived are summarised in Table 9:

***Table 9*: Summary of data used to calculate discard ratios in the hoki fishery**

	Retained (t)	Discard (t)	Total (t)	% discard	Discard ratio
HOK	53 329.5	1 304.4	54 633.9	2.4	0.0243
COM	8 020.3	383.4	8 403.7	4.6	0.0072
OTH	500.4	1 215.5	1 715.9	70.8	0.0228
TOT	61 850.2	2 903.3	64 753.5	4.5	0.0544

Discard ratios and their coefficients of variation are summarised in Table 10.

***Table 10*: Discard ratios and *c.v.*s by species category for the two fishing years combined as well as separately**

	All data	*c.v.*	1994–95	*c.v.*	1995–96	*c.v.*
HOK *R*	0.0243	7.5	0.0237	9.6	0.0250	12.8
COM *R*	0.0072	43.0	–	–	–	–
OTH *R*	0.0228	6.9	0.0170	11.0	0.0293	7.6
TOT *R*	0.0544	6.9	0.0446	9.7	0.0603	9.3

The distributions of discard ratios for the four categories derived from the bootstrap analyses are given in Figure 25.

For hoki, it was assumed that the non-target hoki fishery was negligible, and that consequently the QMR totals are a fairly accurate record of the retained target fishery. These catches totalled 174 000 t in 1994–95, and 210 000 t in 1995–96 (Annala *et al.* 1998).

The discard ratios from Table 10 were applied to these catch figures for hoki to estimate total discards in the fishery (Table 11). Confidence intervals for the estimates from bootstrap analyses are given in parentheses.

Table 11: **Estimates of discards in the HOK trawl fishery for 1994–95 and 1995–96 (rounded to the nearest tonne) and 95% confidence interval in parentheses**

	1994–95	1995–96	Total
HOK	4 228	5 103	9 331 (8 064–10 825)
COM	1 253	1 512	2 765 (953–5 657)
OTH	3 967	4 778	8 745 (6 835–10 330)
TOT	9 448	11 393	20 841 (15 852–26 812)

More detailed information on the species in the above groupings, and the proportion discarded by species, is given in Appendix 4.

Oreo fishery

Distribution of data

Most of the observed catch came from the Chatham Rise (Figure 26), with coverage also of the Southland, Bounty Platform, and Macquarie Ridge fisheries. This corresponds reasonably well with the distribution of the commercial fishery during 1994–95 and 1995–96 (Figure 27), with the exception of the Antipodes and Auckland Islands areas.

Factors affecting discards

A series of plots was examined, comparing discard catch against a number of variables.

Oreo catch (Figure 28a): There was no evident pattern in distribution of discards with size of the oreo catch.

Total catch (Figure 28b): No strong pattern is evident for any category, and large discard events appeared to be random. Most of the observed tows reported catches of less than 10 t, and these tows accounted for the higher levels of discards.

Area (Figure 29a): Discards of oreo, particularly black oreo, were most common on the southwest Chatham Rise, with large but infrequent discards occurring in the Otago, Puysegur Bank, and southeastern Chatham Rise fisheries. Discards were generally very low for COM and high for OTH, particularly in Puysegur and the southeastern Chatham Rise.

Month (Figure 29b): Trawls were recorded from only seven months. Discards of OEO were highest in September, November, and December, with no discards over 100 kg in any other month. Discards of COM and OTH were well spread over the months covered, and the highest discards for all species were in September and November.

Time of day (Figure 30a): The larger discards of OEO (over 100 kg) all occurred between 0800 and 2000, but smaller discards and discards of other species groups, were fairly evenly spread throughout the day.

Bottom depth (Figure 30b): No clear trends are apparent from these plots: the large discard events appear to occur randomly within the bottom depths most commonly fished (between 800 and 100 m).

Vessel length (Figure 31a): Data are from eight vessels which fall into four length groups. Most tows and discards are from the 40–45 m and 65–70 m length groups. There is clearly not enough information to examine a vessel length effect properly, but what is available suggests that there is no linear relationship.

Headline height (Figure 31b): Discards appear greatest for headline heights of 4–6 m and 10 m in all species categories. This is partly due to the data points around the 10 m headline height representing only one vessel, and most other trawls recorded values between 4 and 6 m. There are no obvious trends.

Tow distance (Figure 32): All discards of oreos over about 100 kg came from tows less than 6 km long and there is a suggestion that, particularly for BOE, discards decrease with trawl distance. No clear trends are evident for the COM, OTH, or TOT species groups.

There were 168 tows available for the analysis, too few to give a good spread of data across all the factors that may influence discards. Nation was not included in any analyses as all tows were made by New Zealand vessels. Data were not well balanced between area and month, and only four of the seven areas were represented by more than 20 tows, as shown below.

	BNTY	NCHA	LOUI	OTAG	PUYS	SCRE	SCRW	Total
April	0	0	0	0	0	6	6	12
May	0	0	0	0	0	1	0	1
June	11	1	0	0	0	3	11	26
September	0	0	3	9	3	15	2	32
October	1	0	0	8	0	16	6	31
November	7	0	0	4	10	4	8	33
December	2	0	0	0	0	9	22	33

The north Chatham Rise, Louisville, and Puysegur fisheries had few observed trawls, and only the two Chatham Rise fisheries had good coverage over the seven months.

Linear regression

Stepwise linear regression analyses were performed on log-transformed discard-catch data. The data showed no clear linear trends for any of the factors, so a linear model would not be expected to perform well given the characteristics of the plots in Figures 28 to 32.

Results of the regression analyses are summarised in Table 12.

***Table 12*: Results of GLM linear regression on catch of discards (symbols as in Table 1)**

Factors	OEO		COM		OTH	
Vessel	+	(9)	+	(6)	+	(6)
Vessel length	-		-		-	
Headline height	+	(5)	+	(3)	-	
Month	+	(3)	+	(3)	++	(19)
Area	-		+	(2)	+	(3)
Distance	-		-		-	
Start time	+	(2)	-		-	
Net depth (bottom)	+	(7)	-		-	
Total catch	+	(3)	-		++	(10)
r^2	0.365		0.238		0.569	

For OEO discards, no factor was highly significant and most of the variability was explained by vessel and a positive association between net depth and discard level. With the pattern in headline height explained above, the weak significance shown in Table 12 can be discounted, as can month. The significance of total catch, although weak, seems plausible. Overall, discards of OEO appear to be related to different fishing practices between vessels, net depth, and total catch.

Vessel was the most significant factor for discards of COM, with the automatic GLM procedure including five other factors with small explanatory power. Month and area are both weakly indicated, but are also weakly correlated with each other as shown by low model tolerance values (0.02 and 0.05 respectively). Headline height is likely to be strongly influenced by the one vessel with a consistent and high recorded value, and trawl distance is only very weakly indicated. Vessel and vessel type may be the best variables to explain discards in this group, but with such low levels of discards in this group (nothing greater than 40 kg per tow) the relationship may be misleading.

The four factors automatically selected by the GLM for OTH species explained about 57% of the variability in discard levels. Discards were greatest in this group, with over 100 kg discarded in many tows. Month was the strongest factor, and, with area (the weakest factor) removed, was less confounded by the other variables. Vessel was a significant factor, and total catch was a relatively strong and independent factor. The GLM indicates that discards of OTH are influenced most by variation in fishing practices between vessels, by the time of year, and by total catch.

Discards of all species, TOT, are influenced mostly by OTH species and almost not at all by COM species, and the model chosen automatically explains a similar amount of variation as that for OTH. Headline height is included into the model, however, as is net type, despite not being considered in the model for any other category, and vessel length replaces vessel. Discards of TOT may be best explained by only the strongest factors indicated of total catch and time of year.

Discard estimation

Data from which discard ratios were derived are summarised in Table 13. Discard ratios and their coefficients of variation are summarised in Table 14.

***Table 13*: Summary of data used to calculate discard ratios in the oreo fishery**

	Retained (t)	Discard (t)	Total (t)	% discard	Discard ratio
OEO	1 880.7	21.2	1 901.9	1.1	0.0113
COM	89.4	0.1	89.5	0.1	0.00004
OTH	0.1	32.5	32.6	99.7	0.0169
TOT	1 970.2	53.8	2 024.0	2.6	0.0286

***Table 14*: Discard ratios and *c.v.*s by species category for the two fishing years combined and separately**

	All data	*c.v.*	1994–95	*c.v.*	1995–96	*c.v.*
OEO *R*	0.0113	26.6	0.0093	27.6	–	–
BOE *R*	0.0060	30.6	–	–	–	–
SSO *R*	0.0053	35.4	–	–	–	–
COM *R*	0.00004	61.8	–	–	–	–
OTH *R*	0.0169	20.5	0.0089	36.1	0.0080	21.4
TOT *R*	0.0286	16.8	0.0183	22.3	0.0117	23.0

The distributions of discard ratios for the four categories derived from the bootstrap analyses are given in Figure 33.

For oreos, discard estimation is complicated by the species being taken as a bycatch in the orange roughy trawl fishery. In certain areas, such as the South Chatham Rise and Macquarie Ridge, discard ratios based on the targeted trawl data may not be appropriate. However, experience with deepwater commercial catch and effort fishing returns suggests that the target species is often not reflected in the catch composition. Therefore, it was not considered worthwhile trying to separate the oreo target and oreo bycatch components of the total reported catch. It is assumed that the mix of species in the observed trawls is broadly representative of the overall oreo fishery, and that consequently the QMR totals are a fairly accurate record of the retained target fishery. These catches totalled 18 291 t in 1994–95, and 23 810 t in 1995–96 (Annala *et al.* 1998). Catches of SSO for 1994–95 and 1995–96 were estimated at 11 507 t and 13 906 t respectively, and of BOE at 3212 t and 6187 t.

The discard ratios from Table 13 were applied to these catch figures for oreos to estimate total discards in the fishery (Table 15). Confidence intervals for the estimates from bootstrap analyses are given in parentheses.

***Table 15*: Estimates of discards in the targeted OEO trawl fishery for 1994–95 and 1995–96 (t). 95% confidence intervals are given in parentheses for the total level of discards**

	1994–95	1995–96	Total
OEO	207	270	477 (250–753)
COM	1	1	2 (1–4)
OTH	309	402	711 (875–1,250)
TOT	517	673	1 190 (1,126–2,007

The relatively small amount of data for this fishery means we are not confident of detailed analysis by individual oreo species. However, based on the discard ratios for SSO and BOE in Table 14, the discards of the two species for the two years combined would be about 135 t and 56 t, respectively.

More detailed information on the species in the above groupings, and the proportion discarded by species, is given in Appendix 5.

Discussion

This was the first attempt to estimate discards from major New Zealand trawl fisheries. Data collected by the MFish Scientific Observer Programme were used exclusively. Originally it was planned to supplement these data, where necessary, with information from trawl surveys or commercial catch and effort returns, but this was not done due to time constraints, and also because the observer coverage was extensive. It is unlikely that the analysis would have been improved by using other (less appropriate) data sources. However, for oreos in particular, observer coverage was limited, which affects the overall confidence in the estimates of discards. For other fisheries, the data spread was at times uneven, and so there was a confounding effect of correlated variables in the analysis that required careful interpretation.

A number of factors appeared to affect discard levels, although these varied between fisheries, and between target, other commercial, and non-commercial bycatch species. Catch size appeared significant in several fisheries, which was to be expected given that with large catches there is more crushing of fish in the codend, and more likelihood of processing delays affecting the quality of fish on deck or in the pounds for long periods.

Typically, there was a poor, if any, linear fit to discard data, and linear modelling is not very appropriate for this type of work. However, no other standard model structure would fit well for the range of relationships indicated by the raw data plots. For some of the variables, the response could have been better described by a non-linear model, but the general conclusions based on the linear model would not have been altered. Similarly, results would have remained similar if a different error structure had been applied. The GLM used a normal error distribution, which did not reflect the high frequency of low discards, and a long right-hand tail. Overall, discards in these fisheries appear to be semi-random events, with few systematic causes.

Estimates of total discards were low for each fishery. All the fisheries are based to a large extent on targeting aggregations of fish, and catches tend to be 'clean'. Most of the discards of target or commercial quota species were caused by burst nets when fishing aggregations.

The amount of fish loss is estimated from the time the net arrives at the surface. Fish loss through gear damage while trawling at depth cannot be accounted for. This could lead to underestimation of the total amount discarded. Another source of error is in estimation of the amount of fish lost when a trawl is ripped or the codend bursts at the surface. Fish loss from a net at or near the surface is hard to quantify, unless it occurs when the trawl is coming up the stern ramp, and the change in net volume can be seen. This might not result in bias, as observers could be just as likely to overestimate fish loss as underestimate it.

This work has concentrated on giving a general account of discard levels in the trawl fisheries. Results have not been broken down into great detail, although raw data are presented in the appendices to enable readers to assess the importance of individual species within the grouped categories. With orange roughy and oreos, there is an element of discarding across the fisheries – orange roughy can be discarded by both the target fishery and as bycatch in the oreo fishery, although this did not appear to be substantial during the years examined. Results presented are solely for discards within the target fisheries.

Discard estimates were not based on stratification of catch. Initially it was thought that factors such as area or season would have been important in determining the level of discards. This was not so in these fisheries, and so discard ratios were applied to the entire fishery.

The period covered was only two fishing years and although this gives some idea of the general level of discards, it is uncertain whether this is representative of general fishery practices. It gives no real information on whether the composition or rate of discards has changed or is changing over time. With orange roughy, for example, a progressive decrease in the level of discards has been noted (Francis *et al.* 1993). This work could usefully be extended, both backwards into the 1980s and forwards to more recent years, to give an indication of changes with time.

Acknowledgments

Thanks to Chris Francis for advice on the bootstrap analyses, and to Kevin Mackay (both NIWA, Greta Point) for assistance with database extracts. Stuart Hanchet and Sira Ballara (NIWA) provided commercial catch-effort data for southern blue whiting and hoki fisheries, respectively. Members of the Aquatic Environment Working Group made useful comments on the analyses. Thanks to Suze Baird (NIWA) for a thorough review of the manuscript. This work was funded by the Ministry of Fisheries (project code ENV9703) during the 1997–98 year.

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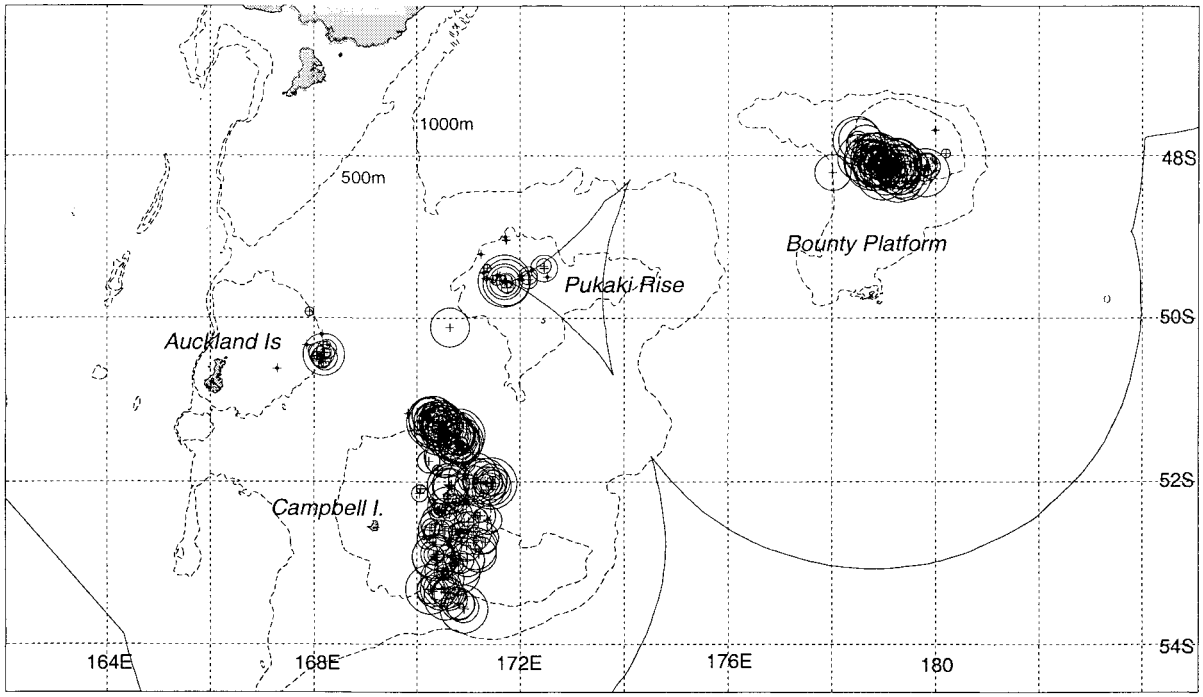

Figure 1: **Distribution of tows and catch recorded by scientific observers on vessels fishing for southern blue whiting during 1994–95 and 1995–96 fishing years (circle size proportional to catch, maximum circle = 100 t).**

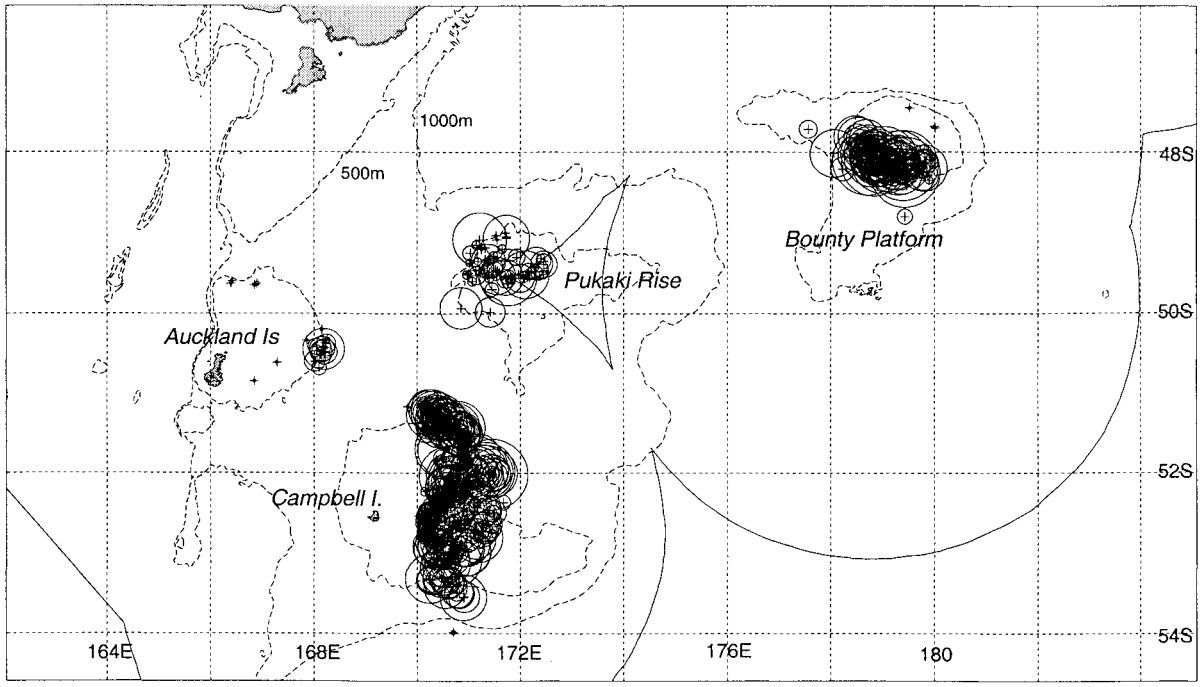

Figure 2: **Distribution of tows and catch of SBW recorded by vessels fishing for southern blue whiting during 1994–95 and 1995–96 fishing years (TCEPR data, circle size as above).**

