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Summary of fisheries structures for the 2016 stock assessment of skipjack tuna in the western and central Pacific Ocean

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Contents

Executive Summary

A "fishery" is the basic unit of the fishing component of models used to assess the stocks of tuna in the western and central Pacific Ocean (WCPO). Typically, these are multi-region models and a fishery is defined as a set of fishing activity extending over a region (or subregion) with similar characteristics such as catch per unit effort (CPUE) and size compositions of the catch. The fisheries structure of these models and how the model is parameterised with respect to these fisheries (selectivities, grouping of fisheries for catchability, tag recaptures etc.) are an integral part of the model development and the scientific conclusions that can be drawn from the modelling.

It is important that the basis for establishment of the fisheries definitions used, and changes between assessments, are documented, so that scientists conducting assessments of the stock in question are aware of their justification. This report details the fishery structure of the 2016 assessment of skipjack tuna in the WCPO including data summaries and changes to fisheries definitions from the 2014 assessment.

Three relatively minor changes were made to the fisheries definitions used in the 2014 assessment of the skipjack stock:

- The longline fisheries in each region were expanded from solely including data from Japanese-flagged vessels to including data for all flags (except Chinese-Taipei) to increase sample sizes and improve temporal coverage of the length composition data that make these fisheries valuable.
- The area of the domestic purse seine fishery in region 4 (S-ID.PH-4) was extended to cover the whole region and hence fishing activity in archipelagic waters, and thus be more consistent with the area used by Bigelow et al. (2016) to calculate the CPUE index received by this fishery in the assessment model.

- The pole-and-line fishery in region 2 was expanded to include all data from all flags using this gear in that region (previously the fishery included only JP). This new definition included a moderate amount of historical catch and effort data for the Pacific Island fleets that are unlikely to have a significant influence on population dynamics, but lead to the inclusion of a moderate number of additional tag recaptures for the Regional Tuna Tagging Programme (1990's) which were previously excluded.

The consequences of these changes in fisheries structures with respect to stock assessment model results were assessed during the stepwise progression from the 2014 to 2016 reference case models and are presented in McKechnie et al. (2016a).

1 Introduction

Assessment models for stocks of tuna in the Western and Central Pacific Ocean (WCPO) are fitted using the the statistical software MULTIFAN-CL[2] (MFCL; Fournier et al., 1998; Hampton and Fournier, 2001; Kleiber et al., 2014). Most models are spatially explicit, consisting of several discrete geographical regions containing region-specific sub-populations linked by biological parameters such as movement and spatially explicit recruitment. The basic unit of the fishing component of these models is a "fishery" - defined as a set of fishing activity extending over a region (or subregion) with similar characteristics such as catch per unit effort (CPUE) and size compositions of the catch.

It is common for fisheries structures to change between subsequent assessments of the same stock. Fisheries might be merged, new fisheries added, or fleets might be removed from one fishery and added to another. Reasons for these changes might include the provision of new data that allow the fishery to be modelled separately, new analyses might suggest that changes are warranted on the basis of the size composition data, or poor fit to aspects of a fisheries' data may have occurred for the previous stock assessment. It is important that the basis for the establishment of the fisheries definitions used, and changes between assessments, are documented, so that scientists conducting assessments of the stock in question are aware of their justification.

The stock assessment of skipjack tuna in the WCPO underwent substantial changes between the 2011 (Hoyle et al., 2011) and 2014 implementations (Rice et al., 2014) in response to the recommendations of the review of the 2011 bigeye tuna stock assessment (Ianelli et al., 2012). The region boundaries were modified to better accommodate the tagging dataset and the fisheries definitions were substantially altered as a consequence. The changes between the reference case models of the

[2] http://www.multifan-cl.org

2014 and 2016 stock assessments are comparatively minor, and reflect subtle refinements of the established fisheries structure aimed at further improving the fit of the model to the data available.

This paper reppresents a brief summary to aid the interpretation of the main paper on the stock assessment of skipjack tuna (McKechnie et al., 2016a), by providing further details of the fisheries structures used, that space prevents from being included in that report. More specifically it will: present graphical summaries of temporal changes in catch and length compositions, including sample sizes, for each fishery in the reference case model at the flag level; and document the basis for, and consequences of, all changes to the fisheries structures since the last assessment of this skipjack tuna stock (Rice et al., 2014).

2 Fisheries definitions

2.1 General notes on fisheries structure

The general fisheries structure of the 2016 assessment remains the same as used for the 2014 assessment, with no additions or deletions of fisheries.

While there were no changes to the overall fisheries structure for the 2016 assessment, minor changes were implemented within several fisheries:

1. Additional (to Japan [JP]) flags were included in the longline fisheries in all regions (fisheries F4, 7, 11, 15, and 23) to increase the sample sizes of length composition data, especially in recent years [section 3].

2. The spatial extent of fisheries F16–F18 (Philippines [PH] miscellaneous, Indonesia [ID] miscellaneous, PH/ID domestic purse seine) was extended to cover the whole of region 4, with purse seine fishing in the western section of the region moved from F16/17 to F18, and ringnet fishing also moved from F16/17 to F18 as the size compositions for this gear were more similar to the purse seine fishery than the other gears in the miscellaneous fishery [section 4].

3. Additional (to JP) flags were included in the pole-and-line fishery in region 2 to include fishing activity for fleets that are no longer active in the fishery but historically recaptured moderate numbers of fish tagged in the RTTP tagging programme [section 5].

Each of these modifications will be outlined in the following sections.

3 Investigation of longline composition data

One longline fishery is included in each region of the skipjack stock assessment to prevent the problem of the so-called “cryptic biomass” by assuming asymptotic selectivity for these fisheries.

In the 2014 stock assessment, these fisheries only included JP-flagged vessels and because the focus of these fisheries is their length composition data, catches are set at the nominal value of 500 fish, and effort as missing for each fishing incident. A general raw data summary of these five fisheries before catch and effort is set to 500 fish in the MFCL input file are given in Figures 16–34.

The availability of length samples varies between regions (Figure 2), but there has been a general decline in sample sizes and in the case of regions 4 and 5, long periods without any samples available. Samples for the JP LL fleet are overwhelmingly dominated by data received from the Japanese size sampling programme (JPSJ) with only a few samples available from the SPC LL sampling programme (SPLL) and the more recent observer programmes.

To supplement the length composition data for these fisheries to improve sample sizes and increase temporal coverage of data, it was decided to add flags to these fisheries. In some regions (2, 3 and to a lesser degree 5) the increases in sample sizes are substantial and occur during the later part of the assessment period when JP sample sizes are often very low, or non existent (Figure 3). However, increases in availability and sample sizes are more limited in regions 1 (though in several years TW contributes large numbers of fish) and 4. Because catch and effort data for these fisheries are essentially disregarded, the decision to add flags to the fisheries is largely related to whether their composition data are comparable to the JP fleet.

An overall summary of the length compositions for the JP fleet (the data currently used in the assessment) is shown in Figure 4. There are several differences in length compositions between regions with perhaps the most notable being less very large fish being caught by LL fishing in the Western equatorial area (regions 4 and 5). A prominent bimodal distribution is evident in the length compositions in region 1. This can also be detected in the time series plots of the general fisheries summaries including Figure 12 where the median length (middle right panel) and the overall length distribution (lower panel) are much reduced over the period 2007–2009. When the composition for this period is compared to that of the rest of the data (Figure 5) it is evident that these few years produce most of the density at shorter lengths in the overall composition. It is unclear whether this relates to potential discarding activity or changes in fishing practice which would require further examination of more fine scale data to reconcile.

These data were included in the last assessment and predictably, were not fitted well by the model. This is apparent in the diagnostic plots in the 2014 report, and it appears that these data are quite influential on the selectivity of this fishery owing to the large number of samples available in these years (see panel L-JPN-1 in Figure 6).

A comparison of the JP compositions with those of other fleets, by region, is shown in Figure 7. Note that the anomalous period of data for JP in region 1 has been removed. The number of fleets with composition data available (only those with >500 fish measured are shown) varies among regions (Figure 7). Differences in compositions among flags are generally low, especially in regions 2 and 3. The Chinese-Taipei fleet shows a tendency to have a disproportionate density at short lengths (e.g. see blue densities in regions 1 and 2; Figure 7). This appears to be related to the source of the data with lengths received from Chinese-Taipei sampling programmes (TWLL) typically being much smaller fish than those measured on Chinese-Taipei vessels from other sources (SPLL and observer programmes; Figure 8).

The other obviously different flag is New Caledonia in region 5 (panel 5 in Figure 7), although the sample size in this case was limited (n=266). This fleet appears to be catching a relatively tight distribution of very large fish and is possibly related to different fishing practices for this fleet and/or these samples presumably coming from the very southerly part of region 5 where it is possible that there is an absence of very small fish due to the more temperate conditions in this part of the range.

Based on these comparisons it was decided that:

- The anomalous length composition data for the JPLL fishery in region 1 during the late 2000's is removed from the dataset.
- The fishery definitions for all longline fisheries be expanded to include all available data for vessels of all other flags.
- Length compositions for Chinese-Taipei vessels be excluded until the source of the anomalous data can be reconciled and/or removed from SPC databases.

4 Philippines and Indonesia domestic purse seine fishery

In the 2014 stock assessment the Philippines and Indonesia domestic fishery was restricted to a 10° by 20° section in the east of region 4 where it was understood the data used for calculating the standardised catch-per-unit effort (CPUE) index of Bigelow et al. (2014) were located. It became evident that the updated CPUE index calculated for the 2016 stock assessment also included data from the archipelagic waters west of the previously defined sub-region for this fishery (see Figure 9 for the spatial distribution of catch for the distant water and domestic purse seine fleets of the Philipinnes and Indonesia). The fishery definition was therefore extended to include domestic purse seine fishing for these fleets for the entire region 4 to be consistent with the CPUE index that it receives in the stock assessment.

Examination of the length compositions for these fleets and the other gear types in the same region (Figures 10 and 11) also indicated that the ringnet fishery catches fish of a more similar size to the domestic purse seine fishery than the other gear-types that comprise the miscellaneous fishery (Z-PH-4). This fleet was therefore incorporated into fishery S-ID.PH-4 to attempt to reduce the poor fit of the stock assessment model to many of the length composition datasets for these fisheries.

5 Expansion to include additional fleets in the region 2 pole-and-line fishery

In the construction of the tagging input file for the 2016 stock assessment (McKechnie et al., 2016b) it became evident that restricting the fishery definition of the pole-and-line fishery in region 2 to just JP-flagged vessels (assumed in the 2014 stock assessment) excluded a number of tag recaptured by other fleets historically operating in this region. These tags were released during the Regional Tuna Tagging Programme in the early 1990's. After adding all other flags to the fishery definition a small amount of extra catch, effort and length composition data became available (Figure 15) and the tag returns are now incorporated into the tagging input file.

The consequences of this change are expected to be very minor as the CPUE for this fishery is detmined by the analyses of Kiyofuji (2016) and even though the tags caught (mainly by Solomon Islands vessels) were not included in the 2014 stock assessment, they were accounted for to a degree by the tag usability correction of Berger et al. (2014). By including them in the 2016 stock assessment however, a small amount of valuable information about movement and fishing mortality is gained.

6 Incorporation in the 2016 stock assessment

Substantial processing and formatting required to make changes to fisheries at the lowest level - flags and gear. Therefore during stepwise development from 2014 to 2016 we propose all fisheries changes occur within one "step" and only if there are major changes to conclusions should the individual changes to fisheries be examined in more detail as this would require the production of several more sets of input files which is time consuming and of little value if management implications of the assessment remain largely unchanged.

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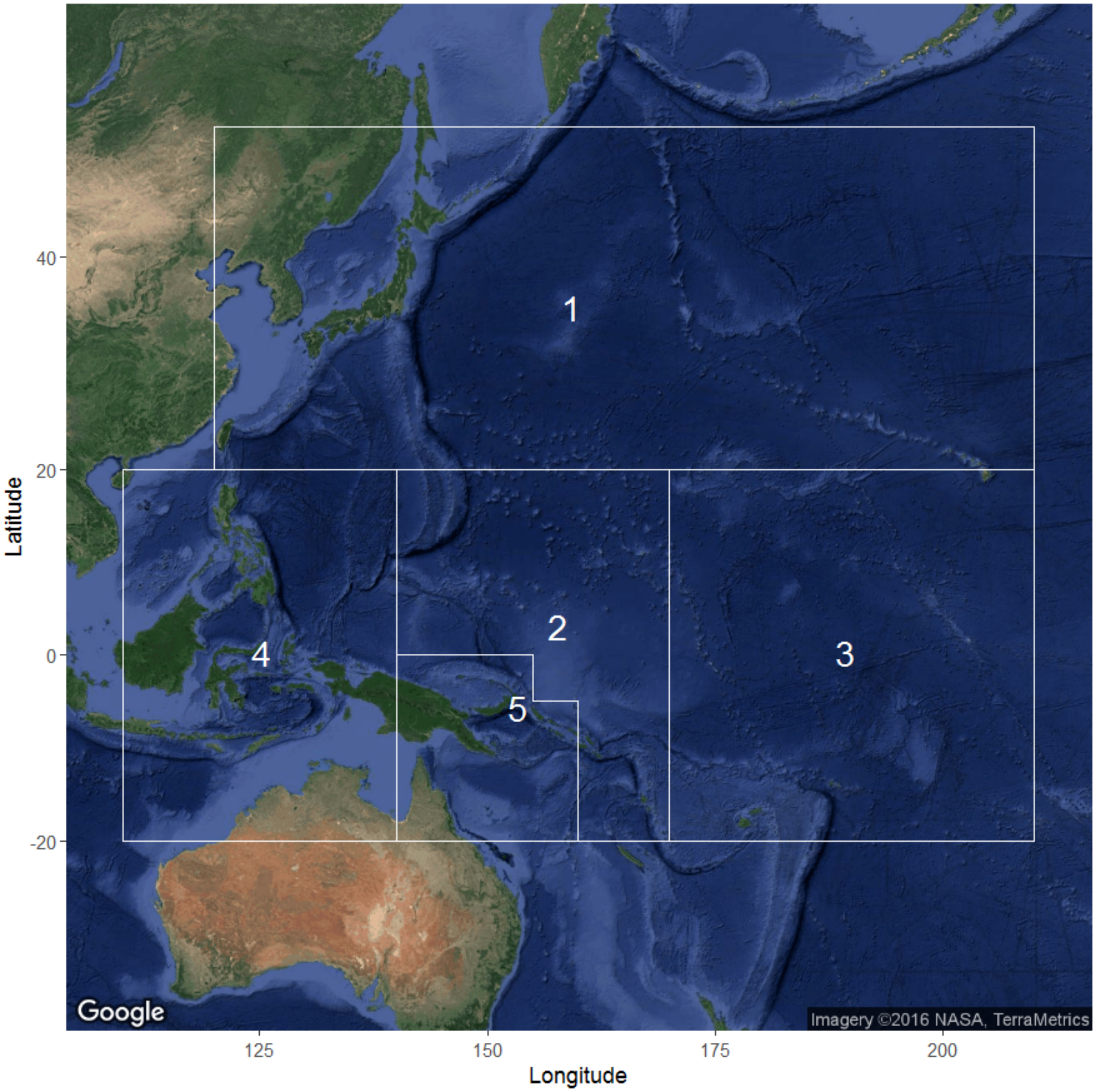

Figure 1: Regional structure of the reference case model.

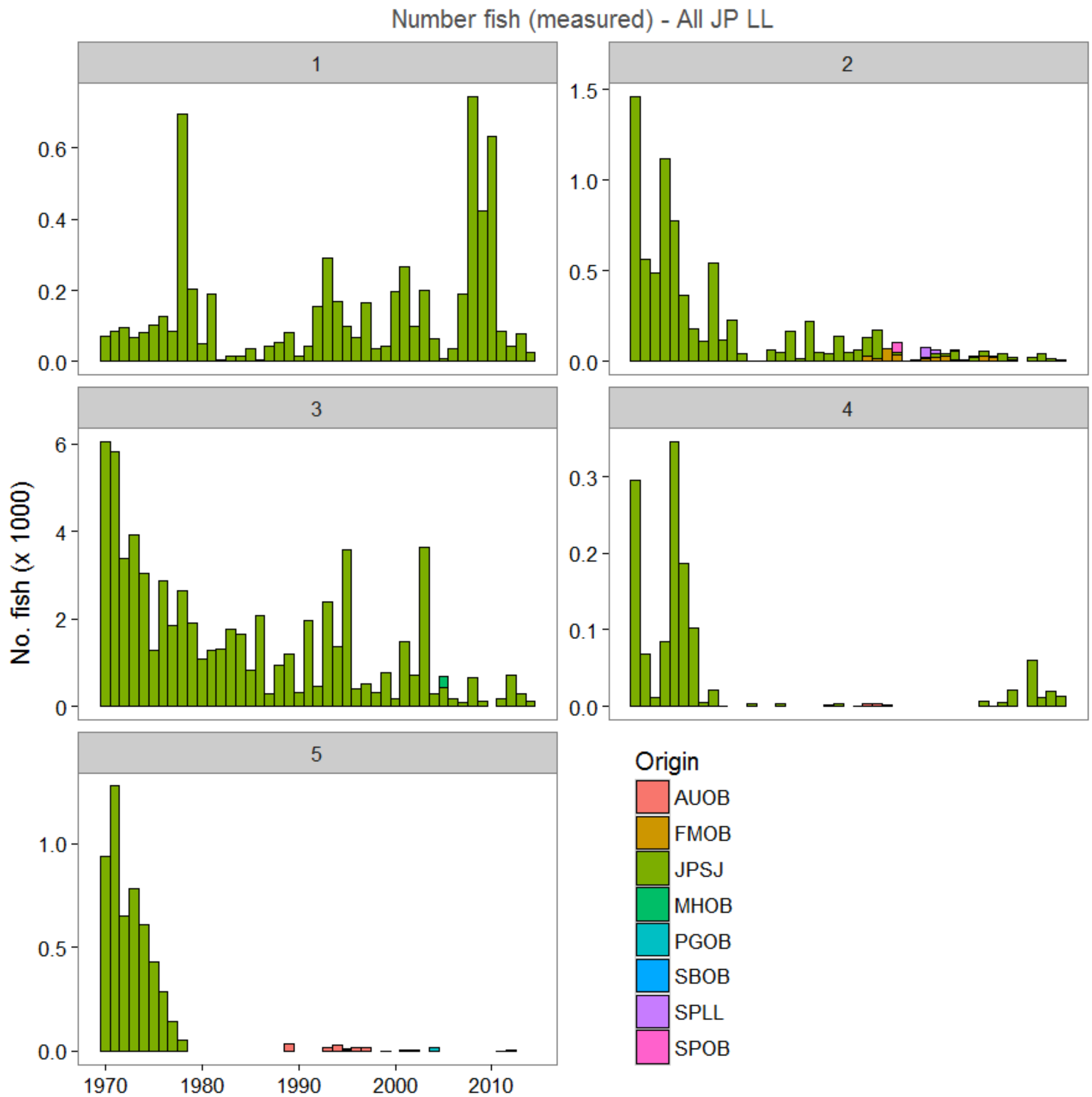

Figure 2: Total number of length samples available for Japanese longline vessels and for all other sources (JPSJ, SPLL and all observer programmes) for the five stock assessment regions.

