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Alfonsino

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

ALFONSINO
(*Beryx splendens* & *B. decadactylus*)

I Introduction

A. Overview

The trawl fishery for alfonsino is newly developed and exploits a densely aggregated but patchy resource. The species is long-lived and has a moderately slow growth rate; other aspects of its biology and behaviour are poorly understood. CPUE data for this fishery indicate that the present TAC is not sustainable.

B. Description of the fishery

Most fish (>>99%) coded as alfonsino (BYX) are *Beryx splendens*; the rest are red bream, *Beryx decadactylus*.

Prior to 1983, alfonsino was virtually an unfished resource, with the first domestic landings being recorded in 1981. Domestic target fishing using a conventional bottom trawl began in 1983 on grounds between Cape Palliser and Cape Kidnappers. The catch on the Palliser Bank and Motukura Ridge (Fig. 1) rose rapidly, particularly after the introduction of a semi-pelagic trawl design that enabled fishing over foul ground. In 1985, the Tuaheni High and Paoanui Ridge became important alfonsino grounds, and from 1986 significant catches have been taken from the Madden Canyon and Kaiwhata Bank.

A recent development in the trawl fishery since the 1986-87 fishing year has been an apparent increase in the catch of bluenose relative to alfonsino. This has caused appreciable management problems in the fishery. Another recent change has been from mainly day fishing during 1983-84 to almost exclusively night fishing by 1986. This has probably resulted from fishermen obtaining a better understanding of alfonsino behaviour.

Alfonsino is currently managed in 6 Quota Management Areas (QMA). TACs (shown below) were based on recorded landings between July 1983 and June 1984 (except in the Kermadec FMA where the TAC was administratively set).

QMA	No.	Domestic TAC (t)	Foreign licenced allocation (t)
Auckland	1	10	0
Central - Central East	2	1510	0
- Central West	8	20	)
Challenger	7	30	) 10
South-East + Southland	3,4,5,6	220	160
Kermadec	10	10	0

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The domestic alfonsino fishery is essentially confined to the Central FMA. Small amounts of alfonsino and red bream are caught in other areas, but little if any target fishing occurs in these areas. Past red bream catches are higher than recorded landings would indicate because of coding errors, but the catch is still thought to have been small. Most red bream is caught in the Auckland FMA.

C. Literature review

Little published information is available on New Zealand alfonsino. Results of a recent study of alfonsino between Gisborne and Cape Palliser are unpublished (Massey & Horn, in prep., Horn & Massey, in press). Various studies of alfonsino from the Atlantic and North Pacific have been published. A review of these studies, including an evaluation of their relevance to New Zealand alfonsino, is given in Appendix 1.

II <u>Review of the Fishery</u>

A. Catch, landings, and effort data

Domestic landings of alfonsino by FMA since 1981 shows the fishery to be confined virtually to the Central East FMA (Table 1). Almost all alfonsino is caught by single (semi-pelagic) trawl (Table 2). The decline in line catches and increase in set net catches are correlated with a reduction in line fishing for bluenose in Central East and an increase in set netting for bluenose in the Bay of Plenty.

Catches per month are erratic on all grounds (Fig. 2). The general absence of landings in July-August results from the diversion of trawlers to other fisheries. Good catches of alfonsino on one ground can influence landings from another. As most vessels involved in this fishery are domiciled in Nelson, they search Palliser Bank at the start of a trip and only move to grounds further north if there is no fish sign or if catches are poor. Hence, peaks in Motukura Ridge catches in April and November 1984 coincide with troughs in Palliser Bank landings. Palliser Bank and Motukura Ridge landings dropped appreciably in 1985 because of an apparent reduction in the amounts of fish on these grounds. Search times appear to have increased, but catches still fell. The overall catch was maintained by increased catches on the Tuaheni High and to a lesser extent the Paoanui Ridge.

Landings of alfonsino by foreign licensed and New Zealand chartered vessels has fluctuated considerably since 1978 (Table 3). The vast majority of the catch has come from EEZ area D (the Chatham Rise).

The ratio of alfonsino to bluenose landings taken by the domestic trawl fleet in QMA 2 has steadily declined since 1983-84.

Fishing Year	83-84	84-85	85-86	86-87	87-88
Landings - BYX	1533	1785	1454	1387[1]	?
- BNS	520	635	742	953[1]	?
Ratio BYX:BNS	2.95	2.81	1.96	1.46	0.97[2]

[1] Landings provisional. [2] Projected value.

Projecting the trend of these ratios implies that catches of alfonsino and bluenose will be approximately equal in the current fishing year, and likely to be in favour of bluenose by 1988-89.

CPUE values were calculated for alfonsino from the 4 main fishing grounds. A more detailed analysis of these figures (Appendix 2) indicates a decline in catch per day targeted on all grounds. On the grounds examined, CPUE for 1987 had decreased by 42-92% below peak rates.

B. Other information

The age composition of commercial landings from the Palliser Bank, Paoanui Ridge and Tuaheni High were derived using age-length keys (Fig. 3). Catch compositions can vary considerably between grounds, but remained relatively constant on the Palliser Bank during a 14 month sampling period. However, within ground differences were apparent; at times when alfonsino were scarce on a ground, larger fish seemed to be relatively less abundant.

C. Recreational, traditional, and Maori fisheries

There is no known recreational or Maori fishery for alfonsino or red bream.

