South Pacific Albacore Stock Review

Albacore Research Group — 2001

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Description of fisheries

Changes in gear and/or fleets

The most notable recent development in South Pacific albacore fisheries has been the increase in Fijian, Samoan and French Polynesian longline effort (and catches) since 1996 with catch averaging 8771 tonnes per year. Small South Pacific island fleets are an increasingly significant component of the longline fishery and jointly have caught 6900—11 845 tonnes of albacore per year since 1996.

Targeting practices

Longline targeting practices are unknown but have been described for the troll fishery (Dotson 1980).

While not describing targeting practices, Wang (1988) states that Taiwanese distant water longliners operating in the South Pacific Ocean solely targeted albacore during the 1971—1985 period. Aside from the USA and New Zealand troll fleets targeting juvenile albacore and older longliners (mostly from Taiwan) with –20º C freezers, most longliners do not appear to target albacore. Lightfoot (1997) largely attributes the decline in albacore targeting by longliners to the better economic prospects of targeting bigeye for the "sashimi" market and the oversupply of skipjack and yellowfin for canning to the change in fleet targeting practices. He notes that despite an annual decline in the price for albacore (adjusted for inflation) of 2.2% per year over the period 1970—1997, distant water fleets still target albacore at some level "when there is no better way of using their vessel".

While albacore targeting by distant water fleets has declined, the proportion of longline operations targeting albacore is unknown both now and historically, as are the operational differences which would allow sets to be identified as target sets. Suzuki et al. (1977) in his analysis of catch rates on deep vs regular longlines notes that catch rates of albacore were similar on both longline types in the western equatorial Pacific Ocean.

The recent expansion of longlining among South Pacific States (eg Tonga, New Caledonia, New Zealand, etc) is also characterised by targeting a mix of tuna species including albacore. Targeting practices of these small fleets are also unknown.

Data availability

Data availability is summarised for surface and longline fisheries by fleet in Table 1. Albacore catch in number is available for all fleets except the longline fleets of American Samoa and the USA where catch is available only in weight.

The need to ensure that compatible data are being collected from all fleets (eg, catch in weight and in number) has been recognized as important, especially for the small Pacific Island longline fleets that are expanding in the region. Data on target species are not readily available for the longline fishery and the catch reported is usually only for a subset of species that are caught and landed by a vessel. Bailey *et al.* (1996) notes that under-reporting and non-reporting of bycatch species, at least for the longline fishery, is problematic.

Trends in catch

Catch by gear type

Catches by surface and longline fisheries in the South Pacific Ocean are shown in figure 1. Longline catches began in 1952 and surface fishery catches in 1960. Longline catches have been variable but within 2 standard deviations of the mean catch since 1960 (mean = 29 508 t, std. dev. = 5116 t per year). In recent years surface fishery catches have been typically much lower than longline catches (usually 10—30%). However, during the peak of driftnet fishing effort (1989) surface fishery catches slightly exceeded those of the longline fishery.

The surface fishery (see figure 2) has been comprised of pole-and-line, driftnet and troll fleets. The pole-and-line fleet is small (a few hundred tonnes in most years since 1960). Driftnet fleets from the North Pacific Ocean began exploratory fishing in the South Pacific in 1983 and rapidly expanded in 1988 and 1989 to exceed 13 400 tonnes before ceasing operations in 1990. The troll fishery, which began in the late 1960s in New Zealand waters, also expanded in the late 1980s into high seas areas east of New Zealand along the Subtropical Convergence Zone (STCZ) with vessels from the USA, Canada, and several South Pacific States. The troll fishery, while variable, accounts for 6321 tonnes per year (average for 1990—99), the peak troll catch in 1989 was 8927 tonnes.

Recent developments

Albacore catches by South Pacific Island fleets are becoming increasingly important components of the total albacore catch. Longline catches of several South Pacific island States and territories exceed 2,000 tonnes, each contributing substantially to the total albacore catch. The combined albacore longline catch in 1999 by Fiji, French Polynesia and Samoa was slightly lower than 1998 in all three areas. This catch, more than 11,000 tonnes, constitutes 29% of all longline catches of albacore in the South Pacific. Catches in Samoa have rapidly increased from 560 tonnes in 1994 to over 4,000 tonnes in 1998, but declined in 1999 to 3,400 tonnes.

Catch composition

Catch composition of the troll fishery, summarised by Bailey *et al*. (1996), indicates that bycatch is small (<1% in the SCTZ and < 5% in the New Zealand fishery). The predominant bycatch species is skipjack (> 70%) but can include a number of other species in low numbers. Troll fishery bycatch is composed of 25 species including: sharks (3 species), scombrids (6 species), billfish (2 species), other fish species (eg, Ray's bream, mahi mahi, kingfish, and others) and can include some seabirds.

The catch composition on longlines, also reviewed by Bailey *et al*. (1996), is more diverse than in the troll fishery but has not been analysed by fleet, target species, or time area strata so as to allow inferences about the longline fishery for albacore. These authors list 20 shark, 12 scombrid, 6 billfish, and 26 other teleost taxa as well as 5 turtle, 6 marine mammal and 3 seabird taxa as longline bycatch.

Distribution of catches by gear type

Albacore are caught in austral summer months by trolling in temperate latitudes usually from 35º S to 45º S across the Tasman Sea and from the coast of New Zealand eastwards along the STCZ to at least 110º W (Murray 1994; Childers & Bartoo 1999).

Longline catches of albacore are shown in figure 3 for the period 1995—99. This figure suggests that while some catches of albacore are made near the equator, highest catches are in the western South Pacific in the area 10º—40º S, west of 170º W. Longline catches do, however, extend to the eastern Pacific Ocean.

Trends in effort

Effort by gear type

Figure 5 shows the trend in effort by all longline fleets combined in the South Pacific. With the exception of 1974 when effort doubled, effort is relatively stable averaging 143 million hooks per year (excluding the 1974 effort). In the surface fishery (see figure 6) pole-&-line vessels have fished for about 2600 days per year since the early 1970s while troll vessels have fished about 9200 days each year on average since the mid-1980s.

Recent developments

The most notable recent development in the albacore fishery has been the increase in effort by small fleets from several South Pacific Islands, especially that of Samoa.

