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EXECUTIVE SUMMARY

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This report fulfils the requirements for Objective 1 of Project BNS 2001/01, "To review methods for the estimation of relative biomass of bluenose". It examines the potential use of quantitative longline fishing techniques for bluenose biomass estimation. It critically reviews research programmes that have used line fishing methods for quantitative fisheries assessment as relevant to bluenose, *Hyperoglyphe antarctica.* A summary of the Bluenose Line Fishing Workshop held 3–5 April 2002 as part of this programme is attached as Appendix 1 to this report. This workshop compared the bluenose fishery to other fisheries where longline methods have been successfully used, and identified issues to be addressed in the development of a pilot survey programme. The report then identifies major fishing grounds from a review of catch data and uses these data to determine the variability of catch rates by fishing ground. These data are then used to estimate the number of sets per area that would be required to provide an estimate of mean catch rate with a coefficient of variation (c.v.) of 20%.

From the statistical area data, major fishing grounds were identified in BNS 1 and BNS 2, but data were insufficiently detailed to allow comparisons among fishing grounds. Data were obtained from the BNS 1 Industry Logbook Scheme to estimate the among-vessel variability in catch rate for four sampling areas selected within the Bay of Plenty (statistical areas 9 & 10). The sampling c.v.s estimated for major fishing vessels in these areas ranged from 2 to 5%, as catches were concentrated in areas of high catch rate. As this level of variability was an unrealistic estimate of likely survey sampling variability, the effect of increasing the proportion of zero catches in the survey was simulated to determine the number of samples required to achieve the required sampling c.v. Assuming a 50% zero catch rate, an estimated 45 samples would be required to achieve this target c.v. in the pilot survey programme. A two-phase survey design is proposed, where an additional 10 sets are sampled in the second phase. Assuming that four sets could be achieved per day, the programme would require 14 days to complete.

This review suggests that longline survey methods have potential for the bluenose fishery, and it is recommended that a pilot survey programme is completed, where the level of variability within area and depth strata can be determined, and the fishing parameters of a standardised set of longline survey fishing gear can be established.

1. INTRODUCTION

Bluenose, *Hyperoglyphe antarctica,* is widely distributed in the southern oceans, and has been recorded from New Zealand, southern Australia, Tasmania, New Caledonia, South Africa, and Tristan da Cunha in the southern Indian Ocean (McDowall 1982) in depths from 100 to 500 m. It supports a commercial fishery in Australia and Tasmania, using long lines and midwater trawl methods, where it is marketed as blue eye, or deep sea trevalla. A substantial bluenose fishery occurs in Tasmanian and southern Australian waters (Anon 1995). In New South Wales state fisheries waters, over 60% of landings were taken in a target dropline fishery on rough, untrawlable ground. A further 35% of landings was taken in a bottom longline fishery, whilst trawl catch represents only 5% of bluenose catch (Rowling 1996, 1999). A midwater trawl fishery has developed on offshore pinnacles that are managed as part of the Commonwealth SEF Fishery (Anon 1995). Although bluenose in New Zealand is fished using longlines, set nets and midwater and bottom trawling methods (Annala et al. 2001), dropline, dahn line, and bottom trawling are more common target fishing methods in Australia (Anon 1995, Baelde 1999, Rowling 1999).

In New Zealand, bluenose is commonly found over middle depth shelf edge/coastal waters (200–800 m), particularly over rough and untrawlable grounds. The bluenose fishery is widely considered to be capable of some expansion into new fishing grounds, but the most important domestic fishery occurs off the Wairarapa coast in BNS 2. Although this BNS 2 fishery was originally developed as a line fishery, target bluenose fishing has declined substantially since the advent of the midwater trawl fishery in 1978 (Blackwell 1999a, 1999b). Bluenose is now a major bycatch in the alfonsino (*Beryx splendens),* gemfish (*Rexea solandri),* and hoki *(Macruronus novaezelandiae)* trawl fisheries (Blackwell et al. 2001). Target fishing represented only 10% of BNS 2 landings in 1988–99 (Blackwell 1999b), and small line fisheries remain north and east of East Cape, off the Wairarapa coast, and to the west of Cook Strait in BNS 7 and BNS 8 (Annala et al. 2002).

Substantial target line fisheries occur in BNS 1 in east Northland, the Bay of Plenty, and there are small target set net fisheries in the Bay of Plenty and off the east and south coasts of the South Island (Annala et al. 2002). The length frequency of bluenose in BNS 1, and the BNS 3–7 fishstocks have been reviewed as part of the adaptive management programme in these fishstocks (CFMC 2000, NIFMC 2001, SEFMC 2002). The length frequency and age structure of BNS have been reviewed by Horn (1988), Horn & Massey (1989), Blackwell (1999b), and Blackwell et al. (2001), although work is still on-going to determine the age-length relationship for bluenose (Annala et al. 2002).

The target line fishery CPUE indices in BNS 1, and trawl fishery CPUE indices in BNS 3, BNS 7, and BNS 8, are used to monitor fishery performance for the adaptive management programme. Although trends have been used to develop a composite picture of the status of each fishery, these indices are unlikely to reflect quantitative changes in bluenose abundance (Annala et al. 2002).

Bluenose is taken as a substantial bycatch of other fishing methods in BNS 2 (Blackwell et al. 2002) and BNS 3 (Langley & Walker 2002). Where bluenose quota is limited, fishers may actively avoid bluenose in these target fisheries. This avoidance may confound the CPUE indices and preclude their use as a relative index of biomass (Blackwell 1999b). Cade et al. (1984) analysed length frequencies of bluenose bycatch from an exploratory midwater research trawl programme for alfonsino off the Wairarapa coast, and found the size frequency and catch rate to be variable, compared with line fishery catch rates. Previous research (Horn 1988, Horn & Massey 1989, Ryan & Stocker 1991, Langley 1995, Blackwell 1999b) has reviewed changes in standardised CPUE for the BNS 2 fishstock. These CPUE series generally were flat with little contrast and the development of a robust index of abundance for bluenose using the MIAEL model (Blackwell & Horn 1999) was unsuccessful. Review of the patterns of bluenose bycatch (Langley 1995, Blackwell 1999c, 2000) determined that the bycatch ratio varied widely among fishing grounds. The target fisheries where bluenose bycatch is taken are geographically widespread, but involve few fishing vessels. As not all grounds were fished in every season between 1989–90 and 1997–98, Blackwell (2000) found trends in bluenose bycatch were difficult to determine from among-vessel effects due to the patchy nature of the data.

Bluenose commonly occur over reefs, and drop-offs and around pinnacles. Horn & Massey (1989) determined that standard quantitative bottom or semi-pelagic trawling techniques are severely limited under these conditions. As bluenose occur in mixed schools with alfonsino and other species, it is unlikely to be satisfactorily assessed by acoustic survey methods (Horn & Massey 1989). Detachable tagging methods (Horn 1989) have provided data on fish movements, but have proven unsuitable for biomass assessment. Fishery independent methods may be more appropriate for assessment of bluenose relative abundance. Line fishing surveys have been used to assess bluenose stocks in Australia (Webb 1979, Winstanley 1980, Wilson 1982a,1982b). Quantitative line fishing surveys are used as part of on-going relative abundance estimation in several major fisheries, including sablefish in Alaska (Sigler 2000), Pacific halibut (Randolph 1998), Greenland halibut (Simonsen et al 2000), Greenland cod (Hoag et al. 1984), and alfonsino off the Azores (Gomes et al. 1998) and New Caledonia (Lehody & Grandperrin 1996).

This report describes work completed as part of Objective 1 of MFish project BNS2002/01. The aim was: To determine the feasibility of using a quantitative longline survey for estimating the relative abundance of bluenose using existing information. There were four activities under this objective:

- determine the feasibility of using a quantitative longline survey for estimating the relative abundance of bluenose, by a literature review.
- review the available bluenose data from the commercial catch sampling programme, CPUE data, and the fishery logbook schemes for bluenose.
- determine appropriate standardised fishing gear for a line fishing survey for bluenose.
- determine an appropriate sample design for a bluenose quantitative longline survey to be carried out in a particular area.

This report is divided into four parts that correspond with these four activities. As part of this programme, the workshop "Development of relative abundance indices for bluenose" was held 3–5 April 2002. The summary of the workshop is included as Appendix 1 of this report. Interviews were conducted with bluenose line fishers to assist in the development of appropriate fishing gear for the pilot programme. The summary of these discussions is attached as Appendix 2 of this report.

2. LITERATURE REVIEW

A total of 718 references on line fishing were reviewed with particular reference to biomass estimation. Of these, very few described the use of line fishing in a quantitative sense, where the aim was to derive a relative abundance index as part of a biomass assessment series. Most of the references described line fishing survey methods used in exploratory fishing, or the qualitative assessment of species composition and catch rates. The extensive literature on gear performance, and methods used to monitor these factors, including hook type and size, hook spacing bait type, soak time, and their influence on gear selectivity has been extensively reviewed (Ferno & Olsen 1994, Bjordal & Lokkeborg 1996, Hovgard & Lassen 2000) and was covered only where it was of direct relevance to bluenose.

The review concentrated on identification of major longline survey programmes, and reasons for their success. It then reviewed published comparisons between longline surveys and alternative methods, such as trawl surveys. General aspects of survey design and appropriate methods and gear for bluenose were also discussed at the April 2002 workshop. The recommendations from the workshop (Appendix 1) are reviewed in the general discussion of this report.

2.1 Review of major line fishing survey programmes

Line fishing methods have been used quantitatively in several fisheries. Ten of the major fishery research programmes are:Alaskan sablefish, Pacific halibut, Greenland halibut, Atlantic (Georges' Bank) halibut, Newfoundland cod, Atlantic (Georges' Bank) cod, Greenland cod, alfonsino in New Caledonia, sea bream and alfonsino in the Azores, and sharks in Chesapeake Bay.

2.1.1 Alaskan sablefish (*Anoplopoma fimbria)*

This extensive quantitative line fishing survey programme covers the entire Alaskan coast and the Aleutian Islands and is administered by the US Fisheries Service. The fishery is extremely valuable (US$100 million), and the survey is run as a self-funding programme, with profits from fish sales being used to offset survey costs. The survey series began as a joint Japanese-US survey programme in 1978 targeting sablefish and Pacific cod, *Gadus macrocephalus* (Sasaki & Teshima 1987, Sigler 1987). hen the United States EEZ proposals appeared likely to limit foreign fishing, and fisheries research in US waters, the US National Marine Fisheries Service decided to continue the survey series (Sigler 1987). A parallel survey programme was initially completed (from 1987 to 1989) to provide continuity with the earlier series (Sigler 2000). A series of annual surveys has been completed, from 1989 to the present (Sigler & Zengler 1989). The series also provided relative abundance data for the Alaskan rougheye (*Sebastes aleutianus),* shortraker rockfish (*S. borealis),* Greenland halibut (*Reinhardtius hippoglossoides),* and shortspine thornyhead (S. *alascanus).* Line fishing is the preferred survey method, partly because the commercial fishery uses line fishing gear, so selectivity and catchability issues between survey data and fishery data are minimised, and also because the sablefish distribution covers untrawlable ground. The age and length data collected from these surveys are used in age-structured models to provide estimates of current biomass of sablefish and other target species (Sigler 2000).

The 2000 survey (Rutecki 2001) used a 46 m chartered commercial line-fishing vessel, with standardised fishing gear that is based on the gear used in the commercial fishery. This consists of a 9.5 mm groundrope divided into 160 sections (skates) each 100 m long and containing 45 13/0 circle hooks. This modern gear contrasts with the earlier Japanese-US surveys, which used the less efficient J-hooks (Sigler & Zengler 1989). The hooks were attached to the groundline by 38 cm gangions (of #60 thread nylon), spaced at 2 m intervals along the groundrope. The ground rope was weighted between each unit of gear, and the hooks were hand-baited with squid.

The sample design is based on fixed stations (Sigler 1989), and is carried out by a single contracted vessel. With a daily target groundline set of 16 km (8.6 n miles, representing 7 200 hooks), the whole of the southern Alaskan coastline was surveyed in four months (Rutecki 2001). Depth data were used to post-stratify the catches, and CPUE was calculated by stratum, multiplied by the area of the stratum to provide a relative population number, weight, and length frequency, then summed across strata and statistical areas to calculate relative population weight for the survey area. Confidence intervals for the estimates were determined by bootstrapping (Sigler & Fujioka 1988).

The survey is supported by the extensive work carried out on gear performance and selectivity, including hook spacing (Sigler 1986, Rutecki 2001), hook size and shape (Sigler 1986, 1988), bait type and soak time (Sigler 1988), and hook density and pattern (Sigler 2000). Extensive modelling of the capture process has been completed (Sigler 2000).

The error on the survey indices as determined by bootstrapping was estimated at less than 10% (Sigler 2000), and estimates, together with commercial CPUE data, were input into an age and sex structured model to give precise estimates of relative abundance and projected catches (Sigler & Fujioka 1988). The survey data were used to monitor the fishing down phase in the early years of joint management of the fishery and the recovery of the fishery after the removal of foreign fishing effort. The survey indices are consistent with several years of successful recruitment where commercial CPUE indices increased during this period (Sigler 2000). The survey data also provide comparisons with gear changes in the commercial fishery (Sigler 2000), the introduction of ITQ, and increases in catching efficiency of the commercial fleet (Sigler & Lunsford 2001).

2.1.2 Pacific halibut (*Hippoglossus stenolepis)*

A series of longline surveys was completed by the International Pacific Halibut Commission (IPHC), to determine the relative biomass of Pacific halibut. The survey is run as a self-funding programme, with profits from fish sales being used to offset survey costs (Randolph 1998).

The line-fishing survey series began in 1963 (Hoag et al. 1979, 1984), but was abandoned in 1986, and replaced by a modelling approach based on commercial CPUE (Quinn 1987, Deriso et al. 1989). This model was able to accommodate simple gear changes (from the J-hook to the more efficient circle hook in 1983), but it was unable to accommodate other changes such as the implementation of ITQs, the introduction of GPS, and local depletion of fishing grounds (Quinn 1987). These factors changed the selectivity by size and age in the commercial fishery data, and the CPUE indices could not be interpreted (B. Leaman, Senior Scientist, IPHC, pers. comm. 2002). The line-survey series, which was initially re-instated to validate the respecification of the age-structured model for the use of the circle hook in 1993, has been continued (from 1993 to 2002) to provide a fishery-independent estimate of relative biomass, after a major review of the fishery (Horwood et al. 1997).

The initial survey series (before 1986) was based on a fixed station design (Hoag et al. 1984) with a 10 x 12 n. mile grid that covered the entire area of the Pacific halibut fishery (from British Columbia to the Aleutian Islands), and is self-funding, from profits on the sale of catch. The re-instated survey initially used the original design, but has subsequently been redesigned to increase the number of stations, extend the survey area into regions of lower CPUE (Randolph 1998), and incorporate geostatistical techniques (Pelletier & Parma 1994).

The survey is carried out by up to 12 vessels using standardised gear and a target of 3–4 sets per day. Sampling gear consists of a 550 m longline, containing several "skates" of 100 16/0 sized circle hooks, with each skate separated by a 20 kg weight. Gangions of 1 m length were placed 5 m apart, and standard preprocessed frozen bait was used. All sampling was in daylight, and protocols implemented to minimise seabird bycatch included a tori line, weighted groundrope, and pre-baited hooks (Anon 2001). The redesigned survey was considered to provide a precise estimate of relative halibut biomass and the trends in survey indices were consistent with trends in commercial CPUE. This survey programme is supported by extensive work on gear effects (Skud 1984), including hook spacing (Hamley & Skud 1978), bait loss and competition for baits (Skud & Hamley 1978), and selectivity (Hoag et al. 1984)

2.1.3 Greenland halibut (*Reinhardtius hippoglossoides)*

Greenland halibut is fished using set net, longline, and trawl methods and the fishery includes considerable areas of untrawlable ground (Nedreaas et al. 1993). The stocks have declined since 1992 (Simonsen et al. 2000), and the fishery is managed by the Northwest Atlantic Fisheries Organization (NAFO). A trial longline survey was completed (Gunderson et al 1997) using similar gear to the commercial line fishery, and a longline survey series was carried out from 1992 to 2000 (Hoines & Korsbekke (2001) using up to 14 vessels, and standardised fishing gear. The sample design, which was initially optimised for the depth ranges of both Greenland cod and halibut, was later modified to target Greenland halibut only. Each vessel used a 1500 hook longline but several hook designs (EZ hook, circle hook) were used. All hooks were hand baited, and the soak time varied between 5 and 15 h per set (Woll et al. 2001). The bait type, hook size, and number of hooks used per set also varied among survey vessels and among survey years.

As the survey design and sampling gear varied considerably during the survey series, trends in survey indices could not be easily interpreted (Woll et al. 2001), and further research was required to compare catch rates and gear selectivity between hook types, bait types (squid or grenadier), and to standardise the number of hooks fished per vessel before the survey data could be properly used. This highlights the need for strict standardisation of survey methodology (Woll et al.. 2001). The Greenland halibut programme is supported by extensive work on setting method, bait type and size, hook design and spacing, gear saturation, and soak time (Bjordal & Lokkeberg 1996, Hovgard & Lassen 2000). Simonsen et al. (2000), who used cluster analysis to review sampling variability for the Greenland halibut longline surveys from 1992 to 2000, found the within-station variance in catch rates was as high as the between adjacent-station variance, and catch rates were also influenced by subarea and fishing year. Some areas showed consistently higher catch rates over the surveys, but catch rates were not affected by the presence of other species, or the time of fishing. The revised longline survey data are considered to provide precise estimates of relative biomass of Greenland halibut (Simonsen et al.. 2000). A joint Greenland-Norwegian longline survey of Greenland halibut was also completed (Gundersen et al. 1997) to compare catch rates among major bycatch species in this fishery.

