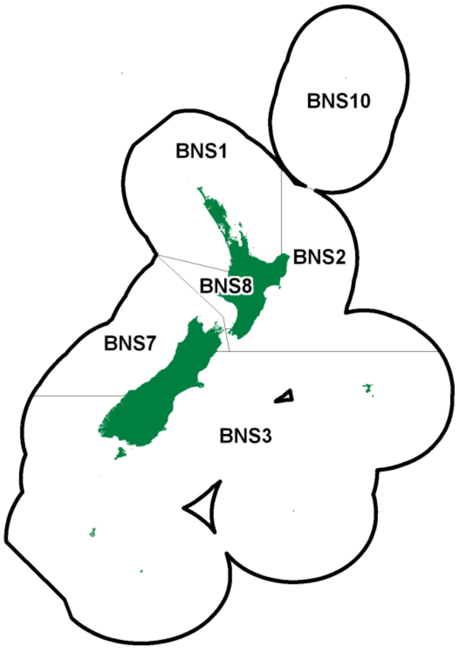
BLUENOSE (BNS)

(Hyperoglyphe antarctica)
Matiri



1. FISHERY SUMMARY

Bluenose were introduced into the QMS on 1 October 1986. A Total Allowable Catch (TAC) was set under the provisions of the 1983 Fisheries Act, initially at 1350 t. In 2010 new TACs were set for all BNS stocks along with recreational allowances, customary non-commercial allowances, and allowances for other sources of mortality. All current allowances, TACCs and TACs can be found in Table 1 below.

Table 1: Recreational and customary non-commercial allowances, TACCs and TACs by Fishstock (t) for Bluenose.

Fishstock	Recreational allowance	Customary allowance	Other mortality	TACC	TAC
BNS 1	15	2	8	400	425
BNS 2	25	2	9	438	474
BNS 3	18	2	3	171	194
BNS 7	3	2	2	62	69
BNS 8	2	1	1	29	33
BNS 10	-	-	-	-	10

1.1 Commercial fisheries

Bluenose have been landed since the 1930s, although the target line fishery for bluenose only developed in the late 1970s, with the trawl fishery on the lower east cost of the North Island developing after 1983, initially as a bycatch of the alfonsino fishery (Horn 1988). The largest domestic bluenose fisheries occur in BNS 1 and 2. Historically, catches in BNS 2 were predominately taken in the target alfonsino and bluenose trawl fisheries, but have been primarily taken by target bottom longline fishing in recent years. There is a target line fishery for bluenose in the Bay of Plenty (BoP) and off Northland (BNS 1). Target line fisheries for bluenose also exist off the west coast of the South Island (BNS 7) and the central west coast of the North Island (BNS 8). Bluenose in BNS 7 are also taken as bycatch in the hoki trawl and ling line fisheries. The BNS 3 fishery is focussed on the eastern Chatham Rise where bottom longline catches were historically a bycatch of ling and häpuku target fisheries. Target bluenose lining has predominated since 2003-04. There has been a consistent bycatch of bluenose in the alfonsino target bottom trawl fishery and bluenose have been targeted sporadically in a mid-water trawl fishery in BNS 3 since the early 2000s. The bottom trawl fishery in BNS 3 has diminished. A small amount of target setnet fishing for bluenose occurred in the Bay of Plenty until 1999 and has occurred again since 2012. Target bluenose setnet fishing also occurs sporadically in the Wairarapa region of BNS 2. Setnet catches and off the east coast of the South Island have been a mix of target and bycatch in ling and häpuku target sets.

Reported landings and TACCs since 1981 are given in Table 2, while the historical landings and TACC for the main BNS stocks are depicted in Figure 1.

Table 2: Reported landings (t) of bluenose by Fishstock from 1981 to 2013-14 and actual TACCs (t) from 1986–87 to 2013-14. QMS data from 1986-present.

Fish stock	BNS 1		BNS 2		BNS 3		BNS 7		BNS 8	
FMA (s)	1 & 9		2		3, 4, 5 & 6				8	
	Landings	TACC	Landings	TACC	Landings	TACC	Landings	TACC	Landings	TACC
1981*	146		101		36		12		-	
1982*	246		170		46		22		-	
1983†	250		352		51		47		1	
1984†	464		810		81		30		1	
1985†	432		745		73		26		1	
1986†	440		1 009		33		53		1	
1986–87	286	450	953	660	93	150	71	60	1	20
1987–88	405	528	653	661	101	166	104	62	1	22
1988–89	480	530	692	768	90	167	135	69	13	22
1989–90	535	632	766	833	132	174	105	94	3	22
1990–91	696	705	812	833	184	175	72	96	5	22
1991–92	765	705	919	839	240	175	62	96	5	22
1992–93	787	705	1 151	842	224	350	120	97	24	22
1993–94	615	705	1 288	849	311	350	79	97	27	22
1994–95	706	705	1 028	849	389	357	83	150	79	100
1995–96	675	705	953	849	513	357	140	150	70	100
1996–97	966	1 000	1 100	873	540	357	145	150	86	100
1997–98	1 020	1 000	929	873	444	357	123	150	67	100
1998–99	868	1 000	1 002	873	729	357	128	150	46	100
1999–00	860	1 000	1 136	873	566	357	114	150	55	100
2000–01	890	1 000	1 097	873	633	357	87	150	14	100
2001–02	954	1 000	1 010	873	+733	+925	70	150	17	100
2002–03	1 051	1 000	933	873	+876	+925	76	150	66	100
2003–04	1 030	1 000	933	873	915	925	117	150	96	100
2004–05	870	1 000	1 162	1 048	844	925	94	150	42	100
2005–06	699	1 000	1 136	1 048	536	925	84	150	20	100
2006–07	742	1 000	957	1 048	511	925	164	150	50	100
2007–08	585	1 000	1 055	1 048	660	925	145	150	53	100
2008–09	627	786	864	902	444	505	80	89	31	43
2009–10	665	786	845	902	419	505	94	89	36	43
2010–11	623	786	560	902	411	505	75	89	27	43
2011–12	417	571	431	629	256	248	94	89	20	43
2012–13	368	400	449	438	245	171	53	62	26	29
2013-14	382	400	435	438	248	171	60	62	28	29

Fish stock	BNS 10			
FMA (s)	10		Total	
	Landings	TACC	Landings	TACC
1981*	0		295	
1982*	0		484	
1983†	0		701	
1984†	0		1 386	
1985†	0		1 277	
1986†	0		1 536	
1986–87	7	10	1 411	1 350
1987–88	10	10	1 274	1 449
1988–89	10	10	1 420	1 566
1989–90	0	10	1 541	1 765
1990–91	#12	#10	1 781	1 831
1991–92	#40	#10	2 031	1 837
1992–93	#29	#10	2 335	2 016
1993–94	#3	#10	2 323	2 023
1994–95	0	10	2 285	2 161
1995–96	0	10	2 351	2 161
1996–97	#9	#10	2 846	2 480
1997–98	#30	#10	2 613	2 480
1998–99	#2	#10	2 775	2 480
1999–00	#0	#10	2 731	2 480
2000–01	#0	#10	2 721	2 480
2001–02	#0	#10	2 784	3 048
2002–03	0	10	3 002	3 058
2003–04	0	10	3 091	3 058
2004–05	0	10	3 012	3 233
2005–06	0	10	2 475	3 233
2006–07	0	10	2 425	3 233
2007–08	0	10	2 498	3 233
2008–09	0	10	2 046	2 335
2009–10	0	10	2 059	2 335
2010–11	0	10	1 696	2 335

Table 2 [Continued]

Fish stock		BNS 10		
FMA (s)		10		Total
2011–12	0	10	1 218	1 590
2012–13	0	10	1 142	1 110
2013-14	0	10	1 190	1110

* MAF data, † FSU data, # Includes exploratory catches in excess of the TAC, + An additional transitional 250 t of ACE was provided to Chatham Islands fishers, resulting in an effective commercial catch limit of 1 175 t in 2001–02 and 2002–03.

Bluenose landings prior to 1981 were poorly reported, with bluenose sometimes being recorded as bonita, or mixed with hapuku/bass/groper and foreign licensed and charter catches in the 1970s included bluenose catches as warehou and butterfish. Landings before 1986–87 have been grouped by statistical area that approximate the current QMAs.

TACCs were first established for bluenose upon introduction to the QMS in 1986–87, with TACCs for all bluenose stocks totalling 1350 t. From 1992 to 2009 all bluenose Fishstocks were included, for at least some of the time, in Adaptive Management Programmes (AMPs). BNS 3 was the first stock to enter an AMP in October 1992, with a TACC increase from 175 t to 350 t. This was further increased within the AMP to 925 t in October 2001, plus an additional transitional 250 t of ACE provided to Chatham Islands fishers in 2001–02 and 2002–03 only. BNS 7 (TACC increase from 97 t to 150 t) and BNS 8 (TACC increase from 22 t to 100 t) entered AMPs in October 1994. BNS 1, the second largest bluenose fishery, entered an AMP in October 1996, with a TACC increase from 705 t to 1000 t. BNS 2, the largest bluenose fishery, was the most recent entry into an AMP in October 2004, with a TACC increase from 873 t to 1048 t. TACCs for all bluenose stocks were reduced on 1 October 2008: 786 (BNS 1), 902 (BNS 2), 505 (BNS 3), 89 (BNS 7) and 43 (BNS 8). AMP programmes were terminated on 30 September 2009.

Under a rebuild plan following the 2011 stock assessment, there have been further phased reductions to TACCs for bluenose stocks. On 1 October 2011, TACCs were reduced to: 571 (BNS 1), 629 (BNS 2), and 248 (BNS 3); BNS 7 and BNS 8 were not reduced at that time. On 1 October 2012, TACCs were further reduced for all bluenose stocks to: 400 (BNS 1), 438 (BNS 2), 171 (BNS 3), 62 (BNS 7) and 29 (BNS 8). The 2011 rebuild plan included a third phase of TACC reductions. This phase has been delayed pending further evaluation.

