

**The age structure of bluenose (*Hyperoglyphe antarctica*)
commercial catches from the Palliser Bank (Fishstock BNS 2) in
1984–86, and estimates of mortality rates.**

P.L. Horn
C.P. Sutton

NIWA
Private Bag 14901
Wellington 6241

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EXECUTIVE SUMMARY

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This report describes an investigation of the age structure, and associated estimates of instantaneous mortality, of the bluenose (*Hyperoglyphe antarctica*) catch taken by the trawl fishery on the Palliser Bank (in Statistical Area 015 in the south of Fishstock BNS 2) from April 1984 to November 1986. The work aimed to determine if the age distribution on a single ground varied over time, and to produce an estimate of instantaneous total mortality (Z). Because bluenose in this area were only lightly exploited before 1985, it was assumed that the estimate of Z would be an estimate of instantaneous natural mortality (M).

The length and age compositions varied markedly between the eight sampled landings, but with no obvious seasonal trends. Between-landing variations are probably related to some short term aspect of fish behaviour that results in different sections of the population being more vulnerable to the trawl at different times. Estimates of Z derived from individual samples ranged from 0.11 to 0.26. Estimates at the high end of this range were clearly inappropriate as M values for a species with a maximum age in excess of 50 years.

When the data were combined they were indicative of three distinct age-related life cycle phases of bluenose on the Palliser Bank. First, young fish start to recruit to the fishery from about ages 5–6, and continue to recruit strongly until about ages 13–15. Second, there is a period of relatively constant numbers per age class from about ages 15 to 27. The relatively flat nature of the catch curve over this age range suggested that natural mortality was being balanced by continued recruitment to the fishing ground. Third, from an age of about 27 there was a marked decline in fish abundance with age, indicative of a Z of about 0.22, which is greater than would be expected from natural mortality alone. It is likely that over this older age range, effects other than natural mortality (probably migration) are removing fish from the fishery.

The age composition of the mid-water trawl catch of bluenose on the Palliser Bank is unlikely to reflect that of the broader population. Estimates of mortality using both analytical Chapman-Robson and regression methods were therefore rejected as estimates of M .

Estimates of M were therefore derived from the likely lifespan of bluenose. A value of 0.11 was calculated assuming that about 1.5% of bluenose live for at least 39 years. However, M could be lower if older fish become less vulnerable to the fishery owing to migration away from the fished areas, or higher if older bluenose actually experience a markedly higher mortality rate than those that are newly mature. A plausible range for M of 0.07 to 0.14 is suggested, with 0.10 being a reasonable point estimate.

1. INTRODUCTION

Similar declining trends for several bluenose Fishstocks (Starr et al. 2008) suggested that standardised CPUE was indexing abundance and that New Zealand bluenose may comprise a single stock. The work presented here aimed to investigate temporal difference in age structure of bluenose catches on a single fishing ground, and estimate instantaneous mortality rates for an essentially unfished stock. This report describes catch-at-age distributions for bluenose from the Palliser Bank (in the south of Fishstock BNS 2) over a 1-year period. It fulfils the reporting requirements of Project BNS2009-01 “Age composition of commercial catch of bluenose in BNS 1, 2, 3, 7 and 8”, funded by the Ministry of Fisheries. The overall objective is:

1. to determine the stock status of bluenose (*Hyperoglyphe antarctica*) by investigating the spatial and temporal age structure of the New Zealand bluenose commercial catches.

Specific objectives are:

1. to investigate temporal and inter-landing variation in length and age composition of the bluenose catch from the Palliser Bank in 1985–86;
2. to estimate total mortality, fishing mortality and natural mortality of bluenose on the Palliser Bank during 1985–86.

2. METHODS

2.1 Catch sampling

Horn & Massey (1989) reported on catch sampling of bluenose from the Palliser Bank between October 1985 and November 1986; seven relatively large and two small samples were taken (Table 1). One large sample is also available from April 1984. The sampled catches were all taken by commercial trawlers which used semipelagic trawl nets with 125 mm mesh codends.

Table 1: Summary of volumes of data (length measurements and otoliths) available from samples of bluenose taken by midwater trawl on the Palliser Bank from 1984 to 1986.

Sample	Sample date	No. of lengths	No. of otoliths
1	14 Apr 1984	1 222	173
2	4 Oct 1985	548	241
3	9 Nov 1985	403	229
4	10 Dec 1985	684	237
5a	11 Feb 1986	61	61
5b	12 Mar 1986	761	242
6	26 Jun 1986	361	266
7a	20 Aug 1986	61	61
7b	9 Sep 1986	566	273
8	30 Nov 1986	348	200

Each sample was from a single fishing trip. In each sample, bins of fish were selected at random from the catch, and each fish in the bin was measured to the nearest cm below actual fork length, and sexed. Otoliths were collected from five bluenose of each sex in each 1 cm size class. Numbers of measured and otolithed fish available from each sample are listed in Table 1.

2.2 Fish ageing

All otoliths listed in Table 1 were prepared for reading. Horn et al. (2010) used the bomb-chronometer method of Kalish (1993) to validate a method to age bluenose by counting zones in thin-sectioned otoliths. The new ageing protocol for bluenose was described in detail by Horn et al. (2008, 2010), and was used here to age all fish. Briefly, the method relies on an examination at high magnification ($\times 80$) of the sulcal region on a thin transverse section through the untreated otolith, and counts all distinct dark (opaque) zones, even if they appear to merge with other zones some distance from the sulcus.

Von Bertalanffy growth parameters were fitted to all the age data; the results are presented in Appendix A. This work was not formally part of project BNS2009-01, but such an analysis was believed to likely be useful for any future assessment of bluenose stocks.