III <u>Research</u>

A. Stock structure

It is not known if there is more than one stock of alfonsino in New Zealand. Few alfonsino were tagged in a recent detachable tagging programme so no information on stock boundaries is expected from that study.

B. Resource surveys

Resource surveys of alfonsino have been generally unsuccessful. Several biomass estimation techniques have been tested (trawl, acoustic, and photographic), but none have proved suitable. The major problems are finding a method for identifying marks seen on the echo-sounder and a suitable method of estimating the density of fish within schools (Horn & Massey, in press).

C. Other studies

No statistically significant differences in growth rates were found for alfonsino from the Palliser Bank, Paoanui Ridge and Tuaheni High. Females grew significantly faster than males (Massey & Horn, in prep.). Alfonsino are moderately slow-growing, long-lived fish. No size-selective mortality was apparent on the Palliser Bank.
The age composition of commercial landings from the Palliser Bank indicates that fish recruit on to the ground in late summer-autumn. Full or near recruitment to the commercial fishery does not occur until fish are 5 years old.

All catch curves (*ln* frequency vs. age) for alfonsino from the Palliser Bank showed a very steep decline in abundance with increasing age, Massey and Horn (in prep.) Also, the age composition of landings was vastly different between Palliser Bank and Tuaheni High when fish were abundant. These two factors indicate that some age-specific migration is occurring. It is unlikely that these age structure differences are due to fishing mortality. The Tuaheni sample was collected after 1 year of concerted fishing, and the first Palliser sample after 2 years. Fishing over 1 year is unlikely to account for the observed differences, especially as the Palliser samples showed no appreciable difference over a year. Given the probable occurrence of age-specific migration, natural mortality cannot be determined at present.

No running-ripe alfonsino were found despite regular sampling on the Palliser Bank over 14 months. Thus, fish probably spawn in other (presently unknown) areas. Spawning may occur in mid-winter because there was a peak in the percentage of fish with yolked eggs around June, and a peak in gonadosomatic index between May and September for both males and females (Horn & Massey, in press).

D. Biomass estimates

Two biomass estimates for alfonsino on the Chatham Rise have been produced from trawl surveys (Table 4), but their precision is low. Trials with trawl survey methods in the alfonsino fishery indicate that this is an unsuitable survey technique because of the erratic response of fish to the net and the very patchy distribution of the fish (Horn & Massey, in press). In addition, the coefficients of variation are very high.

E. Yield estimates

(1) Estimation of maximum constant yield (MCY)

No estimates of mortality are available for alfonsino, although they are known to be moderately slow-growing, long-lived fish.

Catch has been regulated in all except the first year of the domestic trawl fishery, and effort has varied widely in the 4 years since development. Consequently, no MCY can be estimated for alfonsino in QMA 2.

Alfonsino biomass on the Chatham Rise was estimated in two surveys in March and July 1983. The mean biomass value (27,000 t) is an estimate of B_0 since catches of alfonsino on the Chatham Rise prior to 1983 were probably <1000 t. Assuming M = 0.2 (based on known growth parameters) then MCY = 0.2 ¹/4 B_0, or MCY = 1350 t.

(2) Estimation of current annual yield (CAY)

Estimates of CAY were calculated for alfonsino in QMA 2 using a 'status quo' methodology (i.e. maintain a constant fishing mortality, F). An analysis of CPUE data from the domestic trawl fishery indicated a significant decline in abundance on all grounds. The mean catch per day targeted dropped by 42-92%, and the mean decline over all grounds since the development of the fishery was about 67%. Assuming that CPUE is an accurate index of fish abundance, then the yield (= CAY) necessary to equate current F with F in 1983-84 would be 33% of the 1983-84 catch. Landings of alfonsino from QMA 2 in 1983-84 were 1530 t. Hence CAY = 505 t.

IV <u>Management Implications</u>

In the 1986-87 fishing year, the TAC for the Central FMA was caught, and those for all other regions were undercaught.

If it is assumed that the CPUE annual means are an accurate index of biomass then there is cause for some concern. CPUE values for the two longest exploited grounds (Palliser and Motukura) have declined to about one-third of their original levels. The declines on the Tuaheni High and Paoanui Ridge have been even greater. The decline in CPUE, comments from commercial fishermen that alfonsino are less abundant, harder to catch and may be smaller in size than in previous years, and the knowledge that overseas stocks of alfonsino were seriously depleted after only short periods of commercial fishing, suggest that the current TAC may not be sustainable.

The possibility that alfonsino in New Zealand waters are part of a widely distributed South Pacific stock complicates management. It is not known whether the fish exploited here comprise a relatively insignificant component of the whole stock, or whether virtually all pre-reproductive alfonsino visit these waters. If the latter is the case, then heavy exploitation could have serious implications for future recruitment.

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Massey, B.R. & Horn, P.L. in prep: Growth and age structure of alfonsino (*Beryx splendens*) from the lower east coast, North Island, New Zealand.

Table 1: Reported domestic landings of alfonsino for the calendar years 1981-86, from areas approximating each Fishery Management Area (FMA).

	Landings (t)					
FMA	1981	1982	1983	1984	1985	1986
Auckland		0	15	15	9	9
Central		154	766	1814	1541	970
Challenger		0	1	19	0	1
Southern		0	0	10	1	3
Area unknown*	67	0	88	41	165	210
Total	67	154	870	1899	1716	1193

* Area unknown shows the quantity of fish recorded by EEZ area or where no area information was supplied. Of the landings listed for area unknown in 1985 and 1986 respectively, at least 48 t and 210 t were taken from the Paoanui Ridge east of statistical area 014 (Central FMA).