2.1.4 Atlantic (Georges Bank) halibut (*Hippoglossus hippoglossus)*

The Atlantic halibut fishery on Georges Bank off the Scotian shelf is managed by the Canadian Department of Fisheries and Oceans (DFO). The DFO consider that abundance has declined, based on data from a trawl survey series implemented in 1970. However, industry consider that the stock includes a considerable resource that occurs over untrawlable ground, not included in the trawl survey series, and many fishers consider that the stock has actually increased overall (Zwanenburg et al. 1997).

To monitor relative abundance in this untrawlable area, an annual longline survey series was implemented in 1998 (Zwanenburg & Wilson 2000a) as a 10 year self-funding collaborative survey between the DFO and the fishing industry. This survey uses multiple vessels to complete the survey in as short a time as possible, as halibut are highly mobile. Each vessel uses standardised fishing gear consisting of a single 1000 hook set with 14/0 hooks. Bait and soak time (6 h) are standardised, and each set must be completed within 3 nautical miles of a predetermined location (Zwanenburg & Wilson 2000b). The 1999 survey (Zwanenburg & Wilson 1999) covered 200 stations in an 8 week period using 22 vessels, each with a target of 7000 hooks per day. The survey was considered to successfully provide data on halibut distribution, population size, age structure (n = 12 000 fish measured), and diet composition that is used in the DFO stock assessment programme (Zwanenburg & Wilson 2000a).

2.1.5 Newfoundland cod (*Gadus morhua)*

The International Commission for the Exploration of the Sea (ICES) support a series of winter line and trawl fishing surveys for Newfoundland cod (Frechet & Gagnon 1991, Chouinard et al. 1999). Cod landings have declined substantially since the mid 1970s, and target fishing has been banned since 1993 (Frechet 1997). These surveys are part of the "Sentinel Programme", a collaborative ICES/fishing industry research programme for long-term monitoring of relative abundance, run through the Fishermen and Scientists Research Society (FSRS 2002). Of the 11 monitoring projects undertaken, 5 have used longline survey gear and these projects involved a total of 27 line vessels.

Line and trawl surveys targeting Newfoundland cod have been completed annually since 1994. The 1998 survey involved 9 contracted longline vessels that fished at fixed stations, using a standard set of gear (7/32 inch mainline (non-leaded), with 20 inch snoods spaced at 6 foot intervals. The line had 1500 # 12 circle hooks baited with frozen mackerel. The gear was set within a 6 h period (4 h before sunrise), with a minimum 2 h soak time. The survey totalled 253 stations, representing 41 stations for each of the 5 main vessels (FSRS 2002). Frechet & Gagnon (1991) noted that commercial fishers were concerned that the sample design for the Sentinel surveys may not cover all of the ground previously fished in the commercial fishery for Newfoundland cod. The Sentinel Programme was amended to include an additional commercial fishing index phase, where a selected number of vessels were permitted to fish in the closed areas (Hurlburt & Daigle, unpubl. results). The catch rates were reported by logbooks, and vessels carried fishery observers. These data were incorporated into the 1999 survey data, although catch rates varied widely in the 1999 programme (mean 528 kg/100 hooks). The 1999 trawl and longline indices were used in an age structured model to provide biomass estimates (Chouinard et al. 1999).

2.1.6 Atlantic (Georges Bank) cod (*Gadus morhua*)

A longline survey series primarily targeting cod, but also including haddock (*Melanogrammus aeglefinus),* has been conducted annually since 1995 by the Canadian Department of Fisheries and Oceans (DFO) on the Canadian section of Georges Bank. The series was requested by the fishing industry who believed that the method could provide an index that would be independent of the DFO (March) and US National Marine Fisheries Service (NFMS) February to October trawl survey indices currently used for stock assessment (Hunt & Johnston 1999). These surveys follow a box design (Johnston & Hunt 1999), in which each box is 50 square nautical miles. Although the 1995 survey sampled waters less than 90 m depth, later surveys have extended the area covered to the 100 m and 200 m depth contours as survey boundaries. Boxes were assigned to vessels to provide a mix of high and low catch rates per vessel. The number of vessels used annually varied from three to five, and each vessel fished a standard set of longline gear. Stations established in the 1995 survey were resampled annually in the survey series, but if a box remained unsurveyed for 3 years, it was removed.

The standardised gear consisted of a 1500 hook longline, with EZ 12/0 hooks, baited with squid, and fished for a soak time of 6–8 h. Each vessel was instructed to fish within a 0.5 n. mile radius of the designated station position. Johnston & Hunt (1999) describe some of the difficulties in establishing and maintaining this self-funding data series using a number of chartered commercial vessels and scientific observer staff, such as conformity to sample design, variability in hook number (that required standardisation before the data could be analysed), and variability in soak time. Johnston & Hunt (1999) also cautioned against area bias caused by the vessels not fishing where stations were suspected to have low catch rates, but considered these issues could be resolved in further surveys. Although these operational issues may have biased the data, the survey series was considered to provide useful abundance estimates, that are compatible with the estimates derived by Virtual Population Analysis (VPA) from the trawl survey series of Hunt & Johnston (1999).

2.1.7 Greenland cod (*Gadus morhua*)

Greenland cod supports major fisheries in the north Atlantic, and the distribution includes the untrawlable inshore areas of the Greenland fjords. Distribution and abundance have been monitored using longline survey methods (Hoag et al. 1984). Hovgard & Riget (1990) determined the size distribution of Greenland cod from longline surveys of the inshore waters of west Greenland, completed in October 1987–1989. Strata were based on North Atlantic Fishery Organisation (NAFO) geographical divisions and depth strata: under 100 n; 100 to 200 m; 200 to 300 m. Fishing was carried out using two vessels simultaneously, and standardised gear was used. A 7 mm polypropylene ground line was anchored at both ends and weighted at 200 m intervals. The line had 400 snoods, each 50 cm long, fixed at 2 m intervals. Each snood had a 23 mm J-hook, baited with capelin. Stations were fished during daylight only, and average soak time was 4.5 h.

Comparisons of catch rates between longline surveys and associated trawl survey programmes determined that the line surveys selected for larger fish than cod trawl surveys off west Greenland (Hovgard & Riget 1992). Using the longline catch rates, Hovgard & Riget (1992) estimated that 25% of the Greenland cod stock occurred in the inshore non-trawl area, and relative abundance estimates were completed for the whole area. The effects of factors including setting method, bait type and size, hook design and spacing, gear saturation, and soak time on catch rate were examined for this fishery by Bjordal & Lokkeberg (1996).

2.1.8 Alfonsino (Azores) *(Beryx splendens, B. decadactylus)*

Longline surveys have been used to monitor abundance of nine demersal species of the Azores, as part of a joint programme between the University of the Azores (Portugal), the International Council for the Exploration of the Sea (ICES), and the US National Marine Fisheries Service. Other target species include red (blackspot) seabream *Pagellus bogaraveo*, forkbeard *Phycis phycis*, bluemouth *Helicolenus dactylopterus*, yellow-orange scorpionfish *Pontinus kuhli,i* the silver scabbardfish *Lepidopus caudatus*, the red porgy *Pagrus pagrus* and the axillary seabream *Pagellus acarne* (Gomes et al. 1998).

The line survey uses similar gear to the commercial fishery because the fishery is located over rough, rocky bottom with pinnacles and small seamounts, derived from volcanic and plate tectonics (Gomes & Silva 1997, Gomes et al. 1998). The habitat appears similar to the bottom topography of the Bay of Plenty where the bluenose fishery operates in New Zealand (M. Sigler, US National Marine Fisheries Service, pers. comm. 2002).

Relative abundance estimates were determined from surveys completed from 1981 to present, using standardised semi-pelagic longline fishing gear (Gomes et al. 1998, Morato et al. in press). Length data were analysed by MULTIFAN, otoliths were collected (Anibal et al. 1998, Krug et al. 1998), and these data have been used in an age-structured model for biomass estimation of the major target species. The relative biomass indices for these species are considered to successfully monitor relative abundance (Gomes et al. 1998).

2.1.9 Alfonsino (New Caledonia) *(Beryx splendens)*

A longline fishery for alfonsino has operated since the early 1990s over seamounts south of New Caledonia (Lehody et al. 1994). To monitor this resource, a series of 11 longline surveys was completed between 1991 and 1995 by the Marine Biology Centre, Noumea (ORSTOM) as part of a larger study of the fisheries resources of seamounts southeast of New Caledonia (Grandperrin et al. 1991, 1992a, 1992b),

In the first survey (BERYX–1), nine bottom longline sets were made, with a 4000 m groundrope, divided into five sections, each with 840 hooks. Each of the 42 snoods per section carried 20 hooks. Depth of capture was used to post-stratify samples into 25 m depth classes for analysis (Grandperrin et al. 1991).

Alfonsino CPUE was modelled by length and by depth category and seamount, and compared with commercial CPUE from two Japanese longline vessels in the commercial fishery. The distribution of alfonsino over the area of the fishery was modeled using a "recursive" model (Lehody et al 1994), and the age and growth of alfonsino was also determined (Lehody & Grandperrin 1996). Alfonsino catch rates ranged from 11.1 to 22.6 kg per 100 hooks, and bluenose was reported as a substantial bycatch of the line survey programme (Grandperrin et al 1992a). The bathymetry of these seamounts was poorly known, and the swath bathymetry work completed as part of this programme provided detailed bottom topography for survey design, and revealed that the fishery area was larger than initially thought (Grandperrin et al. 1995). Lehody et al. (1994) found that seamounts of identical depth and only a few nautical miles apart varied widely in productivity, and in alfonsino growth rate. Although some of this may be due to variation in seafloor topography and bottom type, seamounts are also known to exhibit short-term temporal variability in productivity. The combined influences of ocean currents and complex bottom topography may create short-term anticyclonic flows that allow deep ocean water to rise to shallow depths above the seamount, and trap, or concentrate plankton. This effect, known as "Taylor's Column" (Dower et al. 1992) may in part explain the high productivity associated with seamounts and similar complex bottom topography, such as that found on the east coast of the North Island. Such local variability may also cause problems in the interpretation of results and in the repeatability of research data (Lehody et al. 1994).

2.1.10 Sandbar shark (*Carcharhinus plumbeus*)

The Virginia Institute of Marine Science (VIMS), in conjunction with the US National Marine Fisheries Service, began a depth-stratified longline survey series in 1973 in Chesapeake Bay, USA. This long-term programme aimed to monitor the distribution and abundance of the sandbar shark (*Carcharhinus plumbeus*), a valuable gamefish species, as well as other inshore shark species. The programme is funded by the US Federal Government to aid in the restoration of recreational sport fishing species. The decline in survey abundance indices between 1973 and 1991 was considered to reflect the decline in shark abundance during this period (Musick et al. 1993, Sminky & Musick 1996). The survey used standardised gear consisting of a 6 mm tarred nylon groundrope with 100 gangions, each spaced 20 m apart, set as a continuous unit and anchored at both ends. The groundrope was buoyed at 20 gangion intervals. Each gangion comprised a 3 m nylon trace with a steel leader, a swivel, and a 9/0 hook baited with mackerel (*Scomber scombrus)* or menhaden (*Brevoortia tyranus)* of a size range 0.1–0.25 kg so as not to exclude the capture of small fish. The standard longline set was 3–4 h. The results of this survey series have been used in stock assessments by the US National Marine Fisheries Service (Musick et al. 1993). The decline in catch rates from the VIMS longline survey has meant that insufficient data are available for other associated VIMS research programmes, and supplementary sampling programmes were initiated (Branstetter & Musick 1991). Catch rates in the commercial shark fishery were higher using monofilament snoods than the older tarred multifilament groundrope (Branstetter & Musick 1991). In gear trials, Branstetter & Musick (1991) found that monofilament gear had a similarly higher catch rate than the the standard VIMS survey rope/steel snoods. This longline survey is considered to successfully monitor the relative abundance of the inshore sandbar shark (Branstetter & Musick (1991).

2.2 Other longline surveys

Two longline surveys were carried out in January 1997 and 1998 to monitor Patagonian ling or kingclip (*Genypterus blacodes*) and Patagonian hake (*Merluccius australis)* in the Chilean fijords (Arana *et al.* 1988) in depths of 100 to 400 m. The standardised fishing gear consisted of a single line set with 16,000 hooks (size 6/0 J-hook), baited with sardine (*Sardinops pilchardus*), fished at night. The depths were recorded and the catch was post-stratified by depth. CPUE was calculated for each set, as kg/1000 hooks by species, fishing zone, vessel, month, and depth interval. Within the surveyed area, ling made up 90% of the average longline catch of the inner fjord area, and 55% of catch in the outer zone of the fjords.

A longline survey for sablefish was carried out jointly between the Fisheries Agency of Japan and the USSR, within the USSR 200 mile zone in 1989 (Sasaki & Fuzii 1989). This survey provided relative abundance indices that were used to compare with data collected by the US National Marine Fisheries Service longline surveys of the Bering Sea conducted from 1982 to 1989.

Several research programmes (Arana & Vega 1999, Ashford & Duhamel 1996, 1997) have used longlines to review the abundance of Patagonian toothfish (*Dissostichus eleginoides*), or changes in the proportion of bycatch (Duhamel et. al. 1999), although these longline surveys are not part of a biomass assessment programme. Ashford & Duhamel (1996) noted that effective soak time increases for fish caught at the end of the longline when the number of hooks set is large. The need for consistency in sample selection, and also in the gear parameters used was highlighted by Ashford & Duhamel (1997). Arana & Vega (1999) described a data from 52 survey sets with 1 440 – 4 320 hooks per line.

Several qualitative line-fishing surveys have completed for bluenose. Cowper & Downey (1957) surveyed the bluenose resources off the southeast Australian continental shelf using droplines. Bluenose longline surveys were completed by Webb (1979) and Wilson (1982a, 1982b) off Tasmania, and by Winstanley (1980) off western Victoria. These surveys covered a limited geographical area, were of limited duration, and were not related to a biomass assessment programme. Webb (1979) used up to 6 droplines per set, with 30-50 10/0 hooks on 30 cm polypropylene snoods, spaced 1 m apart and reported bluenose and spiny dogfish together made up 90% of catches. The catch was post-stratified into 100 m depth intervals, with the main bluenose catch occurring in the 400-600 m range. Mean CPUE (gutted weight/100 hooks) was 5.4 fish/100 hooks or 34.3 kg/100 hooks. Wilson (1981) described a two phase survey programme off Tasmania using trot lines and longlines in depths of 400–600 m where longline catch rates ranged from 1.9 to 2.4 kg/100 hooks. Wilson (1982b) found droplines had a higher catch rate than either trotlines or longlines when catch rates were high, although dropline and trotline methods were slower than longlines to set and to haul. Where catch rates were low, longlines were a better survey tool than droplines or trotlines.

Winstanley (1980) described the results from two exploratory droplining surveys during October-February 1973 and 1974 in depths of 380–460 m. Jones (1985) described an exploratory dropline survey for bluenose carried out in deep water (400–700 m) canyons off the southeast coast of South Australia and a further longline survey was completed in 1988 (Anon 1995). Bolch et al. (1993) described a short-term line fishing survey competed in southeast Australia as part of a review of the stock structure of bluenose.

This review indicates that the use of longline fishing methods as a quantitative assessment tool has been widely accepted, and data from longline surveys have been used to monitor stocks of major fisheries. The review also highlights the need for careful sample design and choice of fishing gear, as well as consistency of fishing method during the survey programme.

3. REVIEW OF FISHING GROUNDS AND MEAN CATCH RATE

3.1 Introduction

This section reviews available bluenose fishery data to determine the most appropriate area to carry out a pilot survey programme.

3.2 Methods

Commercial catch data from target bluenose line fishing are reported on the MFish CELR (Catch effort and landing return) database. These provide catch (kg) and effort (number of sets, number of hooks, or number of tows) data aggregated by fishing day. The database also includes some target bluenose trawling by smaller trawlers, and fishing catch (kg) and effort (no. of tows) is also aggregated by day. Fishing locations on the CELR database are reported by gross statistical area, and catch and effort cannot be separated by fishing ground.

Data from the midwater and bottom trawl fisheries are reported on the TCEPR (Trawl, catch effort and processing return) database, which provides catch (kg) and effort data by tow.

These data were aggregated by fishstock, statistical area and method for the 1997–98 to 2000–01 fishing years to identify the major fishing grounds in BNS 2 and BNS 3. Bluenose landings from statistical areas 1 and 2 were disregarded as possibly representing incorrect location data following fishing industry advice (P. Stevens, commercial fisher, pers. comm. 2001). Data were also extracted from previous research surveys in BNS 1 to BNS 3 that reported bluenose bycatch. These data were summarised for bottom trawl data by Anderson et al. (1998), for midwater trawls by Bagley et al. (2000), and the data were updated by Hurst et al. (2000).

Data were also requested from the Line Fishery Industry Logbook Scheme, operated by the Northern Inshore Fisheries Management Company. These data, collected as part of the BNS 1 Adaptive Management Programme monitoring programme provide accurate catch, effort, and position data by set, although the data set represents only 30–35% of the total landings from the fishery (NIFMC 2001). These data were summarised by fishing year and statistical area, and combined with detailed NIWA bathymetry data (25 m depth contours) to identify major fishing grounds in BNS 1, and to identify an area suitable for a future pilot survey programme.

The variability in mean catch rate for this area was reviewed to assess the suitability of these data for determining the likely sample size required to estimate the mean catch rate from this area with a target sampling c.v. of 20%. Although mean catch rates were determined by area and by vessel, these data are deemed commercially sensitive and cannot be separately reported.

