ISNR: Effect of environment and fishing on Albacore CPUE levels in the northern area of the Cook Islands EEZ

At a regional level, the 2011 stock assessment indicates that south Pacific albacore tuna (*Thunnus alalunga*) is not overfished and overfishing is not occurring. In the Cook Islands EEZ, albacore represents over 80% of the total longline tuna catch indicated in logbook returns, while recorded catches have increased rapidly since 2001 (Figure 1). Analyses for the Cook Island EEZ has been divided into northern and southern areas, as the catch rate of albacore shows considerable local patterns, both across the EEZ and within these areas (Figure 2). This report covers the analysis for the northern area (above 15°S).

The aims of this Issue-Specific National Report (ISNR) were to:

- identify variables affecting albacore catch rates within EEZs;
- identify the specific influence of factors that can be controlled by fisheries managers, and variables that are outside their control but can be monitored;
- examine the potential implications for future albacore fishery CPUE levels.

Previous work has identified a number of factors that affect PICT fishery albacore CPUE:

- vessel effects: the differing ability of vessels to catch albacore. These effects can be managed;
- regional albacore abundance: this effect can be managed at the regional scale, e.g. through WCPFC CMMs, and monitored through stock assessments;
- oceanographic effects: affecting the availability of albacore to the fishing gear. These influences cannot be directly managed, but some can be monitored.

In addition, on a shorter time scale:

- local depletion effects: the potential short-term impact of fishing on the albacore population at a local level. These effects can be controlled through, e.g. through local licensing limits or spatial management measures.

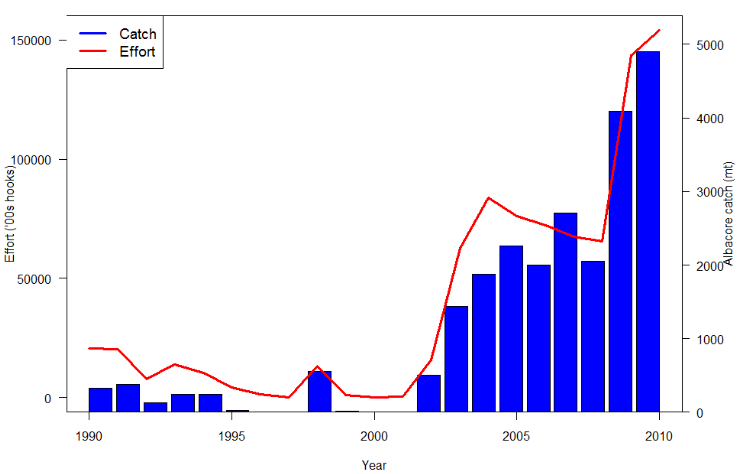

Figure 1. Cook Islands EEZ total fishing effort ('00s hooks) and albacore catch (mt) by year since 1990, from logbook data.

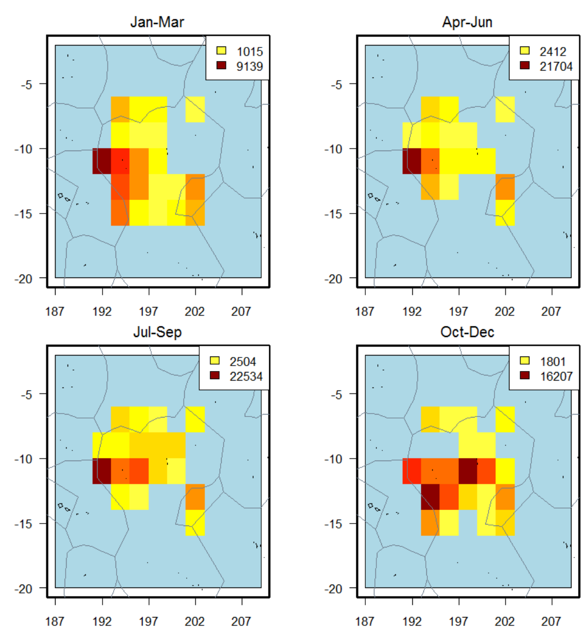

Figure 2. Chart of overall fishing intensity within the northern Cook Islands EEZ area, by quarter of the year (measured in total ‘00s hooks recorded between 1998 and 2009). Darker squares indicate highest number of records in each quarter (see legend for level).