Data adequacy

Effort data appear to be largely complete for both longline and troll fisheries. The only apparent gap in Table 1 is the absence of data on number of hooks for the USA longline fleet. The absence of data on albacore targeting by longline complicates the use of these data since fishing practices are known to have changed over the time this fishery has operated.

Distribution of effort by gear type

As noted in the comments under catch distribution, effort is spread along the STCZ for the high seas troll fishery (38º—41º S) and within the New Zealand EEZ (34º—44º S) in a relatively narrow latitudinal band. The distribution of longline effort is shown in figure 4.

CPUE

Nominal CPUE trends by gear type

Longline CPUE for South Pacific albacore, shown in figure 7, has not been stratified by target species. Most longline fleets do not target albacore and different practices between fleets need to be accounted for if CPUE is to be used as an index of abundance. Evidence of the need to account for differences among fleets is clear when the CPUE trend for the Taiwanese longline fleet is compared with that for all fleets combined (figure 7). Even though the Taiwanese data includes vessels targeting albacore and those targeting bigeye and other tunas, the CPUE values are nearly double that for all fleets combined and Taiwanese CPUE exhibits much greater inter-annual variation.

Troll fishery CPUE also differs between the fleet fishing New Zealand waters and those fishing the STCZ (see figure 8), with the STCZ fishery showing higher CPUE values in all but the most recent years. In the last two years the New Zealand CPUE has increased by a factor of 4 to 5 times its previous levels. This does not appear to be an error but the reason for this increase is unknown.

Biological information

Stock structure

Two albacore stocks are recognized in the Pacific Ocean based on location and seasons of spawning, low longline catch rates in equatorial waters and tag recovery information (Murray 1994). The South Pacific albacore stock is distributed from the coast of Australia and archipelagic waters of Papua New Guinea eastward to the coast of South America south of the equator to at least 49º S. Chow and Ushiama (1995), however, suggest some gene flow may be possible between the North and South Pacific stocks based on an analysis of genetic population structure using restriction fragment length polymorphism analysis of the mitochondrial ATPase gene amplified by polymerase chain reaction.

Size composition by gear type

The troll fishery targets juvenile albacore that are typically about 5 to 8 kg. Longline fleets typically catch much larger albacore with a distinct difference in sizes caught that is a function of latitude and season. The smallest longline caught albacore are those caught in May to June north of the STCZ at the end of the troll fishery season, fish further north are larger.

Size/age at maturity

Ramon & Bailey (1996) report that female albacore from New Caledonian and Tongan waters spawn during the November—February summer season as evidenced by histological studies and a critical gonadosomatic index (≥1.7).

Based on histological studies of South Pacific albacore, males larger than 71 cm fork length (Ratty *et al*. 1990) and females larger than 82 cm fork length (Ramon & Bailey 1996) can be sexually mature. These values represent minimum size at maturity as no maturity ogive has been estimated for South Pacific albacore.

Sex ratios

Sex ratios (males:females) appear to vary with fishery from 1:1 in the New Zealand troll fishery (Griggs & Murray 2000); 1:1 in the New Zealand longline fishery (Murray *et al*. 1999); 2:1 to 3:1 in the Tonga—New Caledonia longline fishery (Yoneta & Saito, 1973; Ramon & Bailey, 1996).

Growth rates

Labelle *et al*. (1993) provide estimates of von Bertalanffy growth parameters for the South Pacific albacore stock based on length frequency analysis using MULTIFAN and counts of vertebral rings, the von Bertalanffy parameters are:

	Length frequency based	**Vertebral ring based**
L_∞, cm	97.1	121.0
K, cm per year	0.239	0.134
t_0	–	-1.922
number of age classes	9	10
youngest age class	3	2

These estimates were largely based on smaller troll caught albacore, recent analyses (Hampton & Fournier, 2000) using MULTIFAN on a larger data set, including longline caught albacore, gave a lower estimate of K (0.09 per year) and higher estimate of L_∞, (141.7 cm).

Mortality (F, Z, M, other sources)

Preliminary estimates of average annual natural (M) and fishing (F) mortality rates have been estimated from the MULTIFAN-CL model of Hampton & Fournier (2000). Natural mortality rates plotted in figure 9, average 0.4 per year for juveniles (ages 1 to 5), increasing to about 1.0 per year for adults. The increase in M after about age 6 approximates the onset of maturity (± 85 cm fork length).

The annual fishing mortality rates shown in figure 10 suggest very low F's on juveniles until the late 1980s when the driftnet fishery briefly operated, before again declining. In contrast the F's for adults (6+ year classes), are substantially higher but when compared to the estimates of M for adults they are also very low. These mortality estimates are considered preliminary because they may be significantly affected by the few tag recoveries that have been made.

Discard mortality is probably insignificant in albacore fisheries. Discards account for a small fraction of the catch in both the troll and longline fishery where it has been observed (1.7% discarded, mostly alive in the troll fishery (Labelle & Murray, 1992) and 1.8% dead when discarded or lost in the New Zealand longline fishery (Murray, *et al*., 1999)).

Conversion factors

Conversion factors are not applied since albacore from both the troll and longline fishery are landed without processing.

Stock assessment

Tagging

Small-scale tagging programmes have been conducted since the 1960s on South Pacific albacore. Large-scale tagging of troll caught albacore began as a cooperative programme between fisheries agencies in the USA, New Zealand, France and the South Pacific Commission. This work, described by Laurs & Nishimoto (1989), Bailey (1988) and Labelle (1993) was conducted between 1986 and 1992 off the Australian coast across the Tasman Sea to New Zealand and then eastwards from New Zealand along the STCZ. Most tagging was onboard commercial troll vessels in the STCZ. Bertinac *et al*. (1996) used these data (17 226 releases, 168 recoveries) in a tag attrition model to estimate natural mortality M at 0.470 (95% confidence interval 0.333—0.611); catchability q at 1.735 E-6 (95% confidence interval 1.203—2.418 E-6), and exploitation rate at 0.0227 (95% confidence interval 0.0188—0.0266). They found von Bertalanffy growth parameter estimates from tagging data were highly variable.

Abundance indices

No abundance indices have been derived for South Pacific albacore. While CPUE is a fundamental part of stock assessment, for South Pacific albacore there may be some ongoing difficulties in providing appropriate catch and effort data. In some cases catch is reported only in weight, necessitating information on size composition to estimate the number of fish caught. The greatest problem, however, is likely to be the difficulty in comparing albacore CPUE among fleets or areas because the target species is not specified and it is not clear whether CPUE is related to abundance or to retention practices. A range of CPUE standardization studies for developing indices of abundance for albacore would contribute to stock assessment work.