3.3 Review of catch and catch rate

Reported landings for 1999–2000 (Table 1) indicate that the most important bluenose fisheries are in BNS 2 (1 136 t), BNS 1 (860 t), and BNS 3 (566 t), although bluenose is taken as bycatch in other areas.

Estimated and actual landings by fishing method and statistical area from 1997–98 to 2000–01 indicate that most (88–96%) of the BNS 1 landings were taken by line fishing (Table 2). Major line fisheries occur in areas 3 & 4 (East Northland), and in areas 8–10 (Bay of Plenty). The mean catch rates (Table 3) for these areas vary widely and the data provided insufficiently detailed location information to determine catch rate by fishing ground.

Data from the industry logbook scheme plotted by 100 m depth contour (Figure 1) indicate that most line fishing sets from 1995–96 to 2000–01 were located along the shelf edge between 200 and 800 m in depth. Major fishing areas were identified off East Northland in statistical area 4 (Figure 2), and in the central Bay of Plenty in statistical areas 9 & 10 (Figure 3).

The central Bay of Plenty was considered the most practical location for a pilot survey, because it is located conveniently close to Port Tauranga, is fished by a range of vessels, and has several fishing grounds. Within this Bay of Plenty fishery (Figure 3), four areas (areas A–D) east of Mayor Island were selected (see Table 4 for definitions) that include most of the fishing ground known as the Mayor knolls, as representative of this area. For the 781 sets completed in these four Bay of Plenty sampling areas, the mean catch rate for the 15 vessels that fished from 1995–96 to 2000–01 varied between 14.8 and 15.2 fish/100 hooks, and the standard errors of these estimates varied from 0.58 to 0.71. These data were used to determine mean weighted catch rates and sample sizes (Section 4).

Line fishery landings in BNS 2 have increased from 31% to 41% of total estimated landings from 1995–96 to 2000–01 (see Table 2), although the number of target line fishing sets in BNS 2 is low (see Table 3), and catch rates are highly variable among statistical areas. Most bluenose is taken as bycatch of midwater trawling (see Table 2), or other target line fisheries in statistical areas 11–16, and in the offshore area 204, where landings were small. The location of the major fishing grounds (Figure 4) has been determined from bluenose bycatch in various trawl fisheries reported on the TCEPR database in BNS 2. Insufficient data exist, to review the variability in mean catch rate from the target line fishery by ground in BNS 2, as the industry logbook scheme has only recently been established, and the target line fishery in BNS 2 has declined (see Table 2). No estimates have been made of sampling variability or required sample size for BNS 2.

Within BNS 3, bluenose is taken by both line and trawl fishing in statistical areas 18, 32, 51, and 404, although only 51 and 404 are important (see Table 2). Most landings are associated with the developing alfonsino target trawl fishery southeast of the Chatham Islands (Langley & Walker 2002), and the line fishery is insignificant (see Table 3). The landings for the remaining New Zealand bluenose fishstocks have been ignored as insignificant. No estimates have been made of sampling variability or required sample size for BNS 3.

4. REVIEW OF FISHING GEAR FOR A PILOT SURVEY PROGRAMME

4.1 Effects of fishing gear

This section briefly reviews the literature on the effects of fishing gear on catch rate. It summarises the results of discussions with bluenose fishers on appropriate fishing gear to use for a pilot bluenose line survey, and reviews the results from discussions on gear and methods from the Bluenose Longline Workshop, held 3-5 April 2002 (see Appendix1).

The substantial literature on the comparative selectivity of line fishing gear was reviewed by Lokkeborg & Bjordal (1992), Engas & Lokkeborg (1994), and Hovgard & Lassen (2000). Factors including the type of groundrope, the spacing of snoods, the choice of braided or monofilament line for groundrope and snoods, length of snood, hook type and size, hook spacing, bait type and size, bait loss, and competition for bait were identified as influencing longline catch rate (Lokkeborg & Bjordal 1992, Skud 1984a, Skud 1984b, Skud & Hamley 1978, Hovgard & Lassen 2000). Understanding of these effects on catch rates is important in determining appropriate survey design (Hovgard & Lassen (2000). Methods and limitations of longline fishing surveys for estimation of absolute biomass are reviewed by Engas & Lokkebork (1994). Whilst much research has been directed at the influence of gear parameters on relative fishing power and catchability, this is of less importance for surveys monitoring relative abundance, because many factors can be adequately controlled through appropriate standardistion of fishing gear (M. Sigler, pers. comm., 2002). However, where multiple vessels are used, unplanned variation in gear and methods may not permit data to be compared (Woll et al. 2001, Johnston & Hunt 1999).

In general, more older/larger fish are taken by line fishing gear than by trawl survey methods (Hovgard & Riget 1992, Lokkeborg & Bjordal 1992), as hook size influences size selectivity. Younger year classes are often under represented in longline catches (Engas & Lokkeborg (1994).

Anon (1995) reviewed the size distribution of catches of Australian blue eye (bluenose) and found longline survey methods to be more efficient than midwater or bottom trawl methods where survey densities were low. Differences occurred in gear saturation, catching capacity, and operational tactics between longline and trawl methods, and small bluenose (under 55 cm in length) were common in demersal trawl and dropline catch, but relatively uncommon in midwater trawl and bottom longline catches. Larger bluenose were common in midwater trawl and bottom longline catches.

The interaction between fish and longline gear begins with an olfactory attraction to the baited hook and is completed either by bait intake and hooking, or by bait rejection and release (Lokkeborg 1994). Although fish become initially aroused by olfactory stimulus, many authors (Murphy 1960, Rothschild 1967, Skud 1978) incorrectly assumed that success rate was proportional to the number of baits remaining. The resulting theoretical models of hooking activity (Rothschild 1967, Skud & Hamley 1978, Eggers et al. 1982, Olsen & Laevestu 1983) failed to take into account the effect of tidal currents, bait plumes, or the aggregation effect of gear in the water (Sigler 2000, Engas & Lokkeborg 1994). More recent research has revealed the complexity of the hooking process. Sablefish upstream of a bait plume respond to the visual stimuli of struggling hooked fish (Sigler 1999), as well as responding to olfactory stimulus, and appear to actively search along an occupied longline for unoccupied baits (Sigler 2000). A similar response was noted for bluenose (P. Jones, pers. comm, 2002). Where fish may possibly move from one experimental depth stratum to another by migrating up a baited longline, fishing gear may not be able to be post-stratified by depth (M. Sigler, pers. comm., 2002). This suggests that simple conceptual models may not be appropriate to describe the reactions of bluenose to bait stimulus, and trials of standardised gear may be necessary.

The effect of gear saturation was reviewed for the Alaskan sablefish surveys using hook timers and video observations of baited fishing gear (Sigler 2000) for Pacific halibut (Kaimmer 1998) and for Greenland halibut (Woll et al. 2001). These data indicated that sufficient baits must be present throughout the length of the set to ensure that capture rates truly reflect soak time (Lokkeborg 1994).

Species selectivity of fishing gear may be influenced by the variation in hooking efficiency between species (Engas & Lokkeborg 1994). The rate of attack to the bait varies between haddock and cod (Lokkeborg 1994). More haddock actively attacked the bait than cod, but they tended to chew on the bait and be mouth hooked, whereas cod completely ingested the bait. As mouth hooking is less certain, the catch rate of haddock was lower than cod. Alfonsino and bluenose commonly occur in mixed schools, as determined from echo-sounder traces, and are commonly taken in up to 1:1 ratio by midwater trawling on these schools. However, bluenose have a higher hooking rate than alfonsino, which suggests that they may be a more voracious feeder than alfonsino (P. Jones, pers. comm, 2002).

Direct observations of bluenose and alfonsino aggregations by underwater still camera were not successful (Horn & Massey 1989), and bluenose abundance and size structure varied widely among nine South Tasmanian seamounts reviewed by Gowlett-Holmes & Koslow (2001) using still cameras, benthic sled observations, and droplines. Priede & Merrett (1996) used the average arrival time to baited lines monitored by underwater video to estimate the abundance of Patagonian toothfish. Fish abundance is proportional to the reciprocal of the square of the arrival time, so a doubling of the average arrival time produced a four fold decrease in abundance. Abundance estimates were lower than for other methods, and toothfish may be repelled by the flash from the camera. The method assumes even fish distribution over the fishing grounds, constant current velocity, and fish swimming speed that are unlikely to hold for bluenose, given the complex bottom topography of its habitat.

Hovgard & Lassen (2000) summarised issues concerning the use of longlines for research surveys, noting the improvements in gear technology associated with the change from j-hook to circle-hook as 15–20%, the use of monofilament instead of multifilament snoods as 10%, and the use of swivels on snoods as 15–20% improvement in efficency. Although Hovgard & Lassen (2000) suggested that mechanised gear and bait systems provided a four-fold improvement in efficiency for Greenland halibut surveys, the use of mechanised longline gear also results in 10–20% of the hooks being unbaited due to auto-baiting gear failure (Pederson 1998). The 2002 Line Fishery Workshop recommended that hand-baited gear be used for bluenose.

Bait size may be more important than hook size (Lokkeborg & Bjordal 1992), and Punt et al. (1996) recommended treating the hook and bait as a single entity that is strictly standardised for line fishing surveys. Although most successful line surveys have used a single hook size (Lokkeborg & Bjordal 1992), Hovgard & Lassen (2000) suggested that several hook sizes could be used together to achieve a better coverage of the length frequency distribution by the sampling gear. Based on the considerable data available (Ralston 1982, Ralston et al. 1986, Bertrand 1988, Otway & Craig 1993, Ralston 1990, Erzini et al. 1996), a minimum size difference between adjacent hooks of 1.4 times is suggested. Such factors of hook type, hook size and spacing, bait, soak time and setting time are important considerations in determining appropriate standardised gear to use in a survey. The programme will initially require some gear trials to determine the most appropriate gear parameters for bluenose.

Where the distribution of the target species extends into areas unavailable to trawl surveys, trawl and longline survey indices are usually regarded as relative abundance indices, and both indices are used as input into an age or size structured model (Sigler 2000, Randolph 1998, Simonsen et al. 2000).

Rose (1986) attempted to convert sablefish line survey relative abundance indices into absolute abundance estimates by comparisons with trawl survey data, by assuming that loss from trawl nets was insignificant (Alverson & Pereya 1969). However, trawl fishing gear has its own selectivity issues, and significant losses of fish may occur under or over the trawl net (Engas & Godo 1989a). Fish may also be herded by wires and sweeps (Engas & Godo 1989b), and such effects were not included in the model. These data were not used for sablefish abundance estimation (Sigler 1999). Jorgenson (1995) reviewed data from longline and bottom survey data for Greenland halibut from August 1991, and derived relative selection indices (RS) for each method that determined longlines were 30 times more effective in catching larger fish than trawl surveys. Although these indices were then used to scale the longline relative abundance indices to derive trawl survey equivalents that were used in abundance estimation, such methods are not widely supported. These techniques are not recommended (M. Sigler. pers. comm, 2002), as they are based on assumptions of gear performance that are rarely tested, and it is more appropriate to use method-based relative indices directly in appropriate age or size structured fisheries models.

4.2 Standardisation of line fishing gear

To determine the most appropriate fishing gear for bluenose surveys, four commercial bluenose target longline fishers were interviewed (see Appendix 2), and their comments were combined with the recommendations from the 2002 Bluenose Longline Workshop (see Appendix 1).

The recommended standardised fishing method should be bottom longline fishing, instead of dropline or trotline gear. Longline gear is easier to deploy and performs better where catch rates may be low (Anon 1995). Stations would be selected randomly within predetermined area and depth strata.

The standardised survey gear should comprise four 500-hook longlines, allowing four lines, and four stations to be fished simultaneously (Hovgaard & Lassen 2000). As bluenose appear to be able to locate unoccupied baited hooks along the groundrope (P. Jones, pers. comm., 2002), the alternative design where a single large longline is post-stratified by depth (Sigler 2000) is not recommended for bluenose. The initial soak time is assumed to be 4 h, although this, and the number, and spacing of hooks would be confirmed by gear trials. The minimum soak time should be sufficient for available fish to encounter the fishing gear during a set (Sigler 2000), but ensure that baited hooks remain available to fish throughout the set.

The groundrope should be 7 mm monofilament with crimps (stoppers) set every 3 m. The snoods would be clipped to the groundrope and be able to move between the stoppers to reduce fouling on rough ground. The monofilament snoods should be 1 m long, equipped with swivels, and clipped on to the groundrope to reduce entanglement. The 2002 workshop recommended 12/0 offset circle hooks for target bluenose fishing. Bait should be preprocessed, frozen, shape and size graded industry standard squid, as this had a higher catch rate than alternative baits (jack mackerel or barracouta). The gear should be manually baited (to reduce the incidence of unbaited hooks), and each hook should be double-hooked (i.e., the hook is passed through the bait twice) to reduce bait loss. All baits should be fresh, i.e., used only once, as wet bait deteriorates rapidly on exposure to air, and use of old bait may introduce bias due to variable handling time between sets. Fishing should start at dawn and be confined to daylight, as bluenose are known to rise off the bottom into midwater to feed on *Pyrosoma* during the night. When fishing occurs during daylight hours, the use of a tori line is recommended to reduce the potential for seabird bycatch.

5. DESIGN OF A PILOT LONGLINE SURVEY

5.1 Introduction

Before a full longline fishing survey is conducted, it is proposed that a pilot survey of a smaller area be carried out. This would test the feasibility of the line survey approach in practice, and would focus on standardisation of gear, sampling variability, development of appropriate depth strata, and comparison between fishing of fixed or random positions. Data from the BNS 1 target line fishery logbook scheme have been used to review the scale of variability in commercial catch rates (Section 2), and to determine the most appropriate site for a pilot survey (Section 3). In this section, the mean weighted catch rates and sampling c.v.s are estimated for the four sampling strata (A – D) and these data are used to broadly estimate the number of stations required per sampling stratum. From Section 4 of this report, suitable fishing methods and gear have been identified. Based on these data, a pilot survey programme is presented for bluenose in BNS 1.

5.2 Methods

To estimate the sampling c.v.s, mean weighted catch rates (no. fish per 100 hooks) were calculated for each of the pilot survey strata (see Table 4). The area of each stratum was determined, and the stratum mean catch rate was weighted by the stratum area, divided by the sum of all four stratum areas, then these were summed to give an overall weighted mean. The stratum standard errors of the means were correspondingly combined (by squaring each standard error times its weighting, summing them, and then taking the square root), to obtain an estimate of the sampling c.v., as defined in Table 6. This sampling c.v. refers to the sampling error of the individual observations, and is the appropriate unit of variance, in determination of the c.v.s.

The standard error of the mean catch rate is affected by the sample size. By changing the sample size, the effect on the standard error of the mean catch rate, and on the associated sampling c.v., can be estimated. This provides a method to determine what minimum sample size may be required to achieve a target overall c.v. of 20%. The sample sizes were optimised to make the s.e.s the same for each stratum.

A research survey must involve random fishing because the mean abundance is determined over the whole area. By contrast, commercial fishers target only the high-density areas. As such, commercial fishery data are not randomly obtained, but are biased towards areas of high catch rate. These data are likely to underestimate the level of variability (and sample size required) for use in a research survey programme which must include fishing effort in strata where catch rates may be low.

It is therefore reasonable to assume that a random survey would be likely to have both a lower catch rate and a higher variability than the commercial fishery. If we were to use the variability estimated above from the commercial fishery, this would be likely to give an unrealistically low number of sets for a hypothetical survey.

To approximate the effect of random fishing we have assumed that the survey will produce a mixture of sets: some like the commercial sets, and some in areas where there are no fish (zero catch rate). This is obviously a crude approximation, but it allows us to obtain broadly plausible values. We can readily calculate the change in mean and variance under this assumption and obtain the required number of sets to achieve the target c.v. We will show the effect of assuming various plausible proportions of zero catch sets. Let p be the proportion of zero catch sets in a stratum. Then the mean catch rate of the mixture distribution in stratum i can be expressed in terms of μ_i, the mean of the commercial catch rates,

$$\mu_i' = (1-p)\mu_i .$$

It can also be shown that the variance of catch rates of the mixture distribution in stratum i can be expressed in terms of μ_i and σ_i^2, the variance of commercial catch rates,

$$\sigma_i'^2 = (1-p)\sigma_i^2 + p(1-p)\mu_i^2 .$$

The standard error of the sample mean for stratum i,

$$s_i = \frac{\sigma_i'^2}{\sqrt{n_i}}$$

where n_i is the proposed sample size. The overall mean catch rate,

$$m = \sum_i w_i \mu_i'$$

where w_i is the stratum weight. The coefficient of variation of the overall mean catch rate,

$$c = \frac{\sqrt{\sum_i s_i^2 w_i^2}}{m} = \frac{\sqrt{\sum_i \frac{\sigma_i'^2}{n_i} w_i^2}}{\sum_i w_i \mu_i'} .$$

To obtain an optimum survey design we use the estimated μ_i and σ_i^2 to obtain μ_i' and $\sigma_i'^2$ and find the minimum number of sets, $\sum_i n_i$, for which $c = 0.20$. This can readily be achieved using "Solver" in Excel.

Catch rate data from the research *trawl* database (Bagley et al. 2000) were plotted against depth to determine the most appropriate depth stratification. From the data, 90% of the 727 stations where bluenose was reported occurred within the depth range 250–750 m, although data from the commercial fishery (Section 3) indicated fishing occurred in the 200–250 m range in the Bay of Plenty. Accordingly, the exclusion of depths less than 100 m and greater than 800 m is proposed for the pilot survey. Although four depth strata are suggested (100–299 m, 300–399 m, 400–499 m, and 500+ m) insufficient data are available from the commercial line fishing data to provide vessel catch rates by depth stratum.