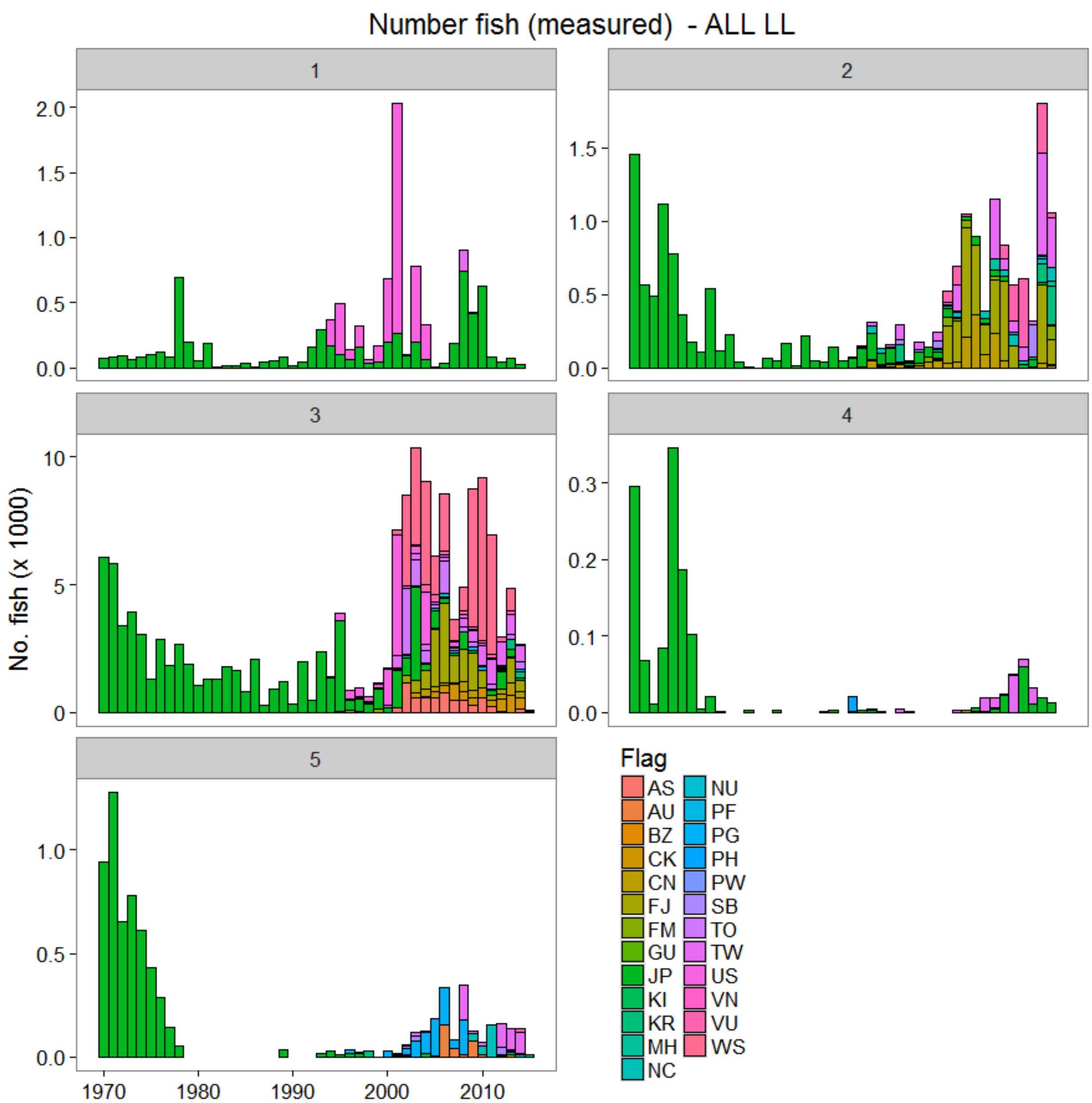

Figure 3: Number of skipjack length samples available for longline vessels by flag from all sources for the five stock assessment regions.

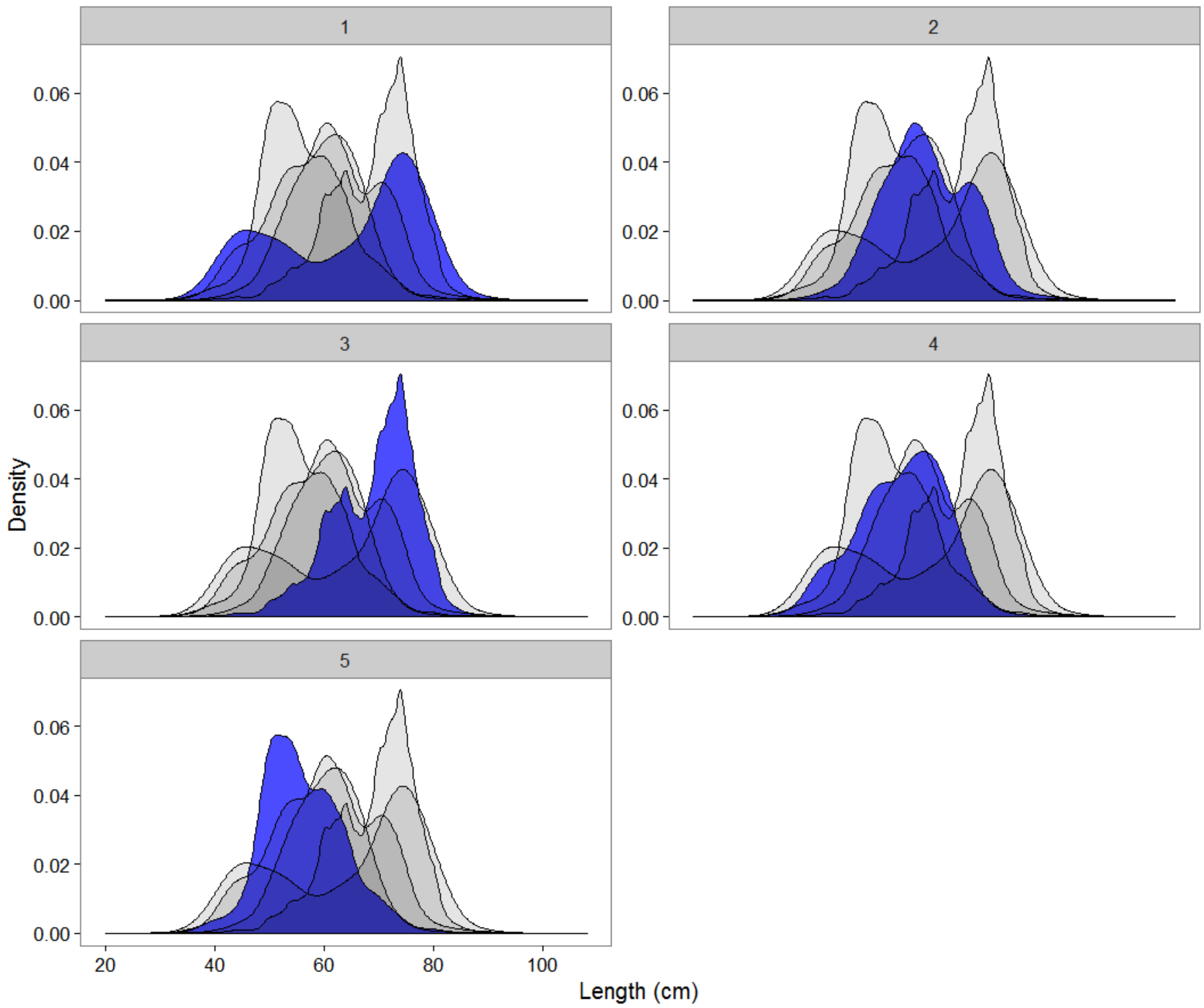

Figure 4: Densities of length composition data for Japanese longline vessels for the five stock assessment regions. Samples are aggregated across all available years to give an overall density for the focal region (blue) with the grey densities showing the compositions for the other four regions on the same plot, for reference. Data are from all sources but are overwhelmingly dominated by JPSJ sourced data.

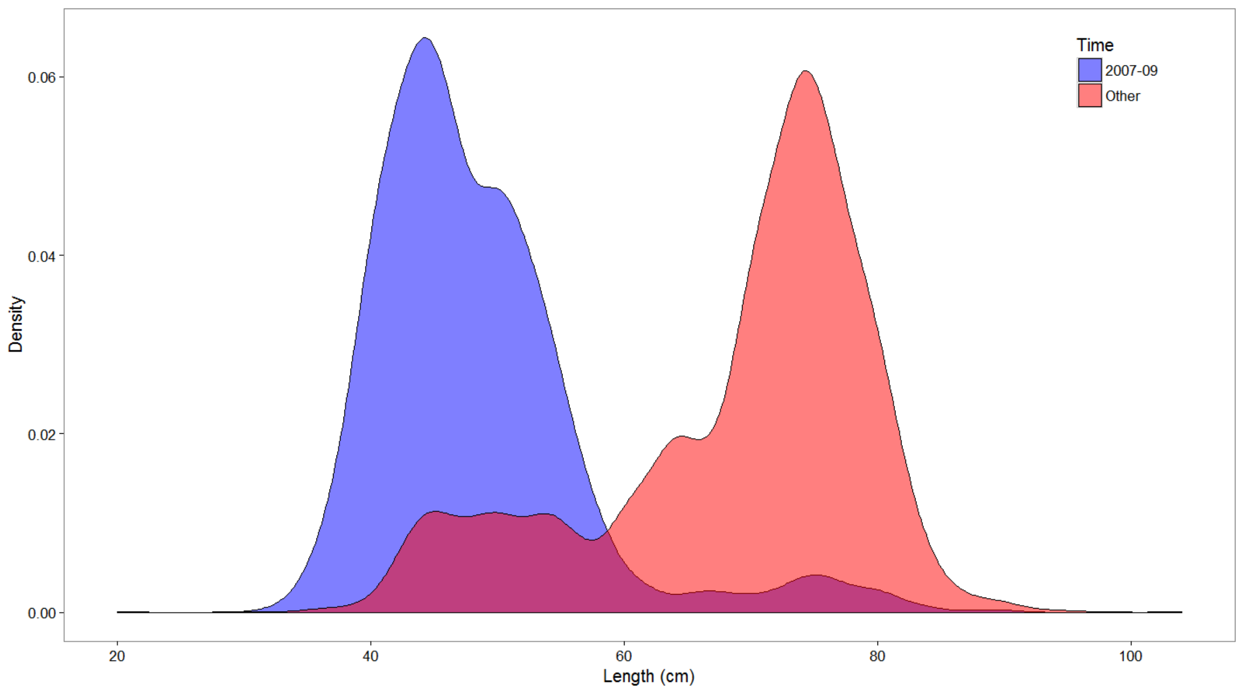

Figure 5: Comparison of densities of length composition data for SKJ from Japanese longline vessels in region 1 for the period 2007–2009 with a density for all other periods.

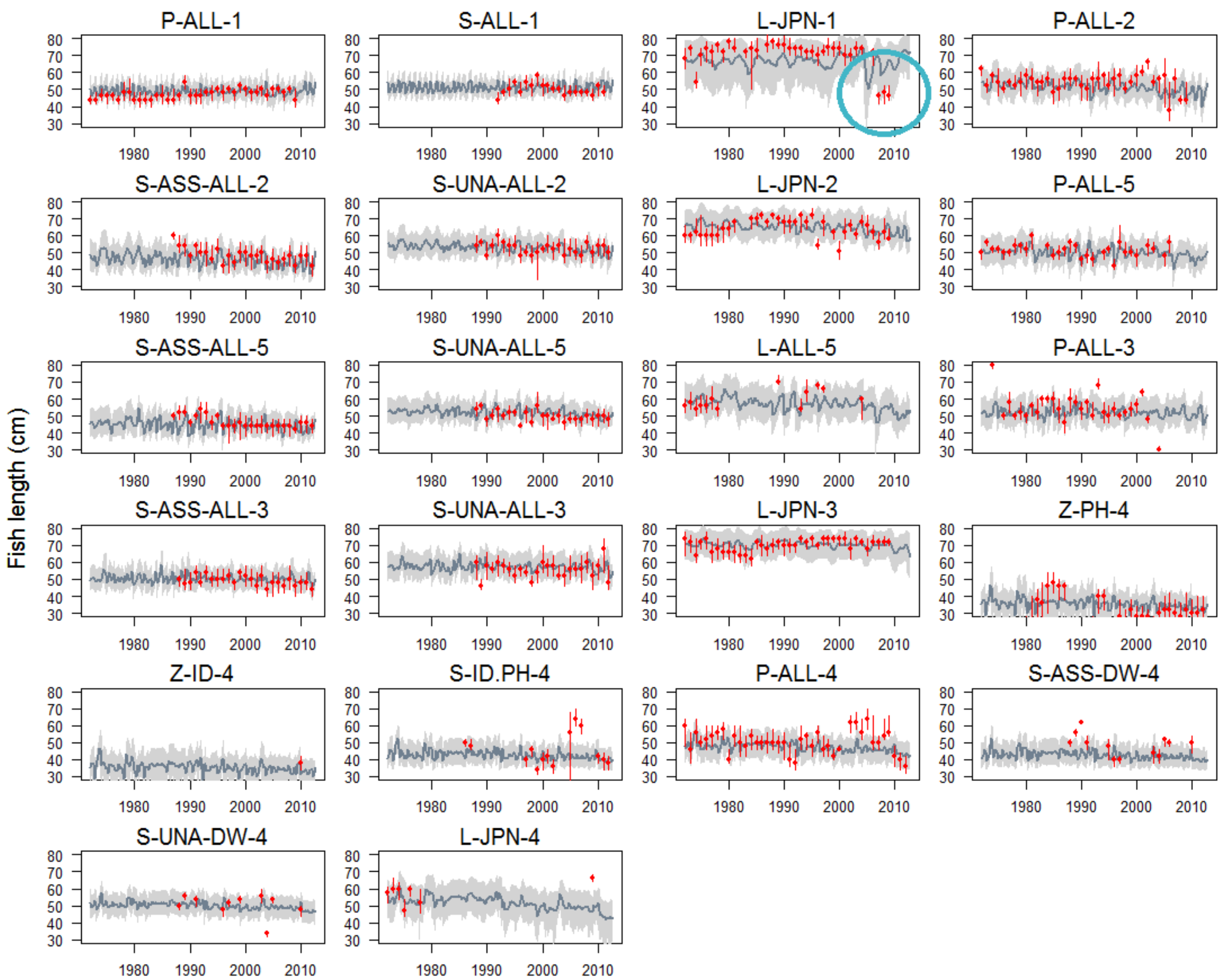

Figure 6: Fit of the 2014 reference case model to the length composition data. The red dot and error bars are the median and interquartile range and the grey line and region is the model predicted median and 95% confidence interval. The anomalous length composition data for fishery 1 in the late 2000's is highlighted by the blue circle.