2.3 Data analysis

Scaled catch-at-age distributions for each sample were calculated by constructing age-length keys separately for each sex and applying them to the scaled length-frequency data using software developed specifically for this task by NIWA (Bull & Dunn 2002). Each individual analysis used only the data pertinent to the sample(s) being analysed.

Estimates of instantaneous total mortality (Z) were derived for various data sets. Throughout this report we assume that $Z = M + F$, where M is instantaneous natural mortality and F is instantaneous fishing mortality. For each scaled age-frequency sample Z was estimated using the Chapman-Robson maximum likelihood estimator (Chapman & Robson 1960). Estimates of Z for combined samples were variously derived using the Chapman-Robson maximum likelihood estimator, the regression of the right-hand limb of the catch curve (Ricker 1975, Dunn et al. 1999), and the A_{\max} estimator (Hewitt & Hoenig 2005).

The Chapman-Robson maximum likelihood estimator is:

$$Z = \log_e \left(\frac{1+a}{a} \right)$$

where a is the mean age above recruitment age. For this estimator, age at recruitment (R) should be the age at which 100% of fish are vulnerable to the sampling method (rather than the often used age at 50% recruitment). The chosen R values varied between the samples, but ranged from 15 to 28 years. A 95% confidence interval around this estimator is $\pm 2 \cdot \sqrt{\text{var}}$, where $\text{var} = (1 - e^{-Z})^2 / (ne^{-Z})$.

Z can also be estimated from minus the slope of the right hand limb (i.e., points where age is R or older) of the relationship between age and the natural logarithm of the frequency of fish in that age class (Ricker 1975). The regression model used here set R at 27 years. A 95% confidence interval around this estimator was taken as $\pm 2 \cdot \text{SE}$ of the slope.

The A_{\max} estimator is:

$$Z \approx \frac{4.22}{A_{\max}}$$

if approximately 1.5% of the population is still alive at the maximum age (A_{\max}).

A previous analysis of Z for line-caught bluenose from Fishstock BNS 1 showed that 200 age data points are insufficient to produce a sufficiently precise Z , while 600 age data points clearly were sufficient (Horn & Sutton 2010). Consequently, it was concluded that a sample of about 500 age

points (and probably no fewer than 400) are probably necessary for a sufficiently precise estimation of Z . None of the samples in Table 1 comprised more than 400 otoliths. Two samples (5a and 7a) were very small, so were combined with temporally adjacent samples (5b and 7b, respectively) before any analyses. Age-frequency distributions and estimates of Z were produced for the resulting eight samples. Samples were further combined to produce estimates of Z based on greater sample sizes. Age-frequency distributions and Z estimates were compared between samples (and groups of samples).

3. RESULTS and DISCUSSION

3.1 Length-frequency distributions

Length-frequency distributions from the eight samples listed in Table 1 are shown in Figure 1. There appears to be three relatively distinct distribution shapes. Both November samples (1985 and 1986) have distinct length modes in the mid 60s and few fish smaller than 57 cm. All other samples (excluding October 1985 and June 1986) have modes from 53 to 58 cm. The October and June samples have characteristics of the other two sample groups, with a relatively flat-topped distribution from 52 to 64 cm.

3.2 Age-frequency distributions

Age-frequency distributions from the eight samples listed in Table 1 are shown in Figure 2. As with the length-frequency distributions, there are marked differences between samples in the age composition, and consequently, in the apparent age at full recruitment (i.e., R) that is necessary for the estimation of Z . The mean weighted c.v.s over all age classes for individual samples range from 36.4 to 53.7% (see Figure 2).

Some of the distributions appear to be bimodal, with a trough generally in the range 15 to 22 years. The December 1985, February-March 1986, and November 1986 distributions are strongly bimodal; weak bimodality is apparent in the November 1985, June 1986, and August-September 1986 distributions.

Although the shapes of the age distributions vary, there is no evidence of a consistent trend over time. Fish from young to old ages are abundant in all samples except for November (when young fish are rare in both 1985 and 1986) and April 1984 (when old fish are relatively uncommon). So while the data are indicative of some temporal changes in the availability or vulnerability of bluenose to midwater trawling on the Palliser Bank (perhaps relating to migration on or off the ground), no seasonal linkage is apparent.