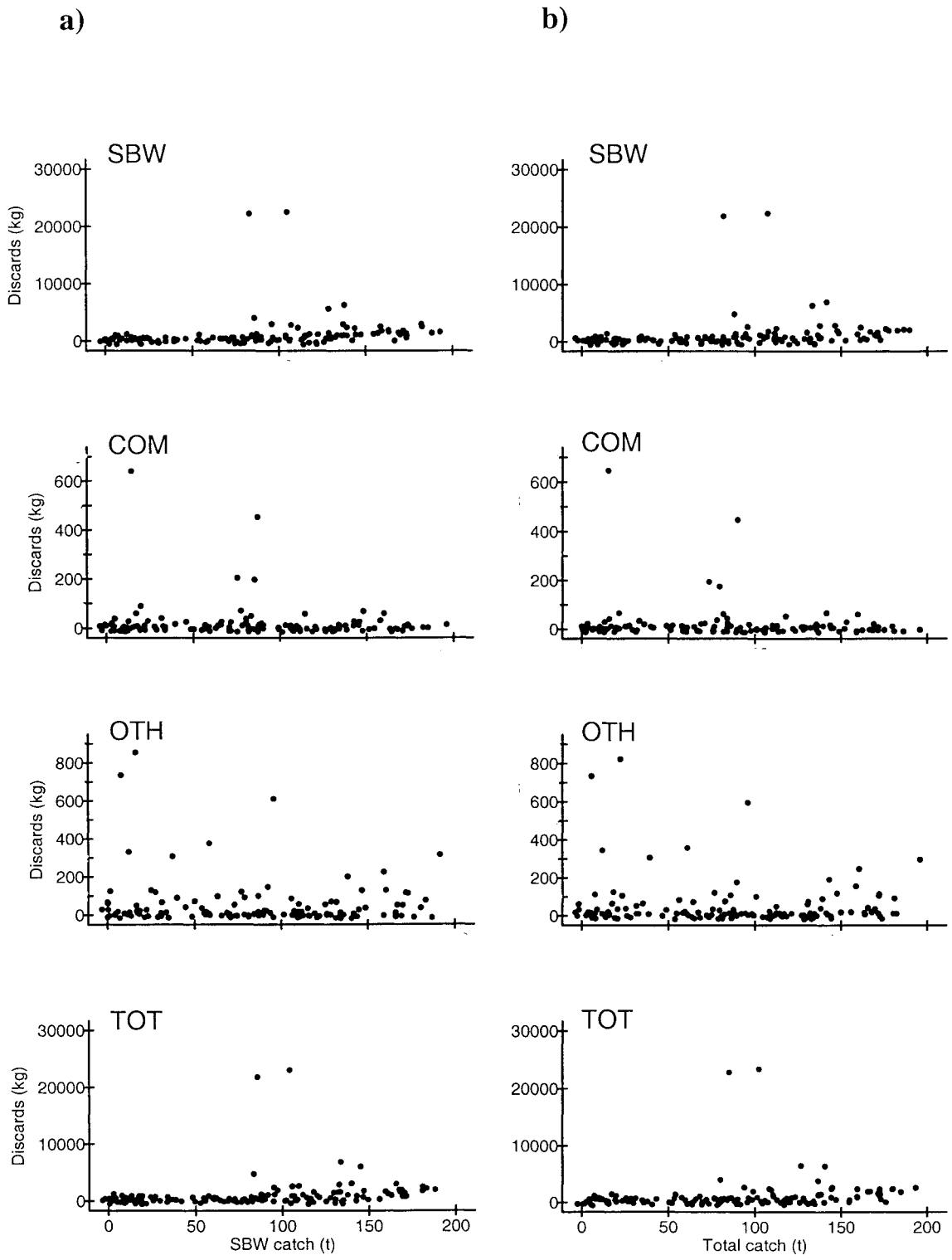

Figure 3: **Discarded catch for SBW, COM, OTH, and TOT categories against SBW catch (a) and total catch (b).**

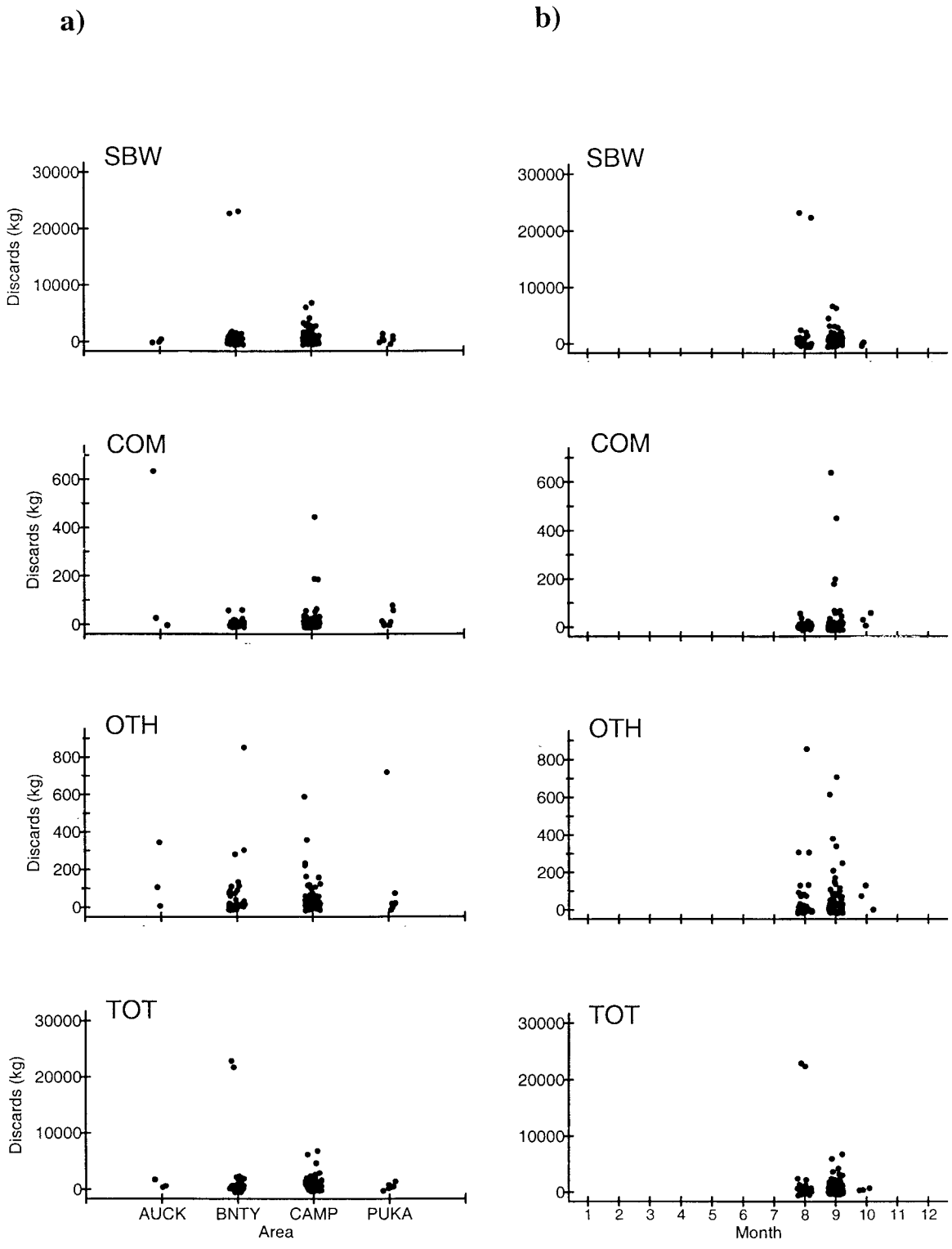

Figure 4: **Discarded catch for SBW, COM, OTH, and TOT categories by area (a), and month of the year (b).**

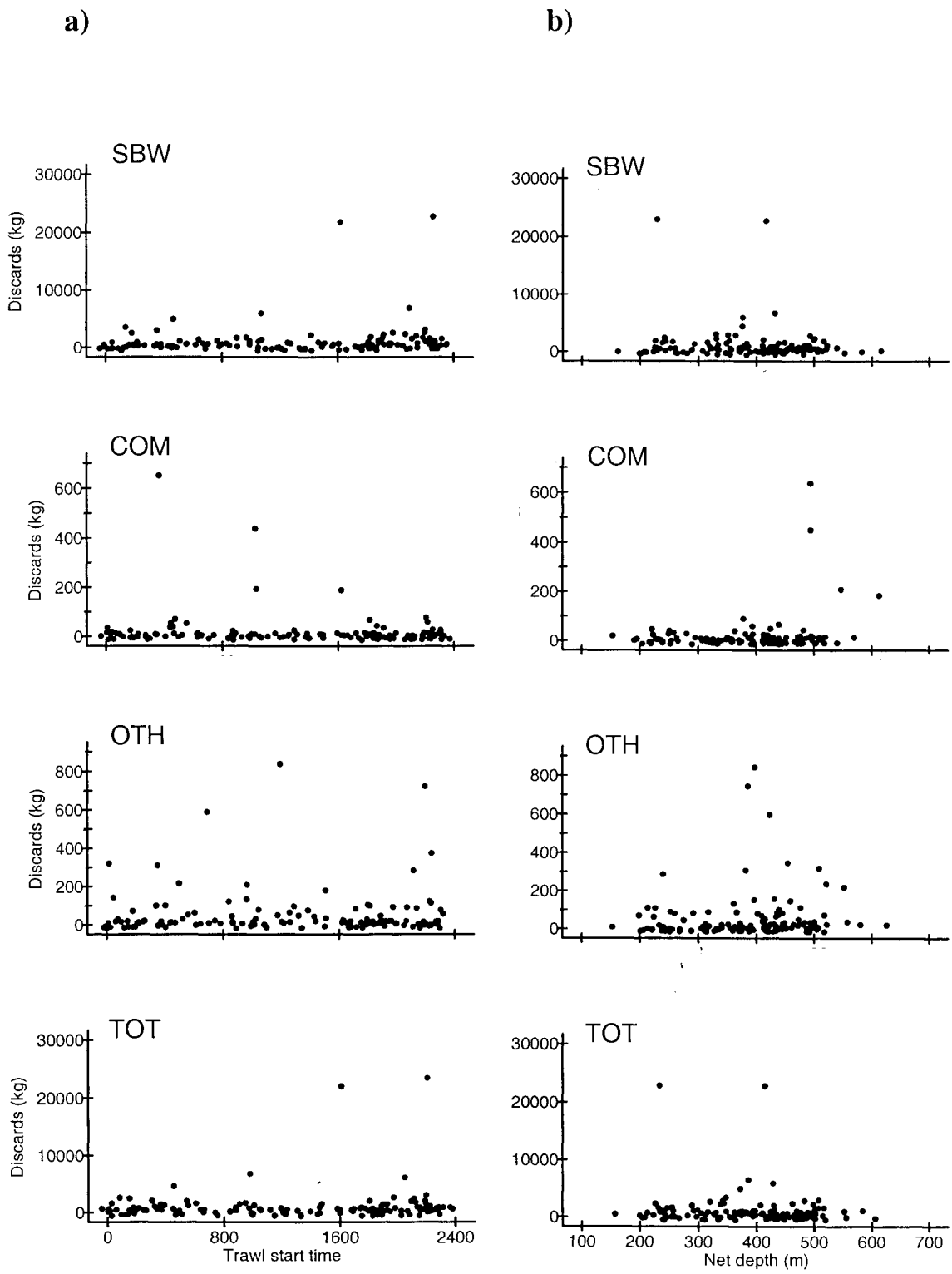

Figure 5: **Discarded catch for SBW, COM, OTH, and TOT categories against time of day (a) and net depth (b).**

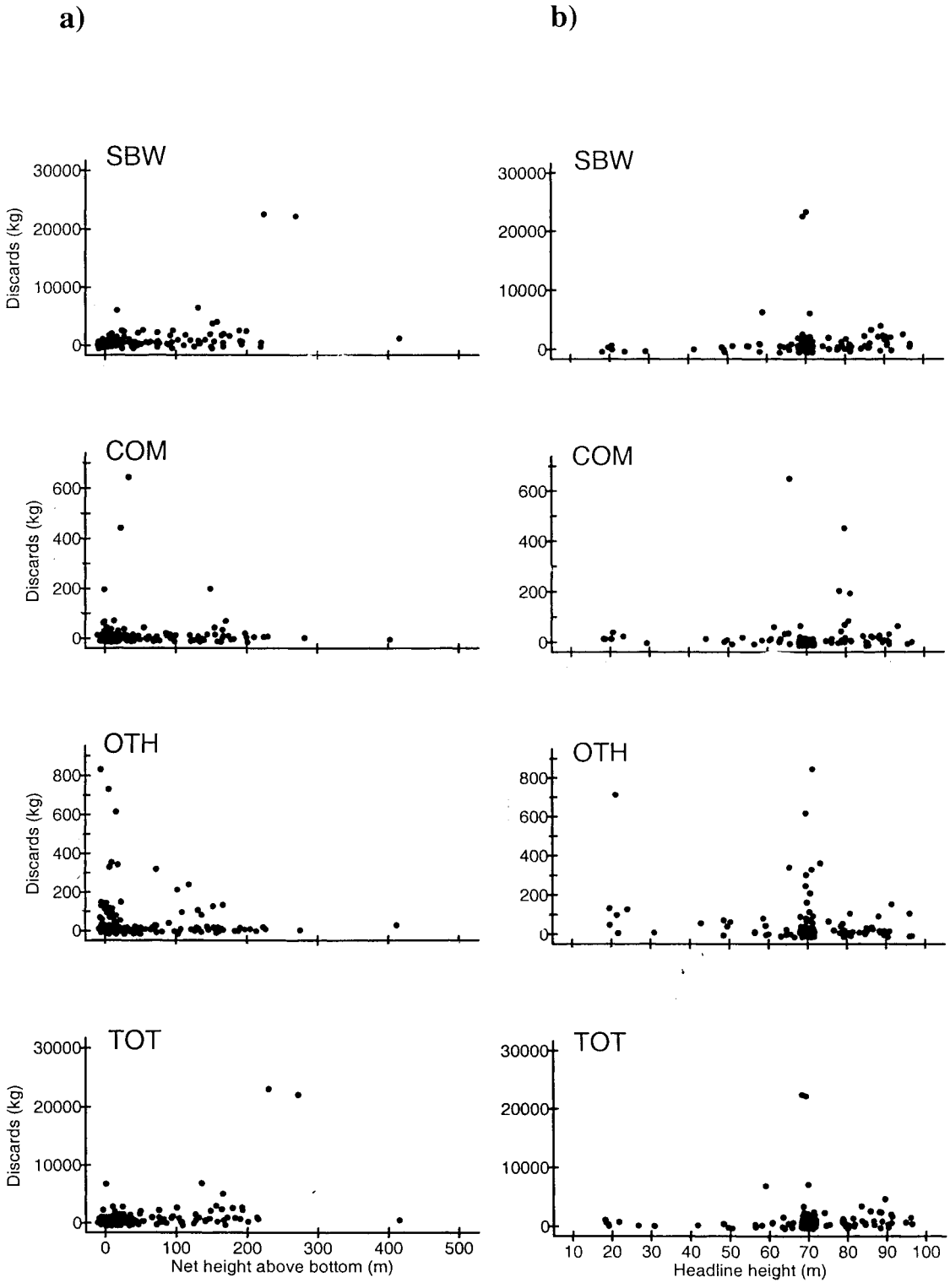

Figure 6: **Discarded catch for SBW, COM, OTH, and TOT categories against net height above the bottom (a) and headline height (b).**

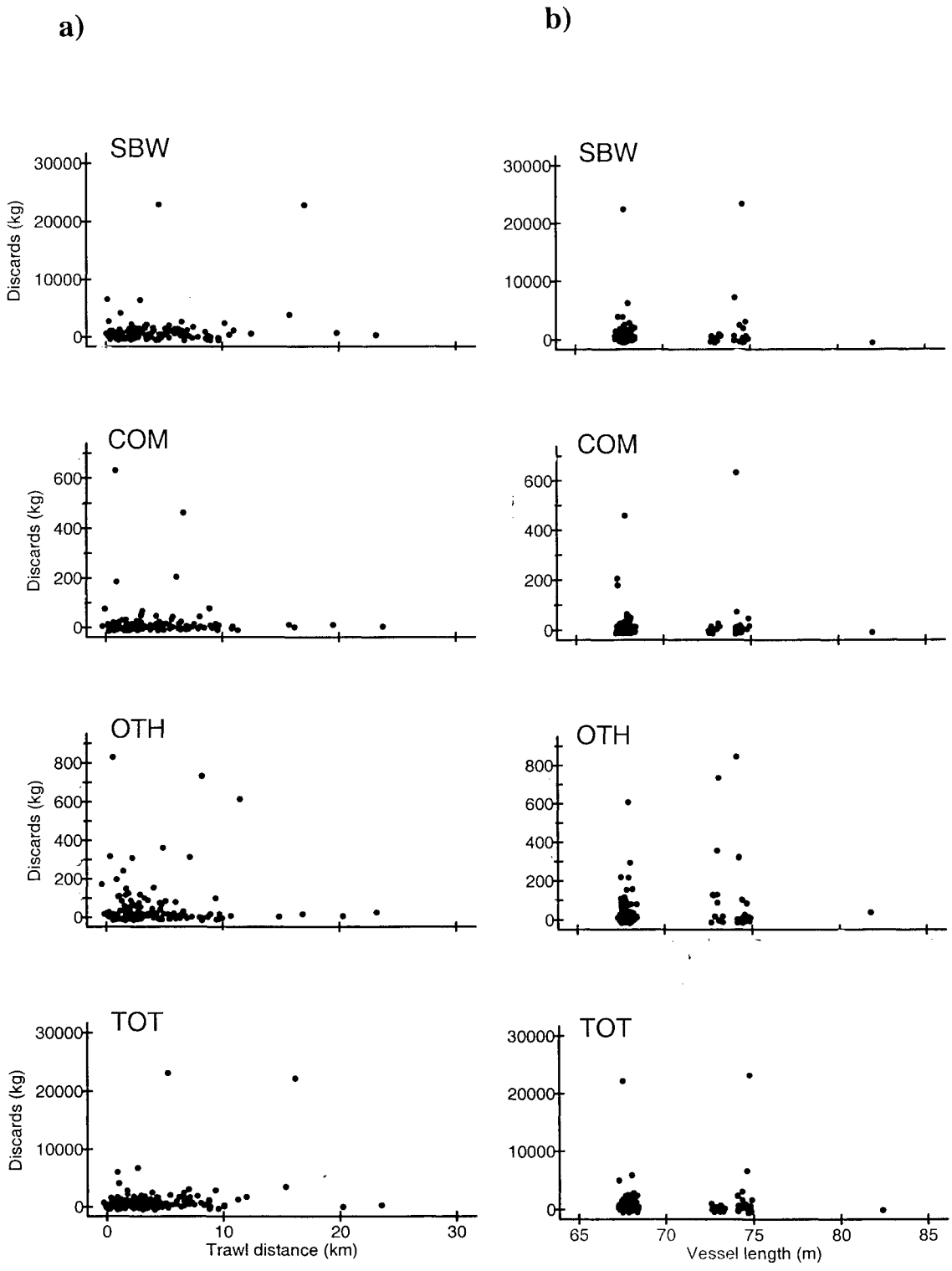

Figure 7: **Discarded catch for SBW, COM, OTH, and TOT categories against tow distance (a) and vessel length (b).**