Table 2: Catch (t) of alfonsino by method, by fishing year. Single trawl includes bottom and semi-pelagic gear.

Method	Fishing year		
	83-84	84-85	85-86
Single trawl	1557	1675	1458
Set net	0	1.5	10
Line	3.6	3.1	0.5

Table 3: Reported catch (t) of alfonsino by foreign licensed (F), New Zealand chartered (C), and large New Zealand factory (N) vessels, by EEZ area. Virtually all foreign landings were taken by Japanese vessels, with Korean vessels taking the rest.

Period		EEZ Area							Total
		B	C	D	E	F	G	H	
Apr 78-Mar 79	C			4.8					4.8
	F	1.0	1.3		0.8	1.1	15.0		19.3
Apr 79-Mar 80	C			205.3					205.3
	F	164.1		314.8	20.2	3.0			502.0
Apr 81-Mar 82	C			5.1			4.3		9.4
	F			57.2					57.2
Apr 82-Mar 83	C		19.1	50.3	0.1	18.1			90.6
	F			52.3					52.3
	N	25.5							25.5
Apr 83-Sep 83	C		0.7	2.8					3.6
	F			155.3					155.3
Oct 83-Sep 84	C		9.4	34.4		0.3		0.4	44.5
	F			82.3	0.2	1.5			84.0
Oct 84-Sep 85	C		14.2	161.2					175.4
	F			104.8					104.8
Oct 85-Sep 86	C		10.2	27.8			4.3	0.9	49.4
	F			515.6		0.2			515.8

Table 4: Biomass estimates (t) for the Chatham Rise from *Shinkai Maru* trawl surveys (from Livingston *et al.*, in prep.).

Survey	Biomass estimate			C.V. (%)
	Wingtip	Door	Mean	
March 1983	26 300	5 800	16 050	76
July 1983	63 500	13 600	38 550	50

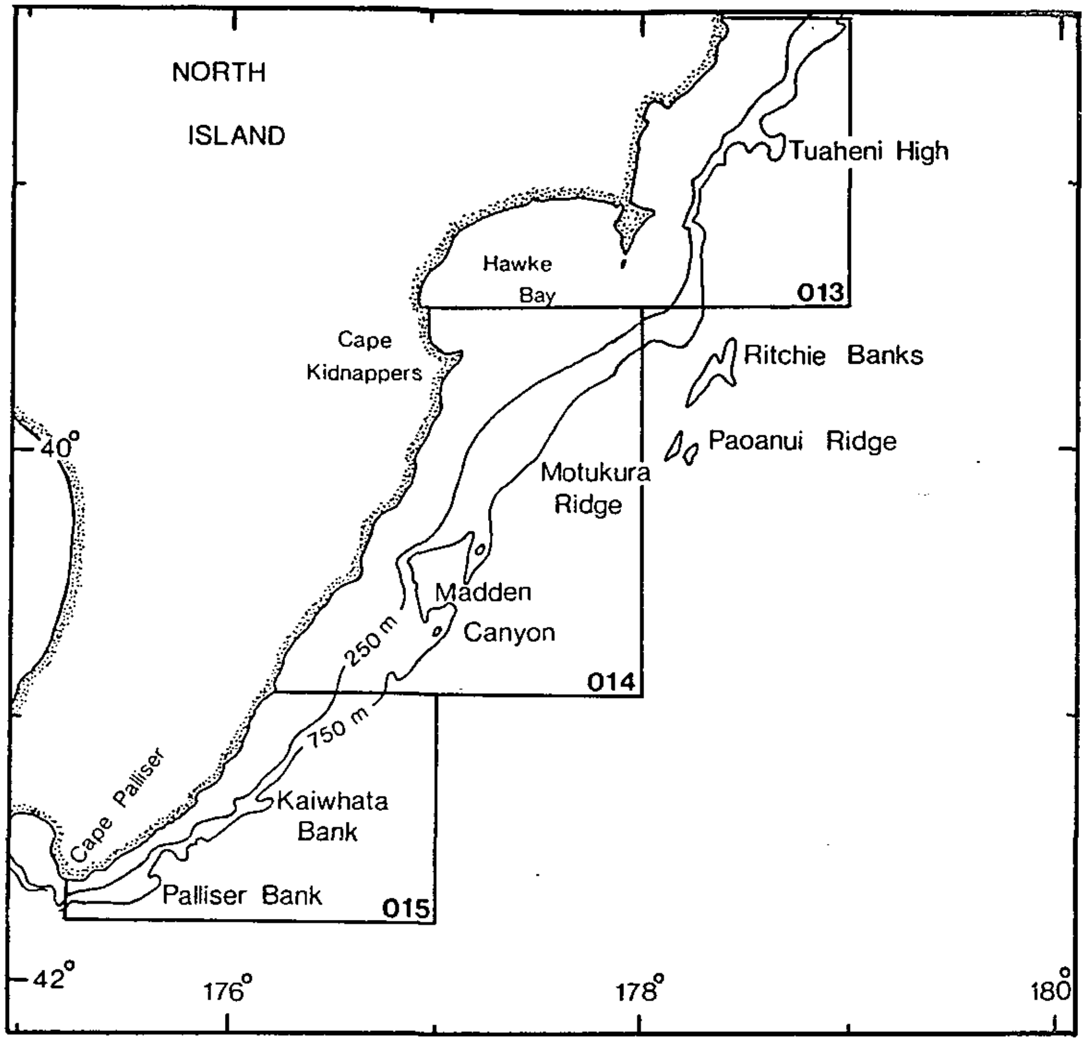

Fig. 1: Alfonsino trawl grounds on the lower east coast, North Island. Fishing return areas 013-015 are also shown.

