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Biomass and yield estimates for bluenose in QMA 2 for the 1991–92 fishing year

Michael Ryan
MAF Fisheries
Private Bag
Nelson

and

M. Stocker
New Zealand Fishing Industry Board
Private Bag
Manners Street Post Office
Wellington

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MAF Fisheries, N.Z. Ministry of Agriculture and Fisheries

This series documents the scientific basis for stock assessments and fisheries management advice in New Zealand. It addresses the issues of the day in the current legislative context and in the time frames required. The documents it contains are not intended as definitive statements on the subjects addressed but rather as progress reports on ongoing investigations.

Biomass and yield estimates for bluenose in QMA 2 for the 1991–92 fishing year

Michael Ryan and Max Stocker

1. INTRODUCTION

1.1 Overview

This document uses an age and sex structured model to estimate 1991–92 biomass for bluenose in QMA 2. $F_{0.1}$ and F_{max} are calculated from a yield per recruit analysis. Current Annual Yield (CAY) is calculated as a function of estimated 1991–92 biomass. Some recent catch and effort data is analyzed with earlier catch and effort data.

1.2 Description of the fishery

Almost all bluenose landed from QMA 2 is now caught by single mid-water trawl, essentially as a bycatch of targeting for alfonsino (the longline fishery for bluenose accounted for an estimated 40 t in 1989). Further detail on the bluenose fisheries in QMA 2 is contained in the documents referred to in the literature review.

1.3 Literature review

Information published before 1988 was summarised in FARD 88/9 (Horn 1988a). Results from a study of bluenose on the alfonsino grounds between East Cape and Cape Palliser were presented in Horn (1988b) and in Horn and Massey (1989).

2. REVIEW OF THE FISHERY

2.1 TACs, catch, landings, and effort data

2.1.1 TACs and landings

Table 1a shows the reported landings of bluenose in all QMAs. The percentage of all bluenose landings accounted for by landings in QMA 2 has varied between 34% and 67% and for the most recent fishing years has been around 50%.

Landings and TACs in QMA 2 since the introduction of the Quota Management System are detailed in Table 1b. The 1986–87 total landings of 953 t corresponded to the largest recorded landings of bluenose from QMA 2 in the history of the alfonsino/bluenose trawl fishery. Landings then decreased in 1987–88 but have since increased steadily, roughly tracking the actual TAC for each preceding fishing year.

In 1986–87 bluenose formed the highest proportion (compared to other years of the fishery) of the sum of the trawl catches of alfonsino and bluenose (Table 1c).

Table 1a. Reported domestic landings (t) from 1981 to 1989–90 and QMA 2 landings as a % of total landings.

Year	QMA 1&9	QMA 2	QMA 3–6	QMA 7	QMA 8	QMA 10	Area unknown	Total	QMA 2 %
1981	146	101	36	12	–	0	–	295	34%
1982	246	170	46	22	–	0	–	484	35%
1983	250	352	51	47	1	0	25	726	48%
1984	464	810	81	30	1	0	25	1411	57%
1985	432	745	73	26	1	0	49	1326	56%
1986	440	1009	33	53	1	0	30	1566	64%
1986–87	286	953	93	71	1	7	0	1411	67%
1987–88	405	653	101	104	1	11	0	1275	51%
1988–89	480	692	90	135	13	10	0	1420	49%
1989–90	528	765	130	91	3	0	0	1518	50%

1981–82 (MAF data) and 1983–86 (FSU data) – calendar years
1986–87 to 1989–90 (QMS data) – 1 October to 30 September fishing years

Table 1b. Reported domestic landings and TACs in QMA 2

Fishing year	Landings (t)	Actual TAC (t) at end of year	Actual TAC (t) versus gazetted TAC of 660 t
1986–87	953	660	100%
1987–88	653	661	100%
1988–89	692	768	116%
1989–90	765	833	126%

Table 1c. Alfonsino and bluenose landings (t) in QMA 2

Landings	Fishing year 83–84	84–85	85–86	86–87	87–88	88–89	89–90
Alfonsino	1533	1785	1454	1387	1252	1588	1488
Bluenose	520	635	742	953	653	692	765
Both	2053	2420	2196	2340	1905	2280	2253
% bluenose	25%	26%	34%	41%	34%	30%	34%

1983–84 to 1985–86 : FSU data, domestic trawl.
1986–87 to 1989–90 : QMS data, all methods.