The results of the line fishing workshop (Appendix 1) have been combined with the review of fishing areas and catch rate analysis to determine a pilot line fishery survey programme. It is likely that further determination of gear parameters would be required as part of the implementation of this pilot survey. No provision for the review of these factors was included in the current programme.

5.3 Results

The mean catch rates from the commercial line fishing data for the four pilot sampling strata are given for all vessels in Table 5. Data for individual vessels have been scaled to total catches, as catch rates are deemed commercially sensitive. These data were used to determine a mean weighted catch rate of 15 fish/100 hooks (Table 6) with a calculated c.v. of 2%. The calculated c.v.s for the mean weighted catch rates determined for the top three vessels by catch rate varied between 3% and 6%, although these data are deemed commercially sensitive and cannot be separately reported.

The estimated minimum number of sets required to achieve a c.v. of the overall catch rate of 20% (Table 7: first line) is considered to be a biased estimate. Additional sets with zero catch were added in various proportions to the commercial catch rate distribution to simulate random sets. These data indicate that where 50% of the possible catches are zero, a total sample size of 45 sets would be required to achieve the design c.v. of 20%. If the rate of zero catch rate is increased to 66%, the number of sets required to achieve the target c.v. would increase to 78.

5.4 Pilot survey design

Timing and location. The 2002 Bluenose Longline Workshop recommended that sampling take place in January-March, when bluenose are thought to recruit into the fishery. The two-phase pilot survey (Francis 1984) would be located adjacent to the "Mayor Knolls" in the Bay of Plenty, and use a single line fishing vessel. It is proposed that a commercial vessel (60–80 m in length) be chartered to complete this work. The skipper should have firsthand knowledge of the grounds being fished. This pilot programme should also compare the variability in mean catch rate as determined by fixed station and random station allocations. It is expected that stratum boundaries determined for the first definitive survey would require redefinition over the first few years to improve the precision of the sample estimates.

Allocation. Four strata are proposed (strata A – D (see Table 4)), with a total of 55 stations. Of these, 45 sets would be allocated to the first phase of the programme as: 10 sets in area 1, 11 sets in area 2, 8 sets in area 3, and 16 sets in area 4. Each station would be randomly located within these strata using a random allocation programme with the constraint that samples must be 1 nautical mile apart. The remaining 10 sets would then be allocated to the second phase of the survey to minimise the stratum variances (Francis 1984).

As the definitive survey would be stratified by area and depth, the data from the pilot programme could also be used to estimate variability due to depth. Most commercial bluenose fishing occurs in the 300–600 m range. The data would be post-stratified into three depth strata (100–299 m; 300–399 m; and 400+ m), within each stratum, with the constraint that there are at least three stations within a stratum to provide an estimate of stratum variability. The performance of the gear would be monitored during the soak time by depth sounder, to ensure that it stayed within the required depth stratum. The depth of the gear can be monitored wile fishing. Use of the wide beam option (15–25 khz) of sonar enables the depth and position of the floats to be determined.

Soak time. Although commercial vessels successfully fish one or two sets per 24 h day, soak time varied widely between 2 h and 12 h. The 2002 Bluenose Longline Workshop reccommended that gear trials be completed to determine an appropriate soak time for most fish to encounter the gear, and that sufficient baits remain available throughout the soak time. It is proposed that gear be fished initially for a 4 h period.

Setting of gear. To standardise fishing time, the gear should be set from dawn (0600 h in January-March) and the bottom topography of the station would be initially reviewed using the depth souder. If the station can be fished, the position of the gear would be standardised to pass through the station location, and be aligned along a depth contour.

Fishing gear. The survey gear should match that of the fishery, to align catchability and selectivity with the commercial fishery. Four standard fishing units are proposed, each having 500 hooks (see Section 4.2). The standard gear parameters initially proposed may be modified after gear trials as part of the pilot survey programme.

Assuming that four sets each with a 4 h soak time were completed per each 12 h fishing day, 8 stations could be completed each day, allowing for setting and hauling time. This suggests that the 55 stations would require 7–8 days to complete. In addition, a further 5 days will be required for gear trials on the standardised fishing gear, providing a total time of 12 days for the pilot programme.

The station location, time and depth of fishing, and the standard survey environmental parameters would be recorded on appropriate survey sampling documentation and/or directly to electronic data capture software if available. The catch would be sorted to species and weighed to the nearest kilogram using motion-compensating scales. The length frequency, sex, and gonad stage would be recorded for all quota species, on appropriate data recording forms and/or elctronic data capture systems. The length and sex of commercially important non-quota species would also be recorded. For bluenose, a subsample of 50 fish would be collected from each set and the otoliths would be removed for age determination. Data would be recorded on appropriate biological survey forms.

The pilot survey programme will review the scale of variability in mean catch rate by set, within and among area strata, and provide an estimate of variability due to depth. It will also compare the results of fixed station and random allocation sampling (Punt et al. 2002). The associated gear trials will compare catch rates using 12/0 and 14/0 hooks, and allow soak time, hook spacing, and other gear parameters to be optimised for bluenose.

6. GENERAL DISCUSSION

Quantitative line surveys are recognised as a useful technique for the estimation of relative abundance, particularly where bottom topography precludes the use of standard trawl survey methods. Their use for bluenose relative abundance estimation was supported by the 2002 Bluenose Longline Workshop. From the literature review, these techniques form an integral part of the stock assessment process of major fisheries research organisations in North America and Europe. These include the US National Marine Fisheries Service for sablefish (Sigler 2000) and sandbar shark (Branstetter & Musick 1991), the NAFO for cod (Nedreeas et al. 1993), the Canadian DFO for cod (Zwanenberg & Wilson 2000, 2000b), and the IPHC for halibut (Hoag et al. 1984).

Qunantitative line surveys provide a fishery-independent estimate of relative biomass (Punt et al. 2002). Although the original IPHC halibut line survey series was discontinued in favour of a commercial CPUE analysis that was considered more cost-effective (Deriso et al. 1989), the series was later reinstated (and has been continued) because the CPUE analysis was unable to accommodate change in fishing patterns in the fishery, or to monitor the effects of local depletion (Quinn 1987, Horwood et al. 1997). Both these trends appear to be features of the bluenose fishery (Blackwell 1999a, Annala et al. 2002).

Line survey techniques can provide abundance indices with c.v.s of less than 10% when used with an age-structured model (Sigler 1998). Although the 2002 Bluenose Longline Workshop noted that the distribution of many of these species (such as sablefish or halibut) appears to be more homogenous than that of bluenose, line fishing surveys have been successfully used for relative biomass estimation of alfonsino in the Azores (Gomes et al. 1998) and New Caledonia (Grandperrin et al. 1995). The habitat of alfonsino off the Azores (M. Sigler. pers. comm, 2002), and off New Caledonia appears to be generally similar to that off the east coast of New Zealand where major bluenose fisheries are located (Annala et al. 2002). Line fishing surveys have also been extensively used for qualitative surveys of many species including bluenose in Australia (Cowper & Downie 1957, Webb 1979, Wilson 1982a, 1982b, Winstanley 1980, Jones 1985, Bolch et al. 1993).

However, this habitat heterogeneity requires careful survey design, inplementation, and standardisation of survey gear and methods to allow comparisons between survey years to be made. (Hovgaard & Lassen 2000). This is particularly so where multiple vessels may fish standardised survey gear (Woll et al. 2001). The pilot sample programme proposed for the Mayor Knolls area will review variability among sampling strata, and permit gear trials to be completed. As insufficient data are currently available from the commercial fishery to properly review stratification by depth in these areas, the pilot programme will also address the scale of variability within depth strata. The more general application of line fishing surveys to bluenose will require the development of appropriate area and depth strata.

Although sufficient data to determine a pilot survey programme currently exist only in BNS 1, a subsequent extension to BNS 2 is recommended. This would initially use the survey parameters developed from the pilot programme in BNS 1, but these would be scaled on the basis of mean catch rates among the statistical areas as appropriate. The full survey will require on-going development of appropriate area and depth stratification, as knowledge of the survey areas increases with time.

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Table 1: Reported landings (t) of bluenose by Fishstock from 1981 to 1999–2000 and actual TACs (t) from 1986–87 to 1999–2000 (from Annala et al. 2001)

Fishstock	BNS 1		BNS 2		BNS 3		BNS 7		BNS 8		BNS 10			
QMA (s)	1 & 9		2		3, 4, 5 & 6		7		8		10		Total	
	Landings	TAC	Landings	TAC	Landings	TAC	Landings	TAC	Landings	TAC	Landings	TAC	Landings	TAC
1981*	146		101		36		12		–		0		295	
1982*	246		170		46		22		–		0		484	
1983†	250		352		51		47		1		0		726	
1984†	464		810		81		30		1		0		1411	
1985†	432		745		73		26		1		0		1326	
1986†	440		1009		33		53		1		0		1566	
1986–87‡	286	450	953	660	93	150	71	60	1	20	7	10	1411	1350
1987–88‡	405	528	653	661	101	166	104	62	1	22	10	10	1274	1449
1988–89‡	480	530	692	768	90	167	135	69	13	22	10	10	1420	1566
1989–90‡	535	632	766	833	132	174	105	94	3	22	0	10	1541	1765
1990–91‡	696	705	812	833	184	175	72	96	5	22	12 #	10	1781	1841
1991–92‡	765	705	919	839	240	175	62	96	5	22	40 #	10	2031	1847
1992–93‡	787	705	1151	842	224	350	120	97	24	22	29 #	10	2335	2026
1993–94‡	615	705	1288	849	311	350	79	97	27	22	3 #	10	2323	2033
1994–95‡	706	705	1028	849	389	357	83	150	79	100	0	10	2286	2171
1995–96‡	675	705	953	849	513	357	140	150	70	100	0	10	2352	2171
1996–97‡	966	1000	1100	873	540	357	145	150	86	100	9 #	10	2846	2490
1997–98‡	1020	1000	929	873	444	357	123	150	67	100	30 #	10	2613	2490
1998–99‡	868	1000	1002	873	729	357	128	150	46	100	2 #	10	2774	2490
1999–00‡	860	1000	1136	873	566	357	114	150	55	100	5 #	10	2736	2490

* MAF data; † FSU data.; ‡ QMS data. # Includes exploratory catches in excess of the TAC.

§ Includes landings from unknown areas before 1986–87, but excludes catches outside the New Zealand EEZ.

Table 2: Estimated and actual landings (t) by method (BT=bottom trawl, MW=midwater trawl, LL= lining (all)), statistical area, and approximated fishstocks, 1988–89 to 2000–01, from CELR and TCEPR data extracted May 2002.

BNS 1

Statistical area	1997/98 Landings (t)				1998/99 Landings (t)				1999/00 Landings (t)				2000/01 Landings (t)			
	BT	MWT	LL	Total	BT	MWT	LL	Total	BT	MWT	LL	Total	BT	MWT	LL	
1	0	0	84	84			112	112	0	0	83	83	0	0	64	64
2	0	0	0	0	0	0	0	0	1	0	108	109	0	0	105	105
3	1	0	132	134	0	0	137	137	0	2	100	102	0	0	55	55
4	1	0	59	60	0	0	54	54	0	0	81	81	0	0	55	56
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	15	15	0	0	0	0
8	8	0	41	49	2	1	39	43	3	0	44	47	2	6	24	33
9	2	0	81	83	3	0	47	51	1	0	65	65	1	0	135	135
10	4	0	166	170	3	2	228	232	1	16	237	254	5	29	286	320
41	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
42	0	0	0	0	0	0	2	2	0	0	0	0	0	0	0	0
43	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
44	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
45	0	5	0	5	0	0	1	1	0	0	4	4	0	0	4	4
46	0	18	0	18	0	0	26	26	1	0	25	26	1	0	14	15
47	0	59	0	59	0	0	13	13	0	0	25	25	0	0	19	19
48	0	0	0	0	0	0	3	3	0	0	0	0	0	0	2	2
Total estimated BNS 1				661				674				811				808
Actual BNS 1 landings				1 020				868								889

BNS 2

Statistical area	1997/98 Landings (t)				1998/99 Landings (t)				1999/00 Landings (t)				2000/01 Landings (t)			
	BT	MWT	LL	Total	BT	MWT	LL	Total	BT	MWT	LL	Total	BT	MWT	LL	Total
11	18	0	32	50	4	0	29	33	3	2	36	41	1	1	66	68
12	4	1	99	104	6	27	87	120	5	19	70	94	5	38	86	129
13	6	16	61	83	10	133	31	173	24	73	77	175	24	71	44	139
14	78	146	47	271	20	58	160	238	42	132	147	320	45	153	123	321
15	44	61	10	115	41	89	10	140	25	136	0	161	32	121	22	174
16	0	9	15	24	2	7	5	13	3	8	1	13	8	6	6	20
201	3	0	0	3	1	0	0	1	25	5	9	39	0	0	11	11
202	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
203	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
204	15	79	0	93	30	60	16	106	35	118	20	173	15	63	31	109
205	0	0	0	0	0	0	0	0	0	2	0	2	0	0	0	0
206	0	0	0	0	0	0	0	0	2	0	0	2	0	0	0	0
Total estimated BNS 2				744				825				1020				971
Actual BNS 2 landings				929				1 002				*				1 096

Table 2: – *continued*

BNS 3

Statistical area	1997/98 Landings (t) BT	MWT	LL	Total	1998/99 Landings (t) BT	MWT	LL	Total	1999/00 Landings (t) BT	MWT	LL	Total	2000/01 Landings (t) BT	MWT	LL	
17	6	9	0	15	3	1	0	3	0	1	0	1	0	1	0	1
18	19	86	2	107	72	98	19	188	124	30	1	154	39	24	0	63
19	0	0	0	0	31	0	5	36	0	0	0	0	0	0	0	0
20	2	0	1	4	2	0	4	6	2	0	0	2	0	0	0	0
21	0	20	0	20	0	6	0	6	1	3	5	9	0	0	0	0
22	0	0	1	1	0	0	1	1	0	0	2	2	0	0	0	0
23	1	0	0	1	10	0	0	10	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26	0	0	0	0	1	0	0	1	1	0	0	1	0	0	0	0
27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28	0	0	0	0	0	0	0	0	2	0	0	2	0	0	0	0
29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	12	0	12	9	0	0	10	3	0	0	3
31	0	0	0	0	0	0	0	0	0	0	16	16	1	0	14	15
32	0	0	0	0	0	0	42	42	0	0	30	30	6	1	49	56
49	0	0	0	0	0	0	5	5	0	0	0	0	0	0	0	0
50	0	0	0	0	30	0	5	34	5	0	0	5	11	0	0	11
51	0	0	0	0	85	7	2	94	58	0	0	58	248	0	0	248
52	0	0	0	0	0	0	10	10	0	0	0	0	0	0	1	2
401	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
402	3	0	0	3	0	0	0	0	2	0	0	2	0	0	0	0
403	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
404	0	0	0	0	4	0	0	4	53	4	0	57	58	0	0	58
405	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
406	25	1	0	26	10	2	0	12	5	0	0	5	1	0	0	1
412	3	0	0	3	9	0	0	9	2	0	0	2	0	0	0	0
Total estimated BNS 3				180				473				356				461
Actual BNS 3				444				729				*				633

BNS 7

Statistical area	1997/98 Landings (t) BT	MWT	LL	Total	1998/99 Landings (t) BT	MWT	LL	Total	1999/00 Landings (t) BT	MWT	LL	Total	2000/01 Landings (t) BT	MWT	LL	
33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
36	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
37	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
38	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total estimated BNS 7				0				0				0				0
Actual BNS 7				123				128				*				87

BNS 8

Statistical area	1997/98 Landings (t) BT	MWT	LL	Total	1998/99 Landings (t) BT	MWT	LL	Total	1999/00 Landings (t) BT	MWT	LL	Total	2000/01 Landings (t) BT	MWT	LL	
39	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total estimated BNS 8				0				0				0				0
Actual BNS 8				67				46				*				13

Table 3: BNS line fishery, number of landings, and mean, standard deviation and standard error of the catch rate (kg/100 hooks) by statistical area, for BNS 1–BNS 3, from 1988–89 to 2000–01. Data from CELR database, extracted May 2002.

