Bayesian Skipjack and Yellowfin Tuna CPUE Standardisation Model for Maldives Pole and Line 1970-2019

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Abstract

An abundance index for skipjack and juvenile yellowfin tuna from 1970 to 2018 has been developed from Maldives pole and line catch and effort data. The index was derived from multiple datasets with differing level of detail over the period. Solutions for missing data were a random effects component used to account for missing mechanization information on the fleet 1974-1979 (Medley et al. 2017a) and the reconstruction of vessel length information using a vessel survival regression (described in Medley et al. 2017c). Fishing power effects related to vessel length are explained using a segmented regression that accounts for different classes of vessel. Both skipjack and yellowfin are combined into a single multivariate model, with skipjack and yellowfin catch rates standardized through a compound poisson-gamma (Tweedie) regression model. Additional fishing power effects which have not been recorded in the data have been estimated using subjective priors based on an expert meeting, and these effects could be included. The model was fitted obtaining a MCMC approximation to the Bayes posterior for the abundance indices using Stan software. Remaining issues include poor estimation of catch rates for the smallest vessels which has only been partially resolved and unaccounted for differences among landing atolls, as the reasons for these differences are not understood. Also, declines in data reporting, which coincided with the introduction of the logbooks, are a cause for concern, although reporting rates are improving. The analysis is fully reproducible and have been made available for peer review.

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Introduction

The first ever model-based Indian Ocean skipjack stock assessment was done in 2011 and used the Maldives Skippack CPUE data (Kolody et al. 2011). Subsequent skipjack stock assessments in 2014 and 2017 also used the Maldives pole and line standardized CPUE as an abundance index. At the time, these data were only available from 2004 when information on each trip was recorded. Earlier data exist from 1970, but these were compiled into monthly records by atoll and did not record individual trips. In addition, significant corollary information about the fleet operations was missing, making it difficult to use all data in a consistent index. Previous attempts have suggested that there was some potential in earlier data, but abundance indices were not proposed because of the problems encountered (Kolody et al. 2010; Sharma et al. 2013).

Pole and line data have not previously been used for an abundance index for yellowfin tuna in the Indian Ocean. As well as being subject to the same issues as those affecting skipjack, pole and line yellowfin should also be considered an index of juvenile abundance since the catch is generally limited to fish weighing less than 5kg.

The primary reason for not using earlier data is because of the substantial changes in the fleet which have led to significant change in fishing power. While these changes have been noted qualitatively, they were at best only partially captured in the catch effort data in quantitative form. The CPUE time series show an increasing trend which is thought primarily caused by increasing fishing power. For these data to be used as an abundance index, these changes need to be accounted for.

In a preliminary evaluation of standardizing these catch and effort data, Medley et al. (2017a) suggested that a Bayesian approach could resolve the main problems encountered. It was proposed to combine the two main data sets into a single standardization model, include reconstructed fleet size composition from partial vessel registry data (Medley et al. 2017c) and use a random effects model to bridge a gap 1974-1979 when information on motorization was missing.

Methods

Data

Catch and effort data collected by the Maldives Ministry of Fisheries and Agriculture extends back to 1959. From 1959 data were only recorded from masdhoni (pole-and-line) vessels. In 1966 the system was expanded to include the vadhu dhoni (trolling) fleet. At this time, numbers of tuna were only recorded in three categories: large skipjack; small skipjack and yellowfin; little (kawakawa) and frigate tuna. The system was expanded again in 1970 to record five categories of tuna separately in addition to catches of reef fish. From 1970, with landings recorded by species, it is possible to estimate a standardized CPUE index for each species.

The fishery and data collection have undergone significant changes over this time (Table 1). Fishery data collection began in 1959 using an enumeration system. Landings were reported in numbers of fish to the island offices, or collected by the staff of island offices at the time of landing. These data were compiled and monthly reports sent to the Ministry of Fisheries. Initially, data collection system did not distinguish between gear. This was because traditionally, the Maldivian vessels would be gear specific to the type of fishing vessel:

- Bokkuraa (small wooden boats 3-5 m. originally powered with oars now mostly by outboard engines) used for trolling and handling within atolls and on coral reefs. Currently they are used exclusively for non-tuna varieties.
- Vadhu dhoni (5–8m originally sail now motorized) used for troll fishing near the islands and within atoll lagoons as well as general coral reef fishing.
- Masdhoni (8-12m standard pole-and-line vessels) which use live bait to catch predominantly skipjack and yellowfin tuna.

Table 1 A summary of the history of data collection and associated issues.

Year	Notes
1970	Reported catches may have been inflated particularly in 1970-71 because a number of fishermen over-reported catches in the hope of qualifying for a government prize. Although this incentive existed from mid 1950s to 1981, the problem was most apparent in 1970-1971 when cash prizes were given directly to top crews (Anderson, 1986).
1974	Vessel mechanisation starts, but is not recorded.
1979	Mechanized vessels begin to record data separately from sailing vessels.
1981	FAD installation begins. Prize money for high catches ceases.
1989	Vessel type and number of dhoni begin to be recorded, but mixed gear trips are not identified in data. Use of conversion factors for enumerated small and large skipjack were also questioned on the grounds that the “traditional size” of large and small skipjack may have been mis-reported due to an artificial cut off weight for commercial purchase (1.5kg).
1995	Vessel specific trip landing data is available from 1995 onward. Earlier trip data may become available in future as it has been reported that such data were collected. However, these data have not yet been located.
2010	Log-book data begins, but does not cover the entire fleet. Landings begin to be reported as numbers and/or weight rather than numbers. The log book records detailed data on trip including bait, fishing times, gear and locations. Weight rather than numbers becomes more common in reporting landings.

In addition, during the latter years to the early 1980s, fishing vessels which completed a certain number of fishing days were exempt from annual registration fee, which may have prompted the over-reporting of effort (number of days fishing) to avoid the fee.

One of the largest potential source of errors for the catch weight data may be the conversion factors used to estimate the weight from recorded fish numbers (Anderson, 1986). Several factors have been derived over the years. For the standard data, mean weights have been estimated as 2.1kg for small skipjack and 5.7kg for large skipjack. These mean weights were derived from various sampling programs from which the results were either used or not depending on the coverage and reliability. Once a set of mean weights were adopted they remained until another revision.

Data were combined from five sources:

1. The vessel specific data 2004-2015 has already been used in CPUE indices (Kolody et al. 2010; Sharma et al. 2013; Medley et al. 2017b).
2. The new 2014-2018 logbook data was processed to be consistent as far as possible with the 2004-2015 trip data and appended to the series.
3. The IPTP/MOFA Merged data 1970-2007 were drawn from previous work (Adam 1999) and represent the monthly catch and effort by vessel type. The structure of these data is different. Only the pole and line data were used.
4. “New” vessel specific data were found in 2017 for the period 1995-2003 inclusive.
5. The reconstructed fleet size composition 1970-2007 (Medley et al. 2017c).

For the IPTP/MOFA Merged data 1970-2007, individual trips were not recorded, but landings and effort are reported in aggregated form, including missing information on vessels and their operations. In some cases, additional information was reported that tracked fleet changes. Notably, the Ministry required island office staff to report catches of sailing and mechanized masdhonis separately from 1979 after much of the fleet had already transitioned. Other changes to the fleet which may well have increased efficiency but have not been recorded include changes in fleet size composition, improved design and engine power, improved bait catching and storage techniques.

These vessel specific and logbook data are compatible as they have the same covariates. However, the logbook data have better information on fishing effort (fishing days rather than trip length), so adjustment was necessary based on the overlapping years 2014-2015.

Most of the data has the same underlying source 1970-2015, namely the island government staff who were required to collect these data. This system has now been replaced by the logbook data collection system. Although all the data 1970-2015 had the same source, they have been processed and maintained in different forms which have led to differences as stated above. The “new” data 1995-2003 discovered recently is important because it was in a form consistent with the 2004-2015 data. This significantly increased the overlap between the vessel specific data and the IPTP/MOFA Merged data 1970-2007, which greatly improves the index as it provides a way to adjust between data sets.

For the 1995-2018 data, records were filtered retaining only pole and line trips. This may include vessels which have been mis-labelled, and it is suspected some trips may have been trolling or targetting other species (e.g. neritic tunas). However, removing trips based on data could bias the result, so all PL trips were retained. It may be possible to exclude trips when other species exceed skipjack, or trips landing large yellowfin.

The presence of "large" yellowfin in catches was a concern. It is not clear what might be considered "large" in this case (they may cover a range 5-30kg). Large free swimming yellowfin could be caught by pole and line, even if this was predominantly captured by troll vessels, and recently with the use of handlines in large yellowfin tuna fishery. Therefore, there is little reason to exclude trips with significant large yellowfin in landings.

Small Vessel Catch Rates

In preparatory analyses, it was found that vessels 7 or less metres in length had catch rates equivalent to much larger vessels and seemed to buck the otherwise clear trend with catch rates declining with vessel size. It was suggested that the smallest vessels may not be pole and line because pole-and-line vessesl were of standard size of roughly 13m LoA. However, this would still not explain the reported high catches from these vessels. This issue was explored, but and no clear reasons found. For example, no evidence was found that it was because smaller vessels had higher proportion of zero catch trips, which had been excluded. It is important because although in recent times these vessels only make up a small proportion of the trips, in the older data they make up a much higher proportion so assuming higher catch rates are correct could bias results. Some response was necessary for the current analyses.

As a solution, it was proposed to remove data which was not consistent with other information. Specifically, small vessels have a tri-modal catch rate distribution. It was decided to remove the upper mode so as to reduce the impact of these suspect data (Figure 1). This is tentatively justified on basis that they may have been incorrectly recorded as pole-and-line, whereas it is suspected that significant numbers of these vessels may have been troll (or mixed gear) vessels. Data for vessels 7m or less with log catch rates above -2.25 were removed from the data (186 records). Otherwise, the fishing power of all small vessels was assumed to be the same in the model.

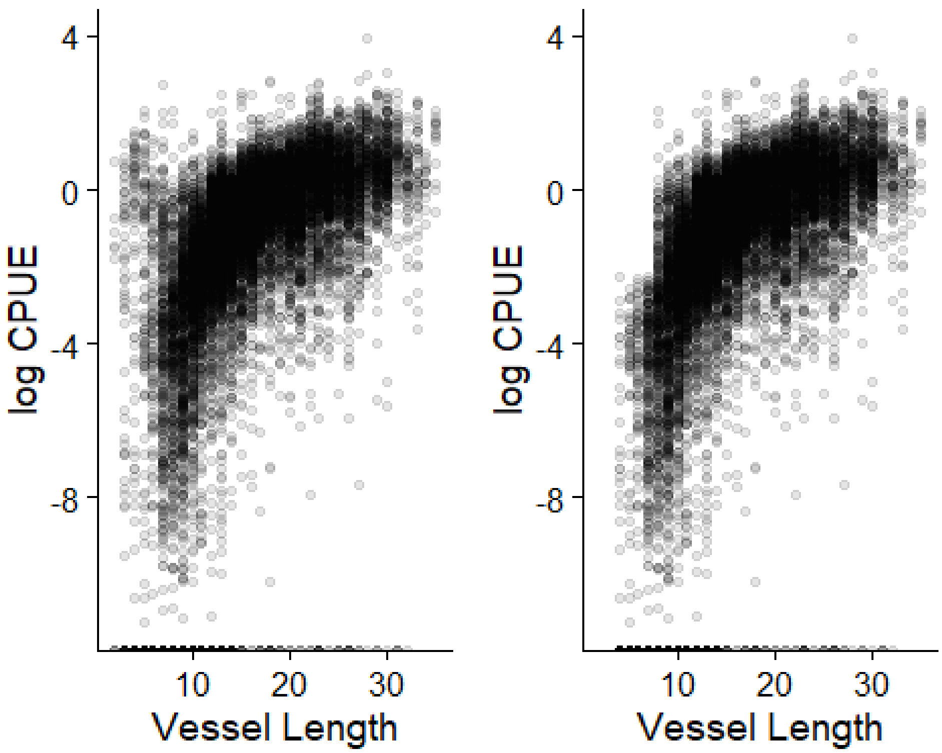


Figure 1: Log CPUE plotted against vessel length (metres) with all data (left) and with suspect small vessel cluster of trips removed based on their unusually high catch rates.

Nominal Indices

Some of the problems with the data can be seen by plotting the CPUE (Figure 2). CPUE shows a positive trend most likely due to increasing fishing power. There are some differences between mean CPUE derived from the different data sources. The variance of the estimates, particularly in recent times, has increased.

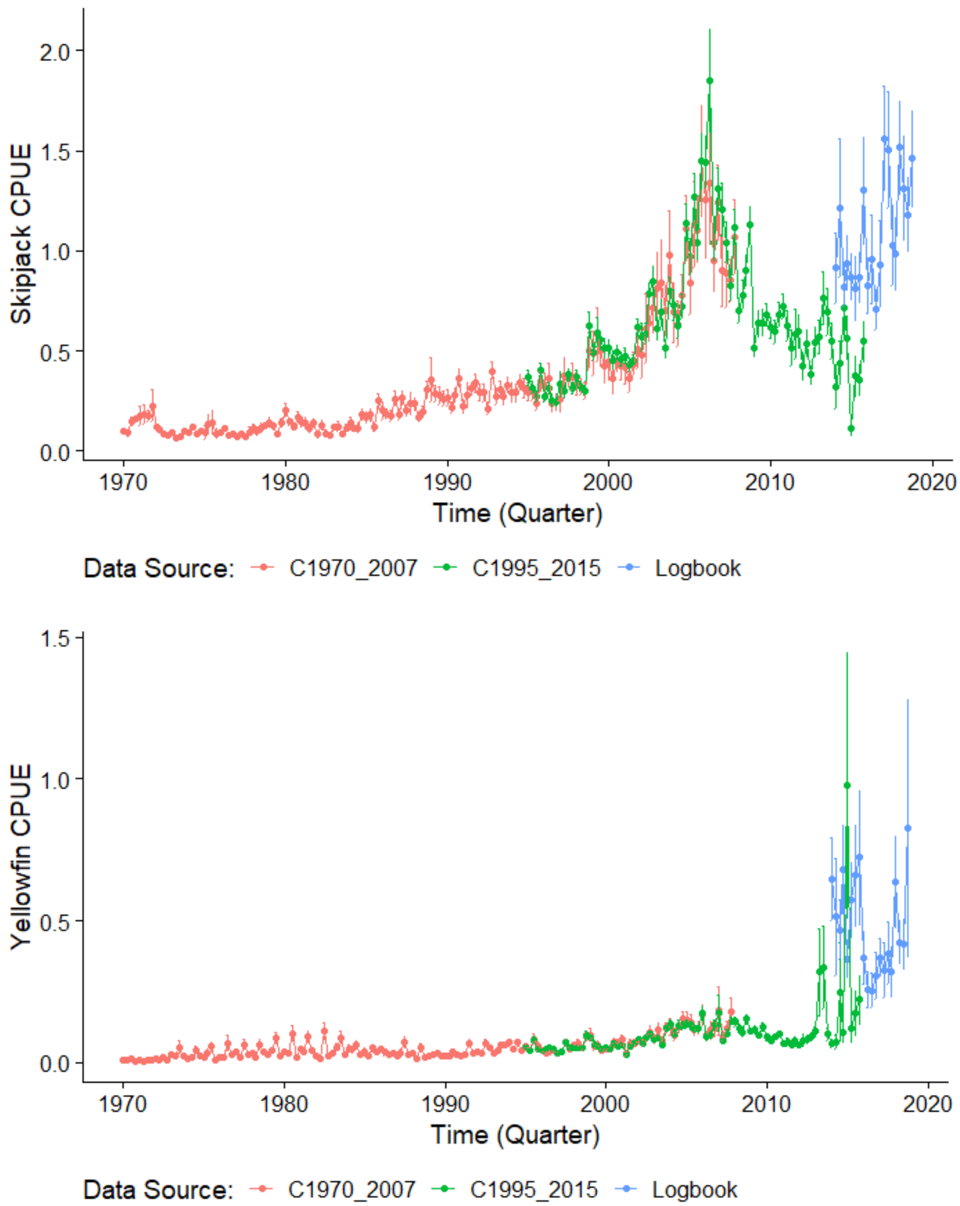


Figure 2: Nominal abundance indices for skipjack and yellowfin with standard errors.

Model Structure

Exploration of the model structure has not been exhaustive, but fairly wide exploration of the data suggested that the main factors have been captured.

The main effects were assumed to be linear in relation to log-catch. Log effort (trip length) was added as an offset (no parameter was fitted to it). This approach is identical to fitting to log-CPUE, but allowed greater flexibility during the exploration phase.

The model had the following components:

- Atoll groups are treated as a categorical variable fitted as a simple main effect. Although there were significant differences between catch rates landed at different atolls, it was not clear how the atoll should affect the skipjack and yellowfin catch rates, so the current formulation may need to be revisited. Sharma et al. (2013) also grouped atolls into North, Centre and South since this had the potential for having different catch rate time series. However, it was found that the chain categorisation (East, Centre and West) explained more variation in the catch rates and therefore these categories were used rather than latitude. Any further development of atolls as a categorical variable in standardization will need to account for varying reporting rates among atolls.
- Vessel size classes were identified. The classes were based on exploratory GLM fits to the data and motivated by expert opinion which implied discrete changes in vessel length upgrades.
- Vessel length is fitted as a separate covariate within each vessel size class.
- Vessel power for the early time series separates sail and motor vessels.

Other factors were identified in an expert meeting (MRC 2018) for which there is no quantitative data. These factors were included as an optional expert opinion offset for the model.

To deal with the various issues arising for the different data sources, it was decided to use a Bayesian approach as the only way to deal with the problems in a consistent and transparent manner. To achieve this, the model is being developed in Stan (Stan 2019), which provides a flexible, robust platform for fitting Bayesian models using MCMC. Stan is designed to improve MCMC performance by using Hamiltonian Monte Carlo (HMC) sampling. Among other things, it uses auto-differentiation to improve MCMC convergence and can cope with complex models which other software is unable to deal with.

In fitting the model above, two important pieces of information were missing. Firstly, we used a reconstruction of fleet size composition described in Medley et al. (2017c) for the IPTP data 1970-2007. This gives a probability matrix of fleet length composition over this period which can be used to account for important changes in fishing efficiency. Secondly a random effects model was used to estimate the probability for vessels being mechanized for the initial period 1974-1979 after mechanization occurred but before it was properly recorded in the data.

Expert Opinion Offset

A small workshop was convened on 26 June 2018 at the Marine Research Centre, Malé with seven invited experts who have a long experience of the tuna fisheries in the Maldives, to assimilate subjective information on the tuna fishery for the period 1970-2018 that have had an impact on the tuna fleet's fishing power (MRC 2018). The workshop consisted of two parts:

1. A scoping to identify relevant changes in the fisheries and a general discussion of their effects.
2. An estimation of the period the change occurred and its impact on catch rates for each significant change identified within the scoping.

The identification of important changes in the fishery, and the period those changes were introduced were agreed by consensus. For estimating the impact of the change, a simple Delphi method was applied (MRC, 2018).

During the Delphi process, there was no encouragement to reach any consensus. Instead it was pointed out that the true answers were unknown and therefore these were subjective estimates, where the levels of difference between participants could indicate uncertainty. This was also used by participants, so that their collective answers reflected appropriate uncertainty in the estimates.