2.1.2 Landings and effort data

Catch and effort data have been used to monitor the QMA 2 alfonsino/bluenose trawl fishery (Horn, 1988; Horn and Massey 1989). Methods and assumptions are found in these documents. The unit of fishing effort for the trawl fishery is a 24 hour day spent targetting alfonsino, for one trawler.

An investigation is under way to determine whether industry changes in targetting and handling practices are likely to have affected the cpue measure used to monitor the abundances of alfonsino and bluenose in the trawl fishery. In lieu of results from this study, the current available cpue data are used in this document. It could be useful to standardize the cpue measure across vessels, but this has not been examined.

The earlier data was summarised by calendar year but has now been converted to fishing year and included with more recent data in Table 2. Most of the data for Table 2 has been extracted by hand from the appropriate MAF Fisheries data forms supplied by fishers. Hand extraction enables a close scrutiny of the raw data. The data in Table 2 may not account for all recorded mid-water trawl landings of bluenose from QMA 2. There are three reasons for this:

(1) catches occur outside the grounds listed;
(2) access was not always available to all data forms;
(3) raw data that could not be interpreted consistently has been excluded.

An indication of the 'coverage' of the yearly data in Table 2 is provided by the final column of the table (the 'coverage' thus measures the combined effect of reasons (1) to (3)).

Mid-water trawl data only appears in Table 2. Bottom trawling was last used on the Palliser ground in 1984–85, and last used on Motukura in 1983–84. The trawl fishery for alfonsino is now solely a mid-water trawl fishery.

Table 2. CPUE (tonnes per vessel day) for mid-water trawl bluenose for the major QMA 2 trawl grounds.

Fishing year		Grounds Palliser	Motukura	Tuaheni	Paoanui	All four	Tonnes counted
83–84	cpue	2.95	4.00			3.03	363
	se	0.39	1.66			0.38	(70%)
	effort	111	9			120	
84–85	cpue	1.60	2.90	3.05	7.65	2.88	409
	se	0.24	0.50	0.73	3.22	0.38	(64%)
	effort	53	45	31	13	142	
85–86	cpue	2.69	1.59	1.90	7.74	2.74	473
	se	0.51	0.33	0.36	3.08	0.39	(64%)
	effort	73	40	43	17	173	
86–87	cpue	1.28	3.50	0.56	7.48	3.34	815
	se	0.22	1.34	0.12	1.26	0.43	(86%)
	effort	112	34	26	72	244	
87–88	cpue	1.30	–	0.43	4.09	1.80	335
	se	0.22	–	0.30	0.50	0.18	(51%)
	effort	107	–	35	44	186	
88–89	cpue	1.75	–	3.07	3.20	2.24	293
	se	0.30	–	1.28	0.73	0.31	(42%)
	effort	85	–	19	27	131	
89–90	cpue	1.62	1.10	1.26	2.79	2.02	461
	se	0.30	0.53	0.48	0.36	0.20	(60%)
	effort	84	17	31	96	228	

Notes
(1) The unit of fishing effort, for one trawler, is a 24 hour day spent targetting alfonsino.
(2) 1983–84 to 1986–87, data extracted by P. Horn.
(3) 1987–88, data from FSU, computer extracted.
(4) 1988–89 and 1989–90, data extracted by R. Blackwell.
(5) The symbol '–' is used to indicate that available data was too limited to be reliable (five or fewer vessel days).
(6) se's (standard errors) were not calculated directly for 1987–88 and were imputed.
(7) The column headed 'Tonnes counted' records the landed tonnes entering into the body of the Table. The bracketed figures are the percentages that "Tonnes counted" are of:
(a) trawl landings for the years 1983–84 to 1986–87;
(b) QMA 2 landings for the years 1987–88 to 1989–90.

The data in Table 2 suggests there has been a decline in the overall cpue across the four grounds. The cpue figures for the four grounds combined are not consistent with the hypothesis of 'no change' (a statistical analysis to support this view is contained in Appendix 1). The change in cpue appears to be a decline from the earlier years of 1983–84 to 1986–87 (inclusive), to the later years of 1987–88 to 1989–90 (inclusive). The pattern of change in cpue varies from ground to ground. Over the history of the mid-water trawl fishery for alfonsino and bluenose, trawlers are likely to have become more efficient. Thus any decline in abundance may be understated by the cpue analysis. The magnitude of this effect is not known for the cpue analysis carried out. It is possible that if the cpue measure was standardized across vessels some of this effect would be removed.