BNS 1

Statistical	1997/98 Landings (t)				1998/99 Landings (t)				1999/00 Landings (t)				2000/01 Landings (t)			
area	n	Mean	Std dev	Std err	n	Mean	Std dev	Std err	n	Mean	Std dev	Std err	n	Mean	Std dev	Std err
1	109	92.49	81.98	7.85	148	109.49	112.86	9.28	125	56.77	55.13	4.93	94	64.85	59.69	6.16
2	237	103.84	76.88	4.99	233	73.34	64.99	4.25	216	63.51	44.52	3.03				
3	124	77.87	73.82	6.63	129	72.34	52.82	4.65	111	58.56	40.70	3.86	62	75.19	70.85	8.99
4	62	95.91	91.31	11.59	79	37.68	34.47	3.87	75	52.84	47.92	5.53	60	61.95	74.50	9.61
5	0				1	87.50			0				5	74.66	32.85	14.69
6	0				0				1	3.00			0			
7	0				1	140.35			12	47.28	39.60	11.43	3	34.18	7.39	4.26
8	39	72.88	56.47	9.04	36	85.37	73.57	12.26	36	78.06	86.90	14.48	25	51.72	39.38	7.91
9	160	45.08	36.50	2.88	80	·46.84	41.89	4.68	81	76.11	92.66	10.29	217	33.51	28.56	1.93
10	247	65.52	53.24	3.38	276	70.11	61.89	3.72	270	68.62	55.36	3.36	0			
41	0				0				0				0			
42	0				0				0				0			
43	0				0				0				0			
44	0				0				0				0			
45	8	16.20	11.37	4.02	0				0				0			
46	16	29.92	17.01	4.25	15	74.46	51.43	13.27	26	42.86	46.05	9.03	13	163.07	87.19	24.18
47	84	122.86	117.71	12.84	10	133.61	85.89	27.16	29	145.19	140.32	26.05	12	149.12	92.01	26.56
48	0				2	109.25	68.79	48.64	1	0.00			3	6.61	5.11	2.95

BNS 2

Statistical	1997/98 Landings (t)				1998/99 Landings (t)				1999/00 Landings (t)				2000/01 Landings (t)			
area	n	Mean	Std dev	Std err	n	Mean	Std dev	Std err	n	Mean	Std dev	Std err	n	Mean	Std dev	Std err
11	34	94.01	128.64	22.06	26	99.06	114.60	22.47	33	104.61	94.32	16.41	57	73.06	69.34	9.18
12	88	99.93	79.03	8.42	77	115.21	99.95	11.39	47	99.48	72.92	10.63	57	79.83	58.63	7.76
13	46	53.66	51.22	7.75	22	52.29	34.97	7.46	25	65.42	68.94	13.78	30	52.33	49.10	8.96
14	29	101.95	47.43	8.80	61	96.52	60.63	7.76	69	48.62	37.80	4.55	61	46.01	31.53	4.04
15	5	82.48	24.50	10.96	6	73.40	13.39	5.46	0				36	123.84	54.69	9.12
16	1	25.00			2	18.33	235.00	1.66	0				9	68.05	34.27	11.42
201	0				0				5	438.58	194.02	86.78	5	230.00	5968.00	26.69
202	0				0				0				0			
203	0				0				0				0			
204	0				2	44.17	11.76	8.31	3	24.42	14.40	8.31	4	35.44	11.72	5.86
205	0				0				0				0			
206	0				0				0				0			

Table 3: – *continued*

BNS 3

Statistical area	1997/98 Landings (t)				1998/99 Landings (t)				1999/00 Landings (t)				2000/01 Landings (t)			
	n	Mean	Std dev	Std err	n	Mean	Std dev	Std err	n	Mean	Std dev	Std err	n	Mean	Std dev	Std er
17	0				0				0				0			
18	6	18.98	34.97	14.27	9	23.47	50.55	16.85	2	15.33	19.56	13.83	0			
19	0				2	7.14	0.00	0.00	0				0			
20	5	8.41	11.32	5.06	4	0.00			0				0			
21	2	79.04	11.95	8.45	0				0				0			
22	1	15.55			1	85.52			3	79.71	33.20	19.17	0			
23	0				0				0				0			
24	0				0				0				0			
25	0				0				0				0			
26	0				0				0				0			
27	0				0				0				0			
28	0				0				0				0			
29	0				0				0				0			
30	2	6.00	5.65	4.00	0				0				0			
31	0				0				0				5	75.13	81.42	36.4
32	2	87.50	17.67	12.50	15	55.09	85.63	22.11	10	44.40	48.04	15.19	17	34.02	43.37	10.5
49	3	37.50	21.65	12.50	0				0				0			
50	0				6	27.50	11.72	4.78	0				0			
51	2	23.75	1.76	1.25	0				0				0			
52	0				6	25.00	19.42	7.93	0				1	10.00		
401	0				0				0				0			
402	0				0				0				0			
403	0				0				0				0			
404	0				0				0				0			
405	0				0				0				0			
406	0				0				0				0			
412	0				0				0				0			

Table 4: Proposed pilot survey programme for BNS 1, Bay of Plenty sampling strata (A–D) by location (rounded to 0.10 of a degree of latitude and longitude for confidentiality), and area of stratum

Stratum		Latitude (D°.o)	Longitude (D°.o)	Area
A	1	176.3	37.2	= 9.6 x 7.6 n. miles
	2	175.5	37.2	=73.62 n miles^2
	3	176.5	37.3	
	4	176.3	37.3	
B	1	176.7	37.2	= 11.7 x 6.7 n miles
	2	176.9	37.2	=79.10 n miles^2
	3	176.9	37.3	
	4	176.6	37.3	
C	1	177.1	37.3	= 5.3 x 11.7 n miles
	2	177.2	37.3	=61.90 n miles^2
	3	177.2	37.6	
	4	177.1	37.6	
D	1	176.8	37.4	= 12.5 x 9.7 n miles
	2	177.1	37.4	=121.76 n miles^2
	3	177.1	37.5	
	4	176.8	37.5	

Table 5: BNS 1: Mean, standard error and standard deviation of catch rate (no. fish/100 hooks), by stratum (A–D). Catch rate is actual data for all vessels combined. Data for individual vessels have been scaled (as percentage of total catch rate) to preserve confidentiality

	Area 1				Area 2			
Vessel	n	Mean	Stddev	Stderr	n	Mean	Stddev	Stderr
1		1.00	0.66	0.38		1.00	0.20	0.06
2		0.70	0.32	0.13		0.84	0.73	0.42
3		0.70	0.19	0.09		0.70	0.36	0.09
4		0.64	0.17	0.10		0.67	0.51	0.21
5		0.54	0.25	0.10		0.66	0.21	0.11
6		0.53	0.32	0.06		0.66	0.46	0.10
7		0.49	0.18	0.04		0.62	0.36	0.14
8		0.49	0.27	0.08		0.59	0.42	0.06
9		0.47	0.22	0.04		0.48	0.47	0.13
10		0.39	0.16	0.08		0.41	0.22	0.15
11		0.38	0.32	0.09		0.26	0.14	0.07
12		0.33	0.20	0.04		0.23	0.05	0.03
13		0.19	0.12	0.06		0.00	0.00	0.00
14		0.14	0.00	0.00		0.00	0.00	0.00
15		0.00	0.00	0.00		0.00	0.00	0.00
All vessels	165	15.25	9.09	0.71	132.00	14.83	9.93	0.86

	Area 3				Area 4			
Vessel	n	Mean	Stddev	Stderr	n	Mean	Stddev	Stderr
1		1.00	0.41	0.24		1.00	0.38	0.12
2		0.68	0.47	0.07		0.83	0.18	0.06
3		0.67	0.00	0.00		0.59	0.38	0.06
4		0.66	0.33	0.06		0.57	0.42	0.09
5		0.62	0.21	0.06		0.51	0.33	0.04
6		0.54	0.37	0.05		0.51	0.17	0.05
7		0.54	0.32	0.08		0.47	0.27	0.03
8		0.53	0.15	0.09		0.46	0.29	0.06
9		0.53	0.25	0.04		0.42	0.29	0.09
10		0.48	0.28	0.09		0.36	0.25	0.06
11		0.37	0.01	0.01		0.00	0.00	0.00
12		0.28	0.16	0.09		0.00	0.00	0.00
13		0.00	0.00	0.00		0.00	0.00	0.00
14		0.00	0.00	0.00		0.00	0.00	0.00
15		0.00	0.00	0.00		0.00	0.00	0.00
All vessels	220	15.54	9.4	0.63	264	14.84	9.39	0.58

Table 6: Bay of Plenty sampling areas: Estimated mean weighted catch rate of BNS (No./100 hooks), showing calculated c.v's by sampling stratum, all vessels combined.

Sampling area		Coastline (km)	Weighting	Raw mean No./100 hooks	Raw SE	n	Weighted mean	SE*wt	(SE*wt)2	c.v.=SE/mean	Calculated c.v.
	1	73.62	0.22	15.25	0.71	165	3.34	0.15	0.02	0.05	4.64
	2	79.10	0.24	14.83	0.86	132	3.49	0.20	0.04	0.06	5.83
	3	61.90	0.18	15.55	0.63	220	2.86	0.12	0.01	0.04	4.08
	4	121.76	0.36	14.84	0.58	264	5.37	0.21	0.04	0.04	3.89
Total		336.38	1.00			781	15.06		0.12	0.02	2.32

Table 7: Estimated means, weightings and standard deviations by stratum of commercial catch rates and estimated minimum total number of sets required to achieve a c.v. of the overall mean catch rate of 0.20. Additional sets that produce a zero catch rate are added in various proportions to the commercial catch rate distribution to simulate random sets.

	Stratum 1	Stratum 2	Stratum 3	Stratum 4
Mean catch rate, μ_i (kg/set)	15.25	14.83	15.55	14.84
Weighting, w_i	0.22	0.24	0.18	0.36
Standard deviation, S_i (kg/set)	9.09	9.93	9.40	9.38

Proportion of zeros, p				Number of sets	Total number of sets
	n_1	n_2	n_3	n_4	
0.00	2	2	2	4	10
0.25	5	5	4	8	22
0.33	6	6	5	10	27
0.50	10	11	8	16	45
0.66	17	18	15	28	78

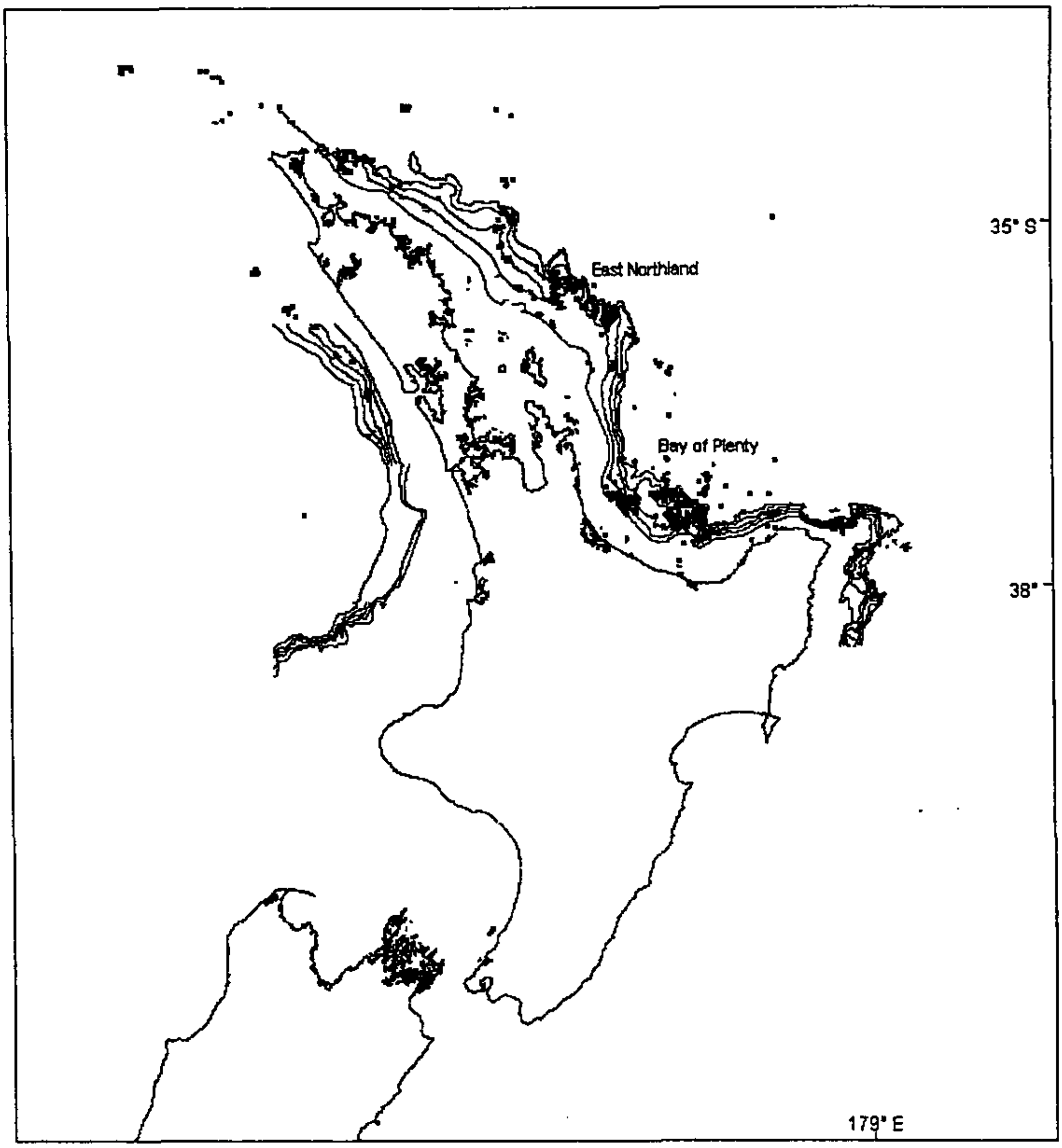

Figure 1: Locations of line fishing sets in BNS 1 for the fishing years 1995–96 to 2000–01 from the NIFMC Logbook scheme, with depth indicated by the 200, 400, 600, 800 and 1000 m depth contours (where available).

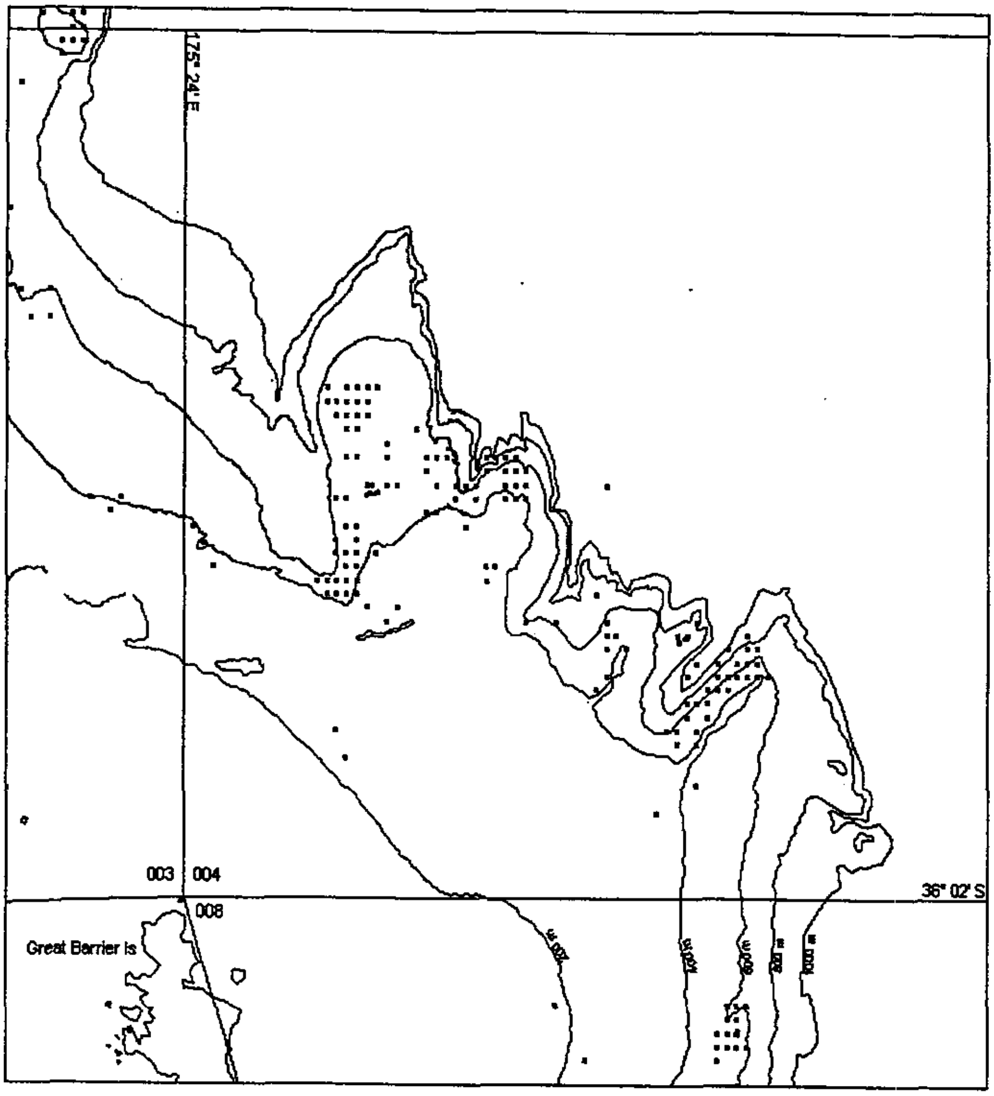

Figure 2: Location of line fishing sets from the NIFMC logbook scheme for the fishing years 1995–96 to 2000–01 in the East Northland fishing ground (statistical areas 004, and parts of 003 and 008), showing the 200, 400, 600, 800 and 1000 m depth contours.