METHODOLOGY

The effect of a range of factors on albacore CPUE levels was analysed using generalised linear models (GLMs). Longline logbook catch and effort data available from SPC member countries (including DWFNs fishing in those waters) were collated at a 2° square geographic resolution (Figure 2). Each vessel-specific record was linked to:

- the corresponding relative albacore regional biomass estimate (see table below); and,
- corresponding oceanographic variables from the GODAS (NCEP Global Ocean Data Assimilation System) database for that 2° square.

Analyses focused on the period 1998 – 2008, due to limitations in the environmental data time series and logbook returns prior to this period. The oceanographic variables selected for modeling were known to influence albacore CPUE in general, and had minimal interaction with each other. These variables are described in the table below. All averages were calculated at the temporal scale of year and month, and unless otherwise stated, by 2° square.

Variable	Code	Description
Vessel	vessel	Each vessel (name) operating in the fishery
Regional albacore biomass	regB_alb	The relative regional biomass of albacore, based on MULTIFAN-CL assessment sub-areas, from the standardised catch rate of the Korean fleet
Average sea surface temperature (SST)	sstavg	The average SST (°C)
Depth of 20°C isotherm	depth20C	The average depth (m) of the 20°C water layer
Average temperature at 155m depth	temp155avg	The average temperature at 155m depth
Average ocean colour	colavg	The average ocean chlorophyll-a level (in mg/m^3), a measure related to ocean productivity
Range of altimetry	altrange	The range in height of the sea surface relative to a standard sea surface height
Average salinity deviation	salavg	The average annual deviation of surface salinity from 35ppt
Current	current	The average overall current velocity
Easterly component of the current direction	currente	The average overall east/west current velocity. +ive values = easterly flow, -ive values = westerly flow
Southerly component of the current direction	currents	The average overall north/south current velocity. +ive values = northerly flow, -ive values = southerly flow
Southern Oscillation Index	SOI	Regional value, calculated from fluctuations in the air pressure difference between Tahiti and Darwin. +ive values = La Niña conditions, -ive values = El Niño conditions

The modeling approach then compared the outputs of alternative models that incorporated vessel, regional biomass, and:

- all oceanographic variables ("Oceanographic model");
- specific oceanographic variables (SST, depth 20°C) that can easily be monitored or purchased commercially ("Strategic model"); or
- the Southern Oscillation Index ("SOI model").

For each, two model types were implemented. The first examined the likelihood of achieving a catch (thereby taking into account that not all sets are successful, identified as 'presence/absence' in the following results). Given that the set had been successful, the second examined the likely level of albacore CPUE achieved ('positive CPUEs'). Model outputs identified the relationships between the factors and albacore fishing success.

These models were implemented for the following PICTs and sub-areas:

New Caledonia, Vanuatu, Fiji, Samoa, American Samoa, Cooks Islands (EEZ separated into north and south areas), and French Polynesia (EEZ separated into northwest and southeast areas).

Results - Influence of different factors on albacore CPUE

For the northern area of the Cook Islands EEZ, almost 66% of the variation in presence or absence of albacore catches can be explained by the 'vessel' factor (see table of model outputs below). The level of albacore regional biomass has a small but significant influence on the likelihood of finding fish on a longline (over the range of regional biomass levels seen in the data), while general oceanography also explains some of the variation.

Where fish are found (positive CPUEs only), the variation in catch rates are again strongly related to the vessel fishing (42%, i.e. some vessels perform better than others). Regional biomass explained over 2% of the variation in CPUE, while over 5% was explained by general oceanography.

Data	Total deviance	% deviance explained by				
		Vessel	Regional biomass	Oceanographic variables	Strategic Variables	SOI
Presence/absence	1444.2	65.9	0.3	2.2	0.5	0.8
Positive CPUEs	3905.9	42.0	2.4	5.4	1.5	0.7

While oceanography explains relatively low levels of the variation in albacore CPUE in the northern Cook Islands EEZ, models indicate that the impact is significant. The full oceanographic model examines the potential influence of nine different variables. 27% of their explanatory power is gained through monitoring sea surface temperature and the depth of the 20°C thermocline alone (i.e. the strategic model), while the Southern Oscillation Index level alone explains only 13% of that variation attributed to all oceanographic variables.