Population dynamic models

Hampton & Fournier (2000) have updated the population dynamic model of Fournier *et al*. (1998) using the program MULTIFAN-CL. The fisheries data used cover the period 1962—98 by quarter. Spatial coverage of the model is the South Pacific Ocean, stratified into three latitudinal bands (boundaries at 10°S and 30°S). Catch, effort and size data for 14 fisheries (11 longline, 2 troll, and 1 driftnet) were used in the analysis. Tagging data from the SPC's Albacore Tuna Tagging Project (1991-1992) were also incorporated.

The model produced an interpretation of the length-frequency data consistent with estimates of age and growth from analysis of vertebral rings by Labelle, *et al*. (1993) and estimates of natural mortality rates consistent with those obtained from analyses of tagging data alone. The pattern of age and size-specific variation in natural mortality is strongly related to changes in sex ratio with size, which may suggest an effect of reproductive activity on female natural mortality. The recruitment pattern is similar to previous analyses with a marked decline in the mid- to late 1970s. The recent increase in recruitment is a new feature in the most recent analysis. The absolute values of recruitment, and population size in general, are much higher than previously estimated when tagging data were not included in the analysis. Biomass trends showing a decline through the late 1980s, followed by an increase are largely driven by the recruitment. A similar biomass pattern was derived using a simple model in which recruitment was assumed to be positively related to the Southern Oscillation Index (i.e. recruitment is *la niña* positive). The low estimates of fishing mortality for both adult and juvenile age classes are probably due to low recovery rates of tagged albacore. These model results are considered preliminary because of the potential sensitivity of estimates of recruitment and mortality rates to tag recovery data.

Suggestions for future work include:

- sensitivity analysis with respect to tag reporting rates;
- standardization of the longline CPUE data using GLM and/or habitat-based methods;
- further examination of the SOI as a possible predictor of recruitment;
- consideration of other models, such as ASPIC or other surplus production models, to compare and contrast with MULTIFAN-CL results; and
- an exploration of possible biological reference points for south Pacific albacore.

<u>Environmental models</u>

Fournier *et al*. (1998) suggest that there is a correspondence between periods of low recruitment and *el niño* years (eg, negative values of the Southern Oscillation Index). While this observation suggests that models with environmental components could be useful, no environmental model has been done.

<u>Other modeling approaches</u>

Estimates of MSY for the South Pacific albacore longline fishery have been done based on simple production models assuming either a small or non-existent surface fishery. Estimates of MSY range from 31—33 000 tonnes (Wang *et al*., 1988) up to 37 000 tonnes (Wetherall & Yong, 1984). Polacheck, *et al*. (1993) compare three approaches (effort-averaging methods, process-error estimators, and observation-error estimators) to fitting stock production models to South Atlantic albacore and two other stocks. They state that of these approaches, effort averaging methods (of which Wang *et al*. (1988) and Wetherall & Yong (1984) are examples) usually leads to overestimates of potential yield and optimum effort, while process-error estimators result in high variance. Polacheck, *et al*. (1993) argue that observation-error estimators be used when fitting production models because their findings show that in Monte-Carlo simulations this approach was the least biased and most precise of the three approaches.

An alternative approach using a surplus production model to estimate carrying capacity (K), intrinsic growth rate (r), and catchability (q) of the South Pacific albacore stock has been done by Wang (2000). Using Taiwanese longline catch and effort data, he estimated K to be 149,733 tonnes, r to be 2.2018 and q to be 4.24098E-09. During the period 1974—98, harvest rates were estimated to vary between 0.14 and 0.23 with a mean of 0.19. A unique "equivalent" point in catch (the point where the theoretical catch equals the surplus production) was estimated to be where F = 0.7339, biomass = 49,911 tonnes and catch = 36,631 tonnes. He interpreted the model results as indicating that the South Pacific albacore stock was close to this point and fluctuations in stock size were deemed to be stable. This approach is not a standard application of stock production modeling and several issues remain for clarification. The key issues include:

- annual production and stock biomass levels appear to be approximately the same – an unusual situation for medium to long-lived fish stocks;
- the fitting procedure needs clarification (e.g. equilibrium assumed or non-equilibrium time series fitting);
- the rationale for excluding early years in the model fitting needs to be clarified; and
- model equations and assumptions need to be fully described.

Fisheries independent indicators

No fisheries independent indicators have been considered in the South Pacific albacore stock assessment.

Factors influencing stock assessment

At present there is no agreed method for conducting a routine stock assessment of South Pacific albacore. Anon (2000) reports a number of factors identified by the SCTB-13 Albacore Research Group which could influence the stock assessment. These include:

- availability of catch and effort data for some fleets;
- timeliness of data provision;
- catch and effort data are provided using a range of units of measurement;
- no means for distinguishing longline sets which target albacore from other target species;
- the desirability of developing indices of abundance based on CPUE standardisation studies;
- the need for sensitivity studies of the MULTIFAN-CL results, especially to the inclusion or exclusion of tag recoveries from the early 19990s tag experiment;
- whether to include the "Southern Oscillation Index" in models to predict recruitment; and
- the evaluation of alternative models, such as ASPIC or stock production models.

Reference points

No reference points have been considered in the South Pacific albacore stock assessment.

Research requirements and work plan for the next assessment cycle

Extracted from SCTB-13 Report:

1. Incorporate data from longline fleet in American Samoa and Canadian troll vessels operating in the SCTZ (**OFP**).

2. Compile summary tables of catch and effort by gear types similar to those in the "Tuna Yearbook" for the South Pacific stock (**OFP**).

3. Compare Australian observer data to vessel logsheets to clarify reported changes in the retention of albacore on Japanese longline vessels (Australia – **BRS** and Japan – **NRIFSF**).

4. With the termination of the SPRTRMP programme there is a need to find ways to enhance observer coverage and improve transshipment information, especially on distant water longliners from Taiwan (**OFP**, **OFDC**, **FFA**, others?).

5. Provide an update on the economics of albacore longline and troll fisheries in relation to trends in catch and effort (**FFA**).