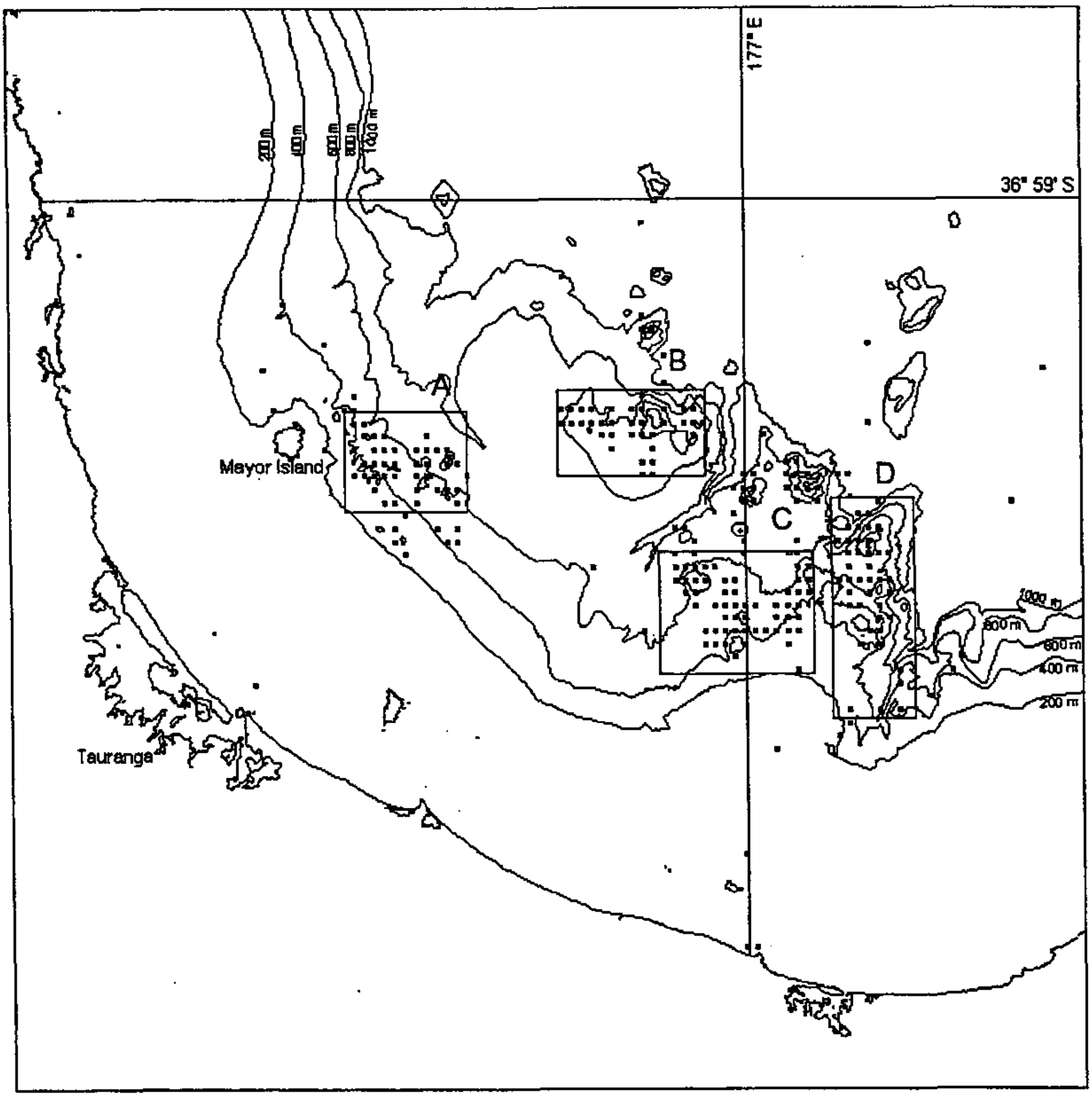

Figure 3: Location of line fishing sets from the NIFMC logbook scheme for the fishing years years 1995–96 to 2000–01 in the Bay of Plenty fishing ground (statistical areas 009, and part of area 010), showing the 200, 400, 600, 800 and 1000 m depth contours, and proposed sampling strata A–D.

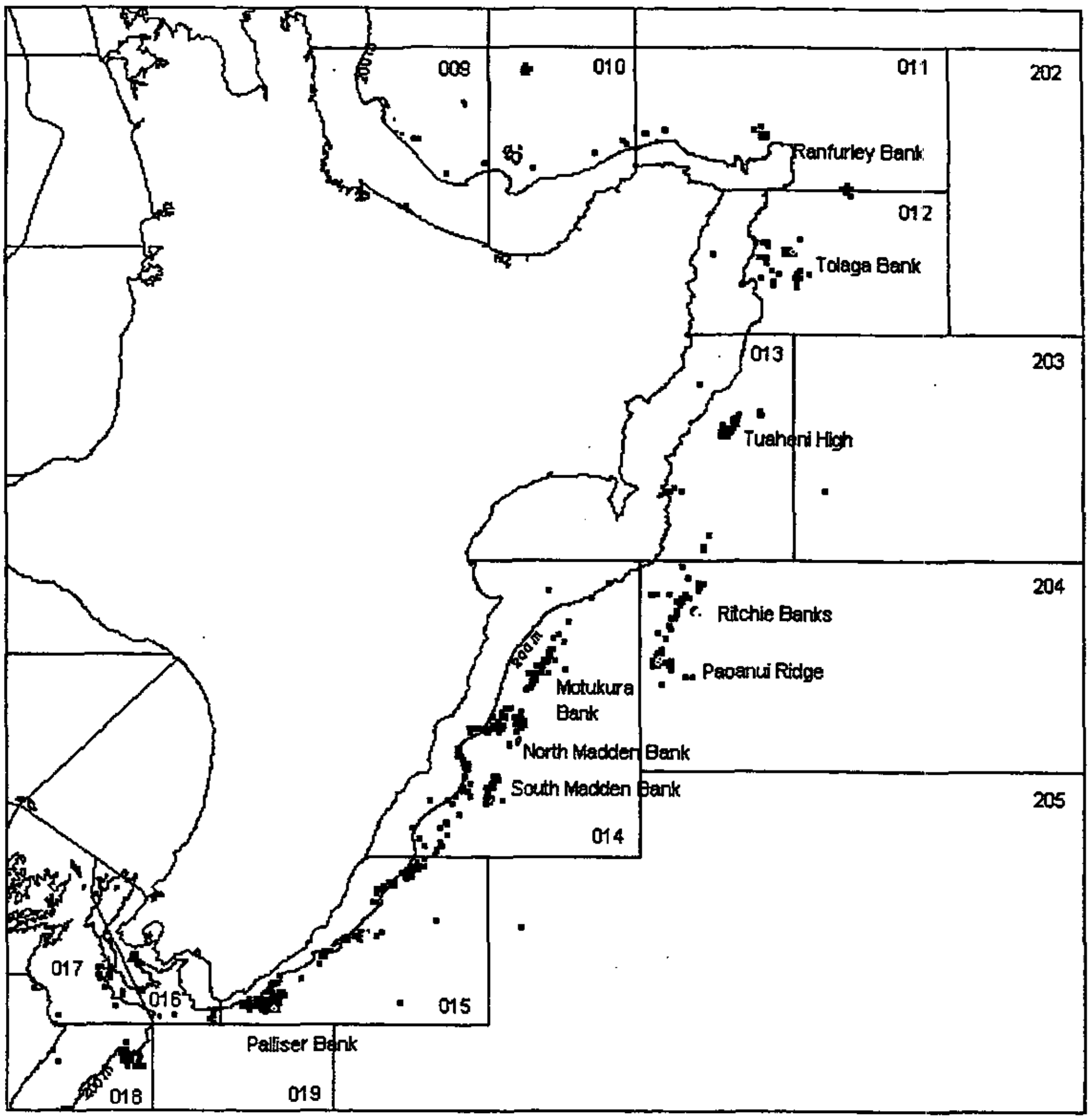

Figure 4: Positions of tows from trawl vessels reporting on the TCEPR (Trawl catch effort and processing Return) database from 1997–98 to 2000–01, by statistical area and major fishing ground.

Appendix 1: Development of relative abundance indices for bluenose. Report from the Line Fishing Workshop 3–5 April 2002, at NIWA, Nelson

1. Summary

The international workshop on bluenose (*Hyperoglyphe antarctica)* held in Nelson, 3–5 April 2002, brought together scientists, fishery managers and fishers from Australia, New Zealand, and the USA to hear keynote speaker Dr Michael Sigler, (Auke Bay Laboratory of the US Fisheries Service) describe line fishery research methods successfully used to estimate the abundance of Alaskan sablefish (*Anoplopoma fimbria)*. In comparison to sablefish, bluenose distribution is patchy, and survey design requires careful determination of appropriate stratification and sample size. The workshop agreed that a quantitative line survey was the most viable fishery-independent assessment method. Review of data from the Industry Logbook Scheme in the BNS 1 line fishery was recommended to determine fine scale variability in catch rate within fishing grounds and among fishing vessels, and identify appropriate areas and strata for a pilot survey programme. This pilot survey should trial the use of standardised commercial longline gear, set at random locations within these defined strata. The soak time must be sufficient for most fish to encounter the gear, and the number of hooks must be sufficient to ensure baits remain available throughout the set. The workshop recommended that a pilot survey be developed for the BNS 2 fishery, based on catch rate data from the trial programme completed in BNS 1.

2. Background

Bluenose (*Hyperoglyphe antarctica*) supports moderately important, but relatively high value fisheries in Australia and New Zealand. Research indicates that relative abundance of this species may not be adequately indexed by standard CPUE indices based on fishery catch and effort data. This is due in part to a high level of vessel-based variability, and the small size of the target bluenose fishery. As the TACCs for bluenose in some areas have been increased under an "adaptive management programme", there is a need to develop mechanisms that more accurately assess relative abundance rather than index fishery performance. Bluenose are not readily assessed by standard bottom trawl surveys, due to their distribution over untrawlable ground. They commonly form mixed schools with alfonsino, and are not easily reviewed using acoustic survey methods.

One possible method involves using line-fishing gear quantitatively to assess relative abundance. This method is new to New Zealand, but has been successfully used in long running fisheries assessment programmes in Alaska (sablefish, Pacific halibut), the US East coast (Atlantic halibut), the Azores (alfonsino, bream), and in New Caledonia (alfonsino).

This workshop brought together scientists working on bluenose in Australia and New Zealand, and sablefish in Alaska, with commercial fishers from New Zealand to assess the feasibility of this method of biomass estimation. The workshop initially described the major bluenose fisheries in New Zealand and their management. Analysis of commercial fishery-based CPUE data for bluenose suggests that indices do not index relative abundance. The workshop compared and contrasted these CPUE indices with the successful use of similar data for the New Zealand ling fishery.

The workshop reviewed the methodology used in the quantitative line fishery survey for sablefish in Alaska that has run for 21 years, and how these methods might be successfully applied to bluenose, and other species of interest.

An alternative approach to provision of management information is to carry out model-based simulations on a theoretical bluenose population. Progress in the development of two population based models was reviewed and their application to bluenose is discussed.

This report includes the timetable and abstracts of presentations to the workshop. It describes the summary and recommendations from the workshop for the biomass assessment of bluenose and other species.

3. Timetable for the Bluenose Line Fishing Workshop, 3-5 April 2002.

3.1 Programme for Wednesday, 3 April 2002.

Introduction and Welcome
(Ken Grange, Regional Manager, NIWA, Nelson)

Session 1. The bluenose fishery in New Zealand.
(Chair: Adam Langley)

(a) Summary of the bluenose fishery in New Zealand
- Development of the bluenose fishery (Ron Blackwell)
- Current management of the bluenose fishery (Kevin Sullivan)
- Fishing methods and gear in BNS1–BNS3 (Peter Jones)

(b) Current methods of monitoring bluenose abundance in New Zealand
- BNS1 line fishery CPUE analysis (Adam Langley)
- BNS 2 line fishery CPUE analysis (Ron Blackwell)
- Previous hook tagging programmes in BNS 2 (Peter Horn)

(c) Discussion and identification of issues in the fishery

Session 2. Monitoring abundance in other line fisheries
(Chair: Mike Sigler)

(a) Bluenose, alfonsino and gemfish in Australia
- The bluenose fishery in Australia (Pascal Baelde)
- The gemfish fishery in Australia (Kevin Rowling)

(b) Ling and sablefish
- The ling fishery in New Zealand (Peter Horn)
- The sablefish fishery in Alaska (Mike Sigler)

(c) Review of Session 2

3.2 Programme for Thursday 4, April 2002.

Session 3. Quantitative longline surveys used for sablefish and other species
(Chair: Dave Gilbert)

(a) Introduction
- Review of standard methods for abundance surveys
- Special considerations for longline surveys

(b) Survey design

- Survey timing
- Area and depth stratification
- Random or standard locations
- Extrapolating to wider fishery area
- Examination of established /exploratory fishing grounds

(c) Survey methods and standardisation techniques for quantitative use of fishing gear

- soak time
- setting techniques
- gear type
- bait type
- bait size
- hook size
- hook spacing

Session 4. **Use of simulation in longline survey design**
(Chair: Stuart Hanchet)

- Introduction to fishery simulations (Ian Ball)
- An example using the toothfish fishery (Ian Ball)

Session 5. ***Applications of quantitative longline surveys to bluenose***
(Chair: Mike Sigler)

- Review of the applicability of longline survey methods to bluenose
- Review of the applicability of longline survey methods to other species

Session 6. **General discussion, recommendations and research ideas**
(Chair Kevin Sullivan)

3.3 Programme for Friday, 5 April 2002.

Session 7. **The "Fish Heaven" software programme**
(Ian Ball)

- An introduction to the "Fish Heaven" software programme (Ian Ball)
- An example using the Ross Sea toothfish fishery (Ian Ball)

Session 8. **Introduction to the MSE bluenose management model**
(Robin Thompson)

Session 9. **Summary and final discussion**
(Chair: Mike Sigler)

Session 10. **Summary and concluding session**
(Chair: Ron Blackwell)

4. List of Participants (in alphabetical order)

Pasale Baelde	Sea Matters Pty. Ltd., Fisheries Consultants Canberra, Australia
Ian Ball	Australian Antarctic Division (AAD), Kingston, Tasmania, Australia
Ron Blackwell	NIWA, Nelson, New Zealand
Dave Gilbert	NIWA, Wellington, New Zealand
Ken Grange	NIWA, Nelson, New Zealand
Stuart Hanchet	NIWA, Nelson, New Zealand
Peter Horn	NIWA, Nelson, New Zealand
Peter Jones	Federation of Commercial Fishermen, Wellington, New Zealand
Adam Langley	SEAFIC, Auckland, New Zealand
Kevin Rowling	NSW Fisheries Service, Cronulla Laboratory, Sydney NSW, Australia
Margot Sachse	Australian Fisheries Management Authority (AFMA), Canberra, Australia
Mike Sigler	US Fisheries Service, NOAA, Auke Bay Laboratory, Juneau, Alaska, USA
Neville Smith	Ministry of Fisheries, Wellington, New Zealand
Kevin Sullivan	Ministry of Fisheries, Wellington, New Zealand
Robin Thompson	CSIRO Marine Research, Hobart, Australia
Sarah Varian	Ministry of Fisheries, Wellington, New Zealand
Richard Wells	Sealord Group, Nelson, New Zealand

5. Abstracts of presentations

5.1 Introduction to the New Zealand bluenose fishery

Ron Blackwell, NIWA Nelson

Bluenose (*Hyperoglyphe antarctica)* is a member of the Centrolophid family, with a wide distribution over outer continental slope and shelf waters of southern Australia and New Zealand. It commonly occurs over rough ground associated with rocky canyons and reefs, drop-offs and pinnacles, in depths ranging from 300 to 1000 m. Bluenose stay close to the bottom during the day, and move into the water column at night, following the concentrations of the pelagic tunicate *Pyrosoma* sp. which form their major food. Bluenose also feed on squid, molluscs, crustaceans, and fish (ranging from small lantern fish (Myctophidae), to juveniles of larger fish such as gemfish (*Rexea solandri*)).

Juvenile bluenose are considered to be pelagic, sometimes found in association with floating debris, such as seaweed. Bluenose possibly grow quickly for the first two years, to average sizes of 31 and 45 cm fork length (FL) in the first and second year, respectively. Juvenile fish recruit to a demersal lifestyle from a presumed pelagic one at a length of about 47 cm FL. Females grow faster than males, and fish first spawn at about 62 cm FL. Little is known about the reproductive biology of bluenose. Spawning probably begins in late summer and may span several months. In the East Cape region bluenose probably spawn from January to April. No distinct spawning grounds are known in BNS 2, although spawning grounds have been identified in Australia, and in BNS 1.

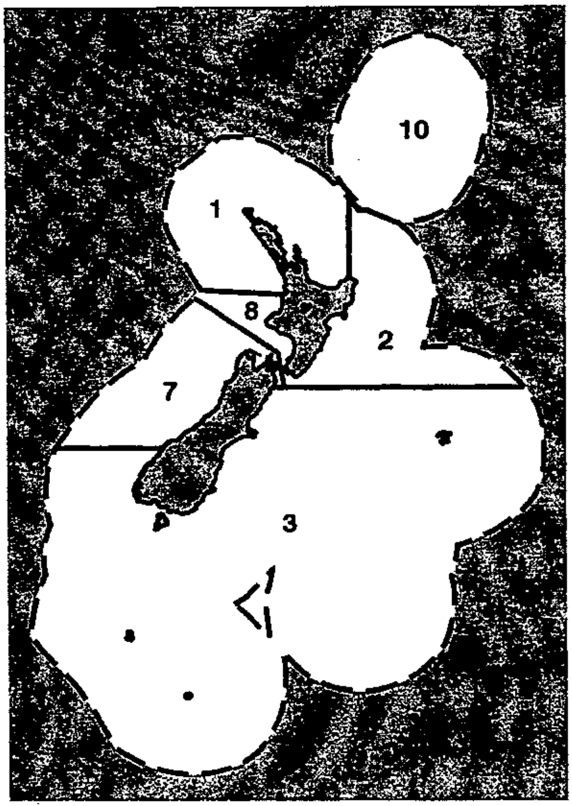

Figure 1: Management zones in the bluenose fishery

The bluenose fishery (Figure 1) is divided into 5 management zones (Figure 1): Northland/Bay of Plenty (BNS 1), East Coast/Wairarapa (BNS 2); Chathams/Southland/Sub-Antarctic (BNS 3); West Coast South Island (BNS 7); Egmont (BNS 8), Kermadec (BNS 10). The target bluenose fishery developed from the groper line fishery. Bluenose bycatch data were often included with groper landings data prior to 1981.