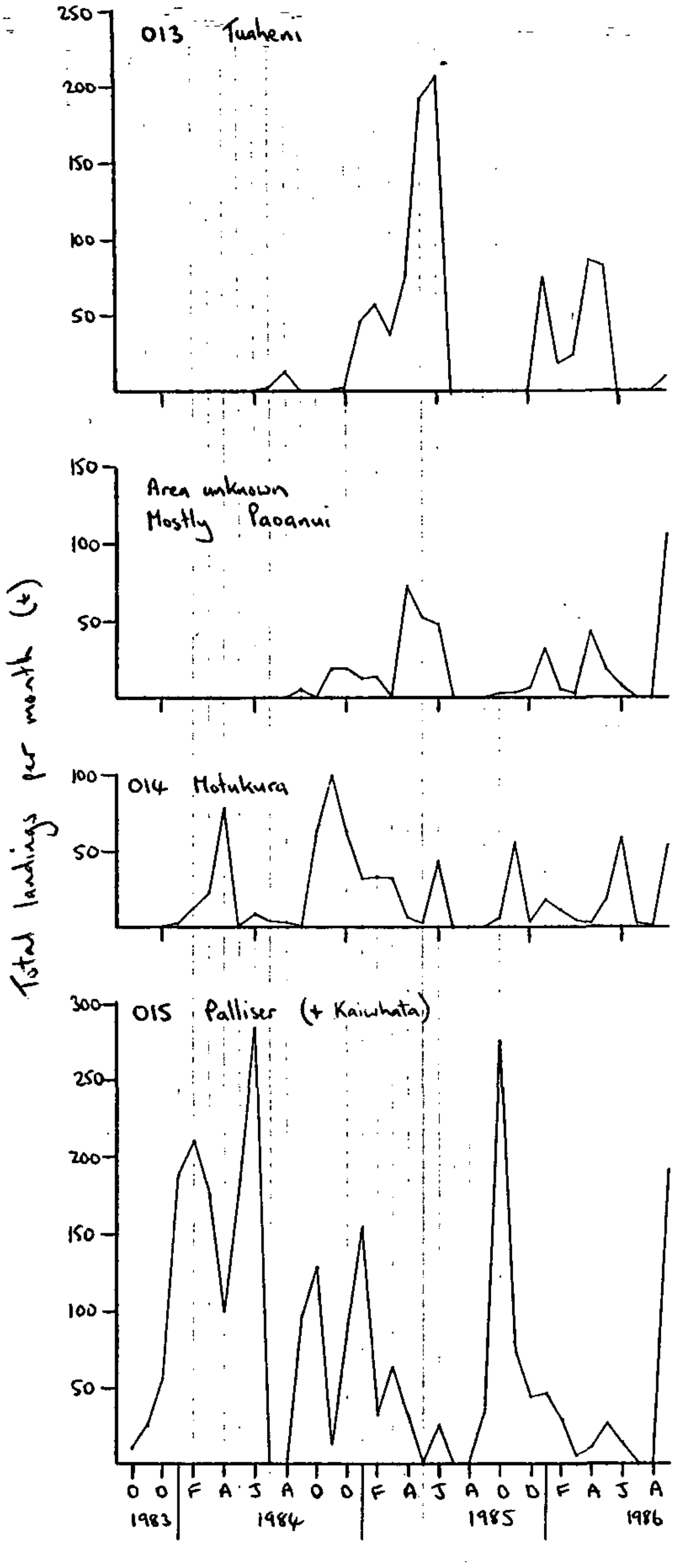

Fig. 2: Landings of alfonsino by month.