Compared to other EEZs (Figure 3), vessels explain slightly more of the variability in the northern Cook Islands EEZ than found in other EEZs, while oceanographic variables explain slightly less of the variability.

- The vessel fishing is a key influence on catch rates - can be influenced through licensing;
- regional albacore biomass has a significant but low influence on CPUE variability;
- oceanographic influences are significant. Monitorable variables explain small amounts of the variation in CPUE;
- compared to other EEZs, more of the CPUE variability is explained by vessel, and less by other variables.

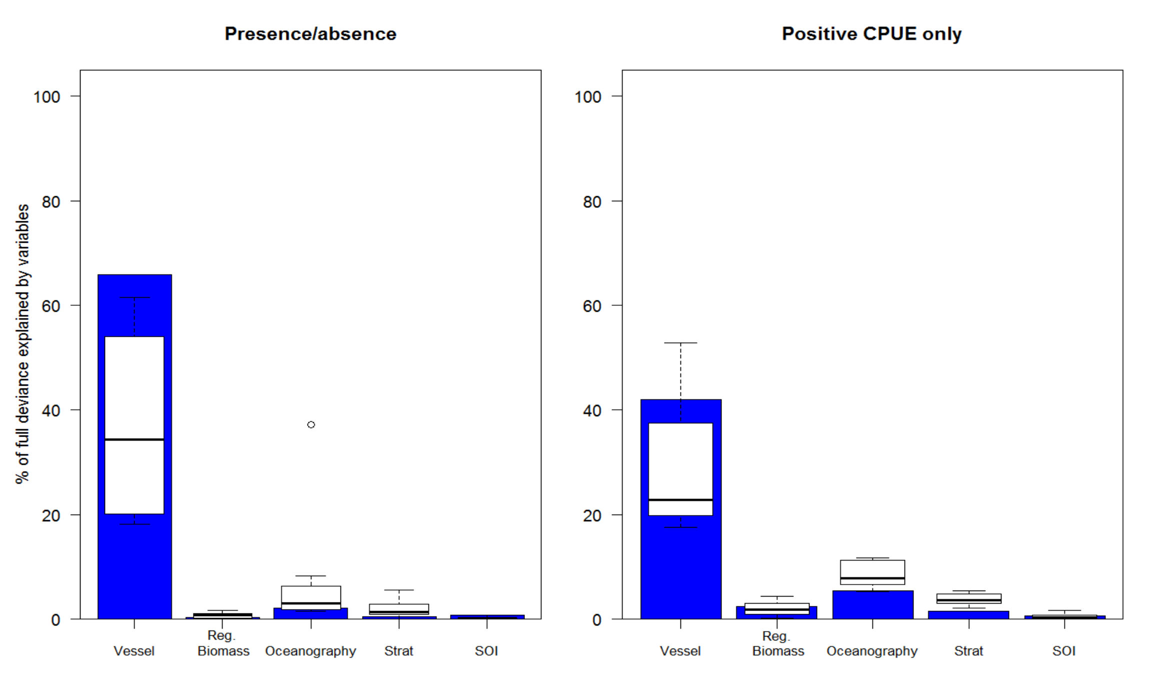

Figure 3. Graphical comparison of the % total model deviance explained by different model components for the northern Cook Islands EEZ (blue bars). Box and whiskers plots show the median and range identified from the models for the other EEZs examined.

Results – Oceanographic and regional biomass effects

The likelihood of a vessel catching albacore was positively influenced by:

- increasing depth of the 20°C thermocline
- increasing regional biomass

and negatively influenced by:

- increasing temperature at 155m depth, above around 25°C
- an increasingly northerly flow in the current

The 'form' of the effect of each significant variable modelled within the GLMs for positive CPUEs is presented in Figure 4. Where albacore was caught, catch rates were positively influenced by:

- increasing regional albacore biomass
- increases in depth of the 20°C thermocline
- increasing altimetry range, up to a value of 0.05
- increasing average salinity deviations above a median level
- a reduced southerly flow in current direction (but a northerly current has a negative effect)
- positive SOI levels (la Niña), although some El Niño conditions have a similar effect.

negatively influenced by:

- increasing sea surface temperature
- increases in the temperature at 155m depth, above about 25°C
- increasing overall current, although there was considerable uncertainty
- an increasing easterly directional component to the current, and a shift to a northerly flow

and a variable influence was found for:

- increasing average ocean colour increased catch rates, up to a value of 0.08. Further increases had a negative impact.