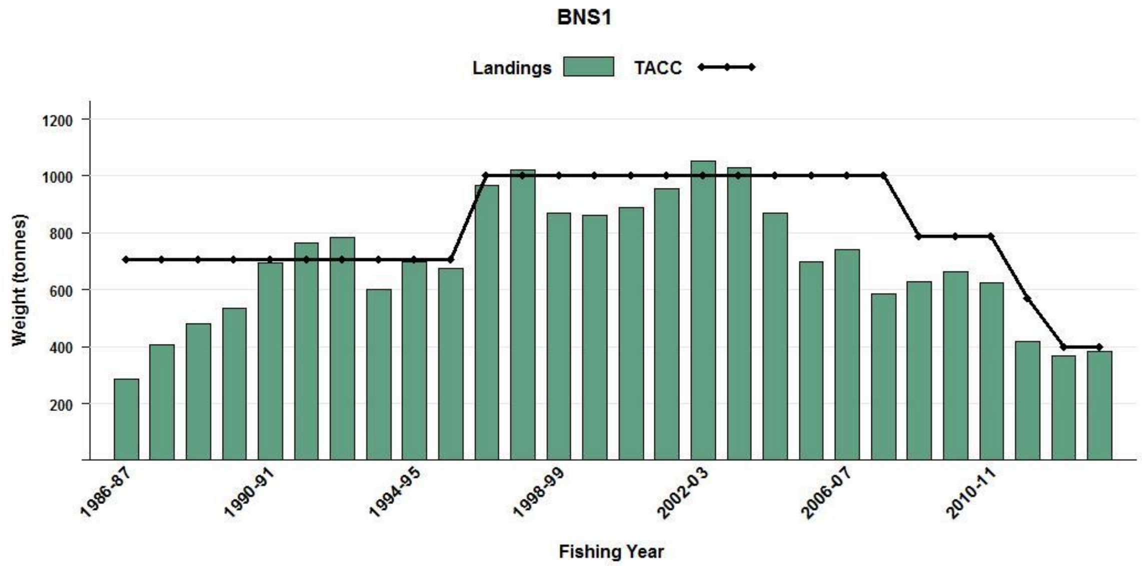
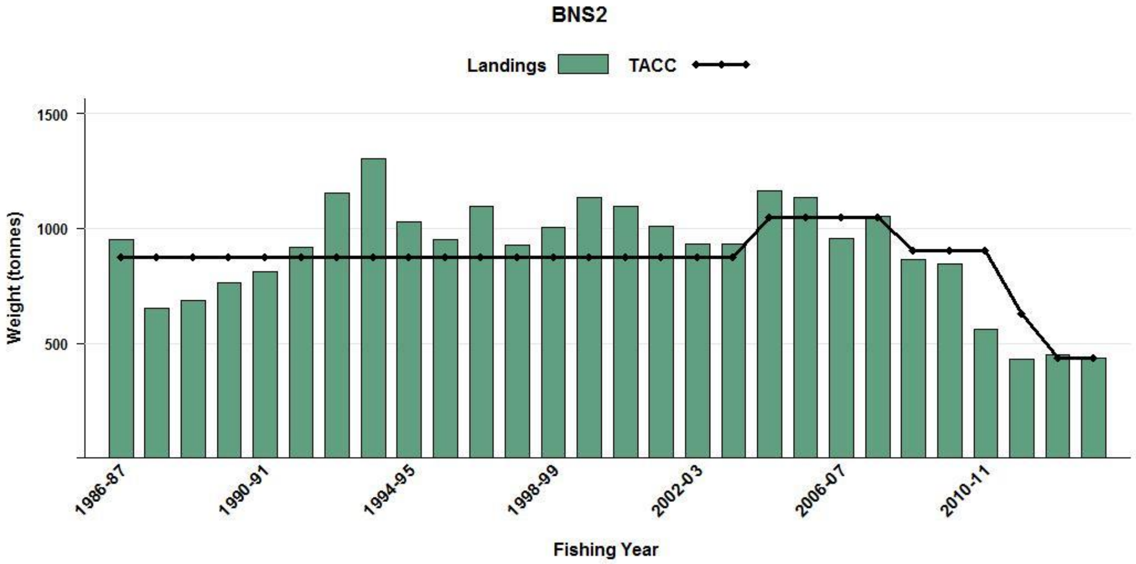
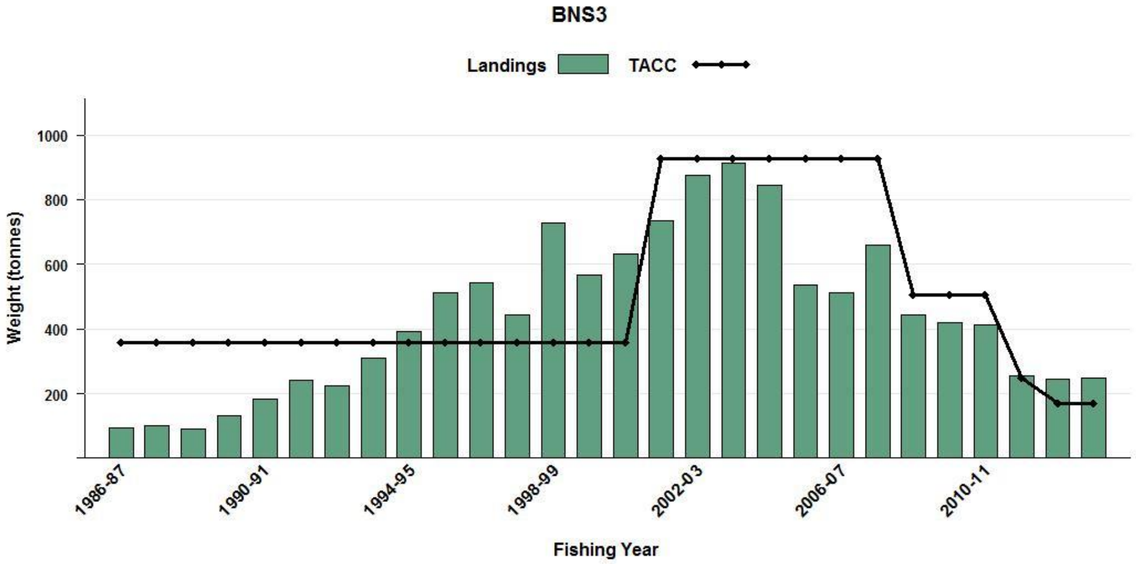


Figure 1: Reported commercial landings and TACC for the five main BNS stocks. BNS1 (Auckland East) [Continued on next page].





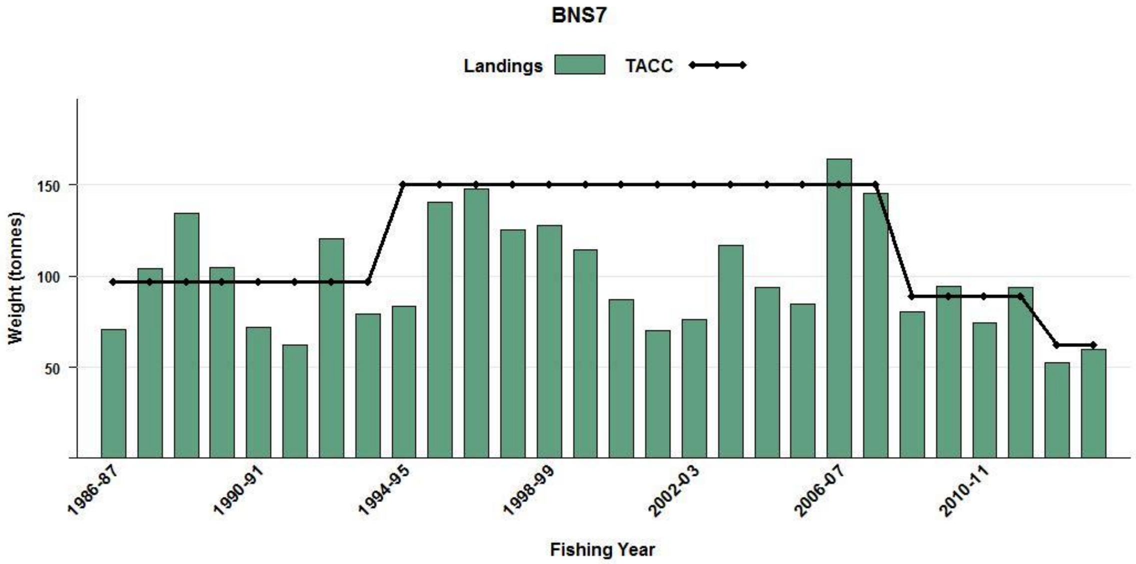


Figure 1: [Continued] Reported commercial landings and TACC for the five main BNS stocks. Top to bottom: BNS2 (Auckland East), BNS3 (Central East), BNS7 (Challenger) [Continued on next page].

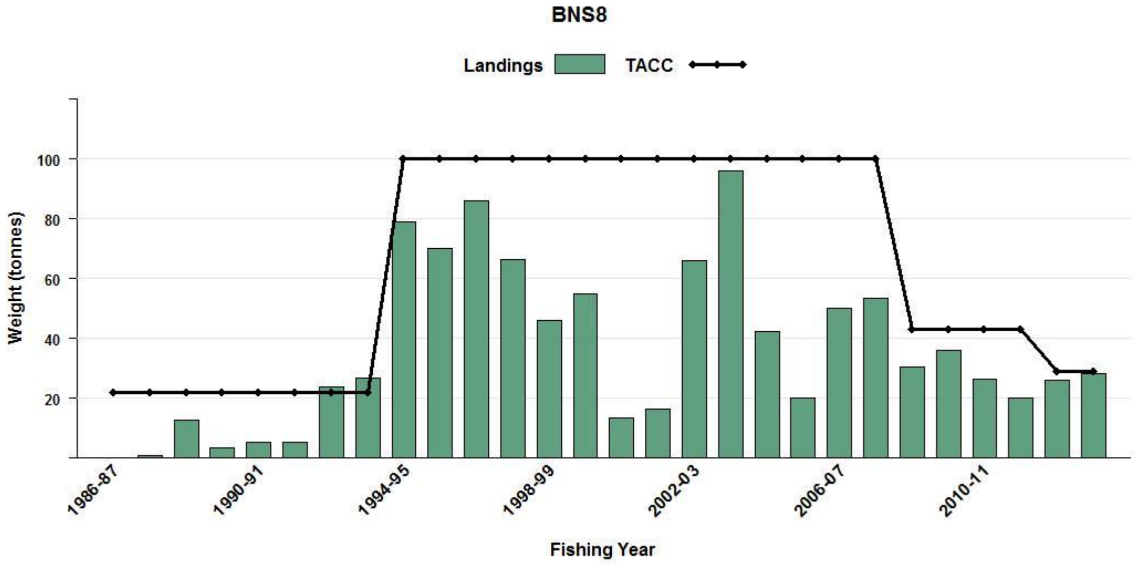


Figure 1 [Continued]: Total commercial catch and TACC for the five main BNS stocks. BNS8 (Central Egmont).