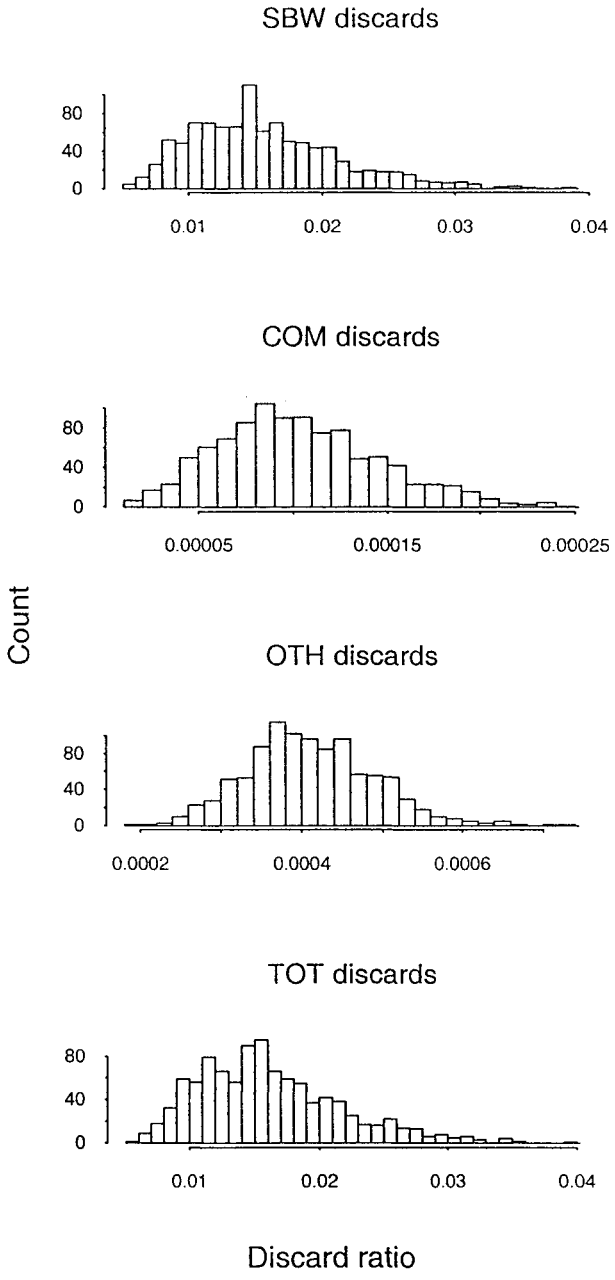

Figure 8: **Distribution of discard ratios derived from bootstrap analysis for the southern blue whiting fishery.**

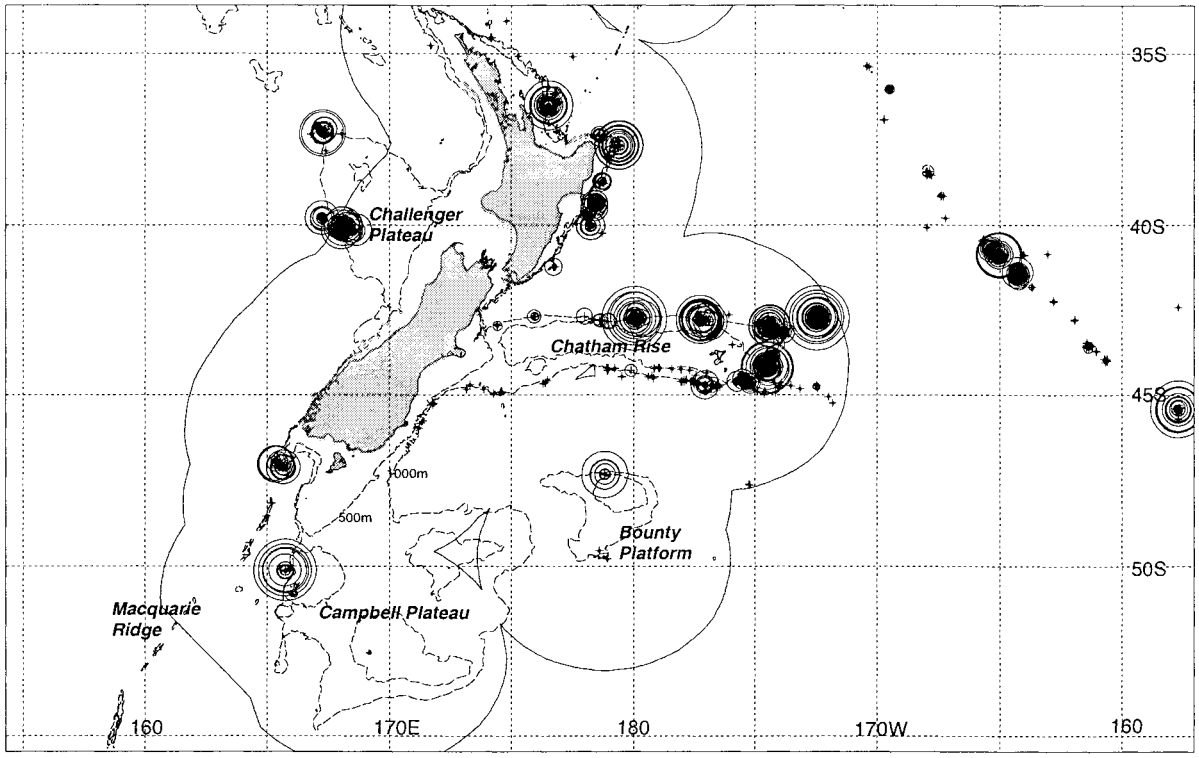

Figure 9: **Distribution of tows and catch recorded by scientific observers on vessels fishing for orange roughy during 1994–95 and 1995–96 fishing years (circle size proportional to catch, maximum circle = 50 t).**

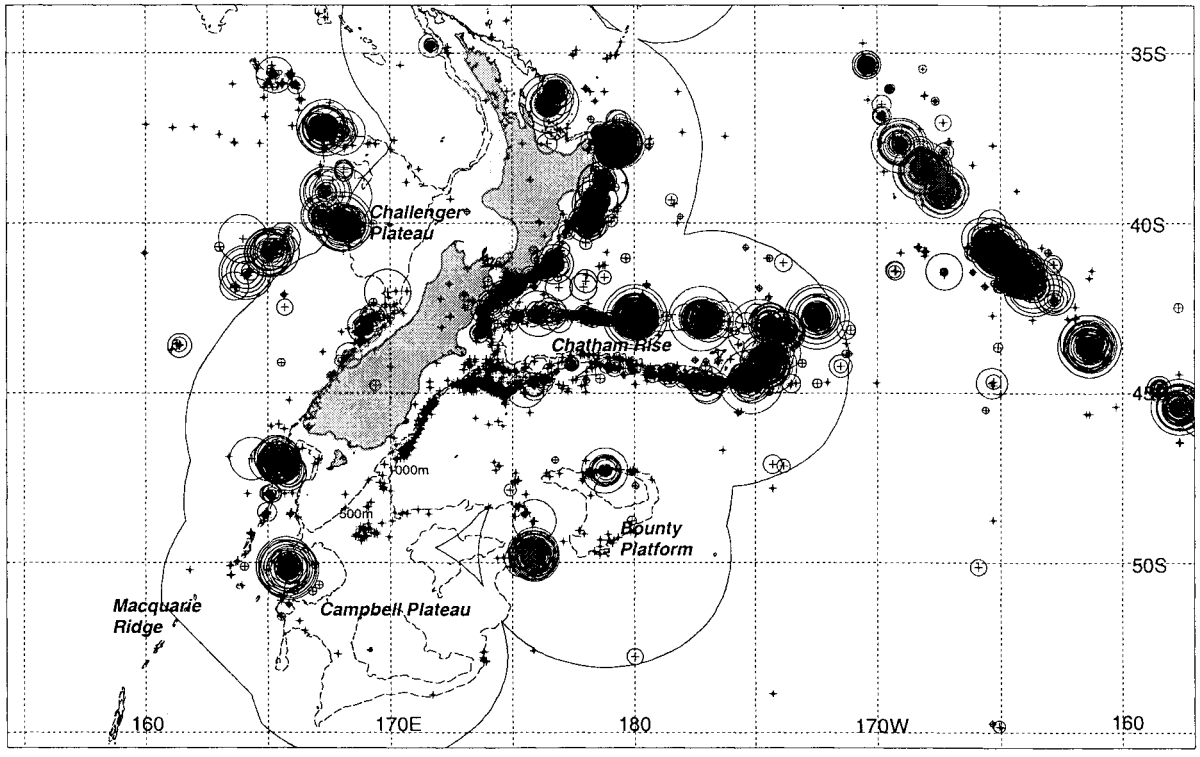

Figure 10: **Distribution of tows and catch of orange roughy recorded by vessels fishing during 1994–95 and 1995–96 fishing years (TCEPR data, circle size as above).**

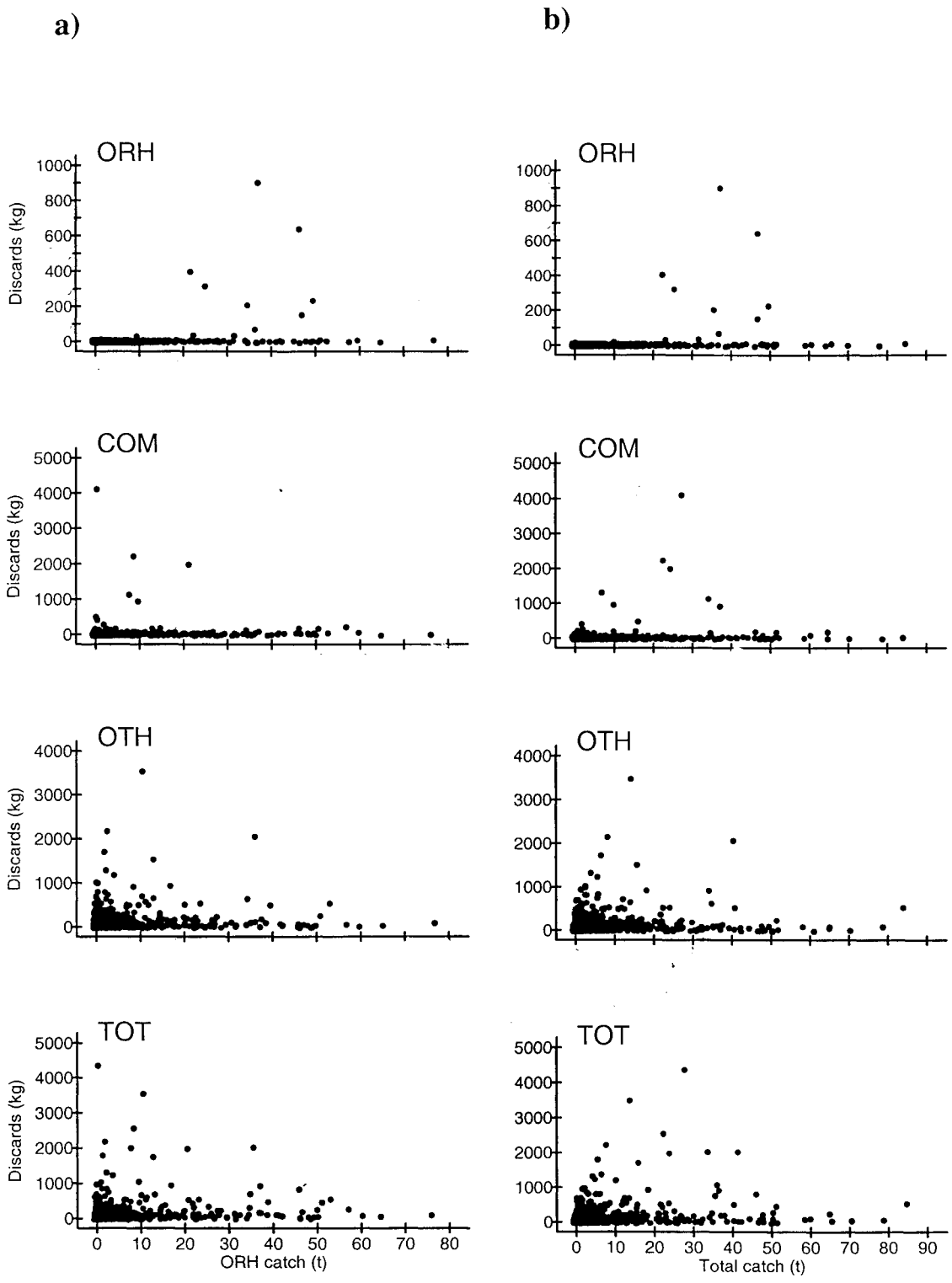

Figure 11: **Discarded catch for ORH, COM, OTH, and TOT categories against ORH catch (a) and total catch (b).**

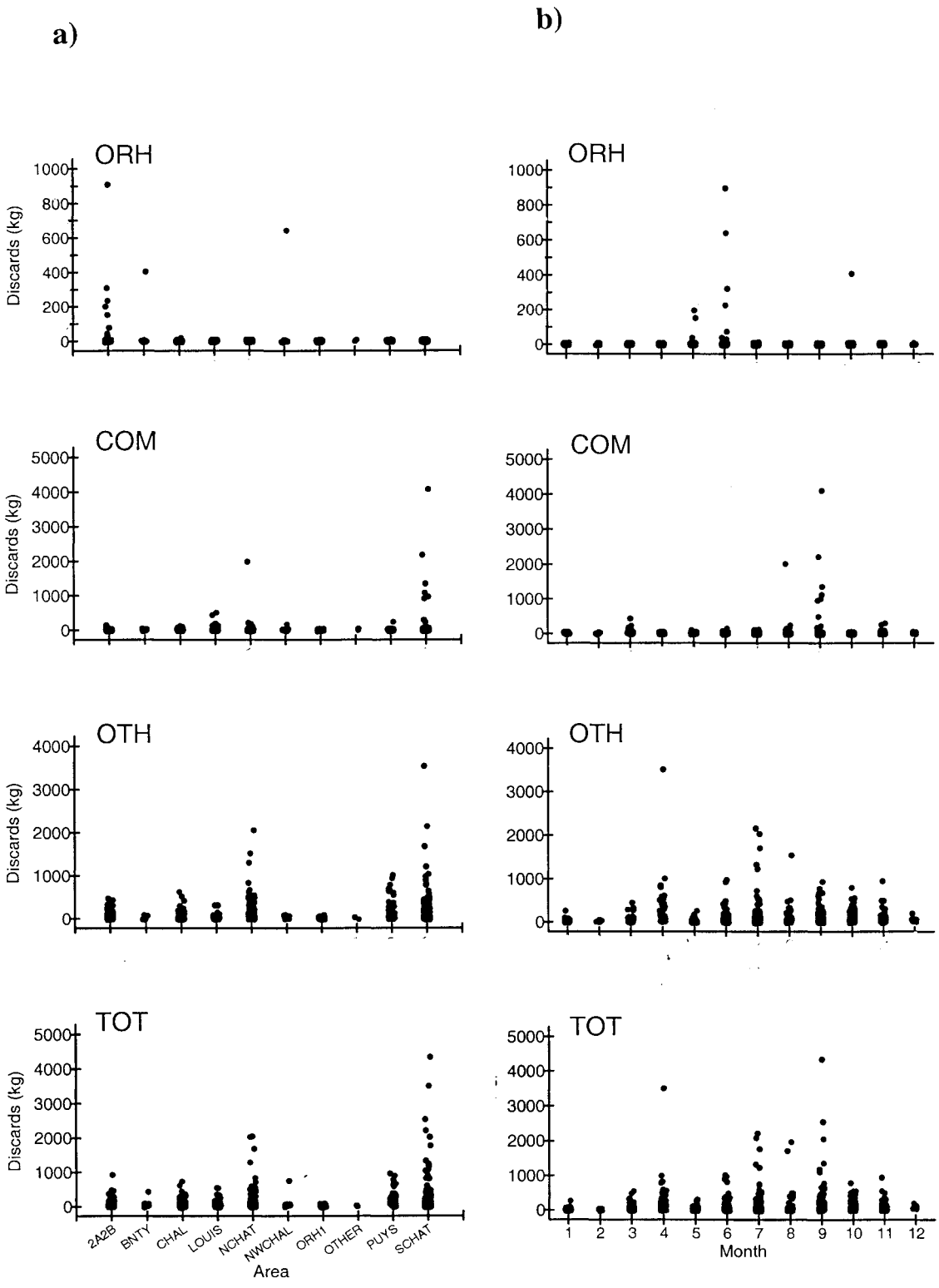

Figure 12: **Discarded catch for ORH, COM, OTH, and TOT categories by area (a), and month of the year (b).**