The model indicated that of the variables examined, the southerly current direction, average ocean colour, and SOI had a relatively notable influence on CPUE levels.

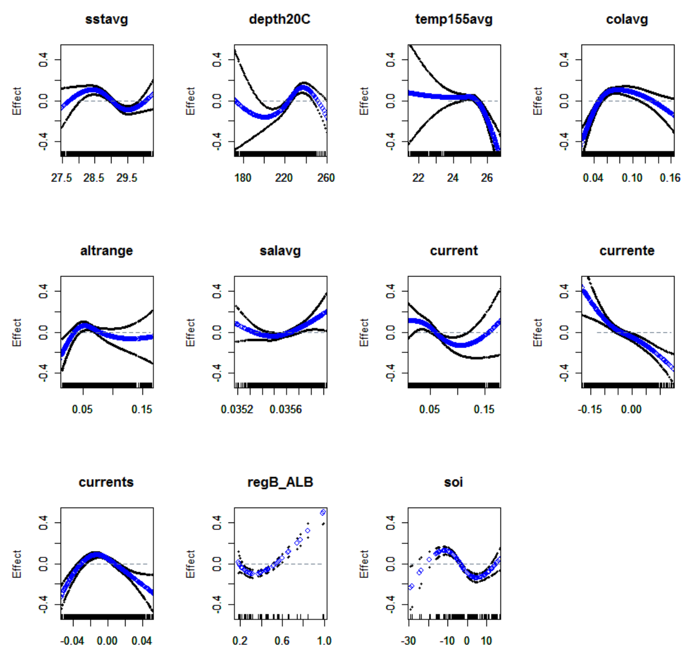

Figure 4. Effect of significant biological and environmental variables on positive albacore CPUE levels only.

Examining those environmental variables that can be more easily be monitored ('strategic' and 'SOI' models), the table below indicates what states have a positive (green) and negative (red) effect on albacore CPUE in this region.

Effect on CPUE	General status of 'strategic' variables
Positive	• El Niño conditions • lower SSTs • deeper 20°C thermocline
Negative	• Neutral SOI/La Niña conditions • higher SSTs • shallower 20°C thermocline

Implications of model outputs

Outputs of models developed for EEZs across the south Pacific region allow us to examine the pattern in the impact of monitorable environmental variables on albacore catch rates at a regional scale. Figure 5 shows the influence of SOI state on catch rates by EEZ or EEZ area. In western EEZs, an El Niño state has a positive influence on albacore catch rates (shown by the green colour). In contrast, in eastern EEZs, a La Niña state has a positive influence on catch rates. For more centrally located regions, including the Cook Islands EEZ, the impact is less consistent. For the northern Cook Island EEZ, El Niño has a positive influence on catch rates, while La Niña has a negative (although weaker – see Figure 4) effect. The influence of SOI on Cook Islands albacore catch rates is, as noted, inconsistent with the geographic pattern across the region. This may result from the slightly more northern location of this EEZ within the southern hemisphere compared to other EEZs.