As a result of the TACC increases under AMPs, the combined total TACC for all bluenose stocks increased from an initial 1350 t in 1986-87 to 3233 t by 2004-05, before the reduction from 2008-09 to 2335 t. Catch performance against the TACC has varied, with the combined TACC being under-caught by an average 9% (average landings 1504 t / year) over 1987-88 to 1990-91, over-caught by an average 11% (average landings 2501 t / year) over 1991-92 to 2000-01, and under-caught by an average 20% (average landings 2602 t / year) from 2004-05 to 2007-08. The reduced TACC of 2335 t was under-caught by 12% in 2008-09 and 2009-10.

1.2 Recreational fisheries

Bluenose is targeted by recreational fishers around deep offshore reefs. They are caught using line fishing methods, predominantly on rod and reel with some longline catch. The allowances within the TAC for each Fishstock are shown in Table 1.

1.2.1 Management controls

From 2010 on the catch limit for recreational fishers in all areas is up to 5 bluenose per person per day as part of their multi-species (combined) individual daily bag limit.

1.2.2 Estimates of recreational harvest

There are two broad approaches to estimating recreational fisheries harvest: the use of onsite or access point methods where fishers are surveyed or counted at the point of fishing or access to their fishing activity; and, offsite methods where some form of post-event interview and/or diary are used to collect data from fishers.

The first estimates of recreational harvest for bluenose were calculated using an offsite approach, the offsite regional telephone and diary survey approach. Estimates for 1996 came from a national telephone and diary survey (Bradford 1998). Another national telephone and diary survey was carried out in 2000 (Boyd & Reilly 2005) and a rolling replacement of diarists in 2001 (Boyd & Reilly 2004 allowed estimates for a further year (population scaling ratios and mean weights were not re-estimated in 2001). The annual recreational catch of BNS 1 was estimated from diary surveys to be 2 000 fish in 1993–94 (Teirney *et al*. 1997), 5000 fish in 1996 (Bradford 1998) and 11 000 fish in 1999–00 (Boyd & Reilly 2005). The harvest estimates provided by these telephone diary surveys are no longer considered reliable.

A new national panel survey was developed, and implemented in the 2011–12 fishing year (Wynne-Jones et al. 2014). The panel survey used face-to-face interviews of a random sample of New Zealand households to recruit a panel of fishers and non-fishers for a full year. The panel members were contacted regularly about their fishing activities and catch information collected in standardised phone interviews. Note that the national panel survey estimate does not include recreational harvest taken Recreational catch estimates from the national panel survey are given in Table 3.

Table 3: Recreational harvest estimates for bluenose stocks (Wynne-Jones et al. 2014). Mean fish weights were obtained from boat ramp surveys; for bluenose the value used was 4.473 kg (Hartill and Davey 2015).

Stock	Year	Method	Number of fish	Total weight (t)	CV
BNS 1	2011/12	Panel survey	6,287	28.15	0.40
BNS 2	2011/12	Panel survey	444	1.99	0.48
BNS 3	2011/12	Panel survey	461	2.05	0.92
BNS 7	2011/12	Panel survey	456	2.02	1.00
BNS 8	2011/12	Panel survey	137	0.61	1.03

The recreational surveys indicate that the recreational harvest of bluenose is relatively small in areas other than BNS 1. There are some locally important fisheries which will not have been adequately sampled by the national panel survey.

1.3 Customary non-commercial fishing
No quantitative information on the level of customary non-commercial take is available.

1.4 Illegal catch
No quantitative information on the level of illegal catch is available.

1.5 Other sources of mortality
There have been reports of depredation by *Orca* on bluenose caught by line fisheries.

2. BIOLOGY

Depth distribution
The depth distribution of bluenose extends from near-surface waters to about 1 200 m. Research trawl surveys record their main depth range as 250–750 m, with a peak at 300–400 m, and they regularly occur to about 800 m (Anderson *et al*. 1998). Commercial catches recorded in logbook programmes implemented for some of the bluenose stocks under AMPs, and catch-effort data for these fisheries, confirm that bluenose catches range in depth from <100 m to about 1 000 m, depending on target species, but with a peak around 400 m for bluenose targeted fishing by any method.

The depth distribution of bluenose changes with size, with small juveniles known to occur at the surface under floating objects (Last *et al*. 1993, Duffy *et al*. 2000). Larger juveniles probably live in coastal and oceanic pelagic waters for one or two years. Fish 40-70 cm in length are caught between 200 m and 600 m, while larger fish, particularly those larger than 80 cm, are more often caught deeper than 600 m. A sequential move to deeper waters as bluenose grow has been confirmed by analysis of the stable radio-isotope ratios in otolith sections. Oxygen isotope ($\delta^{18}O$) ratios of bluenose otolith cores confirm residence of juvenile fish within surface waters. Changes in oxygen isotope ratios across otolith sections indicate changes in preferred mean depth with age of each fish (Horn *et al*. 2008). That study hypothesised that the larger adults may be distributed below usually fished depths on underwater topographic features, but potentially available to fisheries as a result of regular vertical feeding migrations. The largest adults appear to reside in 700-1000 m; i.e., deeper than most trawl or longline fishing for bluenose occurs. However, adult bluenose are also known to associate closely with underwater topographic features (hills and seamounts). Bluenose may undertake diurnal migrations into shallower depths to feed.

Age, growth and natural mortality
Recent ageing validation work by Horn *et al.* (2008, 2010) substantially revised estimates of maximum age and size at maturity for bluenose which were previously considered to be moderately fast growing (Horn 1988). Radiocarbon (^{14}C) levels in core micro-samples from otoliths that had been aged using zone counts were compared with a bomb-radiocarbon reference curve which provided independent estimates of the age of the fish. Horn *et al.* (2010) estimated a maximum age of 76 years, approximately

twice the previous maximum age estimate. This maximum age is consistent with the maximum age of 85 years estimated for the closely related barrelfish (*Hyperoglyphe perciformis*) in the western North Atlantic, also determined, in part, using the bomb chronometer method (Filer & Sedberry 2008). Previous under-estimates of bluenose ages appears to have resulted from the incorrect interpretation of paired, fine ‘split rings’ as single growth zones, when they probably represent two separate growth zones.

Horn & Sutton (2011) recorded a maximum age of 71 years for BNS 1, and estimated natural mortality (M) to be in the range 0.09-0.15, based on 1% of the unfished population living to 30- 50 years. Given the maximum recorded age, they commented that estimates of M less than 0.09 may be appropriate as bluenose live to at least 71 years and older fish may be poorly sampled by the line fishery. From the range of estimates resulting from recent ageing, the working group concluded that M for bluenose was unlikely to be > 0.1.

Instantaneous total mortality was estimated for five BNS 1 line fishery samples (Horn & Sutton 2011). The best estimates of Z ranged from 0.13 to 0.17, indicating that F was probably lower than M. This result was unexpected given recent strong declines in bluenose CPUE and the dramatic increase in targeting beginning in the mid-1980s. It was concluded that Z was underestimated, probably because the sampled fishing grounds did not hold closed populations, resulting in large or old fish being over-represented in the catch.

Maturity and reproduction

Biological parameters relevant to stock assessment are summarised in Table 4.

Table 4: Estimates of biological parameters for bluenose.

Fishstock						**Estimate**	**Source**
1. Natural mortality (M)							
BNS						0.09-0.15	Horn & Sutton (2011)
2. Weight = a(length)^b (Weight in g, length in cm fork length).							
					Both sexes		
BNS 2				a = 0.00963	b = 3.173		Horn (1988a)
3. Von Bertalanffy growth parameters							
			Females			Males	
	K	t_0	L_∞	K	t_0	L_∞	
BNS 2	0.071	-0.5	92.5	0.125	-0.5	72.2	Horn *et al.* (2010)
3. Age at maturity (50%)							
			Females	Males			
a_{50}			17	15			Horn & Sutton (2011)

Little is known about the reproductive biology of bluenose. Maturity ogives derived from aged bluenose caught in BNS 1 from January to may indicated that ages at 50% maturity were about 15 and 17 years for males and females, respectively (Horn & Sutton 2011). Data from commercial logbook programmes implemented under AMPs indicate that bluenose sampled in QMAs 1, 3, 7 and 8 mature at between 60 cm and 65 cm. Analysis of gonad maturity stage proportions for bluenose sampled by commercial logbook programmes, primarily in BNS 1, 7 & 8, indicate that spawning probably peaks from February to April annually. No distinct spawning grounds have been identified for bluenose in New Zealand waters. The logbook programmes have sampled reproductively active fish around the North Island from East Cape to west of Cook Strait, and off the south west coast of the South Island. Observer data includes a small number of observations of spawning fish, but these extend from the southern half of FMA 10 to the Stewart-Snares shelf.

3. STOCKS AND AREAS

Stock boundaries are unknown, but similarity in trends in catch and CPUE across fisheries occurring in each of the five New Zealand BNS QMAs suggests the possibility that there may be a single BNS stock across all these areas, or of some close relationship between stocks in these QMAs. Tagging studies have shown that bluenose are capable of extensive migration, i.e., from the Wairarapa coast to Kaikoura, BoP, and North Cape (Horn 2003). There is a possibility that the long period of relatively stable CPUE observations in the face of increasing catches before the period of decline may be evidence of hyper-stability caused by the replenishment of adult stocks on specific areas or features. Increases in BNS targeting in some areas and increasing catches, could have exceeded the replenishment rate, causing the rapid and synchronous declines observed from about 2001–02 to 2011–12. Alternatively, there could be a simultaneous drop in recruitment due to coincident environmental factors. An environmental mechanism simultaneously affecting availability or catchability of BNS across all QMAs is considered to be less likely than the possibility of a single stock, or of correlated recruitment across sub-stocks in the various areas.