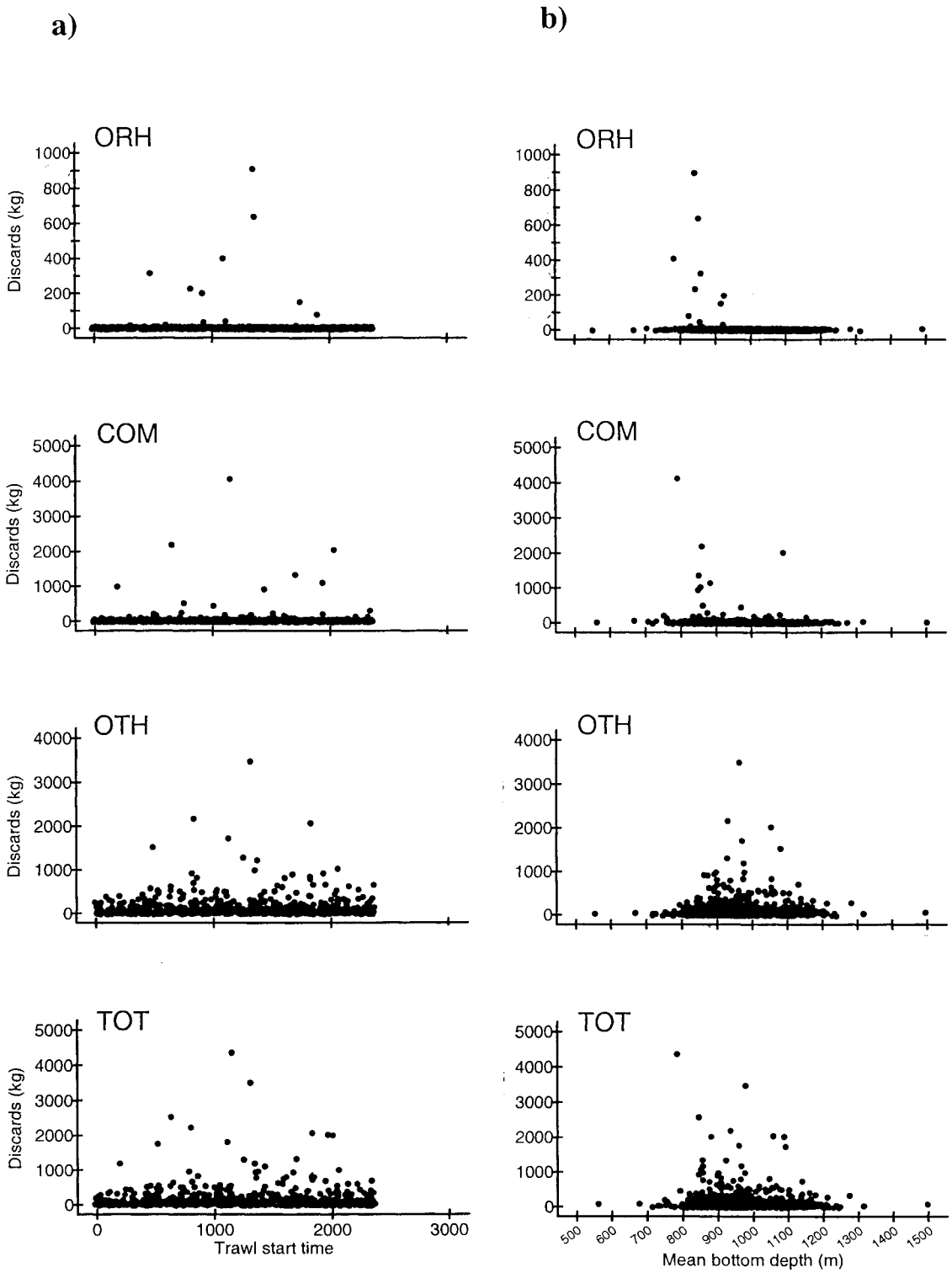

Figure 13: **Discarded catch for ORH, COM, OTH, and TOT categories against time of day (a) and bottom depth (b).**

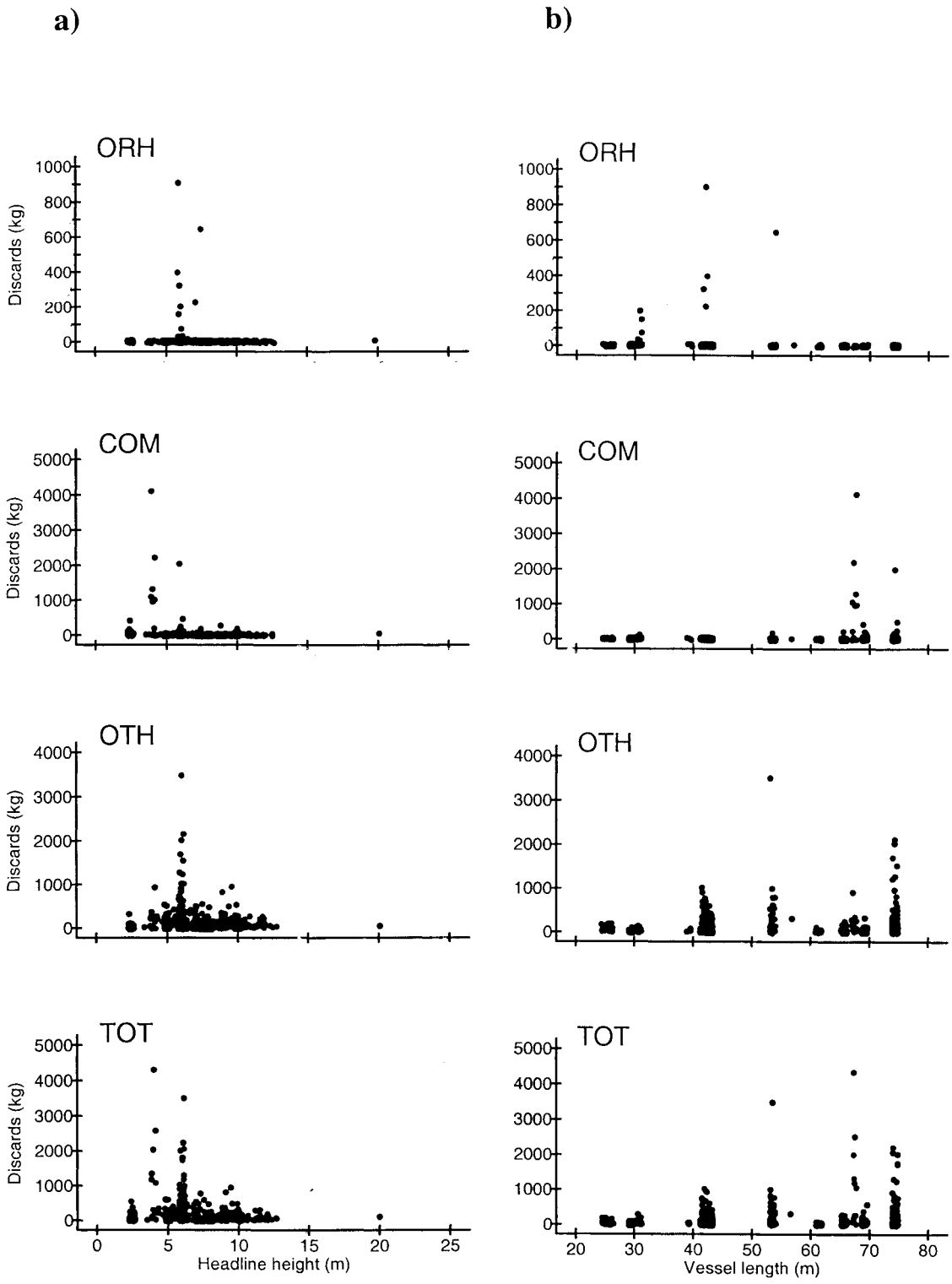

Figure 14: **Discarded catch for ORH, COM, OTH, and TOT categories against headline height (a) and vessel length (b).**

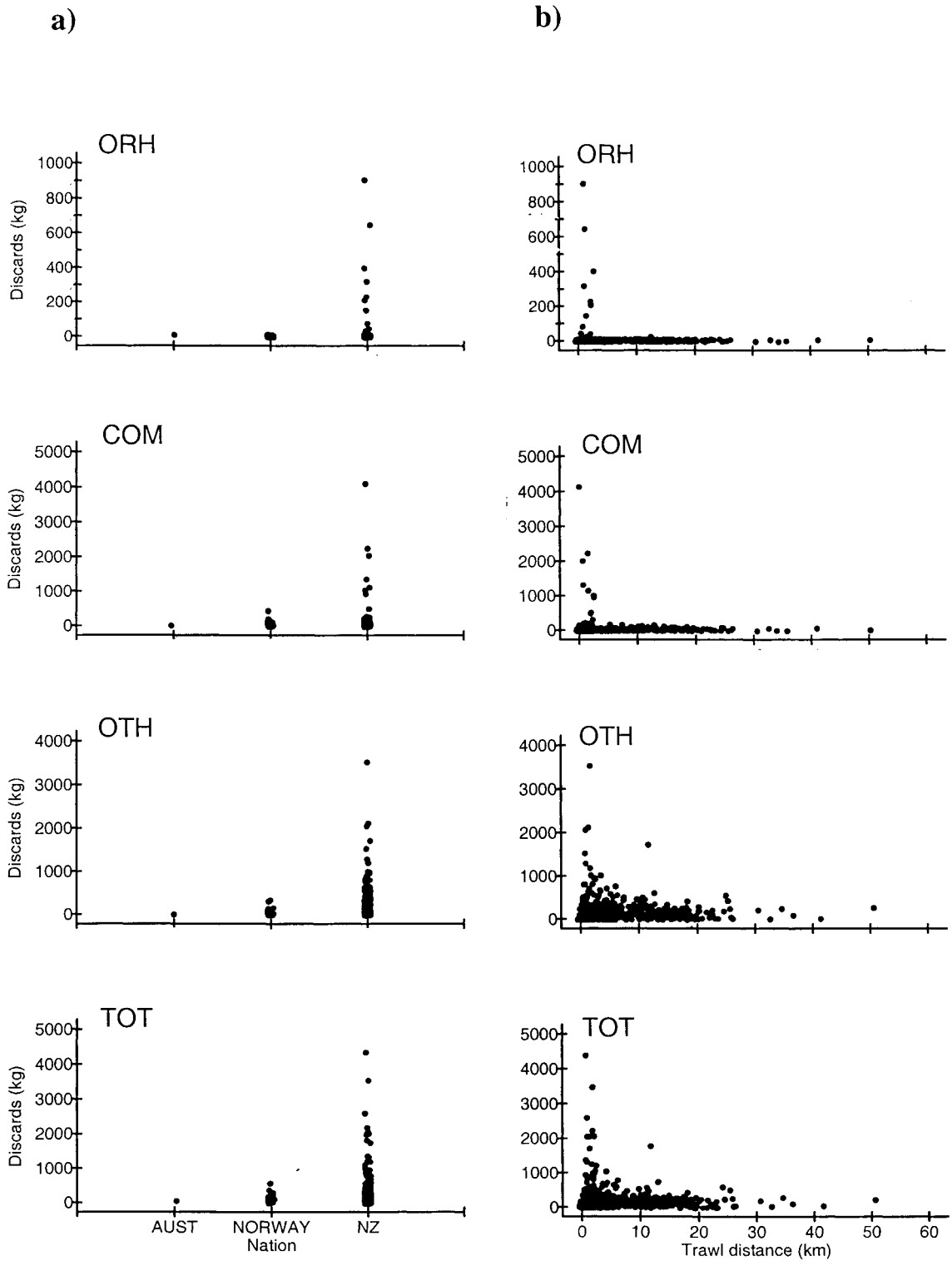

Figure 15: **Discarded catch for ORH, COM, OTH, and TOT categories against vessel nationality (a) and tow distance (b).**

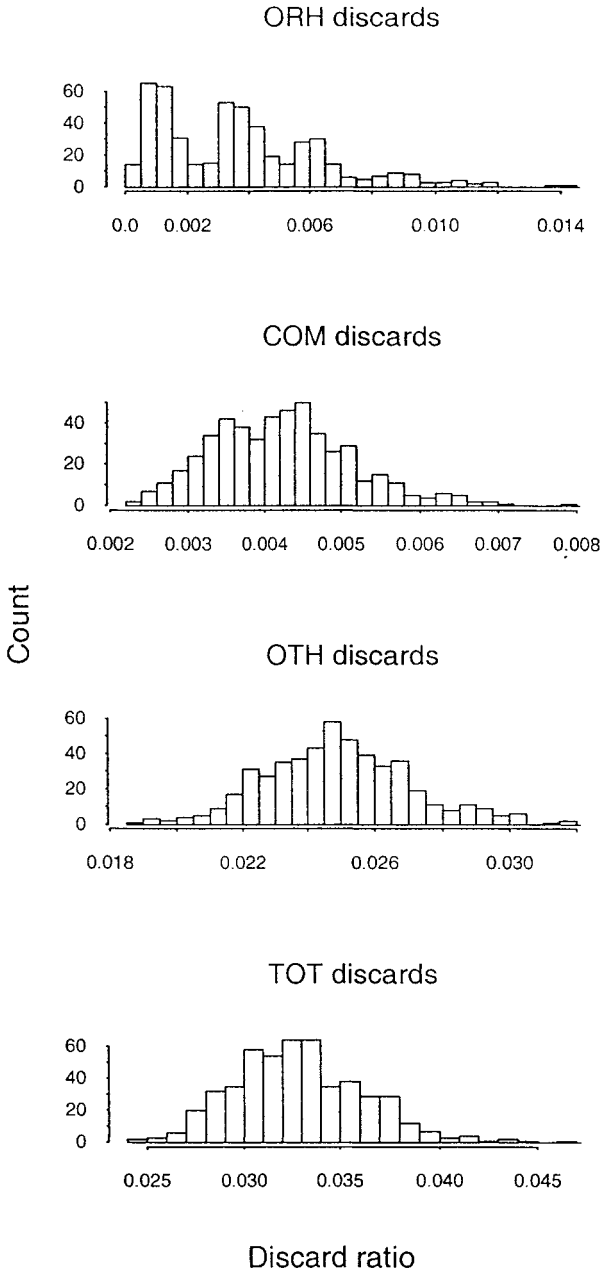

Figure 16: **Distribution of discard ratios derived from bootstrap analysis for the orange roughy fishery.**

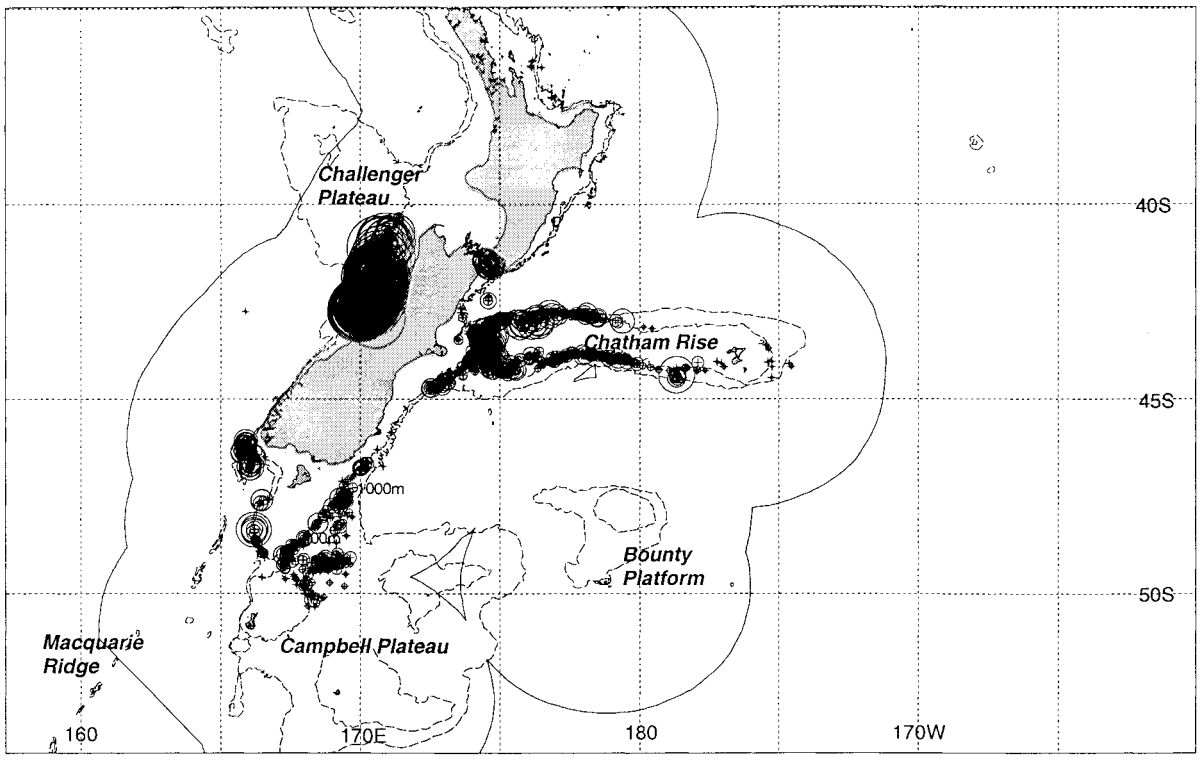

Figure 17: **Distribution of tows and catch recorded by scientific observers on vessels fishing for hoki during 1994–95 and 1995–96 fishing years (circle size proportional to catch, maximum circle = 100 t)**

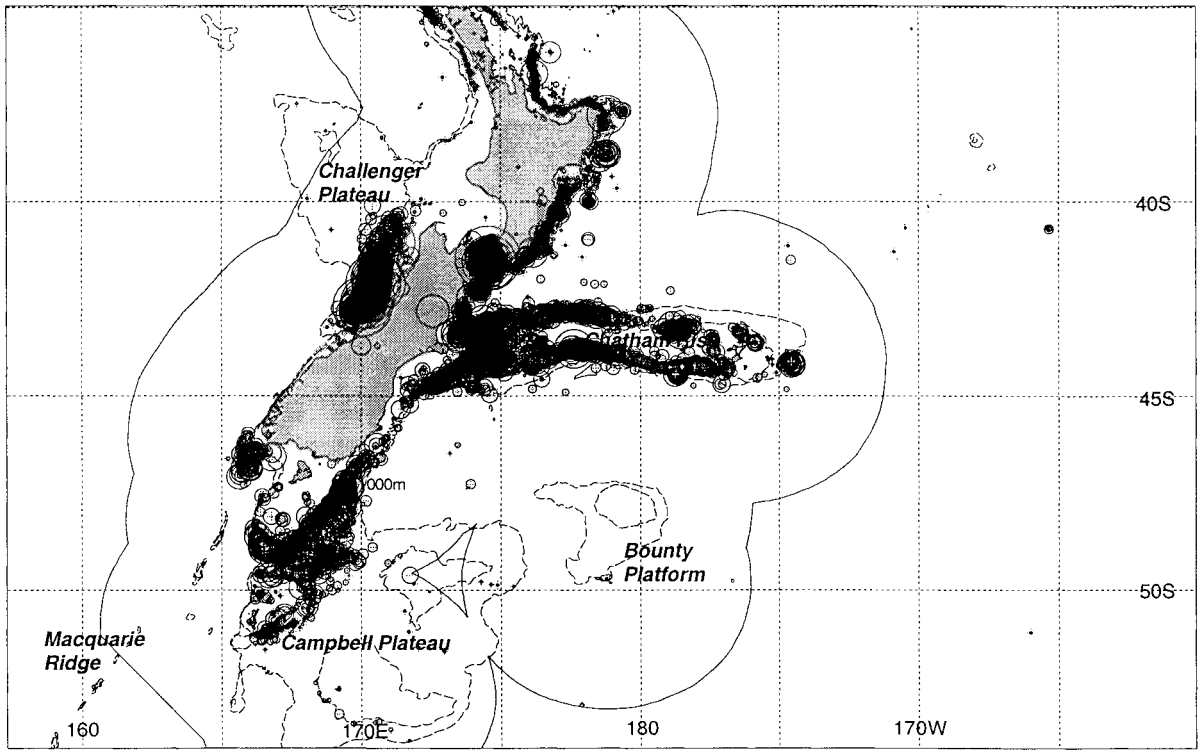

Figure 18: **Distribution of tows and catch of hoki recorded by vessels fishing for hoki during 1994–95 and 1995–96 fishing years (TCEPR data, circle size as above)**