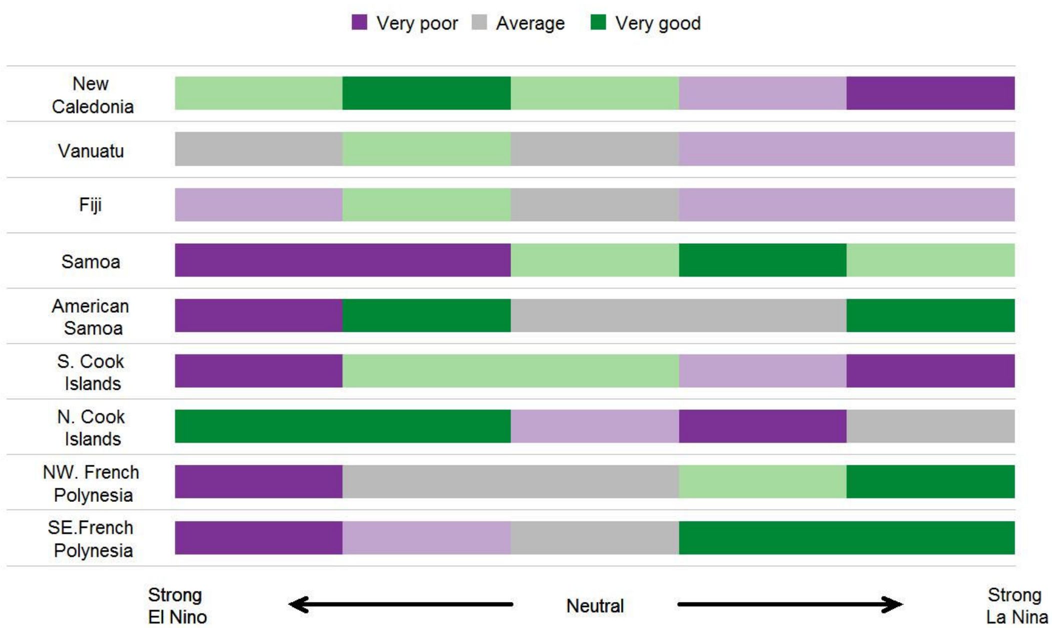

Figure 5. General predicted effect of SOI state on albacore CPUE levels, by EEZ/EEZ area.

- The impact of El Niño/La Niña on albacore CPUE levels within the region shows trends from west to east.
- El Niño has a positive influence in the west, and negative in the east, with La Niña showing the opposite effect.
- In the centre of the region, the impact is variable.
- For the northern Cook Islands EEZ, El Niño has a positive influence on CPUE levels.
- The 2011, strong La Niña should have a neutral influence on albacore CPUE levels.

Depletion analysis

The potential impact of localised effort on catch rate was examined. The difference in albacore catch rate between successive 10-day periods was calculated, and related to the catch taken and effort applied in the previous 10-day period, using statistical models.

Figure 6 (top) indicates that high catch levels in one 10 day period within the northern Cook Islands EEZ relate to lower catch rates in the following 10 day period. At very high catch levels (>150 mt) a decrease in subsequent catch rates of almost 20% are seen. While such catch events are rare, as shown by the few points at this level in the graph, at more common 'high' catch levels (50 - 100 mt) a decrease in catch rate of 5-10% is subsequently seen, with considerable variability. This was confirmed by the model, which predicted high catches in a 10 day period leading to another relatively high (but reduced) catch rate in the next period, perhaps reflecting relative high stock abundance in the region. High effort levels in the first 10 day period were significantly related to lower catch rates in the following 10 day period, although as seen from figure 6, the % decrease in catch rates was relatively small.

- local (short term) depletion effects have been seen in the northern Cook Islands EEZ;
- very high catch levels may result in up to a 20% decline;
- impact of high effort, while significant, is small;
- these effects can be managed.

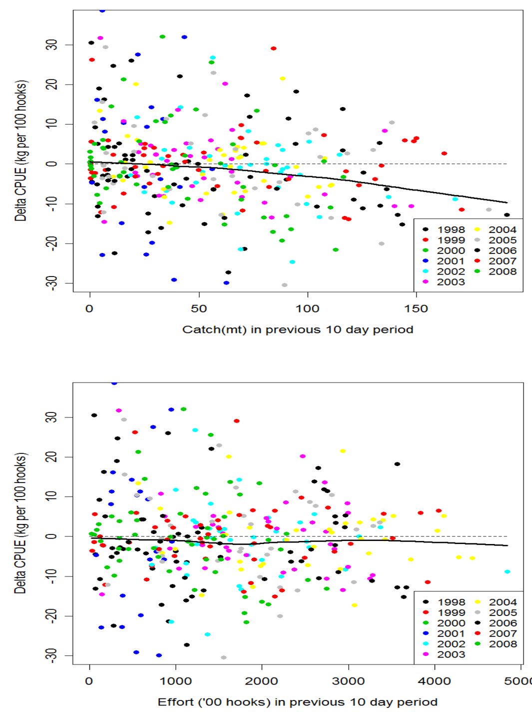

Figure 6. Change in overall albacore CPUE in the northern Cook Islands EEZ between two 10-day periods, relative to the total catch level (mt, top) and effort ('00 hooks, bottom) in the first 10-day period.