6. Improve estimates of effective effort for use as model inputs (**OFP**, others?).

7. Explore ways in which historical Taiwanese longline data could be improved by distinguishing albacore target and non-target sets, especially during the period of increased targeting of bigeye and yellowfin (**OFDC**, **OFP**, others?).

8. Continue the development of the MULTIFAN-CL model, especially through extensions incorporating environmental information and further tests of the sensitivity of outputs to existing model inputs derived from tagging in the early 1990s (**OFP**).

9. Determine whether the depth of longline fishing gear is related to the size composition of the catch (**OFP**, **Samoa**, **NRIFSF**, others?).

10. Identify the benefits of conducting a further albacore tagging programme, especially with respect to providing corroboration of existing views of stock status (**OFP**, others?).

11. Consider a monitoring programme for long-term variation in biological parameters (eg, spawning activity, recruitment strength, etc) (**NFRDI**, others?).

12. Explore the utility of reference points derived from the MULTIFAN-CL and other models of stock trends for summarizing information about current stock status (**OFP**, others?).

Status of stock summary

Extracted from SCTB-13 Report:

Albacore caught in the South Pacific constitute a single stock. Longline, primarily catching adults, accounts for the majority of albacore catches (89%) in the South Pacific with trolling catching the remainder (11%). Albacore catch, estimated at 38,425 tonnes in 1999, was slightly less than in 1998 when catches reached the 10-year peak of nearly 41,000 tonnes. In 1999 longline catches were 33,969 tonnes and troll catches 4,431 tonnes. Longline catches of several South Pacific island States and territories exceed 2,000 tonnes, contributing substantially to the total albacore catch. The combined albacore longline catch in 1999 by Fiji, French Polynesia and Samoa was slightly lower than 1998 in all three areas. This catch, more than 11,000 tonnes, constitutes 29% of all longline catches of albacore in the South Pacific. Catches in Samoa have rapidly increased from 560 tonnes in 1994 to over 4,000 tonnes in 1998, but declined in 1999 to 3,400 tonnes. Longline albacore catches also declined for vessels in American Samoa over the same time period. Slight declines in catches were also reported for Canadian and USA troll vessels fishing the SCTZ in the 1998/99 season relative to 1997/98. Troll caught albacore in the New Zealand EEZ declined by about half over the same period, in this latter case low prices were given as an explanation by the fishing industry, rather than low availability.

There has not been any dedicated field research on albacore since the OFP research programme in 1991/92. Biological data on albacore is regularly collected, however, in observer and port sampling programmes in the region, although some of these data have not been compiled. Length frequency data from port sampling is a critical input to the length-based age-structured stock assessment model (MULTIFAN-CL). This model has been extended to cover the period 1961-98, incorporate tag recovery information, and the Samoan longline fishery. Results from this model are strongly influenced by a small number of tags recovered (135 recoveries) and hence are highly uncertain. Results, however, suggest a decline in biomass from 1961 to 1989/90 (about 50%) followed by an increase which continues to 1998. These results are regarded as highly uncertain due to the influence of the tagging data and the lack of information on tag reporting rates. An alternative stock production model examined stock sustainability from a theoretical perspective. The results of this model were also considered to be highly uncertain and several key parameter estimates were unrealistic and there was no basis for confirming results, including by reference to similar species. A new attempt to incorporate environmental factors (with appropriate time lags) in modeling biomass suggests a possible link between recruitment and ENSO events. This approach requires further work to confirm this interpretation.

A number of areas requiring further work before the next SCTB meeting were identified, these include: incorporate data from additional fleets; review the adequacy of observer coverage; conduct an economic analysis in relation to changes in effort; analyse longline data to determine if retention practices have changed in some fleets; analyse depth of longline sets in relation to albacore size; develop further extensions to the MULTIFAN-CL model; develop procedures for standardising CPUE; evaluate the need for a further tagging programme; and evaluate the use of reference points in assessing stock status.

There was no information presented to suggest a change in interpretation of stock status of South Pacific albacore. Although model results are considered highly uncertain, exploitation rates appear to be moderate and current catches are likely to be sustainable.

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Table 1. Data availability for longline and surface fisheries for albacore in the South Pacific Ocean, information from draft copy of the SPC Tuna Fishery Yearbook - 1999 (as at 6 July 2000), table entries in bold reflect data deficiencies relative to other fleets or doubtful entries.

Gear	**Fleet**	**Years**	**Effort**			**Catch**
			No. vessels	**Days fished**	**No. hooks**	
Longline	American Samoa	1995-98	yes	no	yes	**wt**
	Australia	1985-99	yes	no	yes	wt + no.
	Australia-Japan JV	1989-95	yes	no	yes	wt + no.
	China	1991-99?	no	no	yes	wt + no.
	Chinese Taipei (offshore)	1993-99	no	no	yes	wt + no.
	Chinese Taipei (distant water)	1967-99	no	no	yes	wt + no.
	Cook Islands	1994-96	yes	1994 only	yes	wt + no.
	Fiji	1989-99	yes	no	yes	wt + no.
	French Polynesia	1990-99	yes	yes	yes	wt + no.
	Japan	1962-99	no	no	yes	wt + no.
	Korea	1975-99	no	no	yes	wt + no.(wt only 1958-74)
	New Caledonia	1983-99	yes	1983-86	yes	wt + no.
	New Zealand	1989-99	yes	1991-99	yes	wt + no.
	Papua New Guinea	1995-99	yes	no	yes	wt + no.
	Samoa	1993-99	yes	no	yes	wt + no.
	Solomon Islands	1995-99	yes	1998 only	yes	wt + no.
	Tonga	1982-96	yes	1990-92	yes	wt + no.
	USA	1994-99	yes?	no	**no?**	**wt**
	Vanuatu	1995-99	yes	yes	yes	wt + no.

Gear	**Fleet**	**Years**	**No. vessels**	**Days fished**	**No. hook-hours**	**Catch**
Troll	New Zealand	1982/83 - 1998/99	since 1986/87	yes	1989/90 - 1998/99	wt + no.
	USA	1985/86 - 1998/99	yes	yes	1985/86 - 1998/99	wt + no.