An examination of bluenose longline catch and effort data for the period 1987–90, for fishing return areas 12, 13 and 15, showed some evidence of a decline in cpue (as measured by kg caught per 100 hooks per trip). However, only 127 trips were covered during the years 1987–90 and the usefulness of these data for monitoring changes in the fishery are limited.

3. RESEARCH

3.1 Stock structure

Horn (1988a) notes that it is unknown whether bluenose forms more than one stock in New Zealand.

3.2 Resource surveys

No surveys for measuring the biomass of bluenose in QMA 2 have been successful (Horn and Massey 1989).

3.3 Other studies

As at January 1991, there had been 42 tag returns from bluenose tagged during 1987 on the alfonsino/bluenose fishing grounds in QMA 2 (Figure 3). Of these 42 returns, 26 were returns taken within the first four months of release.Three tag returns indicated movement outside QMA 2 – two to the Bay of Plenty, and one to the Conway Rise, South Island. Thus the limited tag return data available shows some migration of bluenose from QMA 2, while not permiting the extent of this migration to be estimated.

3.4 Biomass estimates

For the purpose of biomass estimation, it is assumed that no bluenose migrate across the QMA 2 boundaries. While this assumption is untrue it is the most workable assumption that can be made on the basis of current knowledge of bluenose migration.

An age and sex structured model (Hilborn et al. 1991) was used to estimate the virgin biomass (B_0), the 1981 biomass (B_{1981}) and current biomass (B_{1990}) for bluenose in QMA 2. The 1981 biomass is taken as a proxy to B_0 since bluenose in QMA 2 were only very lightly exploited from 1944 to 1981. The modelling procedure is very similar to the stock reduction method described by Francis (1990).

The dynamics of the population are described by a standard discrete age and time structured model (Walters 1969). Given a known catch history, some indices of abundance and life history parameters of the fishstock, a deterministic trajectory of stock biomass is estimated. The objective is to search over biological parameters that not only gives the best fit between the model trajectory and the observed indices of abundance, but also gives a posterior distribution of alternative hypotheses about the virgin biomass, the 1981 biomass and current stock size. Two formulations of the catchability coefficient (q) were used (ln q and q) for calculating the posterior distributions of B_0 and B_{1981}.

Reported landings for bluenose in QMA 2 are available only since 1981. Thus two catch histories were used in the analysis: 1) reported landings since 1981, and 2) reported landings since 1981 and assumed landings from 1944 to 1980. Landings were assumed equal to 6 t in 1944 and then to increase linearly to 101 t in 1981 (the first year of accurate data).

The parameter values for growth, survival and recruitment are given in Table 3. Recruitment "steepness" refers to the "a" parameter of the standard Beverton-Holt stock recruitment curve. It is the proportion of mean recruitment at virgin biomass that recruits when spawning biomass is reduced to 20% of virgin biomass.

Table 3. Bluenose life history parameters used in age and sex structured stock reduction analysis.

Parameters	Females	Males
estimate of natural mortality (M)	0.3	0.3
age of recruitment (A_r)	20% @ 2 yr 100% @ 3 yr	20% @ 2 yr 100% @ 3 yr
age of maturity (A_m)	4 yr	4 yr
L_{inf} (cm)	86.1	81.1
k (yr^{-1})	0.308	0.308
t_0 (yr)	–0.384	–0.627

a = 0.0096   b = 3.173
(parameters of the weight-length relationship)

recruitment "steepness" = 0.95

The catch data used in the analysis are given in Appendix 2. The bluenose QMA 2 catch increased from 101 t in 1981 to 953 t in the 1986–87 fishing year. Landings dropped by 31% from the peak in the 1986–87 fishing year to the next fishing year, and gradually increased to 765 t in 1989–90 (Fig. 1a). The mid-water trawl CPUE index shows a 33% decline from 1983–84 to 1989–90 (Fig. 1b).

Estimates of B_0, B_{1981} and B_{1990} for each of the catchability assumptions and catch histories are given in Table 4. The two catch histories and catchability assumptions produced similar results. Thus for subsequent yield calculations only results using the q formulation of catchability and the reported landings since 1981 are used.