While there was clear consensus over which factors had affected fishing power, opinions differed on the scale of the effects. It is clearly difficult to estimate in quantitative terms what effects have been, so any estimate will be highly uncertain.

Vessel length was identified as being a key determinant of vessel fishing power, and reasons were provided why this was the case. The effect of vessel length was estimated from the data, so there was no need to use expert judgement on this. Six other effects not explained by vessel length were identified as important (Table 2). All effects except drifting FADs (dFADs) were used to create a fixed offset combining each effect based on logistic model with 98% of the change occurring between Year 1 and Year 2 and the scale of the change set by the Mean in Table 2 (Figure 3). The scale of the effects suggest an increase in fishing power by as much as 400% over the entire series based on these effects alone. However, it was noted that the combined effects may be exaggerated, as the overall view of the experts was the combined effects, including vessel size, have led to an overall increased efficiency of around 300%. Therefore, this offset should perhaps be taken as an upper limit for these five effects.

The fixed anchored FADs that have been placed around the atolls are not included in the model. These were not included in the last skipjack indices because they did not explain catch rate changes (Medley et al. 2017b). The expert opinion was they are not highly relevant to the commercial pole and line fleet, but are used by other fisheries.

Experts also provided insight on the effects of motorization. Originally this was motivated because early models seem to underestimate the motorization effect, and reasons were provided why this might be the case. These models were incorrect and recent assessments suggest the effect of motorization is in line with early observations (Anderson 1987). However, the experts noted, for example, that engines installed in the early vessel took away hold space for bait and tuna, so not all effects of motorization were positive. They identified vessel design as a key effect, and this would be identified by vessel length. This led to modelling separate vessel classes based on their length so the model would have flexibility to account for discrete changes in fishing power due to vessel design.

Table 2 presents a summary of expert assessment of changes in fishing not related to vessel size. Year 1 and Year 2 refer to the period when the change occurred, the mean is the group estimate of the final percentage increase in fishing power in Year 2 and the final state indicates how much of change has occurred in Year 2. Less than 100% for the final state indicates incomplete spread of the technology among fishing fleets. For dFADs, it is believed changes have been ongoing throughout the period and a simple logistic will probably not model this effect. Note that dFADs were not part of the operations of the Maldives fleet, but rather local fishers have opportunistically used lost or discarded dFADs from fleets outside of the Maldives EEZ which drifted into their fishing grounds.

Table 2: Summary of expert assessment of changes in fishing not related vessel size.

Effect	Year 1	End Year	Mean %	SD %	2018 State
Water sprays	1982	2000	48.6	21.7	
dFADs	1970	>2018	21.4	12.2	Linear
SCUBA bait fishing	2012	>2018	19.3	9.4	33%
Bait fishing lights	1990	2005	65.7	27.7	
Binoculars	1975	1990	39.3	10.2	
Ice availability	1995	>2018	12.9	5.2	70%

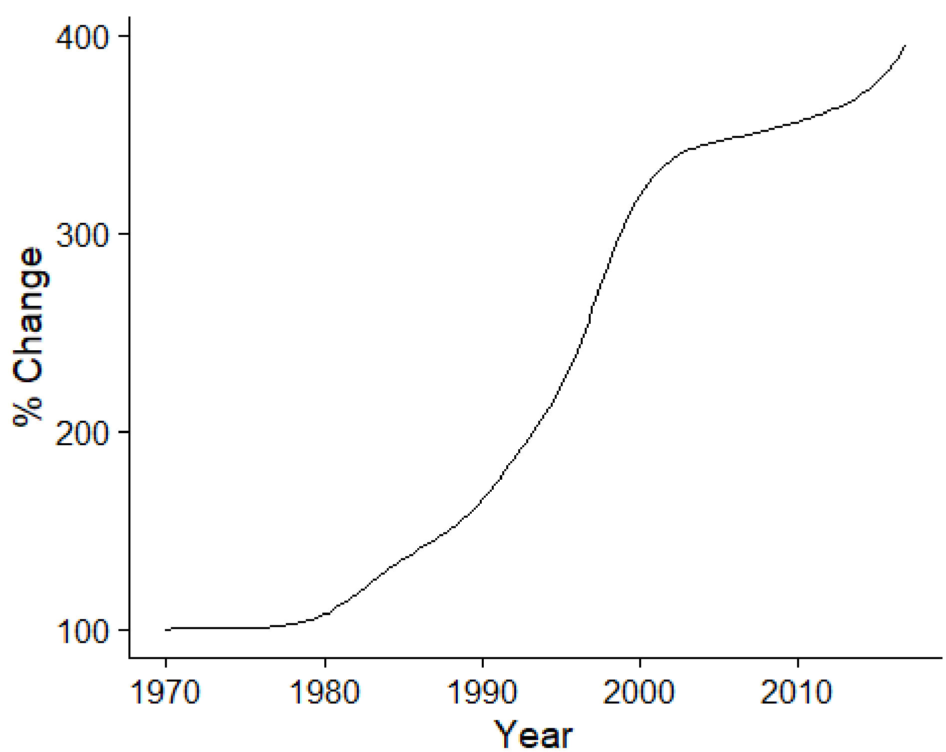


Figure 3: Fixed expert offset in fishing power accounting for five effects not recorded in the catch effort data set.

Motorization

The missing data (proportion motorized effort 1975-1978) is estimated as a latent variable ("random effect") within the model. The probability for the proportion is based on a binomial for the approximate number of vessels in the fishery. Although this is calculated from the effort, effort is not used to calculate the variance because clearly effort days are not independent. The number of vessels contributing to the observed effort is not known, so this is estimated as effort / 20 (assuming each vessel on average fishes 20 days in a month). Lower values for the number of trials are preferred to ensure a reasonable variance around the expected proportion.

Data on the number of motorized vessels in the fleet during this period was available. The following was obtained from Anderson (1987) (Table 3). From 1979 onwards, motorized effort is recorded directly.

Table 3: Numbers of motorised and sail vessels recorded by Anderson(1987).

Year	Motor Vessels	Sail Vessels
1974	1	2131
1975	42	2040
1976	218	1940
1977	413	1801
1978	548	1631

This suggests that mechanization began in 1974, so for 1974-1978 power is treated as "unknown". A posterior probability density function for the probability of vessels were motorized was constructed based on these observations assuming uniform prior and binomial probability based on motor and sail vessels as "success" or "failures". These observations applied to whole years rather than quarters, so assuming vessel counts as independent trials will over-estimate the certainty. Therefore, the effective number of trials was reduced to 12.5% of this total, which downweighted these observations proportionately.

It should be noted that the number of registered motorized vessels as a proportion of the whole fleet (~40%) was lower than the recorded motorized effort in 1979 (60-70%). This suggests that the most active vessels probably became motorized first. As such the register data above is probably most useful to record change in the early years, and may generally underestimate the proportion of motorized effort. This may be another reason to reduce weight these data have in fitting.

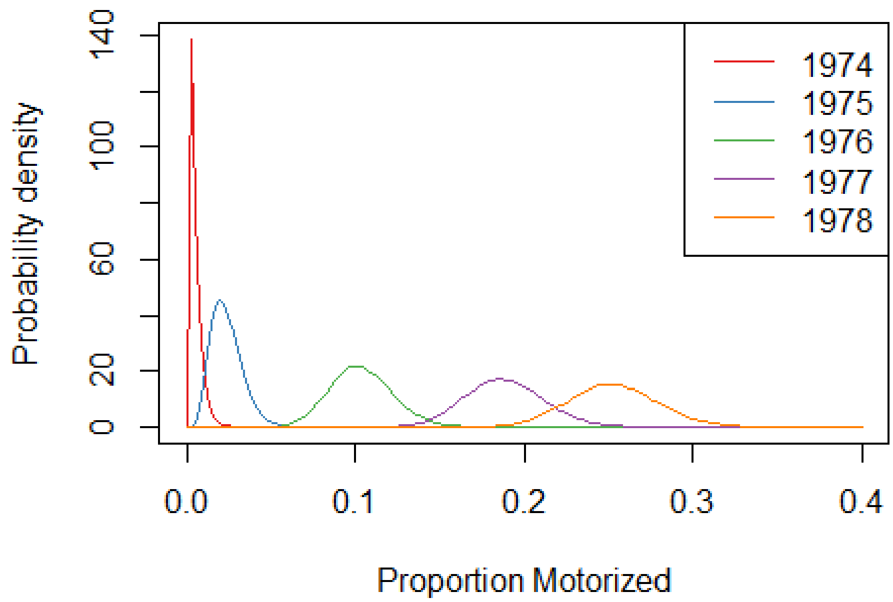


Figure 4: The priors on the proportion of mechanized for years where mechanization data are missing based on Anderson (1987).

The motorization rate appears to have been too rapid for the standard logistic function, and therefore a generalized logistic is used to model the switch:

$$f(x) = (1 + e^{-x})^{\alpha}, \quad \alpha < 0$$

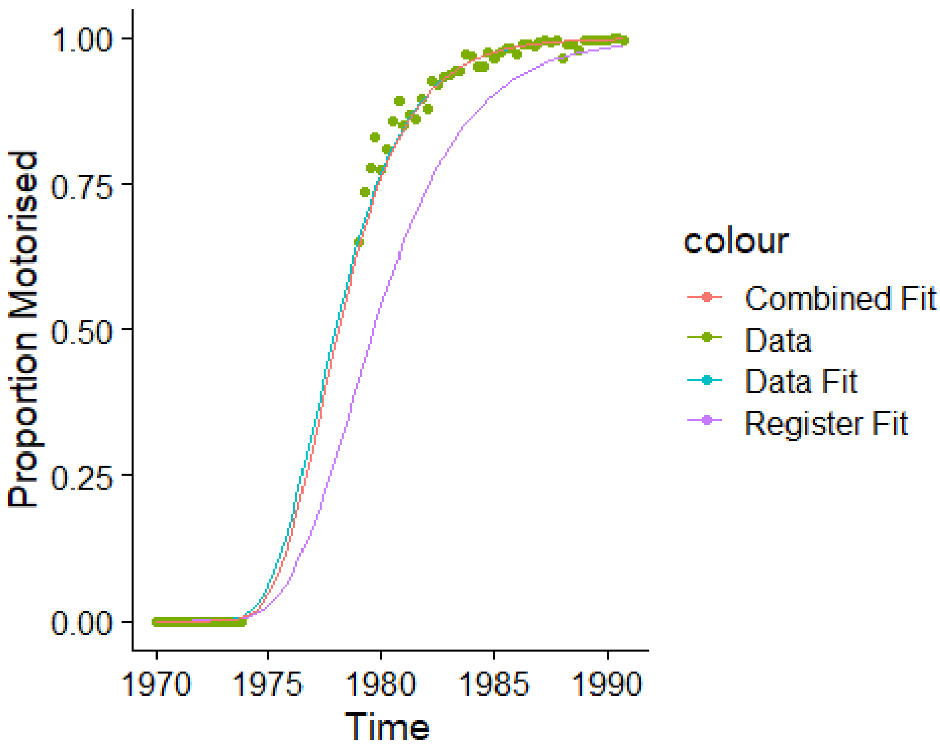


Figure 5: Exploratory fits of a generalized logistic model to separate motor and sail fishing effort data and to register data indicating numbers of vessels motorized.

While the α parameter allows the model to fit the data well, it is difficult to estimate. The data fit has extreme parameters (-15.3955823, 0.118272, -207.1738082). The high non-linearity and lack of information in the likelihood on this parameter will provoke unstable behaviour in MCMC unless a very tight prior is place on it. In fact the model explains the data well with α parameter set to -5. This is essentially the same as having a tight prior on the parameter, but avoids these extra pointless calculations by fixing it. This will make no difference to the final model fit.

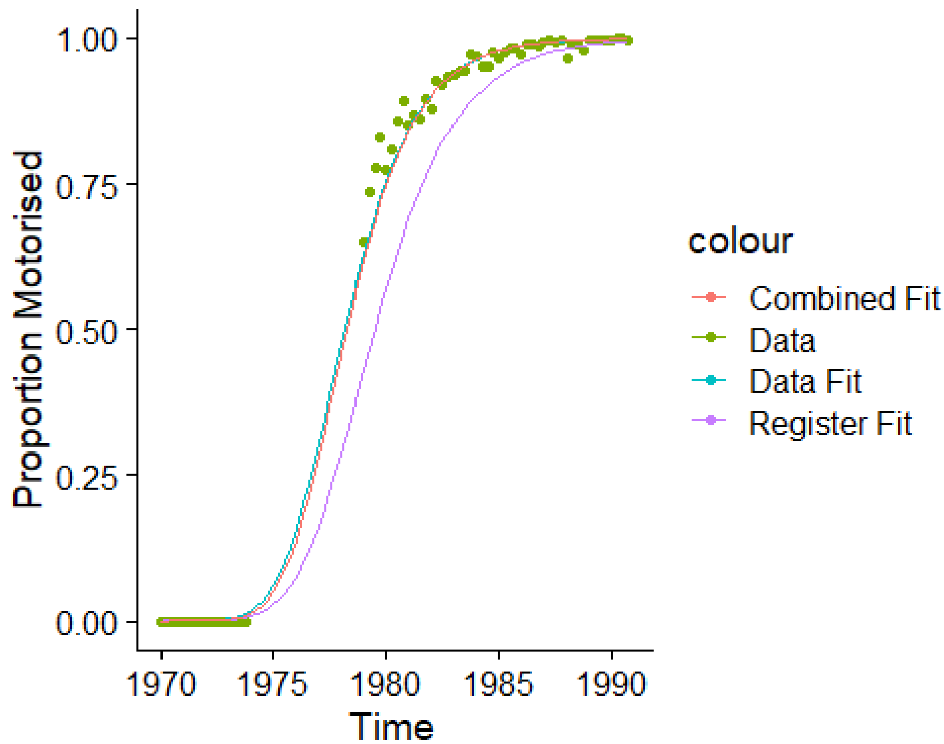


Figure 6: Exploratory fits of a generalized logistic model with fixed α parameter (-5.0), illustrating little difference compared to estimating this parameter.

Tweedie Likelihood

Previous model versions used a lognormal for skipjack and delta-lognormal for yellowfin. Zero catches for skipjack were excluded because it was believed these may not all be pole and line activities even though they are marked as pole and line gear in the database. For these models, the log-normal was believed to be the most robust approach for positive catches although the gamma likelihood provided similar results.

Two problems arose in this approach. Catchability for the smallest vessels still appeared to increase despite removal of some data as described above, reversing the apparent trend applied for the vast majority of the fleet. This seemed unlikely and a possible artefact from removing the zero catches from the dataset. Secondly, the zero catch (delta) model for yellowfin resulted in highly uncertain estimates for the oldest part of the time series. During this period data are not grouped by vessels, so zero catch trips are hidden within the groups and therefore there was little support for the parameters in the bernoulli (delta) model. This becomes an insurmountable problem for skipjack catches since no zeroes are recorded in the older data. Furthermore, data retained in the model may undergo further revision subject to the catch composition, and a flexible likelihood is required to allow inclusion of zeroes when the filtering rules are adjusted.

An alternative compound poisson-gamma likelihood was explored which covers observations of zero within the same likelihood function. The assumption behind this likelihood is that the catch is a random sum of gamma random variables:

$$\Pr(C = 0) = e^{-\lambda}$$

$$\Pr(C \mid C > 0) = \sum_{i=1}^{\infty} \left\{ e^{-\lambda}\, \lambda^{i}/i!\ \ \beta^{i\alpha}\ \ C^{i\alpha-1}\, e^{-\beta C} \,/\, \Gamma(i\alpha) \right\}$$

where λ = expected number of gamma variables in a sum, i = number of gamma variables, and α and β the underlying gamma distribution parameters. So, for example, the number of tuna schools encountered could follow a poisson distribution, with the size of catch from each school being a gamma distribution.

This likelihood addresses both problems outlined above. Firstly, zero-catch records for skipjack can be included in the model as the compound poisson-gamma includes them in the likelihood, which should help account for smallest vessel catchability. Secondly, the poisson provides a probability for zero catch integrated within the model, so these can be accounted for implicitly in the grouped data while the number of parameters needing to be fitted is substantially reduced compared to delta-lognormal.

The main problem with the compound poisson-gamma is the function has no simple closed form. In generalised linear models it can be fitted using a quasi-likelihood form (if the index parameter is fixed) because the mean-variance relationship is well defined. The likelihood in this case is parameterised in a general "Tweedie model" form which is a subfamily of exponential dispersion models that include normal, poisson, gamma and inverse gaussian distributions. For using this likelihood in MCMC, the log-probability density is required and needs to be calculated. To achieve this, relevant likelihood functions were written in Stan based on "Tweedie" package in R (Dunn 2017).

Priors

Model parameters consist of the time series indices fitted to each quarter for skipjack (itsj) and the yellowfin (ityf), regional atoll effect (at: East, West and Centre), regression on vessel length with slopes and intercepts for each of the 3 larger vessel size classes (vc and ve) and motorization effect (pw: Motor and Sail). A log-link function was used, so all effects were multiplicative. For the three main data sources, the older IPTP-MOFA, the newer vessel specific data, and the logbook data, adjustment parameters were fitted to allow seamless change. This parameter should be close to zero, but differences, particularly in assumed mean weights and effort measures, led to some differences. Common data exist for the period 1995-2007 and 2014-15 so these parameters can be estimated.

Very weak normal priors were provided for the abundance indices (itsj, ityf). These were set with a mean close to the mean of the log raw data and large log-normal sigma (4.0). These priors should have little effect on the estimates.

The two vessel length slope parameters for the first size class ("ve[1]") exhibited significant convergence problems during exploratory fits. In addition, the estimates of the regression slope for these vessels was negative, indicating increased catch rates for smaller vessels within this size class. This was already noted as problem, and highly unlikely to be a real effect. Previous removal of some of these data only partially fixed this problem. The estimated slope for the length effect was very close to zero, therefore this parameter was fixed at zero, and effectively all vessels 2-8m length in this model have the same catch rates (see below).

A number of parameters were fixed. Originally these were estimated with informative priors, but it became apparent these cannot be estimated with the current data and model.

For the α generalized logistic parameter, estimation was difficult because of the model form produced discontinuities during the fit, exacerbated by the lack of information on the parameter in the available data. This could be resolved by applying a very informative prior, which was little different to fixing the parameter at a reasonable level based on maximum likelihood fits. The remaining two parameters of the generalized logistic were fitted normally to allow for any error in the observations.

For the expert opinion offset, it was attempted to use the standard deviations from the differences in opinion to represent expert uncertainty by applying a normal prior and fitting these parameters. However, these effects are entirely aliased with trends in the data accounted for with other parameters. Balancing the statistical weight on such priors which have no information in the likelihood against other components in the model is difficult without arbitrary intervention, such as such as setting the prior sigma parameters very low, which would not correspond to the original expert opinion. Therefore, the parameters were fixed so that including the offset would represent an alternative case for a sensitivity run as a worse case scenario for abundance decline.

Table 4: Fitted parameters and priors. Absence of priors implies a uniform distribution over an arbitrary large range.