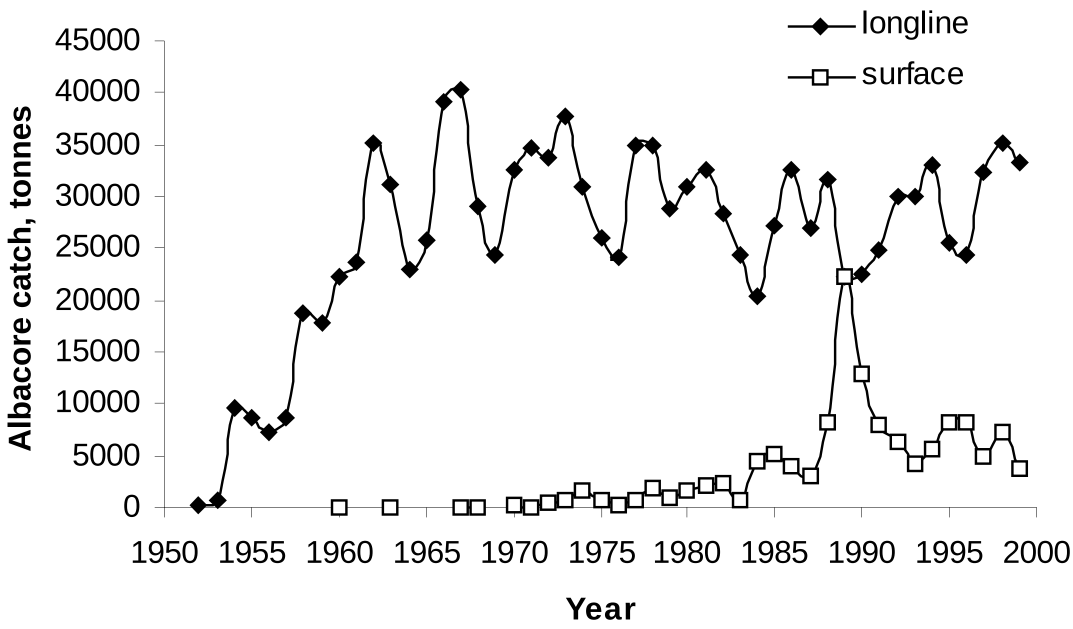

Figure 1. Total catches of South Pacific albacore by longline and surface fisheries, data from Lawson (2000).

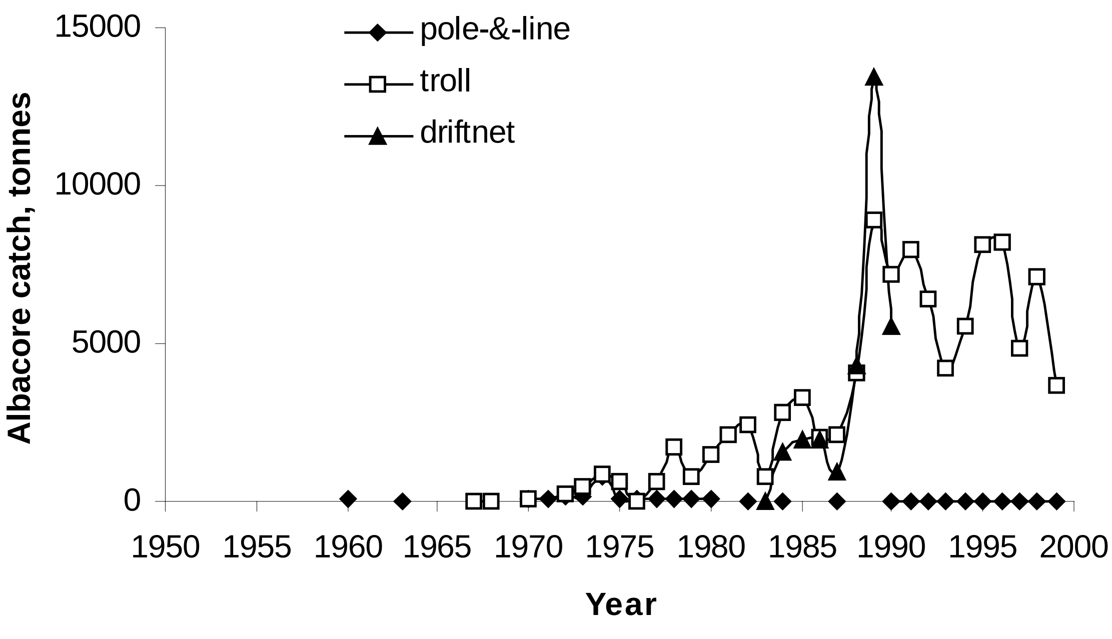

Figure 2. Total catches of South Pacific albacore by surface fisheries by gear type, data from Lawson (2000).