Table 4. Results of a stock reduction analysis for bluenose in QMA 2 for two assumptions about catchability (ln q and q) and two catch histories.

Catch history	ln q	q
a) landings from 1944		
B_0	6 100 t	6 300 t
B_{1990}	3 060 t	3 270 t
B_{1990}/B_0	0.50	0.52
a) landings from 1981		
B_0	6 200 t	6 600 t
B_{1990}	3 210 t	3 630 t
B_{1990} / B_0	0.52	0.55

The posterior distributions show the uncertainty about the true values of B_0 , B_{1981} and B_{1990} (Figs. 2a,b). Also shown is the equilibrium biomass at the long-term sustainable yield using an $F_{0.1}$ fishing strategy (see section 3.5.4 below).

3.5 Yield estimates

3.5.1 Yield per recruit analysis

A yield per recruit analysis was carried out for bluenose with the above growth, recruitment and mortality parameters (Table 3) to determine $F_{0.1}$. The method of Hilborn et al (1991) with a Beverton and Holt stock recruitment model was used for the computations. The resulting estimate of $F_{0.1}$ was 0.36 for the model with landing data from 1981 and the q formulation of catchability.

3.5.2 Estimation of Maximum Constant Yield (MCY)

MCY was estimated using the equation MCY = 2/3 * MSY (Method 3 of the "Guide to Biological Reference Points"). MSY was estimated using the above age structured model with a Beverton and Holt stock recruitment relationship with an assumed steepness of 0.95. The estimate of MCY, with corresponding 50% confidence intervals, is as follows:

	Estimate	50 % confidence interval
B_{1981}	6 600 t	5 400 –7 500 t
MSY	780 t	640 – 890 t
MCY	520 t	430 – 600 t

The level of risk to the stock by harvesting the population the estimated MCY value cannot be determined.

3.5.3 Estimation of Current Annual Yield (CAY)

The CAY was calculated using the Baranov catch equation (Method 1 of the "Guide to Biological Reference Points"), with an estimate of B_{1991} and assuming F_{ref} is equal to $F_{0.1}$.
The beginning-of-season biomass for 1991–92 was estimated by running the model forward from the estimate of B_{1981} using the reported landing history. The 1991–92 catch was assumed to be the actual TAC of 833 t of September 1990.

Estimates of B_{1981} , $B_{1991\text{-}92}$, $CAY_{1991\text{-}92}$, long-term equilibrium biomass (B(equilibrium)) and long-term sustainable yield ($F_{0.1}$ yield) using an $F_{0.1}$ strategy, with corresponding 50 % confidence intervals are as follows:

	Estimate	50 % confidence interval
B_{1981}	6 600 t	5 400 – 7 500 t
$B_{1991\text{-}92}$	3 400 t	2 100 – 4 300 t
$CAY_{1991\text{-}92}$	760 t	470 – 960 t
B(equilibrium)	2 460 t	2 010 – 2 800 t
$F_{0.1}$ Yield	740 t	610 – 840 t

3.5.4 Other yield estimates

$F_{0.1}$ together with an assumed Beverton and Holt stock recruitment model without recruitment variability was used to calculate the long-term sustainable yield using an $F_{0.1}$ fishing strategy. This long-term stable yield of 740 t is 11% of B_{1981} and occurs at a biomass of 37% of B_{1981}. The estimate of $B_{1991\text{-}92}$ is greater than the equilibrium biomass and the estimate of $CAY_{1991\text{-}92}$ is slightly greater than the $F_{0.1}$ yield.

4. MANAGEMENT IMPLICATIONS

If cpue is accepted as a measure of abundance, the risk of an $F_{0.1}$ harvest strategy on bluenose in QMA 2 must be further examined. The $CAY_{1991-92}$ is only slightly greater than the $F_{0.1}$ yield, which suggests that the fishery is near the end of its fishing down phase. The $F_{0.1}$ yield of 740 t is less than the current TACC of 833 t, and this level of TACC may not be sustainable. However, landings during the last three fishing years have ranged from 653 t to 765 t, and catches at this level may be sustainable.

Management strategies for bluenose in QMA 2 should also consider implications for the alfonsino fishery in QMA 2. Bluenose is the major bycatch of alfonsino and the fisheries are interwoven.