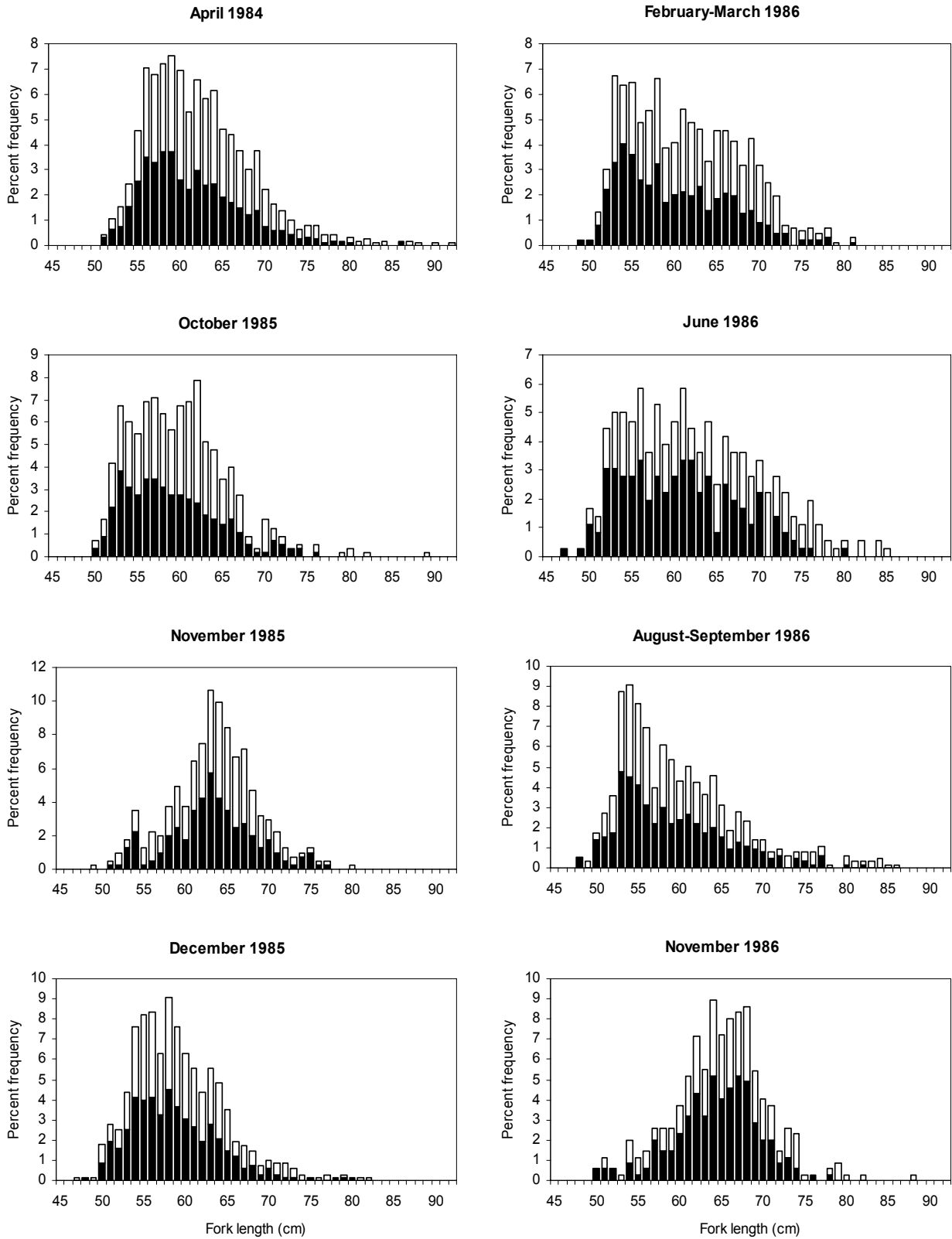


Figure 1: Estimated length-frequency distributions of bluenose from the Palliser Bank. Males, solid bars; females, clear bars.