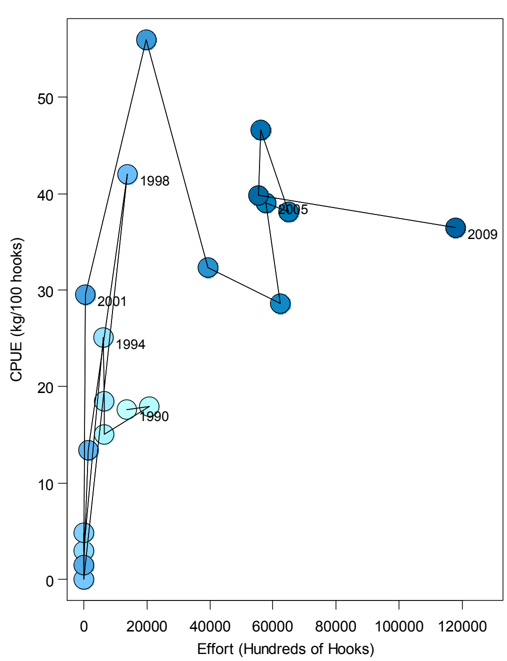

Figure 7. Overall annual albacore CPUE, relative to the total effort ('00 hooks) in each year (raw data from logbooks, not standardised).

Longer-term effects of effort on catch rates

While high fishing effort may influence catch rates in the short term, longer-term effort levels may have longer-lasting implications for catch rates, and hence fishery profitability. Figure 7 shows the pattern in un-standardised annual effort and CPUE for the period of logsheet data available from the northern Cook Islands fishery.

A general trend of increasing effort over time has been seen. Overall annual CPUE levels increased, peaking in 2002, while in subsequent years, albacore CPUE has fluctuated around the 30-40 kg/hundred hooks level.

- There is an insufficient time period of data to suggest that 2002 was a peak in catch rate and that further increases in effort will result in lower overall CPUE;
- Further increases in effort should be closely monitored.

Projecting the potential implications of future environmental and biological conditions

The models developed allowed the potential impact of alternative states of regional albacore biomass and the Southern Oscillation Index on future catch levels to be examined.

These scenarios were developed based upon the 'median' vessel within the fleet (reflecting 'average' vessel performance), the median SOI/regional albacore biomass (dependent upon the scenario), and a set value for the other of those two variables. Confidence intervals around these predictions were developed by randomly selecting 100 individual vessels from those operating within the fishery in the last five years, weighted by the number of sets they had performed during that period (i.e. those vessels that set more longlines in the last five years would have a greater chance of being selected), and predicting the resulting CPUE level.

For the northern Cook Islands area, higher catch rates are predicted where La Nina, and in particular El Nino, conditions occur (Figure 8). Increasing average regional albacore biomass leads to a consistent increase in the albacore CPUE in the northern Cook Islands area. In both cases, there is considerable variability in the future CPUE dependent upon the vessel fishing (shown by the 5th and 95th percentiles), such that differences in the median catch rates seen are likely to be masked by that vessel-specific variability. However, there is a notable increase in the lowest expected CPUE (by about 5kg/100 hooks), and by more than 5kg/100 hooks in the highest expected CPUE, between the low and high biomass estimates examined (see right hand pane of Figure 8).

- increased regional albacore biomass has a significant and positive effect on CPUE levels, and can be managed;
- the effect of SOI is variable. This is monitorable but not controllable;
- different vessels achieve very different CPUE levels, which are likely to mask overall trends.