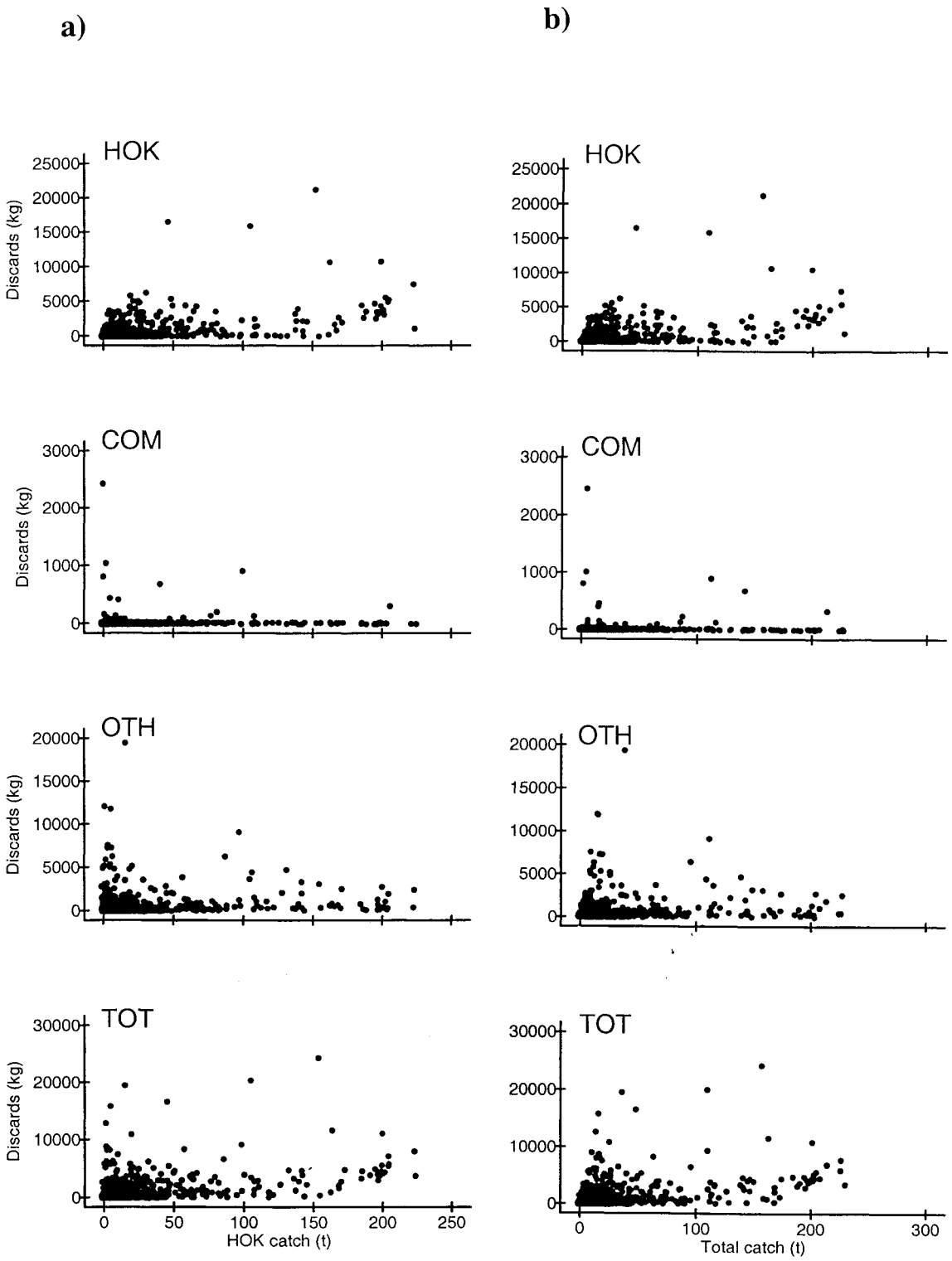

Figure 19: **Discarded catch for HOK, COM, OTH, and TOT categories against HOK catch (a) and total catch (b).**

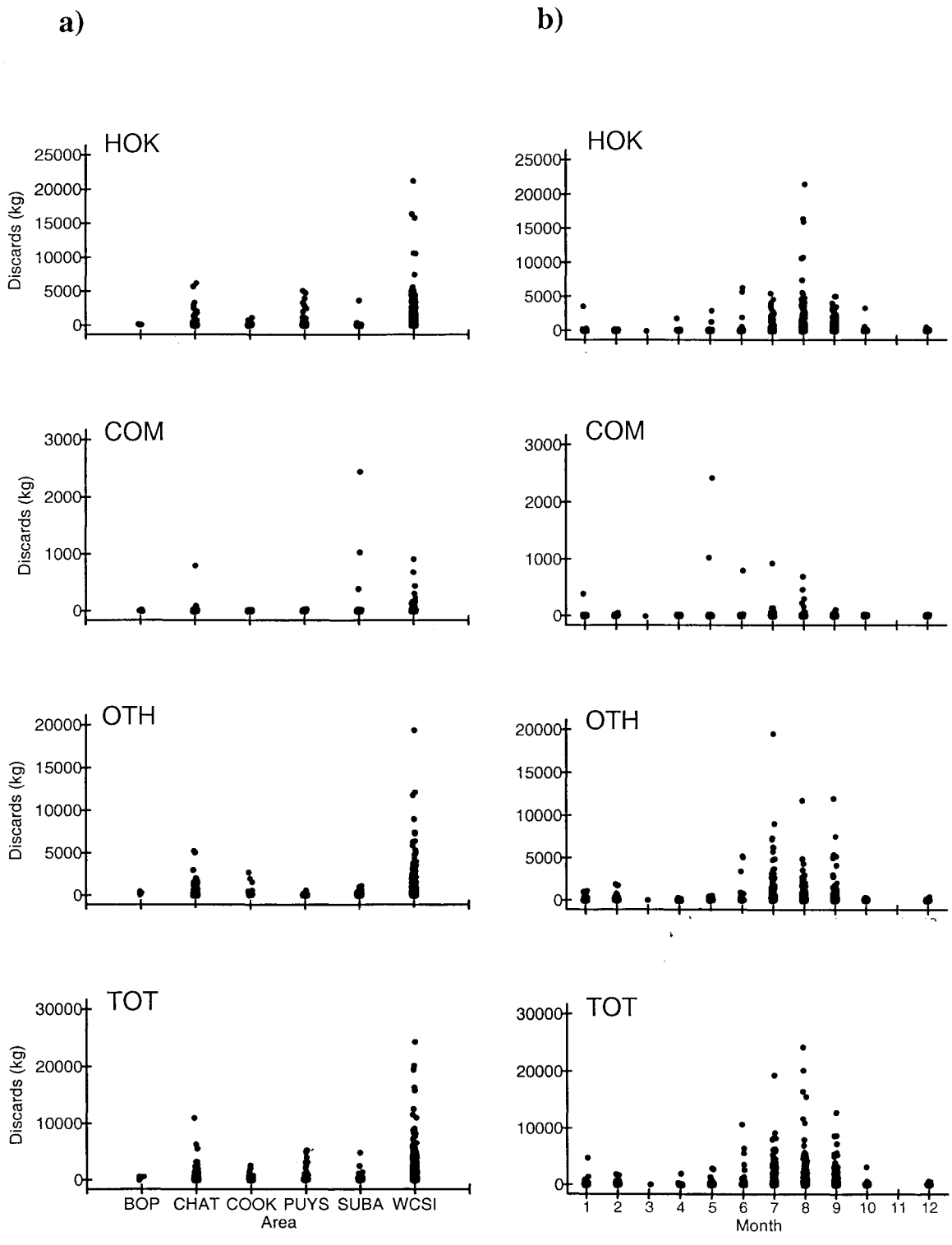

Figure 20: **Discarded catch for HOK, COM, OTH, and TOT categories by area (a), and month of the year (b).**

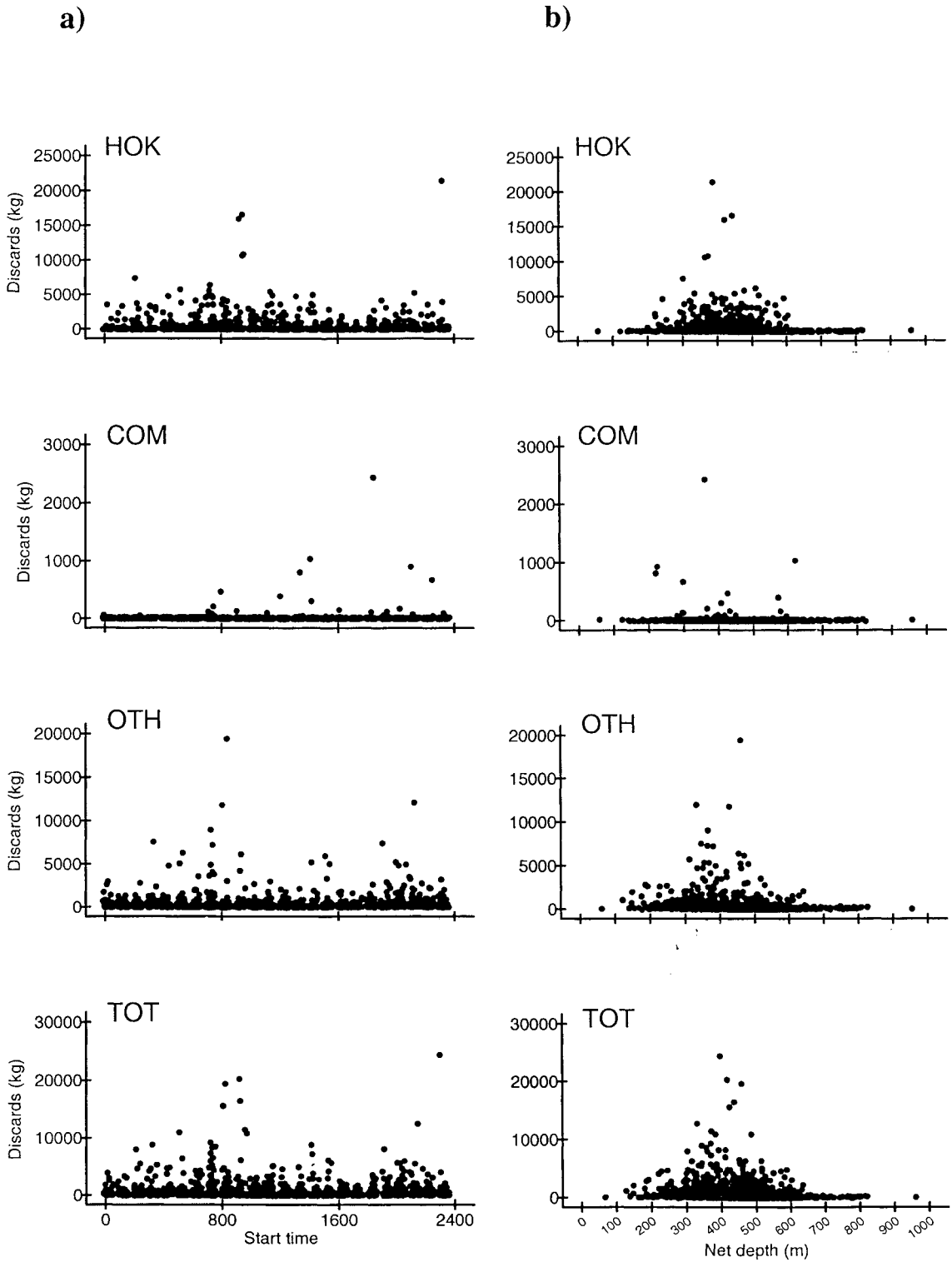

Figure 21: **Discarded catch for HOK, COM, OTH, and TOT categories against time of day (a) and net depth (b).**

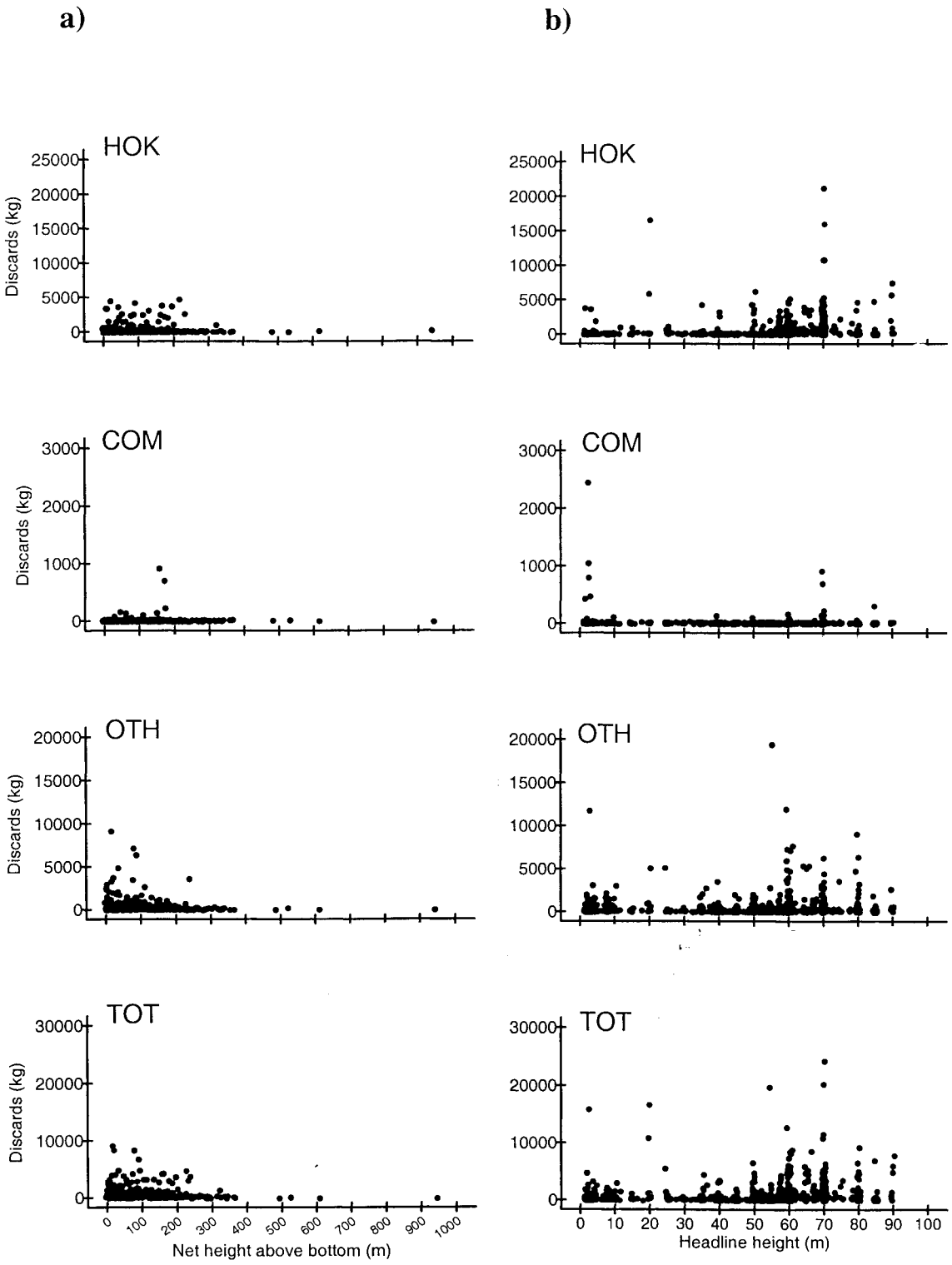

Figure 22: **Discarded catch for HOK, COM, OTH, and TOT categories against net height above the bottom (a) and headline height (b).**

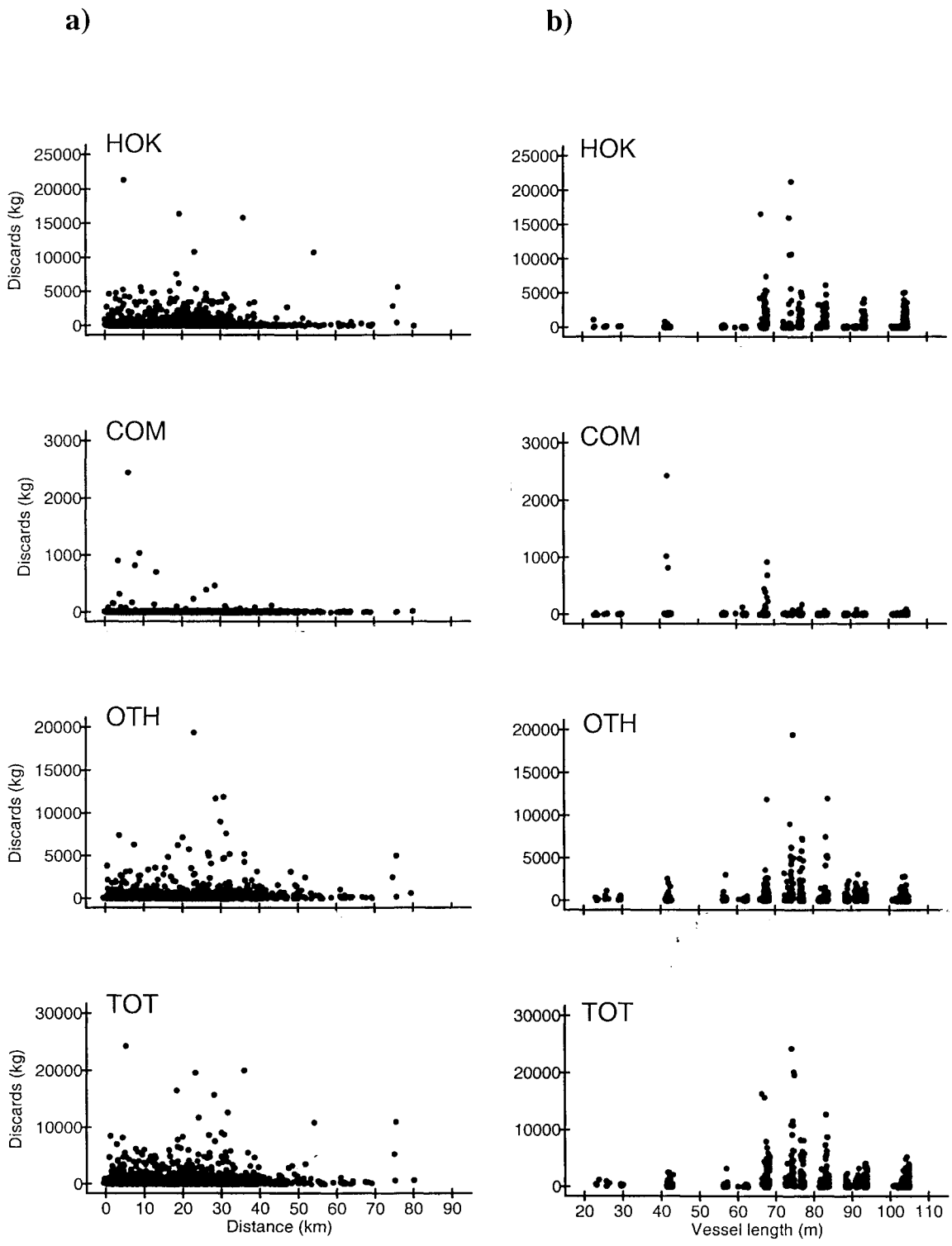

Figure 23: **Discarded catch for HOK, COM, OTH, and TOT categories against tow distance (a) and vessel length (b).**