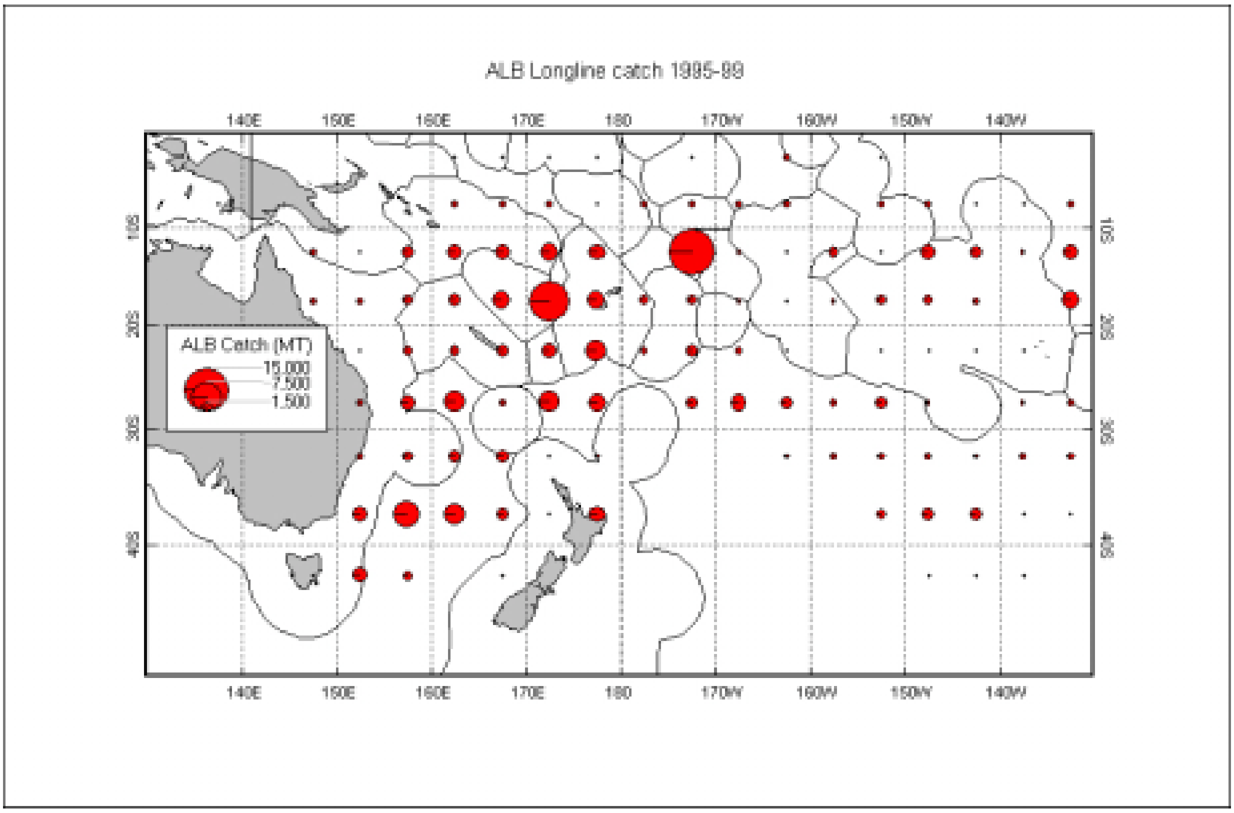

Figure 3. Distribution of albacore catches by longline during the period 1995—99.

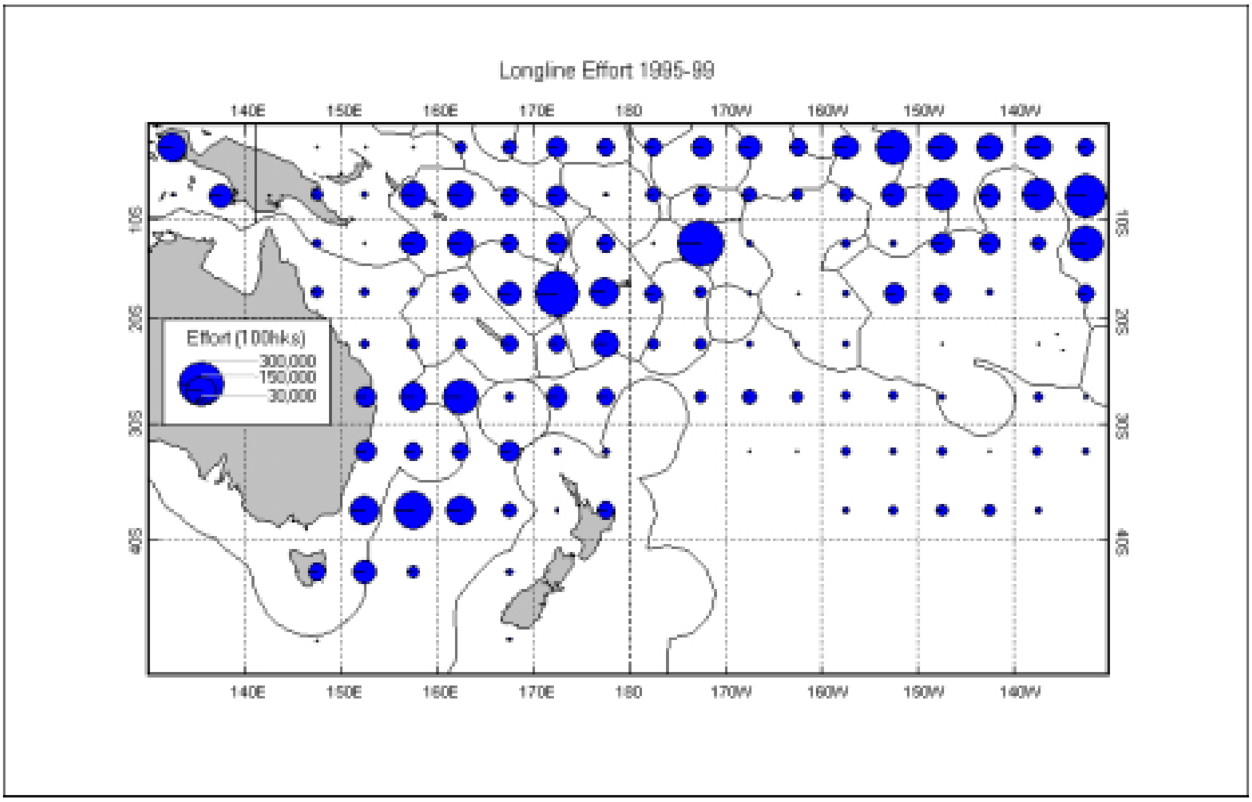

Figure 4. Distribution of longline effort for vessels catching albacore during the period 1995—99.