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Appendix 1. An analysis of changes over time in the overall cpue across the four major alfonsino/bluenose trawl grounds.

The approach taken here to assess the hypothesis of 'no change' in cpue is to look at the combined cpue for the four grounds, i.e. the data of the second last column of Table 2. The combined cpue data is plotted in Fig. 1.

The data of Table 2 enables cpue for each fishing year to be compared to that of other years. A test statistic is used to check on the hypothesis of 'no change in cpue'. This statistic is defined, for two different fishing years, by taking the difference between the cpue statistics for those years, and dividing the difference by the estimated standard error of the difference. The test statistic is taken in the form:

{ cpue (later) - cpue (earlier) } / estimated se of the difference in cpue.

This means that a decline in cpue will give rise to a negative result, and an increase in cpue will give rise to a positive result.

There are two advantages in using this approach: the comparison of two different years of cpue summary data is unaffected by the data of other years and as all year-by-year comparisons are made the approach assists in identifying pattern in the data.

Test statistics for the hypothesis of 'no change in cpue'

	83–84	84–85	85–86	86–87	87–88	88–89	89–90
84–85	–0.28	X	X	X	X	X	X
85–86	–0.53	–0.26	X	X	X	X	X
86–87	0.54	0.80	1.03	X	X	X	X
87–88	–2.93	–2.57	–2.19	–3.30	X	X	X
88–89	–1.61	–1.31	–1.00	–2.08	1.23	X	X
89–90	–2.35	–2.00	–1.64	–2.78	0.82	–0.60	X

If the hypothesis of 'no change' is correct, then the above test statistic would be expected to be greater than 2 in absolute value about 5% of the time. Of the 21 comparisons there are 8 less than –2 (underlined above). These 8 values all arise from the comparisons of the years up to 1986–87 with the years from 1987–88 onwards. In addition, while the remaining three possible earlier and later year comparisons are not less than -2 they are all negative.

Therefore it appears that there has been a drop in cpue from the years up to 1986–87 (inclusive), compared to years following.

Appendix 2. Bluenose 2 : imputed and actual landings 1944 to 1989-90.

Year	landings (t)	Year	landings (t)
1944	6	1966	62
1945	9	1967	65
1946	11	1968	68
1947	14	1969	70
1948	16	1970	73
1949	19	1971	75
1950	21	1972	78
1951	24	1973	80
1952	27	1974	83
1953	29	1975	86
1954	32	1976	88
1955	34	1977	91
1956	37	1978	93
1957	39	1979	96
1958	42	1980	98
1959	45	1981	101
1960	47	1982	170
1961	50	1983	352
1962	52	1984	810
1963	55	1985	745
1964	57	1986	645
1965	60	1986-87	953
		1987-88	653
		1988-89	692
		1989-90	765

Notes

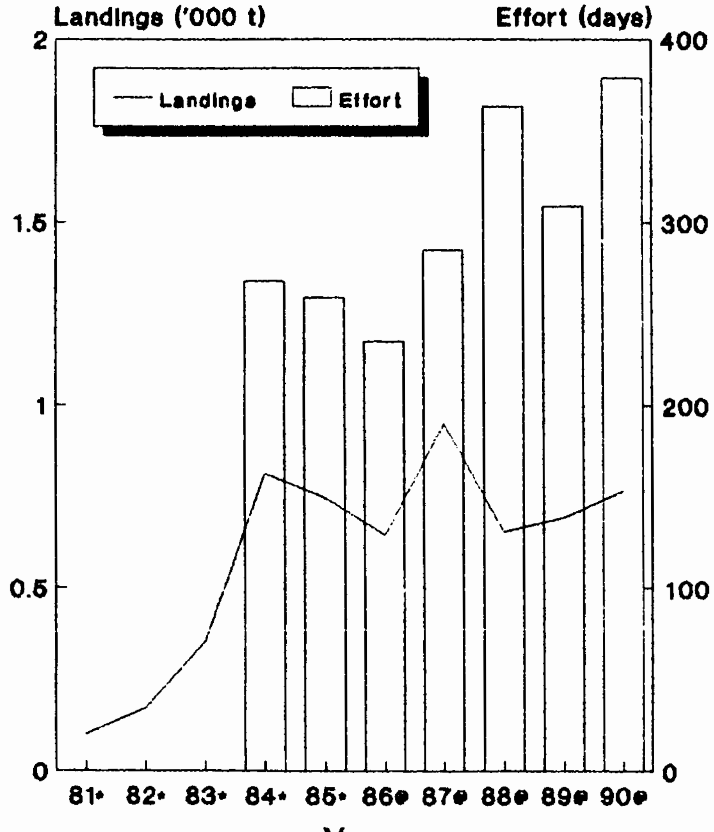
(1) The landings from 1944 to 1981 are imputed, with 1944 landings set at 6 tonnes and then increased linearly to reach 101 t in 1981.

