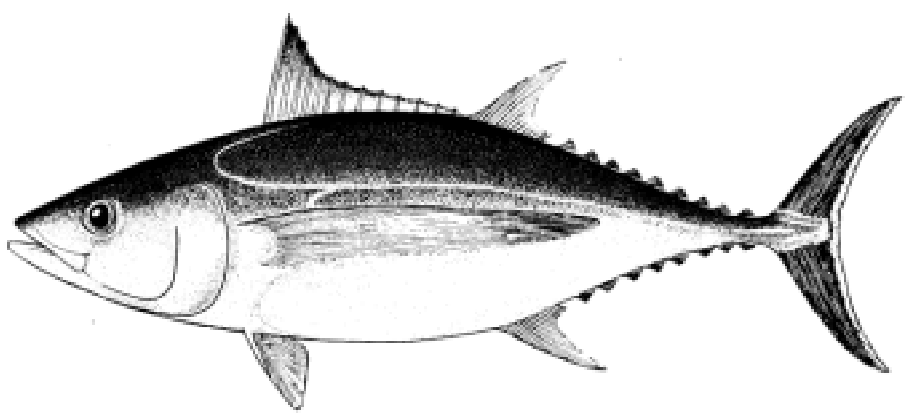
16th Meeting of the Standing Committee on Tuna and Billfish

SCTB 16
Mooloolaba, Qld, Australia
9-16 July 2003

SCTB16 Working Paper

ALB–5

Summary of recent trends in the South Pacific albacore fishery



Adam Langley

Oceanic Fisheries Programme
Secretariat of the Pacific Community
Noumea, New Caledonia

June 2003

1. BACKGROUND

Over the last 10 years, there has been considerable development in the domestic tuna longline fisheries operating within the sub-equatorial waters of the south Pacific Ocean. Domestic longline fleets have developed in New Caledonia, Fiji, Tonga, French Polynesia, Samoa, and, more recently, American Samoa, Vanuatu, and Cook Islands. In general, these fleets have operated exclusively within the Exclusive Economic Zone (EEZ) of the nation. However, in recent years, the activity of some of the domestic fleets has also extended to adjacent waters and neighbouring EEZs.

The domestic tuna fleets principally target albacore, yellowfin, and bigeye with an associated catch of swordfish, marlin species, mahi mahi, and opah. The species composition varies between EEZs, although albacore always comprises the largest component of the catch and exceeds 50% of the catch by weight.

The development of these fisheries has resulted in a considerable increase in longline fishing effort in the respective EEZ areas. Initially, the fishing effort is often concentrated in a relatively small area usually in close proximity to port facilities. This is largely dictated by the operational constraints of the smaller size of the vessels participating in these fisheries.

Recently, some participants in these fisheries have expressed concerns with the state of the albacore fishery within the respective EEZs, including observations of declining catch rates and size of fish caught. The current regional stock assessment for albacore indicates the stock is in a healthy state (reference). However, the impact of the domestic fisheries on the local availability of albacore in the EEZ area is unknown.

The purpose of this paper is to compare trends in the catch rate and length composition of albacore for each of the main domestic fisheries, specifically New Caledonia, Fiji, Tonga, French Polynesia, Samoa, American Samoa, and Cook Islands. This analysis may determine whether recent observations from the fisheries represent local or regional trends in the albacore fishery. Further, the analysis may reveal some consistent trends that occur in the development of local scale domestic fisheries and, thereby, enable fisheries managers to pre-empt issues that may arise during the development phase of these fisheries.

2. DATA ANALYSIS

The analysis of catch rate data was principally undertaken from vessel logsheet data held by SPC. These data were used to determine the monthly trend in the catch rate (kg per 100 hooks) of albacore and the proportion of albacore in the catch by EEZ area from 1998 to 2002. Data from American Samoa were available aggregated by 5 degrees of latitude and longitude and quarter only. Vanuatu was excluded from the analysis, as recent logsheet data are considered incomplete.

For larger EEZ areas that span a wide latitudinal band (Fiji, Tonga, Cook Islands, and French Polynesia), the CPUE series were initially subdivided into two latitudinal zones. This segregation was maintained for fisheries where the CPUE trend differed between zones (Cook Islands), although in most cases the CPUE trend was consistent throughout the EEZ and the areas were aggregated. For the French Polynesia EEZ, the fishery operating around the Marquesas (north of 11° S) was excluded from the entire analysis.

For the New Caledonia and French Polynesia fisheries, the time series of CPUE data were extended back to the initial development of each fishery. For comparison, trends in albacore CPUE from the Taiwanese fleet operating in the 10–25°S latitudinal range were also presented.

For each EEZ area, longline logsheet data were used to determine the level of fishing effort by degree of latitude and longitude and the average annual catch rate of albacore. These data were used to monitor in changes in the distribution of fishing effort and changes in the relative catch rate of albacore. These observations are summarised in the current document. However, to avoid potential data confidentiality issues, the associated figures are not included in this report.

For each EEZ area, annual length frequency distributions were determined for the longline albacore catch. These data were principally derived from port sampling programmes operating in each country and data are held by SPC. For comparison, the annual length composition was compared with the combined albacore length composition from the entire fishery operating in the 10–25°S latitudinal zone.

3. FISHERY SUMMARY

3.1 New Caledonia

Since 1998, monthly catches of albacore from the New Caledonia fishery were relatively constant at about 50–150 t (Figure 1).

In general, catch rates of albacore are high during May–January and low in February–April (Figure 2). The proportion of albacore in the catch corresponded with this trend, with a lower proportion of albacore in the catch from February to May (Figure 3).

Catch rates of yellowfin were generally highest in February–July and low in the last quarter of the year, although there was considerable variability in the seasonal catch rate of yellowfin between years (Figure 4). The catch rate of bigeye followed a similar seasonal trend to yellowfin, although the magnitude of variation in seasonal catch rates was lower (Figure 5).

Monthly catch rates in 2002 were generally higher than for the previous four years (Figure 2). However, recent catch rates are low compared to the high seasonal catch rates achieved during the late 1980s and early-mid 1990s (Figure 6).

In 1998, most of the fishing effort was located in the southwestern area of the EEZ. However, in the subsequent years, there was a steady shift in fishing effort to the northwest. This has coincided with a general decline in albacore catch rates in the southern area of the EEZ.

The annual length composition of the albacore catch from New Caledonia is broadly comparable to the wider south Pacific fishery (Figure 7). This is partly due to the relatively high level of sampling conducted in New Caledonia in recent years and, consequently, the total length composition is biased towards the New Caledonia fishery. The length compositions reveal an increase in the size of albacore caught from 1997 to 2002, with a decline in the proportion of smaller (less than 90 cm) albacore in the catch (Figure 7).

3.2 Fiji

The reported longline catch of albacore in the Fiji EEZ by the domestic fleet increased considerably during the late 1990s. During 2001 and 2002, the fishery yielded the highest albacore catch of the south Pacific domestic longline fisheries (Figure 1). There was a strong seasonal trend in the catches, with high catches taken in November–February and May–July. This trend is consistent with the seasonal variation in the catch rates for albacore in the Fiji EEZ (Figure 2). However, there is some inter-annual variability in the seasonal trend in catch rates and in 2002 the “winter” season was rather protracted, while there was no increase in catch rates late in 2002.

Albacore accounts for a high proportion of the domestic longline catch, although some seasonal variation in the catch composition is evident (Figure 3). These trends are consistent with the seasonal trend in albacore catch rate as well as increased catch rates of yellowfin and, to a lesser extent, bigeye during summer–autumn (Figure 4 and Figure 5). Overall, the catch rates of both these species declined from 2000 to 2002.

The expansion of the Fijian fishery through the late 1990s resulted in an increase in the geographic range of the core area of the fishery, expanding to the south and west of Viti Levu towards the limits of the EEZ and, in more recent years, to the northern and eastern area of the EEZ. There has also been a considerable intensification of fishing effort in the fishing grounds around the south and west of Viti Levu.

Catch rates of albacore were generally low inside the archipelagic waters and highest catch rates were consistently achieved in the southwestern area of the Fiji EEZ. This is the northern edge of the South Fiji Basin and the deepest area of the EEZ. In some years, in particular 1997, higher catch rates of albacore were also achieved in the northern area of the EEZ.

While catch rates of albacore remained relatively stable from 1996 to 2002, the area of lower catch rates around the archipelagic region has generally increased, particularly to the south and west of Viti Levu where fishing effort has been concentrated. The extent of the area in the southwestern extremity that yielded higher catch rates of albacore (40+ kg per 100 hooks) also varied between years.

The length composition of albacore from the Fiji EEZ is broadly comparable to the wider south Pacific fishery (Figure 8), with the exception of 1997–1999 when slightly larger fish were taken in the Fiji EEZ. In 2002, there was a decline in the size of albacore caught with an increase in the proportion of smaller fish (80–90 cm) sampled. This trend was also observed in the albacore catch sampled from the Tonga fishery.

3.3 Tonga

Prior to 2000, the albacore catch from the Tonga domestic fishery was limited. Monthly catches have increased to a modest level in the subsequent years (Figure 1). The seasonal trend in catch rates is comparable to Fiji, peaking in the austral summer (December to February) and in winter (May–July). However, the seasonal trend has diminished in 2001 and 2002 with higher catch achieved during a protracted winter season (May–September) and no subsequent summer fishery (Figure 2). Overall, there has been a gradual decline in the catch rate of albacore largely due to the reduction in the magnitude of the seasonal peak in catch rates.

The proportion of albacore in the tuna catch from the Tonga EEZ varies seasonally and is generally lower during the first half of the year (Figure 3). During this period, catch rates of albacore are lower and higher catch rates of yellowfin and bigeye are achieved (Figure 4 and Figure 5).

In 1998 to 2001, fishing activity was concentrated around Tongatapu. However, there was a strong shift in fishing effort to the north-western area of EEZ in 2002. In 2002, average annual catch rates of albacore were low (less than 20 kg per 100 hooks) in the vicinity of the Tongatapu Group and higher catch rates were only achieved around the periphery of the EEZ.

The annual length compositions of the albacore catch from the Tonga EEZ has been comparable to the length composition of albacore from the wider south Pacific fishery (Figure 9). The length composition of the catch was relatively stable from 1998 to 2001, while there was an increase in the proportion of smaller fish (80–90 cm) in the catch in 2002.

3.4 Samoa

Longline logsheet data were available for the Samoa domestic fishery from 2001 and 2002 and accounted for considerable catches of albacore (Figure 1). However, these data only include the larger vessels (greater than 12.5 m) in the fleet and do not include the large proportion of the catch taken by the alia vessels, particularly in the earlier years of the development of the fishery. Considerable catches of albacore were taken since at least 1996.

Albacore catch rates peak during May–June and are generally low in December–March (Figure 2). Between 2001 and 2002, there was a considerable decline in catch rates, in particular during July–October. The catch rates achieved in 2001 were very high compared to most of the other domestic tuna fisheries in the region and despite the subsequent decline in catch rates average catch rates in 2002 remained higher than most other fisheries (Figure 2).

Despite the decline in albacore catch rates, the proportion of albacore in the catch remained high through 2001 and 2002 (Figure 3) as catch rates of bigeye and yellowfin declined during the same period (Figure 4 and Figure 5).

Insufficient data are currently available to reliably determine the spatial distribution of the catch and effort for a large component of the longline fleet, specifically the alia vessels.