4. STOCK ASSESSMENT

The first fully quantitative stock assessment modelling for bluenose was carried out in 2011. Models were implemented in the general purpose Bayesian stock assessment program CASAL (Bull *et al.* 2009). Standardised catch per unit effort (CPUE) indices were updated in 2015.

4.1 Methods

Model structure
The 2011 assessment model (Cordue & Pomarède 2012) assumed a single New Zealand stock of bluenose, partitioned into two sexes, with 80 age groups (1-80 years with a plus group), and without maturity in the partition. The model has a single time-step, single area, two year-round fisheries (line and trawl), and mid-fishing-year spawning. The stock was assumed to be at B_0 in 1935. The maximum allowable exploitation rate in each fishery was set to 60%.

Data
The catch history in the model starts in 1936 when some bluenose were landed as groper or hapuku. The main uncertainty in the catch history is the foreign catch just prior to the implementation of the EEZ in 1978. Foreign vessels recorded bluenose catch within mixed-species groups, typically as part of a general warehou category. Catch data in the early 1980s were used to estimate the likely proportion of bluenose within a mixed warehou and bluenose group. Where possible, this was done on an area-specific basis and the proportions were applied to the pre-EEZ mixed-species catches. Due to the uncertainties in species attributions mentioned above, alternative bluenose proportions were used to construct three alternative catch histories: low, mid, and high (Figure 2, Table 5).

The catch histories for the line and trawl fisheries from 1989-90 to 2006-07 were derived from the bluenose characterisations conducted for the 2008 AMP review. From 2007-08 onwards, the total recorded catch was split between line and trawl fisheries in roughly the same proportion as the catches from the 2006-07 year. The 2009-10 catch was rounded down to provide the assumed total catch in 2010-11. Recreational and illegal catch were assumed to be zero.

Table 5: The three alternative catch (t) histories used in the BNS model runs. Trawl catch prior to 1970 was assumed to be zero.

	Line				Line				Trawl		
	Low	Mid	High		Low	Mid	High		Low	Mid	High
1936	0	75	150	1963	0	59	119				
1937	0	75	150	1964	0	66	133				
1938	0	75	150	1965	0	64	128				
1939	0	75	150	1966	0	61	123				
1940	0	56	112	1967	0	65	129				
1941	0	50	100	1968	0	57	113				
1942	0	50	100	1969	0	55	111				
1943	0	50	100	1970	0	70	140	1970	0	0	0
1944	0	50	100	1971	0	69	138	1971	0	0	0
1945	0	50	100	1972	0	59	118	1972	0	45	78
1946	0	69	138	1973	0	63	126	1973	0	42	72
1947	0	75	150	1974	0	69	137	1974	0	68	117
1948	0	81	162	1975	111	182	252	1975	0	116	204

Table 5 [continued]

	Line				Line				Trawl		
	Low	Mid	High		Low	Mid	High		Low	Mid	High
1949	0	95	189	1976	618	692	767	1976	0	112	211
1950	0	89	177	1977	821	913	1004	1977	0	385	1505
1951	0	74	147	1978	1	81	161	1978	0	0	0
1952	0	71	142	1979	9	92	176	1979	0	0	0
1953	0	70	141	1980	15	98	180	1980	0	0	0
1954	0	69	137	1981	235	300	365	1981	0	0	0
1955	0	66	132	1982	469	511	554	1982	0	0	0
1956	0	69	138	1983	730	755	780	1983	0	0	0
1957	0	69	138	1984	951	956	962	1984	324	324	324
1958	0	75	149	1985	1013	1013	1013	1985	372	372	372
1959	0	68	137	1986	982	982	982	1986	605	605	605
1960	0	62	124	1987	744	744	744	1987	667	667	667
1961	0	60	121	1988	752	752	752	1988	522	522	522
1962	0	59	118	1989	797	797	797	1989	623	623	623

	No variation	
	Trawl	Line
1990	763	777
1991	577	1192
1992	549	1414
1993	733	1573
1994	860	1459
1995	904	1382
1996	811	1503
1997	1060	1765
1998	779	1728
1999	904	1871
2000	1022	1712
2001	1082	1638
2002	1345	1443
2003	1331	1671
2004	957	2133
2005	1114	1900
2006	710	1765
2007	424	2001
2008	500	2000
2009	300	1746
2010	300	1759
2011	300	1700

Two CPUE indices (Starr & Kendrick 2013) were fitted as indices of abundance, one for line and one for trawl fisheries (Figure 3). CVs of 20% were assumed for each year. This assumption incorporates some process error as the estimated CVs for the CPUE indices are unrealistically low (as is typical for indices estimated using a GLM approach).

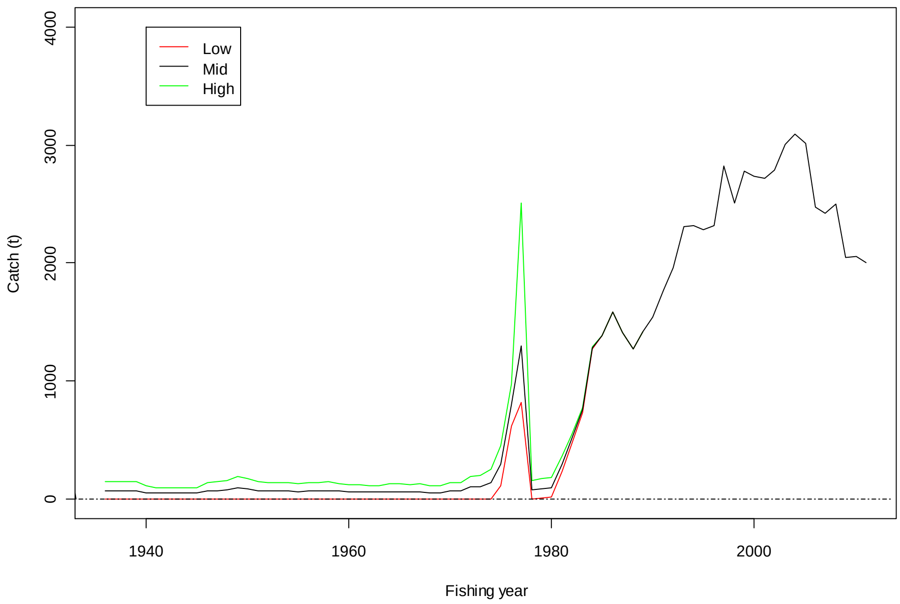


Figure 2: The three alternative catch histories used in BNS model runs.

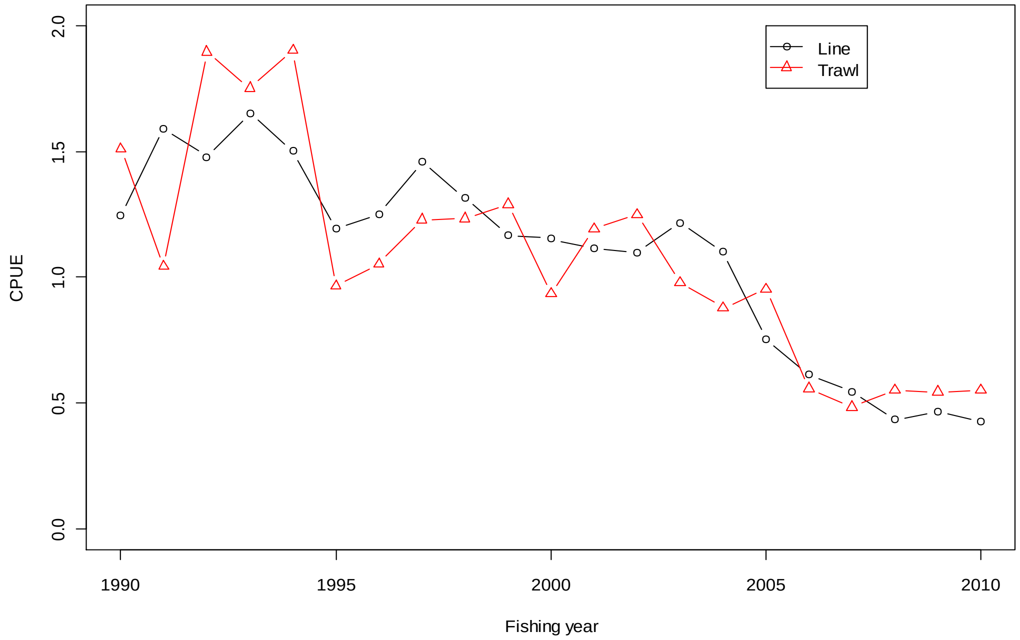


Figure 3: The line and trawl CPUE indices fitted in the 2011 BNS assessment model runs.

Logbook and observer length samples were used to construct annual length frequencies for the line and trawl fisheries for each year when there were more than 500 fish measured (Line: 1993-2008; Trawl: 1995-2004). For each sample, the length frequency was scaled to the numbers of fish in the sampled catch. Catch-weighted samples were then combined with no further scaling or stratification.

Two age frequencies were fitted in each run: one from trawl caught fish on the Palliser Bank, for the single fishing-year 1985-86, and one for line caught fish in the BoP and East Northland, combined across areas for the fishing year 2000-01.

Fixed and estimated parameters

In the final assessment runs, year-class strengths (YCSs) were assumed deterministic and only B_0 (uniform-log prior), the nuisance *q*s (for the two CPUE time series; uniform-log priors), the fishing selectivities (both double normal, uniform priors), and the CV of length at age (uniform prior) were estimated. Natural mortality (*M*) and steepness (*h*) were varied (see MPD runs below).

Fixed parameters were assigned the following values:

	Male	**Female**	**Source**
Length-weight (cm, g)			
a	0.00963	0.00963	Plenary report
b	3.173	3.173	
von Bertalanffy growth			
t_0	–0.5	–0.5	Horn *et al.* 2010
L_∞	72.2	92.5	
k	0.125	0.071	
Maturity (logistic)			
a_{50}	15	17	Horn & Sutton 2010
$a_{95} - a_{50}$	5	10	Horn & Sutton 2010

Assessment runs

Initial assessment runs indicated that the assessment was sensitive to the assumed catch history, natural mortality, and stock-recruitment steepness. As a result the working group agreed to present results from a "grid" of MPD runs. The final set of 18 runs consisted of all combinations of:

- catch history: low, mid, high
- *M*: 0.06, 0.08, 0.10
  h: 0.75, 0.9

The *M* values cover what the working group considered a plausible range. The default assumption of *h* = 0.75 was adopted, and h = 0.9 was included as a sensitivity.