(2) 1981 to 1989-90 data comes from the 1991 Report from the Fishery Asessment Plenary. This is an upgrade over the data used in the 1990 assessment.

(3) 1944 to 1985 data – calendar years
1986 data – 1 Jan to 30 Sep
1986–87 to 1989–90 – 1 Oct to 30 Sep

Figure 1a

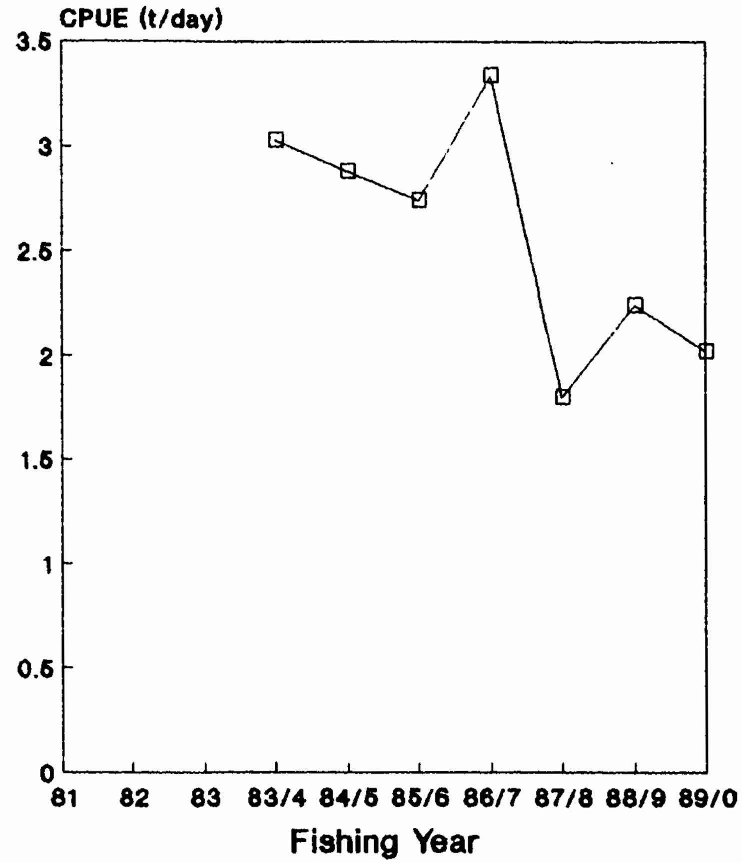
Bluenose (QMA2)



* calendar year; @ fishing year (1986/7)

Figure 1b

Bluenose (QMA2)



1a. Landings (tonnes) and effort (days) for bluenose BNS 2, 1981–90. The unit of fishing effort, for one trawler, is a 24 hour day spent targetting alfonsino.

1b. CPUE (tonnes/day) for bluenose BNS 2, for fishing years 1983–84 to 1989–90.