Annual length frequency data of albacore from the Samoa fishery reveals a considerable reduction in the length composition of the catch from 1998 to 2002 (Figure 10). In 1998 and 1999, fish caught in the Samoa EEZ were generally larger than from the wider albacore fishery, although in subsequent years the length compositions have been similar.

3.5 American Samoa

The American Samoa longline fishery developed rapidly from 2000 to 2002 and catches exceeded 5,000 t in the most recent year (Figure 1). Catch and effort data were only available by year/quarter and, therefore, it was not possible to examine monthly trends in catch rate. Nevertheless, highest catch rates of albacore were achieved in the second and third quarter of the year, which is consistent with the seasonal trends in catch rate for the Samoa fishery (Figure 2).

Between 2001 and 2002, there was a considerable decline in the catch rate of albacore, although catch rates in 2001 were higher than achieved in 1998 and 1999 (Figure 2).

In 2001 and 2002, the proportion of albacore in the catch was very high (Figure 3) and the fishery yielded low catch rates of yellowfin and bigeye compared to other domestic fisheries (Figure 4 and Figure 5).

Catch and effort data were not available at a spatial resolution sufficient to investigate any temporal changes in the distribution of fishing effort.

Annual length frequency data are available for the albacore catch from 2000 to 2002 (Figure 11). There is no apparent change in the length composition of the catch and the length compositions are similar to the data from the wider south Pacific fishery. The length compositions are also similar to length frequency data from albacore sampled from the Samoa fishery.

3.6 Cook Islands

Limited fishing occurred in the Cook Islands EEZ between 1999 and 2001, although fishing activity has recently increased, mainly in the northern area of the EEZ and around Rarotonga. In 1998, there was some activity in the northern EEZ by the Korean longline fleet and these data have been included in the current analysis for comparison (Figure 1).

In 2002, catch rates of albacore in the northern area of the EEZ were very high, particularly from May to August, and were considerably higher than the catch rates achieved in the southern area of the EEZ (around Rarotonga) (Figure 2). The proportion of albacore in the catch was very high (over 80%) due to the high catch rate of albacore relative to the catch rates of yellowfin and bigeye (Figure 3, Figure 4 and Figure 5). Even so, catch rates of bigeye were high in comparison to the catch rates achieved in other domestic fisheries (Figure 5).

No albacore length frequency data are currently available from the domestic longline fishery.

3.7 French Polynesia

The French Polynesia EEZ has supported considerable catches of albacore over the last five years (Figure 1). Catch rates of albacore (excluding bonitiers) were high in 1998, relatively low in 1999, and have gradually increased over the subsequent years (Figure 2). Over the longer term, albacore catch rates were relatively low during the initial period of development of the longline fishery in the early-mid 1990s before increasing in the late 1990s (Figure 6).

There is no strong seasonal trend in albacore catch rates, although catch rates are generally low in summer and peak in May–June (Figure 2).

Albacore generally comprises over 70% of the total tuna catch (Figure 3) and the proportion of albacore in the catch has gradually increased since 2000, partly attributable to a decline in the catch rate of yellowfin (Figure 4).

The French Polynesian fishery has a relatively high catch rate of bigeye compared to other domestic fisheries (Figure 5). However, there was considerable inter-annual variation in the catch rate of bigeye, with catch rates particularly low in 1999. In general, seasonal catch rates of bigeye are lowest during summer (December–February).

During 1995 and 1996, longline effort was concentrated around the Society Islands, in particular Tahiti, in the western area of the EEZ. Over the three subsequent years, effort remained concentrated in this area but also extended to the northwestern area of the EEZ. The northern shift in fishing effort continued from 2000 to 2002, extending to the periphery of the EEZ and also extending the fishing grounds eastwards. Since 2000, the area around the Society Islands has accounted for a relatively small proportion of the total fishing effort.

An examination of spatial distribution of albacore catch rates reveals higher catch rates occur on the periphery of the main fishing area, while catch rates in the main area fished have declined over time. This indicates that the overall annual catch rates for albacore have been sustained, at least to some extent, by the continued expansion of the fishing grounds.

The length composition of albacore from the French Polynesia EEZ is generally larger than for the other fishery areas of the south Pacific (Figure 12). However, no sampling data are available from 1999 to 2002 to investigate recent trends in the length composition of the catch.

3.8 Summary

While considerable data are available from main domestic longline fisheries, it is difficult to draw strong conclusions regarding the performance of the fisheries following the initial period of development. This is essentially due to the considerable differences in the status of the fishery in the EEZ prior to the development of the fishery and the variation in the level of monitoring that occurred following the development of the fishery. In some cases, significant longline fisheries existed in the EEZ for considerable periods prior to the development of domestic fishery, principally operated by the Korean, Japanese, and Taiwanese distant water fleets (Fiji, Tonga?). Other fisheries have only developed in the last few years and the time-series of data is insufficient to establish any significant trends (Cook Islands and American Samoa). In the case of Samoa, insufficient data are currently available from the initial development of the fishery in the mid 1990s. Each fishery also operates in a unique area of ocean with different bathymetric and oceanographic characteristics that may preclude direct comparisons between fisheries.

Of the seven fisheries examined, only French Polynesia and New Caledonia are considered to have a reliable time-series of catch and effort data that spans the period from the development of the domestic fishery to current. These fisheries were also able to develop from a relatively unfished state given that foreign vessels had generally been excluded from the area following the declaration of the EEZs.

In the case of the New Caledonia fishery, seasonal catch rates of albacore were high during the late 1980s and early 1990s, although the level of was relatively low (about 400 t per annum). Catches were low in 1994–1997, but increased considerably in 1998 and averaged about 800 t per annum over the subsequent years. Catch rates were considerably lower in 1998–2002 compared to the earlier years (Figure 6).

An examination of the spatial distribution of catch rates revealed a decline in catch rates in the southeastern area of the fishery where most of the recent catch had been taken and a subsequent movement of fishing effort to the north of the EEZ. This trend suggests the potential of local scale depletion of albacore in areas of high fishing activity. This was investigated further by comparing annual catch rates of albacore in each degree of latitude and longitude with the cumulative catch of albacore from the same area from the preceding years (Figure 13).

The analysis indicates that the highest catch rates were achieved in areas with limited previous catch and that generally lower catch rates occurred in areas where higher cumulative catches were taken (Figure 13). The effect was most pronounced in 2002 following four years of relatively high catch. However, there are some areas where catch rates were low despite only small catches being taken.

The analysis was repeated for the French Polynesia fishery with more conclusive results. Catch rates were highest in areas where limited catch had previously been taken and steadily declined up to a catch level of 200 t per degree of latitude and longitude (Figure 14). Catch rates appeared to stabilise (at about 30 kg per 100 hooks) for areas where greater cumulative catches were taken.

The observations from these two fisheries indicate that catch rates can be expected to be higher during the development of new fishing areas. Catch rates decline with increased effort in these areas and may stabilise at a lower, longer-term average level. This observation is also consistent with the initially high catch rates achieved by the Taiwanese longline fleet and the relatively stable catch rates achieved over the longer-term (Figure 6). With the exception of the recently developing fisheries, catch rates in each of the domestic fisheries have tended to stabilise at a level of about 20–30 kg per 100 hooks (Figure 2). This level is comparable to the longer-term average level of catch rates achieved by the Taiwanese fleet.

Nevertheless, the results also indicate that catch rates, at least in New Caledonia and French Polynesia, have been partly sustained by the expansion of the longline fishery into new areas. This result is also consistent with the shifts in the geographic distribution of fishing effort observed in some of the other domestic fisheries, including Tonga and Fiji. Consequently, trends in catch rates may under-estimate the true level of decline in the density of albacore within a specific EEZ.

There are no apparent trends in the length frequency data from the albacore fishery that suggest a change in size composition during the development of the domestic fisheries. The length of fish sampled from Samoa declined following the development of the fishery, although the same trend was not evident from the other fisheries where sampling was undertaken. Unfortunately, limited sampling has been undertaken in the French Polynesia fishery. In general, the length composition of the albacore catch from each EEZ is broadly comparable to the length composition of the wider south Pacific fishery.

3.9 Oceanographic conditions

For each EEZ area, sea surface temperature (SST) data were sourced for the period 1999 to 2002 (Source: www.noaa.gov). Data were available by week and half degree of latitude and longitude. These data were used to derive average monthly SST for an area approximating each EEZ. For each area, a time-series analysis was undertaken to derive the average seasonal trend in SST and determine the trend in SST from 1999 to 2002.

The analysis indicated that for the New Caledonia, Fiji, and Tonga EEZs seasonally corrected SSTs varied less than 0.5° C during 1999–2002 (Figures 15 to 17). In these areas, SSTs were slightly higher during spring–summer 2001/02.

For the eastern EEZ areas (Samoa, Cook Islands, and French Polynesia), there was a greater variation in SST over the time period with the seasonal corrected trend increasing by about 0.5° C from late 2000 to late 2002 (Figures 18 to 20). This trend is consistent with a decline in the Southern Oscillation Index (SOI) over the same period and the recent El Nino conditions.

4. DISCUSSION

The purpose of this paper was to examine recent trends in the domestic albacore longline fisheries and, where possible, identify any consistent performance indicators for monitoring the development of a new fishery. This analysis should be considered preliminary as a complete time-series of detailed catch and effort and length frequency data were not available for all fisheries. Confidentiality issues also restrict the presentation of detailed location data from the longline fisheries.

Despite the preliminary nature of the study, some initial conclusions are available.

1. Over the last few years, there has been a decline in the catch rate of albacore in a number of fisheries. This decline in catch rate has been relatively gradual in some fisheries (Fiji and Tonga) and stronger in other areas (Samoa and America Samoa).
2. There has been a considerable shift in the distribution of fishing effort from the main area fished to new fishing grounds and/or to the periphery of the EEZ. This trend has been evident in most fisheries and most notable in New Caledonia and French Polynesia.
3. Catch rates were generally higher in fine-scale areas immediately following the commencement of fishing. Catch rates were reduced in areas that had been intensely fished.
4. Over the longer-term, catch rates in the albacore fisheries tend to stabilise at a relatively comparable level between fisheries.
5. Length frequency distributions of albacore are generally comparable throughout the EEZ areas. There were no strong changes in length composition with increased fishing effort (with the exception of Samoa).

These results highlight the importance of undertaking the analysis of catch and effort data on a relatively fine spatial scale that reflects the operation of the fishery. For a number of fisheries, overall catch rates from the fishery have been sustained by the movement of the fleet to previously unfished areas, while the catch rates in the more established grounds have declined. These observations introduce potential biases to an overall CPUE index that need to be corrected before the CPUE data can be applied directly as a index of relative stock abundance.

There has been no fine-scale analysis of the length frequency data from each fishery. Depending on the spatial resolution of the sampling data, it may be worthwhile comparing the length composition of the albacore catch from areas of relatively low and relatively high fishing intensity.

Anecdotal information from the various fisheries has suggested that the recent warmer water temperatures experienced under El Nino conditions has reduced longline catch rates of albacore. A considerably more detailed analysis would be required to determine correlations between albacore catch rates and variation in oceanographic conditions.