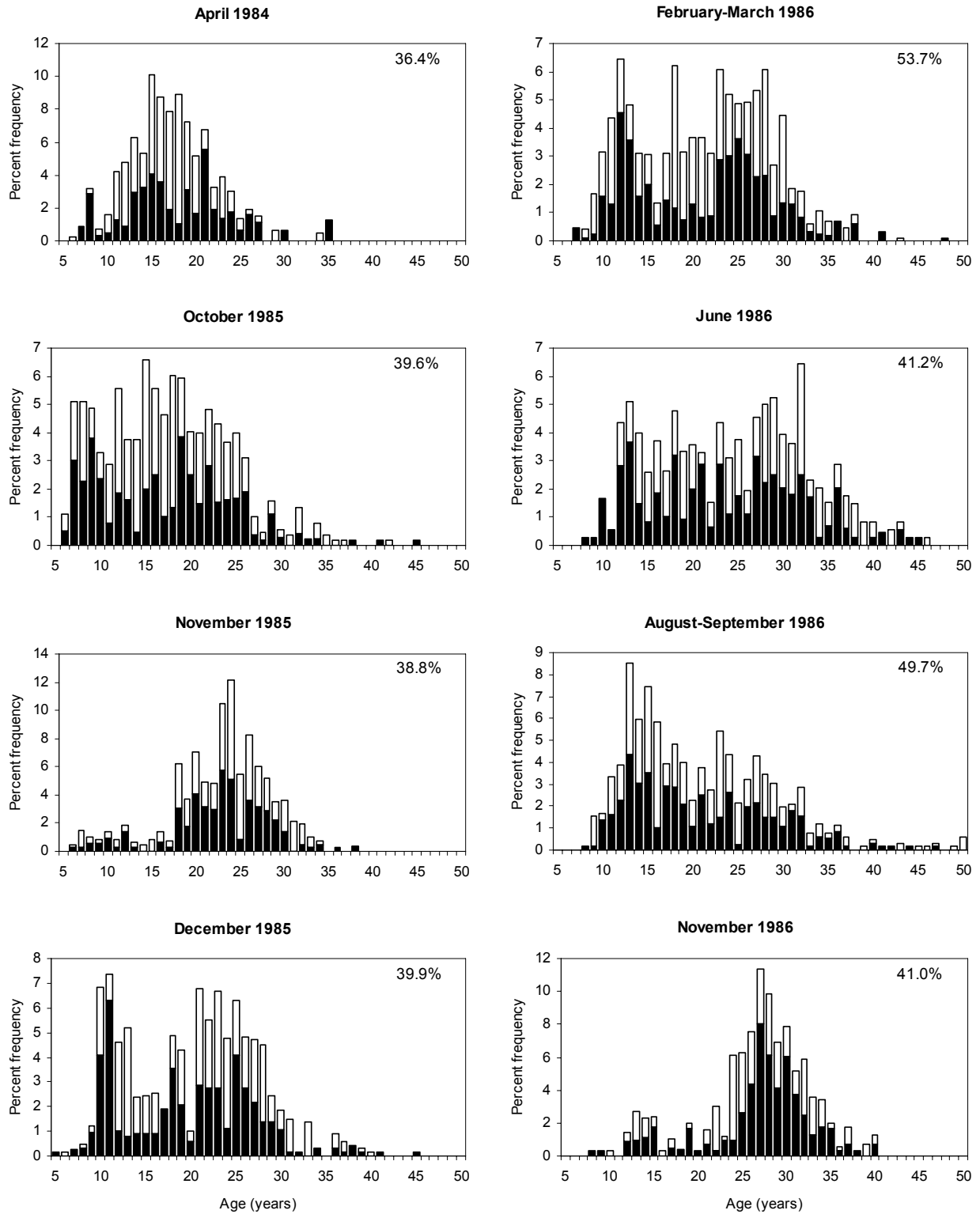


Figure 2: Estimated age-frequency distributions of bluenose from the Palliser Bank. Males, solid bars; females, clear bars. Percentage values are mean weighted c.v.s over all age classes. Note that any bars at 50 years comprise fish aged ≥ 50 years.

3.3 Estimation of Z

Estimates of Z derived from the eight samples using the Chapman-Robson maximum likelihood method are listed in Table 2. Because of the marked differences in the shapes of the age-frequency distributions it was not possible to use a single R value for all estimates without losing much of the data from some samples. Consequently, R was in the range 15–28 years. The Z estimates are very variable (0.11–0.26) with wide confidence bounds. Given that bluenose have a maximum age in excess of 50 years (the oldest fish from the Palliser Bank was 62 years, and Horn et al. (2010) reported a maximum age of 76 years from Bay of Plenty samples), the true value of Z (as a proxy for M) is likely to be closer to the lower end of this range.

Table 2: Estimates of Z (with 95% confidence intervals, and c.v.) derived from the eight individual samples of bluenose using the Chapman-Robson maximum likelihood method. R , chosen age at full recruitment.

Sample	Sample date	R	Z	95% CI	c.v.
1	Apr 1984	15	0.20	0.15–0.26	0.14
2	Oct 1985	15	0.15	0.11–0.19	0.14
3	Nov 1985	23	0.26	0.21–0.34	0.13
4	Dec 1985	21	0.19	0.15–0.25	0.13
5	Feb–Mar 1986	23	0.19	0.15–0.26	0.15
6	Jun 1986	28	0.19	0.15–0.23	0.11
7	Aug–Sep 1986	15	0.11	0.08–0.14	0.14
8	Nov 1986	27	0.25	0.20–0.33	0.13

Age distributions for all samples combined, and for all samples combined excluding the two November samples (that clearly under-sample the young fish) were produced (Figure 3). For these analyses, all available Palliser Bank age data were combined to form a single age-sex-length key. Bimodality in the distributions is weak but still apparent with a trough in the range 15 to 22 years. The distributions indicate that by the time bluenose reach 13–15 years old a large proportion of them are being recruited to the fishery. However, the relatively flat tops of the distributions between ages 15 and 27 suggests that recruitment into the fishery and/or migration on to the Palliser Bank are continuing over that extended age range.

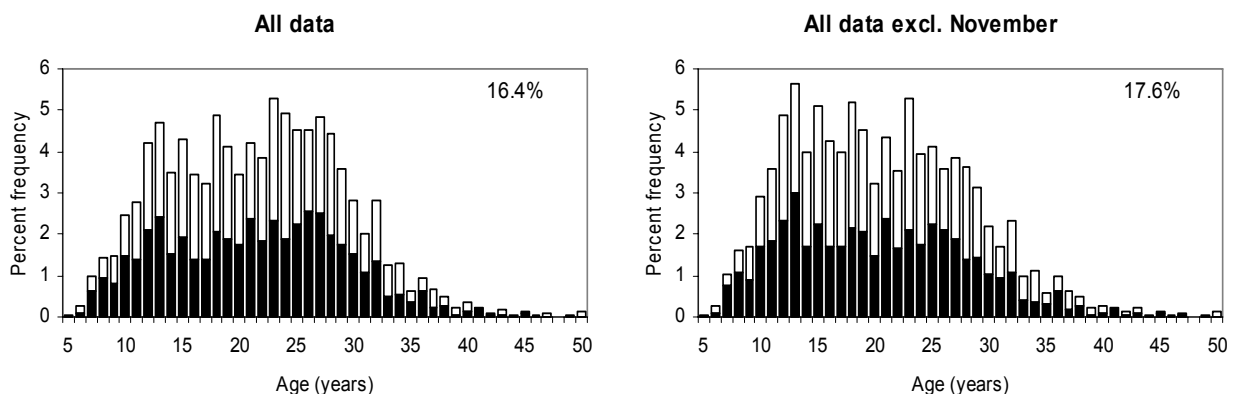


Figure 3: Estimated age-frequency distributions of bluenose from the Palliser Bank. Males, solid bars; females, clear bars. Percentage values are mean weighted c.v.s over all age classes. Note that any bars at 50 years comprise fish aged ≥ 50 years.

In both distributions, there is a relatively steep decline from an age of about 27 years. Estimates of Z using an R of 27 were derived using the regression (Figure 4, Table 3) and Chapman-Robson (Table 3) methods. All these estimates (0.22–0.25) are incompatible as proxies for M for a species with the

apparent age span that bluenose has. This suggests either a relatively rapid die-off of fish older than about 27 years, or, more likely, a reduction in the vulnerability of this section of the population to midwater trawling on the Palliser Bank. It is possible to obtain lower estimates of Z simply by choosing lower R values (Figure 5), but as the true age at full recruitment can not be determined no reliable estimates of Z could be obtained. If we assume that the age at full recruitment is 15 years (i.e., slightly higher than the most abundant age class in the distribution from all samples excluding November (see Figure 3), then the Chapman-Robson estimate of Z is 0.11 (Table 3). A value around this magnitude is logical given the apparent life span of bluenose.