Iterative re-weighting was used to determine weights for the run with mid catch, *M* = 0.08 and *h* = 0.75. The CVs were unaltered from the initial assumption of 20%. These CVs and the sample-sizes, determined from the re-weighting, were fixed for all other runs. Convergence was checked for two runs (mid catch and mid *M*, with h = 0.75 and *h* = 0.90). An MCMC run was also conducted for mid catch and mid *M* with *h* = 0.75. This was to check that the MPD estimates were not substantially different from the medians of the posterior distributions for B_0 and stock status. As all runs had the same simple model structure, MCMCs were not conducted for other runs.

4.2 Results

The fishing selectivities for both trawl and line were estimated to be domed. However, the shapes of the fishing selectivities, especially for the line fishery, were confounded with *M* (Figure 4). The CV of length at age was estimated at 6% for all of the runs.

The fits to the CPUE indices were consistent with the assumed CVs of 20%. However, for both time series, a poor residual pattern was apparent, especially for the line CPUE (Figure 5). The line CPUE is flatter than the predicted values from 1990 to 2004, and then steeper than the predictions from 2005 to 2010.

The trawl and line fisheries showed different trends in exploitation rates, with the trawl fishery peaking from 2002 to 2005 and the line fishery increasing from 1980 to 2011 (Figure 6).

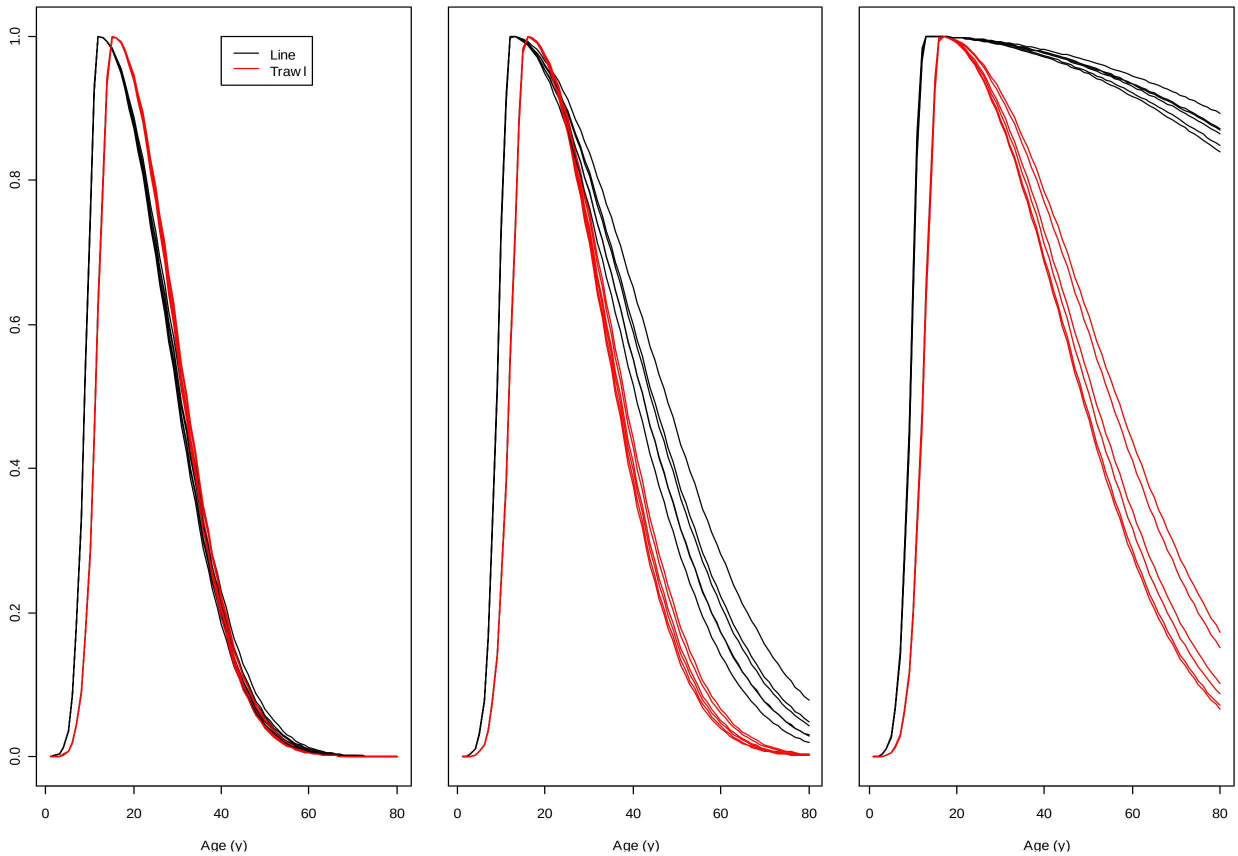


Figure 4: Estimated fishing selectivities for the trawl and line fisheries for the final 18 MPD runs. Each plot shows the results for six runs with the same value of *M* (which increases from 0.06 to 0.08 to 0.10 from left to right in the three plots).

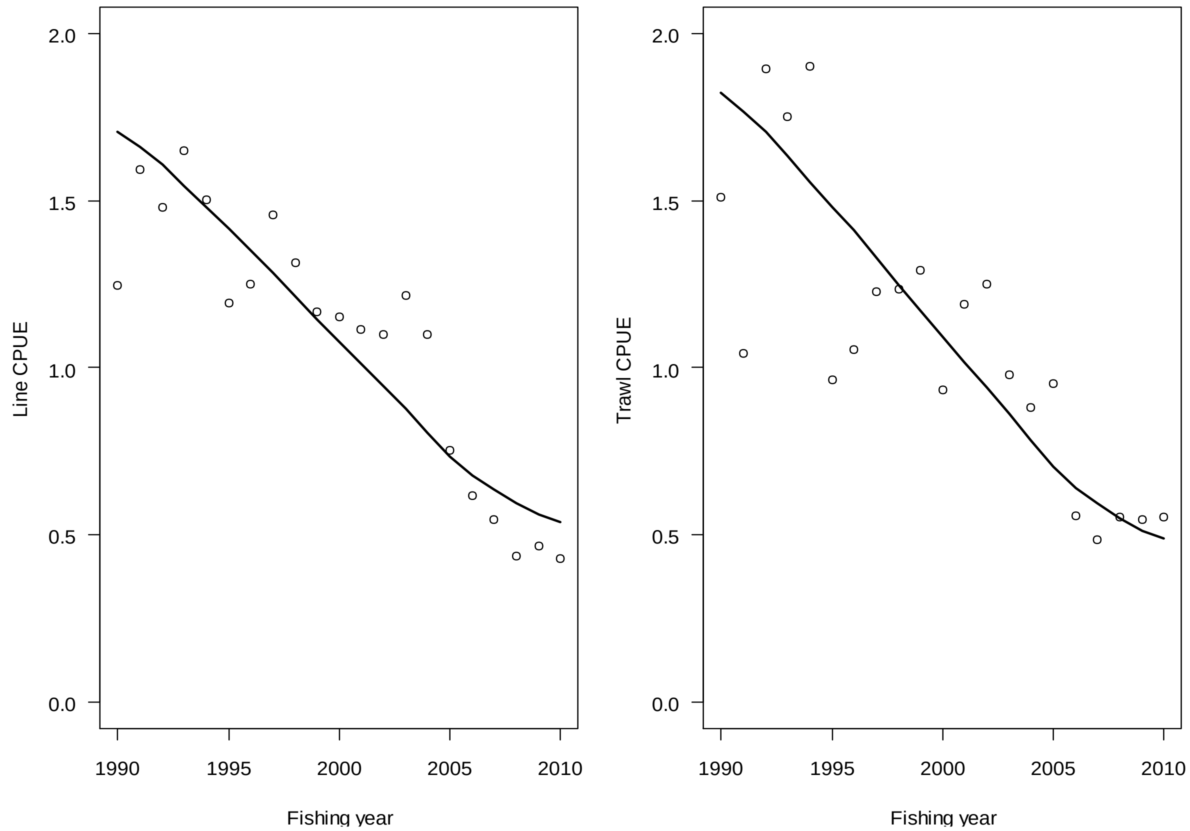


Figure 5: The model fits to the line and trawl CPUE for the run with mid catch, mid *M* and *h* = 0.75. The fits for the other runs were almost identical.

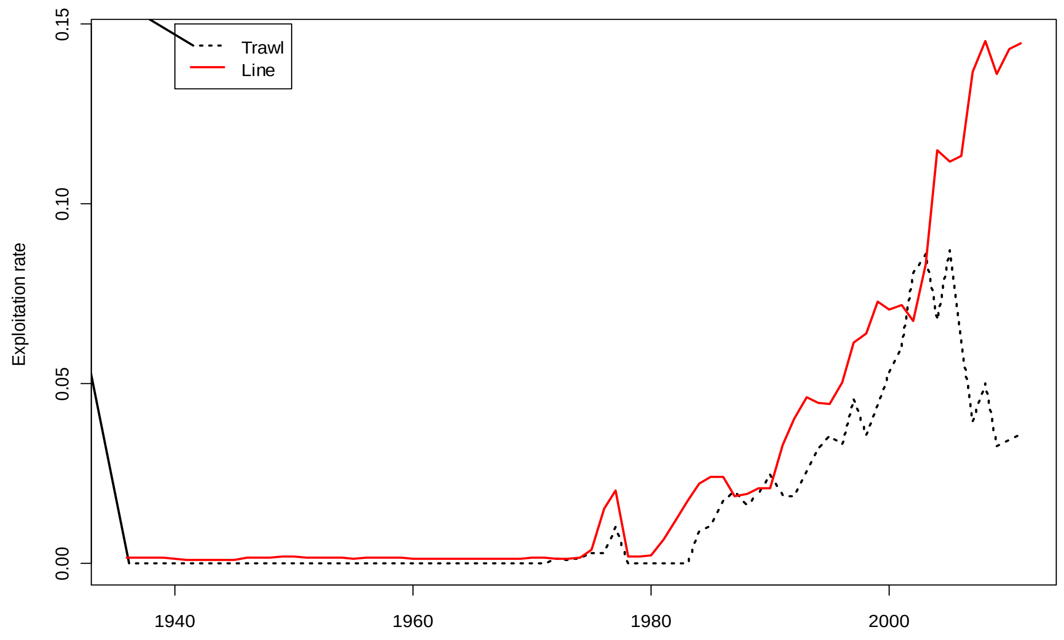


Figure 6: Exploitation rates (catch divided by beginning-of-year selected biomass) for the trawl and line fisheries for the run with mid catch, mid *M*, and *h* = 0.75.