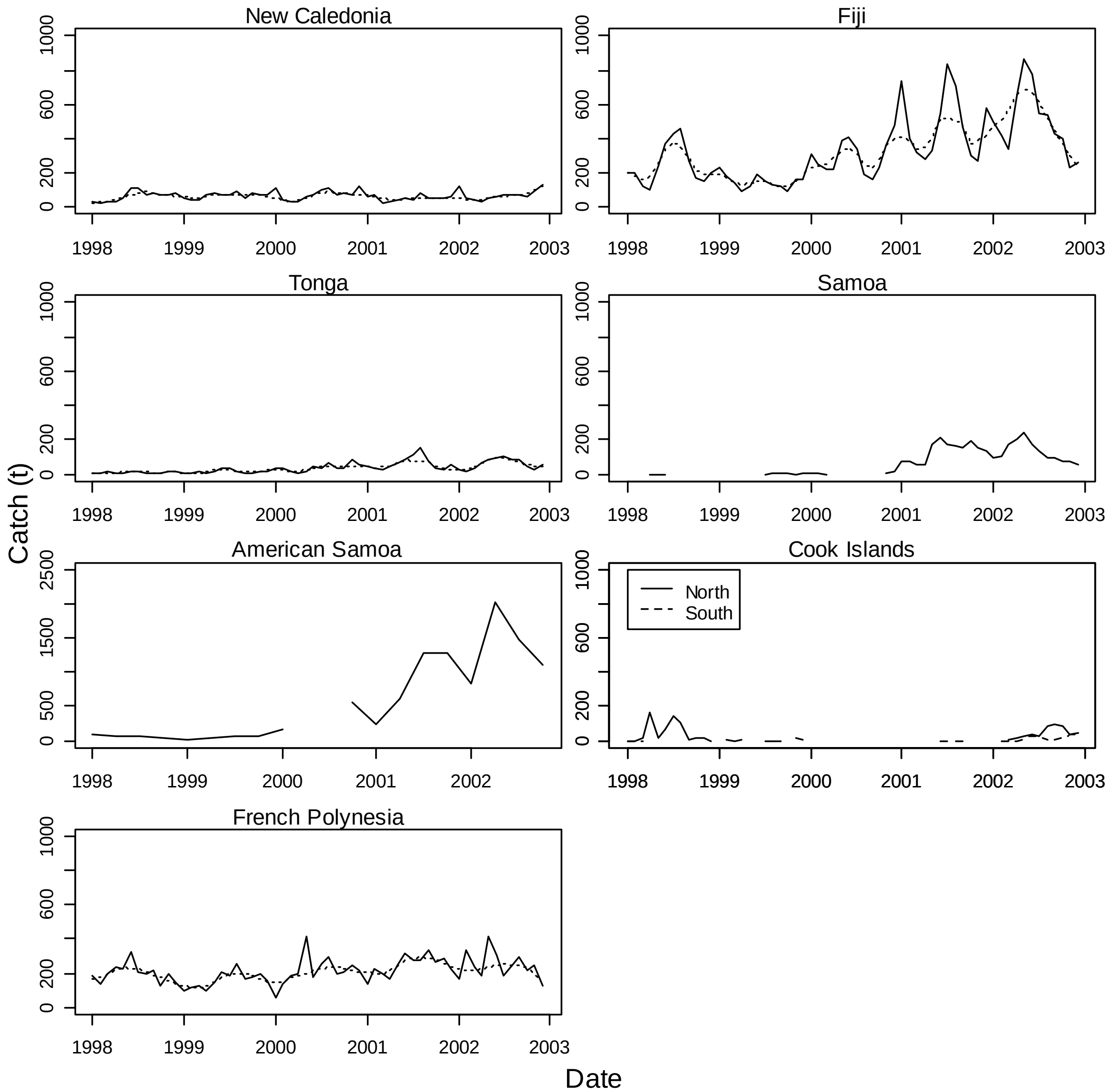


Figure 1: Reported seasonal catch of albacore (tonnes) by EEZ area from 1998 to 2002 (principally from SPC logsheet data). American Samoa data are presented by quarter; all other areas are presented by month. Catch data from mid 2000 were absent for American Samoa. The range of the y-axis for American Samoa differs from the other areas. Data from Cook Islands were stratified by northern (north of 15°S) and southern areas of the EEZ. A lowess smoothing function was applied to the data from some areas (dashed line).

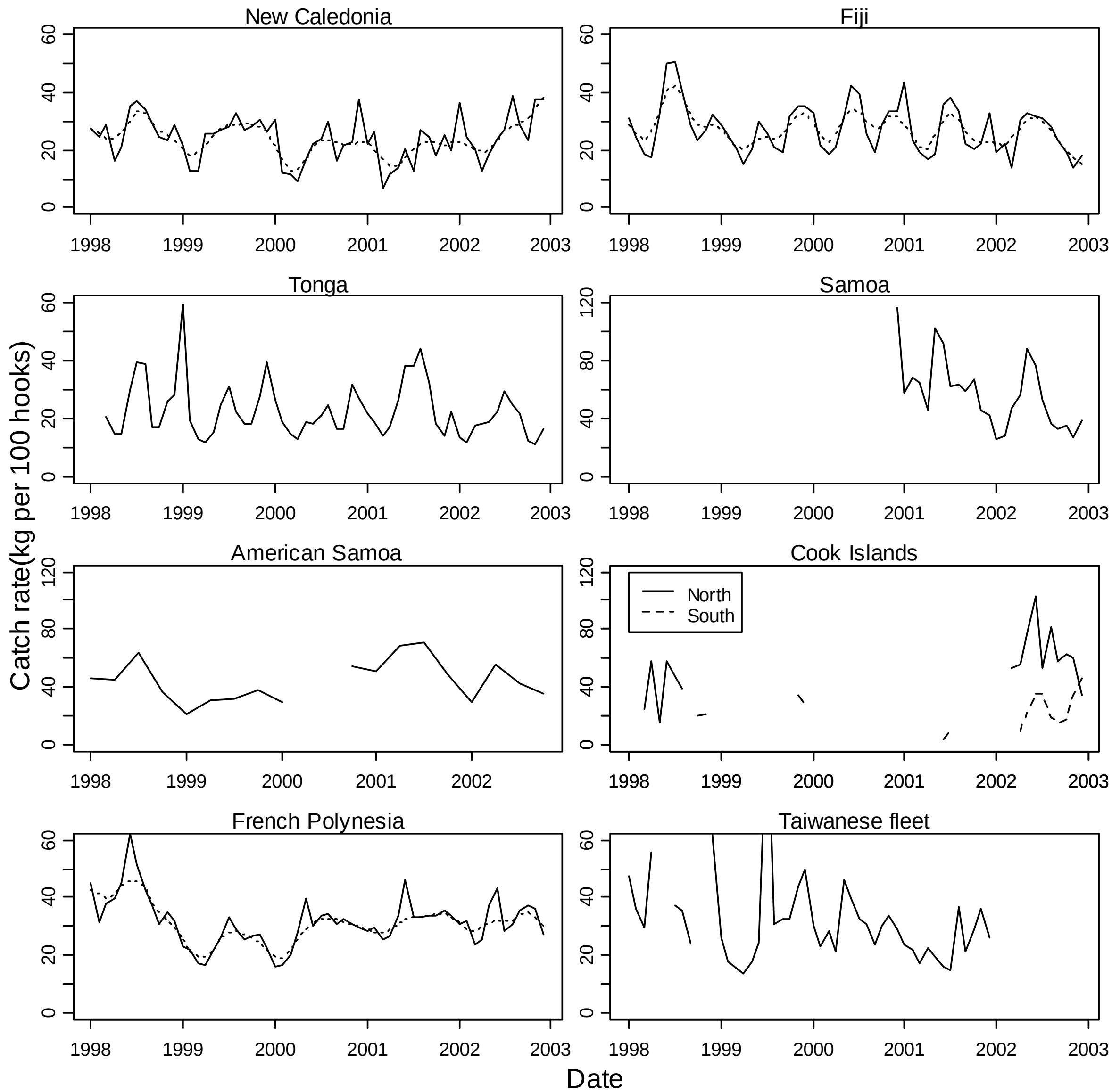


Figure 2: Seasonal catch rates of albacore (kg per 100 hooks) by EEZ area from 1998 to 2002. American Samoa data are presented by quarter; all other areas are presented by month. The catch rate for the Taiwanese fleet from the 10–25°S latitudinal zone is also plotted for comparison. Only months with at least 10,000 hooks set are plotted. Catch data from mid 2000 were absent for American Samoa. The range of the y-axis for Samoa, American Samoa, and Cook Islands is twice the other areas. Data from Cook Islands were stratified by northern (north of 15°S) and southern areas of the EEZ. A lowess smoothing function was applied to the data from some areas (dashed line).

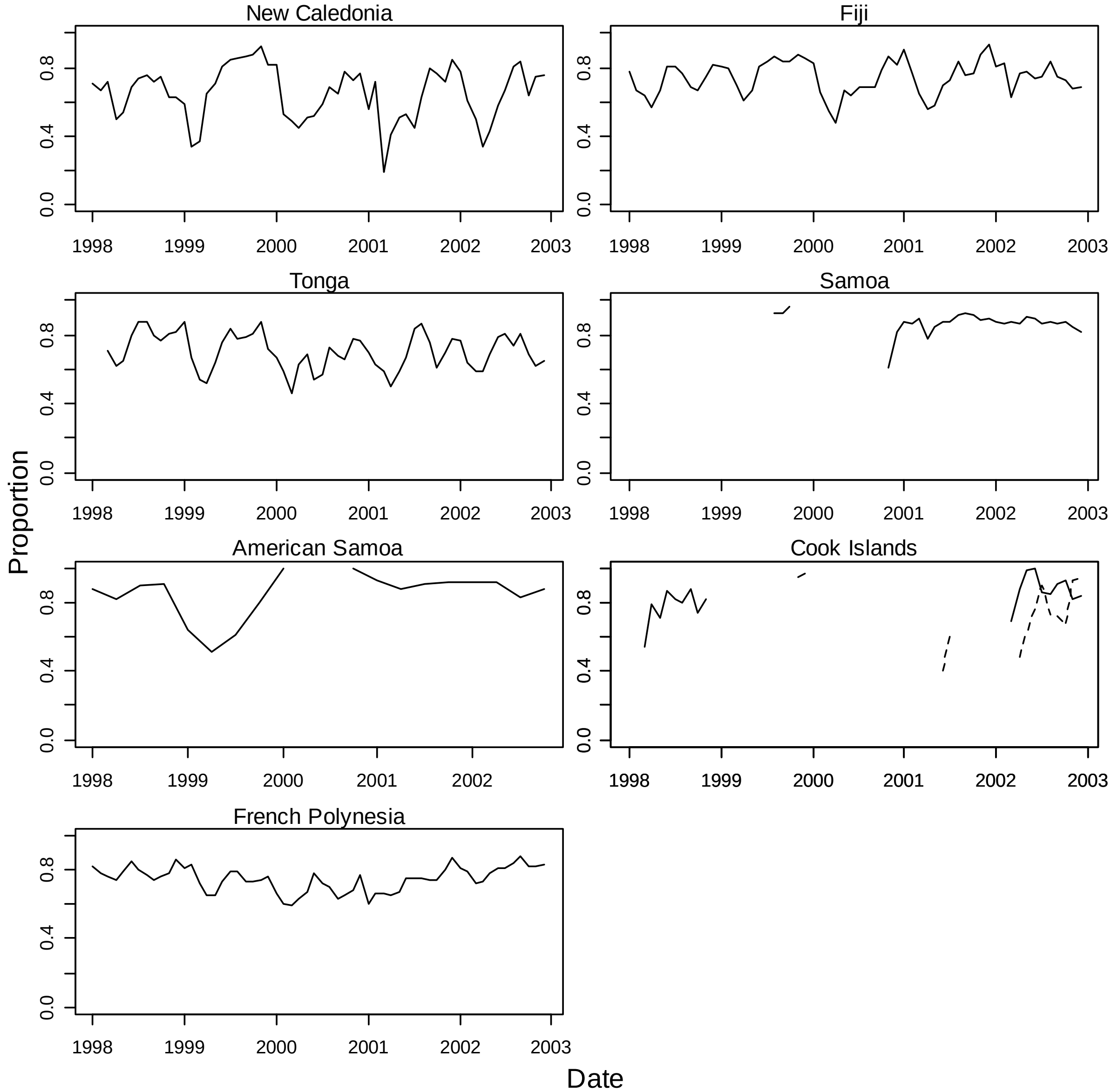


Figure 3: Proportion of albacore (by weight) in the combined longline catch of albacore, yellowfin, and bigeye by EEZ area from 1998 to 2002. American Samoa data are presented by quarter; all other areas are presented by month. Catch data from mid 2000 were absent for American Samoa. Data from Cook Islands were stratified by northern (north of 15°S) and southern areas of the EEZ.