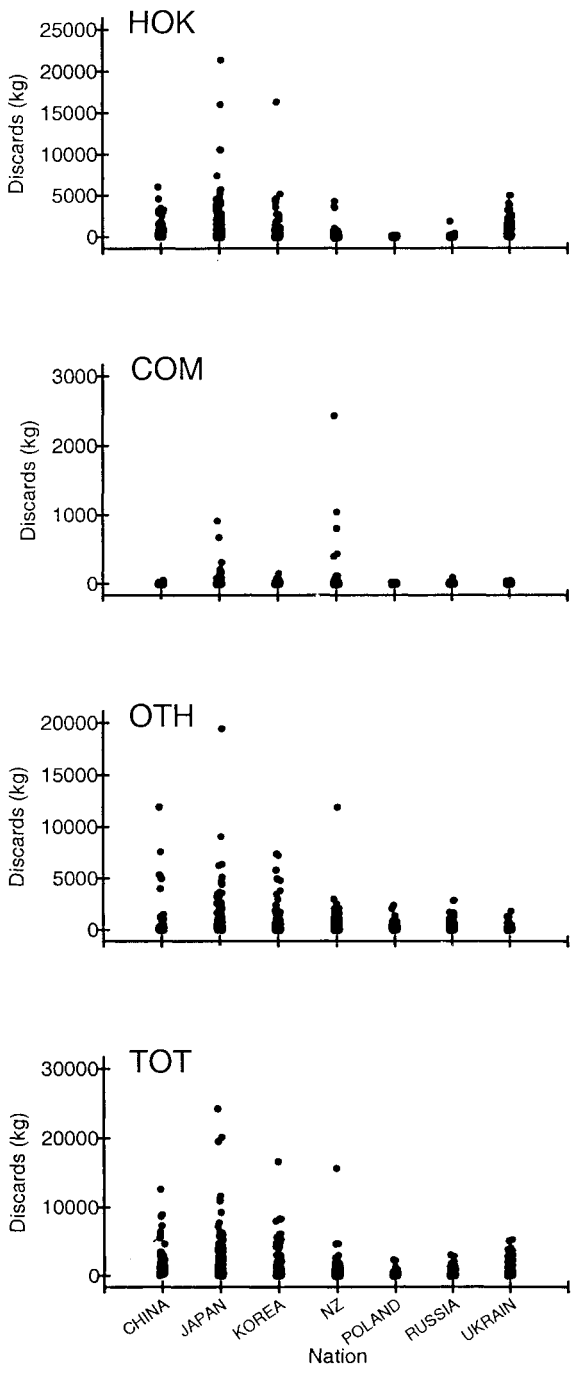

Figure 24: **Discarded catch for HOK, COM, OTH, and TOT categories against vessel nationality.**

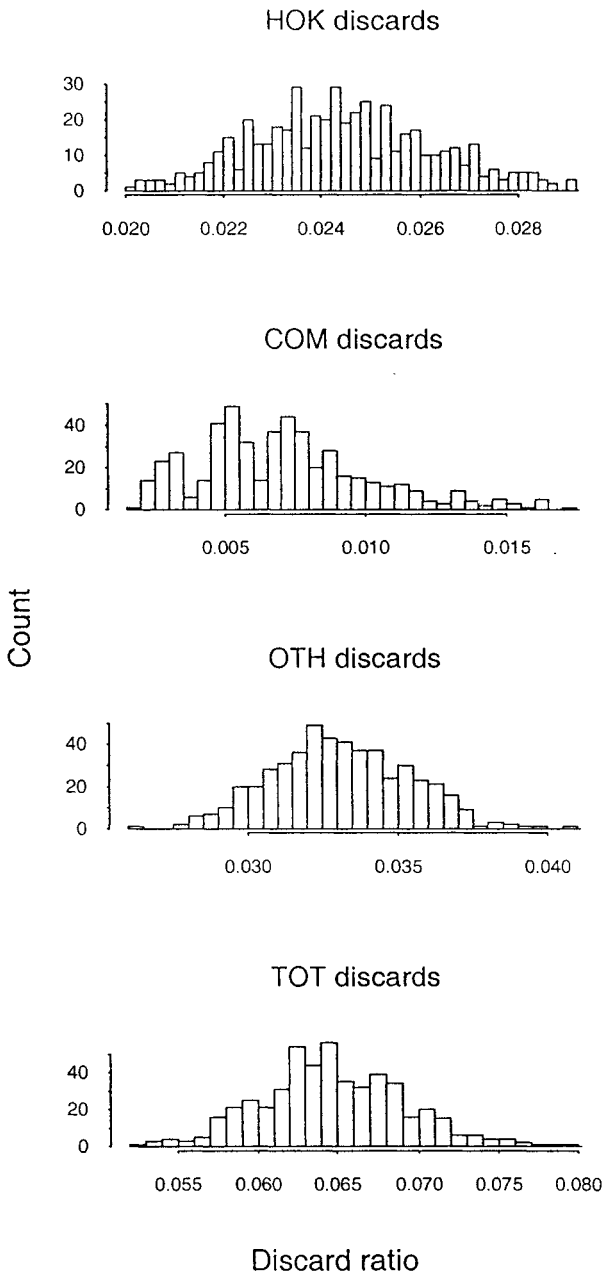

Figure 25: **Distribution of discard ratios derived from bootstrap analysis for the hoki fishery.**

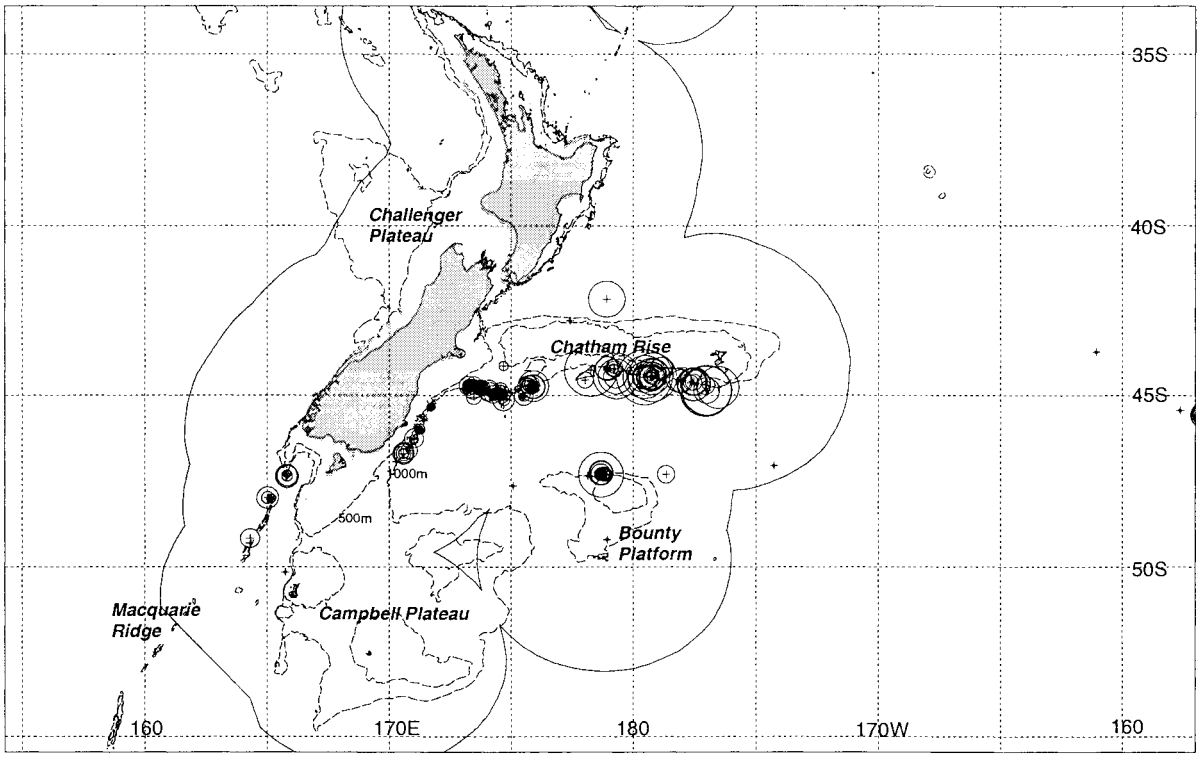

Figure 26: **Distribution of tows and catch recorded by scientific observers on vessels fishing for oreos during 1994–95 and 1995–96 fishing years (circle size proportional to catch, maximum circle = 50 t)**

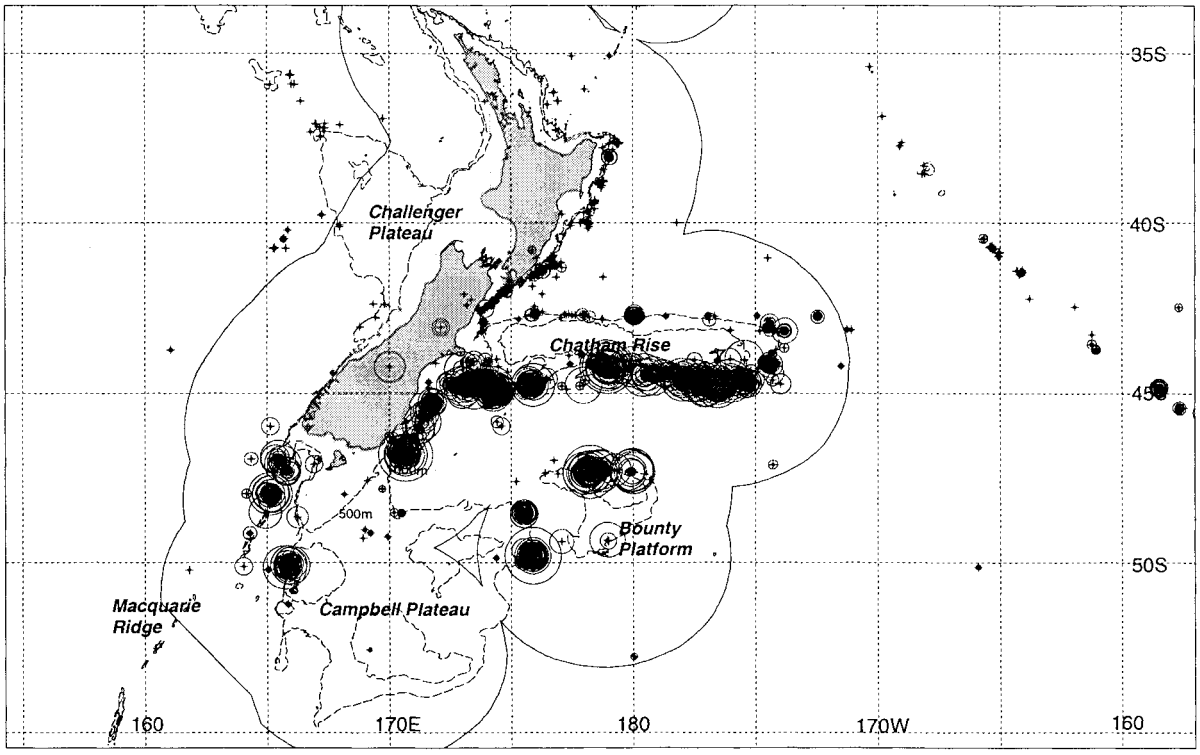

Figure 27: **Distribution of tows and catch of OEO recorded by vessels fishing for oreos during 1994–95 and 1995–96 fishing years (TCEPR data, circle size as above)**

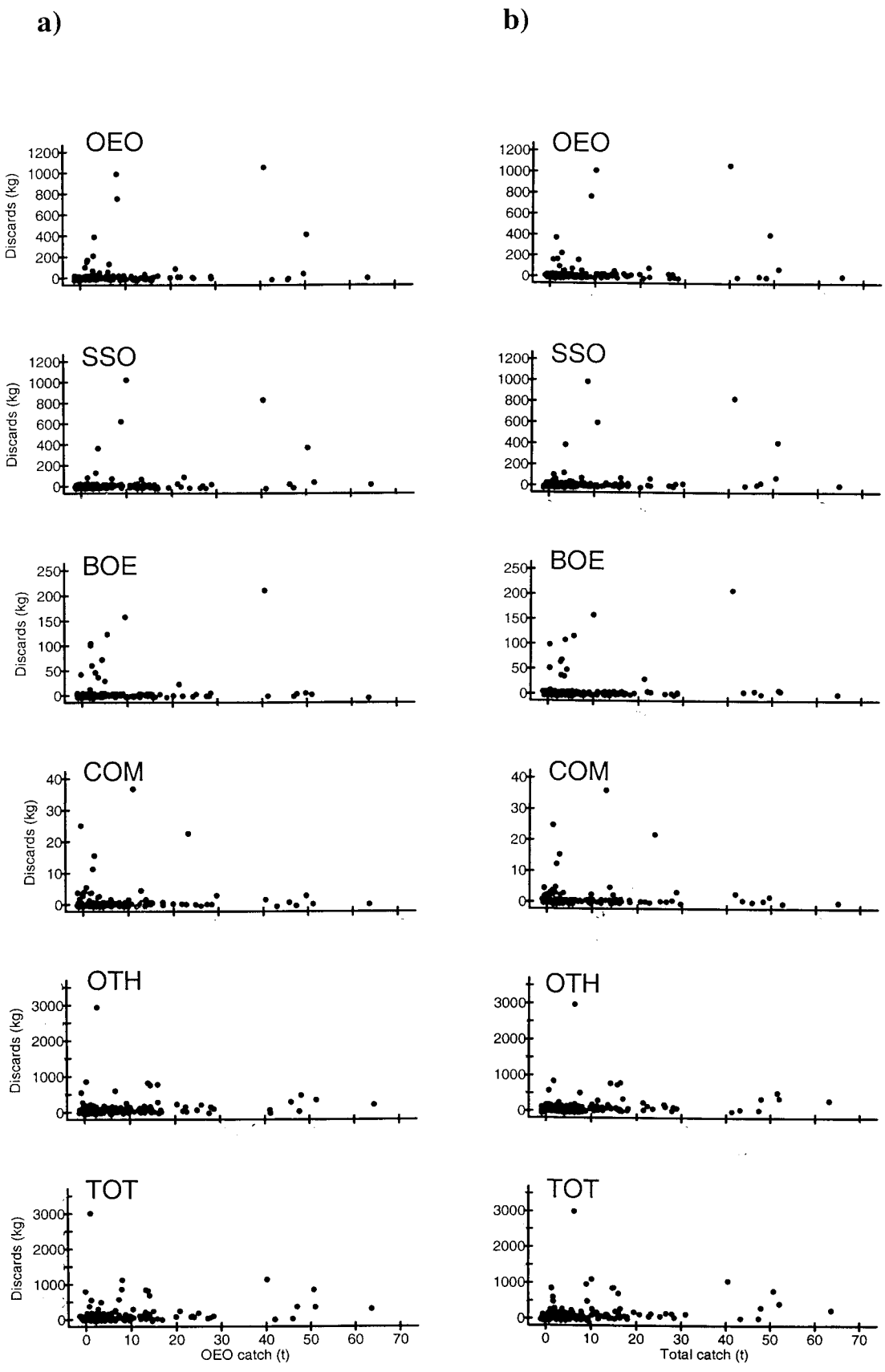

Figure 28: **Discarded catch for OEO, COM, OTH, and TOT categories against OEO catch (a) and total catch (b).**

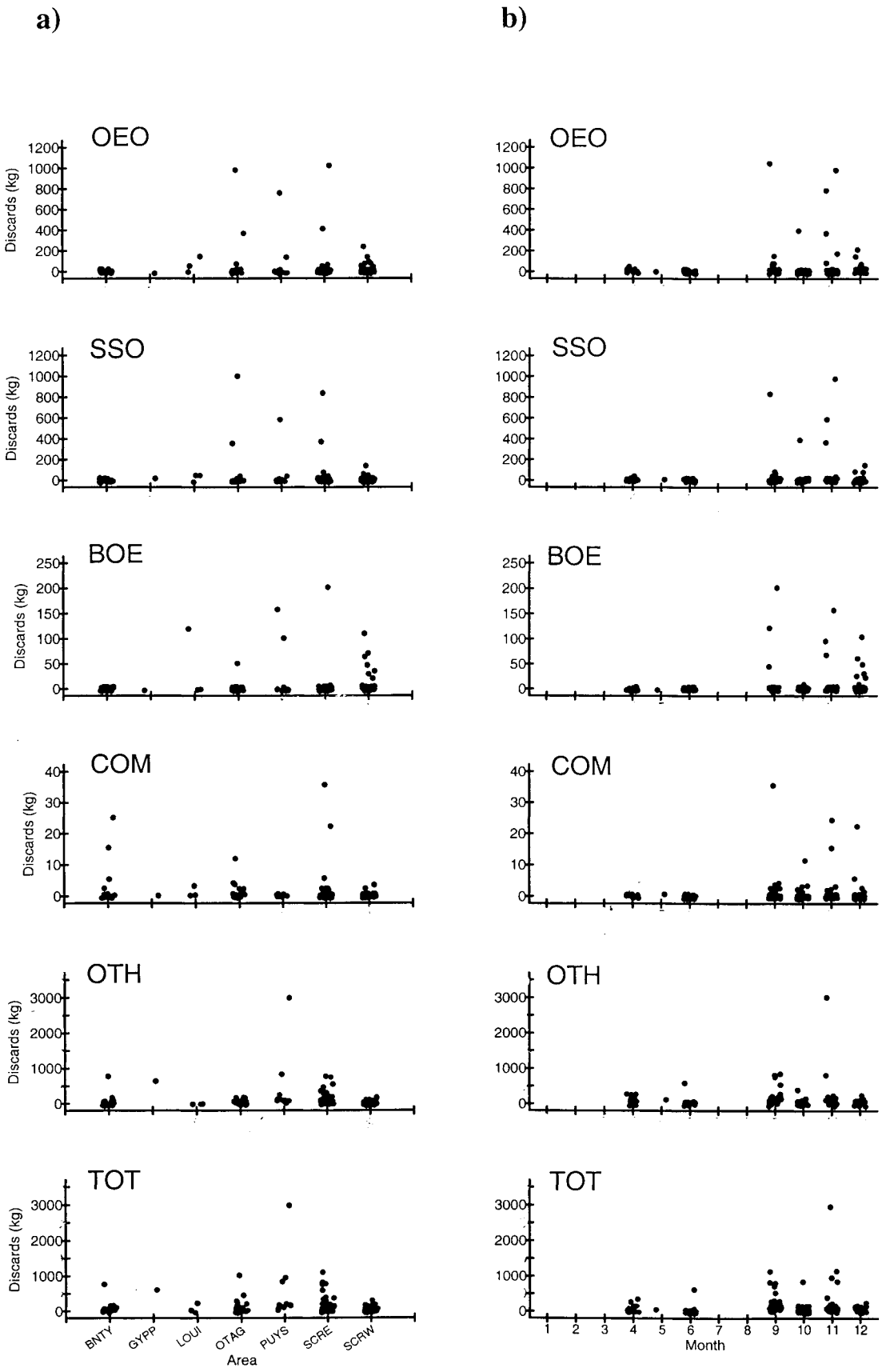

Figure 29: **Discarded catch for OEO, COM, OTH, and TOT categories by area (a), and month of the year (b).**