The differences between the biomass trajectories from the 18 assessment runs are driven by the value of *M* (Figures 7 & 8) with estimates of B_0 ranging from just over 30 000 t at an *M* of 0.1 to around 60 000 t with an *M* of 0.06.

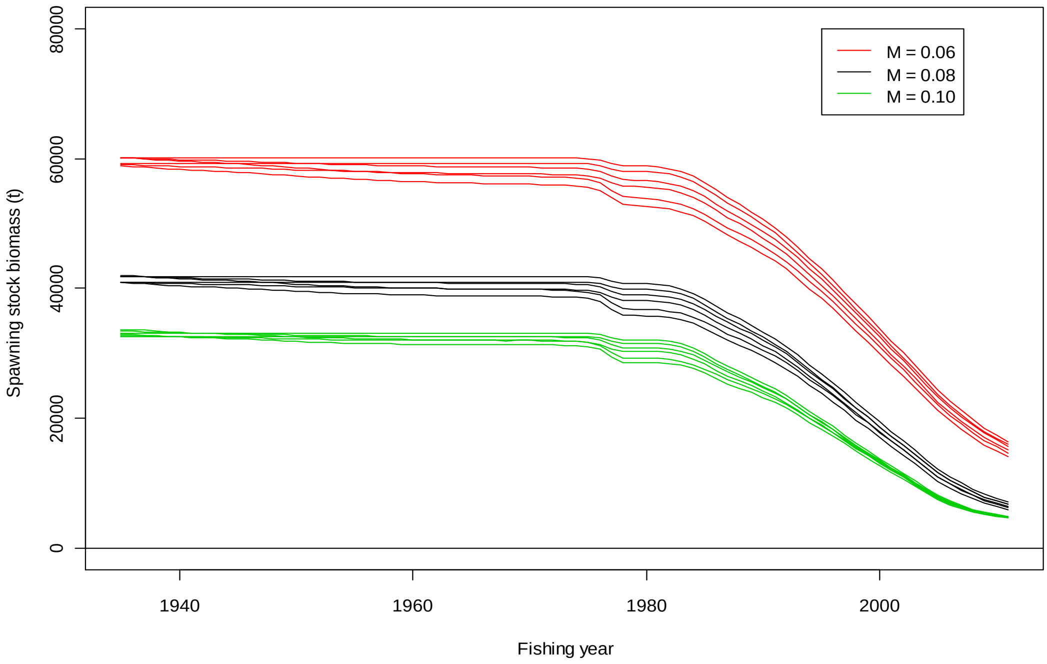


Figure 7: Biomass trajectories (t) for the final set of 18 MPD runs.

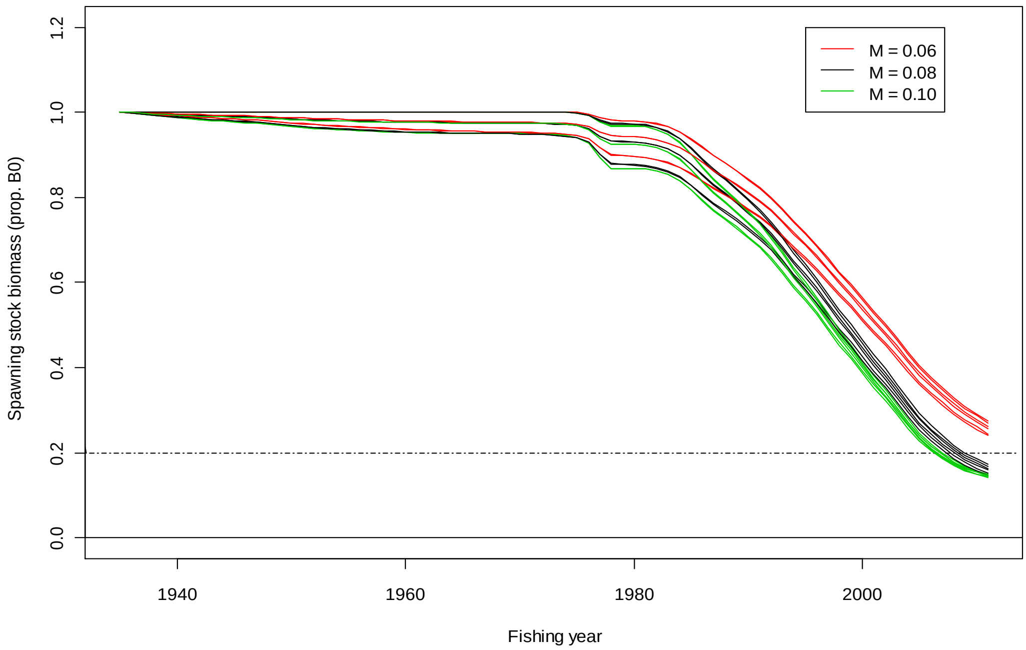


Figure 8: Biomass trajectories (proportion of B_0) for the final set of 18 MPD runs.

Biomass trajectories, as a proportion of B_0, all show a similar trend with a continuous decline from the late 1980s to 2011 (Figure 8). The runs presented are in two groups with regard to current stock status. The 6 runs with M = 0.06 are above 20% B_0 while the 12 runs with M = 0.08 or M = 0.10 are below 20% B_0 (Figure 8, Table 6). These results should not be interpreted as there being a 66% probability that the stock is below 20% B_0. It is the range of the results that is important. The proportion of runs above or below 20% B_0 can be altered by including additional runs at different M values.

Table 6: Estimates of B_0, B_{2011} and stock status (B_{2011}/B_0) for the final 18 runs. The range is given for the 6 runs at each value of M. B_0 and B_{2011} are mid-spawning season (after half the annual catch has been removed).

M	B_0 (000 t)	B_{2011} (000 t)	B_{2011}/B_0
0.06	60-60	15-16	0.24-0.27
0.08	42-42	6.3-7.0	0.15-0.17
0.10	33-34	4.8-5.0	0.14-0.15

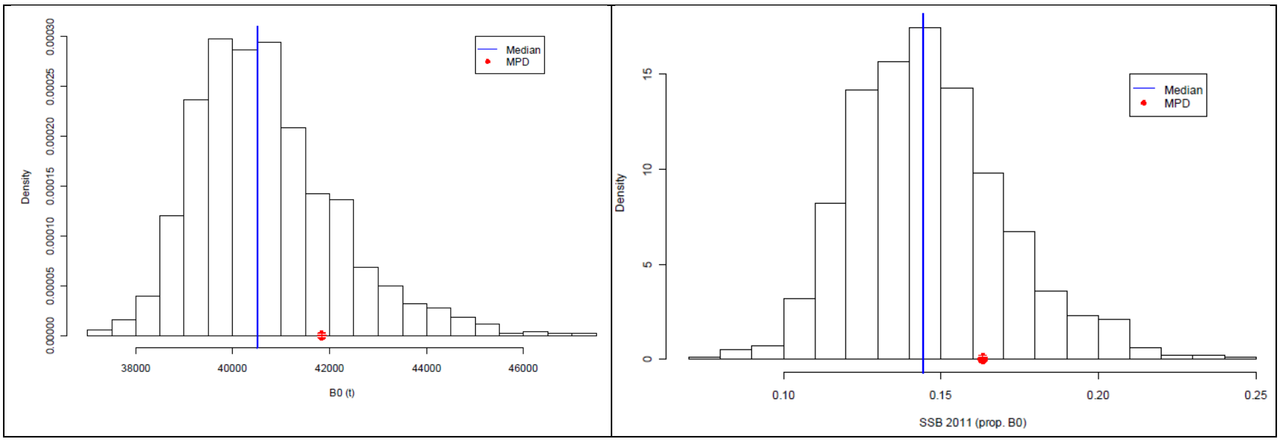


Figure 9: MCMC posteriors for B_0 and B_{2011}/B_0 for the mid catch, M = 0.08 and h = 0.75.

The MCMC run for the mid catch, M = 0.08 and h = 0.75 confirmed that the MPD and median of the posterior were similar for B_0 and stock status (Figure 9).

Assuming trawl and line catches remain in the same proportions as those used for 2010-11 in the model catch history, deterministic B_{MSY} was estimated as 25% B_0 when h = 0.75 and 15-18% B_0 when h = 0.9.

4.3 Projections

Deterministic projections to 2050 were carried out for a range of future constant catches, maintaining the 2009/10 ratio between catches from the line and trawl fisheries. Projections were carried out for the models fitted with the mid catch history only, as the different catch history scenarios had little effect on model estimates.

Catches at the level of the 2010/11 TACC or the 2009/10 catch (which was not much less than the TACC) were predicted to cause the stock to decline to very low abundance over the next 20 years (Figure 10). For a stock below the soft limit of 20% B_0, the time required for SSB to rebuild to 40% B_0 with no future catch is called T_{min}. Although the point estimates for some runs with low M are above 20% B_0, the time required to rebuild to 40% B_0 was calculated for each run and is denoted as T_{min}. The estimates of T_{min} range from 10 to 13 years (Table 7) and the maximum catches that allow a rebuild to 40% B_0 within twice T_{min} (the maximum rebuilding time under the Harvest Strategy Standard) range from 570–840 t (Table 8).