Parameter	Number	Description	Prior
Tweedie Model			
itsj	188	Skipjack time series log-means	normal(-2, 4)
ityf	188	Yellowfin time series log-means	normal(-3, 4)
so	2	Data source effect: old IPTP data, monthly vessel data, logbook data	normal(0, 0.4)
at	2	Atoll effect by chain	
vc	3	Vessel class intercept	
ve	3	Vessel length slopes for each larger class	
pw	1	Sail vessel effect	
tw_phi	4	Tweedie dispersion parameter	normal(3.6, 3) T[0,]
tw_cp	2	Tweedie power parameter	beta(30, 30) T[1.55, 1.75]
Motorization Model			
lg_mot	3	Generalized logistic parameters for the motorised proportion	
		50% Motorized	uniform(1970, 1979)
		Steepness	gamma(1.0, 0.5)
		alpha	Fixed: -5.0
mot_p	20	Proportion motorised effort where unknown	
FPoffset	5	Expert opinion on percentage increase of 5 effects	
		Water sprays	Fixed: 0.486
		SCUBA baitfishing	Fixed: 0.193
		Baitfishing lights	Fixed: 0.657
		Binoculars	Fixed: 0.393
		Ice availability	Fixed: 0.129

Fitting the Model

For the vessel specific data, the main effects were fitted with a Tweedie likelihood, with 4 separate dispersion parameters, for the two data sources and two species, and 2 separate power parameters for the two species.

For the motorized random effects model, the proportion motorized is fitted through a beta-binomial (assuming a uniform prior) to the observed motorized / non-motorized trips for those quarters where the data exist with the expected proportion as a logistic function of time. The random effect variable is then estimated using the beta probability function consistent with a binomial having mean and variance taken from this logistic function and overall number of trips in that quarter.

For the vessel length model in the older data 1970-2007, the proportion of trips undertaken by vessels at each length is assumed to be proportional to the vessel fleet size composition estimated separately (Medley et al. 2017c). This proportion is multiplied by vessel length effect on the catch rate to generate the expected overall effect for each quarter.

Stan Data

The data was assembled as a list in R of simple vectors with the same names as data structures in the Stan model. The data were split as appropriate between skipjack and yellowfin, and the old IPTP data with known and unknown proportion of vessels motorized, the new vessel specific data and the new logbook data.

Initialising Parameters

Standard generalized linear models are used to provide first guesses for parameter estimates. These first estimates will be poor primarily because they do not take proper account of the vessel sizes in the IPTP data. However, they still provide a start point reasonably close to the posterior mode.

Initial parameters were then adjusted towards the posterior mode using the Stan "optimizing" function. The output initial parameters were then checked by plotting and the optimizing function run as many times as necessary. Models with and without the expert opinion offset were fitted separately.

The individual functions were run to check whether individual calculations were correct and then an MCMC test run was conducted to check the model was running correctly overall.

MCMC Fit

The Stan model is written in C++ modelling language and compiled connecting to a C++ compiler. The model includes the following components:

1. Combining yellowfin and skipjack into a single model, where we expect fishing power effects to be the same for both species.

2. Compound poisson-gamma (Tweedie) likelihood for skipjack and yellowfin to explain inflated zero landings.

3. Piece-wise regression on vessel length allowing for discrete vessel classes.

4. Simple main effect adjustment for East and West regions relative to the Centre.

5. Combining older 1970-2007 IPTP/MOFA revised data (Adam 1999) with recent vessel specific reports (1995-2015) and logbook data (2014-2018).

6. Estimating the unknown proportion of motorized vessel landings 1974-1979. The model estimates the proportion motorized fishing effort where they are missing using the beta distribution with the same mean and variance as the binomial for the proportion motorized, so the beta distribution parameters are calculated as: $\alpha = p * (n - 1)$ and $\beta = (\alpha / p) - \alpha$, where p is the expected proportion motorized and n = number of vessels operational in that quarter.

7. The unknown fleet length composition for the IPTP/MOFA revised data 1970-2007 using a length probability matrix derived from the vessel register (Medley et al. 2017c).

The Stan model is compiled and run in R (R Core Team, 2018) using the package "rstan" (Stan Development Team, 2018). In this case, 4 MCMC chains were run in parallel after 500 warm-up simulations to create 1000 random draws in total from the posterior. The full Stan model code is available in "CPUE_MaldivesPL_tw.stan".

Results

MCMC Convergence

The Stanfit object has a lot of R functions which help evaluate MCMC convergence. There are a large number of parameters, so not all results are presented here, but further review can be carried out on the saved Stanfit objects (No offset model fit: "Stan_SY_19702018_No.rda" and fit with expert opinion offset "Stan_SY_19702018_Of.rda").

For all fits, the slope for the vessel length regression for the largest vessels is not well estimated, but otherwise parameters appear well mixed. This can be seen from examining the $\hat{R}$ statistic which should be close to 1.0. Values above 1.1 suggest the estimate is poorly estimated and the fit may need to be rerun.

Table 5: Summary of parameters (apart from the index parameters) for the model without expert opinion offset.

```
><> Inference for Stan model: MalInd.
><> 4 chains, each with iter=6500; warmup=1500; thin=2;
><> post-warmup draws per chain=2500, total post-warmup draws=10000.
><>
><>                  mean se_mean    sd        10%        50%        90% n_eff
```

```
Rhat
><> so[1]         -0.69    0.00  0.02      -0.72      -0.69      -0.67  7793
1
><> so[2]         -0.20    0.00  0.08      -0.30      -0.20      -0.09  5083
1
><> at[1]          0.28    0.00  0.01       0.27       0.28       0.30  7202
1
><> at[2]         -0.15    0.00  0.02      -0.17      -0.15      -0.13  7710
1
><> vc[1]          1.20    0.00  0.10       1.07       1.20       1.34  1109
1
><> vc[2]          1.84    0.00  0.20       1.58       1.84       2.10  3269
1
><> vc[3]          2.65    0.00  0.07       2.56       2.65       2.74   507
1
><> ve[1]          0.08    0.00  0.01       0.07       0.08       0.09  9525
1
><> ve[2]          0.10    0.00  0.02       0.08       0.10       0.12  9695
1
><> ve[3]          0.07    0.00  0.00       0.06       0.07       0.07  7548
1
><> pw            -0.64    0.00  0.04      -0.69      -0.64      -0.59  7763
1
><> lg_mot[1]      7.89    0.01  0.48       7.27       7.89       8.50  8650
1
><> lg_mot[2]      0.09    0.00  0.00       0.09       0.09       0.09  7955
1
><> tw_phi[1]      3.07    0.00  0.07       2.98       3.07       3.17  7435
1
><> tw_phi[2]      3.17    0.00  0.06       3.08       3.16       3.25  7642
1
><> tw_phi[3]      3.07    0.00  0.03       3.03       3.07       3.11  7454
1
><> tw_phi[4]      3.30    0.00  0.03       3.26       3.30       3.34  7382
1
><> tw_cp[1]       0.59    0.00  0.01       0.57       0.59       0.61  9006
1
><> tw_cp[2]       0.77    0.00  0.01       0.75       0.77       0.78  7678
1
><> tw_p[1]        1.67    0.00  0.00       1.66       1.67       1.67  9006
1
><> tw_p[2]        1.70    0.00  0.00       1.70       1.70       1.71  7678
1
><> lp__      -150076.62    0.19 14.89 -150095.88 -150076.14 -150058.01  6126
1
><>
><> Samples were drawn using NUTS(diag_e) at Wed Apr 29 08:52:37 2020.
><> For each parameter, n_eff is a crude measure of effective sample size,
><> and Rhat is the potential scale reduction factor on split chains (at
><> convergence, Rhat=1).
```

The effective sample size (n_eff) also indicates the rate of convergence for particular parameters, and therefore how well they are estimated. However, the important parameters in this context are the time series indices which need to be reasonably well estimated.

Table 6: Summary worst MCMC diagnostics for time series parameters without (top) and with (bottom) expert opinion offset.

Parameters	Minimum	Maximum
SKJ Eff. samp. size	446.0858119	7885.847086
SKJ Rhat	0.9998667	1.007355
YFT Eff. samp. size	664.9080747	8797.507894
YFT Rhat	0.9997659	1.005258

Parameters	Minimum	Maximum
SKJ Eff. samp. size	522.3877508	7020.020781
SKJ Rhat	0.9997500	1.005731
YFT Eff. samp. size	775.3330631	7672.645990
YFT Rhat	0.9997743	1.004905

The simulations can be run for longer to improve the estimates.

Other standard diagnostic plots include the MCMC trace and pairs plots for looking at parameter correlation. For this model, most parameters are uncorrelated, but some have been slow to converge.

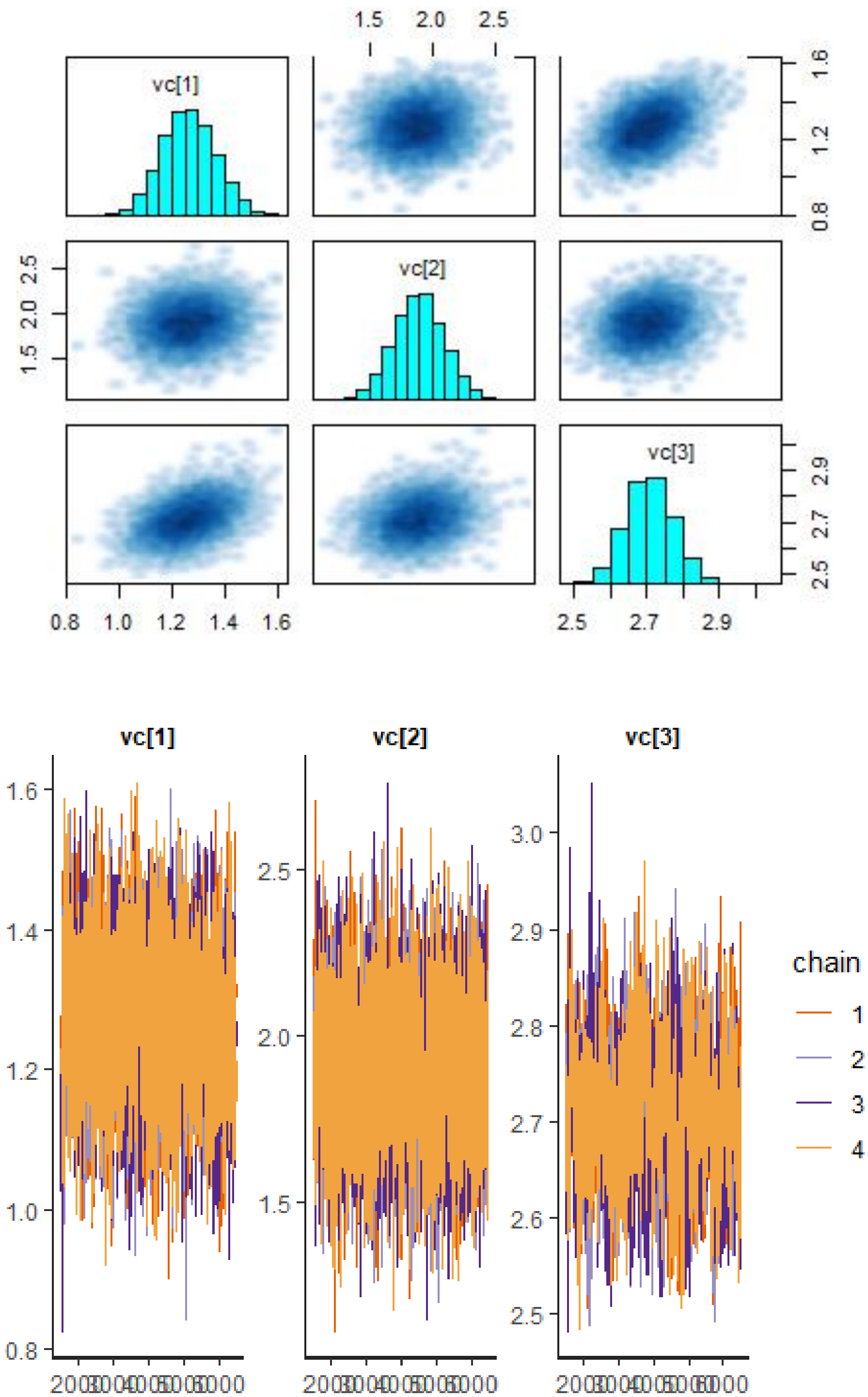


Figure 7: Selected diagnostic output from MCMC fit for worst parameter performance vessel size class parameters.

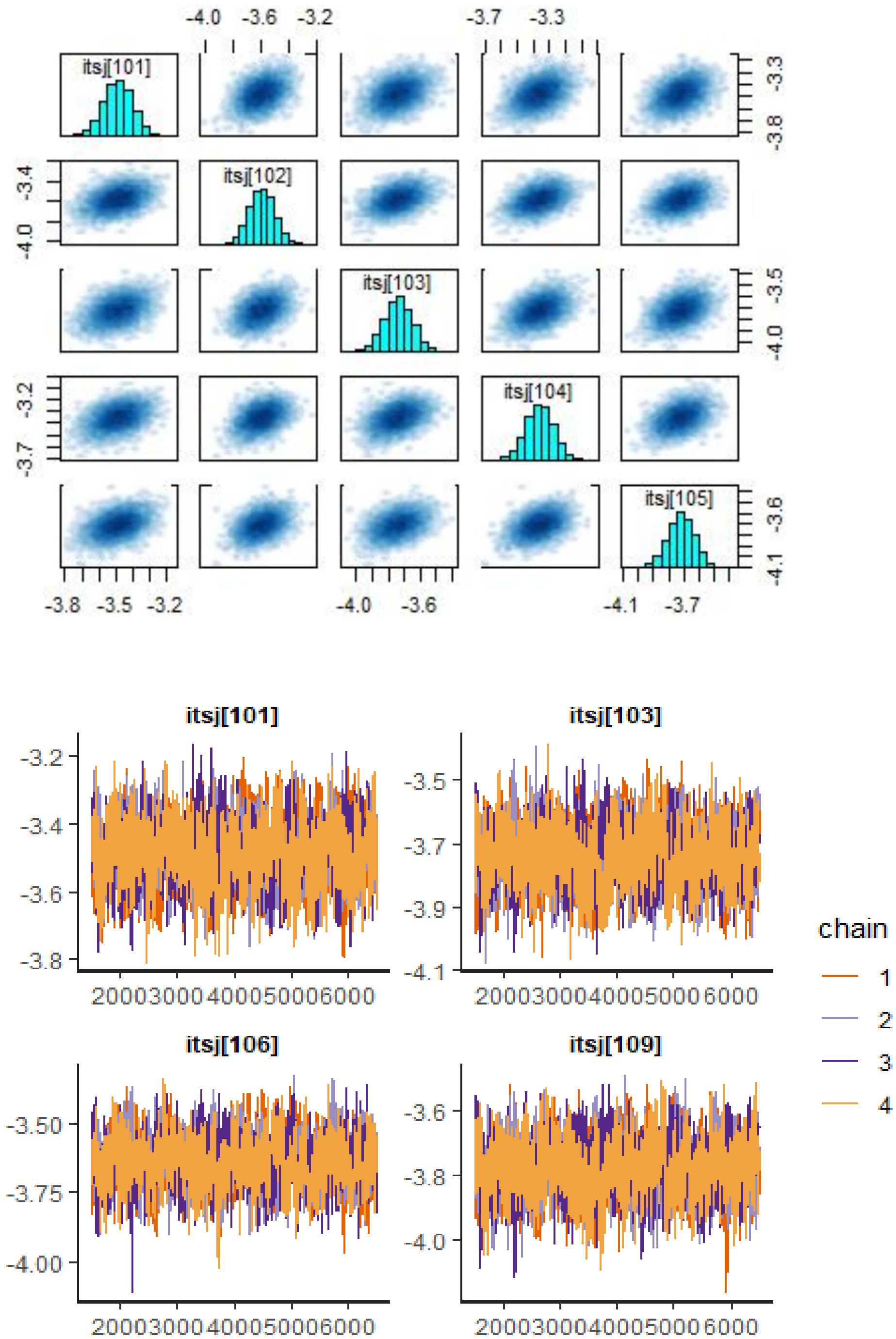


Figure 8: Diagnostics for selected worse parameter estimates from the time series indices.

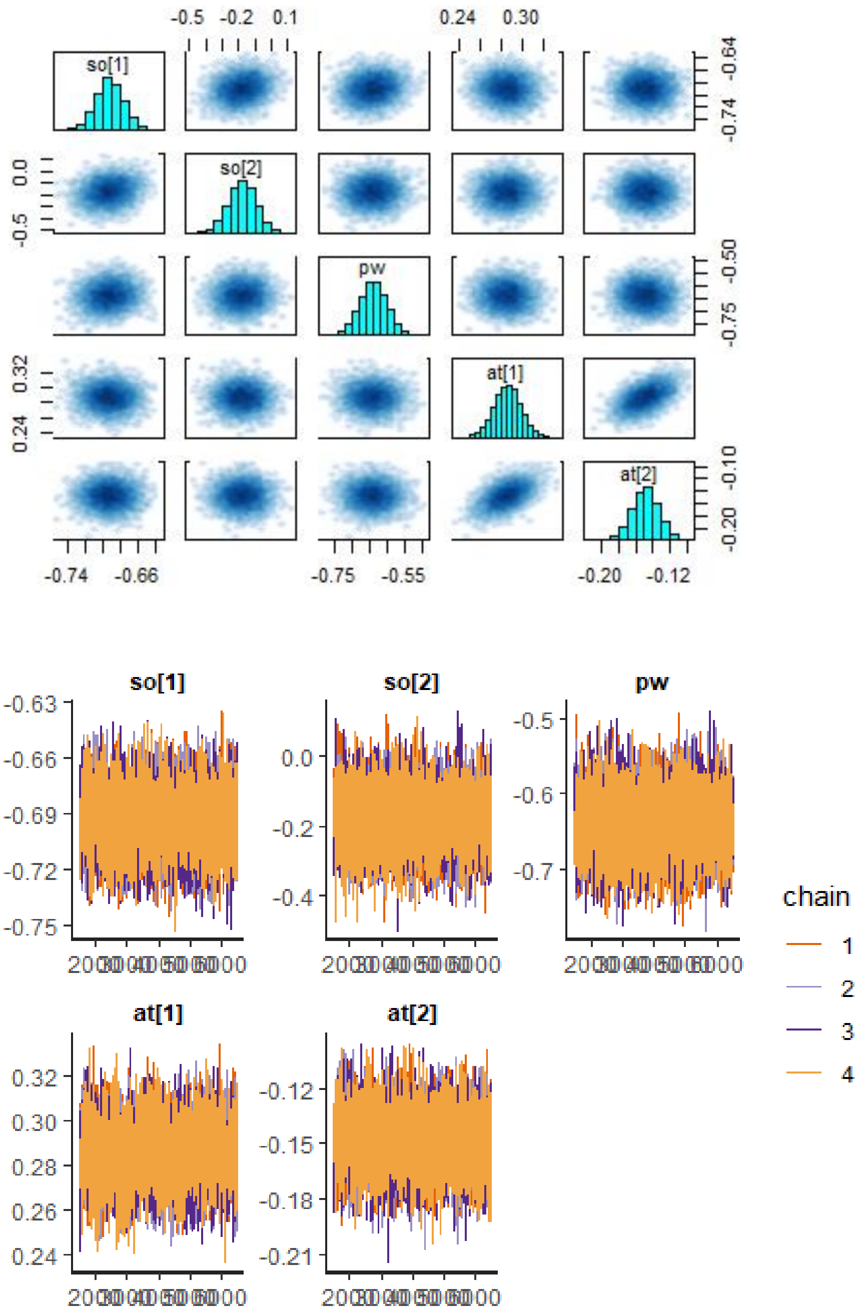


Figure 9: Diagnostics for data source (so), atoll chain (at) and power (sail vs engine).