The apparent age structure and the estimates of Z derived for samples of bluenose taken by the longline fishery in BNS 1 (Horn & Sutton 2010) are different to those estimated here for Palliser fish. The longline age modes tended to range from about 7 to 15 years (much younger than the Palliser trawl modes), and the slopes of the right-hand limbs of the BNS 1 catch curves were less steep, producing Z estimates generally in the range 0.14 to 0.18 (lower than the Palliser estimates). It is unlikely that these differences represent true productivity differences between populations. They are much more likely to be a result of differences in factors like fishing selectivity, distribution of fish in space and time, and fish behaviour. Size or age dependent movement or migration by bluenose was indicated from analyses geochemical signatures in otoliths (Horn et al. 2008), and was proposed as a possible reason for apparent uneven vulnerability across the bluenose population in BNS 1 (Horn & Sutton 2010). It is likely that the Palliser Banks samples suffer from a similar complication, resulting in unreliable estimates of Z from the data available here.

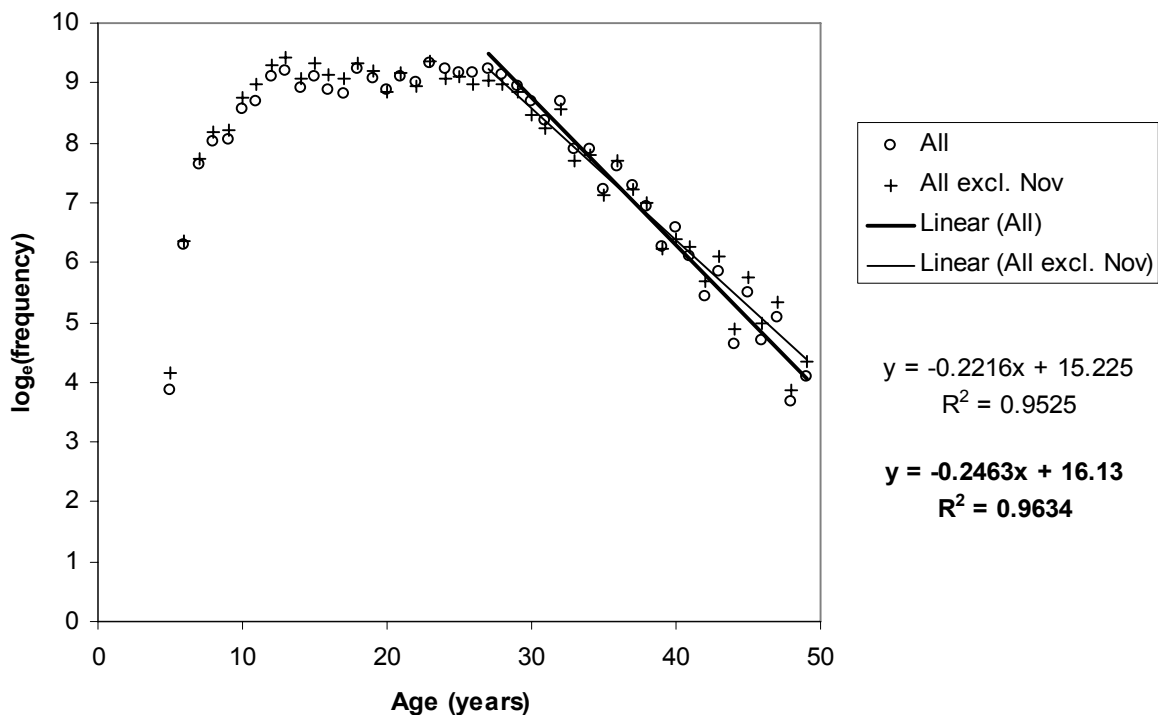


Figure 4: Estimating Z for bluenose from the Palliser Bank using regression of the right-hand limb (from ages 27 to 49) of the catch curve. Fits are to data from all samples combined (All) and all samples combined excluding the two November samples (All excl. Nov). Regression equations are presented for the two fits.

Table 3: Estimates of Z (with 95% confidence intervals, and c.v.) derived from all samples combined (All) and all samples combined excluding the two November samples (All excl. Nov) using the regression and Chapman-Robson methods.

Method	Sample date	R	Z	95% CI	c.v.
Regression	All	27	0.25	0.22–0.28	–
	All excl. Nov	27	0.22	0.19–0.25	–
Chapman-Robson	All	27	0.22	0.19–0.27	0.09
	All excl. Nov	27	0.21	0.18–0.25	0.09
	All excl. Nov	15	0.11	0.09–0.13	0.10

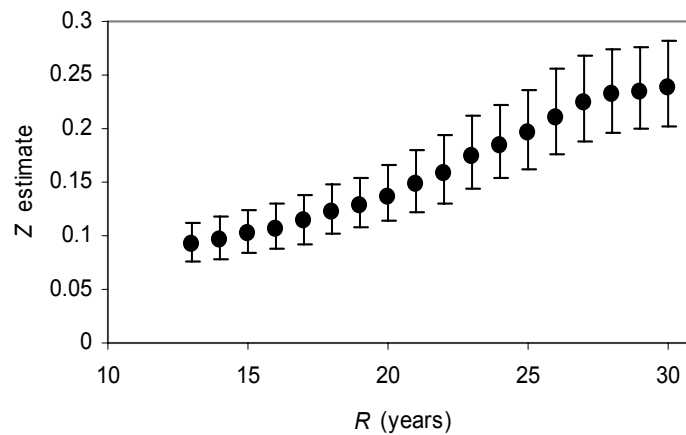


Figure 5: Chapman-Robson estimates of Z (with 95% confidence intervals) for a range of R values, for all samples combined excluding the two November samples.