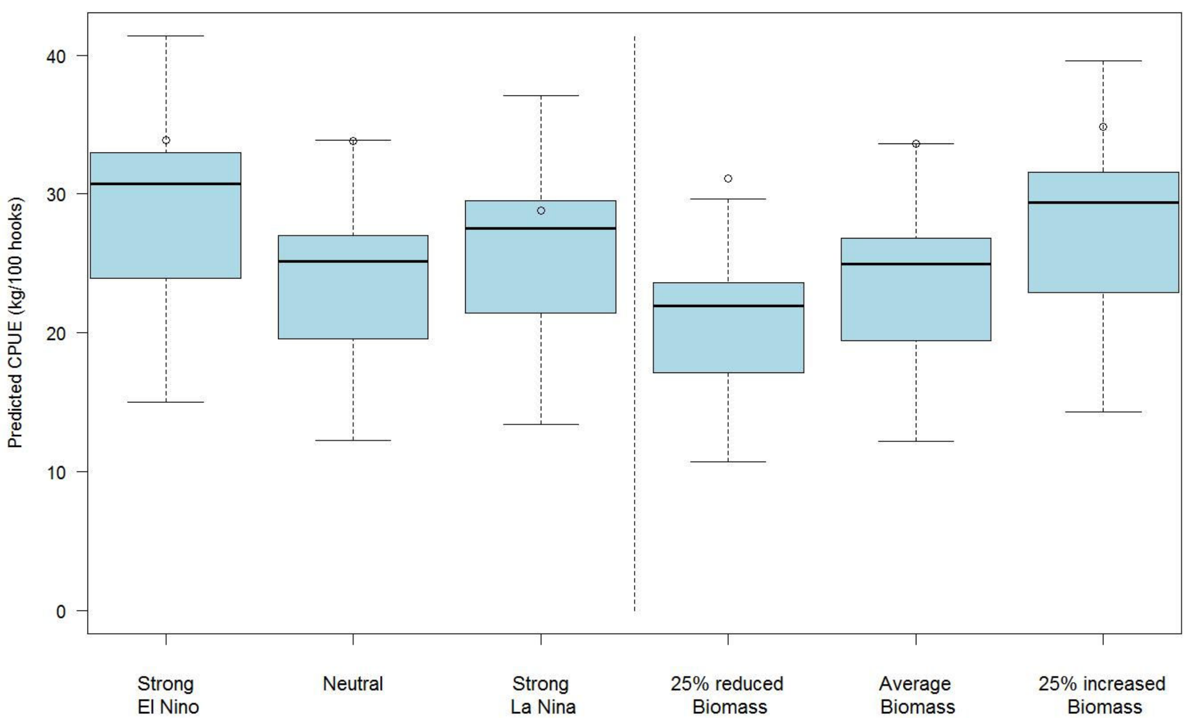

Figure 8. Predicted average and range of albacore CPUE (kg/100 hooks) under different SOI and regional albacore biomass states (positive catches only). Box represents 25th and 75th quartiles, horizontal line represents the median CPUE, extremes represent the 5th and 95th quartiles.

CONCLUSIONS

This ISNR examined the effect of environment, stock abundance and fishing practices on albacore CPUE levels in the northern area of the Cook Islands EEZ. It identifies the influence of those factors that can be controlled by fisheries managers, and those variables that can be monitored but not influenced by them.

- All factors examined affect catch rates to some extent:
  - Much of the variability in finding albacore, and the level of subsequent catch, was explained by the vessel doing the fishing. This can be influenced through licensing.
  - Increased regional albacore biomass had a positive and significant effect on CPUE levels. This is controllable through regional management measures.
  - Oceanographic factors had variable influences on albacore CPUE levels. Of those that can be easily monitored by managers, lower sea surface temperatures, deeper 20°C thermoclines and El Niño conditions positively influenced albacore CPUE levels.
  - the regional impact of the southern oscillation index (SOI) varied between EEZs. In the west, El Niño conditions positively influenced albacore CPUE levels, while La Niña positively influenced CPUE levels in the eastern EEZs.
- Evidence of local depletion, resulting from high effort levels in the EEZ, were identified.
  - High catches were likely to result in lower (but still relatively high) catch rates in subsequent periods, with decreases of up to 20% in catch rates.
  - High effort levels were also likely to reduce catches in subsequent periods, to a lesser degree.
- Longer-term effects of effort on catch rates were seen in unstandardised logsheet data. From the limited time series available, catch rates in the northern Cook Islands EEZ peaked in 2002. There were insufficient data to show whether increases in effort above 2009 levels (the historical high) would lead to declines in overall CPUE levels.
- The potential implications of future environmental and biological conditions were examined.
  - average catch rates predicted for an 'average' vessel varied from just over 20kg/100 hooks under a 'low albacore biomass' scenario to over 30kg/100 hooks under strong El Niño conditions, with considerable vessel-related variability around this.
  - increased regional albacore biomass has a significant positive influence on CPUE levels, with a 25% higher than average biomass resulting on average in over a 5kg/100 hook increase over conditions with a 25% lower than average biomass.
  - the impact of SOI was, as already noted, variable but significant, with El Niño conditions resulting in the highest CPUE levels.
  - variability in CPUE due to the vessel fishing was high, and may mask the influence of other factors.

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