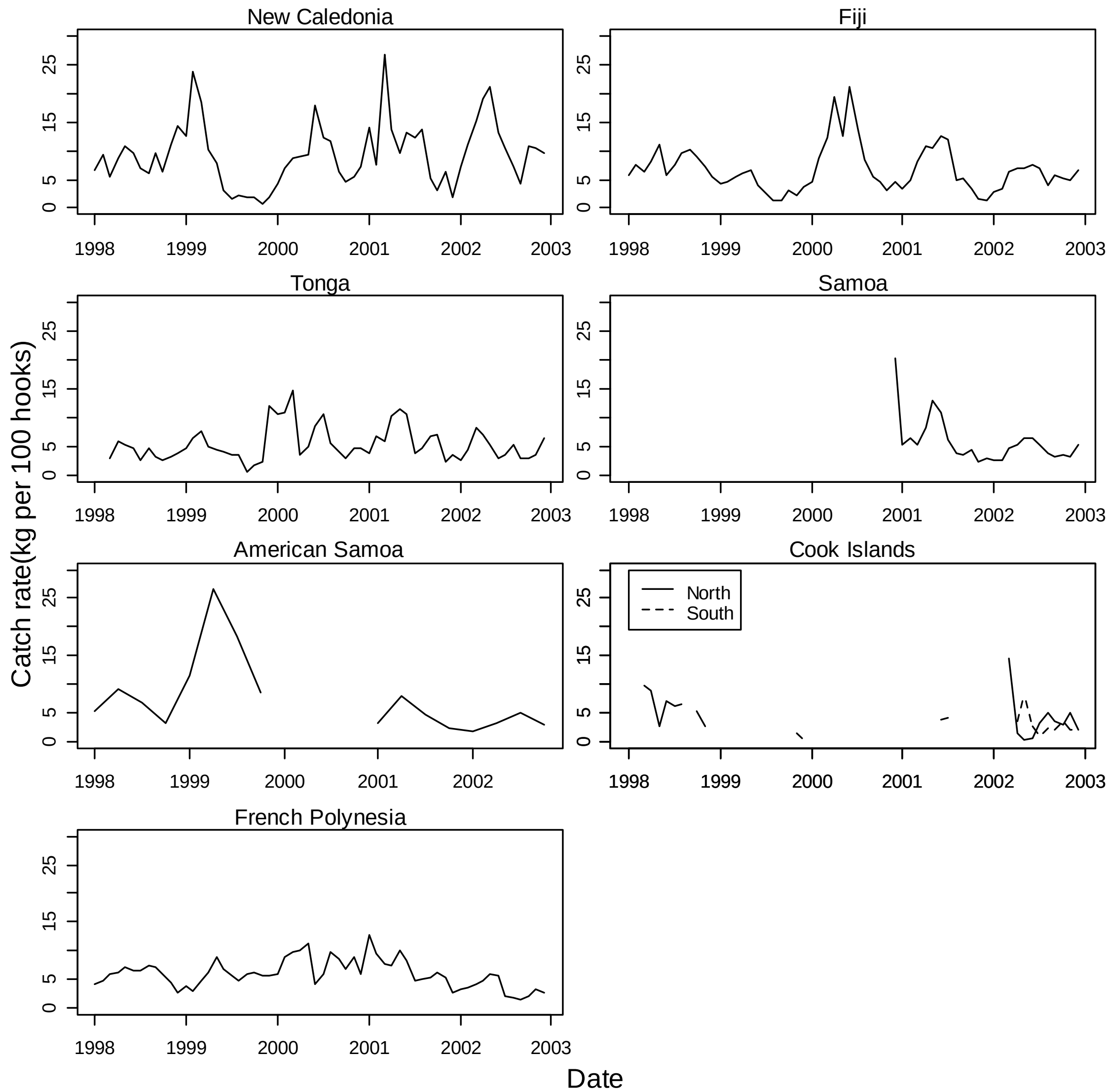


Figure 4: Seasonal catch rates of yellowfin (kg per 100 hooks) by EEZ area from 1998 to 2002. American Samoa data are presented by quarter; all other areas are presented by month. Only months with at least 10,000 hooks set are plotted. Catch data from mid 2000 were absent for American Samoa. Data from Cook Islands were stratified by northern (north of 15°S) and southern areas of the EEZ.

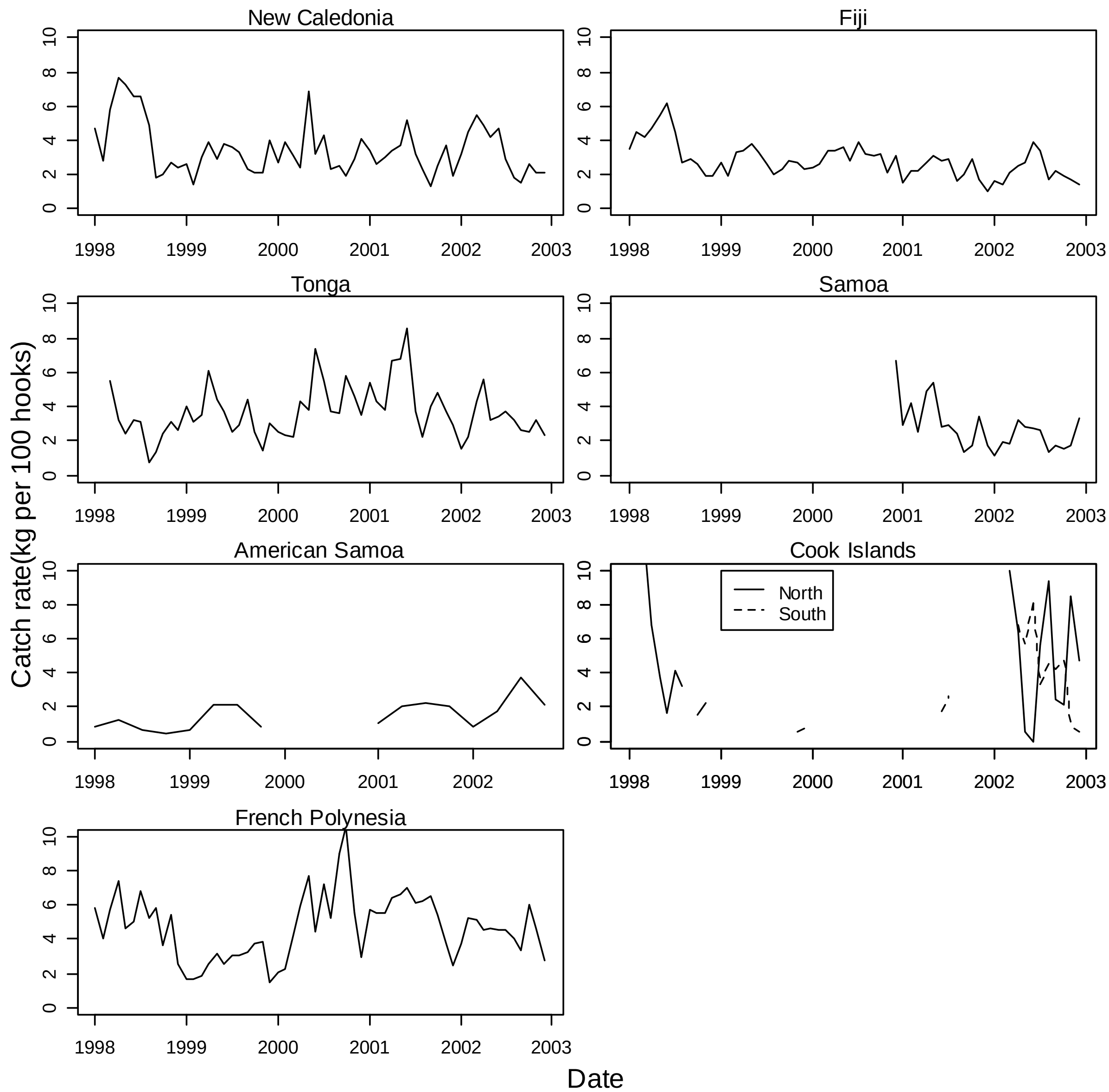


Figure 5: Seasonal catch rates of bigeye (kg per 100 hooks) by EEZ area from 1998 to 2002. American Samoa data are presented by quarter; all other areas are presented by month. Only months with at least 10,000 hooks set are plotted. Catch data from mid 2000 were absent for American Samoa. Data from Cook Islands were stratified by northern (north of 15°S) and southern areas of the EEZ.