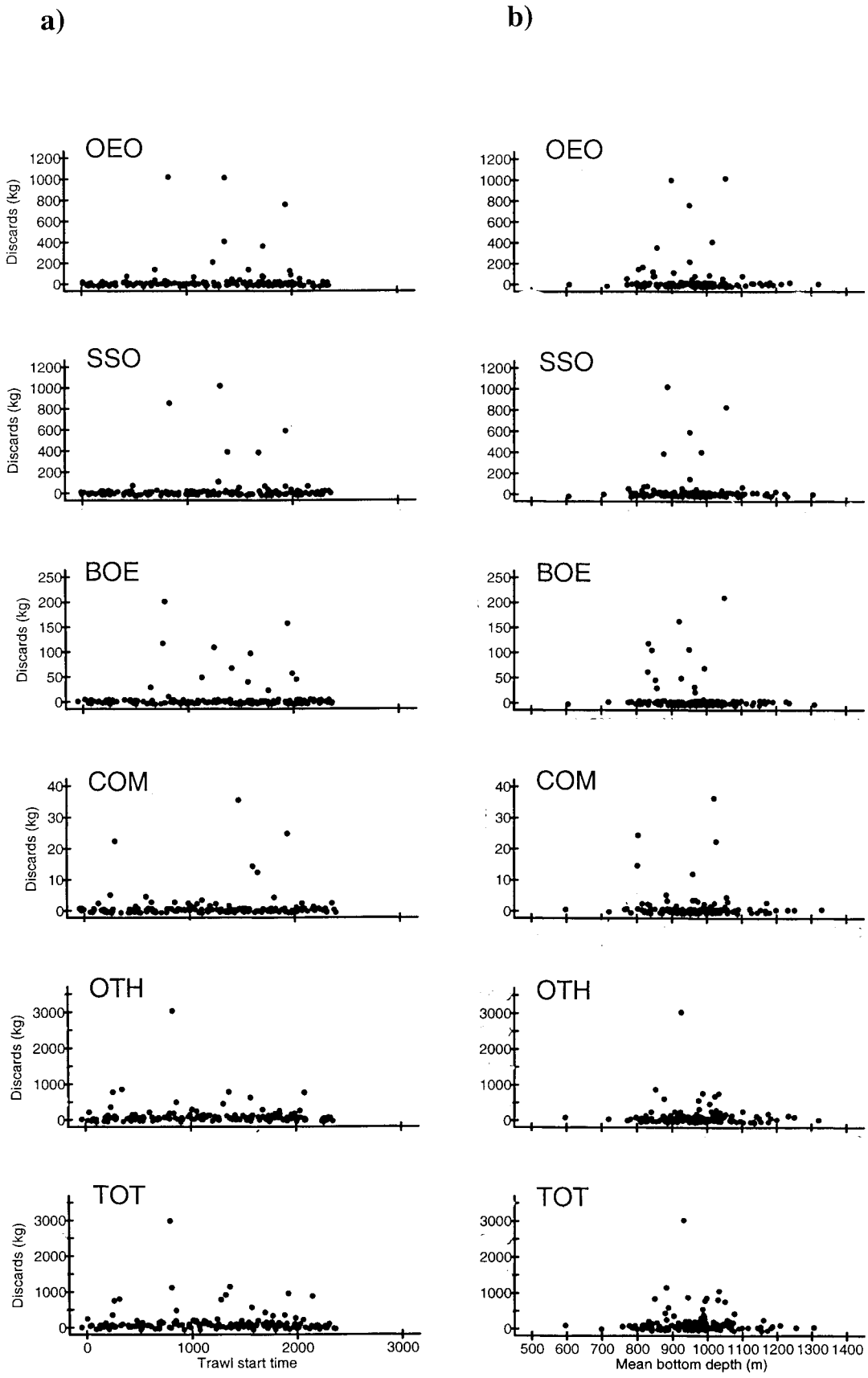

Figure 30: **Discarded catch for OEO, COM, OTH, and TOT categories against time of day (a) and net depth (b).**

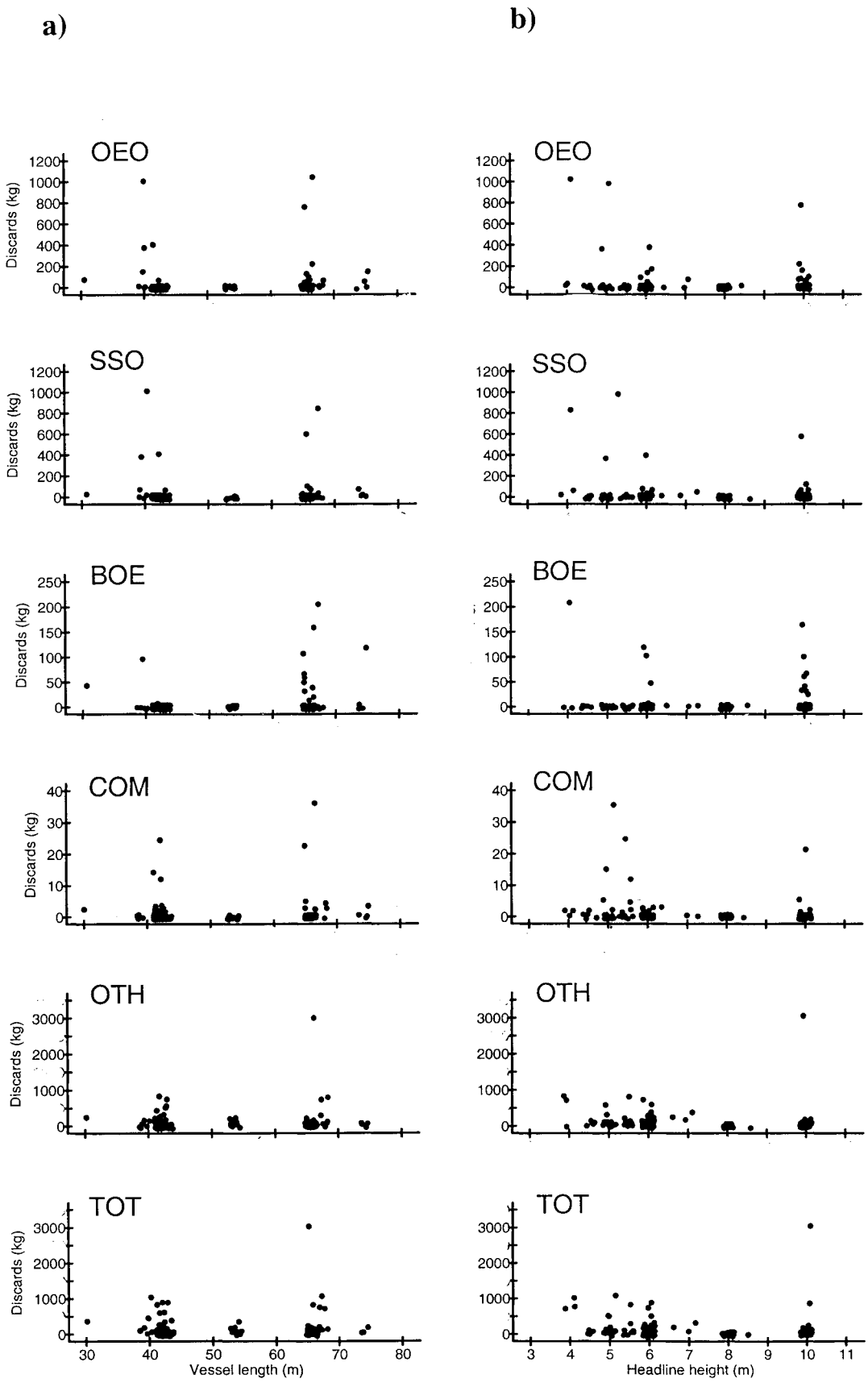

Figure 31: **Discarded catch for OEO, COM, OTH, and TOT categories against vessel length (a) and headline height (b).**

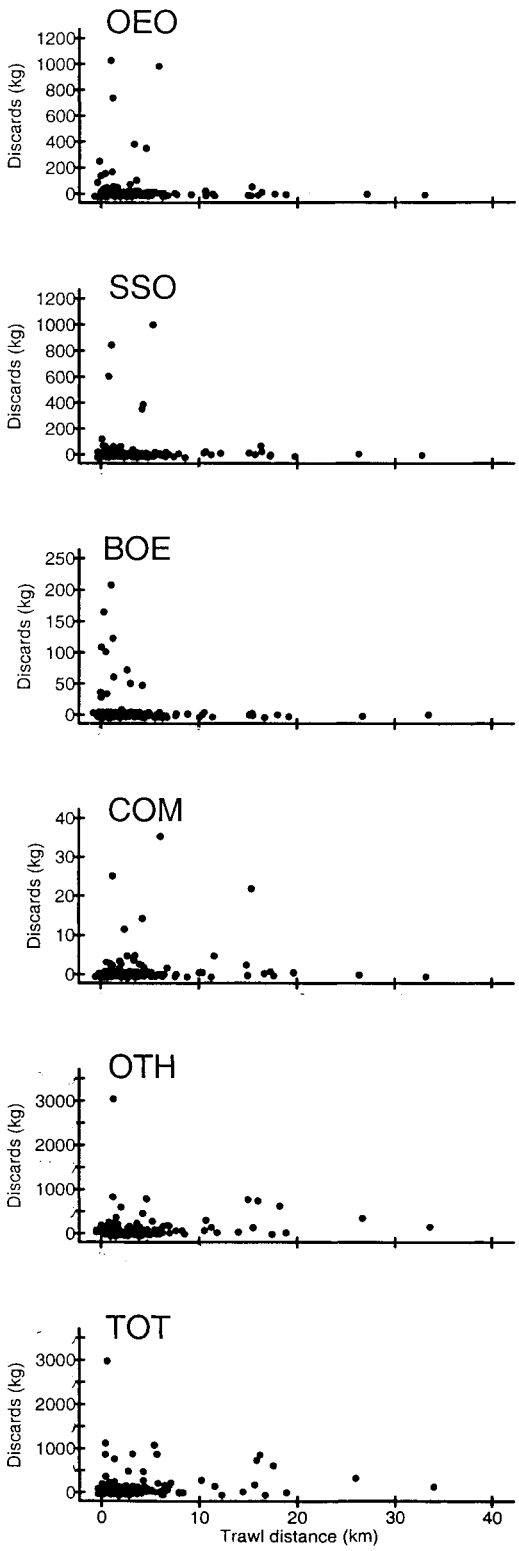

Figure 32: **Discarded catch for OEO, COM, OTH, and TOT categories against tow distance.**

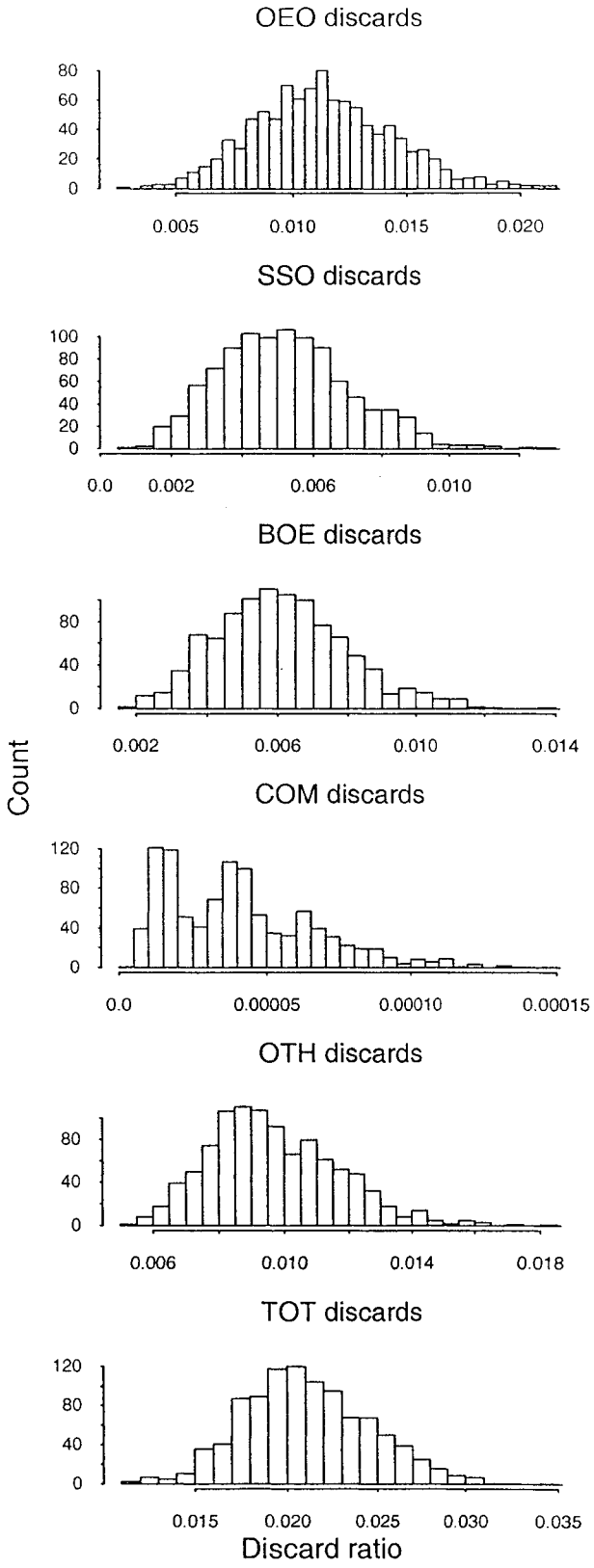

Figure 33: **Distribution of discard ratios derived from bootstrap analysis for the oreo fishery.**

Appendix 1: **Summary of the distribution of trawls sampled by observers from the southern blue whiting, orange roughy, hoki, and oreo fisheries during 1994–95 and 1995–96 (*see* p. 8 for area code definitions)**

Southern blue whiting

Month	AUCK	BNTY	CAMP	PUKA	Total
Aug	0	107	0	1	108
Sep	15	15	211	28	269
Oct	5	0	0	2	7
Total	20	122	211	31	384

Orange roughy

Month	ECNI	BNTY	CHAL	NCHAT	NWCHAL	BOP	OTHER	SCHAT	Total
Jan	0	0	0	65	0	24	115	0	204
Feb	0	0	0	0	0	15	0	0	15
Mar	15	0	0	3	0	19	233	0	270
Apr	0	0	0	64	0	23	30	51	168
May	15	0	0	108	0	23	56	35	237
Jun	131	4	0	54	55	29	48	20	341
Jul	39	0	141	23	2	15	156	10	386
Aug	4	0	0	22	0	1	53	0	80
Sep	0	0	23	66	17	0	81	178	365
Oct	0	11	0	167	0	12	6	149	345
Nov	0	0	0	3	0	11	39	65	118
Dec	0	0	0	7	0	0	0	14	21
Total	204	15	164	582	74	172	817	522	2 550

Hoki

Month	BOP	CHAT	COOK	OTHER	PUYS	SUBA	WCSI	Total
Jan	0	67	0	0	0	132	0	199
Feb	4	76	0	0	0	40	0	120
Mar	0	1	0	0	0	0	0	1
Apr	0	178	0	0	0	6	0	184
May	0	261	0	0	0	177	0	438
Jun	0	104	0	0	0	7	21	132
Jul	1	61	13	0	0	0	645	720
Aug	0	9	28	1	0	0	824	862
Sep	0	215	0	1	85	51	381	733
Oct	0	198	0	0	0	33	0	231
Dec	0	77	0	0	0	0	0	77
Total	5	1 247	41	2	85	446	1 871	3 697

Appendix 1 (cont.)

Oreo

Month	BNTY	NWCHAT	LOUI	OTAGO	PUYS	SCRE	SCRW	Total
Apr	0	0	0	1	0	6	8	15
May	0	0	0	0	0	1	0	1
Jun	19	1	0	0	0	4	14	38
Jul	0	1	0	0	0	2	22	25
Sep	0	0	43	11	3	15	60	132
Oct	3	0	0	10	0	20	7	40
Nov	7	0	0	6	13	5	14	45
Dec	4	0	0	1	0	9	22	36
Total	33	2	43	29	16	62	147	332

Appendix 2: **List of species codes, and summary information on processed and discarded weights (kg) by individual species for the southern blue whiting fishery (codes in bold are those species combined in the COM category, *see* Appendix 6 for species names)**

Species	Greenweight	Discard	Proportion kept
AGR	7	7	0.000
API	72	72	0.000
BBE	224	224	0.000
CAR	7	7	0.000
DSP	720	720	0.000
FUR	805	665	0.174
GSH	1 526	165	0.892
GSP	6	6	0.000
HAK	22 944	82	0.996
HOK	12 178	218	0.982
JAV	17	16	0.059
LCH	20	20	0.000
LDO	7	7	0.000
LIN	32 439	1 058	0.967
MIX	2 770	2 734	0.013
MOO	864	747	0.135
NOS	11	11	0.000
OSD	51	51	0.000
POS	3 035	2 845	0.063
RAT	186	186	0.000
RBM	226	209	0.075
RCO	35	9	0.743
RSQ	18	8	0.556
SBW	22 958 784	191 726	0.992
SCI	13	0	1.000
SKA	15	15	0.000
SPD	57	57	0.000
SQU	111	15	0.865
SSI	1 374	596	0.566
SSK	8	5	0.375
STA	112	0	1.000
STU	24	13	0.458
SWA	10	0	1.000
TOA	15	15	0.000
UNI	12	12	0.000
WIT	2	0	1.000
WSQ	97	20	0.794
WWA	68	0	1.000

Appendix 3: **List of species codes, and information on processed and discarded weights (kg) by species for the orange roughy fishery (codes in bold are those species combined in the COM category, *see* Appendix 6 for species names)**

Species	Greenweight	Discard	Proportion kept
ANO	1	1	0.000
APR	437	437	0.000
ASQ	24	24	0.000
BAT	1	1	0.000
BBE	4	4	0.000
BCR	1	1	0.000
BEE	13 257	13 257	0.000
BNS	209	0	1.000
BOE	390 292	8 070	0.979
BSH	23 537	20 787	0.117
BSL	22	22	0.000
BYS	7 081	0	1.000
BYX	9 756	150	0.985
CAN	11	11	0.000
CAR	20	20	0.000
CBO	75	75	0.000
CDL	184 073	802	0.996
CEN	145	145	0.000
CHG	80	80	0.000
CHI	80	80	0.000
CHP	87	87	0.000
CHX	1	1	0.000
COD	18	18	0.000
COU	200	200	0.000
CPD	3	3	0.000
CRB	17	16	0.059
CSH	3	3	0.000
CSQ	3 516	3 516	0.000
CYO	8	8	0.000
CYP	730	730	0.000
DEA	37	37	0.000
DSD	440	440	0.000
DSK	4	4	0.000
DWD	55 328	55 072	0.005
DWE	75	75	0.000
ECH	12	12	0.000
EEL	19	19	0.000
EPL	3 125	3 125	0.000
EPT	9	9	0.000
ERA	6	6	0.000
ETB	6 864	6 864	0.000
ETL	46	46	0.000
ETM	13 884	13 884	0.000
ETP	52	52	0.000
FAN	1	1	0.000
GAD	30	0	1.000
GSH	1 336	901	0.326
GSP	66	66	0.000

Appendix 3 (cont.)