Since 1981, total landings of bluenose (Table 1) increased to 1400 t (1984), and remained stable from 1984 to 1989–90. Landings then rose to about 2300 t from 1992–93 to 1995–96. The recent landings from 1998–99 to 1999–2000 have exceeded 2700 t, and are associated with the development of new fisheries in the north and east of New Zealand.

Two major fisheries occur in BNS 1 and BNS 2 (Table 1). A substantial target fishery occurs in the Bay of Plenty and East Northland (BNS 1), and this fishery has been managed under the Adaptive Management Programme since 1996–97. A smaller set net fishery also exists in the Bay of Plenty. The target line fishery that developed off the Wairarapa coast, and latterly the east coast of the North Island (BNS 2) has declined subsequent to the development of the midwater trawl fishery for alfonsino (BYX 2) in the mid 1980s. Most bluenose in BNS 2 is now taken as bycatch of the midwater trawl fishery for alfonsino. Bluenose is a minor bycatch of other trawl fisheries including gemfish and hoki (*Macruronus novaezelandiae).*

Table 1: Reported landings (t) of bluenose by Fishstock from 1981 to 1999–2000, and actual TACCs (t) from 1986–87 to 1999–2000.

Fishstock	BNS 1		BNS 2		BNS 3		BNS 7		BNS 8		BNS 10			
QMA (s)	1 & 9		2		3, 4, 5 & 6		7		8		10		Total	
	Landings	TAC	Landings	TAC	Landings	TAC	Landings	TAC	Landings	TAC	Landings	TAC	Landings	TAC
1981*	146		101		36		12		–		0		295	
1982*	246		170		46		22		–		0		484	
1983†	250		352		51		47		1		0		726	
1984†	464		810		81		30		1		0		1411	
1985†	432		745		73		26		1		0		1326	
1986†	440		1009		33		53		1		0		1566	
1986–87‡	286	450	953	660	93	150	71	60	1	20	7	10	1411	1350
1987–88‡	405	528	653	661	101	166	104	62	1	22	10	10	1274	1449
1988–89‡	480	530	692	768	90	167	135	69	13	22	10	10	1420	1566
1989–90‡	535	632	766	833	132	174	105	94	3	22	0	10	1541	1765
1990–91‡	696	705	812	833	184	175	72	96	5	22	12 #	10	1781	1841
1991–92‡	765	705	919	839	240	175	62	96	5	22	40 #	10	2031	1847
1992–93‡	787	705	1151	842	224	350	120	97	24	22	29 #	10	2335	2026
1993–94‡	615	705	1288	849	311	350	79	97	27	22	3 #	10	2323	2033
1994–95‡	706	705	1028	849	389	357	83	150	79	100	0	10	2286	2171
1995–96‡	675	705	953	849	513	357	140	150	70	100	0	10	2352	2171
1996–97‡	966	1000	1100	873	540	357	145	150	86	100	9 #	10	2846	2490
1997–98‡	1020	1000	929	873	444	357	123	150	67	100	30 #	10	2613	2490
1998–99‡	868	1000	1002	873	729	357	128	150	46	100	2 #	10	2774	2490
1999–00‡	860	1000	1136	873	566	357	114	150	55	100	5 #	10	2736	2490

* MAF data; † FSU data; ‡ QMS data. # Includes exploratory catches in excess of the TAC.
§ Includes landings from unknown areas before 1986–87, but excludes catches outside the New Zealand EEZ.

A small target line and trawl fishery has recently developed off the Chatham Islands (BNS 3), where bluenose is also taken as bycatch of midwater trawling for alfonsino. Bluenose is a minor bycatch of line fishing in the south and west of Cook Strait (BNS 7) and off the west coast of the North Island (BNS 8). Bluenose stocks in BNS 3, 7 & 8 are currently managed under the Adaptive Management Programme.

5.2 Current management of the bluenose fishery

Kevin Sullivan, Ministry of Fisheries, Wellington

Bluenose is really a middle-depth fishery, as it is found mainly between 300 and 700 m, and catches commonly follow the 400 m contour. It is included in the Inshore grouping as it is fished by smaller longline or trawl vessels, and for many fishers, catch rates are maintained by fishing on a patch system, where fishers have almost a husbandry role.

Bluenose is widely distributed, and has been recovered from research trawls in depths of 1000 m. It is known to occur in areas such as the Kermadecs (BNS 10), or off the West coast of New Zealand (BNS 7, BNS 8), although historical catch rates in these areas have been low. These fishing grounds are some distance from convenient ports, and the fishery historically has used relatively small day fishing vessels. The fisheries in BNS 1 and in BNS 3–8 are considered to be developing fisheries. There is limited knowledge of the fishing grounds. The biology of bluenose is poorly understood. The length and age composition is unknown. There is limited catch and effort data. It is unknown if the current catch is sustainable, but there may be the potential for higher yields. Such species may be managed under the adaptive management scheme.

The TACC for BNS 1 was increased to 1000 t for the 1996–97 fishing year, under the adaptive management scheme and the programme will continue until 2006. Quota owners are responsible for monitoring catch and effort and collecting data to improve our knowledge of the fishery. The performance of the CPUE is compared to an agreed standard (the decision rule). For BNS 1, the decision rule is defined as a drop of 40% from the average abundance in any year using commercial CPUE data, and based on the average for the entire six years [1989/90–1994/95], as calculated in that year). Failure to achieve this minimum would require that this assessment be referred back to the

Inshore Working Group for a full assessment. This decision rule was not triggered in the 1999-2000 fishing year.

The TACC for BNS 3 was increased under the adaptive management programme to 350 t for the 1992–93 fishing year, although total landings continue to exceed the TACC (566 t in 1999–2000). The TACCs for BNS 7 and 8 were increased to 150 t and 100 t respectively for the 1994–95 fishing year and landings since this time have approached the new TACCs, particularly for BNS 7. However, the area was developed by small line vessels where operational constraints have limited the transfer of effort to these grounds on the west coast of the North Island.

The Adaptive Management process depends upon being able to reliably track the relative abundance of bluenose. However, reviews of all bluenose stocks indicate that the CPUE from the commercial fishery is unlikely to index bluenose abundance. This is why alternative fishery-independent methods of relative biomass estimation are now being considered.

5.3 Fishing methods and gear in the bluenose fishery

Peter Jones, Federation of Commercial Fishermen

In 1974 when I started dahn line fishing on the ex-Sanford 50 ft trawler FV *Frances*, bluenose was a bycatch of the groper, bass, and ling dahnline and longline fisheries. Fishers supplied local markets, and grounds were identified using a black and white sounder, using landmarks to locate positions. Then, 500–1000 hooks were set using barracouta, squid, or jack mackerel as bait. Wiggin chain was used on the backbone with about 45 hooks (12/0 J-hooks) spaced 1 metre apart, per dropper, with floats set to balance the weight of the chain. A 7mm rope was then used from the dropper to the dahn buoy on the surface. Most fishing was done in 180–540 m with groper fished on the shallow (180 m), bass and bluenose in 360–450 m, and bass and ling from 540 m. The bluenose was relatively lightly fished, as this was rarely targeted unless the groper catch was low, or we had a bluenose order to fill. When targeting bluenose we often fished the side of a hill, joining up two or three droppers together on one dahn line.

In the early 1980s, I purchased FV *Sunniva* and changed to trotlining. Here, we used 12 hook droppers which were clipped to the 7 mm rope backbone at 45–90 m intervals on a longline with about 500 hooks per set. The droppers had a float on the top to keep the gear flying off the bottom, and for bluenose we would join droppers to make up 24, 36, or 60 hooks per drop, which was useful when trying to fish a small pinnacle or ridge.

After the 1986 quota cuts, bluenose became a valuable species, and export markets had developed. After some experimentation, we found smaller hooks better target-fished bluenose. Using the trotline method, we were able to fish more hooks effectively, with less downtime retrieving dahn lines that had been misplaced by tidal currents. During this time, fishing became more efficient due to technological improvements in radar, sat-nav, and finally GPS, for positioning the gear.

In the early 1990s, improvements in winch design allowed the change from multifilament to 3 mm monofilament longline fishing gear. This was used to target bluenose, and by flying the gear 10 m off the bottom, the catch of bluenose increased in proportion to the groper bycatch. The line was set with an anchor and float at one end, then stoppers were placed at 3 m intervals along the groundrope. These were spaced so 16 hooks covered 54 m of ground rope. Then, an 45 cm float was fixed on the line, followed by another 18 hooks. The process was completed until 500–700 hooks were set. Up to 2–3 lines could be set (1500–1700 hooks per day) if required. Fishing started about 0100 h, and the gear was set slowly, to avoid over-tensioning the gear. This allowed the baits to sink quickly and thus minimise potential seabird interactions.

Longline gear was considered to be better than trot-line gear in target fishing bluenose. If the gear went too deep, we would get ling, if too shallow wewould get trumpeter, tarakihi, school shark, and gemfish. When set correctly, the gear would catch 95% bluenose, in contrast to 33% bluenose for trot-line fishing.

The next big improvement came with the change to the 16/0 circle-hook design, which set into the side of the mouth and provided a higher strike rate than the original J-hook design. This gear allowed areas previously considered to have a low catch rate to be fished, and allowed us to "spell" our favorite fishing spots. Since then, catch rates have been maintained, although patterns in the fishery were being influenced by TACC levels and quota allocations. The benefits of the quota system were by now really showing, as the pressure on the fishstock was governed by the TACC tonnage. The secret now is fishing for the local and export markets with improved product quality to provide the best prices for the tonnage of quota available.

5.4 The BNS 1 longline fishery

Adam Langley, SeaFIC, Auckland

The longline fishery accounts for most of the catch from the BNS 1 fishery. The BNS 1 fishery is included within the Adaptive Management Programme that has provided additional quota in return for a higher level of fishery monitoring. The monitoring includes the analysis of catch and effort data from the target line fishery and the collection of detailed catch and effort and biological data from the fishery under a logbook scheme. The presentation will include a summary of the commercial fishery and the results of the analysis of catch and effort data and biological data from the fishery. The utility of the current monitoring regime for the ongoing management of the fishery will also be discussed

5.5 BNS 2 line fishery CPUE analysis

Ron Blackwell, NIWA, Nelson

Landings have exceeded the TACC for bluenose in BNS 2 since 1991–92, generally associated with overcatch in the target alfonsino midwater trawl fishery. Landings in the target line fishery fluctuated between 25 and 30% of BNS 2 landings between 1988–89 and 1996–97, and standardised CPUE indices (kg/hook) remained generally stable, around a long-term mean, but displayed little contrast during this period. The presence of strong vessel and fishing ground interactions which varied between fishing years indicated that not all grounds were fished in all years, and that the analysis was strongly influenced by vessel-level variations in fishing practices.

Estimates of biomass and yield were using the MIAEL model, but the lack of contrast in CPUE indices and high variability in the data resulted in high variability in the model estimates, and the analysis was considered to be inaccurate. Although most bluenose in BNS 2 is now taken as bycatch of midwater trawling, fishers actively avoid bluenose. The trends in CPUE are likely to be masked by changes in fishing practices in the target fisheries, particularly where active avoidance of bluenose occurs, and it is unlikely that trends in the CPUE indices satisfactorily monitor bluenose abundance. The use of target longline CPUE data to monitor abundance is also likely to be problematic, due to possible serial depletion issues, and the small size and low coverage of the target line fishery, the Inshore Working Group recommended that the potential use of fishery independent methods be investigated for bluenose.

5.6 Tagging bluenose (*Hyperoglyphe antarctica*) with detachable hook tags

Peter Horn, NIWA, Nelson

This work, conducted in 1987, aimed to investigate the migration of bluenose off the lower east coast of the North Island, New Zealand. The method of using detachable hook tags was chosen as it was believed that conventional tagging at the surface was unlikely to be successful for physiological reasons. An initial pilot study established the best tag and fishing gear configuration (testing four hook types, four tag designs, and four breakable trace strengths). Tagging was conducted on six known bluenose fishing grounds between Gisborne and Wellington. The species composition of the tagged fish was assumed based on catches from droppers of full-strength gear fished concurrently with the detachable hook droppers. It was estimated that about 1970 bluenose were tagged (although this is not adjusted for tagging efficiency, tag loss, or tagging mortality). There have been 44 tagged bluenose recaptured. Half of the recaptures were within 2 months of tagging; none of these fish had moved from the ground on which they were tagged. However, of the 22 fish recaptured after more than 2 months at liberty, 4 had travelled over 450 km. The longest period at liberty is 8 years 5 months, and the fastest movement equated to about 3.5 km per day (490 km in 137 days).

5.7 Overview of the blue-eye trevalla (bluenose) fishery off southeast Australia

Pascal Baelde, Sea Matters Pty Ltd, Sydney, Australia

Blue-eye trevalla (*Hyperoglyphe antarctica*) are caught by trawl, line, and gill-net in the Australian South-East Fishery (SEF). The so-called trawl and non-trawl fishing sectors are under a global TAC of 690 t (110 t and 580 t, respectively – excluding catches off New South Wales which are under State jurisdiction). Non-trawl catches are mostly targeted catches off Tasmania and trawl catches are mostly bycatches of other species throughout the SEF. About 80% of blue eye trevalla non-trawl catches are made using hook fishing methods, including trotlines, demersal longlines and, more importantly, droplines.

Dedicated scientific analysis of the blue eye trevalla fishery began only in the early 1990s and, in the non-trawl sector, detailed catch and effort data have been collected only since late 1997. Our understanding of the biology of the species is also patchy. At present, available data are not sufficient to permit conventional stock assessment methods to be used and an alternative modelling approach is being taken. This approach is based on developing hypotheses, or what-if-scenarios, about the behaviour of the fishing fleet and identifying consequences for the fish stock and the management of the fishery, using available information and expert advice from fishers, scientists and managers.

To develop meaningful hypotheses, potentially leading to agreed management actions, relies on effective collaboration between fishers, scientists, and managers. Over the years, fishers have played an essential role in collaborating with scientists and helping them better understand the fishery. Ongoing research is designed to facilitate the integration of industry's information in the assessment and management of the fishery.

In this presentation, available information on changes in fishing fleet dynamics, trends in catch and effort, and factors affecting the size composition of blue eye trevalla in commercial catches will be reviewed, focusing on key implications for the assessment and management of the fishery. The effects of changes in fishing gear and fishing practices on the definition of a unit of fishing effort and on the analysis of catch rate will be shown through some examples.

5.8 Assessment of blue-eye (bluenose) and gemfish fisheries in New South Wales, Australia

Kevin Rowling, NSW Fisheries Service

Blue-eye (*Hyperoglyphe antarctica)* and gemfish (*Rexea solandri)* are target species of a deepwater dropline fishery which has operated off New South Wales (NSW) since at least the 1960s. Demersal trawlers have also taken both species since the deepwater trawl fishery developed in the 1970s. However, while gemfish formed a major target species for trawl fishers, blue-eye have been taken incidentally in trawls targeted at other species.

Despite an active dropline fishery along the NSW continental slope, and the expansion of this fishery to the chain of offshore seamounts in the late 1980s, biological sampling of NSW blue-eye landings began only in 1993. Significant seasonal and geographic patterns were found in the size composition of blue-eye landed in NSW, but these patterns remained stable over the period 1993–2000, indicating a stable stock structure during this period. Newly recruited fish (45–50 cm, fork length) were present in catches year-round but were most abundant in the 'spring' (October-December). Large, mature blue-eye (over 70 cm) occurred in continental slope catches during the spawning period (April – June) but were less available to the fishery during the rest of the year. Blue-eye landings from ports on the southern NSW coast contained a higher proportion of 'sub-adult' fish (60 to 70 cm). Catch rates (kg per day fished) for continental slope fishers fluctuated on a seasonal basis, but showed no long-term decline over the period analysed (1985–1997). Catch rates for seamount fishers increased until 1991, but declined sharply in following years, suggesting a significant impact by fishing on the seamount stocks. The degree of overlap between the various seamount stocks and the blue-eye stock on the NSW continental slope is unknown.

Monitoring of NSW gemfish catches began in 1975, and more detailed biological studies of gemfish were carried out during the 1980s. Stock assessments in the 1990s showed a significant decline in gemfish abundance, based mainly on changes in the age composition of the stock, and a decline in trawl catch rates during 1981-1983. Catch rates stabilised after the main decline, but recent assessments indicate that the gemfish stock continued to decline during the 1990s, and there is considerable concern about the current status of the stock. As gemfish form aggregations, it is questionable if catch rate (either trawl or dropline) provides an adequate index of abundance for use in population models, especially at low levels of abundance.

5.9 The ling fishery in New Zealand

Peter Horn, NIWA, Nelson

The fisheries for ling in New Zealand were briefly described; there are both trawl and longline components in all areas. Series of longline CPUE indices from the four major biological stocks of ling off the South Island of New Zealand have been derived from data collected over the last 10 years. They have been used in fisheries models as a measure of the relative abundance of those sections of the ling populations exploited by this fishing method (longliners tends to catch larger ling than trawlers). The series are believed to be good indices of relative abundance for ling because there is a reasonable expectation that changes in CPUE reflect changes in abundance, there are adequate data free of major error, and trends from trawl surveys in two of the stocks mirrored trends in the CPUE series. The success of longline CPUE for ling is largely due to it being derived from a target fishery on a very widespread and evenly distributed species.