Figure 2a

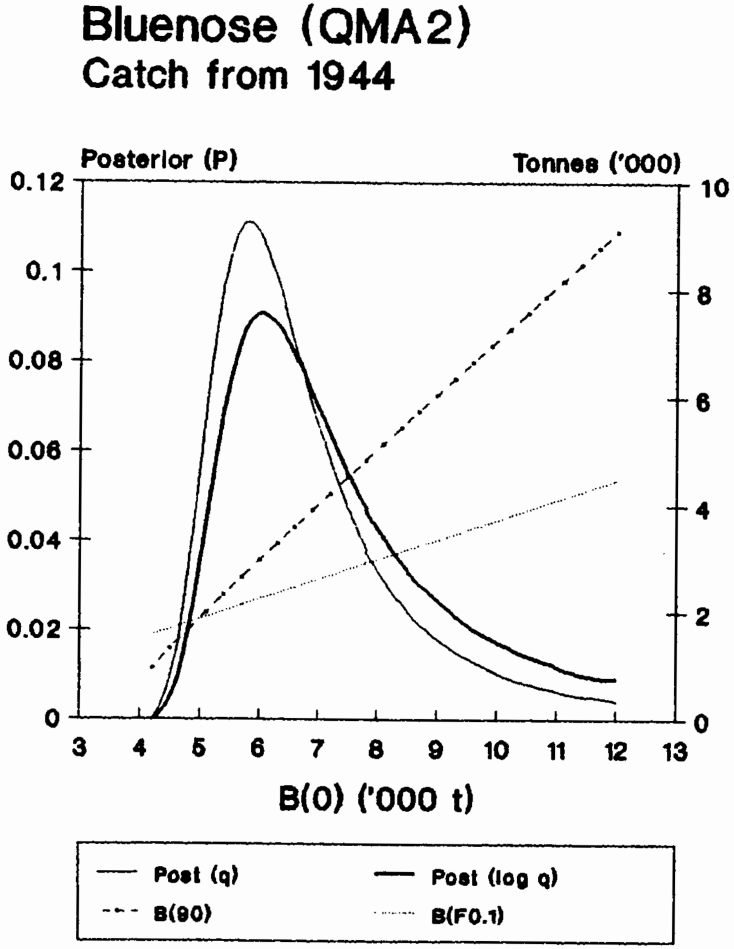
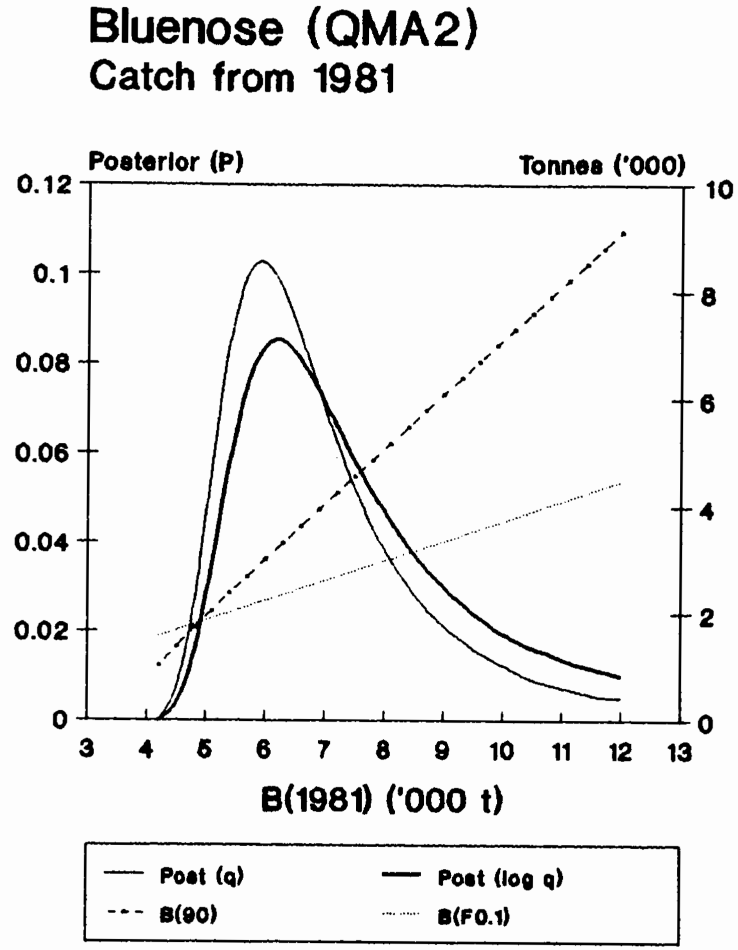


Figure 2b



2a. Posterior distributions of probable values of B_0, corresponding to results of the stock reduction analysis (with catch from 1944) presented in Table 4. Comparing the effect of two formulations of the catchability coefficient (q) and (ln q), and showing corresponding values of B_{1990} and B_{equil}.