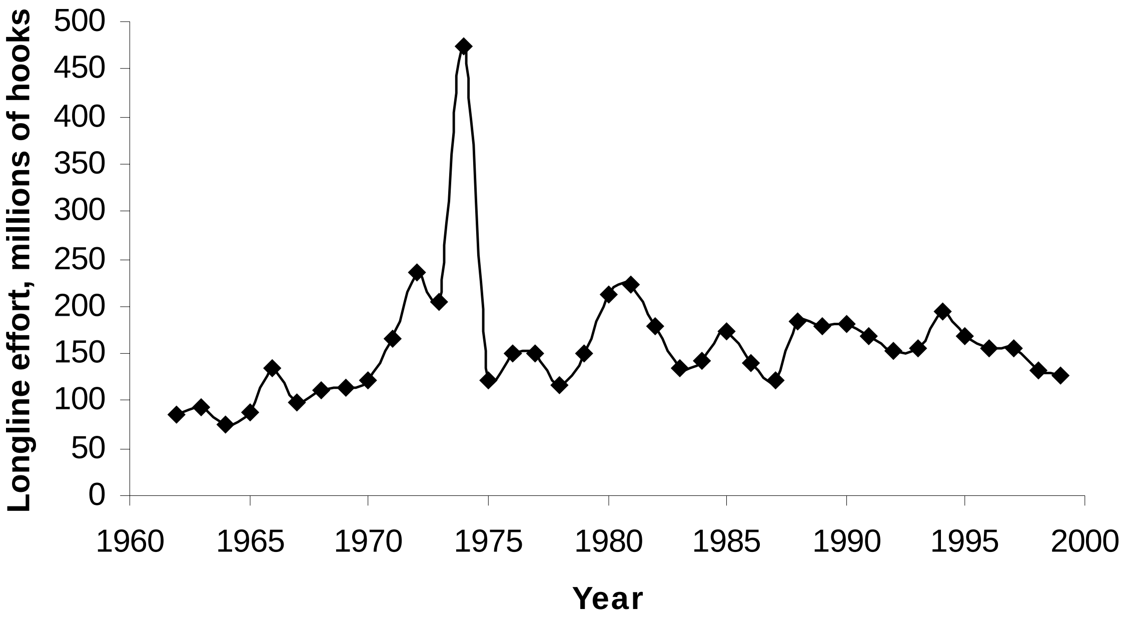

Figure 5. Longline effort in millions of hooks set per year, all fleets combined.

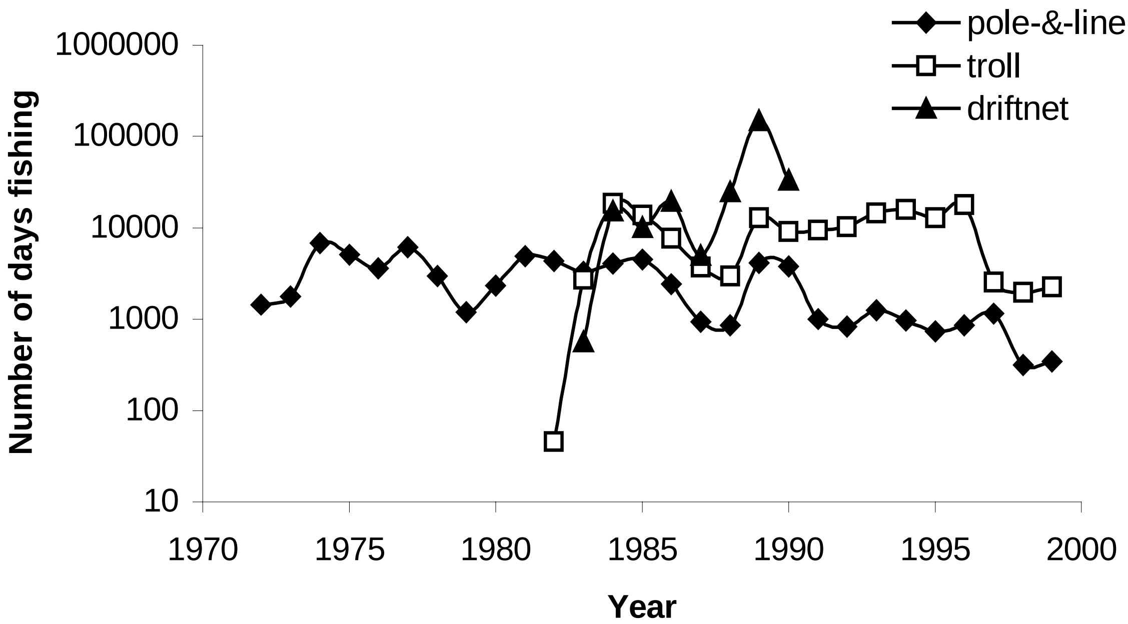

Figure 6. Surface fishery effort by gear type in numbers of days fished per year, all fleets combined.

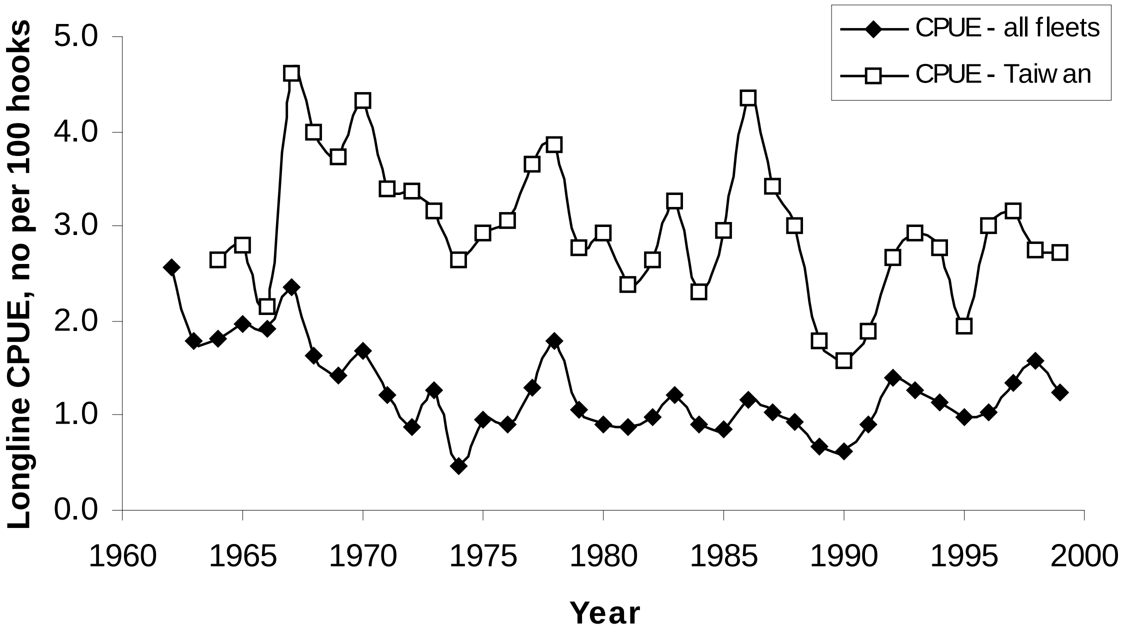

Figure 7. Longline CPUE for South Pacific albacore for the Taiwanese fleet and all fleets combined.