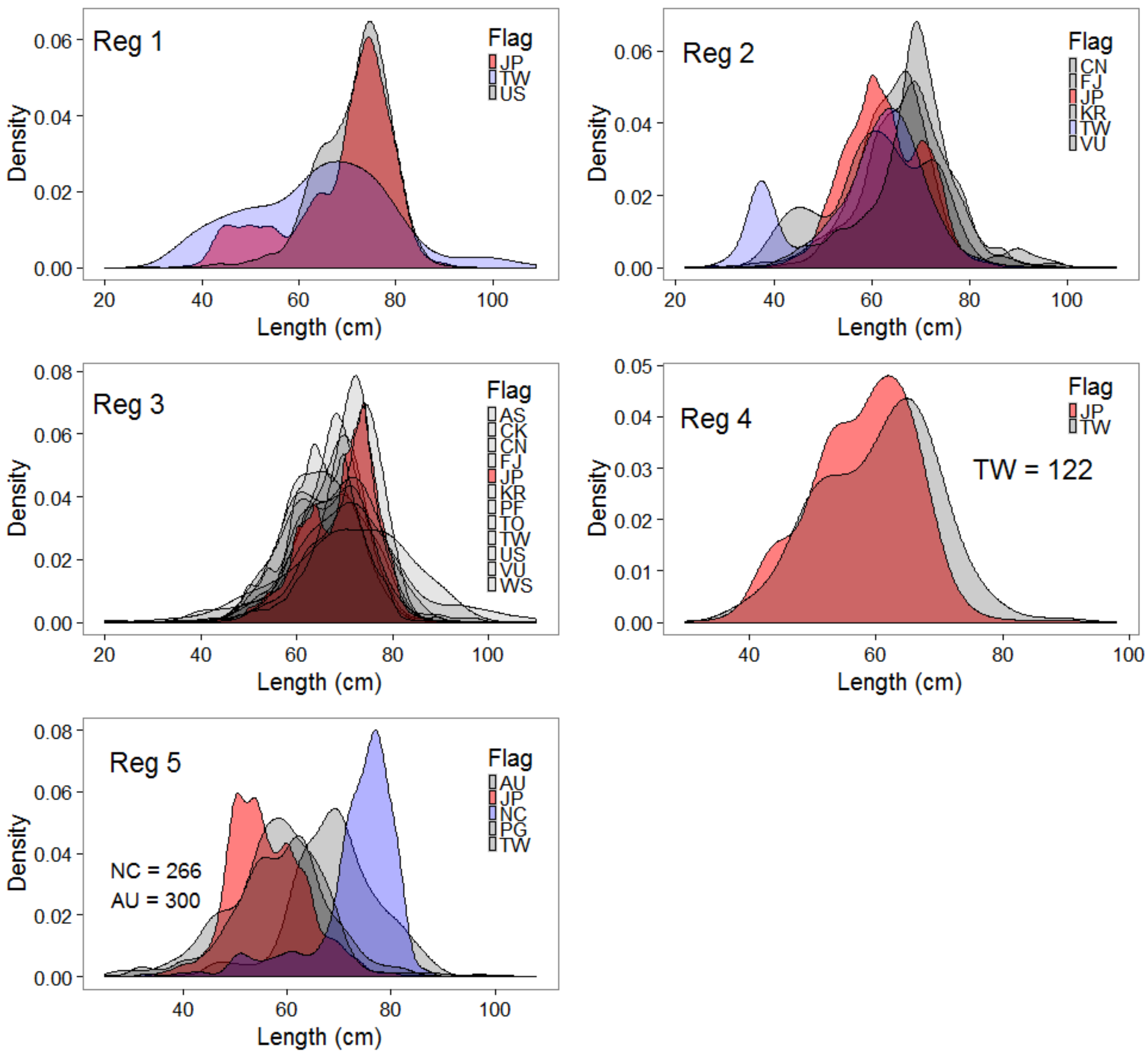

Figure 7: Comparison of densities of length composition data for SKJ from longline vessels for different flags for the five stock assessment regions. Each black line represents a density for a single flag for all length samples for that flag aggregated over the full time period of the assessment. Japanese composition densities are shown in red and other densities of interest are highlighted in blue. Only flags with >500 fish measured over the full period are displayed although in regions 4 and 5 few flags met this criterion and several with fewer samples are displayed, with the sample size given in text.

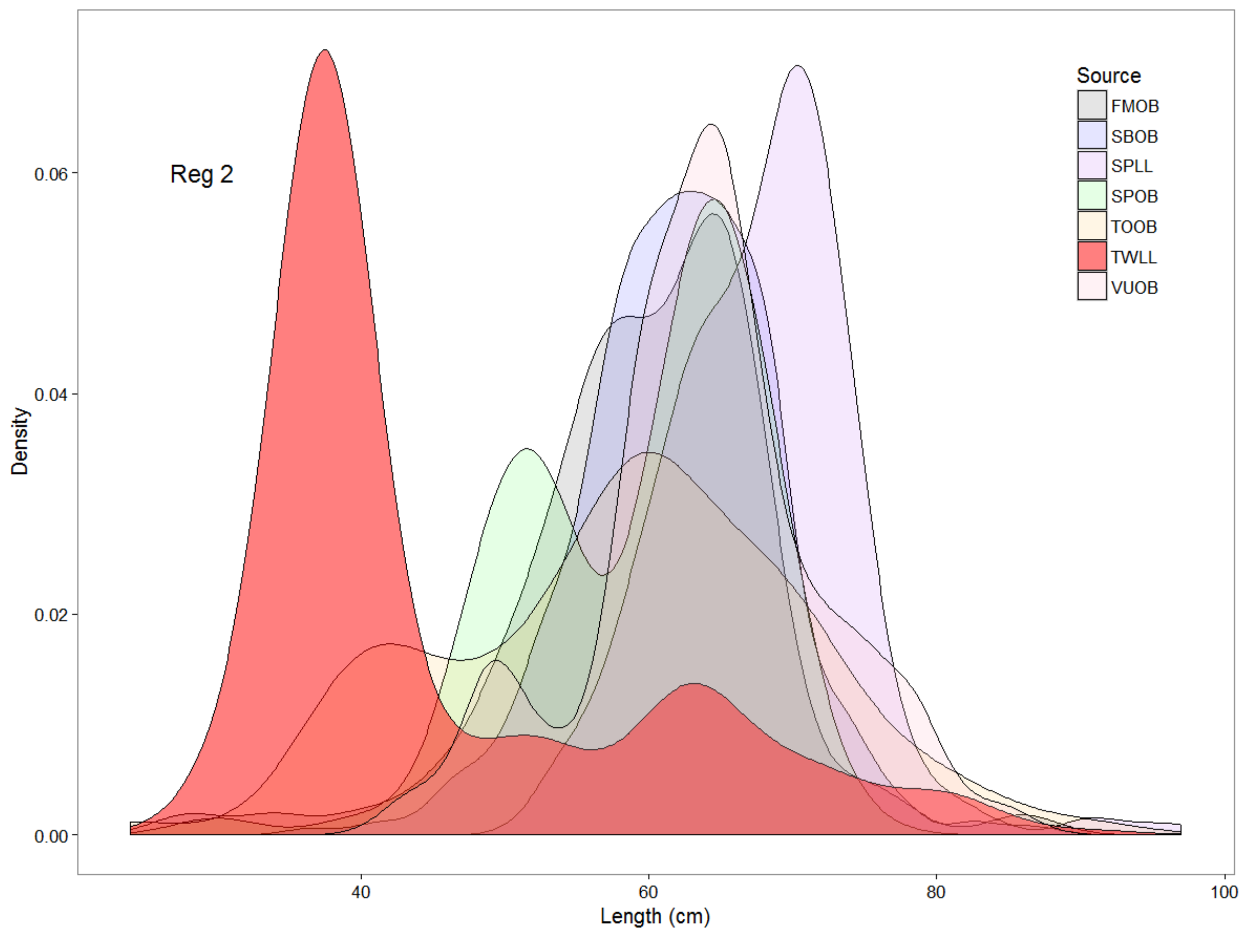

Figure 8: Figure showing densities for length composition data for Chinese Taipei longline vessels in region 2, with samples separated by their source. The red density shows the composition for samples sourced from the Taiwanese size sampling programme (TWLL) which shows anomalous features, while the more transparent densities are sourced from observer programmes and the SPC size sampling programme (SPLL).

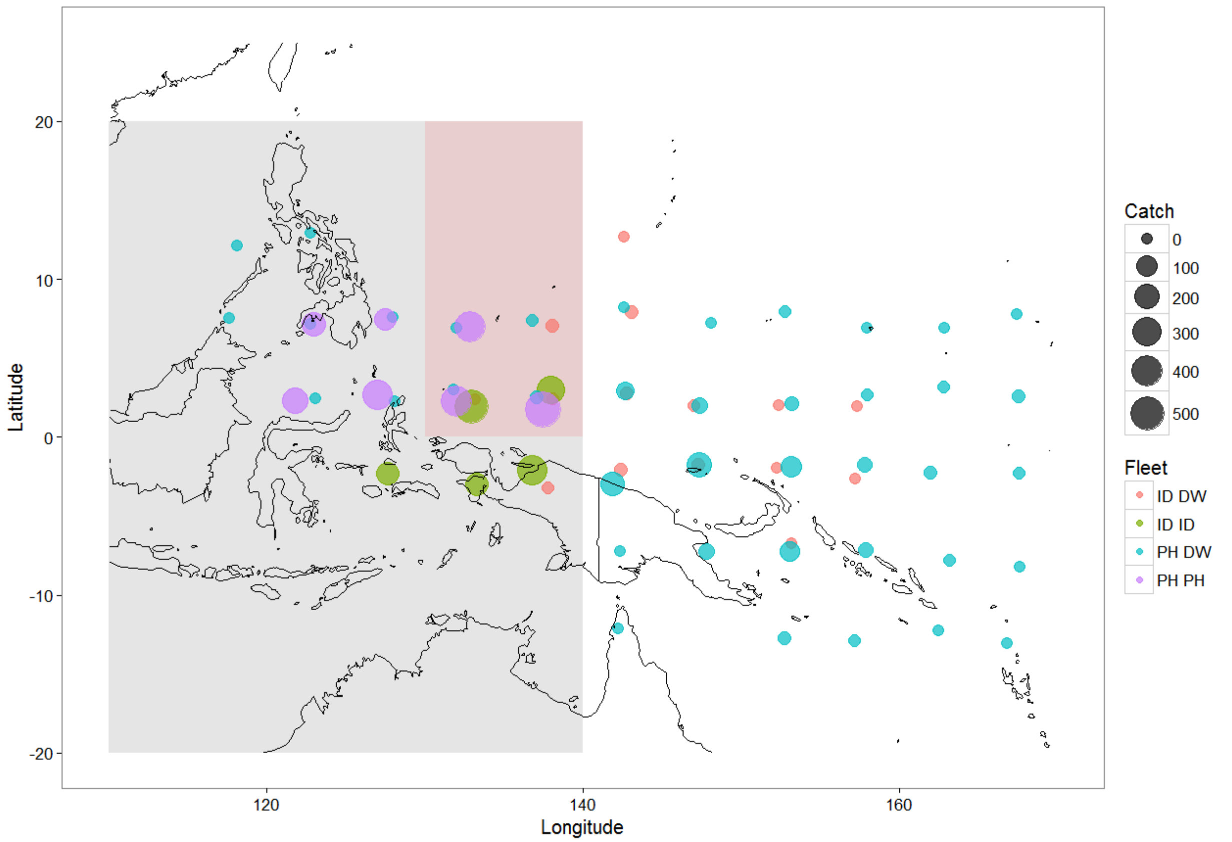

Figure 9: Spatial distribution of purse-seine fishing by Philippines and Indonesia vessels at the 5° by 5° scale. Region 4 of the stock assessment is the grey region and the pink region is the previous sub-region used for fishery 18 (S-ID.PH-4). The different fleet components are represented by different coloured circles with the size of the circle proportional to the weight of their catch. Slight jittering of the data is introduced to prevent obstruction of some values.

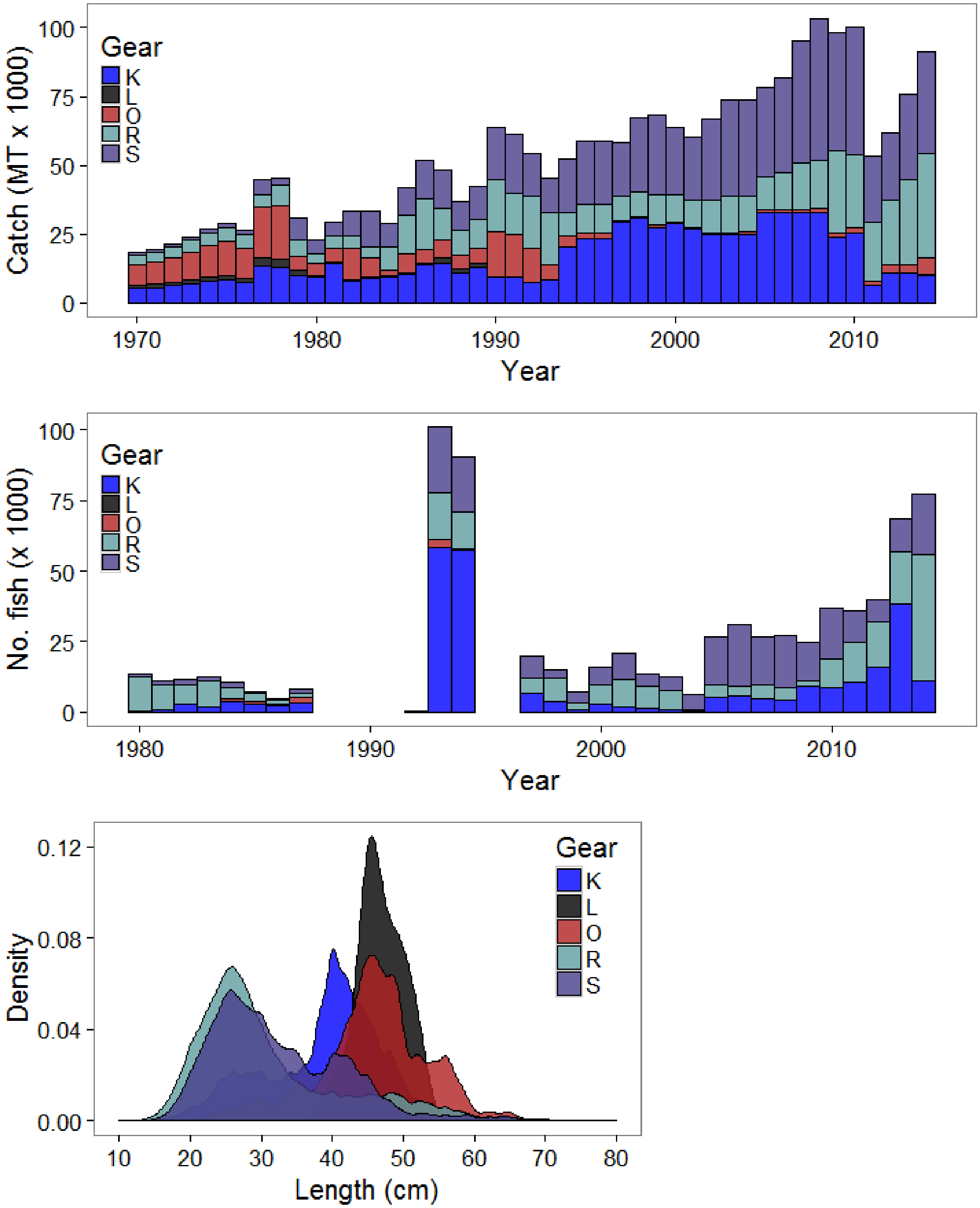

Figure 10: Data summaries for the Philipines and Indonesia miscellaneous and domestic purse seine fisheries. Panels are catch (top), number of fish with length measurements (middle) and the length compositions of measured fish (bottom). Gear-types are colour-coded; K - gillnet, L - longline, O - other/unknown, R - ringnet and S - purse seine.

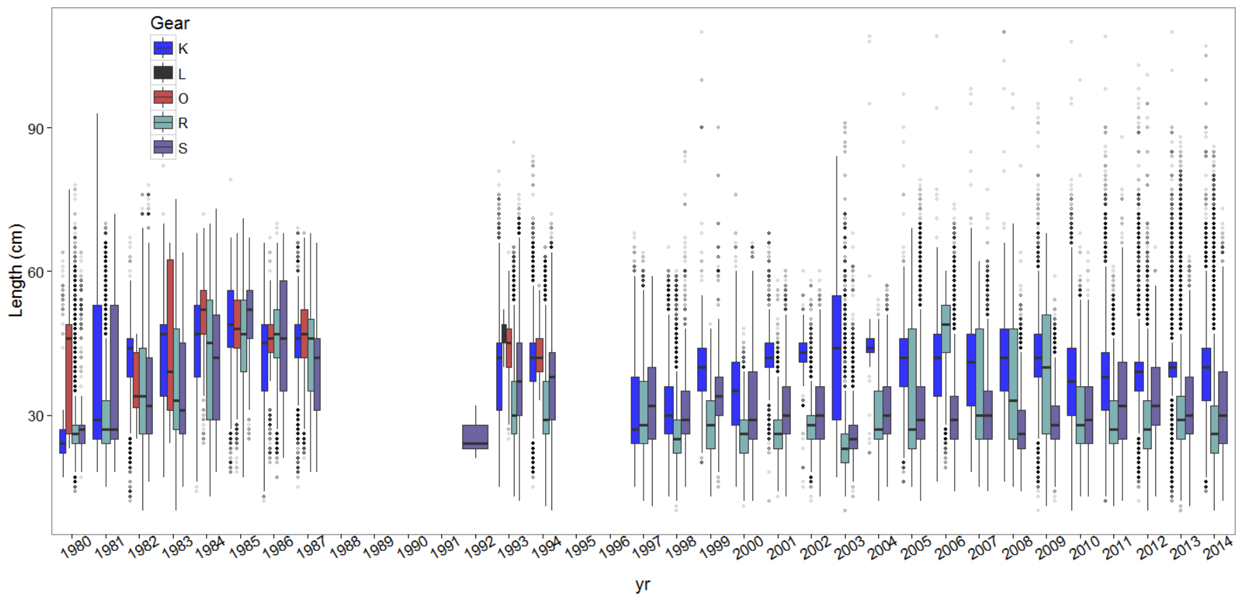

Figure 11: Box and whisker plot of the temporal patterns in length compositions of fish measured for the miscellaneous fishery in region 4. Gear-types are colour-coded; K - gillnet, L - longline, O - other/unknown, R - ringnet and S - purse seine.