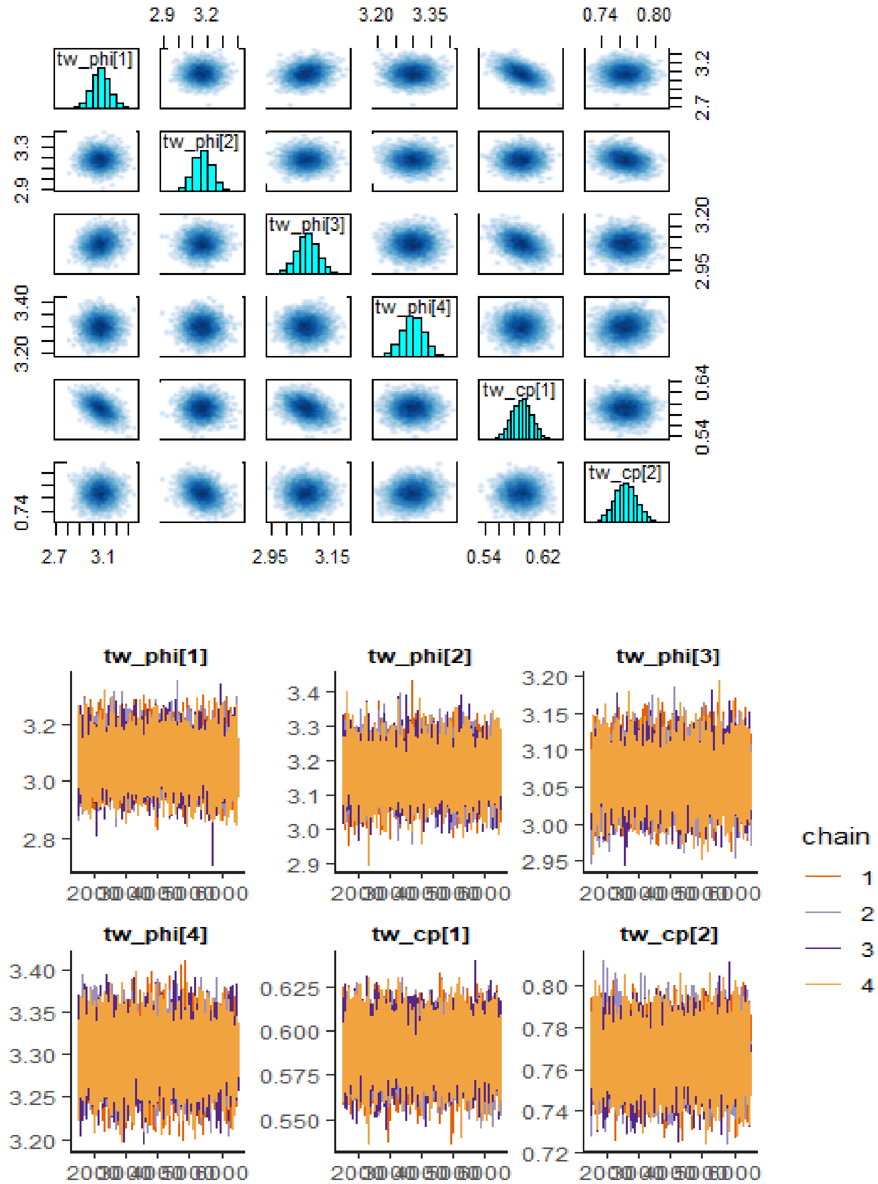
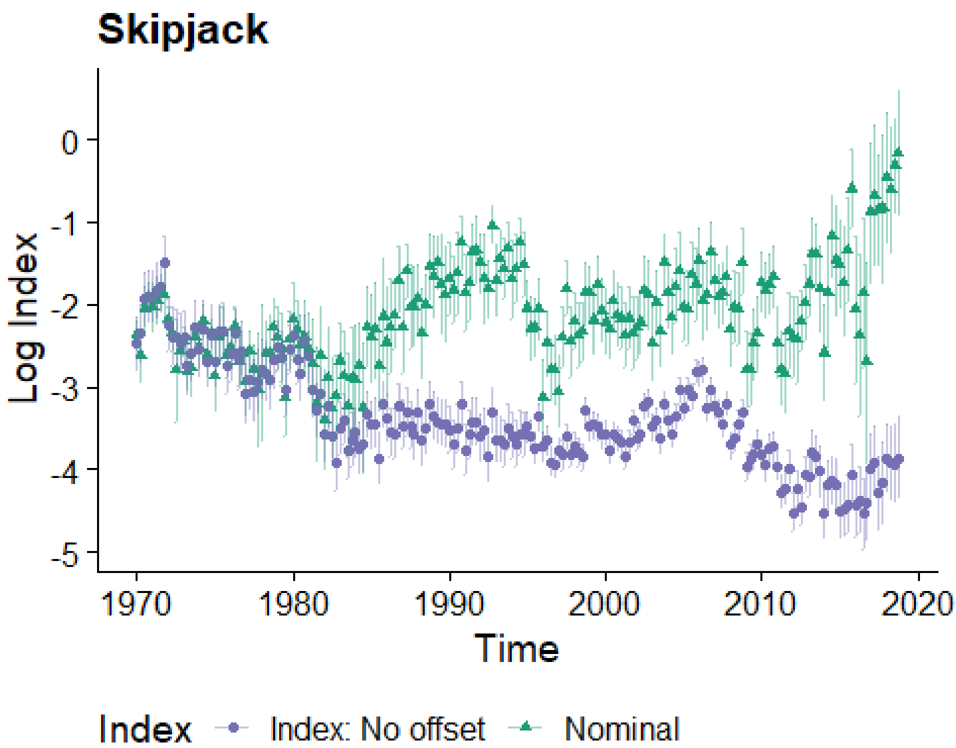
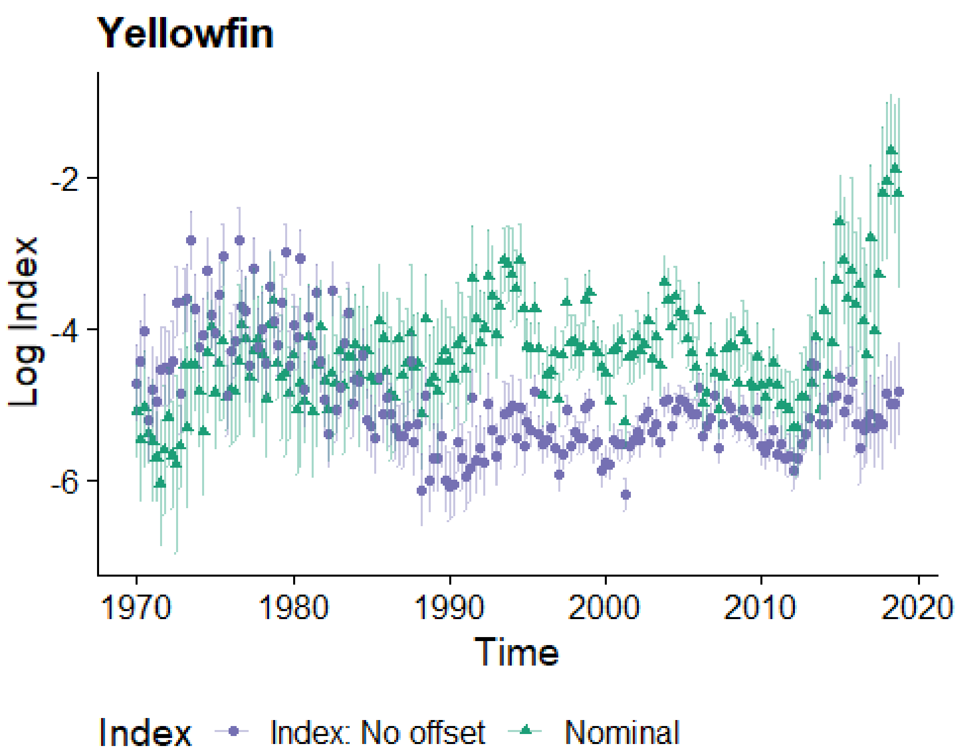


Figure 10: Diagnostics for the Tweedie parameters phi (dispersion) and p (index).

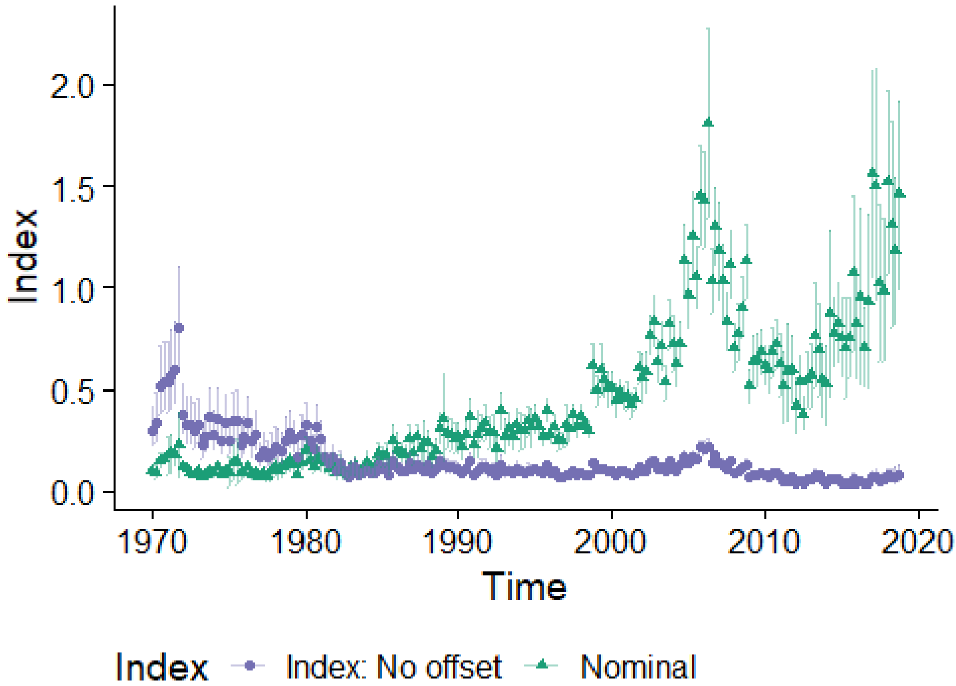
Abundance Indices

The quarterly indices are directly estimated as parameters in the model (itsj, ityf).


Skipjack
Log Index
0
-1
-2
-3
-4
-5
1970
1980
1990
2000
2010
2020
Time
Index
Index: No offset
Nominal


Yellowfin
Log Index
-2
-4
-6
1970
1980
1990
2000
2010
2020
Time
Index
Index: No offset
Nominal

Skipjack



Yellowfin

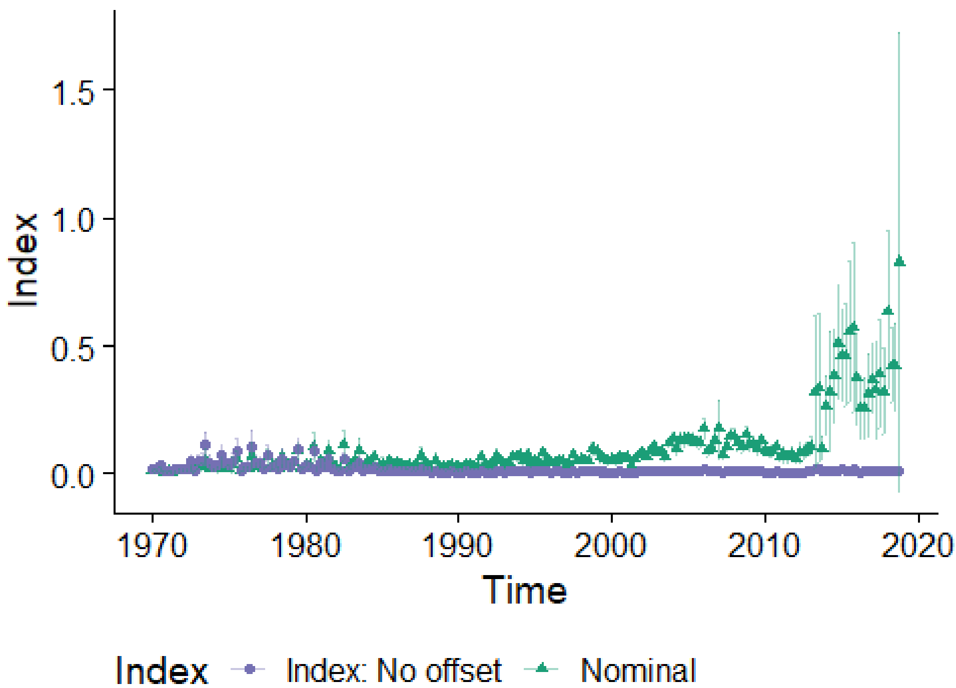


Figure 11: Nominal (CPUE) and fitted abundance indices estimated from the model without the expert opinion offset for skipjack and yellowfin on log and linear scales.

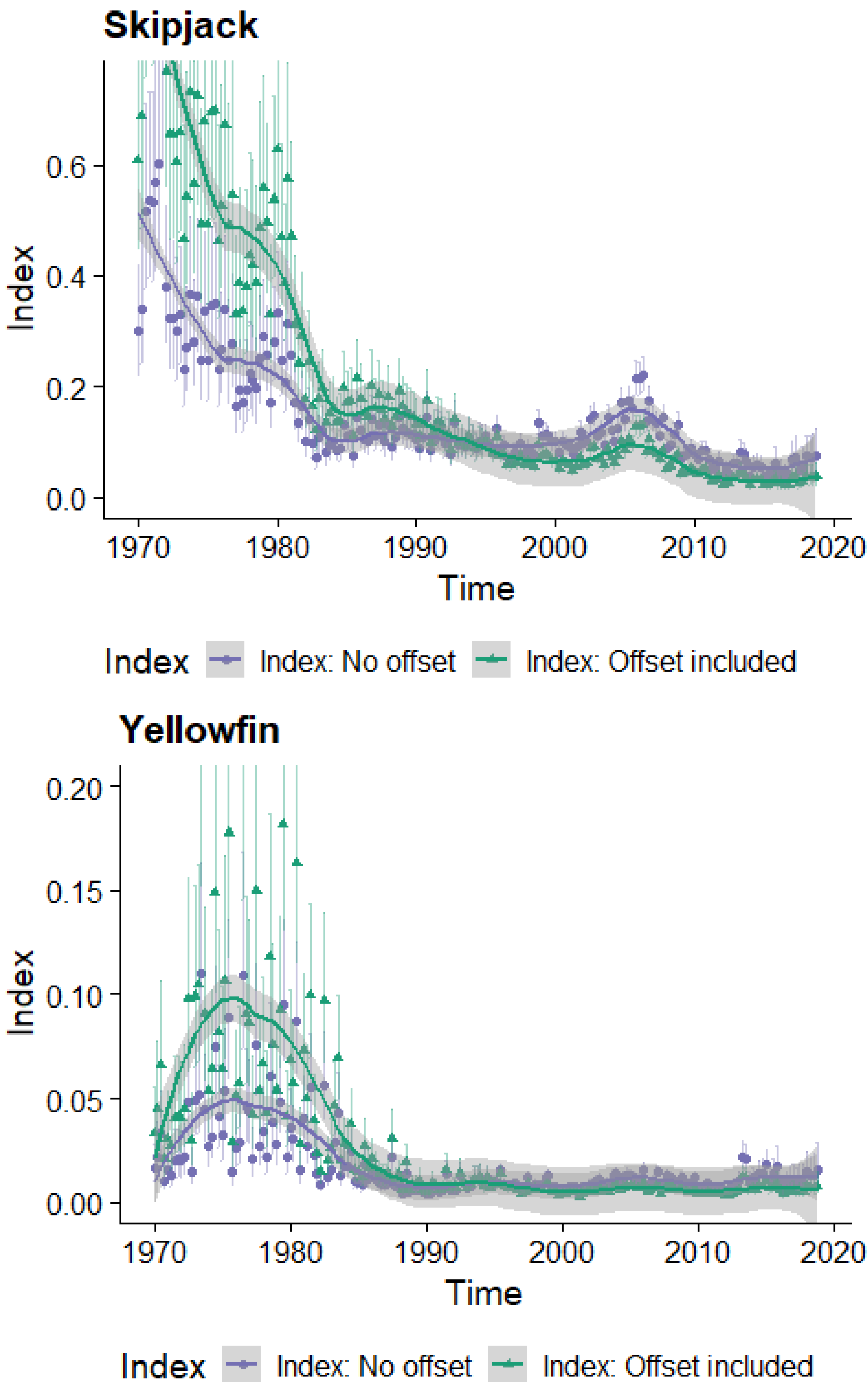


Figure 12: Fitted abundance indices estimated from the model with and without the expert opinion offset for skipjack and yellowfin on linear scales. A loess smoothing function has been added to each index.

Vessel Size Effect

The vessel size category regression estimates are similar to the maximum likelihood estimates. Note that the slope regression estimate for the smallest size class has been enforced to be flat to avoid significant increasing catch rates with decreasing length.

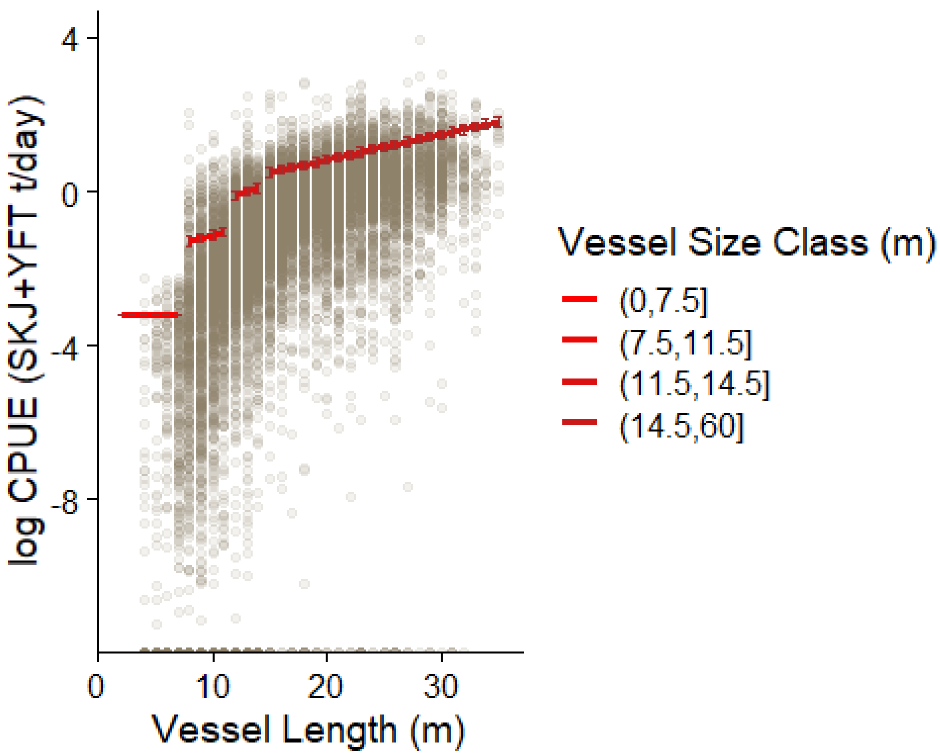


Figure 13: Median and 95% probability interval for vessel size parameters, adjusted to plot over log-CPUE observations 1995-2016.