2b. Posterior distributions of probable values of B_0, corresponding to results of the stock reduction analysis (with catch from 1981) presented in Table 4. Comparing the effect of two formulations of the catchability coefficient (q) and (ln q), and showing corresponding values of B_{1990} and B_{equil}.

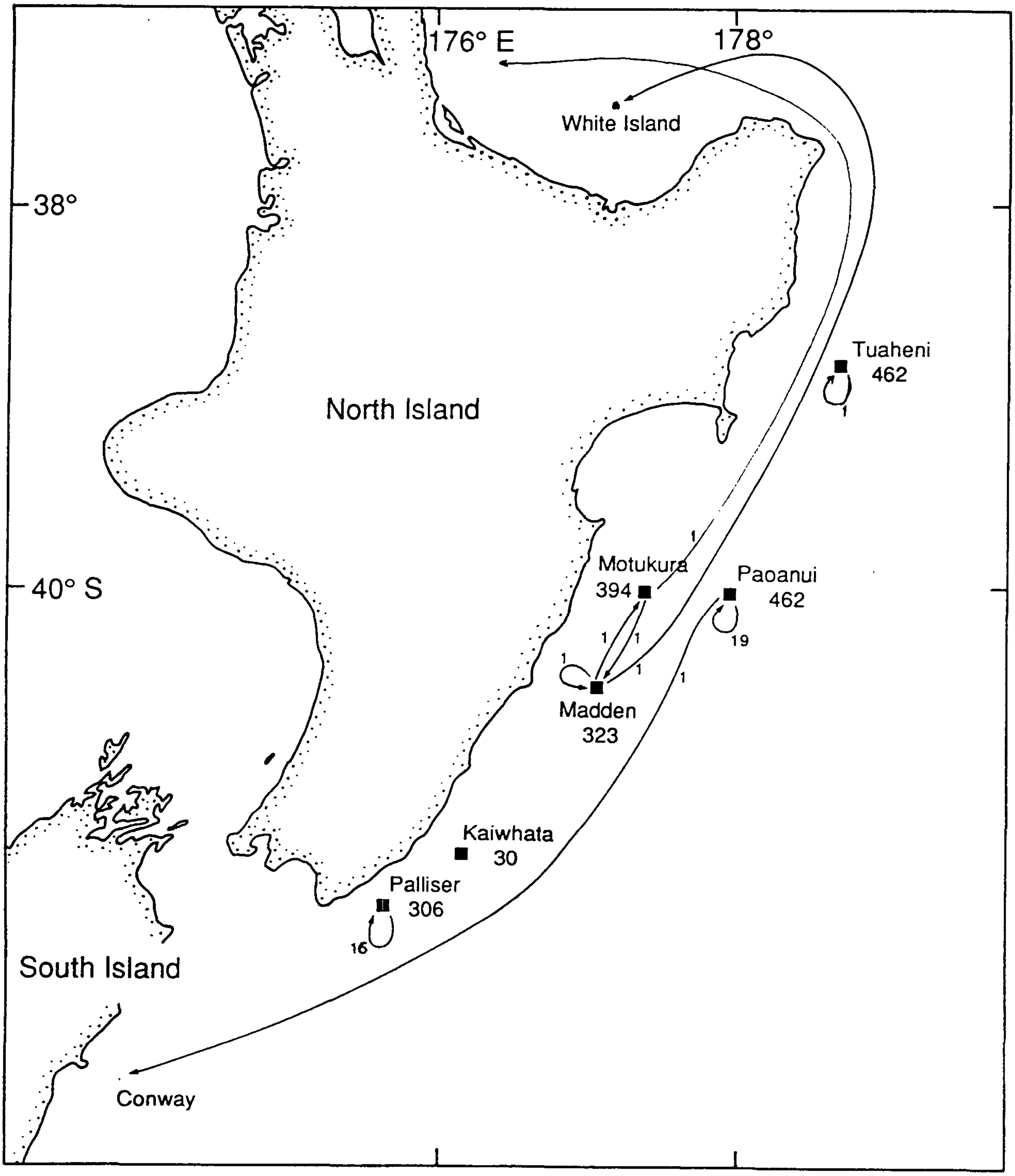


Figure 3. Distribution and movement of recaptured tagged bluenose as at January 1991.

The estimated number of bluenose tagged is shown for each ground (large numbers); place of recapture and numbers of recovered tagged fish are shown by arrows and small numbers.