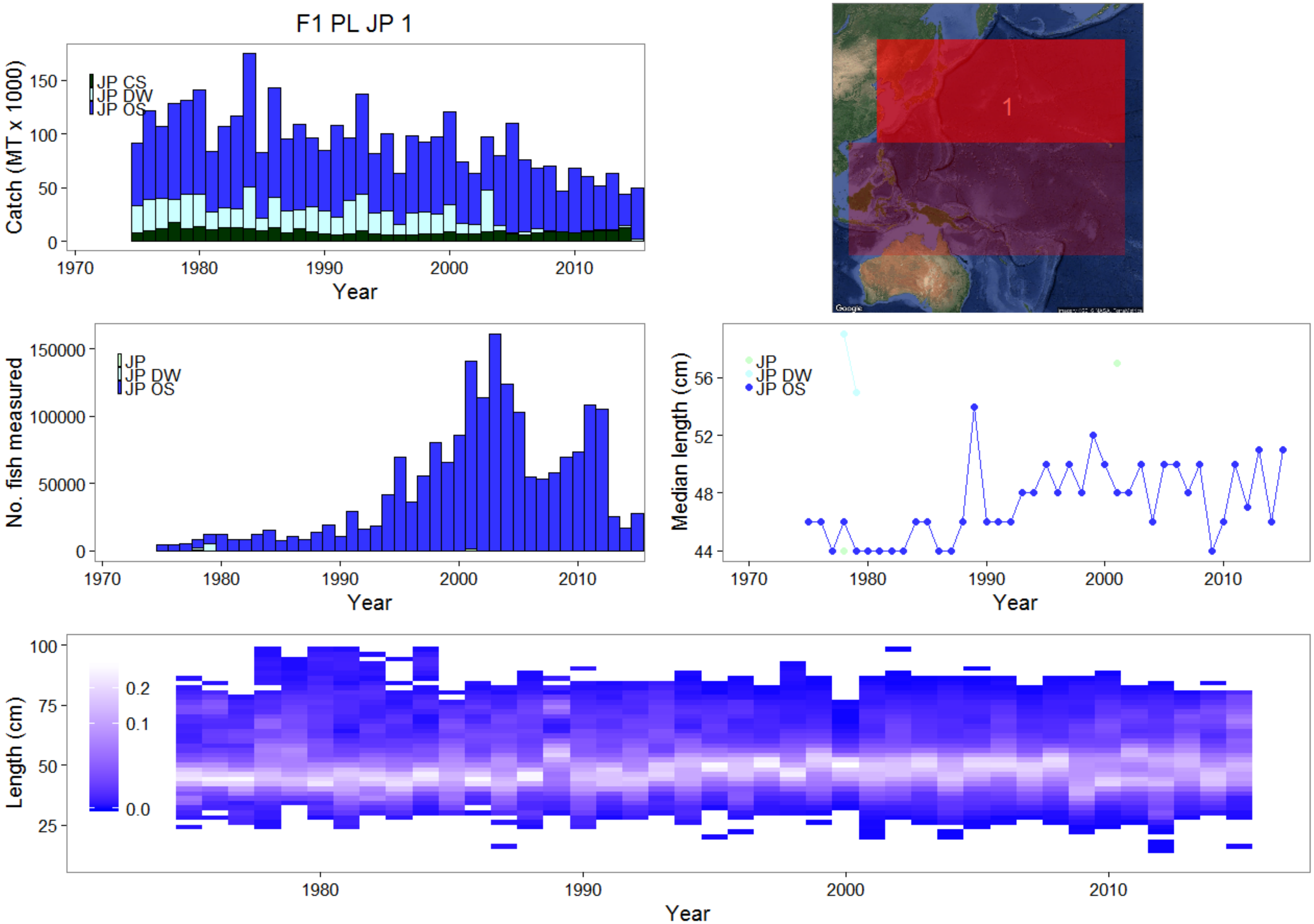

Figure 12: Summary of raw data available for fishery 1. The panels display; annual catch (top left), region of occurrence (top right), the annual number of fish with measured length (middle left), median length of available length composition data (middle right) and a tile plot of the annual length distribution of fish (bottom).

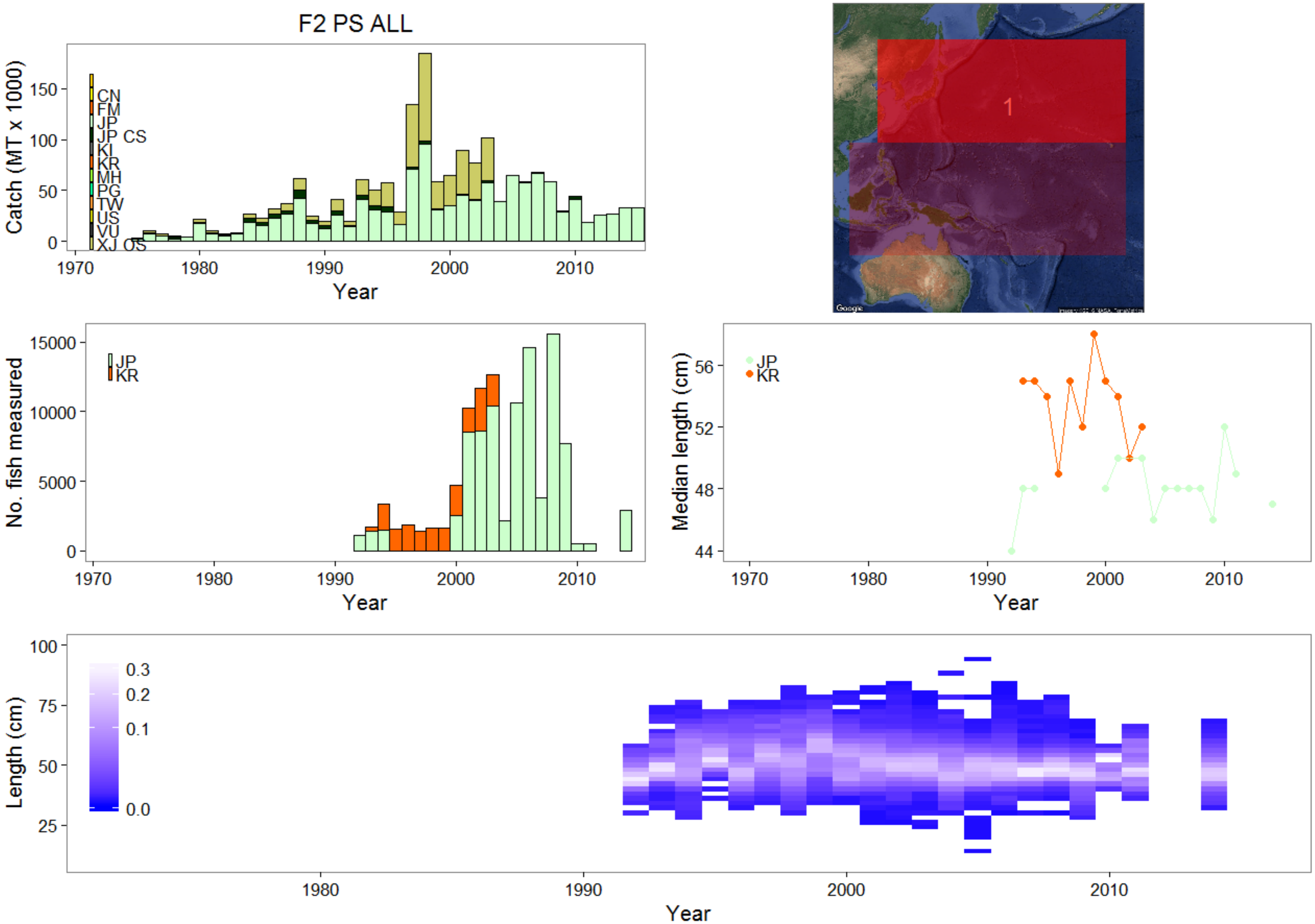

Figure 13: Summary of raw data available for fishery 2.

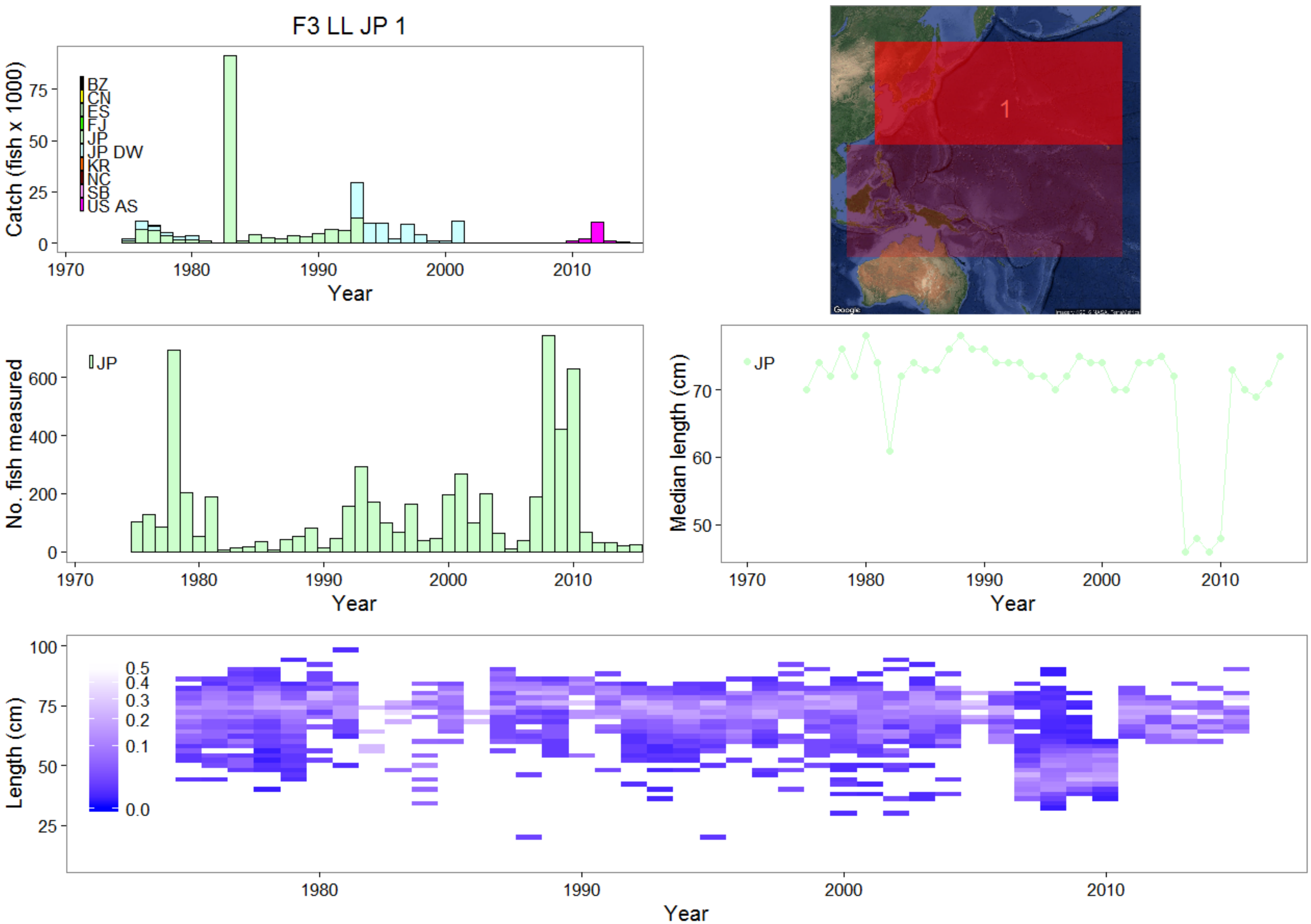

Figure 14: Summary of raw data available for fishery 3.

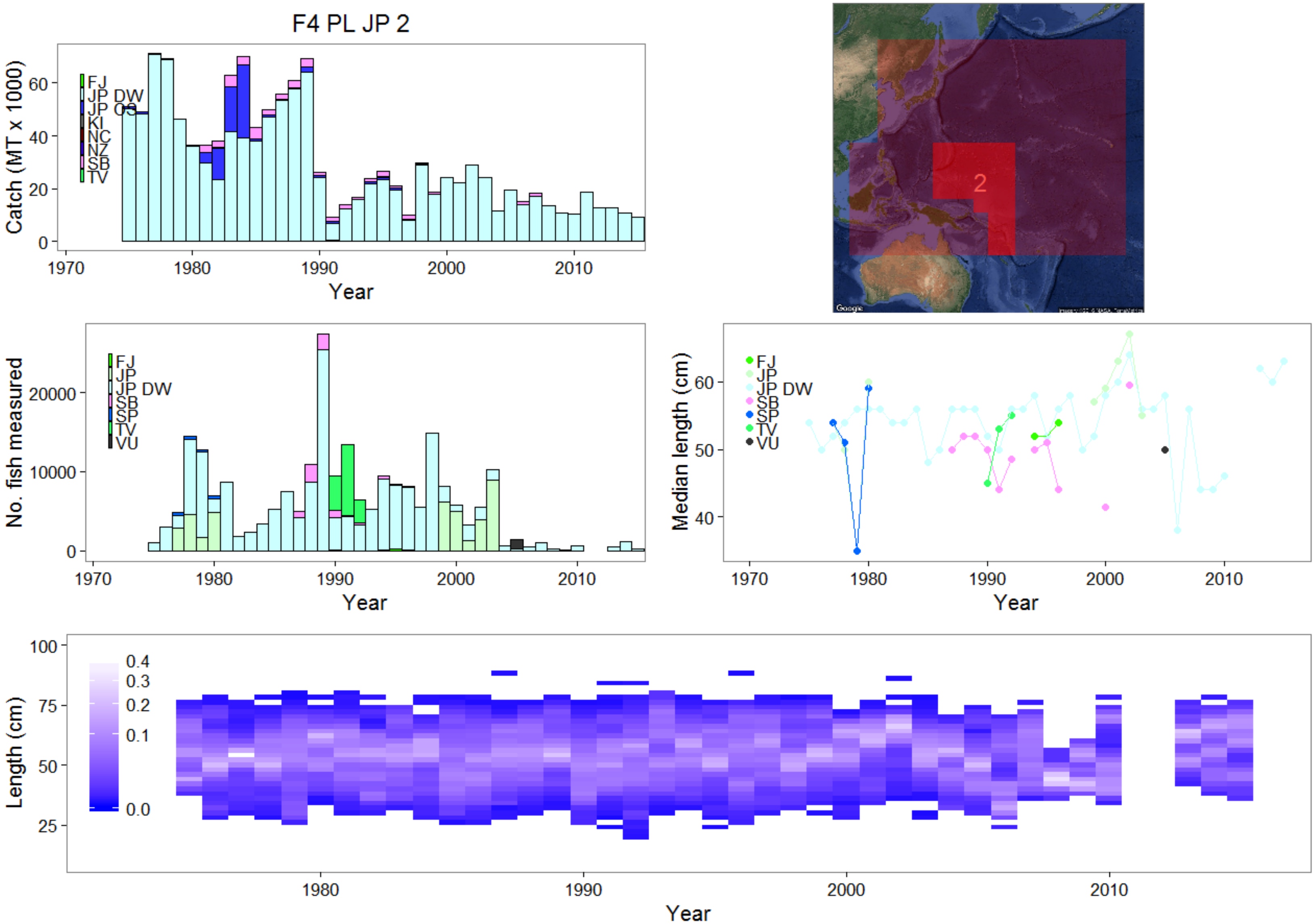

Figure 15: Summary of raw data available for fishery 4.

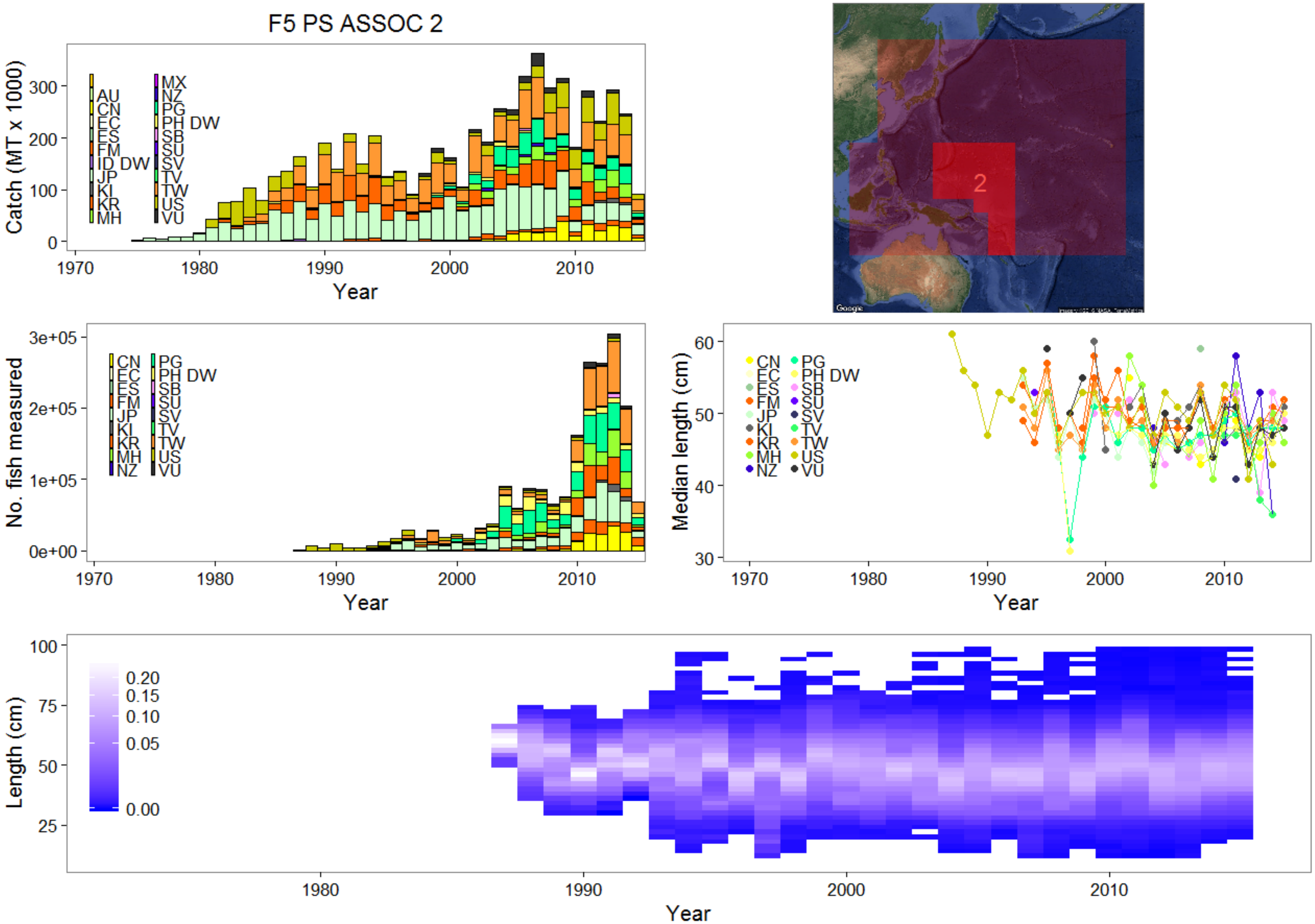

Figure 16: Summary of raw data available for fishery 5.