Motorization

The motorization model bridges the gap when motorization does not exist reasonably well. The use of sail significantly reduced the catch rates for vessels and explains the early increasing catch rate trend in the 1970s as motors were installed. The results suggest sail boats had around 30% of the catch rates for motor vessels and were less likely to land yellowfin.

Table 7: Motorization model parameter estimates.

```
><> Inference for Stan model: MalInd.
><> 4 chains, each with iter=6500; warmup=1500; thin=2;
><> post-warmup draws per chain=2500, total post-warmup draws=10000.
><>
><>             mean se_mean   sd   10%   50%   90% n_eff Rhat
><> mot_p[1]   0.16       0 0.04  0.12  0.16  0.21  8097    1
><> mot_p[2]   0.18       0 0.04  0.13  0.18  0.24  8488    1
><> mot_p[3]   0.21       0 0.04  0.15  0.21  0.27  8185    1
><> mot_p[4]   0.23       0 0.05  0.17  0.23  0.30  8645    1
><> mot_p[5]   0.26       0 0.05  0.20  0.26  0.33  8394    1
><> mot_p[6]   0.29       0 0.05  0.22  0.29  0.36  8812    1
><> mot_p[7]   0.32       0 0.06  0.25  0.32  0.39  8763    1
><> mot_p[8]   0.35       0 0.06  0.27  0.35  0.42  8556    1
><> mot_p[9]   0.38       0 0.05  0.32  0.38  0.44  8586    1
><> mot_p[10]  0.41       0 0.06  0.34  0.41  0.48  8354    1
><> mot_p[11]  0.44       0 0.06  0.36  0.44  0.52  8378    1
><> mot_p[12]  0.47       0 0.06  0.39  0.47  0.55  8042    1
><> mot_p[13]  0.50       0 0.06  0.42  0.50  0.57  8356    1
><> mot_p[14]  0.53       0 0.06  0.45  0.53  0.61  8989    1
><> mot_p[15]  0.55       0 0.06  0.47  0.55  0.63  9030    1
><> mot_p[16]  0.58       0 0.07  0.49  0.58  0.67  8525    1
><> mot_p[17]  0.61       0 0.06  0.53  0.61  0.68  8820    1
><> mot_p[18]  0.63       0 0.07  0.53  0.64  0.72  8779    1
><> mot_p[19]  0.66       0 0.07  0.56  0.66  0.75  8255    1
><> mot_p[20]  0.68       0 0.08  0.57  0.68  0.78  8324    1
><> pw        -0.64       0 0.04 -0.69 -0.64 -0.59  6387    1
><>
><> Samples were drawn using NUTS(diag_e) at Mon Apr 27 11:31:58 2020.
><> For each parameter, n_eff is a crude measure of effective sample size,
><> and Rhat is the potential scale reduction factor on split chains (at
><> convergence, Rhat=1).
```

The random effects model fits observations well 1979 onwards, but the model may have a tendency to overestimate early motorization despite increasing the steepness in the generalized logistic model. There may be an argument to fix the random effects mean to a model that most agrees with available registry and effort data (Figure 5) rather than fit it in the final model.

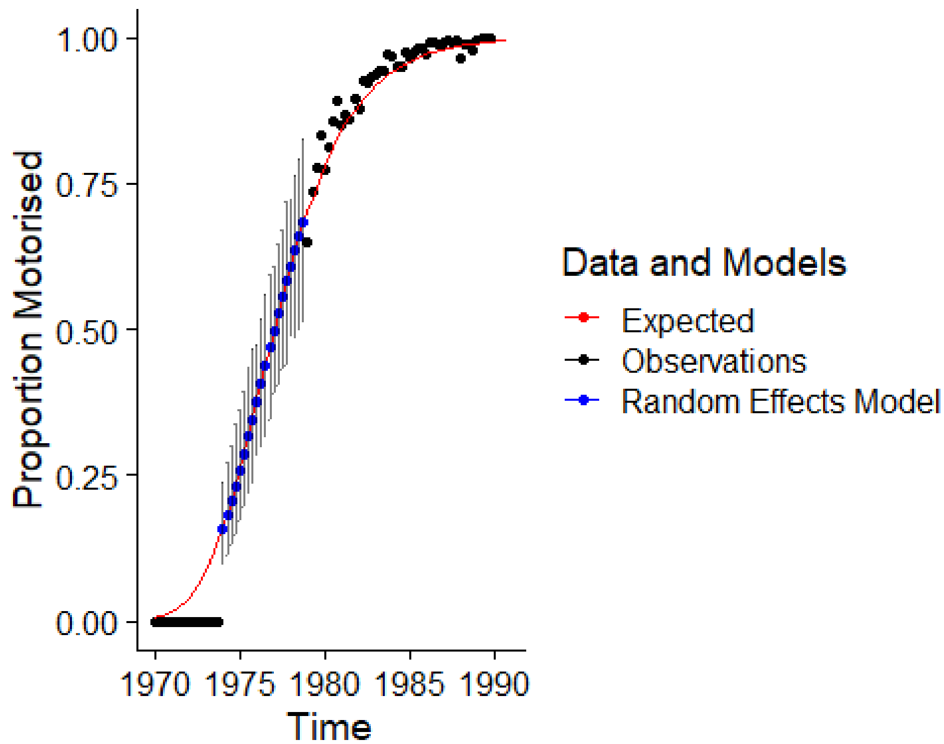


Figure 14: Proportion mechanized with observations, logistic curve defining expected proportion and "random effect" estimates with 90% confidence interval.

Conclusion

The objective has been to estimate abundance indices suitable for use in stock assessments. The model has used all available information to develop credible indices of abundance for skipjack and yellowfin. Abundance indices show a clear decline consistent with possible population trends and in contrast to the nominal catch rates. The standardization process has been carefully documented and justified. The analysis is fully reproducible and have been made available for peer review. This should allow independent review of the indices and the process applied to obtain them, to ensure they are correct and as far as possible reflect changes in abundance of these species.

Two types of indices were produced. The "no offset" model only used the available data, whereas the "expert opinion offset" model used subjective information on the likely impact of changes in fishing operations which have not been recorded. Including the "expert opinion offset" results unsurprisingly in lower abundance estimates for these species. These might be considered as best and worst case scenarios for tuna abundance.

Outstanding issues that may require further consideration and research include:

- The unrealistic increasing catch rates for small vessel less than 8m length, which include troll vessels.

- Mean fish weight has been included in the data as a mixture of observations and best guesses. This has added to the index errors in ways that are not fully understood. Further review of the use of fish mean weight to convert recorded fish numbers to estimated landings weight could improve the index further.

- Government initiatives to encourage fish production, such as prizes for highest reported catches and minimum effort compensation schemes, may have affected data records but no clear pattern emerged. There could still be hidden biases and this adds to general uncertainty, but lack of a pattern suggests that any biases are most likely small compared to other effects.

- Recent reporting rates declined when the previous island-based reporting switched to logbooks reporting. The recent changes to the regulations should improve the reporting rates and improvements have already been observed in the most recent data.

- Some of the observed fluctuations in the abundance indices could be due to other unmeasured effects. Perhaps of most concern are drifting FADs, which are known to have increased use by purse seiners, but could also increase through natural events (e.g. Tsunamis) and other human activities (e.g. lost fishing gear, floats, litter). Increased availability of floating FADs that drift into the Maldivian waters may not only add to the overall trend, but could raise the effective catchability over short term events producing fluctuations in catch rates.

- The data set may benefit from further filtering of vessels that are not pole and line trips. For this analysis, the default has been to include data rather than exclude. However, these vessels cannot be excluded from the IPTP data, and with the older data containing more small vessels, it is these data that may be most affected.

- The earliest years in the time series (1970-1980) show a sharp decline in catch rates that may be an artefact of the unknown effects such as inaccurate recording of activity (e.g. non-successful trips) and species (not discriminating between skipjack and yellowfin).

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Appendix 1: Tables of Log-abundance indices

Table A: Skipjack log abundance indices: No expert opinion offset

Year	Quarter	Mean	SD	CI 2.5%	Median	CI 97.5
1970	1	-2.477217	0.16834516	-2.800262	-2.479822	-2.143200
1970	2	-2.353236	0.17968278	-2.701687	-2.356188	-1.999453
1970	3	-1.939255	0.16176756	-2.250303	-1.940650	-1.615835
1970	4	-1.900849	0.15814979	-2.205404	-1.901199	-1.591326
1971	1	-1.906516	0.16251768	-2.222351	-1.909656	-1.588110
1971	2	-1.839890	0.16692379	-2.166316	-1.841525	-1.502800
1971	3	-1.785203	0.16654562	-2.109650	-1.786891	-1.455112
1971	4	-1.493856	0.15597208	-1.797841	-1.495253	-1.182658
1972	1	-2.246166	0.16444386	-2.562619	-2.245803	-1.923350
1972	2	-2.402769	0.17788458	-2.742947	-2.406765	-2.039624
1972	3	-2.400979	0.17686748	-2.737682	-2.404429	-2.049406
1972	4	-2.477714	0.18260531	-2.832242	-2.477573	-2.113861
1973	1	-2.390795	0.16355794	-2.708808	-2.390085	-2.071496
1973	2	-2.736500	0.18248186	-3.090223	-2.738309	-2.376854
1973	3	-2.580813	0.17336436	-2.919404	-2.583159	-2.243828
1973	4	-2.284982	0.16637610	-2.603063	-2.285319	-1.956830
1974	1	-2.541812	0.16680425	-2.863718	-2.543534	-2.210006
1974	2	-2.292543	0.16381710	-2.608858	-2.294307	-1.965965
1974	3	-2.677877	0.17737647	-3.021038	-2.679851	-2.329183
1974	4	-2.360225	0.17369240	-2.694508	-2.362967	-2.015464
1975	1	-2.676545	0.17639133	-3.017467	-2.679518	-2.327021
1975	2	-2.333332	0.16895510	-2.660932	-2.335827	-1.995356
1975	3	-2.327029	0.17705837	-2.669667	-2.326944	-1.976531
1975	4	-2.736742	0.18661558	-3.088787	-2.740655	-2.363248
1976	1	-2.604420	0.16898102	-2.929828	-2.603483	-2.273887
1976	2	-2.357318	0.16713057	-2.677703	-2.359425	-2.029698
1976	3	-2.676046	0.18526899	-3.038001	-2.675149	-2.310385
1976	4	-2.556438	0.18151840	-2.905505	-2.561999	-2.190136
1977	1	-3.074026	0.18360927	-3.433007	-3.073758	-2.705931
1977	2	-2.906933	0.18273084	-3.253202	-2.910462	-2.539388
1977	3	-3.045011	0.18447457	-3.402205	-3.048067	-2.671786
1977	4	-2.922899	0.19384898	-3.295459	-2.924854	-2.538162
1978	1	-2.776182	0.17783730	-3.121512	-2.777550	-2.423799
1978	2	-2.826936	0.19138065	-3.191661	-2.828713	-2.451698

Year	Quarter	Mean	SD	CI 2.5%	Median	CI 97.5
1978	3	-2.902686	0.19166267	-3.274504	-2.901627	-2.522859
1978	4	-2.665619	0.19175747	-3.037451	-2.666934	-2.286766
1979	1	-2.519383	0.15385155	-2.815557	-2.519519	-2.213026
1979	2	-2.634369	0.15167699	-2.932235	-2.635417	-2.335183
1979	3	-3.038173	0.16425058	-3.359594	-3.037458	-2.719439
1979	4	-2.546460	0.15342717	-2.840311	-2.547547	-2.242791
1980	1	-2.377748	0.14585499	-2.656299	-2.378757	-2.094302
1980	2	-2.669522	0.15149588	-2.962526	-2.669772	-2.373569
1980	3	-2.847161	0.15720588	-3.152798	-2.847171	-2.541251
1980	4	-2.435181	0.15686172	-2.739438	-2.436771	-2.127710
1981	1	-2.629481	0.15383872	-2.929023	-2.629753	-2.324771
1981	2	-3.035927	0.16563150	-3.352986	-3.039825	-2.701404
1981	3	-3.276016	0.16342946	-3.589601	-3.278445	-2.953974
1981	4	-3.075416	0.16233719	-3.395368	-3.076050	-2.757414
1982	1	-3.568650	0.17299744	-3.904707	-3.571370	-3.226099
1982	2	-3.225017	0.16213670	-3.540991	-3.227516	-2.902474
1982	3	-3.605960	0.16732582	-3.932112	-3.607567	-3.277109
1982	4	-3.903957	0.17464881	-4.247148	-3.906973	-3.560809
1983	1	-3.510322	0.16175916	-3.826673	-3.511119	-3.189895
1983	2	-3.398035	0.15498813	-3.700002	-3.399853	-3.090737
1983	3	-3.771134	0.16945939	-4.100112	-3.773600	-3.439368
1983	4	-3.643586	0.16797038	-3.973771	-3.645433	-3.315226
1984	1	-3.555481	0.15152198	-3.845443	-3.557373	-3.260709
1984	2	-3.741817	0.15436630	-4.035435	-3.742255	-3.436740
1984	3	-3.699813	0.15503971	-4.003702	-3.700366	-3.396188
1984	4	-3.322575	0.14085676	-3.598388	-3.320026	-3.049405
1985	1	-3.460769	0.14383518	-3.735172	-3.462089	-3.175954
1985	2	-3.439929	0.15082881	-3.728162	-3.441402	-3.144024
1985	3	-3.870623	0.16276599	-4.180561	-3.872635	-3.547356
1985	4	-3.209845	0.14345447	-3.491377	-3.208638	-2.930376
1986	1	-3.382003	0.14571124	-3.670194	-3.382456	-3.090435
1986	2	-3.550170	0.15175335	-3.846284	-3.550524	-3.257722
1986	3	-3.571122	0.15395271	-3.868786	-3.570080	-3.265396
1986	4	-3.238380	0.13836243	-3.507191	-3.237730	-2.963663
1987	1	-3.461680	0.14800091	-3.738502	-3.465727	-3.162810
1987	2	-3.305578	0.14717777	-3.588219	-3.305912	-3.013351
1987	3	-3.465251	0.14841183	-3.749555	-3.465696	-3.171717

Year	Quarter	Mean	SD	CI 2.5%	Median	CI 97.5
1987	4	-3.572687	0.15270571	-3.864176	-3.573943	-3.268367
1988	1	-3.298746	0.13484227	-3.562707	-3.299019	-3.033537
1988	2	-3.652978	0.15207765	-3.945283	-3.653388	-3.346673
1988	3	-3.500421	0.14701718	-3.787374	-3.501380	-3.210269
1988	4	-3.210278	0.13403990	-3.467801	-3.210816	-2.942926
1989	1	-3.352056	0.14408163	-3.632449	-3.353032	-3.066319
1989	2	-3.414979	0.14834318	-3.702014	-3.414724	-3.129909
1989	3	-3.439624	0.14646965	-3.726072	-3.440127	-3.152862
1989	4	-3.453449	0.14781246	-3.745555	-3.453094	-3.153693
1990	1	-3.516953	0.14878532	-3.801825	-3.519257	-3.224404
1990	2	-3.692387	0.14892745	-3.982766	-3.693087	-3.402870
1990	3	-3.496684	0.14873554	-3.792065	-3.497564	-3.208732
1990	4	-3.205512	0.13971281	-3.476176	-3.206068	-2.932319
1991	1	-3.758903	0.15575571	-4.059884	-3.758844	-3.455649
1991	2	-3.566412	0.14892743	-3.855797	-3.567001	-3.268429
1991	3	-3.418166	0.14206383	-3.694333	-3.418754	-3.134836
1991	4	-3.418916	0.14481056	-3.700834	-3.420255	-3.138623
1992	1	-3.605331	0.14700431	-3.893297	-3.603960	-3.316535
1992	2	-3.523639	0.14190944	-3.798508	-3.525930	-3.244840
1992	3	-3.841698	0.15231011	-4.135349	-3.842637	-3.541259
1992	4	-3.296859	0.14052418	-3.568747	-3.296025	-3.020042
1993	1	-3.641844	0.14198170	-3.923571	-3.641479	-3.363791
1993	2	-3.638436	0.14703653	-3.924694	-3.638923	-3.349751
1993	3	-3.685892	0.14657558	-3.975761	-3.686231	-3.400191
1993	4	-3.491443	0.14260907	-3.772760	-3.492351	-3.209519
1994	1	-3.598420	0.14270574	-3.878902	-3.600955	-3.316210
1994	2	-3.689839	0.14358906	-3.963886	-3.688735	-3.404605
1994	3	-3.561381	0.13732244	-3.829381	-3.563430	-3.286929
1994	4	-3.569219	0.13739396	-3.837475	-3.570435	-3.296741
1995	1	-3.486762	0.08876742	-3.666004	-3.485912	-3.313433
1995	2	-3.588127	0.09017531	-3.762384	-3.588329	-3.410371
1995	3	-3.736765	0.09030435	-3.912485	-3.736820	-3.558395
1995	4	-3.360017	0.08582668	-3.530651	-3.359241	-3.195185
1996	1	-3.718289	0.08864145	-3.893687	-3.717740	-3.544768
1996	2	-3.641165	0.08781978	-3.815642	-3.639581	-3.473255
1996	3	-3.903722	0.08846144	-4.079695	-3.904159	-3.731264
1996	4	-3.937663	0.08738204	-4.108742	-3.937767	-3.767317

Year	Quarter	Mean	SD	CI 2.5%	Median	CI 97.5
1997	1	-3.780236	0.08671990	-3.947721	-3.779153	-3.612349
1997	2	-3.829918	0.08863490	-4.002562	-3.830401	-3.657730
1997	3	-3.608345	0.08457108	-3.777651	-3.608274	-3.443468
1997	4	-3.807399	0.08580964	-3.976836	-3.807247	-3.639636
1998	1	-3.709531	0.08482190	-3.876683	-3.708461	-3.546489
1998	2	-3.794290	0.08483771	-3.962109	-3.793687	-3.630142
1998	3	-3.854943	0.08508928	-4.026272	-3.853302	-3.694233
1998	4	-3.284843	0.08048877	-3.443365	-3.284706	-3.129239
1999	1	-3.479655	0.08113472	-3.639381	-3.477833	-3.322514
1999	2	-3.452605	0.08098274	-3.613790	-3.451585	-3.294657
1999	3	-3.478743	0.07984905	-3.637554	-3.477966	-3.323651
1999	4	-3.578148	0.08273817	-3.744544	-3.577425	-3.420422
2000	1	-3.563455	0.08127936	-3.724753	-3.562747	-3.407952
2000	2	-3.781954	0.08355786	-3.948215	-3.780043	-3.620277
2000	3	-3.576206	0.08095384	-3.734548	-3.576338	-3.419832
2000	4	-3.631961	0.08160874	-3.795054	-3.631596	-3.476073
2001	1	-3.679386	0.08163106	-3.842434	-3.677784	-3.519613
2001	2	-3.836442	0.08245011	-3.995638	-3.835515	-3.678586
2001	3	-3.680960	0.08017923	-3.839035	-3.680460	-3.528120
2001	4	-3.416512	0.07714830	-3.570293	-3.413956	-3.268169
2002	1	-3.616667	0.07875657	-3.773397	-3.616183	-3.463696
2002	2	-3.568742	0.07845552	-3.721407	-3.569363	-3.420510
2002	3	-3.225228	0.07615076	-3.377019	-3.224828	-3.078829
2002	4	-3.189376	0.07573601	-3.341035	-3.189205	-3.040830
2003	1	-3.475393	0.07944950	-3.635050	-3.475257	-3.322283
2003	2	-3.409329	0.07819007	-3.562888	-3.407545	-3.259518
2003	3	-3.625692	0.08113307	-3.785533	-3.625899	-3.469433
2003	4	-3.214444	0.07837381	-3.368982	-3.213786	-3.062183
2004	1	-3.397347	0.08308968	-3.560482	-3.396657	-3.234359
2004	2	-3.562550	0.08484320	-3.736150	-3.561999	-3.399288
2004	3	-3.364561	0.08324795	-3.528733	-3.363665	-3.201773
2004	4	-3.047073	0.07944787	-3.203008	-3.045735	-2.895122
2005	1	-3.242933	0.07656468	-3.395065	-3.243061	-3.094052
2005	2	-3.031844	0.07535329	-3.185880	-3.031202	-2.886979
2005	3	-3.114715	0.07664220	-3.269852	-3.112431	-2.968841
2005	4	-2.819825	0.07409257	-2.965276	-2.818697	-2.676885
2006	1	-2.826212	0.07408619	-2.973638	-2.824873	-2.684420