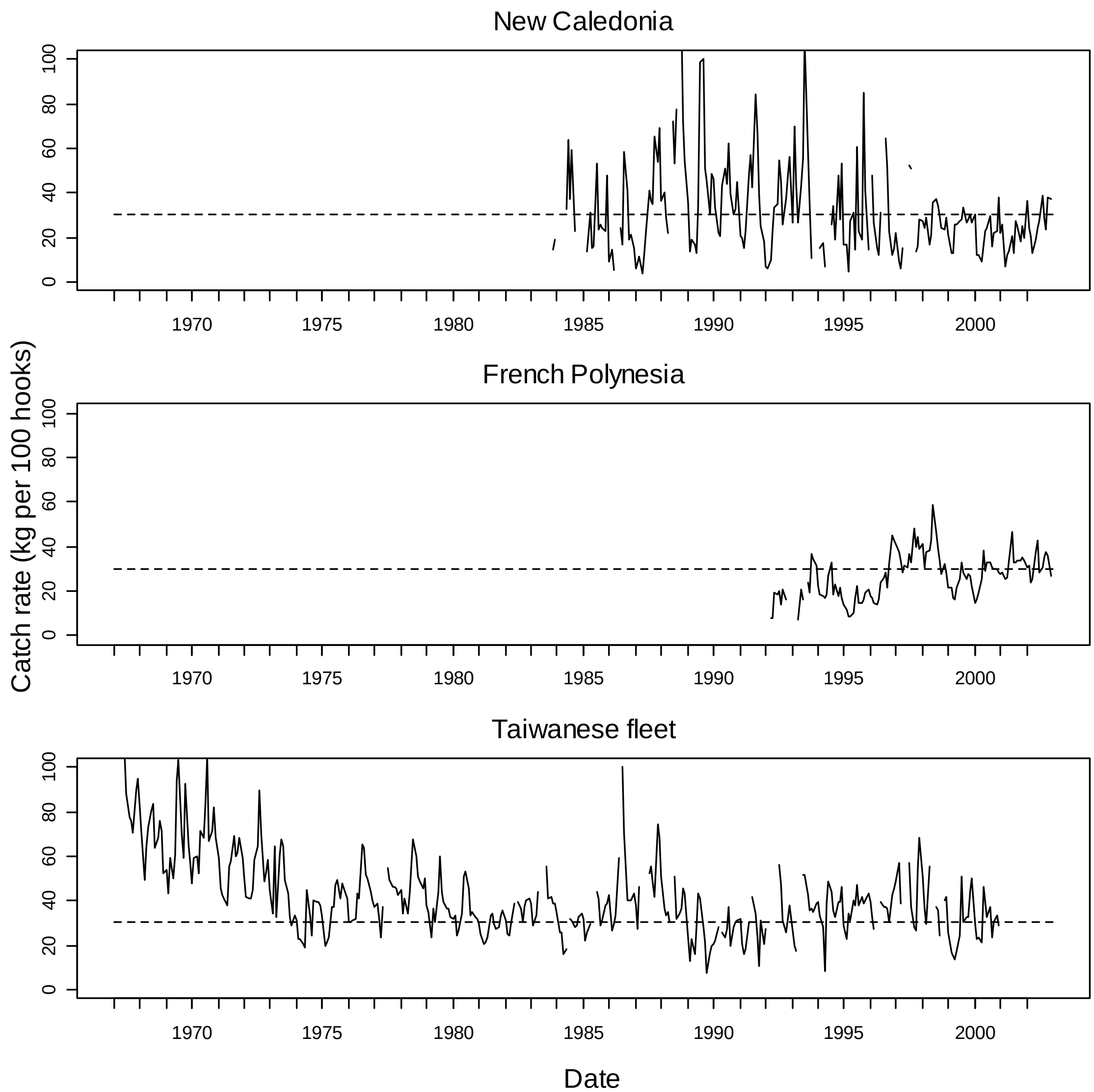


Figure 6: Monthly trends in the catch rate of albacore (kg per 100 hooks) from New Caledonia, French Polynesia, and the Taiwanese distant water fleet (Source: data held by SPC). The Taiwanese fleet is restricted to data from the 10–25°S latitudinal zone. For visual reference, a line representing 30 kg per 100 hooks is plotted.

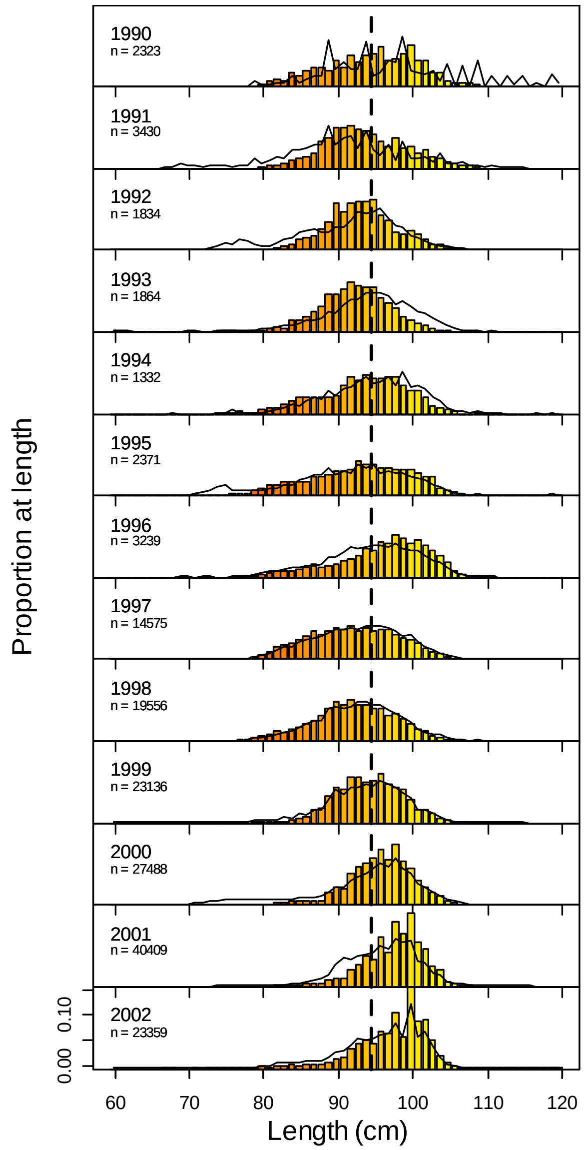


Figure 7: Bar plots of the annual length composition of albacore catch sampled from New Caledonia from 1990 to 2002. N represents the number of fish measured. For comparison, the combined length composition of albacore sampled from the south-western Pacific in the 10–25°S latitudinal range is also plotted (line). For visual reference, a vertical line is plotted at length 95 cm.

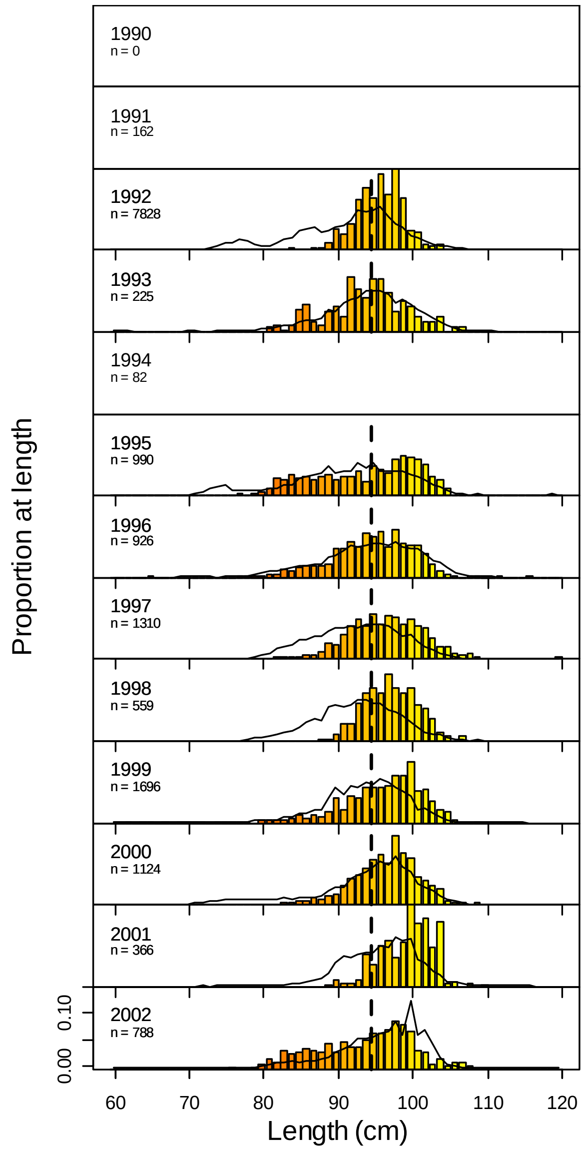


Figure 8: Bar plots of the annual length composition of albacore catch sampled from Fiji from 1990 to 2002. N represents the number of fish measured. For comparison, the combined length composition of albacore sampled from the south-western Pacific in the 10–25°S latitudinal range is also plotted (line). For visual reference, a vertical line is plotted at length 95 cm.

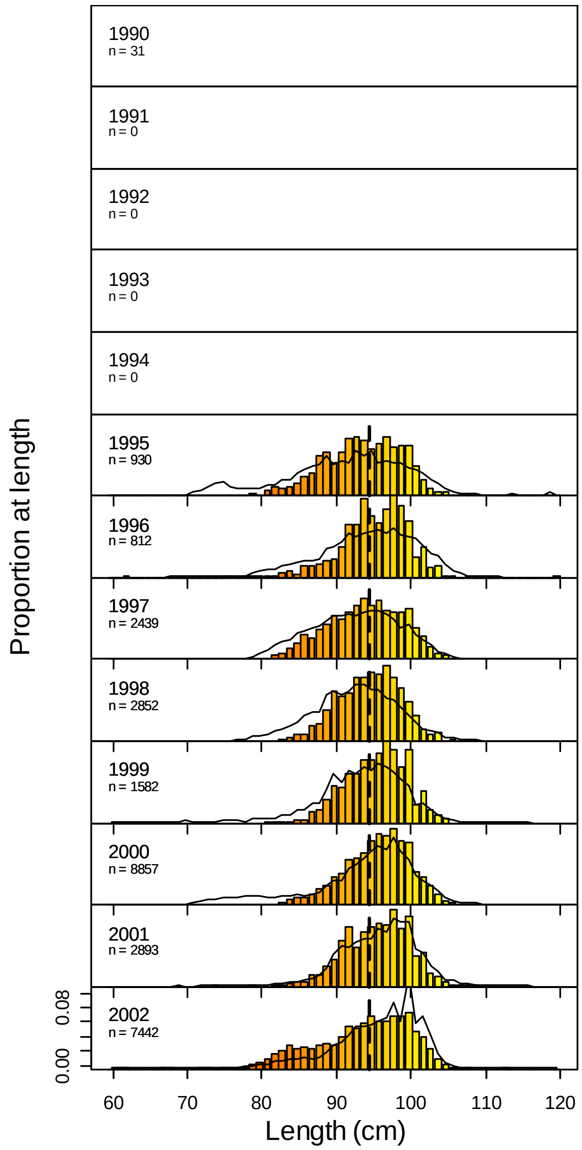


Figure 9: Bar plots of the annual length composition of albacore catch sampled from Tonga from 1990 to 2002. N represents the number of fish measured. For comparison, the combined length composition of albacore sampled from the south-western Pacific in the 10–25°S latitudinal range is also plotted (line). For visual reference, a vertical line is plotted at length 95 cm.

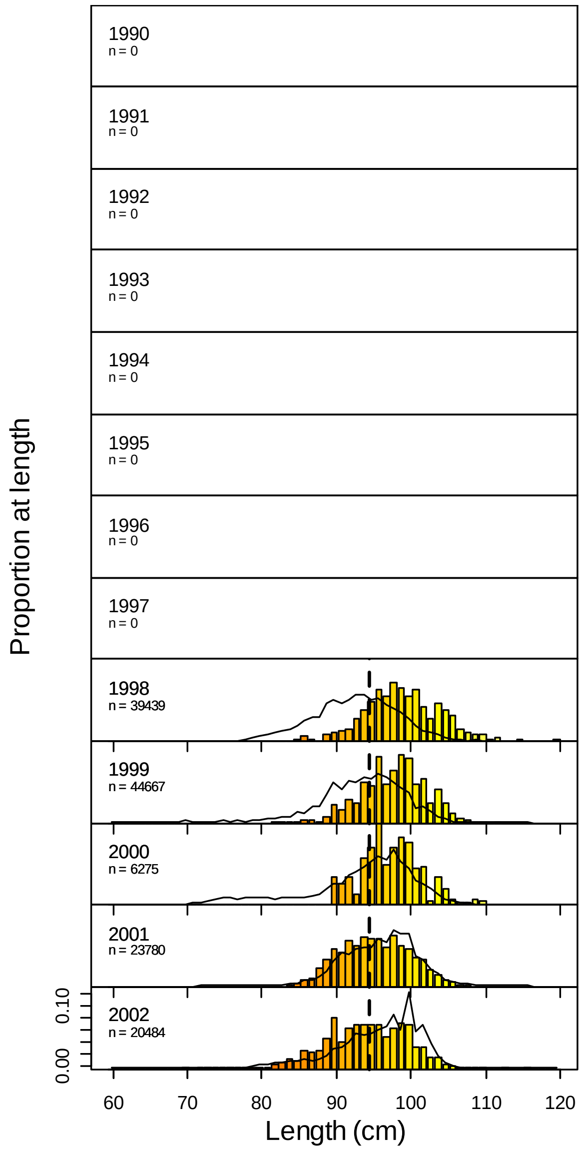


Figure 10: Bar plots of the annual length composition of albacore catch sampled from Samoa from 1990 to 2002. N represents the number of fish measured. For comparison, the combined length composition of albacore sampled from the south-western Pacific in the 10–25°S latitudinal range is also plotted (line). For visual reference, a vertical line is plotted at length 95 cm.