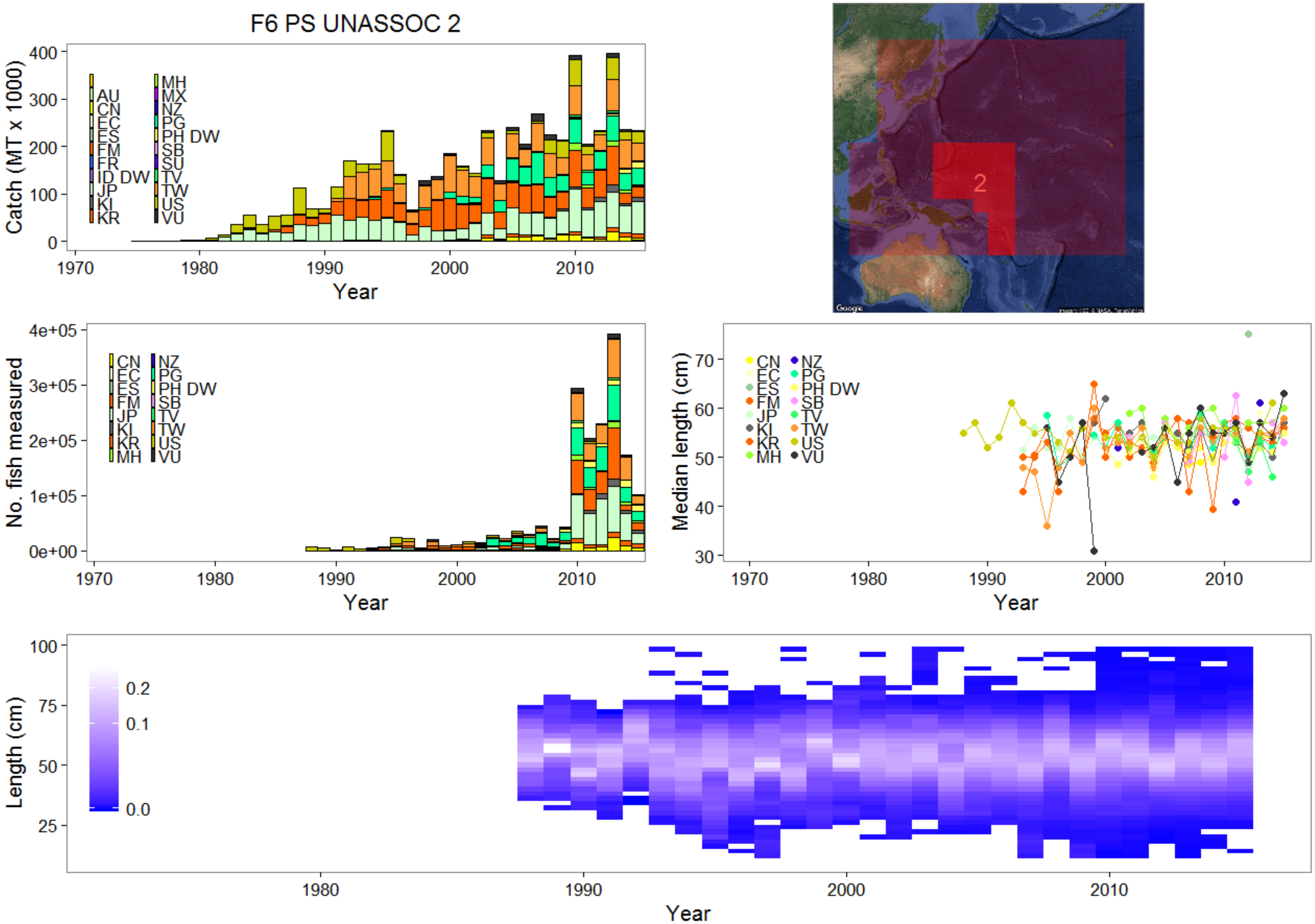

Figure 17: Summary of raw data available for fishery 6.

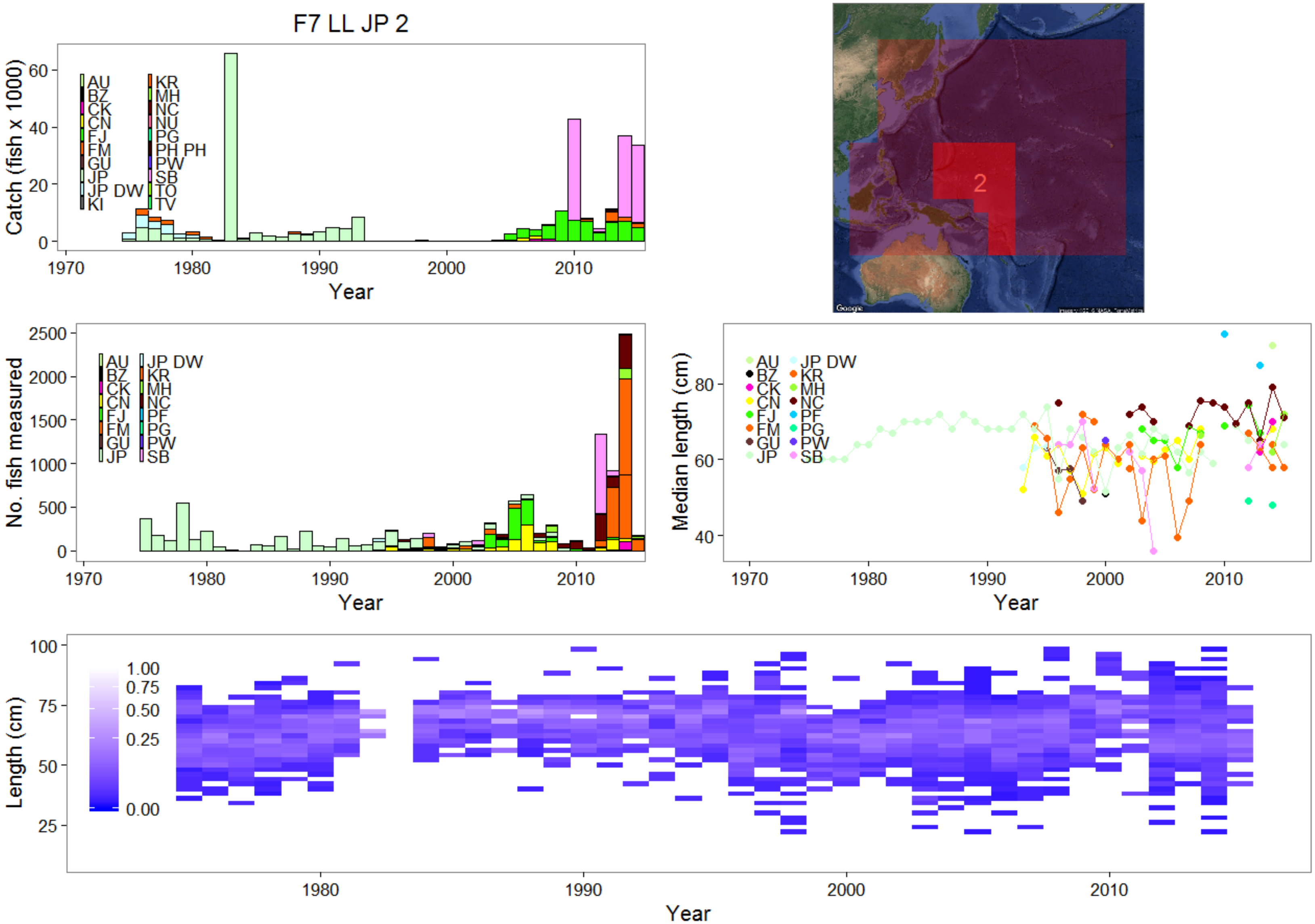

Figure 18: Summary of raw data available for fishery 7.

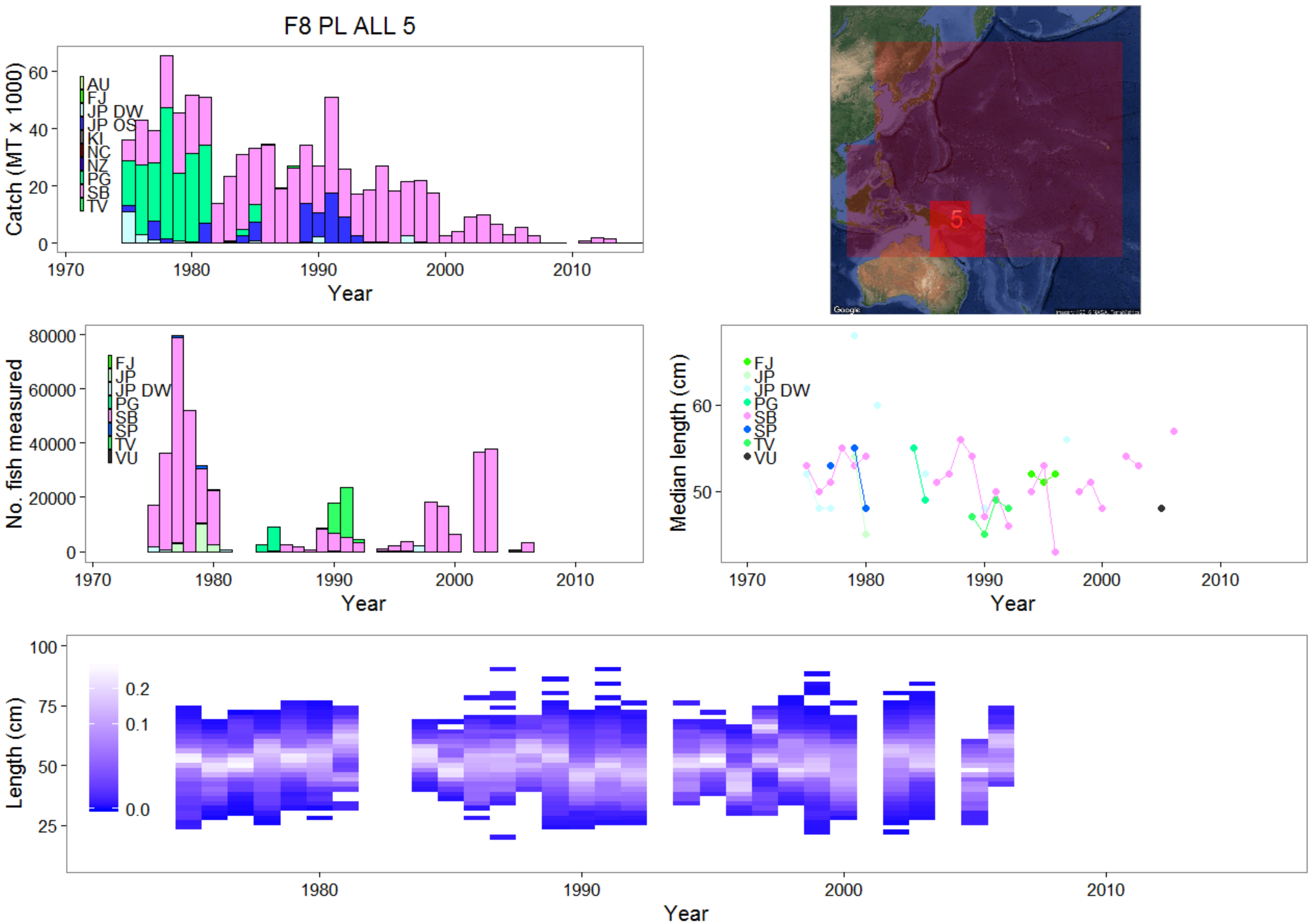

Figure 19: Summary of raw data available for fishery 8.

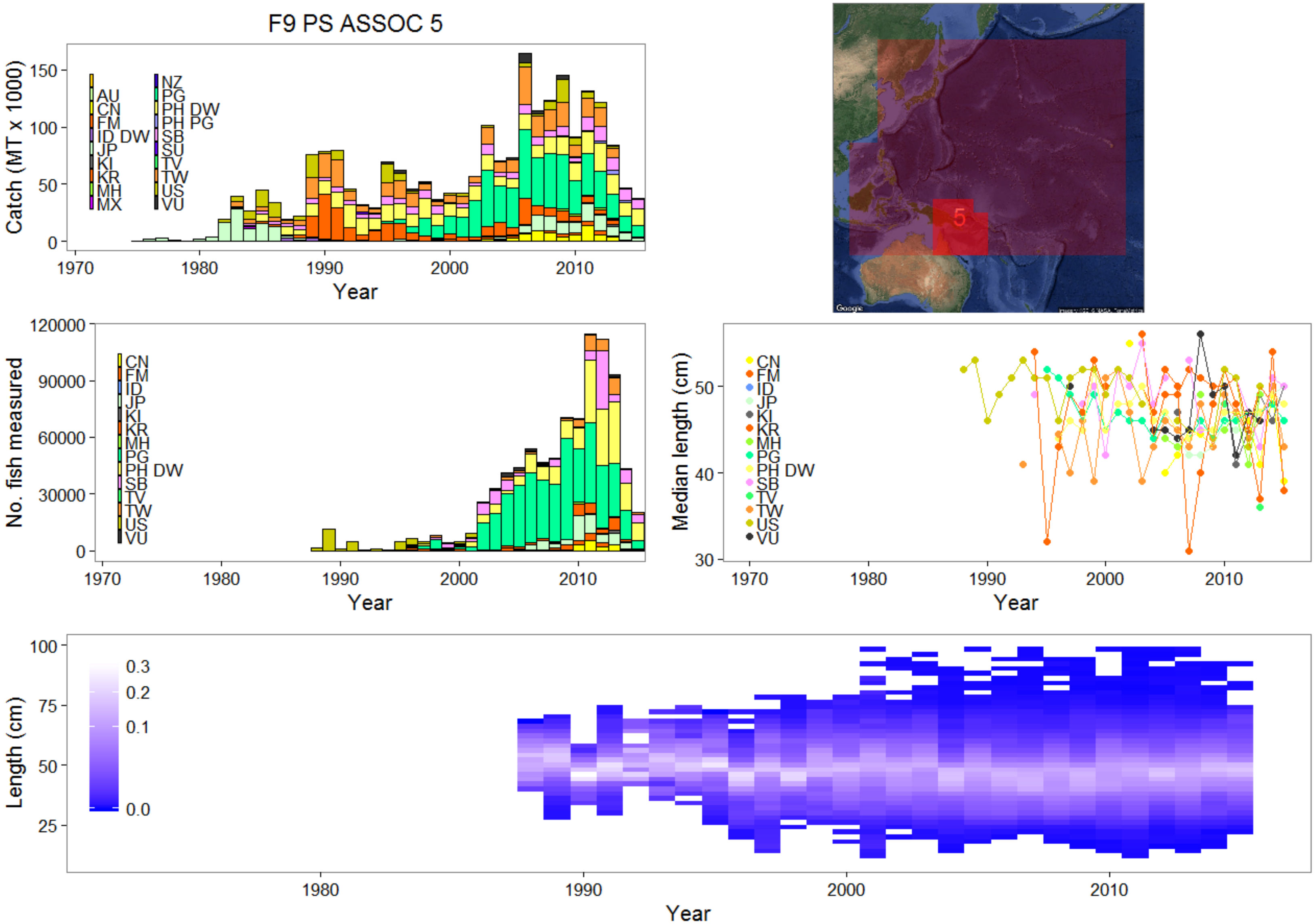

Figure 20: Summary of raw data available for fishery 9.