5.10 Abundance estimation and capture of sablefish (*Anoplopoma fimbria*) by longline gear

Michael F. Sigler, US Fisheries Service, NOAA

Longline surveys in Alaska measure sablefish relative abundance and are the primary information source used for abundance and quota estimation. Hook timer, on-bottom (soak) time, hook density, hook pattern, bait type, and bait condition experiments and mathematical models were used to evaluate the performance of the longline surveys for estimating sablefish relative abundance. The rate that sablefish encountered the longline gear decreased with on-bottom time independently of sablefish density in the sampled area. Sablefish were adept at locating available baits, even when few remained. The decrease in encounter rate appears related to odour concentration at the leading edge of the odour plume. The ability to locate baits, even when few remain, differs from previous models of fish capture by longline in which the probability that a fish located a bait was proportional to the number of available baits. Decreased encounter rate and the ability to locate baits efficiently imply that longline catch rates likely provide an accurate index of fish abundance if the on-bottom time is long enough to cover the period when most fish encounter the gear and the initial bait density is high enough that baits remain available throughout the soak; the weak link between catch rate and abundance is the unknown extent to which factors such as temperature and food availability affect the proportion of fish caught.

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5.11 Use of longline surveys used for sablefish and other species

Chair: Dave Gilbert, NIWA, Wellington

In this session a general discussion was held on survey methodology. The longline capture process was identified as a function of gear encounter rate, bait availability, and the hooking fraction.

Encounter rate. Most fish are taken in the first period of fishing, when the odour plume is strongest. The encounter then decreases with a decreasing rate with on-bottom time.

Bait availability. Sablefish will search to locate available baits. Searching behaviour has not commonly been included in theoretical fishing gear models, and gear saturation is less unlikely to occur in practice. Bluenose are also likely to pull the lines down in the water column as fish are taken, and this may attract other fish to the baits.

Hooking fraction. In a well designed survey, sufficient soak time should be provided to include all captures, and there should be sufficient baits so that some remain available at the end of the soak time, i.e., if the same gear is set where abundance is higher, there would still be untouched baits left at the end to avoid gear saturation.

5.12 Longline survey methods.

Chair: Dave Gilbert, NIWA, Wellington

Commercial CPUE is typically associated with many small areas of high catch rate. For bluenose, the complex bathymetry and small fishery size suggests that variance in the commercial CPUE data is likely to be high. From the logbook data, individual vessel catch rates have been highly variable, due to a strong vessel effect related to skipper experience. A survey may provide a consistent year-to-year comparison, including the low density areas where little fishery activity occurs.

Survey area

- The location of fishing grounds can be determined from the logbook data
- Patchy distribution requires appropriate stratification and sample size to address the expected level of variability within each stratum
- Logbook data may be used to simulate the required sample size from the observed level of variability within and among strata

Fishing time

- Optimum time per area will vary, but effects will be addressed by random sampling
- Need to monitor gear placement during fishing
- Need to determine minimum soak time by experiment
- Need to ensure sufficient baited hooks remain available until the end of the soak time

Survey timing

- Insufficient data exist to optimise surveys based on spawning behaviour and migration strategies. As the main commercial fishery is on the pre-recruits, and the larger spawning fish form only the tail of the distribution, we should sample March-April to target the spring aggregations of recruited fish

Area and depth stratification

- Need to fly the gear 6–10 m off the bottom to target bluenose, to reduce the incidence of sealice and blind eels
- Where habitat has highly contoured bathymetry, random stations and stratification by depth may be more appropriate than fixed station design with post-stratification by depth
- Major grounds can be divided into high and low catch rate strata, but insufficient data are available to review size distribution by depth from the logbook data
- Stratum boundaries would require redefinition over the first few years, and then be reviewed over subsequent years to improve the precision of the estimates. For example, low density strata may be collapsed and combined

Gear types

- Standardise gear, including specified maximim and minimum number of hooks
- Randomise stations, but leave actual placement of the gear at a station to the skipper to optimise catch rates for a particular feature
- Manual setting techniques allow the maximum efficiencies in gear placement within depth strata. Auotoline gear is not recommended for bluenose
- Longlines are more effective than droplines for New Zealand fishing conditions, and require less work than droplines. To achieve 1500 hooks per day requires thirty 50 hook droplines, but only three 500 hook longlines
- Although droplines may be more accurately placed in depth strata, they move due to current and tides more than longline gear
- Most contours are steep, and bottom substrate is variable. Between Whakatane and Cape Runaway the bottom is gently sloping mud. Around White Island and Mayor Island, the bottom is steeply jagged volcanic rock Further round the east coast, to Gisborne, the bottom is softer papa rock
- A large vessel has more movement in a swell, and gear is easier to operate off a smaller vessel.
- Gear is normally set in the dark or early morning to minimise seabird bycatch. For daylight sets, tori lines are recommended to minimise bait loss to birds.

Bait type

- Use pre-processed, size graded industry standard squid bait
- Ensure bait is fresh, as seawater quickly causes bait decomposition leading to a luminosity that results in reduced catch rates particularly for night sets
- All hook must be hand-baited, as auto-baiting gear has 10% bait failure rate
- Bait size may be as important as hook size. Because fish initially suck the bait into the mouth before capture, bait size should be optimised for the shape and size of the mouth of the target species
- Double-hooking of bait (passing bait through the hook twice) improves the bait retention rate

Hook spacing

- Minimum distance between hook stoppers on the backbone of the longline gear should be 3 m
- Have specific research gear made to appropriate specifications
- Snoods must be able to move between stoppers to avoid fish entanglement
- Need baited hooks available for fish at the end of the soak time, at all surveyed densities
- Snood spacing must be short to reduce entanglement (45 cm)
- Snoods length between 45 cm and 1 m to allow fish to suck in bait

Hook size

- Use industry standard 12/0 hooks. Lighter gear may not retain fish
- Hook selectivity is only an issue if you are trying to estimate total population size
- Some gear selectivity data may be available from the logbook scheme
- Gear trials may be required

5.13 Introduction to the Fish Heaven simulation programme

Ian Ball., Australian Antarctic Division, Tasmania

Prospective evaluation of fisheries management strategies is becoming a more common way to determine how well fisheries will perform in relation to a number of metrics including the status of a fish population and the economics of a fishery. Plausible models of fish populations and the behaviour of the fishing vessels are used as "laboratories" to test how well decisions can be made to achieve sustainable fisheries given uncertainties in the data being obtained from the natural and fishery systems. This paper presents a new simulation package, Fish Heaven, which is designed for this purpose. It is different from other packages in that it is a spatially structured model while maintaining a great level of user-control in the dynamics of the fish stocks, the configuration of the spatial environment, and the operation of the fisheries. Fish Heaven is described along with the issues that it was designed to address. This is followed by two case studies. The first covers very preliminary results using the software to test the efficacy of catch per unit effort as a measure of relative abundance for a spatially structured population. The second and more detailed case study examines the use of survey shots across landscapes which are either smoothly changing in terms of fish habitat quality or are very sharply changing with highly localised hot spots.

5.14 MSE model for blue-eye trevalla in the South East Fishery, Australia

Robin Thomson, CSIRO, Hobart, Tasmania

Researchers in the South East Fishery, Australia, have recognised that a conventional single species stock assessment is not appropriate for blue-eye trevalla (*Hyperoglyphe. antarctica*) due to the complex nature of its biology and to the large number of gear types used.. Management Strategy Evaluation (MSE) methodology will be used instead and the operating model that will be developed will attempt to capture as much of the complexity that has prevented the development of reliable stock assessment. In addition to using the operating model to test management strategies, the potential usefulness of future data collection, such as surveys, will be tested. Important aspects of uncertainty regarding the blue-eye stock and fishery, such as migration, will be captured by developing several operating models each expressing a different hypothesis regarding, e.g., migration. Because the operating model will capture much of the complexity of this system, it will be possible to examine the potential for using commercial CPUE to index blue-eye abundance. Other indicators of stock status will also be chosen and their potential examined. Development of the computer program that will be used to implement the alternative operating models is already underway.

5.15 Recommendations for developing relative abundance indices for bluenose (*Hyperoglyphe antarctica*)

Michael Sigler, US Fisheries Service, Auke Bay Laboratory, Alaska

Challenges

The challenges for developing relative abundance indices for bluenose are these:

- The distribution of bluenose is patchy. Where abundant, they are typically associated with rough ground (steep slopes, cliffs). Catch rates are highly variable and can be affected by factors such as time of day and tides. The usual ways of handling such challenges is to stratify data to create relatively homogenous strata and increase sample size to average out uncontrollable factors affecting catch rates.
- The location of fishery sets is often unknown for the bluenose fishery. Serial depletion of fishing grounds may occur and overall abundance may decrease, yet not be reflected in aggregate catch rates. The usual way of avoiding this bias is to increase collection of detailed location data from the fishery.

Abundance indices for bluenose

Three abundance indices currently are available or could be developed for bluenose are:

- Fishery catch per hook by statistical area. Catch and effort data are collected by statistical area from all vessels as a statutory requirement. Fleet coverage is complete, so sample size is relatively high. However, no detailed location data are collected so serial depletion within statistical areas, typically 50 miles across, may unknowingly occur.
- Fishery catch per hook by location. A logbook programme collects catch and effort data by set, providing detailed location information. There is no statutory requirement for this data collection and data are reported for only about 30% of sets. An increased participation rate could substantially increase sample size of the preferred, detailed location data collected by this programme.
- Survey catch per hook. Fishery catch rates may not reflect changes in abundance if fishery efficiency increases, detailed location data are not available, or data are misreported. A well designed, standardised survey can provide an index that avoids these problems. Cost considerations may prevent designing a full abundance survey with low coefficient of variation for bluenose. A small-scale survey for bluenose may provide a method to index abundance and test for catchability changes in the fishery abundance indices. Sample sizes for the small-scale survey would be smaller than sample sizes from a full-participation logbook programme. A longer time-horizon is necessary for the survey to detect statistically significant changes in abundance. The survey would provide long-term insurance that fish catchability was not changing.

Survey design

A reasonable design for a quantitative line fishing survey includes the following:

- Longline gear. A longline survey can deploy more hooks per day than a dropline survey. Measurements of off-bottom hook distance will probably not be more accurate for droplines than longlines because of water currents.
- The survey gear should match the fishery gear, so that catching power and selectivity of the two gears is the same.
- Stratify the survey by habitat and, if feasible, depth.
- Randomly choose location(s) within strata. The skipper then chooses how to lay the set subject to criteria you develop and intersecting the randomly chosen location. For example, the set must lay at least 100 hooks in each of five depth strata.
- Once sample locations are randomly chosen, return to all or a subset of those stations each year. Typically, a location must be surveyed by echo-sounder before deploying gear and this

may consume substantial time. You could avoid this time cost and instead deploy more sets by revisiting standard, known locations.

- Use local skippers familiar with the fishing grounds.
- Allow the gear to soak long enough for most fish to encounter the gear.
- Allow sufficient bait density so that enough baits remain throughout the soak.
- Index exploitable abundance of bluenose by surveying the fishing grounds.
- Determine sample size and survey cost from analysis of existing data. Attempt to account for between-vessel (skipper) differences in catching ability. Determine if catch rate variability is lower during particular times of the year.
- The survey also may provide an index of co-occurring species such as groper species in addition to bluenose.
- Apply a longer time horizon (e.g., 5 years) in determining sample size necessary to detect a statistically significant abundance change.

6. Summary and conclusions from the workshop

Ron Blackwell, NIWA, Nelson

Distribution

Bluenose occurs over much of the New Zealand continental shelf and slope, but the known distribution is patchy. Where abundant, they are typically associated with rough ground and drop-offs such as steep slopes, cliffs, and canyons). Commercial catch rate data are highly variable, and are affected by factors such as time of day and tides, as well as by skipper experience.

These distribution patterns can be properly sampled in a line fishing survey by appropriate stratification to create relatively homogenous strata, and by increasing sample size to average out uncontrollable factors affecting catch rates.

Analysis of CPUE data

Although target line fishery-based CPUE indices in BNS 1 and BNS 3-8 provide an index of fishery performance, it was agreed that these indices are unlikely to monitor the relative abundance of bluenose. For BNS 2, most bluenose is taken as bycatch in the target BYX 2 midwater fishery, and the use of bluenose bycatch CPUE indices has been discounted due to confounding with trends in the target fishery. Analysis of aggregate level CPUE data may not determine the effects of serial depletion of fishing grounds. Commercial fishery-based CPUE data cannot reflect changes in bluenose abundance because the measures of CPUE are sensitive to changes in management practices such as catch quotas and changes in gear leading to increased fishery efficiency. For this reason, the important line fisheries for sablefish and halibut in the U.S. are now monitored using line fishery surveys.

Alternatives to commercial fishery-based data

It was generally agreed that bluenose are unsuitable for assessment by acoustic survey methods, due to their mixed schooling behaviour. Trawl surveys are not possible because bluenose is distributed over grounds that are substantially unavailable to bottom or mid-water trawl gear. The bluenose fishery is small, but occurs over a wide area and depth range. Although detachable hook tagging has been attempted, and baited underwater cameras have been trialled, these methods are not an option due to cost and the large area of habitat to be examined. The simulation models being developed for bluenose may determine more robust decision rules for management, but they cannot provide an abundance index.

Line fishing surveys

The workshop recommended that a quantitative line fishing survey was the most viable fishery-independent method of monitoring bluenose abundance. A well designed, standardised line fishing survey series would avoid many of the problems inherent in bluenose fishery-based data. It would provide an index that would monitor long-term changes in relative abundance and fishery efficiency. Features identified as important for survey design include:

Appendix 2: Results of discussions with commercial bluenose fishers on gear methodology

Fisher 1. This fisher used droplines which he considered were superior to longlining, with a higher catch rate. They allowed more accurate positioning of gear on known localised areas of high bluenose density. This accuracy meant that fewer hooks were required per day (450–600), to achieve a daily target catch (500 kg), than for hand-baited longlines (1200–1500 hooks), or autoline methods (5000–7000 hooks). The fisher set 5–8 droplines with a minimum 2 h soaktime. Each line contained 70–80 hooks, size 11/0 or 12/0 hooks baited with pilchard, squid, or barracouta.

Fisher 2. This fisher used multi-purpose longline gear capable of target fishing ling, groper, or bluenose. He set 2500 hooks per day by alternating two 1250 hook lines. Both lines were set from 0500 h, with a 2 h soak time, and then hauled at 0730–0800 h. Depending upon catch rate, the lines were worked alternately throughout the day, until dusk. The tarred polypropylene ground rope was set with crimps or stoppers spaced 1 m apart, and the snoods were set on every alternate clip. Snoods were short (300–350 mm) as autobaiting was used. The snood was equipped with 12/0 or 13/0 hooks, although 11/0 were considered more suitable for bluenose, and the hooks were baited with barracouta. Weights and floats were set to fly the gear about 10 m off the bottom.

Fisher 3. This fisher used Mustad autoline gear, which allowed 7000 hooks to be set per day, although this incurred a 10–15% bait loss. The 7 mm tarred polypropylene ground rope was pre-set with 1 m spacing and the pre-baited gear was stored in barrels. The 12/0 hooks were baited with fresh barracouta, jack mackerel, or squid. The autoline gear was considered quick to deploy, with 1200 hooks requiring a set time of only 8 minutes. This was noted as an advantage, particularly in areas of strong tidal action. The gear was generally set throughout the day, from at 0300 h, with a soak time of only 10 minutes, before the gear was hauled.

Fisher 4. This fisher used longline gear which he considered superior to trot lines or droplines for bluenose target fishing. The 7 mm monofilament ground line was set at 10 m off the bottom, using floats and weight, with stoppers at 3 m intervals. Snoods were clipped at 3 m intervals, providing 500 hooks per set. Where 2–3 lines were set per day, a total of 1500–1700 hooks could be fished per day. The 16/0 circle hooks were baited with barracouta, squid, or jack mackerel.

Fisher 5. This fisher used a 7 mm groundrope with stoppers spaced 1 m apart, clip-on monofilament snoods, with swivels and 14/0 offset circle hooks. Bait used was fresh barracouta, and the soak time was 2–3 h. The gear was fished from pre-dawn and 1500–2000 hooks were set per day. This number of hooks provided enough fish for the rest of the day to be given over to heading and gutting the catch.

Given these constraints, the workshop recommended that the Bay of Plenty fishery was the most appropriate place for a pilot survey to be carried out. Much accurate location and catch rate data exist, and skippers are available with local knowledge of the fishery. Longline fishing is also the predominant fishing method for bluenose in this area. It was also recommended that a pilot survey be developed for the BNS 2 fishery, although such a programme would, by necessity, use the estimates of variance developed from the BNS 1 fishery.

- use of longline gear
- stratification by habitat and depth
- revision of stratification in subsequent years, as habitat becomes better known
- random positioning of stations within strata
- use of a subset of previously sampled stations in subsequent years
- use of local skippers familiar with the fishing grounds
- minimum soak time must be determined, to allow most fish to encounter the gear. This may require use of gear trials
- bait density must allow baited hooks to be available throughout the soak time
- where more than one vessel is used, between-vessel differences in catching aability should be quantified

Quantitative longline surveys have potential for monitoring the relative abundance of co-occurring species such as groper and bass. They may be applicable to other species such as toothfish and snapper, where trawl survey methods may not be appropriate due to bottom topography.

New Zealand bluenose line fishing surveys

Data are available to assist in the development of appropriate sample size and stratification for bluenose, although these estimates should be only considered preliminary. Sample size and stratification would evolve, particularly during the first few years of the programme. The seasonal variability in catch rate should be reviewed to determine whether variability is lower during particular times of the year. Available series are:

- BNS 1: bluenose catch rate (numbers of fish per 100 hooks), and position data from the target line fishery logbook scheme.
- BNS 2: bluenose catch rate (kg/hour), and position data from the BYX 2 target midwater trawl fishery (TCEPR data).