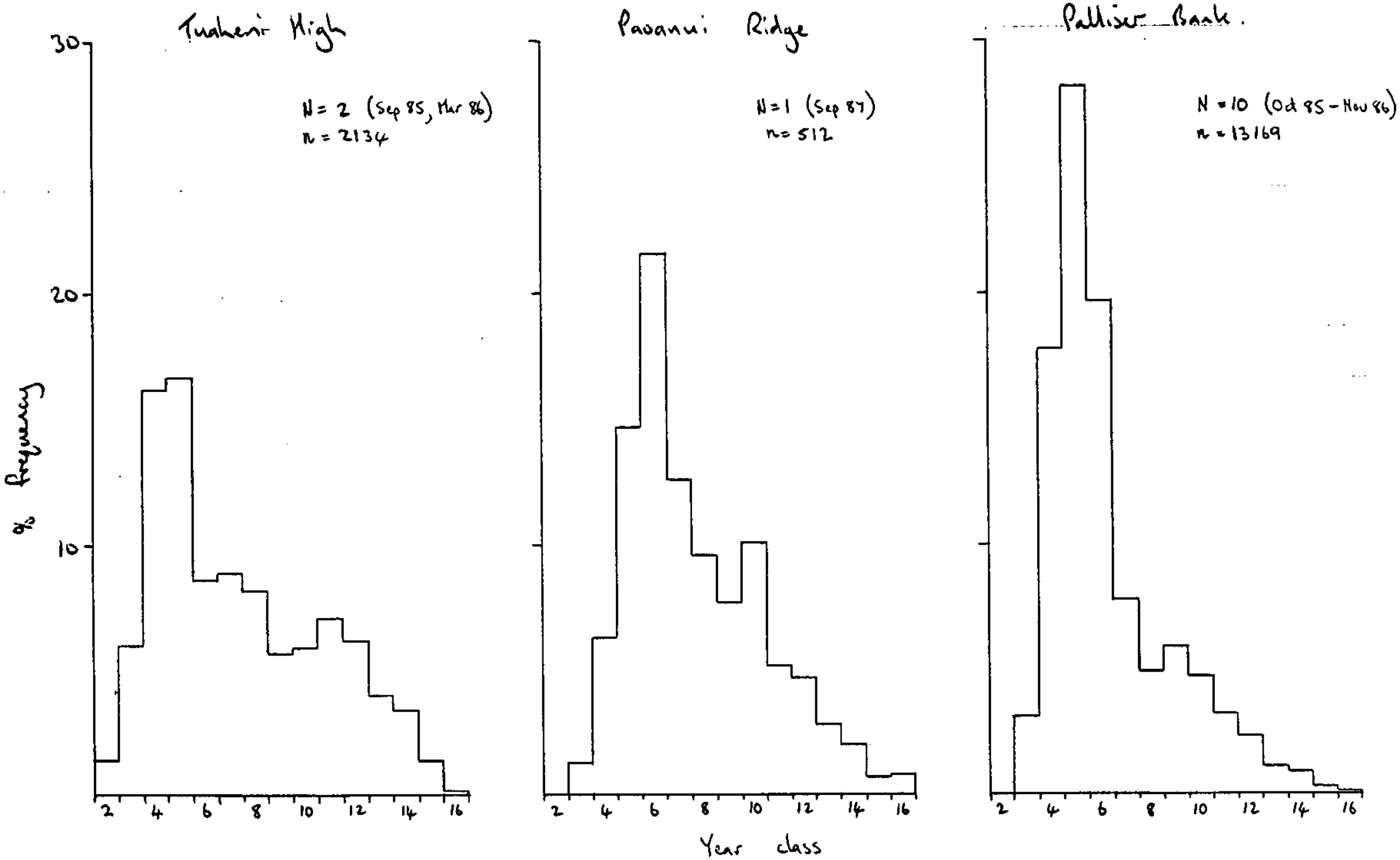

Fig. 3: Age-frequency distb^ns, BYX.

APPENDIX 1

Alfonsino: a review of biological information

Busakhin (1982) reviewed the published records of alfonsino and red bream and found that these species are widespread throughout the worlds's tropical and temperate waters. The depth range at which they are found varies markedly for both species. In some areas they are found in very shallow water (e.g. 25 m for alfonsino off the coast of Oman in the Indian Ocean), whereas in others they are found in very deep waters (e.g. down to 1200 m for alfonsino in the south-west Atlantic). In New Zealand, alfonsino are generally distributed between 200 and 1000 m, but they appear to be most abundant between 300 and 500 m (Francis & Fisher 1979; Ayling & Cox 1982; MAF unpublished data). Iguchi (1973), Yamamoto et al (1978) and Seki & Tagami (1986) reported that alfonsino size increased with depth. A similar trend was observed on the Chatham Rise in 1979 (Kerstan & Sahrhage 1980).

Alekseev et al (1986) examined length-frequency distributions and sexual maturity stages of alfonsino from various areas in the north and south Atlantic. They suggested that at least 3 separate populations of alfonsino existed in the Atlantic Ocean, each found in a macroscale oceanic eddy system (Appendix Fig. 1). In each system was a reproductive zone where large fish predominated and spawning occurred, and a "vegetative" zone where juveniles and first-maturing fish were found. Currents carried the eggs and larvae from the reproductive to the vegetative zone, and first-maturing fish migrated back with the current to the reproductive zone, where they remained. Data for New Zealand alfonsino do not clearly fit with this hypothesis. Despite the length-frequency distributions being biased towards larger fish (30-45 cm) there is no evidence of reproductive activity, and the relative scarcity of small alfonsino (<25 cm) suggests that New Zealand waters are not a vegetative zone. Many New Zealand alfonsino appear to be in their late vegetative phase (i.e. just prior to first maturity), and hence, just prior to their migration to the reproductive zone. This would explain the steep decline with increasing age of the catch curves. Size-frequency distributions from areas only short distances apart can differ markedly, and are not always related to differences in depth (e.g. Uchida & Tagami 1984).

Alfonsino show strong diurnal migratory behaviour. Galaktionov (1984) stated that fish are densely distributed on the bottom during the day (though not visible on the echo sounder), and that they form large schools at dusk and ascend into mid-water before dispersing. The fish feed while dispersed in midwater (Uchida & Tagami 1984). Schools form again at dawn and descend to the bottom where the fish spread out. Juvenile and adult fish (with the exception of pre-spawning and spawning fish) show the same behaviour. Masuzawa et al (1975) briefly alluded to a similar pattern of daily migration for Japanese alfonsino, as did Darnitsky (1985) for fish on the Hawaiian seamount chain.

However, Darnitsky found that the vertical movement was not related to feeding, but was possibly caused by upward currents. Diurnal variability in the availability of alfonsino in New Zealand waters is also apparent, and the best catches are generally taken at night near the bottom.