Given that the estimates of Z derived from the Chapman-Robson and regression methods do not appear to be useful as proxies for M , some estimates were derived based on the apparent life span of bluenose, i.e., using the A_{\max} method of Hewitt & Hoenig (2005). The maximum age estimated from the current work is 62 years, compared to 76 years from Bay of Plenty samples (Horn & Sutton 2010). These values are lower than a validated maximum age of 85 years for the closely related barrellfish (*Hyperoglyphe perciformis*) in the western North Atlantic (Filer & Sedberry 2008). Just over 1.5% of all the aged Palliser Bank bluenose were at least 39 years old. Estimates of Z using the A_{\max} method with maximum age values from the Palliser Bank samples of 39 and 62 years are 0.11 and 0.07, respectively.

4. CONCLUSIONS

The length and age compositions of landings of bluenose taken from the Palliser Bank when the midwater trawl fishery was first developing were analysed. Between-trip variation was marked, but there were no obvious seasonal trends in the length or age data. Each sampled trip completed multiple tows on the fishing ground, and sampled fish were taken from throughout the landing. Consequently, it seems most likely that between-trip variations in catch composition are related to some short term and non-seasonal aspect of fish behaviour that results in different sections of the population being more vulnerable to the trawl at different times.

Estimates of total mortality (Z) derived from each of the eight samples ranged from 0.11 to 0.26. Because these samples were collected as the midwater trawl fishery was developing, and because bluenose had

been only lightly exploited before 1984 (Horn & Massey 1989), these estimates of Z could be considered as reasonable proxies for natural mortality (M) because F would be very small. However, the Z estimates at the high end of the range are clearly inappropriate as M values for a species with a maximum age in excess of 50 years (Horn et al. 2010). Based on the age data alone, and using the method of Hewitt & Hoenig (2005), M is likely to be about 0.1 or lower, and is very unlikely to be higher than 0.15.

The age distributions from the combined samples (see Figures 3 and 4) are indicative of three distinct age-related life cycle phases of bluenose on the Palliser Bank. First, young fish start to recruit to the fishery from about ages 5–6, and continue to recruit strongly until about ages 13–15. Most of this recruitment will occur as fish move from their juvenile surface pelagic habitat to more of a demersal environment. Second, there is a period of relatively constant numbers per age class from about ages 15 to 27. This is when most bluenose become sexually mature (Horn & Sutton 2010), so it is likely to be when they experience their lowest levels of natural mortality (Chen & Watanabe 1989). However, the relatively flat nature of the catch curve over this age range indicates that natural mortality is essentially being balanced by continued recruitment on to the fishing ground. Finally, from an age of about 27 onwards there is a relatively marked decline in fish abundance with age. The slope of the catch curve (about -0.22) is greater than would be expected from natural mortality alone. So over this age range it is suggested that effects other than natural mortality are removing fish from the fishery. Although fishing would account for a small amount of the removals, the most likely significant cause would be migration, either off the fishing ground, or to areas on the Palliser Bank that are not generally fished. It is useful to note here that Paul et al. (2004) deduced from an analysis of stable isotopes in otoliths that with increasing size (and, presumably, age) bluenose reside at depths from 800–1000 m, which is deeper than waters normally fished on the Palliser Bank in the mid 1980s (i.e., about 360–550 m). A similar apparent lack of older fish in the sampled population was also found in catches from the longline fishery in BNS 1, as indicated by a steeper than expected decline in the right hand limb of the catch curve (Horn & Sutton 2010). This incongruity was attributed to the migration of large, old fish away from the main fishing grounds (Horn & Sutton 2010).

It seems likely, therefore, that no part of the bluenose population on the Palliser Bank vulnerable to the midwater trawl fishery could be considered to be both fully recruited and experiencing extractions related only to natural mortality. This led to the rejection of M estimates based on the analytical Chapman-Robson and regression methods because both these methods require an age at full recruitment with the abundance of fish older than this age being reduced only by natural (and fishing) mortality.

The conclusion that bluenose on the Palliser Bank might not be a closed population is not surprising. There may be a positive correlation between fish size and preferred depth (Paul et al. 2004), resulting in large or old fish migrating into depths that are generally beyond the range of the normal bluenose target trawl fishery. Also, tagging studies indicate that bluenose are capable of migrating large distances (Horn 2003). If some of the older fish are often not available to the fishery then this would result in over-estimates of true Z . However, movement of middle-aged fish onto the fishing grounds from other areas could result in under-estimates of Z . Besides migration by large or old fish away from the main fishing grounds, there are other possible complications that could result in uneven vulnerability across a population, e.g., localised depletion on a feature (bluenose fishers, pers. comm.), schooling by size (author's unpublished data), and different size structures on different geographical features (Horn & Massey 1989).

Consequently, the estimates of M for bluenose that are probably the most reliable are based on the likely life span of the species. The value of 0.11 based on the assumption that about 1.5% of bluenose live for at least 39 years is considered to be a reasonable point estimate. However, if older fish do become less vulnerable to the fishery owing to migration away from the fished areas, then M could be much lower; an M of 0.07 results from the assumption that 1.5% of fish live for at least 60 years. Conversely, older bluenose may experience a markedly higher mortality rate than those that are newly mature, so an M estimate higher than 0.11 is also possible. We suggest that a plausible range for M is 0.07 to 0.14, with an M of 0.10 as the best point estimate.