Year	Quarter	Mean	SD	CI 2.5%	Median	CI 97.5
2006	2	-2.787457	0.07419244	-2.934543	-2.785567	-2.644327
2006	3	-3.250118	0.07748846	-3.403903	-3.248678	-3.100807
2006	4	-3.025159	0.07483119	-3.174592	-3.024849	-2.879768
2007	1	-3.230953	0.07675134	-3.381261	-3.229530	-3.083655
2007	2	-3.295504	0.07739105	-3.448067	-3.294917	-3.148480
2007	3	-3.461386	0.07880013	-3.615850	-3.460654	-3.312630
2007	4	-3.207774	0.07594950	-3.358289	-3.207659	-3.062938
2008	1	-3.706929	0.08622704	-3.880616	-3.705277	-3.543650
2008	2	-3.621292	0.08500767	-3.786878	-3.620448	-3.456680
2008	3	-3.442289	0.08298236	-3.604810	-3.440878	-3.280301
2008	4	-3.302154	0.08257105	-3.468005	-3.301712	-3.145267
2009	1	-3.960040	0.08582801	-4.129324	-3.960074	-3.792252
2009	2	-3.875622	0.08637224	-4.047215	-3.874611	-3.707308
2009	3	-3.813043	0.08520836	-3.984018	-3.812024	-3.650841
2009	4	-3.689375	0.08404818	-3.853499	-3.689174	-3.526931
2010	1	-3.823044	0.08835345	-3.996969	-3.823494	-3.649579
2010	2	-3.952563	0.08971638	-4.131251	-3.951560	-3.781013
2010	3	-3.753861	0.09002706	-3.930200	-3.752787	-3.578596
2010	4	-3.729915	0.08848986	-3.904192	-3.728475	-3.557201
2011	1	-3.958282	0.09551730	-4.144369	-3.958969	-3.772366
2011	2	-4.270990	0.10171033	-4.468575	-4.271872	-4.072324
2011	3	-4.224026	0.10442764	-4.428796	-4.223385	-4.019645
2011	4	-3.987440	0.10639880	-4.194955	-3.988717	-3.775620
2012	1	-4.519736	0.11698538	-4.750888	-4.520218	-4.290550
2012	2	-4.232109	0.11272155	-4.451957	-4.232033	-4.014977
2012	3	-4.463927	0.11247170	-4.684773	-4.464095	-4.245600
2012	4	-4.066526	0.11535720	-4.294453	-4.065443	-3.837849
2013	1	-4.077747	0.12485567	-4.322307	-4.078712	-3.831603
2013	2	-3.784980	0.13355338	-4.041710	-3.784203	-3.523891
2013	3	-3.846259	0.12645796	-4.094062	-3.846029	-3.602696
2013	4	-4.025719	0.15981862	-4.335258	-4.026431	-3.708755
2014	1	-4.531894	0.14755044	-4.815285	-4.532748	-4.243867
2014	2	-4.191339	0.15555998	-4.492399	-4.190418	-3.884312
2014	3	-4.139845	0.15064668	-4.429086	-4.139990	-3.839066
2014	4	-4.189358	0.16199308	-4.502788	-4.190144	-3.868778
2015	1	-4.511964	0.16767158	-4.841250	-4.509297	-4.183109
2015	2	-4.486155	0.16938766	-4.819454	-4.487388	-4.155503

Year	Quarter	Mean	SD	CI 2.5%	Median	CI 97.5
2015	3	-4.423174	0.17902527	-4.768773	-4.422201	-4.069976
2015	4	-4.064104	0.18951404	-4.427884	-4.066709	-3.685946
2016	1	-4.424202	0.20084919	-4.813648	-4.423667	-4.030629
2016	2	-4.383582	0.20540280	-4.778913	-4.383069	-3.975488
2016	3	-4.539944	0.21599907	-4.958743	-4.539804	-4.119331
2016	4	-4.419523	0.22026438	-4.844846	-4.417582	-3.984098
2017	1	-3.978878	0.20116372	-4.374350	-3.980709	-3.577106
2017	2	-3.905498	0.21205441	-4.311131	-3.909113	-3.485707
2017	3	-4.293261	0.22601227	-4.733975	-4.290827	-3.841844
2017	4	-4.166600	0.24525519	-4.649928	-4.166951	-3.677198
2018	1	-3.869382	0.20655980	-4.265489	-3.868603	-3.462633
2018	2	-3.926434	0.22883758	-4.376693	-3.927542	-3.475614
2018	3	-3.935296	0.24787636	-4.418441	-3.938820	-3.439513
2018	4	-3.863585	0.25474571	-4.360372	-3.867021	-3.351671

Table B: Yellowfin log abundance indices: No expert opinion offset

Year	Quarter	Mean	SD	CI 2.5%	Median	CI 97.5
1970	1	-4.730856	0.25283431	-5.208646	-4.737331	-4.226025
1970	2	-4.443069	0.27293641	-4.961804	-4.446146	-3.889304
1970	3	-4.043899	0.24211219	-4.508196	-4.047425	-3.560340
1970	4	-5.212704	0.27916069	-5.739609	-5.216761	-4.647918
1971	1	-4.801310	0.26932581	-5.312885	-4.802302	-4.249194
1971	2	-4.955169	0.28979100	-5.506647	-4.962661	-4.379683
1971	3	-4.536798	0.27092487	-5.051992	-4.543802	-3.986021
1971	4	-4.519163	0.26567521	-5.023331	-4.520155	-3.991355
1972	1	-4.535100	0.25700987	-5.022741	-4.536411	-4.023456
1972	2	-4.442298	0.26285123	-4.942538	-4.446122	-3.913855
1972	3	-3.652527	0.23483453	-4.102081	-3.658143	-3.181984
1972	4	-4.848897	0.28594558	-5.400640	-4.852791	-4.276862
1973	1	-3.644591	0.21812722	-4.068149	-3.645612	-3.216137
1973	2	-3.595651	0.23051003	-4.038517	-3.597797	-3.142295
1973	3	-2.837637	0.19628991	-3.217705	-2.839940	-2.447781
1973	4	-3.729295	0.22476508	-4.161642	-3.732789	-3.279076
1974	1	-4.251145	0.23792276	-4.704674	-4.255838	-3.773958
1974	2	-4.079638	0.23191665	-4.524249	-4.083237	-3.612221
1974	3	-3.228664	0.21342584	-3.644456	-3.231020	-2.807978
1974	4	-3.822501	0.23503014	-4.276929	-3.824449	-3.354015

Year	Quarter	Mean	SD	CI 2.5%	Median	CI 97.5
1975	1	-4.070737	0.24306166	-4.528984	-4.072804	-3.584086
1975	2	-3.561350	0.22423463	-3.995265	-3.564978	-3.114963
1975	3	-3.050193	0.21369012	-3.454639	-3.050577	-2.632032
1975	4	-4.873363	0.28261471	-5.416793	-4.879676	-4.303968
1976	1	-4.287101	0.24170502	-4.744729	-4.292526	-3.805575
1976	2	-4.177411	0.24307617	-4.640598	-4.177995	-3.689553
1976	3	-2.838558	0.20849296	-3.240589	-2.844895	-2.416733
1976	4	-3.708830	0.24075627	-4.169716	-3.713714	-3.237356
1977	1	-3.760727	0.22420299	-4.182551	-3.763703	-3.312977
1977	2	-4.484795	0.25664562	-4.981392	-4.487666	-3.968809
1977	3	-3.213622	0.20878572	-3.614493	-3.214557	-2.799580
1977	4	-4.242973	0.25206260	-4.714954	-4.247547	-3.739035
1978	1	-4.011776	0.23695397	-4.465120	-4.013766	-3.531835
1978	2	-4.448884	0.26258062	-4.943945	-4.454776	-3.919649
1978	3	-3.436823	0.22804946	-3.875041	-3.439234	-2.980138
1978	4	-3.890646	0.25297343	-4.367440	-3.896087	-3.387334
1979	1	-4.214841	0.21440432	-4.619149	-4.219556	-3.787933
1979	2	-3.671263	0.19410262	-4.038714	-3.674200	-3.284676
1979	3	-2.985065	0.17674182	-3.327795	-2.986807	-2.630938
1979	4	-4.472142	0.22398166	-4.910314	-4.477261	-4.025462
1980	1	-3.950775	0.19944141	-4.335743	-3.953401	-3.551880
1980	2	-4.122696	0.20820378	-4.529592	-4.125537	-3.711885
1980	3	-3.067609	0.17939418	-3.411562	-3.070740	-2.712373
1980	4	-4.815935	0.23974996	-5.277204	-4.818241	-4.337198
1981	1	-3.851003	0.20280201	-4.237793	-3.853913	-3.437950
1981	2	-4.229800	0.21347288	-4.641809	-4.231201	-3.807382
1981	3	-3.521015	0.18623070	-3.881094	-3.526285	-3.143201
1981	4	-4.433324	0.21601926	-4.850688	-4.437040	-4.002072
1982	1	-4.938652	0.22965083	-5.376513	-4.937910	-4.493528
1982	2	-5.386592	0.24474521	-5.855626	-5.388103	-4.901320
1982	3	-3.502218	0.18231373	-3.852539	-3.505051	-3.139294
1982	4	-5.070392	0.22395641	-5.503246	-5.075353	-4.625185
1983	1	-4.782591	0.21228064	-5.190071	-4.787310	-4.354721
1983	2	-4.194789	0.18947182	-4.560181	-4.197221	-3.811430
1983	3	-3.780961	0.18797603	-4.143327	-3.783382	-3.401449
1983	4	-5.006956	0.22525382	-5.443746	-5.009453	-4.556827
1984	1	-4.679014	0.19604687	-5.055282	-4.681767	-4.286174

Year	Quarter	Mean	SD	CI 2.5%	Median	CI 97.5
1984	2	-4.689830	0.19780269	-5.064739	-4.691425	-4.292503
1984	3	-4.358782	0.18338797	-4.717810	-4.359967	-3.998028
1984	4	-5.222599	0.20501877	-5.615487	-5.221917	-4.820219
1985	1	-5.288960	0.20033353	-5.677401	-5.291370	-4.888095
1985	2	-5.459737	0.22124066	-5.892378	-5.461089	-5.017595
1985	3	-4.661614	0.19713143	-5.048541	-4.661950	-4.274061
1985	4	-5.123408	0.20292541	-5.520361	-5.123088	-4.717729
1986	1	-4.912161	0.19515963	-5.288421	-4.914267	-4.521914
1986	2	-5.140968	0.21068431	-5.545530	-5.142119	-4.719269
1986	3	-5.321902	0.21435989	-5.735672	-5.324381	-4.897507
1986	4	-5.421333	0.20893533	-5.829925	-5.424011	-5.010404
1987	1	-5.420792	0.21591187	-5.837717	-5.421073	-4.988043
1987	2	-5.285598	0.21821791	-5.702253	-5.287331	-4.847315
1987	3	-4.444954	0.19032453	-4.809413	-4.448267	-4.063063
1987	4	-5.501116	0.21898334	-5.925314	-5.503287	-5.069532
1988	1	-5.258990	0.19785277	-5.639402	-5.259374	-4.866372
1988	2	-6.138581	0.23960623	-6.601860	-6.141558	-5.667395
1988	3	-4.894922	0.19440080	-5.264839	-4.897244	-4.504039
1988	4	-6.004751	0.21831986	-6.424271	-6.007507	-5.565497
1989	1	-5.720886	0.22298576	-6.146970	-5.722342	-5.275255
1989	2	-5.721247	0.23264291	-6.165736	-5.722683	-5.262189
1989	3	-5.433528	0.21450395	-5.843634	-5.434466	-4.999666
1989	4	-6.010405	0.22925450	-6.446784	-6.013136	-5.551008
1990	1	-6.090644	0.23501789	-6.537580	-6.091087	-5.625887
1990	2	-6.052859	0.23066526	-6.497983	-6.055519	-5.595678
1990	3	-5.490270	0.21989440	-5.912761	-5.492905	-5.057635
1990	4	-5.726316	0.22281602	-6.150111	-5.729197	-5.276568
1991	1	-5.953735	0.23695497	-6.414482	-5.955769	-5.481470
1991	2	-5.843519	0.23256901	-6.292325	-5.848881	-5.374012
1991	3	-4.923340	0.19268085	-5.298844	-4.923878	-4.540435
1991	4	-5.740283	0.22427103	-6.174163	-5.741823	-5.294098
1992	1	-5.580839	0.21174047	-5.981013	-5.584082	-5.150131
1992	2	-5.767178	0.22074352	-6.193228	-5.771728	-5.323989
1992	3	-4.993565	0.20383569	-5.389340	-4.996509	-4.589205
1992	4	-5.330607	0.20600504	-5.729648	-5.334056	-4.924462
1993	1	-5.683724	0.21422029	-6.093774	-5.684164	-5.251862
1993	2	-5.472408	0.21038668	-5.873836	-5.475577	-5.053396

Year	Quarter	Mean	SD	CI 2.5%	Median	CI 97.5
1993	3	-5.122863	0.20170876	-5.510553	-5.125580	-4.712005
1993	4	-5.107729	0.19736973	-5.483383	-5.108939	-4.716014
1994	1	-5.020818	0.19385891	-5.394130	-5.025699	-4.633638
1994	2	-5.449571	0.20150149	-5.836724	-5.452830	-5.040067
1994	3	-5.041262	0.19055329	-5.413248	-5.044433	-4.667549
1994	4	-5.548059	0.20112839	-5.931637	-5.549108	-5.142676
1995	1	-5.226780	0.11396966	-5.448589	-5.228251	-5.003893
1995	2	-5.337734	0.11471723	-5.560123	-5.338748	-5.113027
1995	3	-4.825699	0.10792394	-5.034876	-4.827364	-4.617567
1995	4	-5.389920	0.11267862	-5.608405	-5.389708	-5.166825
1996	1	-5.529627	0.11668175	-5.759459	-5.530048	-5.297201
1996	2	-5.463360	0.11236680	-5.680026	-5.463676	-5.237482
1996	3	-5.322521	0.10805411	-5.535038	-5.322841	-5.111751
1996	4	-5.583758	0.11037232	-5.799495	-5.583982	-5.361661
1997	1	-5.942451	0.11596331	-6.172046	-5.941804	-5.712313
1997	2	-5.658272	0.11272470	-5.883306	-5.657855	-5.435722
1997	3	-5.087001	0.10673417	-5.299534	-5.085518	-4.880951
1997	4	-5.559528	0.11000690	-5.772375	-5.559418	-5.345393
1998	1	-5.361703	0.10570855	-5.566465	-5.361099	-5.155306
1998	2	-5.438313	0.10669695	-5.651580	-5.436740	-5.229614
1998	3	-5.452036	0.10587955	-5.660500	-5.451994	-5.246097
1998	4	-5.050884	0.10042001	-5.245811	-5.052459	-4.850411
1999	1	-5.009028	0.10005334	-5.205122	-5.008274	-4.813269
1999	2	-5.552570	0.10580012	-5.758095	-5.552931	-5.345517
1999	3	-5.500852	0.10393735	-5.704683	-5.501701	-5.296818
1999	4	-5.873869	0.11134122	-6.094331	-5.873198	-5.653874
2000	1	-5.768616	0.10557572	-5.972932	-5.769670	-5.556113
2000	2	-5.793777	0.10630751	-6.001311	-5.793391	-5.584354
2000	3	-5.479171	0.10313493	-5.676660	-5.481060	-5.272829
2000	4	-5.533662	0.10313244	-5.730670	-5.534639	-5.331160
2001	1	-5.534048	0.10279017	-5.732824	-5.535189	-5.333705
2001	2	-6.202566	0.10900659	-6.418309	-6.201813	-5.989973
2001	3	-5.568393	0.10051536	-5.765897	-5.568751	-5.374702
2001	4	-5.485720	0.10026269	-5.683704	-5.485837	-5.292617
2002	1	-5.358755	0.09733752	-5.548487	-5.357960	-5.166633
2002	2	-5.487679	0.09877906	-5.684878	-5.486500	-5.295648
2002	3	-5.193397	0.09648872	-5.383689	-5.192425	-5.000103

Year	Quarter	Mean	SD	CI 2.5%	Median	CI 97.5
2002	4	-5.103079	0.09618414	-5.293812	-5.102407	-4.917971
2003	1	-5.372586	0.09916237	-5.564992	-5.373081	-5.178083
2003	2	-5.273341	0.09769161	-5.467918	-5.272880	-5.080280
2003	3	-5.495201	0.10081562	-5.694579	-5.495437	-5.298070
2003	4	-4.981765	0.09693705	-5.170814	-4.982084	-4.792941
2004	1	-4.932416	0.10136663	-5.131160	-4.932655	-4.733045
2004	2	-5.278445	0.10914643	-5.491551	-5.277359	-5.066840
2004	3	-5.067993	0.10681375	-5.277791	-5.067861	-4.859772
2004	4	-4.955908	0.10248463	-5.159251	-4.954213	-4.755425
2005	1	-4.970337	0.09180475	-5.151965	-4.970029	-4.791669
2005	2	-5.052277	0.09464128	-5.237736	-5.051832	-4.866847
2005	3	-5.122594	0.09514692	-5.308375	-5.122824	-4.939173
2005	4	-5.121690	0.09515351	-5.304920	-5.123498	-4.934234
2006	1	-4.785776	0.09200846	-4.967097	-4.784525	-4.608755
2006	2	-5.416264	0.09820615	-5.613475	-5.415558	-5.225249
2006	3	-5.278016	0.09752727	-5.467031	-5.278736	-5.086742
2006	4	-5.183924	0.09444053	-5.366552	-5.183175	-4.995694
2007	1	-4.887938	0.09236436	-5.070656	-4.887123	-4.709916
2007	2	-5.592586	0.10152230	-5.795743	-5.592404	-5.395061
2007	3	-5.272084	0.09764316	-5.464706	-5.272346	-5.081022
2007	4	-4.981804	0.09230693	-5.164542	-4.981890	-4.801005
2008	1	-5.049056	0.10424163	-5.254781	-5.048818	-4.846583
2008	2	-5.210408	0.10667714	-5.423264	-5.210308	-5.001458
2008	3	-5.287318	0.10541056	-5.491934	-5.287567	-5.083967
2008	4	-5.086755	0.10363078	-5.292635	-5.086354	-4.882728
2009	1	-5.279506	0.10414291	-5.483560	-5.279753	-5.073018
2009	2	-5.356055	0.10468810	-5.563050	-5.356020	-5.152952
2009	3	-5.399919	0.10512461	-5.607850	-5.399276	-5.191211
2009	4	-5.075606	0.10389159	-5.280405	-5.075842	-4.874212
2010	1	-5.567386	0.11128799	-5.786234	-5.567564	-5.352749
2010	2	-5.627387	0.11628835	-5.855657	-5.627472	-5.401608
2010	3	-5.525701	0.11606708	-5.752974	-5.526193	-5.298227
2010	4	-5.335988	0.11383930	-5.558187	-5.335895	-5.113072
2011	1	-5.657144	0.12263159	-5.899956	-5.657555	-5.417467
2011	2	-5.541858	0.12575559	-5.788233	-5.541266	-5.297872
2011	3	-5.706646	0.13262999	-5.967252	-5.707772	-5.443360
2011	4	-5.679845	0.13872409	-5.947796	-5.680322	-5.406260