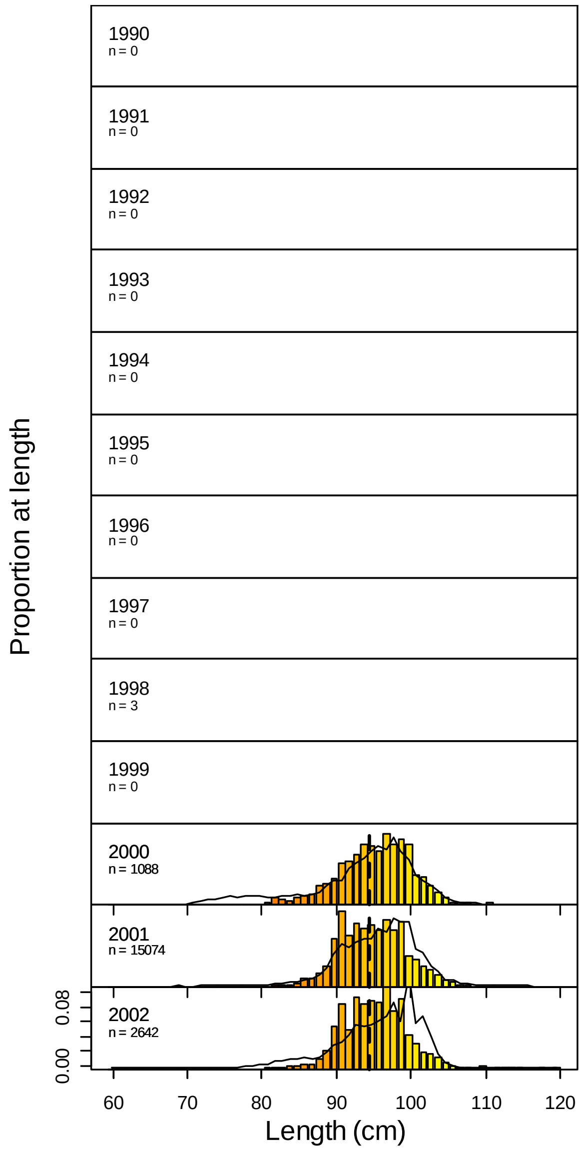


Figure 11: Bar plots of the annual length composition of albacore catch sampled from American Samoa from 1990 to 2002. N represents the number of fish measured. For comparison, the combined length composition of albacore sampled from the south-western Pacific in the 10–25°S latitudinal range is also plotted (line). For visual reference, a vertical line is plotted at length 95 cm.

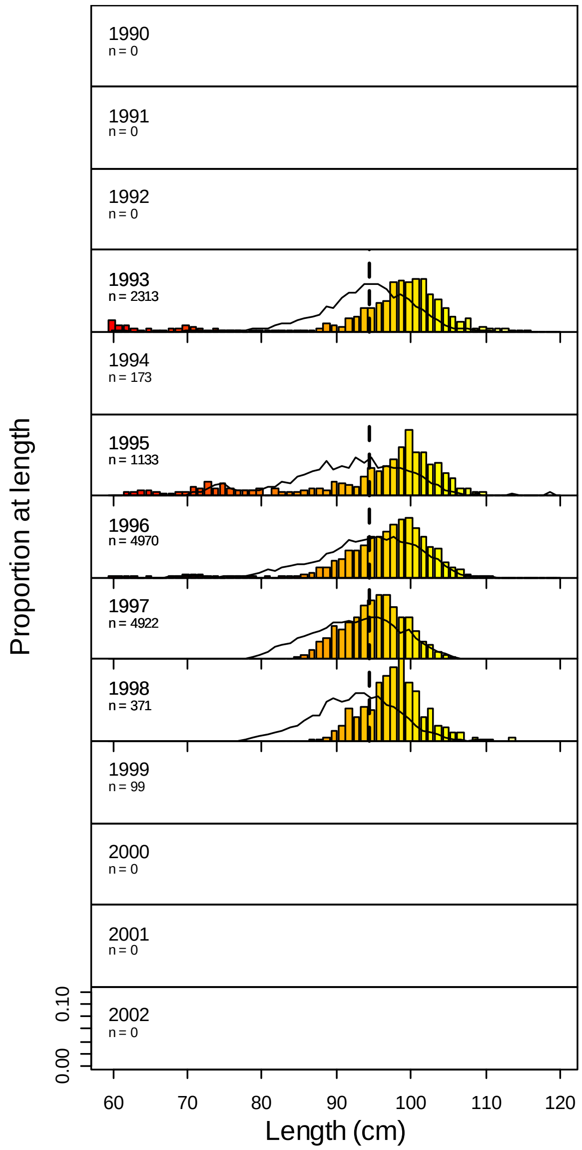


Figure 12: Bar plots of the annual length composition of albacore catch sampled from French Polynesia from 1990 to 2002. N represents the number of fish measured. For comparison, the combined length composition of albacore sampled from the south-western Pacific in the 10–25°S latitudinal range is also plotted (line). For visual reference, a vertical line is plotted at length 95 cm.

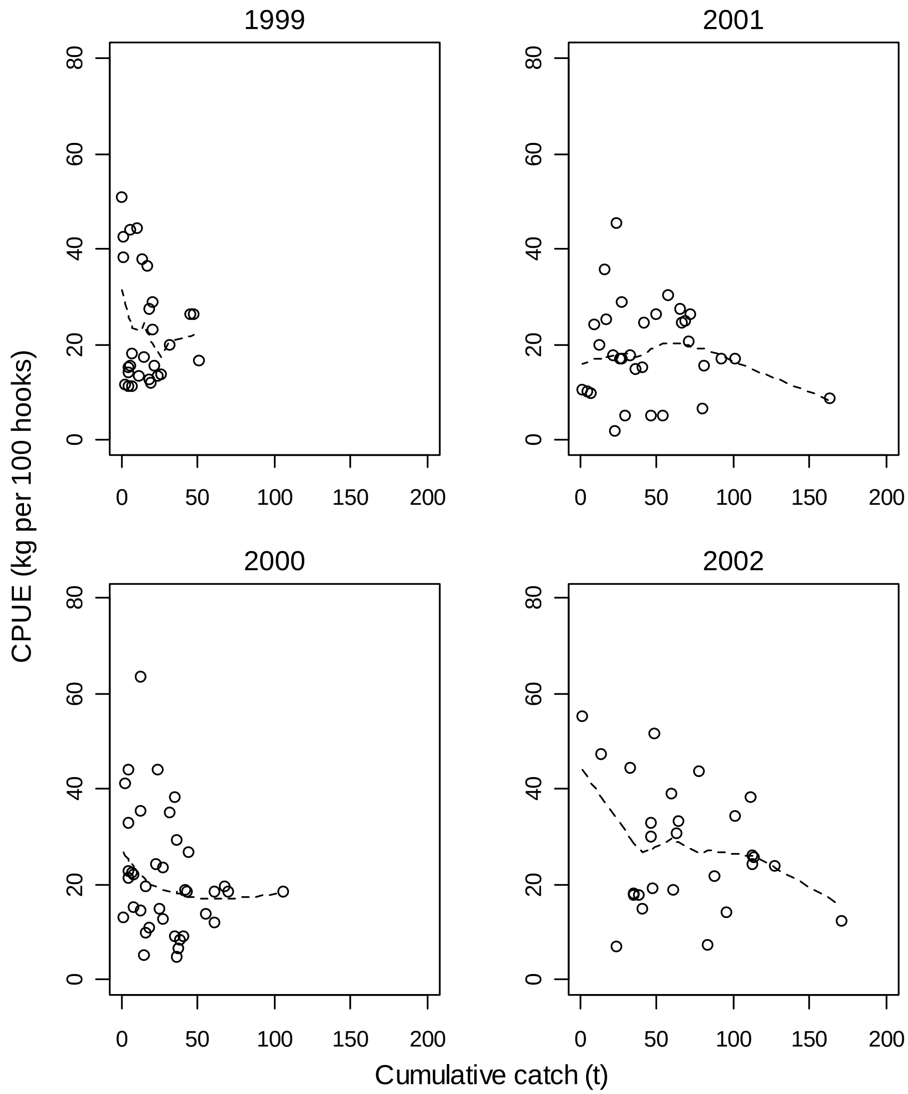


Figure 13: Comparison of the annual catch rate of albacore (kg per 100 hooks) with the cumulative catch of albacore (from all previous years) by degree of latitude and longitude for the New Caledonia fishery from 1998 to 2002.

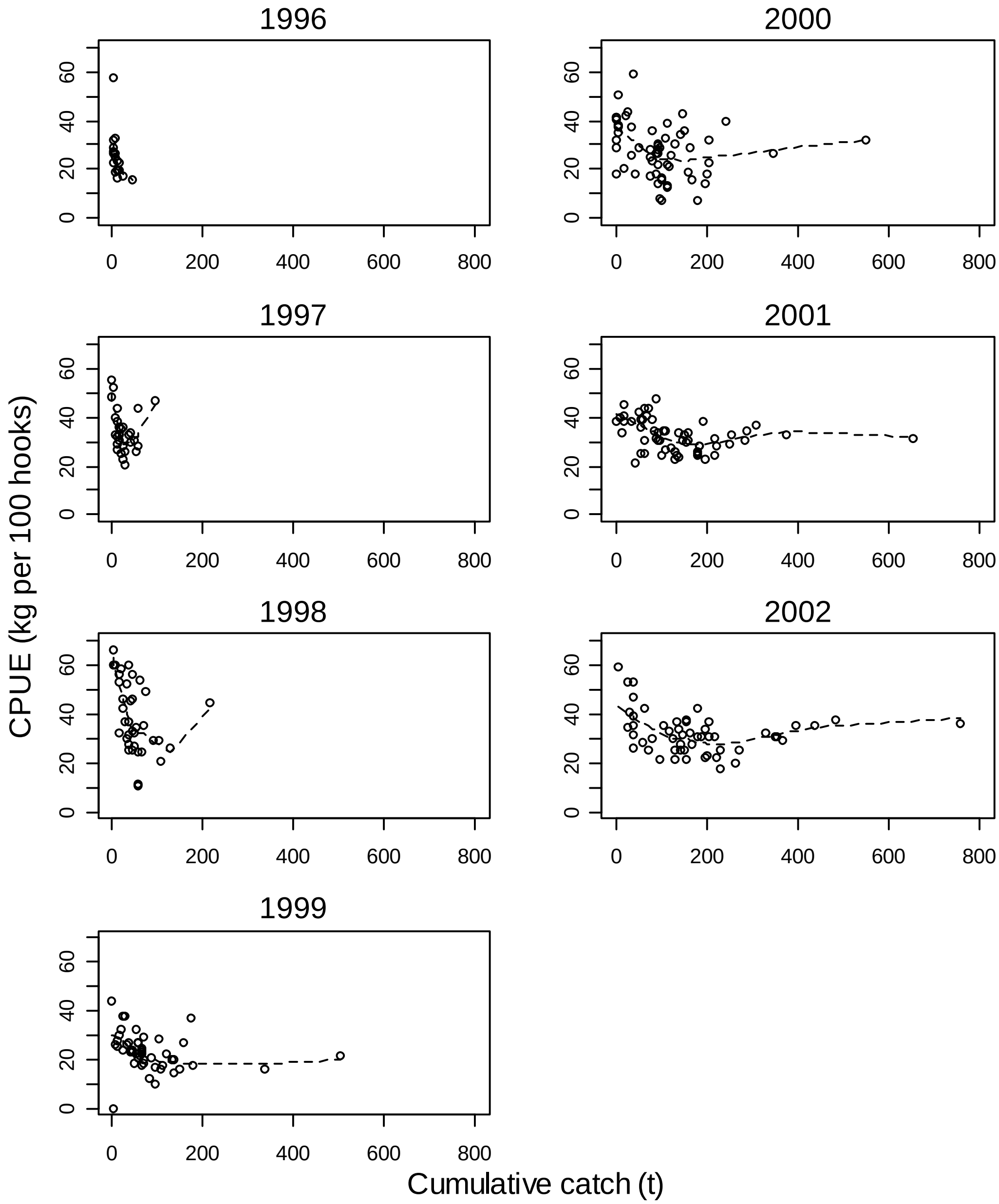


Figure 14: Comparison of the annual catch rate of albacore (kg per 100 hooks) with the cumulative catch of albacore (from all previous years) by degree of latitude and longitude for the French Polynesia fishery.