Tagging studies indicate that alfonsino do not migrate over wide geographical areas in the short term (<1 yr). Of the 146 fish recaptured from 3925 fish released in a Japanese tagging study, only 26 had moved from their tagging site, even though many were free for more than a year (Masuzawa et al 1975). Most had moved from higher to lower latitudes. This was considered to represent a return to their natal areas for spawning. A longer term drift from higher to lower latitudes was also evident from length and age composition data.

Alfonsino spawn in summer to early autumn, i.e. from June-October near Japan, in the northwest Hawaiian Islands, and in the northeast Atlantic Ocean (all lying from 30-36° N) (Masuzawa et al 1975; Uchida & Uchiyama 1986; Sherstyukov & Nostov 1986), and in January-March in the southeast Atlantic (Alekseev et al 1986). The apparent winter peak in gonadosomatic indices for New Zealand alfonsino is in conflict with a summer-autumn spawning period. However, it must be remembered that no spawning alfonsino were found during the New Zealand study. Alfonsino reproduce in the areas they normally inhabit. They are serial spawners that first spawn at about 34 cm or 4 years of age in Japanese waters (Masuzawa et al 1975). Each season, 10-12 spawning bouts occur each about 4 days apart (Alekseev et al 1986). Eggs are free floating and hatch in about 1 day at 23°C or 6-8 days at 5-10°C. Onishi (1968) and Masuzawa et al (1975) describe the egg and larval development up to 10 days after hatching. Mundy (in prep.) has recently described the larvae to a much more advanced stage. The pelagic larvae are broadly distributed by surface currents, until they adopt a demersal existence, possibly at about 1 year (Chikuni 1971).

Several growth studies in Japan using a number of different techniques revealed confusing and quite different results (Ikenouye & Masuzawa 1968; Ikenouye 1969; Masuzawa et al 1975). None of the ageing methods were validated satisfactorily in these studies. However, all indicated a moderate growth rate (32-37 cm fork length at 5 years). An unvalidated study on central west Atlantic alfonsino by de Leon & Malkov (1979) also indicated a moderate growth rate (31-35 cm fork length at 5 years). These growth rates are comparable to those calculated for New Zealand alfonsino.

Few data on recruitment and natural mortality exist. Masuzawa et al (1975) stated that recruitment of young fish onto the Furase fishing ground occurred around autumn to early winter each year, indicating recruitment was seasonal rather than continuous. Recruited fish had fork lengths of 24-26 cm and were considered to be 2 years old.

Masazawa _et al_ (1975) calculated survival rates for alfonsino from tagging experiments and age composition data. No attempt was made to estimate the natural mortality rate as neither tag-induced mortality or tag loss were estimated. Age composition data could not be used to estimate mortality rates as age composition varied considerably between grounds and migration patterns between grounds were not adequately understood. Similar reasons have precluded the calculation of mortality coefficients for alfonsino off New Zealand.

Crustaceans and fish are the most important constituents of alfonsino diet. In one study done on the Emperor Seamount Chain, small fish predominated in 43% of the stomachs, and crustaceans (decapods, mysids and euphausids) predominated in 37% (Aomori Prefectural Fisheries Experimental Stations 1976, cited in Uchida & Tagami 1984). In another study in Japanese waters, fish were present in 48% of the alfonsino sampled, crustaceans (including euphausids, isopods, shrimps and amphipods) occurred in 36% of the fish, and squid in 14% (Masuzawa _et al_ 1975). The proportions of different dietary components were found to vary between grounds.

Alfonsino appear to be vulnerable to overfishing. Sasaki (1986) found a considerable decline in catch per unit of effort in the Hawaiian seamount chain after only 4 years of intensive exploitation. Yamamoto (1986) also noted declining catch rates on several Japanese seamounts after large increases in lining effort. The susceptibility of alfonsino to overfishing may be due to a combination of their schooling behaviour and moderately slow growth. One feature of their behaviour which may lend them some protection in New Zealand is that they probably spawn in unknown areas away from the fishing grounds.

Virtually no information is available on the biology of red bream (_Beryx decadactylus_). The species is similar in appearance to alfonsino, though the body is slightly deeper, and fish average between 20 and 40 cm. Young fish have a long filamentous dorsal ray (Ayling & Cox 1982) and are thought to live in mid water for their first year or more. They are believed to grow rapidly up to 25 cm after which they adopt a deepwater bottom dwelling existence and have a fairly slow growth rate (Wheeler 1969).

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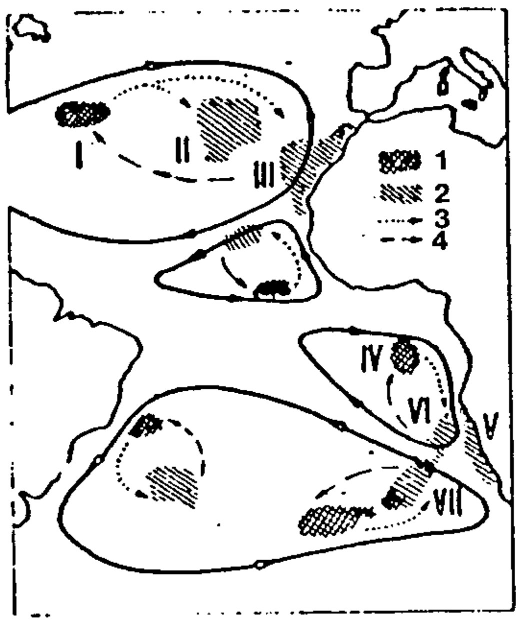
APPENDIX 1 - Figure

1.a.