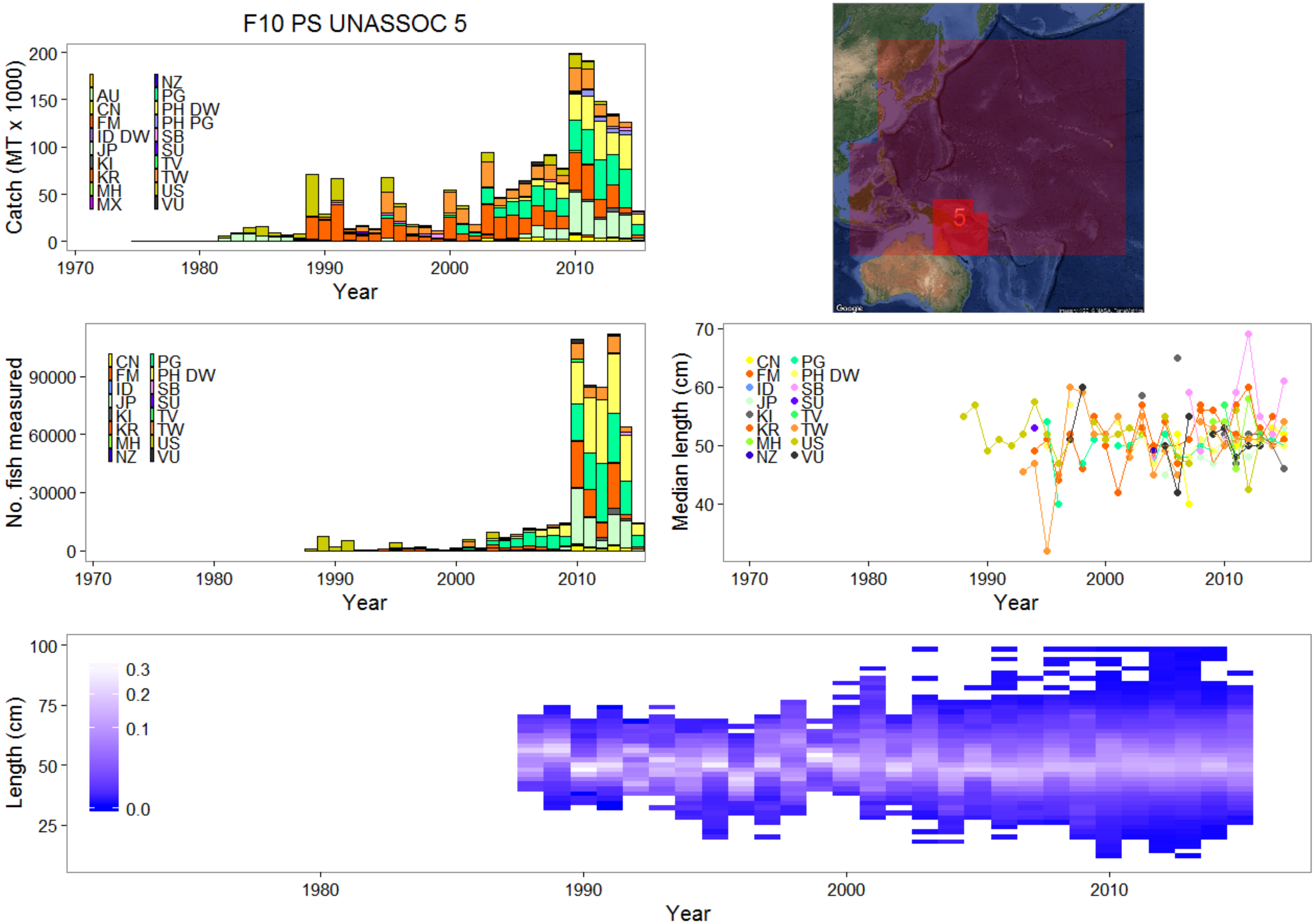

Figure 21: Summary of raw data available for fishery 10.

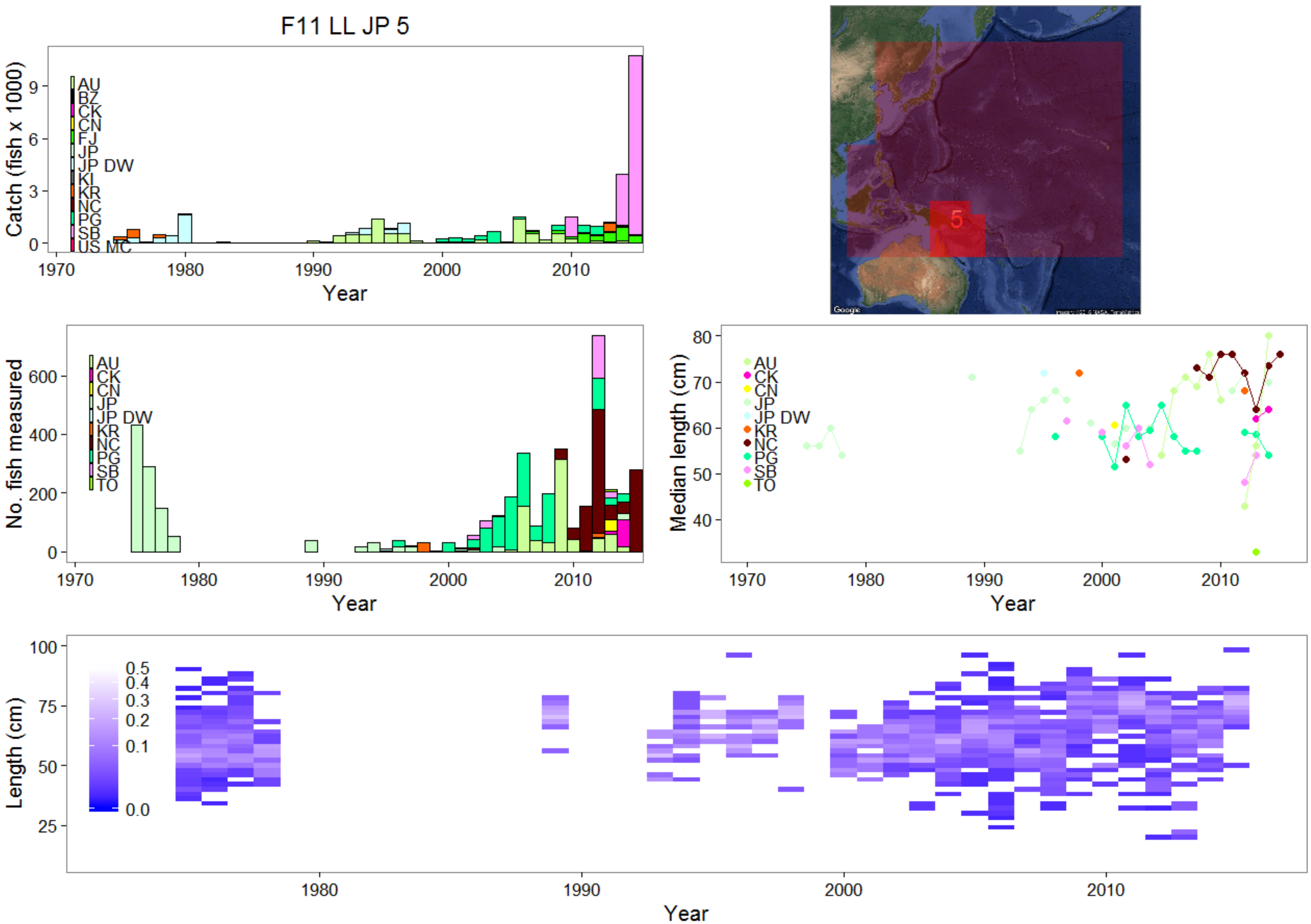

Figure 22: Summary of raw data available for fishery 11.

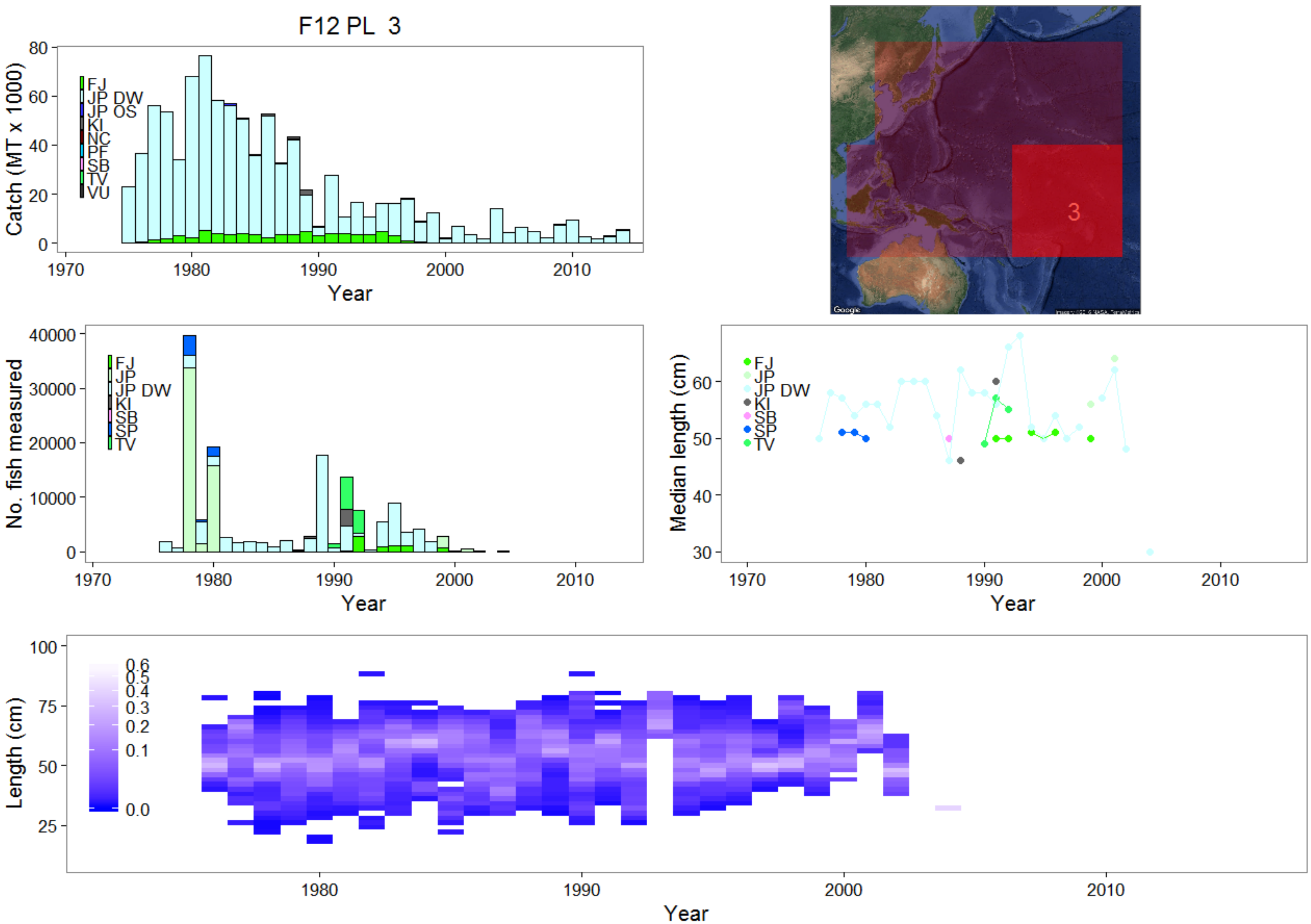

Figure 23: Summary of raw data available for fishery 12.

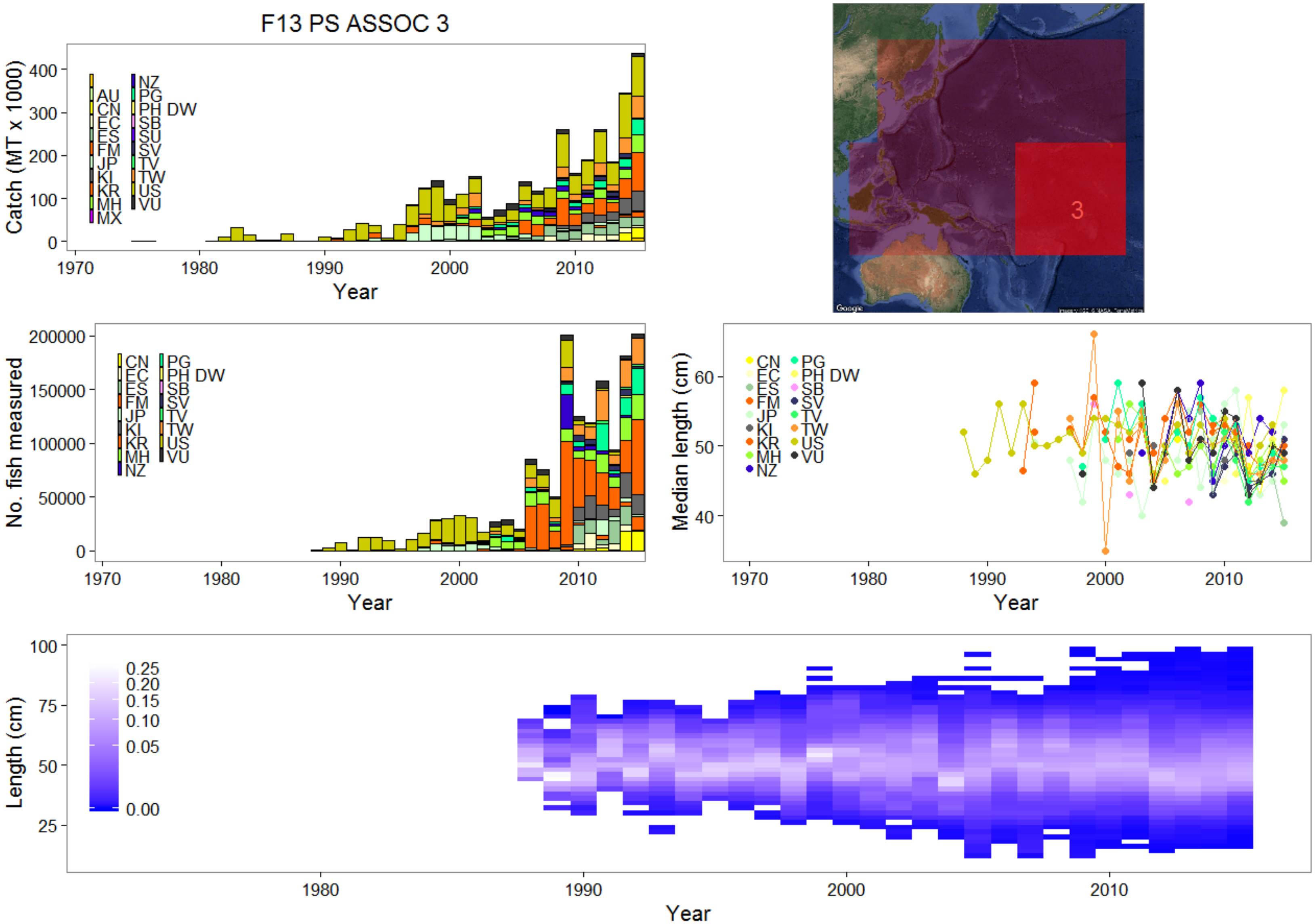

Figure 24: Summary of raw data available for fishery 13.

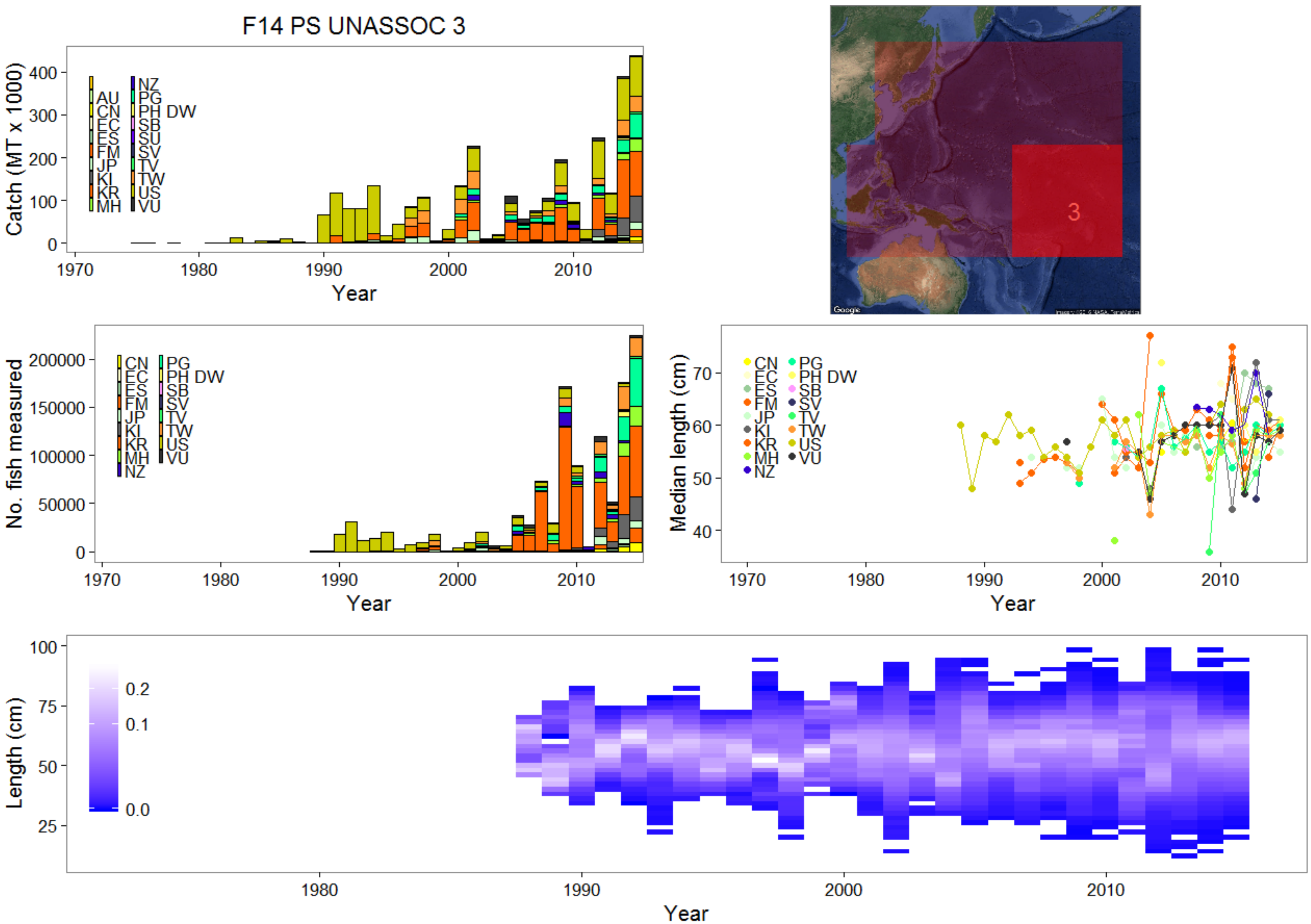

Figure 25: Summary of raw data available for fishery 14.