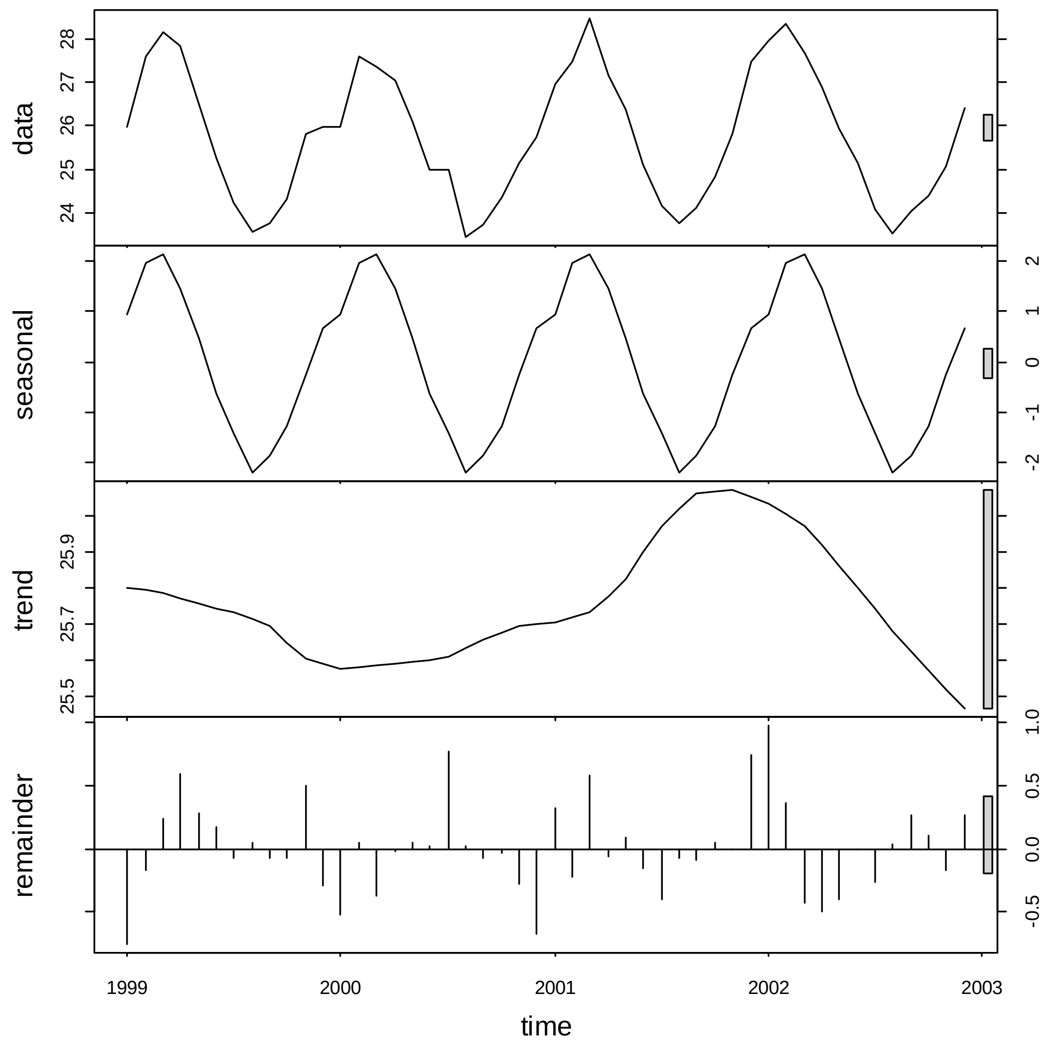


Figure 15: Time-series analysis of SST data from an area approximating the New Caledonia EEZ. Source: www.noaa.gov.

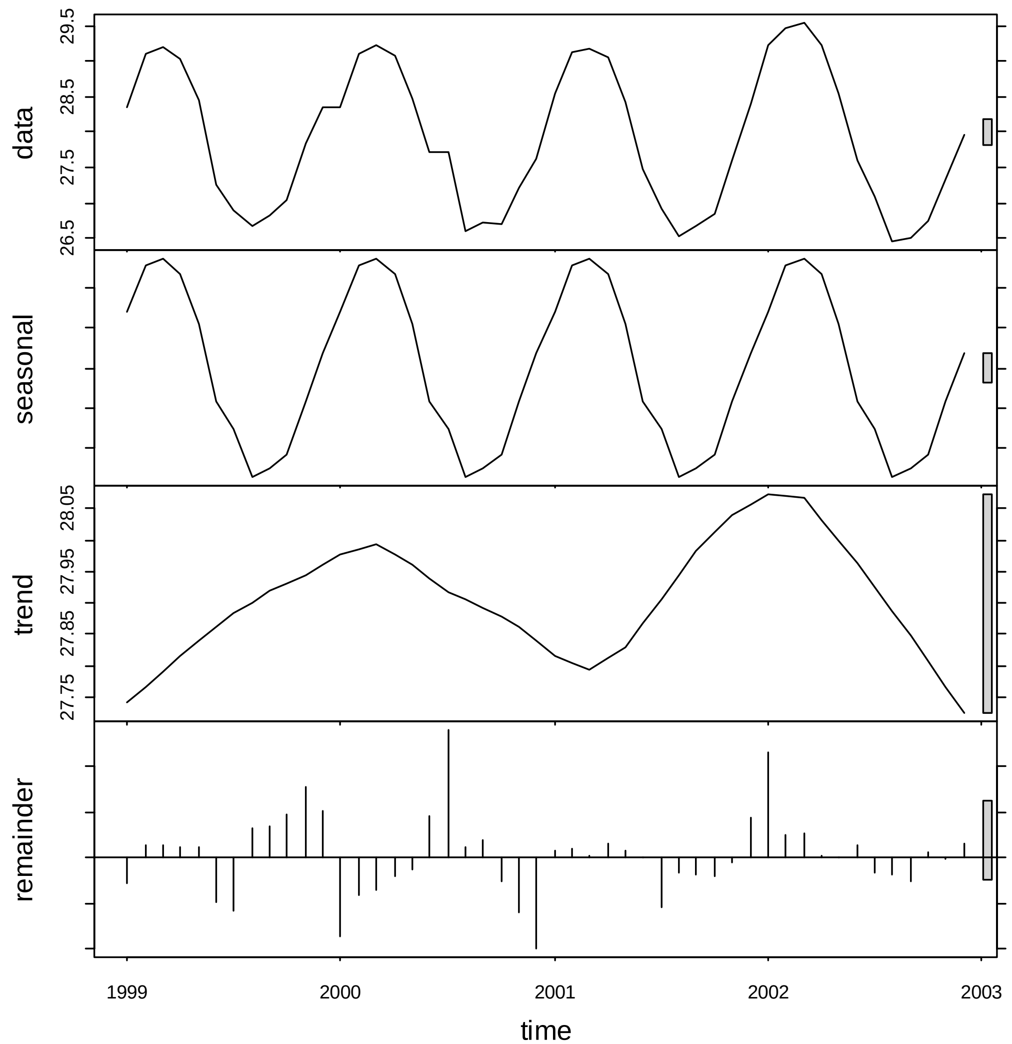


Figure 16: Time-series analysis of SST data from an area approximating the Fiji EEZ. Source: www.noaa.gov.

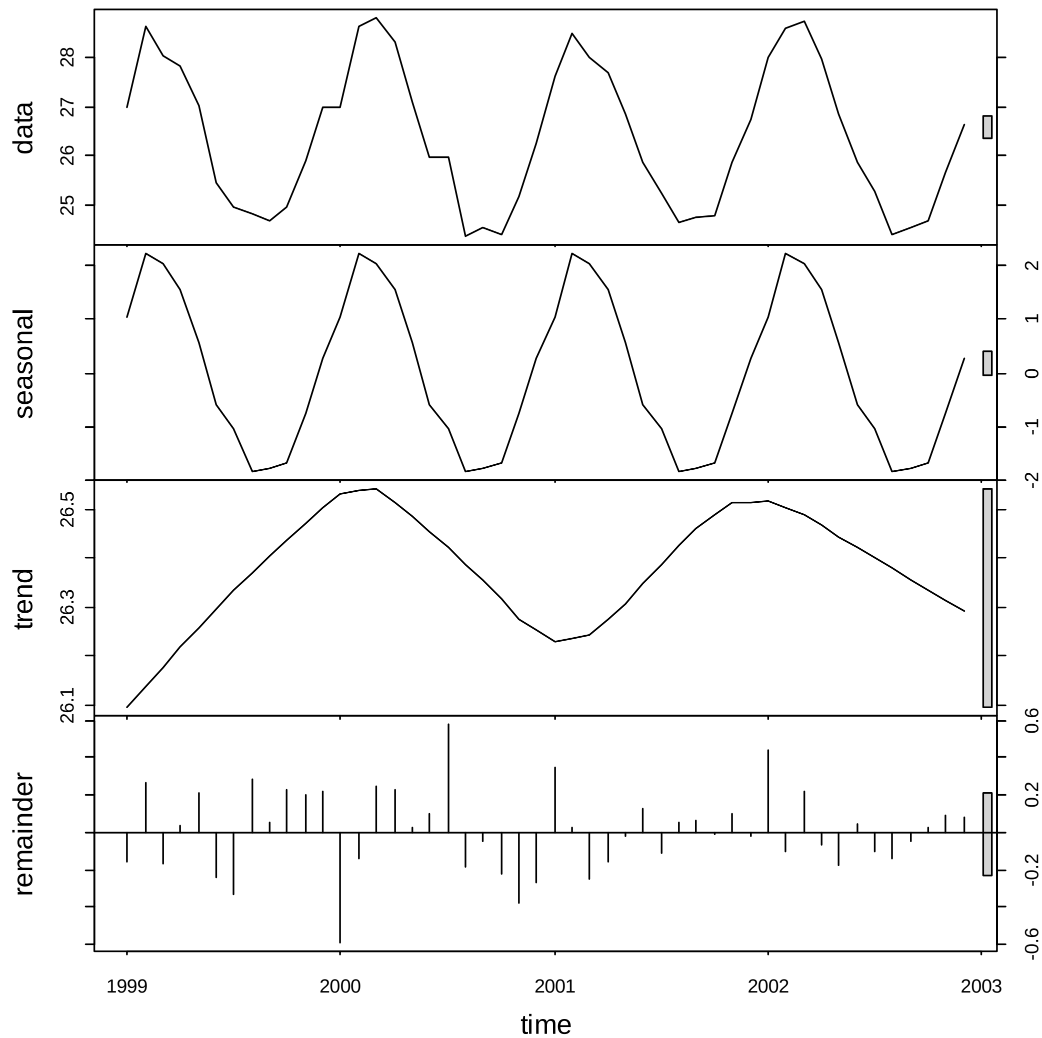


Figure 17: Time-series analysis of SST data from an area approximating the Tonga EEZ. Source: www.noaa.gov.