Year	Quarter	Mean	SD	CI 2.5%	Median	CI 97.5
2012	1	-5.868251	0.14570905	-6.155659	-5.868894	-5.582653
2012	2	-5.702336	0.14195833	-5.974391	-5.704514	-5.418621
2012	3	-5.541262	0.13635196	-5.807029	-5.542271	-5.273587
2012	4	-5.394446	0.14402267	-5.671504	-5.394870	-5.109776
2013	1	-5.178961	0.15292090	-5.478415	-5.178944	-4.876858
2013	2	-4.472170	0.15801597	-4.780899	-4.473658	-4.157630
2013	3	-4.499882	0.14919128	-4.792584	-4.501315	-4.207349
2013	4	-5.270825	0.20655835	-5.665548	-5.273976	-4.855762
2014	1	-5.077879	0.17146783	-5.415423	-5.078276	-4.737676
2014	2	-5.259537	0.18975159	-5.634767	-5.260143	-4.878559
2014	3	-4.919295	0.18071004	-5.269993	-4.920476	-4.562216
2014	4	-4.893648	0.19038242	-5.260566	-4.896329	-4.520058
2015	1	-4.649105	0.17024073	-4.977184	-4.650725	-4.315214
2015	2	-5.116592	0.19643283	-5.504356	-5.116332	-4.731950
2015	3	-4.928864	0.20586999	-5.325197	-4.931749	-4.522490
2015	4	-4.695898	0.22272561	-5.128839	-4.699029	-4.250661
2016	1	-5.254190	0.23267953	-5.702702	-5.255154	-4.801332
2016	2	-5.567604	0.25826184	-6.063327	-5.572491	-5.058520
2016	3	-5.349654	0.25570251	-5.844930	-5.352172	-4.850597
2016	4	-5.246157	0.26595741	-5.758149	-5.247889	-4.713418
2017	1	-5.119898	0.24869203	-5.596038	-5.122538	-4.628037
2017	2	-5.314236	0.26871662	-5.828919	-5.318596	-4.767341
2017	3	-5.178833	0.26992699	-5.698598	-5.179909	-4.638607
2017	4	-5.255990	0.31124002	-5.844611	-5.263774	-4.631867
2018	1	-4.858967	0.25769453	-5.353669	-4.866094	-4.343136
2018	2	-5.006185	0.27956617	-5.538629	-5.007372	-4.448176
2018	3	-5.002356	0.31178126	-5.604899	-5.008730	-4.380676
2018	4	-4.821510	0.31194607	-5.418231	-4.825100	-4.196508

Table C: Skipjack log abundance indices: Includes expert opinion offset

Year	Quarter	Mean	SD	CI 2.5%	Median	CI 97.5
1970	1	-2.439250	0.16551284	-2.753357	-2.442007	-2.107946
1970	2	-2.321132	0.18019553	-2.668764	-2.321931	-1.965097
1970	3	-1.909031	0.16183027	-2.222956	-1.910019	-1.590523
1970	4	-1.869038	0.15712810	-2.168701	-1.869460	-1.555261
1971	1	-1.879234	0.16164161	-2.194027	-1.881573	-1.562852
1971	2	-1.809261	0.16785625	-2.136754	-1.812197	-1.474628

Year	Quarter	Mean	SD	CI 2.5%	Median	CI 97.5
1971	3	-1.760641	0.16640950	-2.083262	-1.760836	-1.434951
1971	4	-1.465791	0.15642961	-1.768535	-1.466730	-1.158632
1972	1	-2.208173	0.16724721	-2.530275	-2.208370	-1.877913
1972	2	-2.369958	0.17871106	-2.719750	-2.370915	-2.016550
1972	3	-2.369040	0.17578462	-2.711664	-2.369100	-2.022807
1972	4	-2.448915	0.18643847	-2.808477	-2.449635	-2.081121
1973	1	-2.361796	0.16310936	-2.684203	-2.362214	-2.043614
1973	2	-2.707700	0.18387252	-3.066052	-2.710833	-2.343228
1973	3	-2.556837	0.17457017	-2.895023	-2.559311	-2.212069
1973	4	-2.259607	0.16451920	-2.575795	-2.259219	-1.932572
1974	1	-2.516187	0.16903351	-2.850247	-2.517708	-2.182939
1974	2	-2.266781	0.16346657	-2.582618	-2.269726	-1.942390
1974	3	-2.654638	0.17875074	-3.000583	-2.655520	-2.299108
1974	4	-2.332432	0.16993314	-2.659349	-2.334871	-1.989497
1975	1	-2.653762	0.17722708	-2.999914	-2.653823	-2.305894
1975	2	-2.309497	0.16920731	-2.637384	-2.311492	-1.971686
1975	3	-2.305011	0.17393262	-2.631063	-2.307721	-1.955558
1975	4	-2.714091	0.18595636	-3.071895	-2.716552	-2.343359
1976	1	-2.583798	0.16778836	-2.911795	-2.587229	-2.241568
1976	2	-2.343112	0.17080494	-2.678134	-2.345236	-1.999018
1976	3	-2.657284	0.18314024	-3.012796	-2.657682	-2.288580
1976	4	-2.548493	0.18394314	-2.901504	-2.552100	-2.181014
1977	1	-3.056033	0.18188424	-3.406854	-3.057650	-2.692044
1977	2	-2.894400	0.18518431	-3.250483	-2.896404	-2.525790
1977	3	-3.028850	0.18634297	-3.391529	-3.033504	-2.661047
1977	4	-2.908744	0.19111870	-3.286612	-2.911235	-2.532759
1978	1	-2.772898	0.17704776	-3.115899	-2.773942	-2.422640
1978	2	-2.816537	0.19098613	-3.185071	-2.817358	-2.441301
1978	3	-2.896842	0.19123238	-3.269599	-2.897994	-2.522007
1978	4	-2.668932	0.19415659	-3.050176	-2.669257	-2.282231
1979	1	-2.527053	0.15521483	-2.831447	-2.529308	-2.216954
1979	2	-2.647207	0.15580097	-2.949874	-2.650048	-2.337896
1979	3	-3.055167	0.16338512	-3.365371	-3.056134	-2.733005
1979	4	-2.568019	0.15401096	-2.868211	-2.567375	-2.266434
1980	1	-2.408773	0.14608008	-2.691694	-2.411137	-2.119403
1980	2	-2.703132	0.15545596	-3.000838	-2.703457	-2.395246
1980	3	-2.895239	0.15881795	-3.202151	-2.895898	-2.581659

Year	Quarter	Mean	SD	CI 2.5%	Median	CI 97.5
1980	4	-2.495350	0.15491607	-2.794726	-2.496204	-2.187109
1981	1	-2.697295	0.15362851	-2.994962	-2.698909	-2.389827
1981	2	-3.111094	0.16775496	-3.433836	-3.111366	-2.777427
1981	3	-3.362388	0.16280280	-3.679919	-3.363640	-3.040302
1981	4	-3.176265	0.16378703	-3.488663	-3.179746	-2.850153
1982	1	-3.681472	0.17545893	-4.023048	-3.679809	-3.330232
1982	2	-3.352711	0.16342282	-3.668655	-3.353500	-3.031616
1982	3	-3.745821	0.17056214	-4.072674	-3.746807	-3.406131
1982	4	-4.053556	0.17850993	-4.403795	-4.052174	-3.700262
1983	1	-3.677229	0.16276196	-3.991894	-3.679232	-3.350848
1983	2	-3.575185	0.15551003	-3.878423	-3.576054	-3.267246
1983	3	-3.961162	0.16962519	-4.285643	-3.964228	-3.621249
1983	4	-3.844667	0.16905310	-4.173428	-3.844472	-3.515241
1984	1	-3.766688	0.15189586	-4.057683	-3.766899	-3.468350
1984	2	-3.962273	0.15813286	-4.271071	-3.963375	-3.647671
1984	3	-3.932220	0.15841430	-4.242257	-3.933257	-3.623501
1984	4	-3.562667	0.14097928	-3.832090	-3.565362	-3.280720
1985	1	-3.709002	0.14346098	-3.982057	-3.711128	-3.422942
1985	2	-3.699523	0.15151784	-3.994326	-3.700421	-3.402234
1985	3	-4.139483	0.16292398	-4.454688	-4.138721	-3.814147
1985	4	-3.487515	0.14096495	-3.760276	-3.486762	-3.209487
1986	1	-3.666825	0.14837647	-3.956557	-3.667993	-3.375341
1986	2	-3.839838	0.15350702	-4.140001	-3.840580	-3.540883
1986	3	-3.870527	0.15353866	-4.174873	-3.870193	-3.573375
1986	4	-3.546030	0.14050059	-3.818832	-3.545252	-3.270180
1987	1	-3.778165	0.14787029	-4.066604	-3.776811	-3.482006
1987	2	-3.629978	0.14764315	-3.923362	-3.629521	-3.345578
1987	3	-3.803104	0.14867497	-4.089389	-3.802437	-3.510290
1987	4	-3.915095	0.15243187	-4.215047	-3.914976	-3.609508
1988	1	-3.649542	0.13805446	-3.919594	-3.650194	-3.379476
1988	2	-4.011094	0.15409265	-4.305610	-4.012163	-3.703056
1988	3	-3.876305	0.14609246	-4.157219	-3.876047	-3.585803
1988	4	-3.595004	0.13513795	-3.859123	-3.594162	-3.332035
1989	1	-3.748422	0.14408155	-4.021927	-3.748313	-3.466334
1989	2	-3.825332	0.14926512	-4.122332	-3.824897	-3.529831
1989	3	-3.859486	0.14735793	-4.149423	-3.860143	-3.564093
1989	4	-3.886542	0.14567929	-4.171529	-3.887012	-3.602355

Year	Quarter	Mean	SD	CI 2.5%	Median	CI 97.5
1990	1	-3.964578	0.14635029	-4.243786	-3.965779	-3.672878
1990	2	-4.152467	0.14996142	-4.444478	-4.153429	-3.856449
1990	3	-3.972657	0.14824615	-4.258475	-3.971859	-3.682874
1990	4	-3.691835	0.13972240	-3.962952	-3.692980	-3.420000
1991	1	-4.262370	0.15232369	-4.553314	-4.265871	-3.960729
1991	2	-4.082591	0.14959437	-4.371877	-4.082986	-3.786189
1991	3	-3.946514	0.14310800	-4.220199	-3.950525	-3.658637
1991	4	-3.963689	0.14439288	-4.240267	-3.964473	-3.673865
1992	1	-4.163850	0.14721099	-4.451714	-4.164202	-3.879855
1992	2	-4.099661	0.14428634	-4.377224	-4.101818	-3.809926
1992	3	-4.429541	0.15578111	-4.728263	-4.430588	-4.116412
1992	4	-3.901314	0.14134505	-4.172189	-3.902412	-3.621016
1993	1	-4.257225	0.14149668	-4.532374	-4.256778	-3.977421
1993	2	-4.268927	0.14530926	-4.549598	-4.269335	-3.980286
1993	3	-4.335355	0.14593842	-4.615372	-4.337990	-4.046134
1993	4	-4.154327	0.14387048	-4.434888	-4.155556	-3.872686
1994	1	-4.276333	0.14300740	-4.552749	-4.279018	-3.989594
1994	2	-4.385259	0.14174984	-4.663967	-4.386531	-4.101483
1994	3	-4.268067	0.13880452	-4.540349	-4.268239	-3.995269
1994	4	-4.292635	0.13909903	-4.563009	-4.293196	-4.016232
1995	1	-4.226246	0.08909774	-4.401075	-4.226061	-4.051516
1995	2	-4.346649	0.09026931	-4.519409	-4.348058	-4.165766
1995	3	-4.514554	0.09013270	-4.689238	-4.514609	-4.334821
1995	4	-4.157041	0.08593787	-4.322301	-4.156942	-3.985450
1996	1	-4.534447	0.08973442	-4.712671	-4.534059	-4.358395
1996	2	-4.478358	0.08889440	-4.649662	-4.479341	-4.300324
1996	3	-4.760955	0.08787975	-4.932528	-4.761531	-4.590712
1996	4	-4.816368	0.08844427	-4.988462	-4.816823	-4.639510
1997	1	-4.679422	0.08695552	-4.849260	-4.679833	-4.509214
1997	2	-4.750385	0.08831573	-4.922541	-4.750115	-4.574569
1997	3	-4.548620	0.08412973	-4.711552	-4.549808	-4.381327
1997	4	-4.768212	0.08705445	-4.938012	-4.769333	-4.595966
1998	1	-4.689299	0.08419001	-4.851973	-4.689310	-4.526818
1998	2	-4.794182	0.08493066	-4.958969	-4.794822	-4.627639
1998	3	-4.871935	0.08432605	-5.034574	-4.873517	-4.704376
1998	4	-4.319143	0.08086111	-4.473100	-4.319866	-4.157055
1999	1	-4.529117	0.08218269	-4.688656	-4.529575	-4.368099

Year	Quarter	Mean	SD	CI 2.5%	Median	CI 97.5
1999	2	-4.516157	0.08198735	-4.676800	-4.516489	-4.353505
1999	3	-4.555142	0.08122876	-4.710959	-4.555541	-4.395154
1999	4	-4.668951	0.08261150	-4.833702	-4.669172	-4.510489
2000	1	-4.663319	0.08103575	-4.819526	-4.664337	-4.501733
2000	2	-4.891121	0.08398400	-5.051944	-4.891289	-4.726170
2000	3	-4.695076	0.08037871	-4.850311	-4.695830	-4.534615
2000	4	-4.758850	0.08292310	-4.918853	-4.760132	-4.593539
2001	1	-4.810853	0.08289240	-4.968797	-4.811172	-4.645941
2001	2	-4.974799	0.08303746	-5.135082	-4.975603	-4.808096
2001	3	-4.825592	0.08105959	-4.981237	-4.826662	-4.665671
2001	4	-4.566372	0.07769183	-4.715208	-4.566796	-4.411892
2002	1	-4.770449	0.08106435	-4.927174	-4.771405	-4.610902
2002	2	-4.726712	0.07854286	-4.879913	-4.726791	-4.570629
2002	3	-4.385206	0.07768058	-4.534859	-4.384917	-4.230584
2002	4	-4.353898	0.07843534	-4.505769	-4.354833	-4.200600
2003	1	-4.643232	0.07885932	-4.794258	-4.643641	-4.487831
2003	2	-4.579403	0.07975130	-4.733106	-4.580532	-4.418510
2003	3	-4.797557	0.08074892	-4.954895	-4.798102	-4.636896
2003	4	-4.386590	0.07756345	-4.537005	-4.385562	-4.235679
2004	1	-4.572616	0.08281852	-4.734989	-4.573083	-4.407983
2004	2	-4.738915	0.08774743	-4.914099	-4.739709	-4.569922
2004	3	-4.542073	0.08344092	-4.706177	-4.542236	-4.376983
2004	4	-4.226917	0.08105764	-4.383357	-4.227636	-4.067157
2005	1	-4.423699	0.07792671	-4.574286	-4.424376	-4.270261
2005	2	-4.212794	0.07659210	-4.361985	-4.213522	-4.058245
2005	3	-4.297917	0.07610829	-4.446725	-4.298984	-4.148654
2005	4	-4.004050	0.07494883	-4.149151	-4.004242	-3.858151
2006	1	-4.012984	0.07586119	-4.159459	-4.013620	-3.863522
2006	2	-3.972904	0.07537296	-4.118990	-3.973652	-3.824063
2006	3	-4.437869	0.07865620	-4.591973	-4.438451	-4.282796
2006	4	-4.216569	0.07533158	-4.362775	-4.217637	-4.064873
2007	1	-4.423779	0.07675305	-4.568974	-4.424292	-4.270617
2007	2	-4.487745	0.07743319	-4.637547	-4.488919	-4.334347
2007	3	-4.654773	0.07869250	-4.808707	-4.655006	-4.501442
2007	4	-4.402297	0.07684401	-4.551677	-4.402013	-4.253358
2008	1	-4.901631	0.08686439	-5.070479	-4.902047	-4.730173
2008	2	-4.817058	0.08477656	-4.981529	-4.817975	-4.652960

Year	Quarter	Mean	SD	CI 2.5%	Median	CI 97.5
2008	3	-4.641204	0.08329275	-4.804104	-4.640506	-4.477789
2008	4	-4.501319	0.08215930	-4.657722	-4.502225	-4.341979
2009	1	-5.160673	0.08594039	-5.327092	-5.161248	-4.991637
2009	2	-5.077765	0.08498111	-5.244827	-5.077297	-4.915266
2009	3	-5.018702	0.08543477	-5.184717	-5.018727	-4.852246
2009	4	-4.894264	0.08507740	-5.058891	-4.894075	-4.726010
2010	1	-5.031183	0.08846277	-5.203386	-5.030781	-4.856024
2010	2	-5.162268	0.09227564	-5.342608	-5.162763	-4.980609
2010	3	-4.964714	0.09231452	-5.140319	-4.966724	-4.779084
2010	4	-4.940654	0.09015825	-5.116346	-4.940565	-4.767488
2011	1	-5.174611	0.09664125	-5.363498	-5.175852	-4.988560
2011	2	-5.486474	0.10266205	-5.687313	-5.487363	-5.281274
2011	3	-5.443125	0.10510885	-5.649527	-5.442338	-5.235061
2011	4	-5.208206	0.10804244	-5.418402	-5.208688	-4.994771
2012	1	-5.739055	0.11534834	-5.965195	-5.740345	-5.515325
2012	2	-5.455882	0.11378444	-5.674223	-5.457409	-5.232229
2012	3	-5.694096	0.11244374	-5.909555	-5.695306	-5.472446
2012	4	-5.296575	0.11368208	-5.515506	-5.297187	-5.072894
2013	1	-5.309401	0.12432103	-5.554223	-5.309117	-5.062210
2013	2	-5.023460	0.13592537	-5.285520	-5.023436	-4.752200
2013	3	-5.084435	0.12740904	-5.331951	-5.085159	-4.830061
2013	4	-5.265118	0.15965508	-5.571826	-5.269292	-4.941594
2014	1	-5.768065	0.14810668	-6.055439	-5.769091	-5.477005
2014	2	-5.428180	0.15660780	-5.730138	-5.430692	-5.115096
2014	3	-5.385030	0.15299138	-5.681831	-5.386092	-5.085385
2014	4	-5.434717	0.15872694	-5.743246	-5.434776	-5.125328
2015	1	-5.756888	0.16795990	-6.087202	-5.759261	-5.422795
2015	2	-5.738503	0.16998818	-6.065167	-5.740731	-5.400548
2015	3	-5.680964	0.18327676	-6.036192	-5.681072	-5.318817
2015	4	-5.329443	0.19120002	-5.698323	-5.329921	-4.954343
2016	1	-5.693165	0.20177288	-6.093050	-5.693447	-5.299180
2016	2	-5.654482	0.20803880	-6.055482	-5.657208	-5.244356
2016	3	-5.824084	0.21673155	-6.245124	-5.825381	-5.396091
2016	4	-5.716106	0.22579133	-6.149355	-5.720192	-5.271347
2017	1	-5.276870	0.20425302	-5.672101	-5.279125	-4.867502
2017	2	-5.213932	0.21319761	-5.629927	-5.216874	-4.796493
2017	3	-5.606461	0.22760289	-6.050776	-5.606987	-5.155183