5. ACKNOWLEDGMENTS

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Appendix A: Estimation of growth parameters for Palliser Bank bluenose

Otoliths from 1967 bluenose sampled randomly from commercial midwater trawl operations on the Palliser Bank (41.7°S, 175.6°E) from 1984 to 1986 were aged, using the method described in section 2.2 above. The resulting unweighted length-at-age data were fitted using the Von Bertalanffy growth model:

$$L_t = L_\infty (1 - \exp(-K*(t-t_0)))$$

where L_t is the expected length at age t years, L_∞ is the asymptotic maximum length, K is the von Bertalanffy growth constant, and t_0 is the theoretical age at zero length. Growth curves were fitted separately for males, females, and both sexes combined using the nonlinear least squares procedure in the R statistical package (R Development Core Team, 2008), and assuming a lognormal error structure of age at length.

Calculated and fitted Von Bertalanffy parameters are shown in Table A1 and Figure A1. The estimated parameters were clearly not adequate to describe the growth of juvenile bluenose. Owing to the general lack of short and young fish in the samples, the estimated von Bertalanffy parameters (particularly K and t_0) are biologically meaningless, even though the estimated curves fit the raw data reasonably well. In an attempt to calculate more meaningful parameter values, curves were fitted to the mean length-at-age data for ages 8 years and older, while forcing t_0 to be -0.5. This removed the influence of the younger aged fish (which would probably have been only the fastest growing specimens of their respective year classes). The resulting curves (shown in Figure A1) had values of L_∞ and K , respectively, of 71.7 cm and 0.112 for males, and 78.9 cm and 0.091 for females. This problem of a lack of juvenile fish leading to unrealistically low t_0 values has been experienced in all other recent ageing studies of *Hyperoglyphe* species (see Table A1).

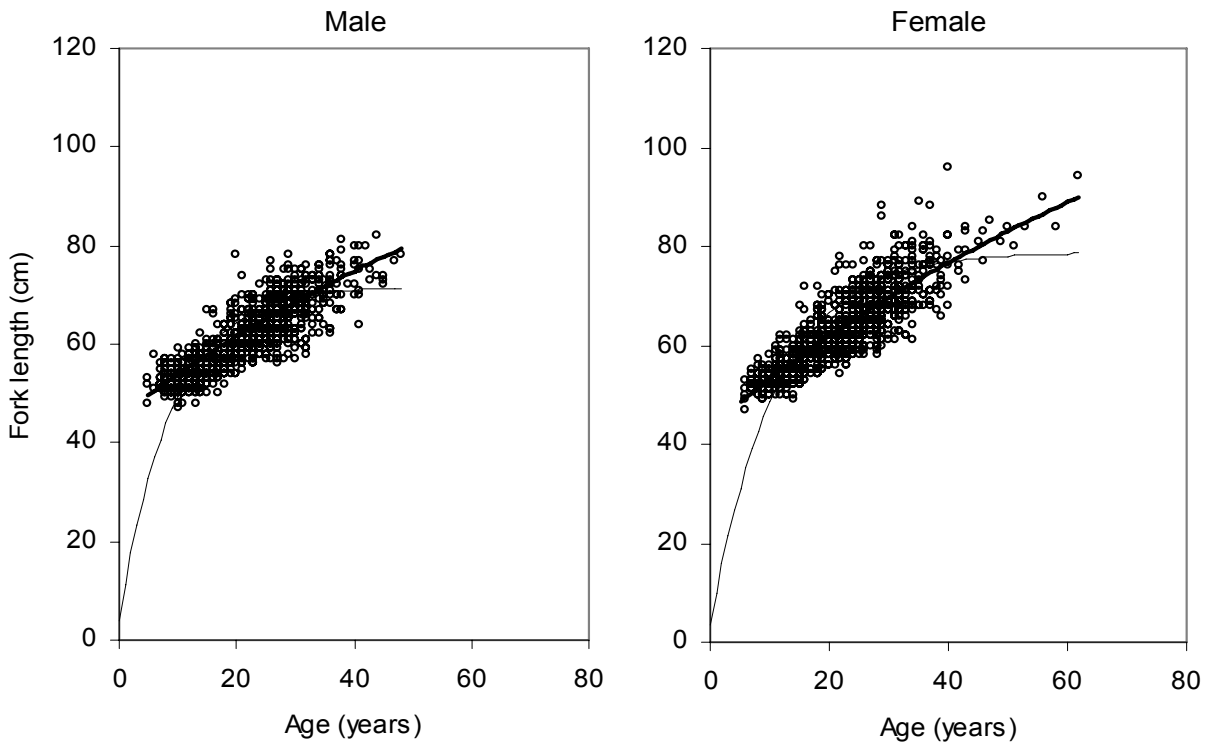
The von Bertalanffy parameters calculated with t_0 constrained to be -0.5 are believed to be more biologically meaningful than the simple fits to all the available data. The ‘constrained’ curves indicate that males approach their asymptotic length faster than females, but females grow to a larger size than males. Similar growth trends were apparent from other studies of bluenose (Morison 1995, Horn et al. 2010). The parameters derived from this constrained subset of data are likely to better represent average growth in the population, whereas the curves fitted to the raw data describe the growth of fish recruited to the fishery. However, Figure A1 does indicate that the constrained von Bertalanffy growth model results in a very poor fit to age-length data for bluenose; the residuals are strongly unbalanced.