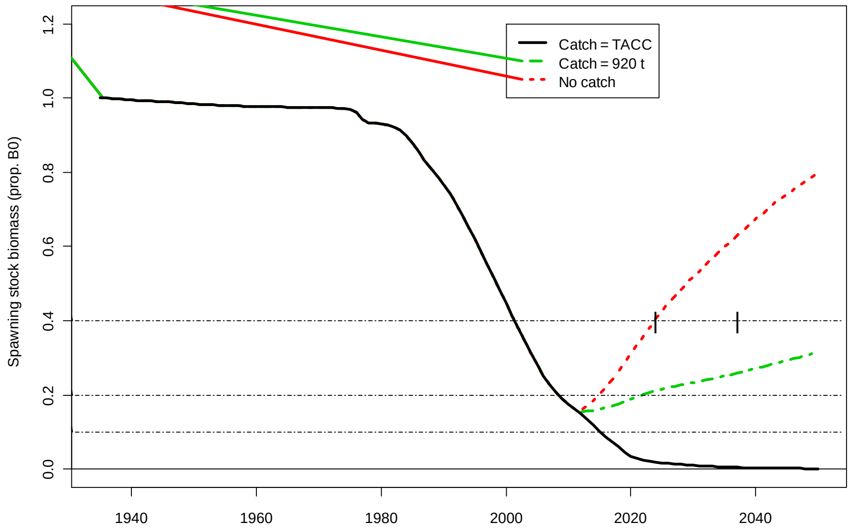


Figure 10: Projected SSB at different catch levels from the run with mid catch, M = 0.08 and h = 0.75. The two short vertical lines at 40% B_0 mark 2011 + T_{min} and 2011 + 2 T_{min}.

Table 7: The number of years before SSB reaches 40% B_0 when no future catch is taken. The duration, in a whole number of years, is defined as "T_{min}" and is shown for the six runs with the mid catch and combinations of *M* and h.

	h	
M	**0.75**	**0.90**
0.06	13	12
0.08	13	12
0.10	11	10

Table 8: The maximum catch (t) that allows SSB to rebuild to at least 40% B_0 within twice T_{min} for the six runs with mid catch.

	h	
M	**0.75**	**0.90**
0.06	600	720
0.08	570	770
0.10	600	840

4.4 Other factors

This assessment relies on standardised catch per unit effort as an index of abundance. Members of the fishing industry have noted that bluenose fisheries have undergone a number of changes not all of which are adequately captured in the statutory catch effort data. These include changes in quota holdings, company structures and vessel operators, and subtle shifts in fishing practice. The effect of increasing the number of hooks per line set and per day was investigated by identifying vessels that had changed their practice over time. The CPUE analysis was repeated without these vessels and the resulting standardised indices were very similar to those derived from the full dataset (Starr 2011).

Prior to 2008, CPUE was not considered to be a reliable indicator of abundance of bluenose. However, in 2008, close coincidence observed in declining trends in most trawl and line CPUE indices in recent years increased confidence in their value as indices of abundance. Standardised CPUE series, based on data from six fisheries spanning most major fisheries taking BNS in the NZ EEZ, declined an average of 64% over the period 2001-02 to 2006-07.

Catch at age data are limited, but suggest that the composition of catches can vary significantly on small spatial and temporal scales. The available catch-at-age data are insufficient to allow reasonable estimation of variation in year class strengths.

Information relating to bluenose stock structure is limited. In 2008, the AMP Working Group conducted full reviews of all bluenose Fishstocks which included separate CPUE abundance index standardisations for each Fishstock (Ministry of Fisheries 2008). The close coincidence between trends in the indices for all bluenose Fishstocks led the AMP Working Group to conclude that bluenose may constitute a single New Zealand-wide stock.

More complex spatial structuring of bluenose populations, such as the replenishment of the population on fished features from a wider stock pool, is also plausible and may imply a non-linear relationship between CPUE and abundance. However, preliminary modelling exploring a non-linear relationship between longline CPUE and abundance did not improve the fit to the CPUE indices.

4.5 Updated standardised CPUE indices

The approach to standardising CPUE indices for bluenose was reassessed in 2014 and the key indices were updated in 2015. For the line CPUE, effort and estimated catch data were summarised for every unique combination of vessel, date and statistical area. This reduced the higher resolution catch effort records (from LTCER and LCER forms) to lower resolution data compatible with records from the earlier CELR forms. The trawl CPUE used the higher resolution tow by tow data (from TCEPR and TCER forms) at their original resolution.

In 2014, separate CPUE indices were estimated for line fisheries targeting BNS, HPB and LIN as the high resolution data provides evidence of spatial separation in these fisheries, and they target differing depth ranges and achieve markedly different catch compositions. The BNS target line CPUE index was selected as the primary line index. The trawl CPUE index included both BT and MW trawling and BNS and BYX target tows.

The primary BLL.BNS standardisation used a Weibull error distribution and model selection retained fishing year, vessel, hooks and statistical area as explanatory variables. The influence of hook numbers was examined in detail to ensure that changes in reporting and fleet composition were dealt with appropriately in the standardisation.

Nine zones were defined, as groupings of statistical areas, which better separated the bluenose fisheries than the QMA boundaries. An amalgamated national line index was estimated by weighting the zone indices by the number of 0.1 degree cells they contained that accounted for 95% of the nationwide bluenose catch. These cells were used as a proxy for bluenose habitat.

Zone indices were calculated by fitting a zone x year interaction (Figure 11). In general the individual zone indices show the same pattern as the overall index, with the exception of the southwest zone which has a much flatter index.

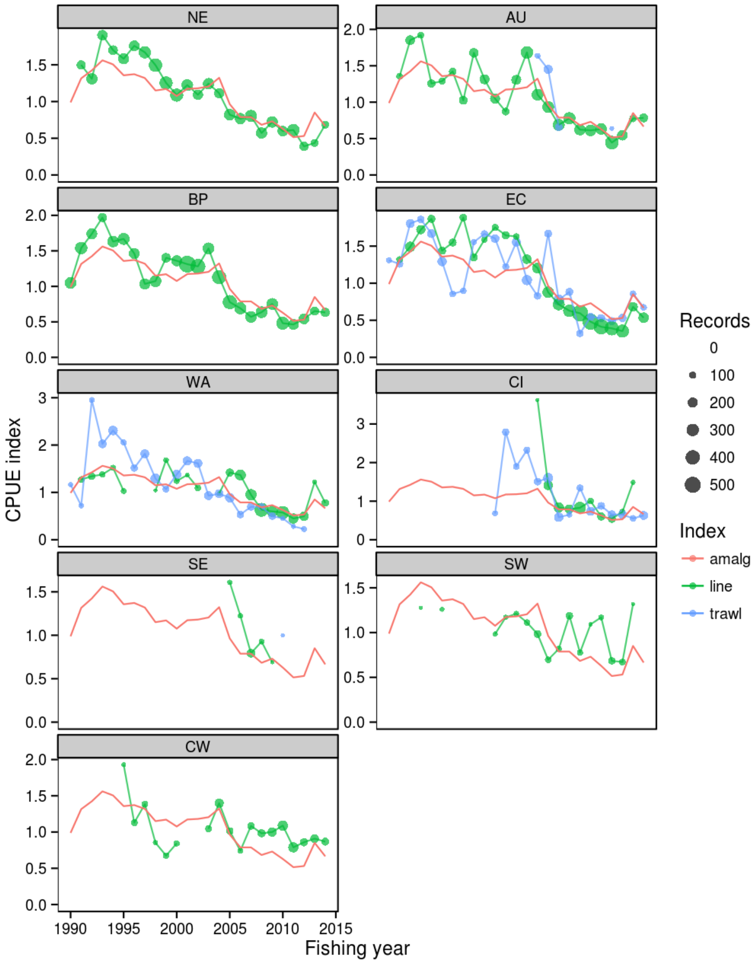


Figure 11: Zone-year indices for the line and trawl indices with the amalgamated national line index shown for reference. Zone-year combinations with less than 30 records are not shown.

The key bluenose target line and bluenose/alfonsino target trawl indices both showed an upturn in CPUE for 2012/13 (Figure 12). There is a decrease in both indices from 2012/13 to 2013/14 but they both remain above the 2011/12 nadir.

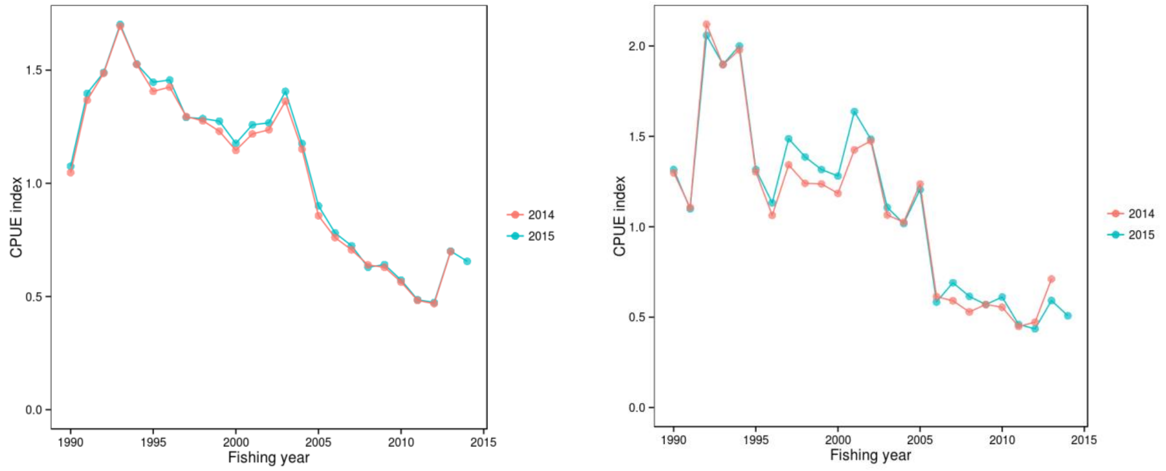


Figure 12: Standardised CPUE indices for bluenose in bluenose target longline (BLL.BNS) and bluenose/alfonsino target trawl (MW+BT.BYX+BNS). The updated 2015 indices with a new core vessel selection are shown in comparison to the 2014 estimated series.

Detailed analyses were undertaken of catch rates at the level of discrete spatial areas ("features"). No obvious, consistent changes in the distribution of catch/effort by feature since 2007/08 were apparent and there was general consistency among feature CPUE indices within a zone.