1.b

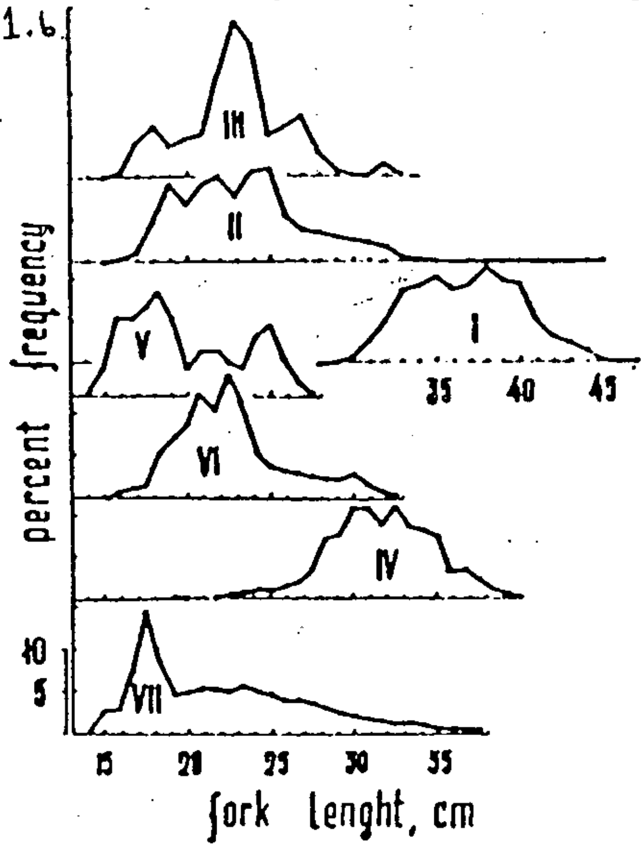


Fig. 1.a: A scheme of population differentiation and functional structure of distribution areas of alfoncino in the Atlantic Ocean. Roman numerals (I-VII) denote studied areas.

1 - reproductive zones;

2 - vegetative zones (those not denoted by Roman numerals are hypothetic);

3 - supposed direction of drifting of planktonic stages;

4 - supposed directions of migrations of first maturing fish.

Fig. 1.b: Size composition of alfoncino in I-VII areas.

(From Alekseev et al 1986)

APPENDIX 2

Alfonsino and Bluenose: analysis of catch-per-unit-effort data

Summary

Catch-per-unit-of-effort data from the alfonsino-bluenose trawl fishery were analysed. The unit of measure used was kg per day targeted, for each ground and species separately. Data were approximately normalised using a log transformation, and analysed using 1-way ANOVA and Student-Newman-Keuls' test for comparing means. Sources of bias in these data are discussed. CPUE data are interpreted as reasonable indices of fish abundance. Serious stock depletion of both alfonsino and bluenose appears to have occurred since the development of this fishery.

An attempt to examine changes in relative abundance of alfonsino and bluenose over time was made by analysing catch-per-unit-of-effort data from the trawl fishery on the lower east coast, North Island.

CPUE data were calculated for each ground and for each species separately. The measure of effort considered best for this fishery is the number of days or part days on which alfonsino or bluenose were targeted. A normal alfonsino fishing trip involves some search time, some target fishing, and, if fish are scarce or not visible on the sounder, some long "prospecting" tows. The measure "kg per day targeted" enables the data to be separated by ground, takes account of the time when fishing is not possible (e.g. due to weather or mechanical problems), and takes some account of search time as 1 or 2 prospecting tows are often conducted even though no fish are "visible". Other often-used measures of effort are less suitable. Catch per trip does not differentiate between grounds or take account of time when fishing is not possible. Catch per tow and catch per time towed do not take account of search time which can be long and relatively unproductive. Also, even if fish are relatively scarce on a ground, it is still possible to get a large catch if one of the few remaining schools is eventually discovered and successfully targeted.

Most operators of vessels fishing in the alfonsino trawl fishery fill out tow-by-tow records showing position of tow and giving estimates of the number of cases of each species caught. At the end of each trip, a landed catch return is filled out. By examining each tow record, the estimated number of cases of each species caught each day (midnight to midnight) on each ground can be obtained. The catch per trip (from the landed catch return) is then apportioned relative to the number of cases caught per day. Hence, an estimate of kg caught per 24 hour period is available for each day a ground was fished on. These values were analysed.

Data are available from the Palliser Bank for 1983-87, the Motukura Ridge for 1984-87, and the Tuaheni High and Paoanui Ridge for 1985-87. All catches on the Palliser Bank in 1983 and some from 1984 were taken by bottom trawl; all others, including those from other grounds, were made by semi-pelagic trawl.

CPUE data for bottom and semi-pelagic trawls were compared using the 1984 Palliser Bank catches. Mean CPUE values were not significantly different for alfonsino (t=0.82, df=154), but were significantly different for bluenose (t=2.31, df=156). Fewer bluenose were caught in bottom trawls than in semi-pelagic trawls. Hence, in later analyses the 1984 semi-pelagic and bottom trawl data for alfonsino were combined, and data from 1983-87 were used. For bluenose, only semi-pelagic data from 1984-87 were examined.