Year	Quarter	Mean	SD	CI 2.5%	Median	CI 97.5
2017	4	-5.486843	0.24666233	-5.956698	-5.492522	-4.992324
2018	1	-5.205104	0.21152926	-5.614424	-5.204358	-4.785641
2018	2	-5.268426	0.22593344	-5.706248	-5.270317	-4.818544
2018	3	-5.296452	0.25105165	-5.780418	-5.300458	-4.793603
2018	4	-5.229049	0.25539163	-5.716543	-5.231917	-4.722892

Table D: Yellowfin log abundance indices: Includes expert opinion offset

Year	Quarter	Mean	SD	CI 2.5%	Median	CI 97.5
1970	1	-4.694141	0.25600202	-5.185373	-4.697704	-4.191139
1970	2	-4.408096	0.26898453	-4.926995	-4.410296	-3.862919
1970	3	-4.014933	0.24191199	-4.488272	-4.019069	-3.538576
1970	4	-5.185164	0.28159772	-5.720462	-5.192060	-4.618555
1971	1	-4.773723	0.26575571	-5.271997	-4.782474	-4.237080
1971	2	-4.922791	0.29628731	-5.486407	-4.928282	-4.323431
1971	3	-4.503737	0.27243637	-5.036421	-4.505454	-3.959883
1971	4	-4.485011	0.26702005	-4.999561	-4.487766	-3.950781
1972	1	-4.503696	0.25819914	-4.998807	-4.507552	-3.991879
1972	2	-4.413656	0.26388125	-4.914120	-4.416231	-3.889144
1972	3	-3.623743	0.23490621	-4.075115	-3.624547	-3.156784
1972	4	-4.816592	0.28243168	-5.359283	-4.824054	-4.249574
1973	1	-3.613464	0.21632764	-4.028341	-3.613795	-3.183436
1973	2	-3.557343	0.22372594	-3.988752	-3.558576	-3.118302
1973	3	-2.808896	0.19683544	-3.182362	-2.812386	-2.414047
1973	4	-3.700417	0.22145243	-4.127620	-3.699662	-3.254580
1974	1	-4.227660	0.23701301	-4.679340	-4.232495	-3.739453
1974	2	-4.045846	0.23493080	-4.502720	-4.048794	-3.580373
1974	3	-3.202931	0.21057791	-3.604250	-3.205618	-2.786339
1974	4	-3.801608	0.23695996	-4.253709	-3.807943	-3.331820
1975	1	-4.050767	0.24223796	-4.513257	-4.054012	-3.567803
1975	2	-3.541839	0.22484351	-3.971220	-3.544231	-3.090976
1975	3	-3.026311	0.21545314	-3.441063	-3.029354	-2.594667
1975	4	-4.853399	0.27432322	-5.380578	-4.857235	-4.307655
1976	1	-4.271146	0.23921749	-4.730312	-4.274803	-3.798138
1976	2	-4.159820	0.24444598	-4.626465	-4.165032	-3.668882
1976	3	-2.825914	0.20948098	-3.232080	-2.826450	-2.415671
1976	4	-3.700323	0.23969810	-4.158840	-3.703746	-3.219019
1977	1	-3.744763	0.22369812	-4.177941	-3.749748	-3.299489

Year	Quarter	Mean	SD	CI 2.5%	Median	CI 97.5
1977	2	-4.463007	0.25518281	-4.960041	-4.465899	-3.951968
1977	3	-3.197905	0.20796040	-3.594667	-3.199919	-2.779692
1977	4	-4.221083	0.25765332	-4.715920	-4.223007	-3.711897
1978	1	-3.999946	0.23423152	-4.448307	-4.007239	-3.523242
1978	2	-4.437727	0.26114509	-4.937882	-4.441156	-3.918816
1978	3	-3.435596	0.22661442	-3.871614	-3.439937	-2.980701
1978	4	-3.885253	0.25216942	-4.377368	-3.886584	-3.387233
1979	1	-4.217316	0.21583205	-4.624693	-4.221010	-3.786228
1979	2	-3.679071	0.19827382	-4.053759	-3.682981	-3.283543
1979	3	-3.003465	0.17740429	-3.340494	-3.005556	-2.652842
1979	4	-4.497011	0.22111207	-4.921911	-4.498290	-4.059883
1980	1	-3.980937	0.19990120	-4.361972	-3.984566	-3.580682
1980	2	-4.160652	0.20787741	-4.562758	-4.161626	-3.753427
1980	3	-3.112037	0.17941132	-3.460139	-3.112655	-2.761325
1980	4	-4.877866	0.24010092	-5.340789	-4.879848	-4.398476
1981	1	-3.920390	0.20643036	-4.315282	-3.921723	-3.511631
1981	2	-4.302124	0.21644604	-4.724066	-4.302277	-3.880224
1981	3	-3.607235	0.18524258	-3.963891	-3.608059	-3.243696
1981	4	-4.530180	0.21534776	-4.942953	-4.532211	-4.095397
1982	1	-5.047286	0.23186377	-5.492098	-5.052994	-4.577006
1982	2	-5.519747	0.24175367	-5.984276	-5.522123	-5.035350
1982	3	-3.637029	0.18560302	-3.997365	-3.635449	-3.270416
1982	4	-5.218413	0.22588793	-5.656029	-5.223023	-4.758927
1983	1	-4.943679	0.21281749	-5.347564	-4.947053	-4.519413
1983	2	-4.369475	0.18975913	-4.730846	-4.375281	-3.989796
1983	3	-3.966327	0.18274102	-4.313636	-3.970085	-3.606059
1983	4	-5.202738	0.22550501	-5.635106	-5.206464	-4.746038
1984	1	-4.891370	0.19691338	-5.275491	-4.892178	-4.508135
1984	2	-4.913234	0.19631147	-5.292045	-4.914944	-4.523096
1984	3	-4.589510	0.18826655	-4.951999	-4.589141	-4.216251
1984	4	-5.460686	0.20515171	-5.849114	-5.464988	-5.042085
1985	1	-5.535317	0.20058317	-5.914670	-5.538601	-5.134965
1985	2	-5.717054	0.21887249	-6.138144	-5.721403	-5.277647
1985	3	-4.924836	0.19899655	-5.302475	-4.928472	-4.520279
1985	4	-5.403767	0.20828786	-5.806191	-5.405502	-4.995870
1986	1	-5.191828	0.19949233	-5.579205	-5.192532	-4.800361
1986	2	-5.429104	0.21209382	-5.830067	-5.432410	-5.000743

Year	Quarter	Mean	SD	CI 2.5%	Median	CI 97.5
1986	3	-5.621800	0.21560893	-6.041635	-5.623286	-5.200035
1986	4	-5.730034	0.20718610	-6.136262	-5.729435	-5.326876
1987	1	-5.738159	0.21455039	-6.146528	-5.740585	-5.304422
1987	2	-5.607367	0.21587536	-6.020323	-5.608594	-5.178474
1987	3	-4.778607	0.18613681	-5.136483	-4.782040	-4.408209
1987	4	-5.837702	0.21879201	-6.260705	-5.839188	-5.404101
1988	1	-5.617388	0.19567319	-5.999017	-5.620953	-5.227788
1988	2	-6.500656	0.23896147	-6.956544	-6.505849	-6.023626
1988	3	-5.267109	0.19512347	-5.646762	-5.266136	-4.885386
1988	4	-6.390386	0.21837891	-6.813654	-6.392948	-5.954304
1989	1	-6.113139	0.22313051	-6.545080	-6.116709	-5.672243
1989	2	-6.131707	0.22920992	-6.571306	-6.133294	-5.674374
1989	3	-5.852881	0.21453913	-6.259805	-5.858847	-5.423775
1989	4	-6.444785	0.23255099	-6.881203	-6.445785	-5.986114
1990	1	-6.531753	0.23680704	-6.982196	-6.535396	-6.058561
1990	2	-6.513249	0.23150683	-6.963235	-6.513326	-6.052548
1990	3	-5.959371	0.21920762	-6.382645	-5.962394	-5.526040
1990	4	-6.214469	0.22233973	-6.638481	-6.217646	-5.775332
1991	1	-6.453219	0.24072098	-6.905817	-6.455917	-5.968570
1991	2	-6.355180	0.22840677	-6.785723	-6.359602	-5.898768
1991	3	-5.454516	0.19806180	-5.831691	-5.455427	-5.056055
1991	4	-6.289827	0.22034006	-6.717347	-6.292861	-5.850886
1992	1	-6.142521	0.21464144	-6.557624	-6.145514	-5.720918
1992	2	-6.340462	0.21869620	-6.762644	-6.340554	-5.905511
1992	3	-5.583096	0.20056823	-5.968625	-5.587841	-5.187953
1992	4	-5.934666	0.21090871	-6.337796	-5.939404	-5.508149
1993	1	-6.301144	0.21039117	-6.717098	-6.302148	-5.888028
1993	2	-6.109581	0.21277005	-6.523261	-6.110972	-5.687030
1993	3	-5.768944	0.19847021	-6.155482	-5.771699	-5.379097
1993	4	-5.767677	0.20059998	-6.159334	-5.769932	-5.363633
1994	1	-5.697413	0.19232030	-6.073380	-5.698408	-5.322853
1994	2	-6.144171	0.20260892	-6.532207	-6.145924	-5.741678
1994	3	-5.748317	0.19286409	-6.116101	-5.751833	-5.361172
1994	4	-6.274146	0.20534274	-6.666572	-6.277675	-5.860573
1995	1	-5.968984	0.11546339	-6.190489	-5.970459	-5.738949
1995	2	-6.098096	0.11608363	-6.323765	-6.100295	-5.867664
1995	3	-5.601758	0.10923204	-5.812525	-5.601935	-5.384646

Year	Quarter	Mean	SD	CI 2.5%	Median	CI 97.5
1995	4	-6.189183	0.11230259	-6.413762	-6.190677	-5.966696
1996	1	-6.349975	0.11563451	-6.576198	-6.349887	-6.121388
1996	2	-6.300738	0.11367620	-6.522127	-6.300726	-6.074141
1996	3	-6.179675	0.10784012	-6.390809	-6.179968	-5.969895
1996	4	-6.463568	0.11184314	-6.680099	-6.464461	-6.244489
1997	1	-6.844432	0.11288547	-7.064963	-6.844798	-6.619401
1997	2	-6.577851	0.11496362	-6.799880	-6.578863	-6.348891
1997	3	-6.029165	0.10630293	-6.238163	-6.028623	-5.822169
1997	4	-6.520115	0.10949208	-6.732624	-6.520542	-6.301602
1998	1	-6.345545	0.10489348	-6.553424	-6.344012	-6.142515
1998	2	-6.439390	0.10771530	-6.648961	-6.437773	-6.233114
1998	3	-6.470715	0.10724736	-6.679517	-6.470656	-6.260807
1998	4	-6.084246	0.10025841	-6.281717	-6.084797	-5.886310
1999	1	-6.060348	0.10000530	-6.254163	-6.061507	-5.859785
1999	2	-6.614820	0.10749201	-6.827196	-6.615069	-6.406810
1999	3	-6.577785	0.10356929	-6.781509	-6.577666	-6.376792
1999	4	-6.963119	0.11185791	-7.179331	-6.962801	-6.742695
2000	1	-6.869799	0.10920969	-7.084305	-6.870600	-6.656353
2000	2	-6.904244	0.10710456	-7.115125	-6.904916	-6.694849
2000	3	-6.594893	0.10335420	-6.794599	-6.596422	-6.389873
2000	4	-6.660625	0.10314147	-6.862229	-6.661643	-6.455816
2001	1	-6.668425	0.10336902	-6.870363	-6.669657	-6.464262
2001	2	-7.341440	0.11140074	-7.556802	-7.342756	-7.120697
2001	3	-6.712886	0.10133231	-6.910854	-6.713134	-6.512935
2001	4	-6.635700	0.09993753	-6.828152	-6.634804	-6.439163
2002	1	-6.512080	0.09807969	-6.702047	-6.511760	-6.321177
2002	2	-6.645451	0.09921013	-6.840555	-6.646298	-6.452695
2002	3	-6.353327	0.09749309	-6.542819	-6.354679	-6.159348
2002	4	-6.267109	0.09689332	-6.455529	-6.267038	-6.078347
2003	1	-6.539636	0.10037008	-6.733423	-6.540604	-6.339521
2003	2	-6.441411	0.09940926	-6.632278	-6.441003	-6.240781
2003	3	-6.665832	0.10269989	-6.867049	-6.666002	-6.463459
2003	4	-6.155576	0.09705102	-6.340052	-6.156903	-5.961100
2004	1	-6.108415	0.10200311	-6.307083	-6.107728	-5.909132
2004	2	-6.453950	0.10872984	-6.666551	-6.453916	-6.237084
2004	3	-6.244735	0.10555998	-6.451745	-6.245454	-6.032850
2004	4	-6.136967	0.10235521	-6.335702	-6.137333	-5.935821

Year	Quarter	Mean	SD	CI 2.5%	Median	CI 97.5
2005	1	-6.152772	0.09351476	-6.334939	-6.152112	-5.966851
2005	2	-6.234455	0.09348934	-6.416126	-6.234262	-6.050179
2005	3	-6.304497	0.09614325	-6.494407	-6.303652	-6.114809
2005	4	-6.307139	0.09633693	-6.497193	-6.307574	-6.116667
2006	1	-5.972709	0.09211613	-6.149269	-5.973797	-5.789522
2006	2	-6.600178	0.09926562	-6.792363	-6.600921	-6.408024
2006	3	-6.466442	0.09861615	-6.659318	-6.466192	-6.273145
2006	4	-6.370921	0.09580432	-6.557937	-6.371179	-6.182013
2007	1	-6.077462	0.09348560	-6.259619	-6.078903	-5.890358
2007	2	-6.785597	0.10015545	-6.981487	-6.785940	-6.589986
2007	3	-6.464606	0.09828966	-6.654437	-6.465521	-6.267497
2007	4	-6.177734	0.09407234	-6.363985	-6.178982	-5.992407
2008	1	-6.246378	0.10494962	-6.448051	-6.246848	-6.041997
2008	2	-6.407405	0.10662296	-6.614703	-6.409496	-6.195285
2008	3	-6.489423	0.10690398	-6.701970	-6.488920	-6.279438
2008	4	-6.286799	0.10398507	-6.483459	-6.288343	-6.080055
2009	1	-6.480799	0.10356714	-6.681298	-6.481206	-6.277692
2009	2	-6.560277	0.10508393	-6.760099	-6.559709	-6.353019
2009	3	-6.604992	0.10387410	-6.807918	-6.606065	-6.404348
2009	4	-6.283895	0.10339931	-6.484592	-6.283960	-6.082373
2010	1	-6.774994	0.10919981	-6.986812	-6.775579	-6.563296
2010	2	-6.839680	0.11299891	-7.059616	-6.840948	-6.617145
2010	3	-6.736680	0.11770443	-6.964457	-6.737802	-6.502477
2010	4	-6.547674	0.11171381	-6.765408	-6.547399	-6.326567
2011	1	-6.874620	0.12015794	-7.112369	-6.874205	-6.638161
2011	2	-6.761138	0.12592058	-7.006883	-6.761119	-6.512343
2011	3	-6.924852	0.13219726	-7.184919	-6.925282	-6.661532
2011	4	-6.902583	0.14034162	-7.173324	-6.905328	-6.619076
2012	1	-7.099257	0.14598880	-7.377259	-7.100438	-6.811449
2012	2	-6.936181	0.14178391	-7.208406	-6.936485	-6.656427
2012	3	-6.773939	0.13473829	-7.036496	-6.774936	-6.505171
2012	4	-6.622526	0.14352914	-6.903590	-6.623678	-6.338465
2013	1	-6.417513	0.15209515	-6.714863	-6.419603	-6.114297
2013	2	-5.706748	0.15956071	-6.014844	-5.707931	-5.385080
2013	3	-5.734308	0.14940729	-6.025433	-5.733603	-5.437764
2013	4	-6.517877	0.20560993	-6.916990	-6.522124	-6.115976
2014	1	-6.319063	0.17007097	-6.645969	-6.319383	-5.982533

Year	Quarter	Mean	SD	CI 2.5%	Median	CI 97.5
2014	2	-6.495163	0.19205917	-6.865918	-6.496133	-6.115420
2014	3	-6.161697	0.17600356	-6.498841	-6.162868	-5.810001
2014	4	-6.138040	0.19240362	-6.517963	-6.141735	-5.764493
2015	1	-5.896268	0.16926725	-6.228464	-5.897810	-5.563435
2015	2	-6.367394	0.19805237	-6.746855	-6.369573	-5.971087
2015	3	-6.186091	0.20658161	-6.585360	-6.187737	-5.771823
2015	4	-5.958463	0.22496577	-6.389455	-5.962504	-5.505856
2016	1	-6.517596	0.23559210	-6.965186	-6.519524	-6.047257
2016	2	-6.835727	0.25729694	-7.323564	-6.842150	-6.321101
2016	3	-6.631903	0.25721097	-7.126409	-6.631095	-6.116485
2016	4	-6.537425	0.26857521	-7.054327	-6.540628	-6.004223
2017	1	-6.414834	0.24696072	-6.889163	-6.417687	-5.923048
2017	2	-6.616036	0.27044079	-7.136382	-6.621601	-6.070565
2017	3	-6.494354	0.26911586	-7.010785	-6.497208	-5.954042
2017	4	-6.583673	0.30660354	-7.165034	-6.589237	-5.961648
2018	1	-6.193661	0.25485165	-6.688178	-6.196569	-5.689572
2018	2	-6.357300	0.28112752	-6.899152	-6.361826	-5.800297
2018	3	-6.355078	0.31605711	-6.957568	-6.361294	-5.721807
2018	4	-6.188099	0.31891740	-6.806341	-6.190685	-5.548740