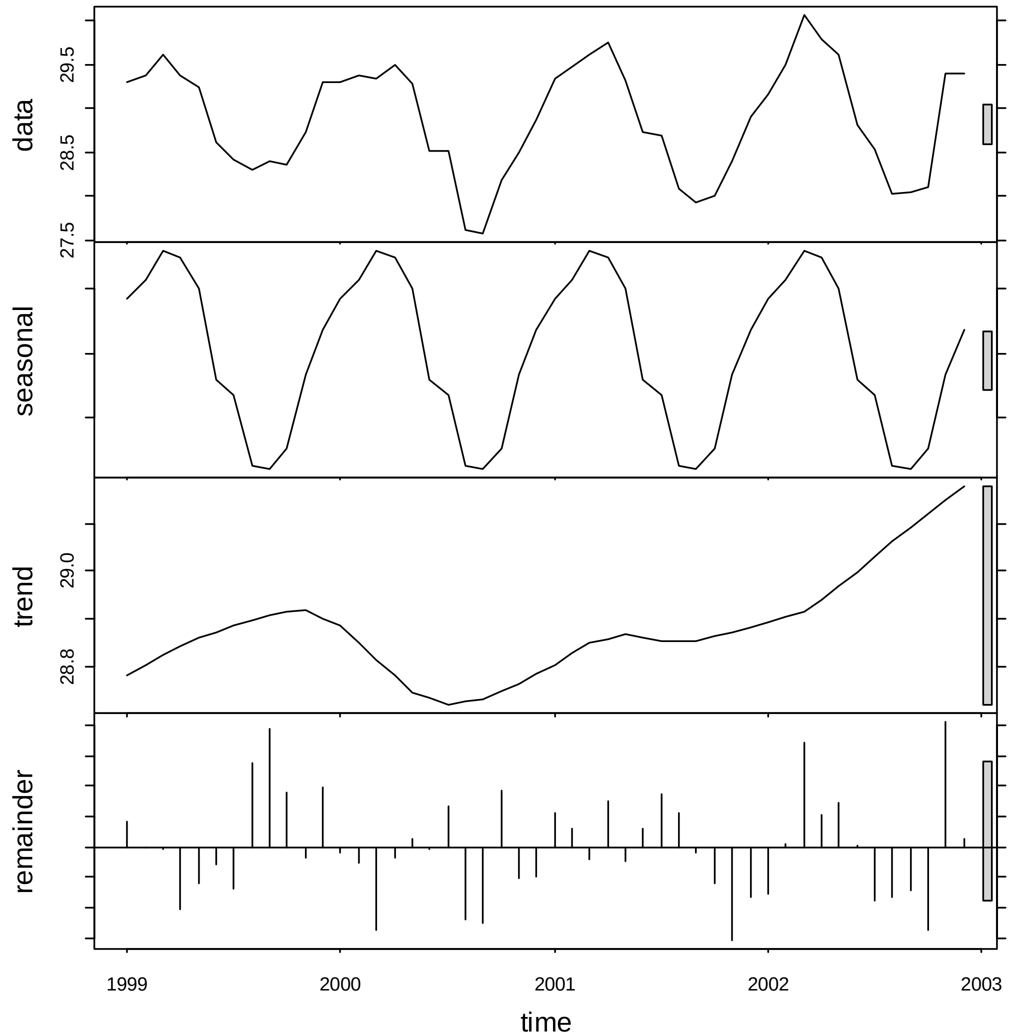


Figure 18: Time-series analysis of SST data from an area approximating the Samoa EEZ. Source: www.noaa.gov.

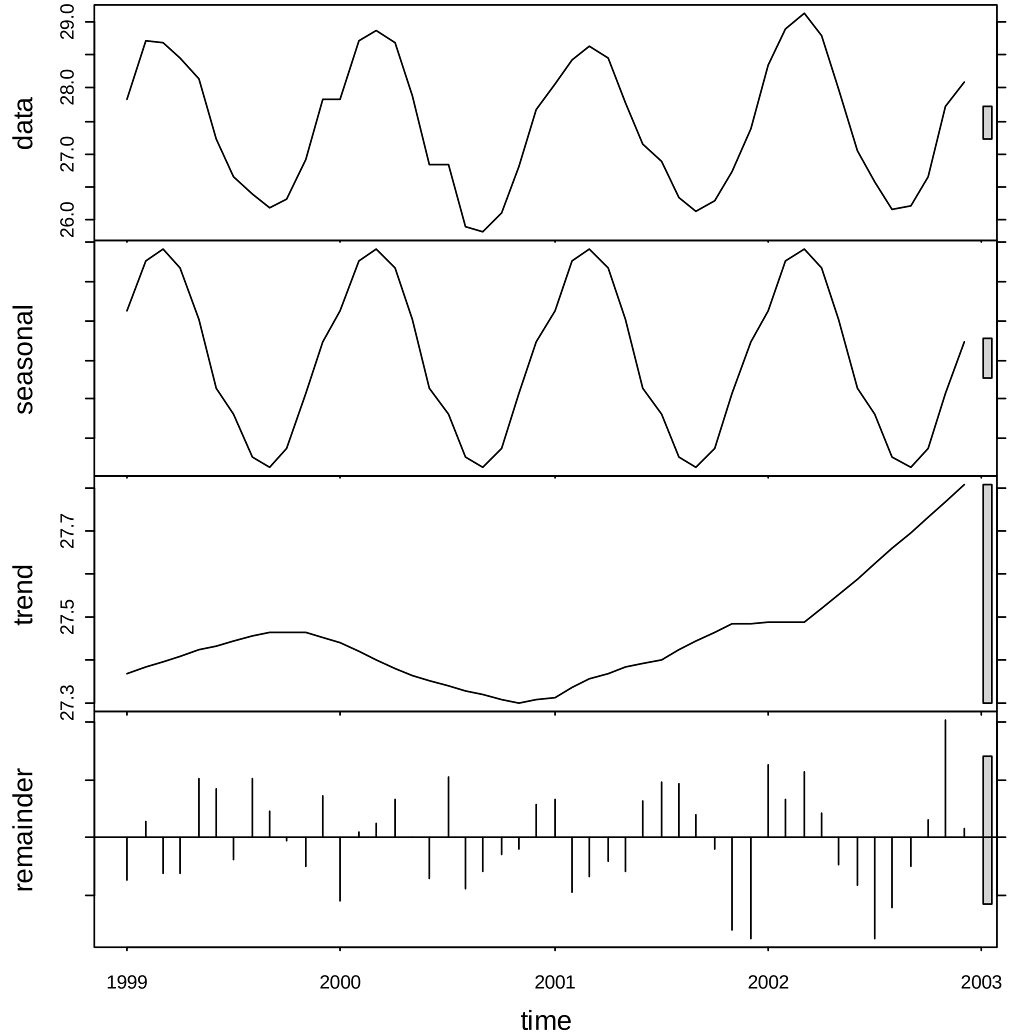


Figure 19: Time-series analysis of SST data from an area approximating the Cook Islands EEZ. Source: www.noaa.gov**.**

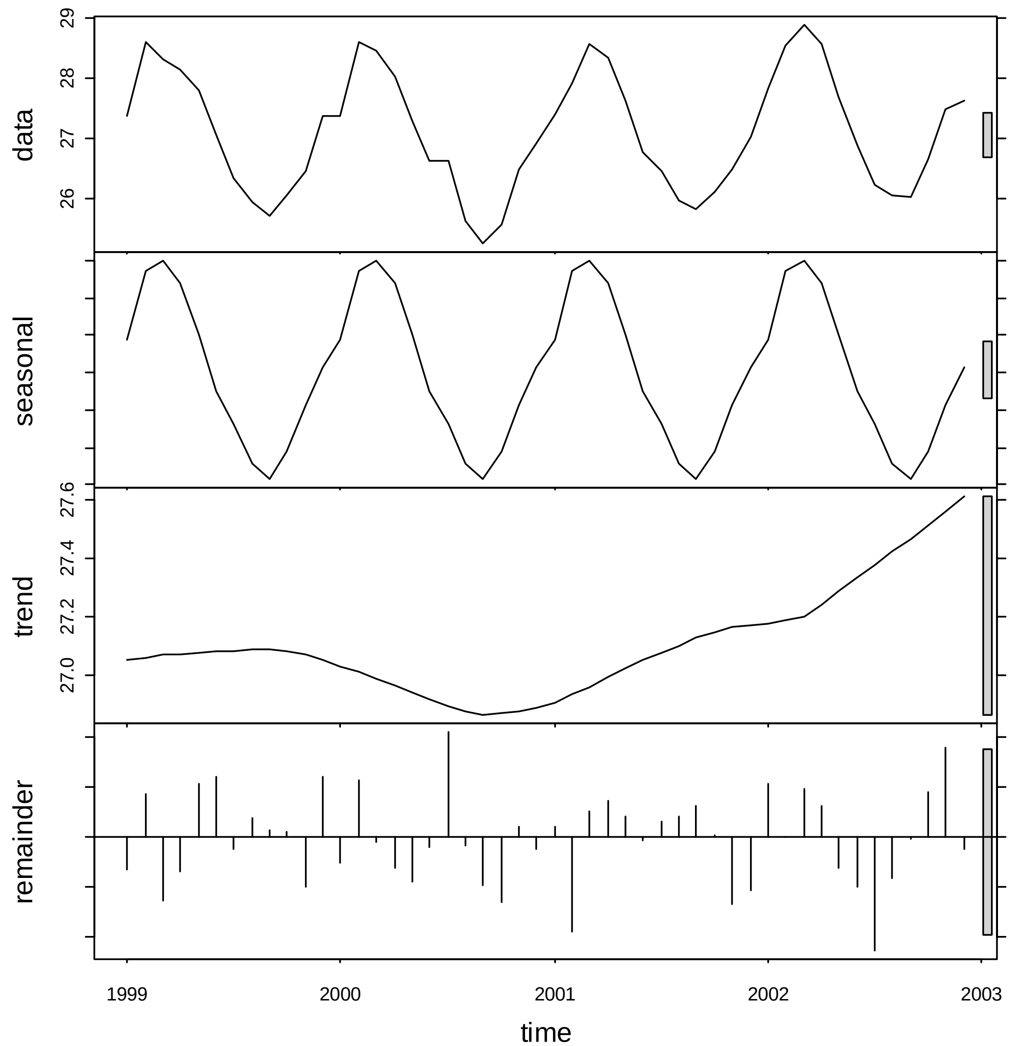


Figure 20: Time-series analysis of SST data from an area approximating the French Polynesia EEZ. Source: www.noaa.gov**.**