The estimated constrained curves for males from the Palliser Bank and Bay of Plenty datasets are not significantly different (see Table A1), although the Bay of Plenty sample does have more larger and older fish than at Palliser Bank. The von Bertalanffy parameters for females from the two areas are significantly different, and, as found for males, the largest fish tend to be from Bay of Plenty. If we assume that bluenose in the two sampled areas comprise a single biological stock (and evidence from tagging studies (Horn 2003) and CPUE analyses (Starr et al. 2008) supports this assumption), then the constrained curves from the Bay of Plenty study are probably the best to use in any assessment of this species as they comprise a greater length (and age) range. However, the three-parameter von Bertalanffy curve may not be the most appropriate growth model for bluenose.

Table A1: Von Bertalanffy growth curve parameters (with 95% confidence intervals) for *Hyperoglyphe* species from Palliser Bank (current study), Bay of Plenty (Horn et al. 2010), Australia (Morison 1995), and the northwest Atlantic (Filer & Sedberry 2008). Parameters from the two New Zealand locations have been estimated in two ways, i.e., constraining t_0 to be -0.5, and allowing it to be freely estimated. –, not available.

Species/Area	Sex	N	Ages (yr)	L_∞ (cm)	95% CI	K	95% CI	t_0	95% CI
<i>H. antarctica</i> Palliser Bank, NZ	M	942	5–48	128.1	102.1–154.5	0.011	0.007–0.015	-39.7	-45.7 to -33.3
	F	1025	6–62	143.8	115.8–172.2	0.010	0.007–0.013	-36.2	-40.8 to -31.2
	M	923	8–48	71.7	69.4–74.1	0.112	0.099–0.127	-0.5	–
	F	1007	8–62	78.8	75.8–81.9	0.091	0.079–0.104	-0.5	–
Bay of Plenty, NZ	M	1637	4–71	74.0	72.2–75.9	0.066	0.057–0.074	-10.6	-12.2 to -8.9
	F	777	4–76	136.5	114.6–165.5	0.017	0.011–0.023	-20.7	-24.5 to -17.0
	M	1480	8–71	72.2	70.7–73.9	0.125	0.113–0.138	-0.5	–
	F	685	8–76	92.5	89.6–95.6	0.071	0.064–0.079	-0.5	–
Tasmania, Australia	M	1178	2–39	75.0	69.9–80.1	0.070	0.069–0.071	-11.7	-39.1 to 15.8
	F	1148	2–42	119.9	112.2–127.7	0.030	0.029–0.031	-13.8	-77.0 to 49.4
<i>H. perciformis</i> Northwest Atlantic	Both	824	5–85	85.8	–	0.099	–	-9.0	–

Palliser Bank



Bay of Plenty

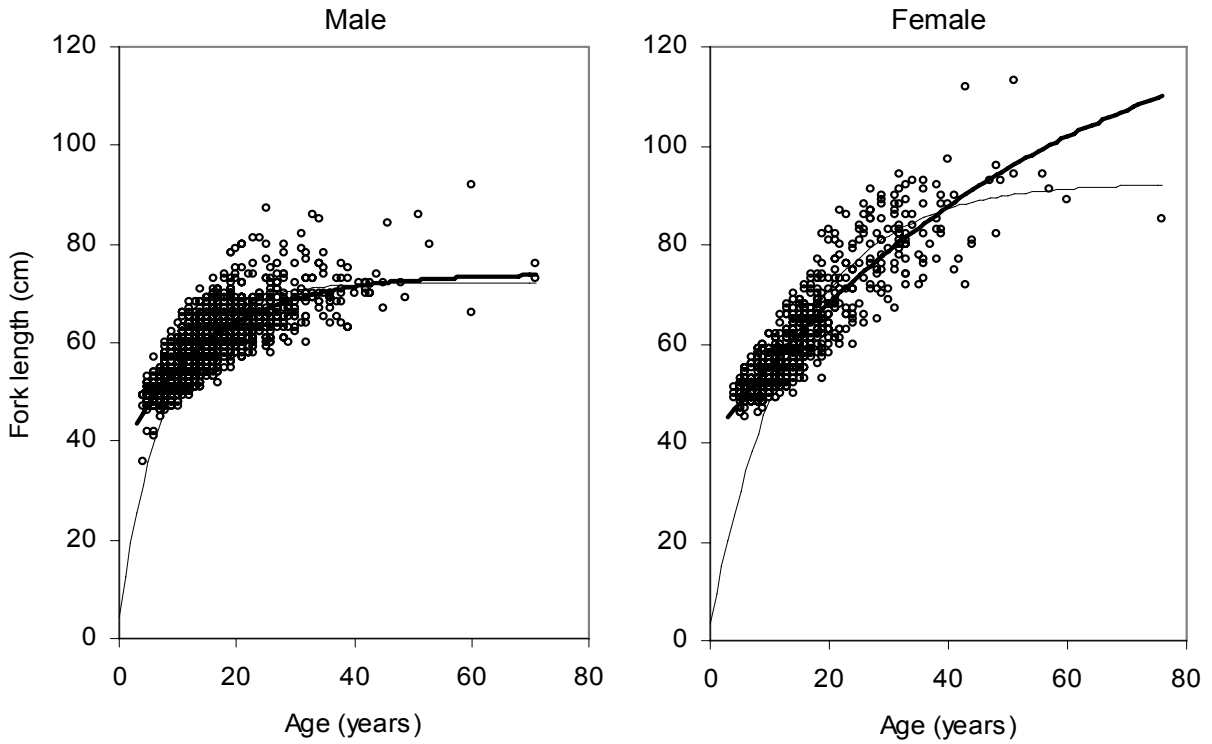


Figure A1: Raw age-length data with von Bertalanffy curves fitted to the raw data (thick lines) and constrained to have a t_0 of -0.5 (thin lines), by sex, for data from Palliser Bank (current study) and Bay of Plenty (Horn et al. 2010).