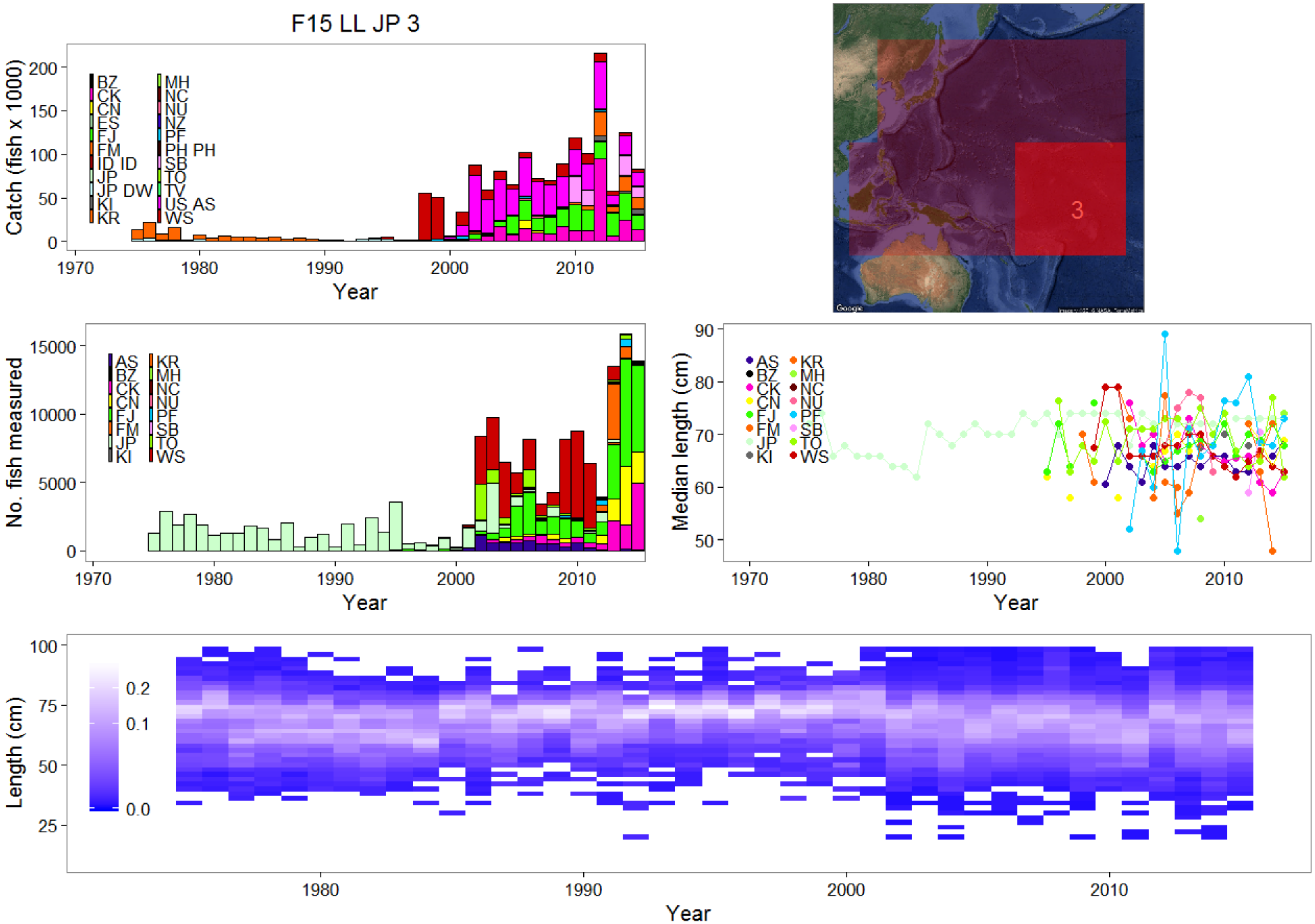

Figure 26: Summary of raw data available for fishery 15.

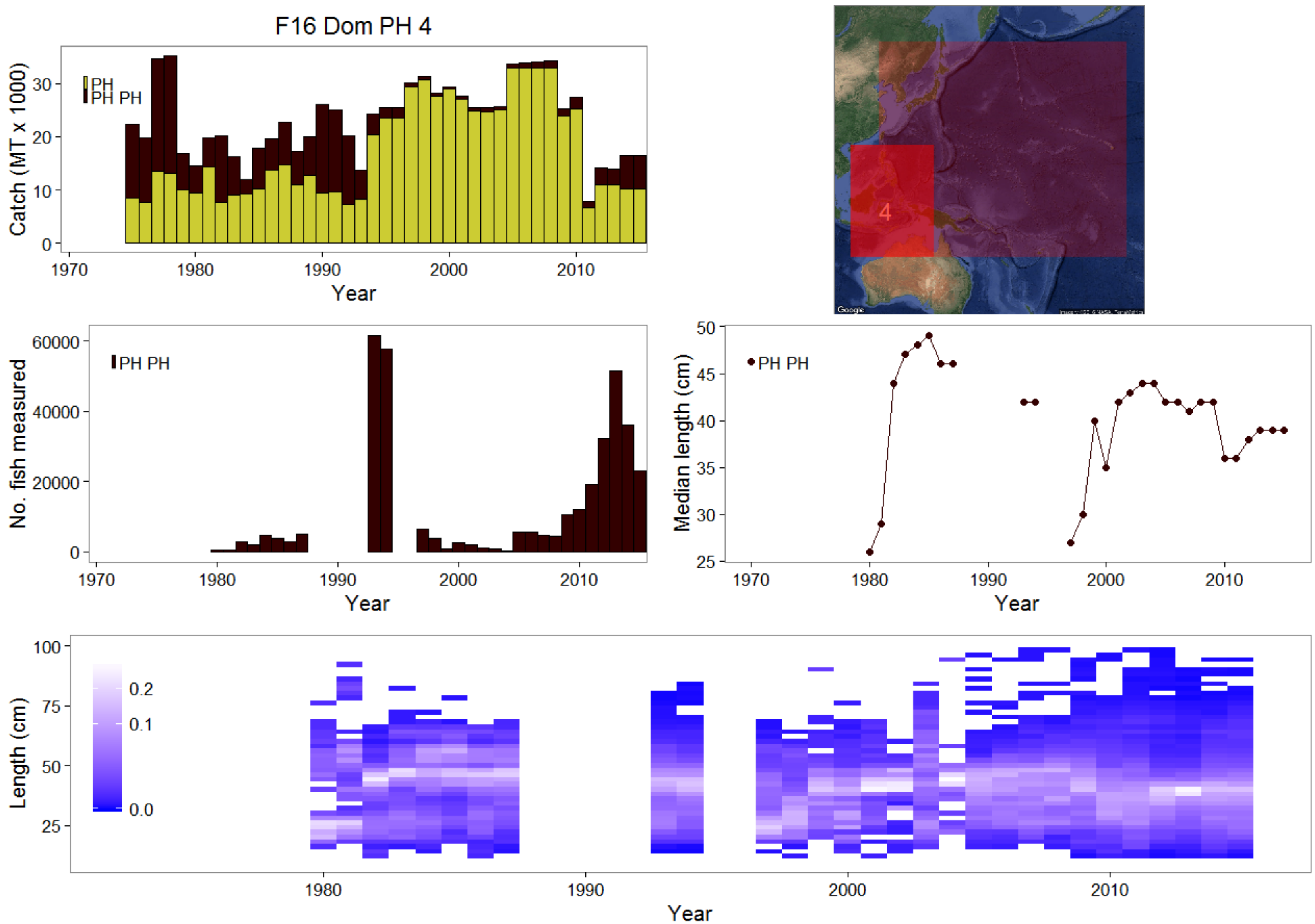

Figure 27: Summary of raw data available for fishery 16.

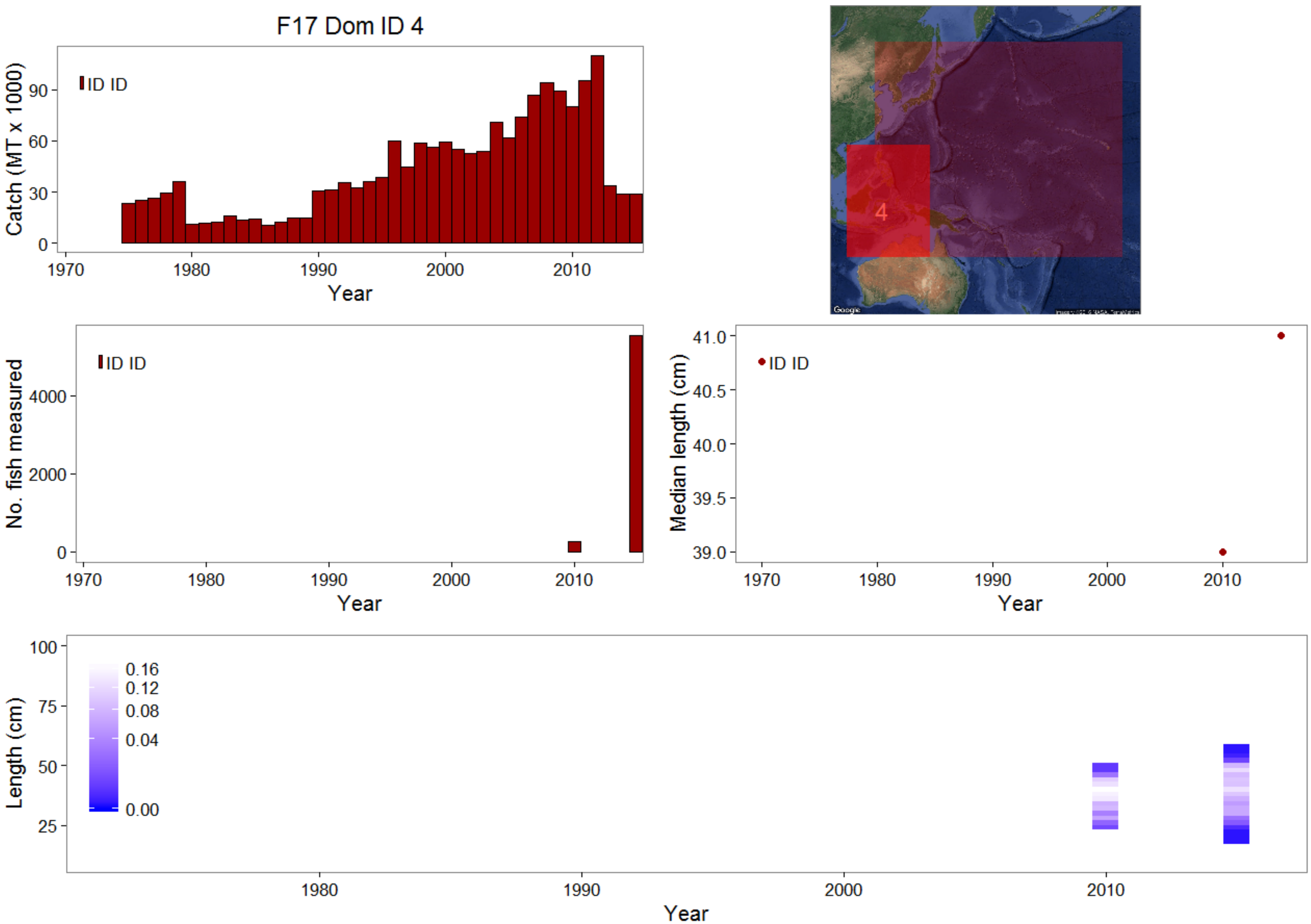

Figure 28: Summary of raw data available for fishery 17.

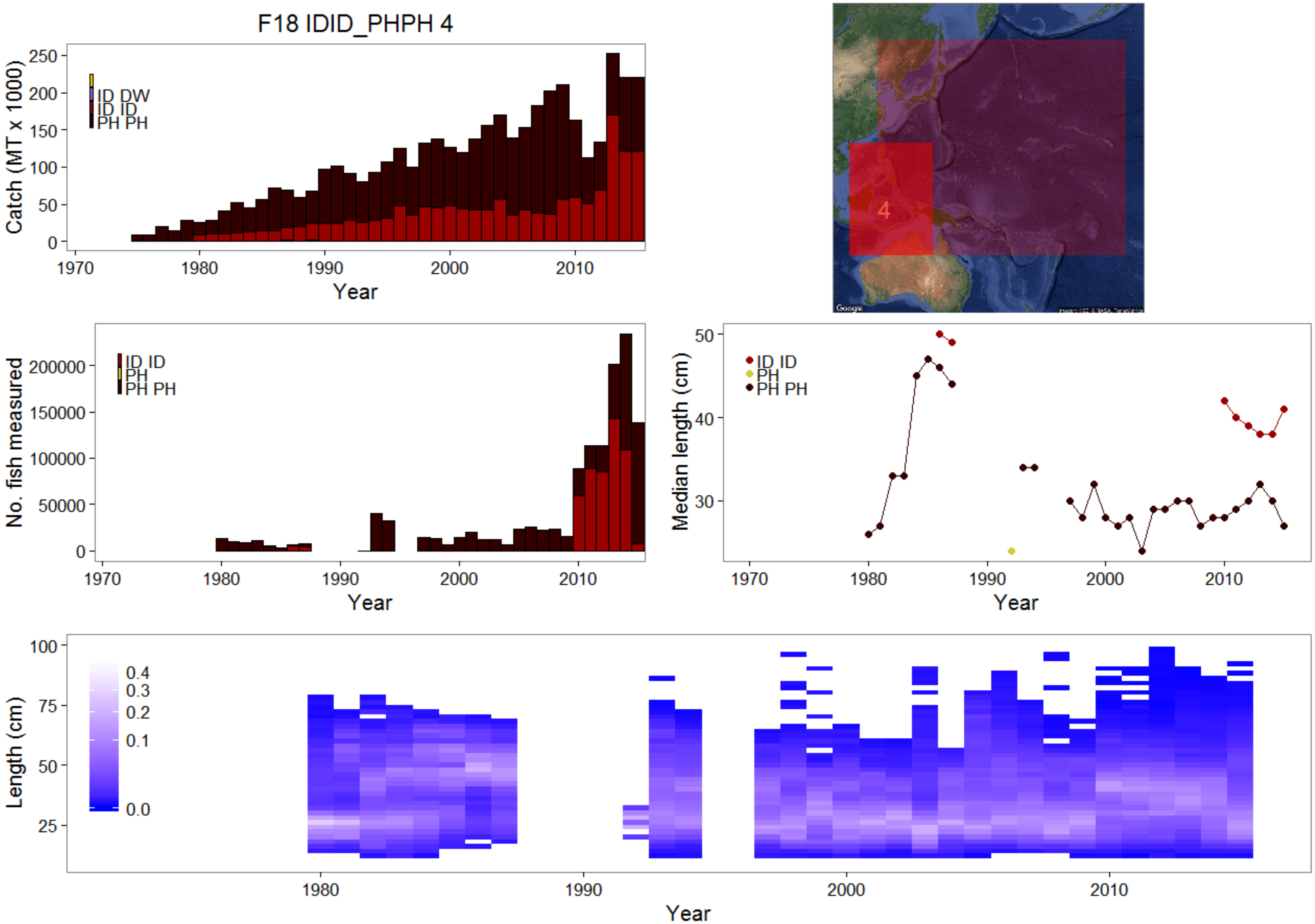

Figure 29: Summary of raw data available for fishery 18.