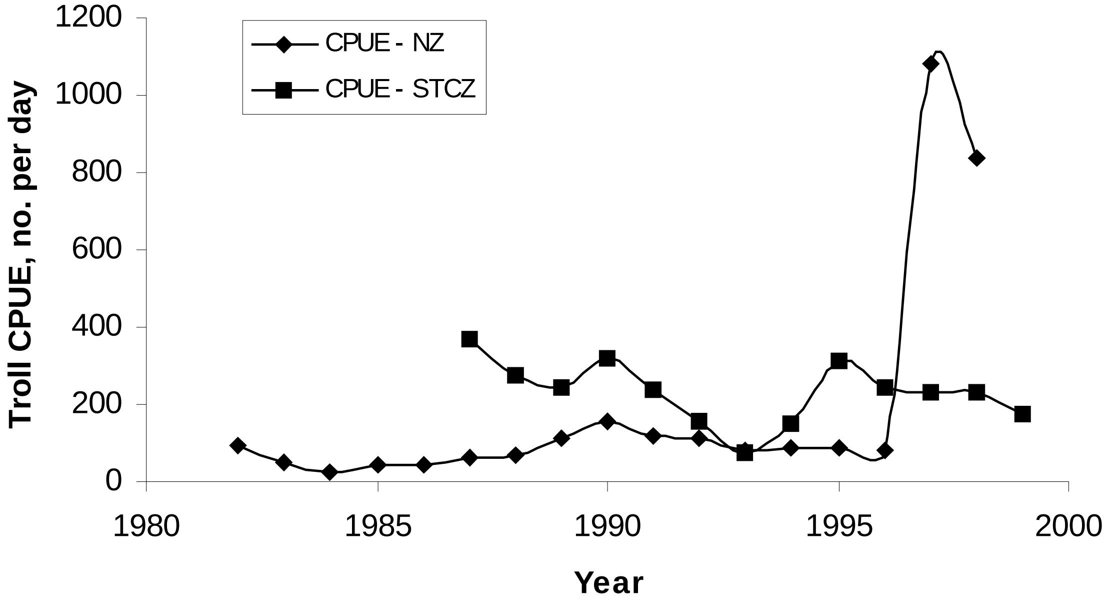

Figure 8. Troll fishery CPUE for the New Zealand and STCZ fisheries.

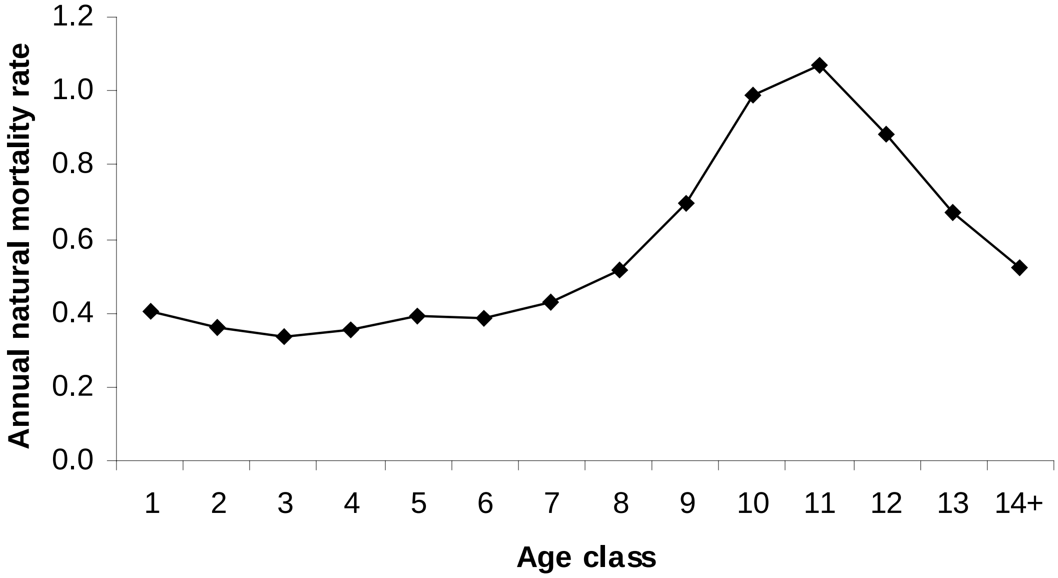

Figure 9. Estimates of average annual age-specific natural mortality rates M for South Pacific albacore (from Hampton & Fournier, 2000).

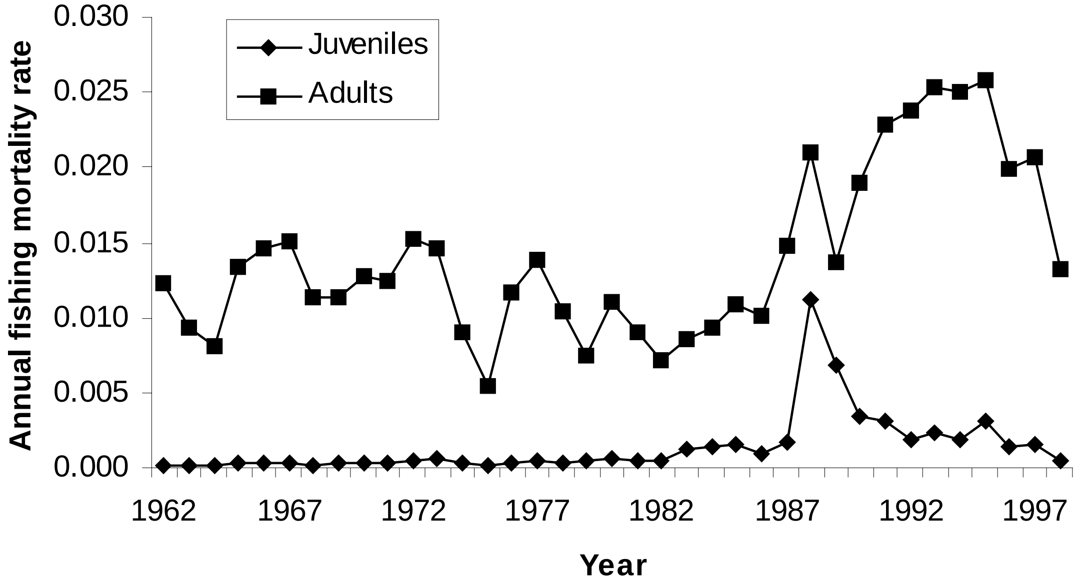

Figure 10. Estimates of average annual fishing mortality rates F for juvenile (age classes 1-5) and adult (age classes 6-14+) South Pacific albacore (from Hampton & Fournier, 2000).