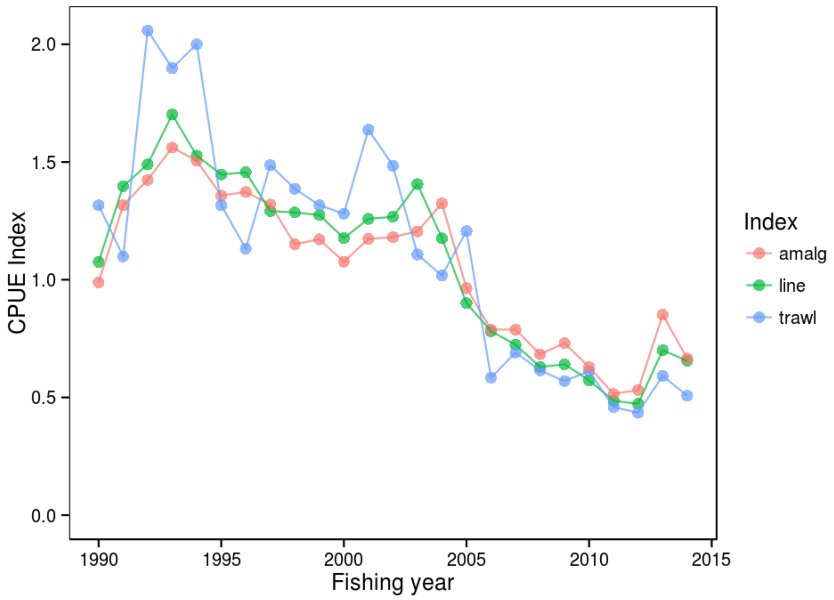
5. STATUS OF THE STOCKS

Stock Structure Assumptions
The assessment presented here assumes that bluenose in New Zealand waters comprise a single biological stock.

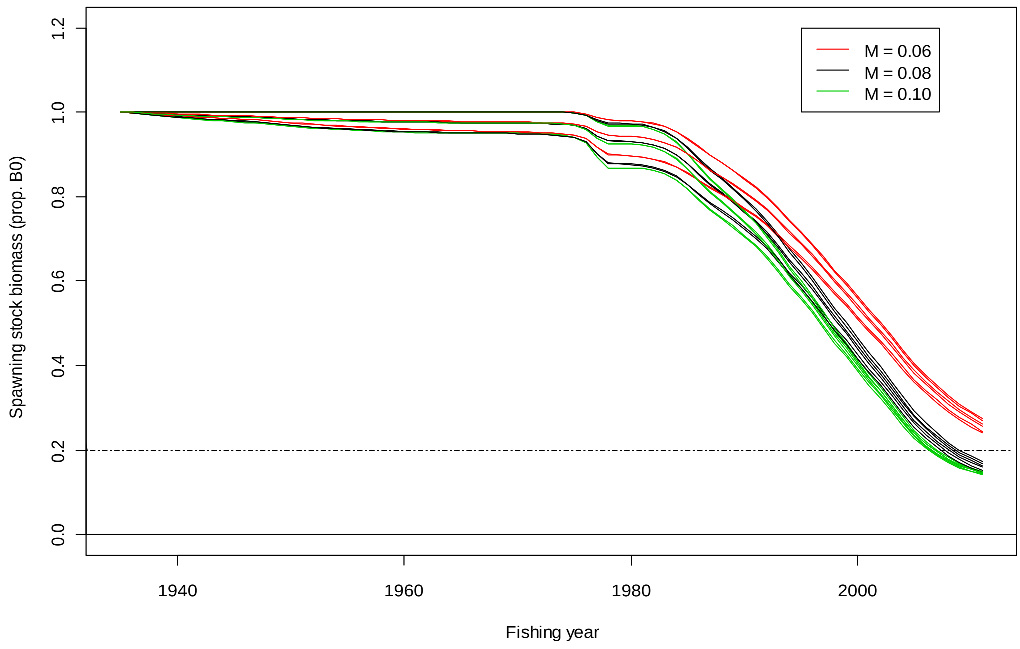
BNS 1, BNS 2, BNS 3, BNS 7, BNS 8, BNS 10

Stock Status	
Year of Most Recent Assessment	2011: Stock assessment 2015: CPUE update
Assessment runs presented	Assessment Eighteen MPD runs exploring a plausible range of catch history, natural mortality rate, and stock-recruitment steepness CPUE Standardised CPUE for bluenose target longline and bluenose/alfonsino target trawl
Reference Points	B_{MSY}: 15-25% B_0 Target: Not formally established; assumed to be 40% B_0 (based on Harvest Strategy Standard Operational Guidelines, low productivity stock) Soft Limit: 20% B_0 (HSS default) Hard Limit: 10% B_0 (HSS default)
Status in relation to Target	The New Zealand bluenose stock was assessed in 2011 to be Very Unlikely (< 10%) to be at or above the default target (MPD range B_{2011} = 14-27% B_0) but abundance indices have subsequently increased. Unlikely (< 40%) to be at or above the default target.
Status in relation to Limits	About as Likely as Not (40–60%) to be below the Soft Limit Unlikely (< 40%) to be below the Hard Limit

Historical Stock Status Trajectory and Current Status



CPUE for bluenose target longline and bluenose/alfonsino trawl. The amalgamated index is obtained by combining the individual zone line indices according to the area of bluenose habitat in each.



Spawning stock biomass trajectories (proportion of B_0) for the final set of 18 MPD. Runs.

Fishery and Stock Trends

Recent Trend in Biomass or Proxy	The MPD estimates of stock size in 2011 ranged from 14-27% B_0. Biomass was estimated to have declined continuously since the 1980s and to have been below the default target biomass since around 2000. Abundance indices showed a sharp increase in 2012/13.There was a decrease in the indices from 2012/13 to 2013/14 but they remain above the 2011/12 nadir.
Recent Trend in Fishing Mortality or Proxy	Exploitation rates were estimated to have increased from 1980 as the stock declined. In 2011 exploitation rates in the trawl fishery were estimated to have declined since 2005, but remained high in the line fishery. Reduced TACCs since 2011 have resulted in

	substantially reduced catches. Fishing mortality is therefore likely to have decreased.
Other Abundance Indices	A second BLL index based on bycatch of bluenose in the HPB fishery had a trend that was very similar to the target BNS series, but with a less pronounced increase in 2012/13. This series was not updated in 2015
Trends in Other Relevant Indicator or Variables	-

Projections and Prognosis		
Stock Projections or Prognosis	Deterministic projections with M = 0.08 and h = 0.75 predicted that stock abundance would decline to below the hard limit within the next 20 years (from 2010) under 2010 catch levels. The time to rebuild (T_{min}) to the assumed target (40% B_0) under zero catches ranges from 10 to 13 years, depending on model assumptions. Within the range of model runs explored, the maximum catch (EEZ wide) that would rebuild the stock to the target within twice T_{min} was 570-600 t for h = 0.75 and 720-840 t for h = 0.9. A rebuilding plan to reduce catches and rebuild the stock to target levels within twice T_{min} was developed. Two stepped reductions in TACC were implemented and a third has been put on hold following a substantial increase in the standardised CPUE abundance indices.	
Probability of Current Catch or TACC causing Biomass to remain below or to decline below Limits	Soft Limit: Unlikely (< 40%) Hard Limit: Very Unlikely (< 10%)	
Probability of Current Catch or TACC causing Overfishing to continue or to commence	Very Unlikely (< 10%)	
Assessment Methodology		
Assessment Type	Level 1: Full Quantitative Stock Assessment (2011) Level 2: Partial Quantitative Assessment (2014)	
Assessment Method	Age-structured CASAL model with MPD estimation over a range of plausible catch histories, natural mortality rates and steepness.	
	-	
Assessment Dates	Latest assessment: Stock Assessment: 2011; CPUE: 2015	Next assessment: 2016
Overall assessment quality rank	1 – High Quality	
Main data inputs (rank)	- CPUE indices derived from statutory catch and effort reporting - Length frequency data from sampling conducted under the Adaptive Management Programme, and from observer data - One age frequency distribution for each of the trawl and line fisheries	1 – High Quality 1 – High Quality 1 – High Quality

Data not used (rank)	-	
Changes to Model Structure and Assumptions	Stock Assessment The 2011 assessment was the first full quantitative assessment of bluenose and assumes a single NZ-wide stock. CPUE indices for longline and trawl fisheries were assumed to index abundance. CPUE The 2015 CPUE index for the longline fishery is based only on BNS target fishing rather than BNS, HPB and LIN target sets (used in the 2011 assessment), and combined indices by zone weighted by a habitat proxy.	
Major Sources of Uncertainty	- Stock structure and spatial dynamics are uncertain. - The assessment assumes that CPUE indexes abundance. - Natural mortality is uncertain; the plausible range considered affects the estimate of current status, and is confounded with the estimated fishery selectivities. - Method specific selectivities are considered constant across areas. - Deterministic recruitment is assumed; variations in year class strengths are not estimated. - Catches are known and the catch history is complete.	

Qualifying Comments
Alternative plausible stock hypotheses have not been explored. Although some increase in BNS biomass is likely to have occurred as a result of the recent TACC reductions, the low productivity of BNS suggests that biomass is unlikely to have increased from 2011–12 to 2012–13 to the same degree as CPUE. Since bluenose aggregate on features, and CPUE is consequently likely to be hyper-stable, it is possible that smaller increases in abundance could be disproportionately reflected in CPUE. The increase in BNS CPUE was not nearly as pronounced when targeting HPB or LIN. The 2013–14 CPUE index was consistent with an increase in abundance.

Fishery Interactions
Bluenose is taken in conjunction with alfonsino in target midwater trawl fisheries directed at the latter species and in target bluenose bottom trawl fisheries. These fisheries are frequently associated with undersea features. Bluenose is also taken by target bottom longline fisheries throughout the NZ EEZ. Other commercially important species taken when longlining for bluenose are ling, hapuku and bass. Incidental captures of seabirds occur in the bottom longline and setnet fisheries, including black petrel in FMA 1 and 2, that are ranked as at very high risk in the Seabird Risk Assessment.[1]

7. FOR FURTHER INFORMATION

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[1] The risk was defined as the ratio of the estimated annual number of fatalities of birds due to bycatch in fisheries to the Potential Biological Removal (PBR), which is an estimate of the number of seabirds that may be killed without causing the population to decline below half the carrying capacity. Richard and Abraham (2013).

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