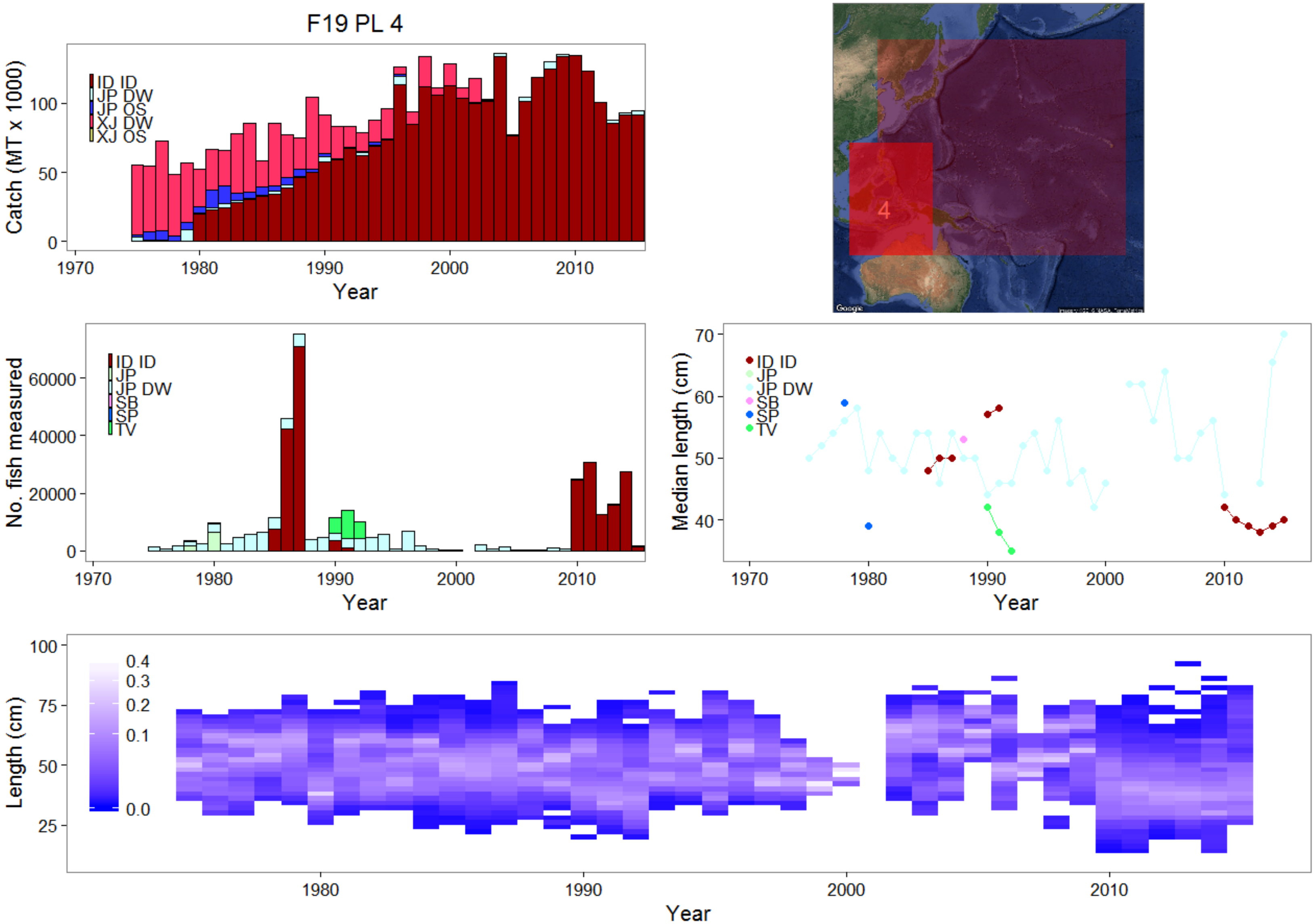

Figure 30: Summary of raw data available for fishery 19.

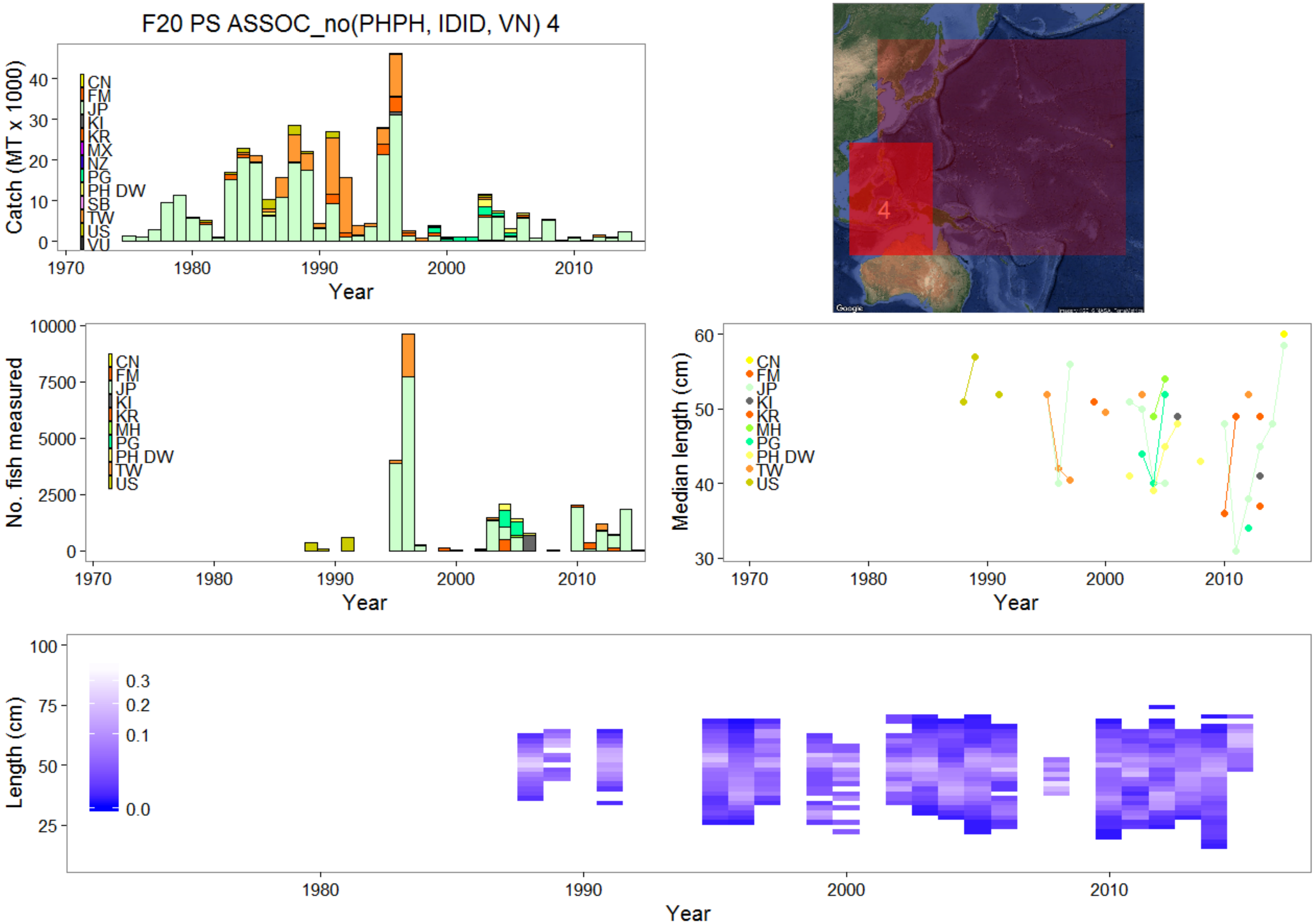

Figure 31: Summary of raw data available for fishery 20.

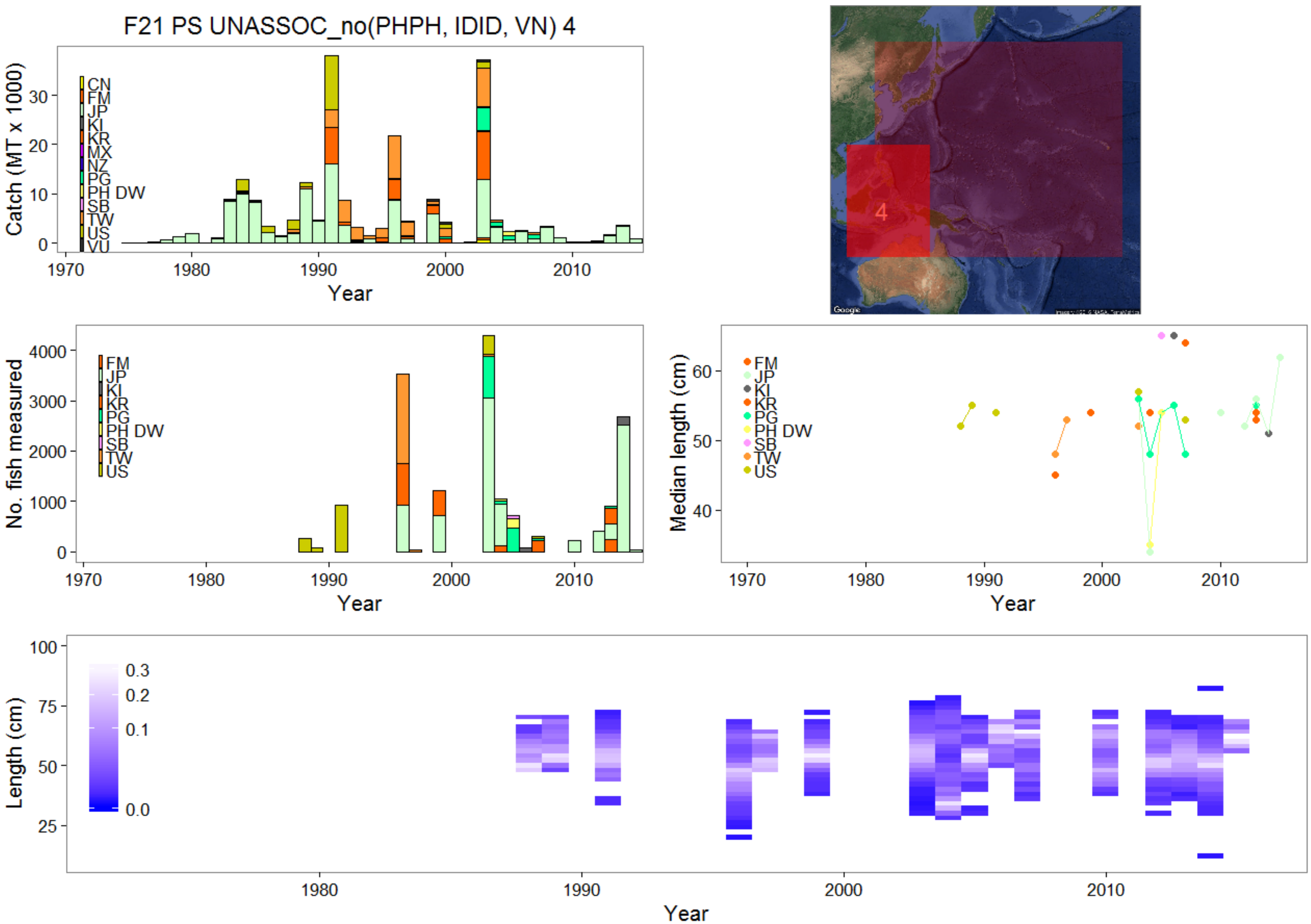

Figure 32: Summary of raw data available for fishery 21.

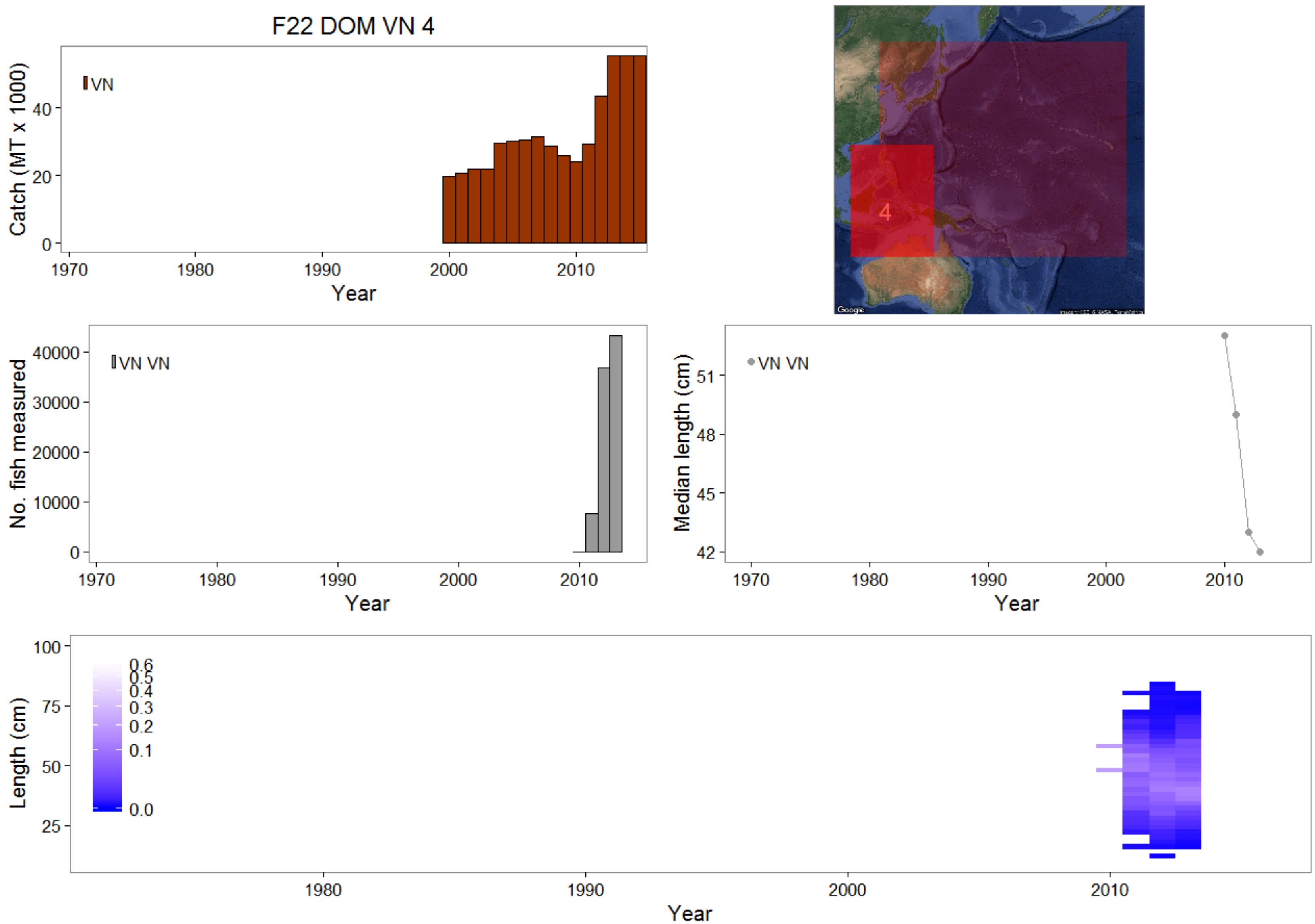

Figure 33: Summary of raw data available for fishery 22.

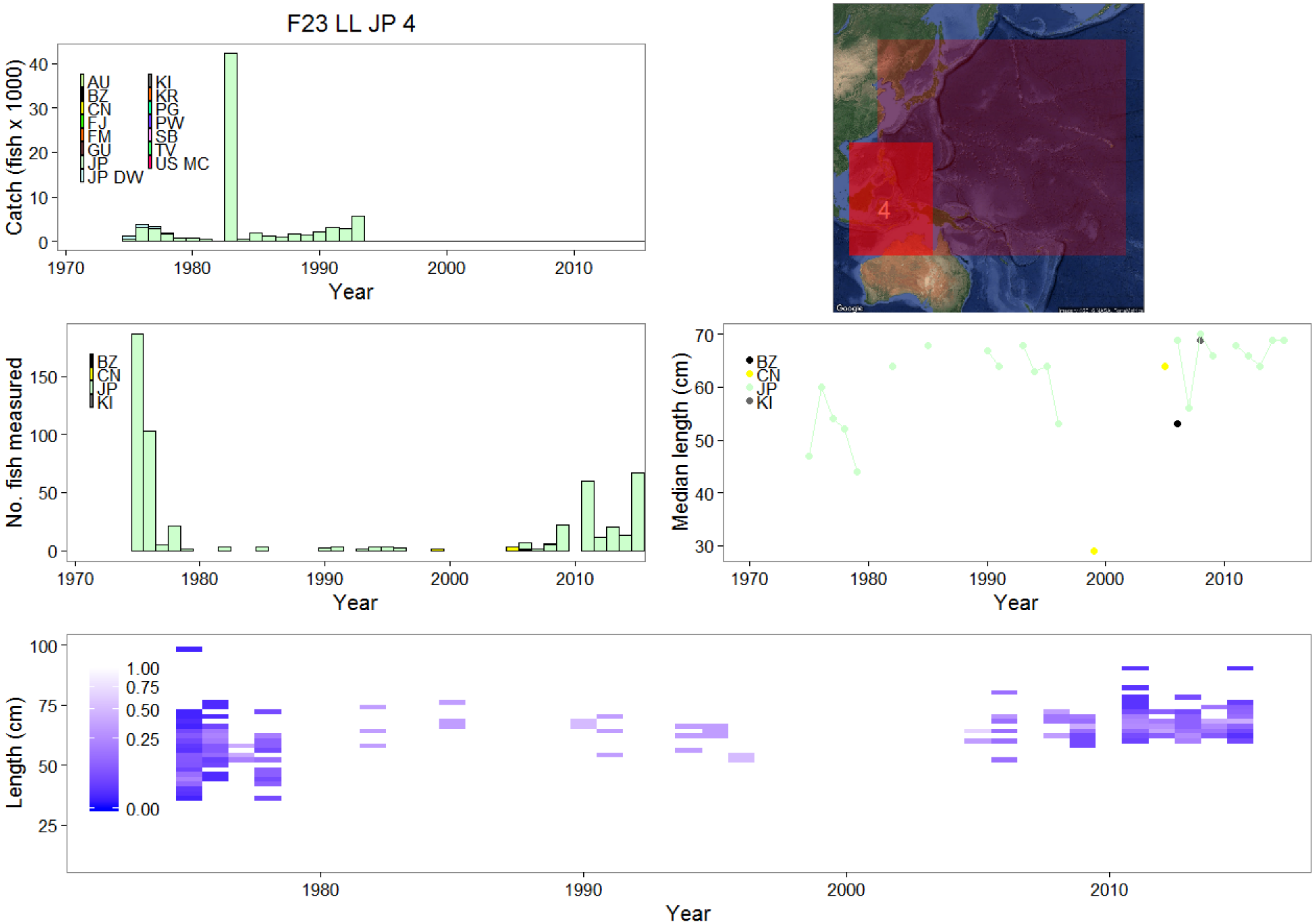

Figure 34: Summary of raw data available for fishery 23.