Species	Greenweight	Discard	Proportion kept
GSQ	53	53	0.000
GUL	6	6	0.000
HAK	1 706	85	0.950
HAL	3	3	0.000
HCO	16	16	0.000
HJO	1 972	1 972	0.000
HOK	38 427	643	0.983
HPB	20	0	1.000
HYD	11	11	0.000
JAV	3 070	2 670	0.130
LAN	2	2	0.000
LCH	911	911	0.000
LDO	12	2	0.833
LEG	23	23	0.000
LFC	18	12	0.333
LIN	146	0	1.000
MDO	500	0	1.000
MIC	12	12	0.000
MIQ	845	845	0.000
MIX	13 519	12 948	0.042
MOD	1 974	1 959	0.008
MRQ	3	3	0.000
MUR	260	260	0.000
NEX	50	50	0.000
NOG	2	1	0.500
NOS	2	2	0.000
OCT	17	17	0.000
OEO	86	0	1.000
OFH	275	35	0.873
ORH	7 103 249	3 531	1.000
OSD	4 019	4 019	0.000
PDG	12	12	0.000
PJS	8	8	0.000
PLS	1 346	1 346	0.000
PSK	5	5	0.000
PSY	2	2	0.000
RAG	15	15	0.000
RAT	12 903	12 809	0.007
RBM	43	38	0.116
RBY	7	2	0.714
RCH	36	36	0.000
RHY	4	4	0.000
RIB	12 914	4 637	0.641
RSC	1	1	0.000
RSK	9	9	0.000
RSN	2	0	1.000
RSQ	9	9	0.000
RUB	1	0	1.000
RUD	71	71	0.000
SBI	153	153	0.000
SBK	2	2	0.000

Appendix 3 (cont.)

Species	Greenweight	Discard	Proportion kept
SBO	2	2	0.000
SBR	303	303	0.000
SCH	38	0	1.000
SCM	145	145	0.000
SDE	6	6	0.000
SHA	20	20	0.000
SKA	79	79	0.000
SKI	2	2	0.000
SLK	6 982	6 981	0.000
SMC	262	262	0.000
SND	3 373	3 373	0.000
SNE	1	1	0.000
SNR	321	321	0.000
SOM	25	25	0.000
SOP	1 500	1 500	0.000
SOR	23 450	4 407	0.812
SPE	437	34	0.922
SQU	116	97	0.164
SQX	62	62	0.000
SRH	2	2	0.000
SSH	4	4	0.000
SSI	25	25	0.000
SSK	385	375	0.026
SSO	2 241 068	9 451	0.996
STA	10	0	1.000
SWA	38	0	1.000
TET	1	1	0.000
TOA	52	52	0.000
TOP	4	4	0.000
TRS	75	75	0.000
TUB	2	2	0.000
UNI	13	13	0.000
VCO	444	444	0.000
VSQ	10	10	0.000
WHR	195	195	0.000
WHT	5	5	0.000
WOE	799	41	0.949
WSE	6	6	0.000
WSQ	1 411	1 411	0.000
WWA	22	0	1.000

Appendix 4: **List of species codes, and information on processed and discarded weights (kg) by species for the hoki fishery (codes in bold are those species combined in the COM category, *see* Appendix 6 for species names).**

Species	Greenweight	Discard	Proportion kept
AGR	134	134	0.000
ARC	50	50	0.000
BAR	154 589	3 588	0.977
BAS	30	5	0.833
BBE	3 680	3 425	0.069
BCA	42	6	0.857
BCO	257	0	1.000
BCR	325	325	0.000
BEE	79	72	0.089
BEL	132	57	0.568
BEN	4 322	4 322	0.000
BER	20	20	0.000
BNS	32 486	388	0.988
BOE	23 297	34	0.999
BOR	1	1	0.000
BPE	1	1	0.000
BRC	7	5	0.286
BSH	1 455	1 282	0.119
BSK	5 950	5 950	0.000
BSP	156	44	0.718
BSQ	15	0	1.000
BTH	1	1	0.000
BWS	396	346	0.126
BYS	421	53	0.874
BYX	9 245	2 746	0.703
CAR	1	0	1.000
CBE	3	3	0.000
CDL	101	39	0.614
CDO	26	7	0.731
CHI	276	58	0.790
CON	696	598	0.141
CRA	1	0	1.000
CRB	68	15	0.779
CSQ	1 342	1 269	0.054
CST	4	0	1.000
CYO	290	290	0.000
CYP	228	228	0.000
DCS	29	29	0.000
DEA	7 730	3 902	0.495
DOG	6	6	0.000
DSK	5	5	0.000
DWD	24 901	24 901	0.000
EEL	250	154	0.384
ELE	23	21	0.087
EMA	1 778	16	0.991
ERA	359	353	0.017
ETL	1 435	1 431	0.003
ETM	16 353	12 791	0.218

Appendix 4 (cont.)

Species	Greenweight	Discard	Proportion kept
FHD	1 356	1 069	0.212
FLA	144	69	0.521
FLO	38	11	0.711
FRO	253 511	145 860	0.425
FRS	5	5	0.000
FUR	3 389	1 349	0.602
GSC	313	5	0.984
GSH	90 279	5 177	0.943
GSP	1 351	3	0.998
GSQ	1 006	1 006	0.000
GUR	32	23	0.281
HAG	2	2	0.000
HAK	2 579 001	21 294	0.992
HAP	460	30	0.935
HCO	180	60	0.667
HEX	45	45	0.000
HJO	3	0	1.000
HOK	54 483 912	1 154 443	0.979
HPB	2 021	45	0.978
JAV	224 515	97 698	0.565
JDO	2	0	1.000
JFI	10	10	0.000
JGU	2	0	1.000
JMA	721 736	205 482	0.715
JMD	5 482	0	1.000
JMM	43 736	0	1.000
LAN	200	200	0.000
LCA	24	4	0.833
LCH	5 052	2 575	0.490
LDO	33 819	2 159	0.936
LHA	6	0	1.000
LIN	977 896	935	0.999
LSK	2	0	1.000
LSO	38	3	0.921
MAK	2 436	2 436	0.000
MAN	7	7	0.000
MDO	244	1	0.996
MIX	191 969	172 273	0.103
MOD	25	25	0.000
MOK	18	0	1.000
MON	49	0	1.000
MOO	1 674	1 154	0.311
NOG	22	3	0.864
NOS	496	42	0.915
OAR	64	26	0.594
OCT	179	117	0.346
OEO	3 863	0	1.000
OPE	16	0	1.000
ORH	13 451	1	1.000
OSD	2 215	2 060	0.070
PDG	80	78	0.025

Appendix 4 (cont.)

Species	Greenweight	Discard	Proportion kept
PHO	1	0	1.000
PIG	9	8	0.111
PLS	174	174	0.000
POP	6	0	1.000
POR	410	410	0.000
POS	15 587	14 187	0.090
RAG	725	612	0.156
RAT	308 698	198 548	0.357
RBM	40 669	9 644	0.763
RBT	3 178	1 228	0.614
RBY	351	34	0.903
RCH	2	2	0.000
RCO	56 383	1 397	0.975
RDO	2	2	0.000
RHY	145	112	0.228
RIB	36 168	1 682	0.953
RMU	220	220	0.000
RSK	186	110	0.409
RSQ	171	43	0.749
RUB	124	124	0.000
RUD	14 012	5 136	0.633
SBK	196	62	0.684
SBO	15	10	0.333
SBR	3	0	1.000
SBW	3 366	57	0.805
SCH	2 087	1 214	0.418
SCI	2 708	1 625	0.400
SCM	297	297	0.000
SCO	144	141	0.021
SDE	2	1	0.500
SDO	128	13	0.898
SEE	3	0	1.000
SHA	1 227	647	0.473
SKA	6 553	6 294	0.040
SKI	8 115	347	0.957
SLK	6	0	1.000
SND	9 611	8 684	0.096
SNE	45	7	0.844
SOL	10	10	0.000
SOR	2 852	69	0.976
SPD	543 951	489 286	0.100
SPE	50 429	1 213	0.976
SPF	10	10	0.000
SPI	60	50	0.167
SPZ	26	18	0.308
SQU	31 240	3 330	0.893
SRH	42	38	0.095
SSC	12	12	0.000
SSH	110	110	0.000
SSI	2 797	1 050	0.625
SSK	10 899	4 684	0.570

Appendix 4 (cont.)

Species	Greenweight	Discard	Proportion kept
SSO	52 578	2	1.000
STA	30 346	261	0.991
STG	1	0	1.000
STN	482	8	0.983
STU	511	307	0.399
SUN	110	110	0.000
SWA	887 365	1 760	0.998
SWO	510	120	0.765
TAR	1 591	107	0.933
TET	2	0	1.000
THR	4 077	3 897	0.044
TOA	235	191	0.187
TOD	5	0	1.000
TRA	7	0	1.000
UNI	3	0	1.000
WAR	44 474	63	0.999
WIT	38	2	0.947
WSQ	11 520	11 094	0.037
WWA	60 383	113	0.998
XBM	4	0	1.000
XSH	15	0	1.000
YBO	25	2	0.920
YFN	45	0	1.000

Appendix 5: **List of species codes, and information on processed and discarded weights (kg) by individual species for the oreo fishery (codes in bold are those species combined in the COM category, *see* Appendix 6 for species names)**

Species	Greenweight	Discard	Proportion kept
APR	3	3	0.000
BEE	598	598	0.000
BNS	30	0	1.000
BOE	446 392	5 800	0.987
BSH	1 207	1 207	0.000
BTH	10	10	0.000
CHI	35	35	0.000
CHP	13	13	0.000
CHX	3	3	0.000
CSQ	1 802	1 802	0.000
DSK	15	15	0.000
DWD	4 227	4 227	0.000
ECH	4	4	0.000
ELE	3	3	0.000
EPL	150	150	0.000
ETB	4 376	4 376	0.000
ETM	335	335	0.000
GSH	161	161	0.000
GSP	37	37	0.000
HAK	144	3	0.979
HJO	141	141	0.000
HOK	10 529	19	0.998
JAV	30	30	0.000
LAN	2	2	0.000
LCH	98	98	0.000
LFC	30	30	0.000
MIQ	33	33	0.000
MIX	652	652	0.000
MOD	1 520	1 510	0.007
ORH	78 305	0	1.000
OSD	4	4	0.000
RAT	1 776	1 776	0.000
RIB	421	0	1.000
RUD	16	16	0.000
SBK	2	2	0.000
SBR	56	56	0.000
SKA	24	19	0.208
SLK	457	457	0.000
SND	12	12	0.000
SQU	10	10	0.000
SQX	53	53	0.000
SSI	4 667	0	1.000
SSO	1 444 047	3 957	0.997
STA	14	16	0.000
SYN	18	18	0.000
TOA	5	5	0.000
WSQ	131	131	0.000

Appendix 6: **Species codes and scientific/ common names of species identified by observers.**

Code	Scientific/ common name
AGR	*Agrostichthys parkeri*
ANO	*Anoplogaster cornuta*
API	*Alertichthys blacki*
APR	*Apristurus* spp.
ASQ	*Nototodarus sloanii* & *N. gouldi*
BAR	*Thyrsites atun*
BAS	*Polyprion americanus*
BAT	*Rouleina* sp.
BBE	*Centriscops humerosus*
BCA	*Magnisudis prionosa*
BCO	*Parapercis colias*
BCR	*Brotulotaenia crassa*
BEE	*Diastobranchus capensis*
BEL	*Centriscops* spp.
BEN	*Benthodesmus* spp.
BER	*Typhlonarke* spp.
BNS	*Hyperoglyphe antarctica*
BOE	*Allocyttus niger*
BPE	*Caesioperca lepidoptera*
BRC	*Pseudophycis breviuscula*
BSH	*Dalatias licha*
BSK	*Cetorhinus maximus*
BSL	*Xenodermichthys* spp.
BSP	*Taratichthys longipinnis*
BSQ	*Sepioteuthis australis*
BTH	*Bathyraja* sp.
BWS	*Prionace glauca*
BYS	*Beryx splendens*
BYX	*Beryx splendens* & *B. decadactylus*
CAN	*Cataetyx niki*
CAR	*Cephaloscyllium isabellum*
CBE	*Notopogon lilliei*
CBO	*Caelorinchus bollonsi*
CDL	Apogonidae
CDO	*Capromimus abbreviatus*
CEN	Squalidae
CHG	*Chimaera phantasma*
CHI	*Chimaera* spp.
CHP	*Chimaera* sp.
CHX	*Chaunax pictus*
COD	Cod
CON	*Conger* spp.
COU	Coral (unspecified)
CPD	Centrolophidae
CRA	*Jasus edwardsii*
CRB	Crab
CSH	Catshark
CSQ	*Centrophorus squamosus*
CST	*Caristius* sp.
CYO	*Centroscymnus owstoni*
CYP	*Centroscymnus crepidater*

Appendix 6 (cont.)

DCS *Halaelurus dawsoni*
DEA *Trachipterus trachypterus*
DOG Dogfish
DSK *Raja (Amblyraja)* sp.
DSP *Congiopodus coriaceus*
DWD Deepwater dogfish
DWE Deepwater eel
ECH Echinodermata
EEL Marine eels
ELE *Callorhinchus milii*
EMA *Scomber australasicus*
EPL *Epigonus lenimen*
EPT *Epigonus telescopus*
ERA *Torpedo fairchildi*
ETB *Etmopterus baxteri*
ETL *Etmopterus lucifer*
ETM *Etmopterus* sp.
ETP *Etmopterus pusillus*
FAN *Pterycombus petersii*
FHD *Hoplichthys haswelli*
FLA Flats
FLO Flounder
FRO *Lepidopus caudatus*
FRS *Chlamydoselachus anguineus*
FUR *Arctocephalus forsteri*
GAD Gadidae
GSC *Jacquinotia edwardsii*
GSH *Hydrolagus novaezealandiae*
GSP *Hydrolagus* sp.
GSQ *Architeuthis* spp.
GUL *Eurypharynx pelecanoides*
GUR *Chelidonichthys kumu*
HAG *Eptatretus cirrhatus*
HAK *Merluccius australis*
HAL *Halosauropsis macrochir*
HAP *Polyprion oxygeneios*
HCO *Bassanago hirsutus*
HEX *Hexanchus griseus*
HJO *Halargyreus johnsonii*
HOK *Macruronus novaezelandiae*
HPB *Polyprion oxygeneios & P. americanus*
HYD *Hydrolagus* sp.
JAV *Lepidorhynchus denticulatus*
JDO *Zeus faber*
JFI Jellyfish
JGU *Pterygotrigla picta*
JMA *Trachurus declivis, T. murphyi., T. novaezelandiae*
JMD *Trachurus declivis*
JMM *Trachurus murphyi*
LAN Myctophidae
LCA *Lophotus capellei*
LCH *Harriotta raleighana*
LDO *Cyttus traversi*
LEG *Lepidion schmidti & L. inosimae*

Appendix 6 (cont.)

LIN	*Genypterus blacodes*
LSK	*Arhynchobatis asperrimus*
LSO	*Pelotretis flavilatus*
MAK	*Isurus oxyrinchus*
MAN	*Neoachiropsetta milfordi*
MDO	*Zenopsis nebulosus*
MIC	*Microstoma microstoma*
MIQ	*Moroteuthis ingens*
MIX	Mixed fish
MOD	Moridae
MOK	*Latridopsis ciliaris*
MOO	*Lampris guttatus*
MRQ	*Moroteuthis robsoni*
MUR	Muraenolepididae
NEX	Nemichthyidae
NOG	*Nototodarus gouldi*
NOS	*Nototodarus sloanii*
OAR	*Regalecus glesne*
OCT	*Octopus cordiformis*
OEO	*Pseudocyttus maculatus, Allocyttus niger, & Neocyttus rhomboidalis*
OFH	*Ruvettus pretiosus*
OPE	*Lepidoperca aurantia*
ORH	*Hoplostethus atlanticus*
OSD	Other sharks and dogfish
PDG	*Oxynotus bruniensis*
PHO	*Photichthys argenteus*
PIG	*Congiopodus leucopaecilus*
PJS	*Heterodontus portusjacksoni*
PLS	*Centroscymnus plunketi*
POP	*Allomycterus jaculiferus*
POR	*Nemadactylus douglasi*
POS	*Lamna nasus*
PSK	*Bathyraja shuntovi*
PSY	*Psychrolutes* sp.
RAG	*Icichthys australis*
RAT	Macrouridae
RBM	*Brama brama*
RBT	*Emmelichthys nitidus*
RBY	*Plagiogeneion rubiginosus*
RCH	*Rhinochimaera pacifica*
RDO	*Cyttopsis roseus*
RHY	*Paratrachichthys trailli*
RIB	*Mora moro*
RMU	*Upeneichthys lineatus*
RSC	*Scorpaena papillosus*
RSK	*Raja nasuta*
RSN	*Centroberyx affinis*
RSQ	*Ommastrephes bartrami*
RUB	Rubbish other than fish
RUD	*Centrolophus niger*
SBI	*Alepocephalus australis*
SBK	*Notacanthus sexspinis*
SBO	*Pseudopentaceros richardsoni*
SBR	*Pseudophycis barbata*

Appendix 6 (cont.)

SBW	*Micromesistius australis*
SCH	*Galeorhinus galeus*
SCI	*Metanephrops challengeri*
SCM	*Scymnodon macracanthus*
SCO	*Bassanago bulbiceps*
SDE	*Cryptopsaras couesi*
SDO	*Cyttus novaezealandiae*
SEE	*Gnathophis habenatus*
SHA	Shark
SKA	Rajidae, Arhynchobatidae
SKI	*Rexea solandri*
SLK	Alepocephalidae
SMC	*Lepidion microcephalus*
SND	*Deania calcea*
SNE	*Simenchelys parasiticus*
SNR	*Deania histricosa*
SOL	Sole
SOM	*Somniosus rostratus*
SOP	*Somniosus pacificus*
SOR	*Neocyttus rhomboidalis*
SPD	*Squalus acanthias*
SPF	*Pseudolabrus miles*
SPI	Spider crab
SPZ	*Genyagnus monopterygius*
SQU	*Nototodarus sloanii & N. gouldi*
SQX	Squid
SRH	*Hoplostethus mediterraneus*
SSC	*Leptomithrax australis*
SSH	*Gollum attenuatus*
SSI	*Argentina elongata*
SSK	*Raja innominata*
SSO	*Pseudocyttus maculatus*
STA	*Kathetostoma giganteum*
STG	Stargazer
STN	*Thunnus maccoyii*
STU	*Allothunnus fallai*
SUN	*Mola mola*
SWA	*Seriolella punctata*
SWO	*Xiphias gladius*
SYN	Synaphobranchidae
TAR	*Nemadactylus macropterus*
TET	*Tetragonurus cuvieri*
THR	*Alopias vulpinus*
TOA	*Neophrynichthys* sp.
TOD	*Neophrynichthys latus*
TOP	*Neophrynichthys angustus*
TRA	Trachichthyidae
TRS	*Trachyscorpia capensis*
TUB	*Tubbia tasmanica*
UNI	Unidentified
VCO	*Antimora rostrata*
VSQ	*Histioteuthis* spp.
WAR	*Seriolella brama*
WHR	*Trachyrincus longirostris*