The raw CPUE data for both alfonsino and bluenose appeared to be skewed. There were strong linear relationships between log (mean CPUE) and log (variance of CPUE).

Alfonsino: log Var = 1.25 + 1.69 log Mean, n=18, r=0.95,
Bluenose: log Var = -0.47 + 2.21 log Mean, n=16, r=0.97.

The slopes of these lines are both approximately 2, implying that the CPUE distributions are skewed approximately logarithmically.

However, regression lines were fitted to the data (untransformed, log CPUE, square root CPUE) for each ground, and the residuals were examined. In general for both species on all grounds, the highest r^2 values were obtained from the untransformed data (although r^2 was never greater than 0.25), but this model gave the most unbalanced residuals. The log and square root transformations gave lower r^2 values, but reasonably balanced residuals. Raw data were therefore transformed using log (x+1) as there were some zero values.

A 1-way ANOVA was performed on each data set (species by ground) to test for changes in CPUE with time. Significant variation occurred with alfonsino on all grounds except the Palliser Bank, and with bluenose on all grounds except the Paoanui Ridge (see Table 1).

Table 1. Results of ANOVA on alfonsino and bluenose CPUE

Ground	Alfonsino		Bluenose	
	F	p	F	p
Palliser Bank	2.19	0.0694	3.07	0.0280*
Motukura Ridge	3.92	0.0102*	2.71	0.0479*
Tuaheni High	8.71	0.0003**	3.54	0.0329*
Paoanui Ridge	3.45	0.0356*	1.36	0.2612

A test between transformed CPUE annual means (Student-Newman-Keuls') was performed to isolate significantly varying years or groups of years. Non-significant year groupings are bracketed in the Table 2. Days targeted per year are shown in parentheses for alfonsino.

Table 2. Results of Student-Newman-Keuls test on CPUE (kg per day) values. Values which are not significantly different from each other are grouped in square brackets.

Alfonsino

Year	Palliser CPUE	Motukura CPUE	Tuaheni CPUE	Paoanui CPUE
1983	(*73*) 1676			
1984	(*169*) 3156	(*35*) 3519		
1985	(*46*) 1786	(*23*) 1034	(*31*) 5967	(*13*) 407
1986	(*103*) 2082	(*59*) 658	(*58*) 2746	(*44*) 2581
1987	(*122*) 1584	(*29*) 342	(*16*) 487	(*48*) 1260

Bluenose

Year	Palliser CPUE	Motukura CPUE	Tuaheni CPUE	Paoanui CPUE
1984	928	843		
1985	847	1273	922	1269
1986	732	256	573	2407
1987	446	248	154	928

The log transformation has reduced the influence of a few very high daily catches, particularly for alfonsino in 1983 on the Palliser Bank and in 1985 on the Paoanui Ridge (apparent when comparing the above table with Alfonsino Table 4). A few exceptionally large, among otherwise moderate catches is often a characteristic of a newly developing fishery, as fishermen learn the best way and best places to fish on each ground. Learning probably also explains an initial rise in CPUE in the second year of exploitation on some grounds. However, for both species and on all grounds (except the Palliser Bank for alfonsino) CPUE declined steadily every year following the initial peak. Palliser CPUE for alfonsino recovered slightly in 1986, but still shows a declining trend. A similar conclusion was drawn from initial examination of the raw data.

The general lack of statistically significant differences between yearly means is caused by the relatively wide variance in the raw data. This is due to a variety of factors, e.g. different vessel size and power, differing degrees of skipper experience, and the behaviour of the fish which can radically alter their availability over short time periods.

CPUE data are considered a reasonable index of fish abundance. However, various factors can bias the figures either up or down. As already noted, vessel characteristics and fishing experience can influence catch. Improved understanding related to characteristics of the grounds, the gear, and the fish, can cause rapid increases in CPUE early in the development of the fishery. Improved learning and technology may still be boosting CPUE, but not to the extent it did in 1983-85.

Several aspects peculiar to the alfonsino-bluenose fishery may also bias CPUE. More days are spent targeting on the Palliser Bank than on any other ground, and other grounds may be fished only if fishing is poor on the Palliser Bank. If fish availability is related to some macroscale characteristic (e.g. weather, lunar cycle), rather than individual ground characteristics, then the other grounds may not be being fished randomly in relation to fish availability on them, hence biasing their CPUE. The change in fishing patterns over time may also have influenced CPUE. When fewer grounds were fished, more time would be spent on searching and prospecting. In more recent years, grounds would be searched quickly, rather than for several days, with a consequent lower catch per day from fewer prospecting tows. However, this bias would have occurred only prior to 1985.

It is also possible that fishing pressure has modified fish behaviour in ways that reduce fish availability. Alfonsino and bluenose may have become more wary of the trawl; fishermen involved in the fishery for several years have commented that alfonsino in particular are now more flighty and less abundant. Fish could also move off the trawl grounds. Suitable bluenose habitat occurs all along the coast, but alfonsino appear to prefer a small number of areas, so their opportunities to migrate to unexploited grounds may be limited.

Changes in fishing patterns and in fish availability may have caused reductions in CPUE over time. However, it is considered most unlikely that these factors could cause changes of the magnitude apparent on all grounds for both alfonsino and bluenose. Declines in CPUE are therefore interpreted as indicating declines in fish abundance. Stocks of alfonsino and bluenose appear to have at least been halved since the alfonsino fishery developed, with some values indicating a significantly greater reduction on some grounds.