A MODELING APPROACH TO ESTIMATE OVERALL ATLANTIC FISHING EFFORT BY TIME-AREA STRATA (EFFDIS)

Interim Progress Report to the ICCAT secretariat

Doug Beare

14 July 2015

# Executive summary

The Sub-Committee was supportive of the work, approved the outline methodology, and recommended that GCS focus on longline and purse-seine fisheries since by-catch is typically low in baitboat fisheries. It was also suggested that Ghanaian scientists be consulted on the analysis of their purse-seine fisheries which are particularly interesting due to the close working relationships among 'fishing cooperatives' in that country.

# Introduction

The International Commission for the Conservation of Atlantic Tunas (ICCAT) (www.iccat.int), an intergovernmental organization whose Secretariat headquarters is based in Madrid, Spain, contracted Globefish Consultancy Services (GCS) to develop a modeling approach to estimate overall Atlantic long-line (LL), bait-boat (BB) and Purse Seine (PS) effort by time-area strata (EFFDIS). Using the ICCAT fisheries data currently available at the Secretariat, GCS is required generate a database of historic and current fishing effort distribution that meets the stated needs of the ICCAT Standing Committee on Research and Statistics (SCRS). The update of the EFFDIS dataset is believed to be critical, especially with regard to by-catch evaluations.

## The Proposal

GCS is developing a statistical modeling approach to estimating overall Atlantic fishing effort stratified by flag/fleet, gear, area (5ºx5º degree square grid), year and month. The current EFFDIS estimations for longline (LL) gear are being updated using the new modeling approach. Effort estimation procedures for baitboat (BB) and purse-seine (PS) gears will then also be developed with the appropriate units of effort. Tangible deliverables are scheduled to take the form of the outputs summarized below.

## Deliverables

1. Detailed descriptions of the methodological approach for SCRS submitted to the ICCAT secretariat.
2. An intermediate report on the status of development of the work as related to LL estimations to be presented to the 2015 Sub Committee on Ecosystems.
3. A progress report on estimations for all fisheries to be presented at the Blue Shark stock assessment session.
4. The development of a comprehensive User Guide and Reference Manuals describing algorithms and code developed.
5. Provision to the Secretariat of fishing effort and distribution (EFFDIS) estimates (including LL, BB, and PS) for all the main fleets in electronic format (e.g. csv files) compatible with the current ICCAT-DB structures.
6. An SCRS paper presenting the final estimates with a description of the methods submitted to the 2015 Species group meeting.
7. As part of a continuous process of feedback and comments from the SCRS the contractor will implement any changes requested for final approval.

# Progress and Activities

## Progress toward Deliverables

Detailed descriptions of the methodological approach have been submitted to the ICCAT Secretariat (Deliverable 1). The status of development of the work for LL estimations (Deliverable 2) was presented to the 2015 Sub-Committee on Ecosystems (SCRS/P/2015/026) by Dr L. Kell between June 8 to 12 since GCS were unable to attend. Details are available in the final report here, <http://www.iccat.es/en/meetingscurrent.htm> and a summary of the recommendations is presented below. The presentation, current report and verbal discussions that took place at the Blue Shark Stock Assessment satisfy the requirements of Deliverable 3. Deliverables 4 - 7 are in progress.

## Recommendations of the Sub-Committee on Ecosystems (SCRS/P/2015/026)

In the past, both the Sub-Committee on Ecosystems and the Working Group on Stock Assessment Methods have both made a number of recommendations for updating and improving EFFDIS, which will be incorporated in the new estimates. The Sub-Committee agreed that the EFFDIS data are complex. GCS has been working to understand the data and identify issues related to non-random, non-representative sampling. All the analysis are being made available on a github repository <http://iccat-stats.github.io/>.

It was also clarified that the EFFDIS data are reliant on Task II catch and effort information, and it is known that there are errors in these data. The secretariat clarified that data screening will take place to eliminate problems such as effort duplication. This revision should reduce the amount of problematic data used for the EFFDIS estimation. The secretariat and GCS are also working to harmonise the very heterogeneous catch and effort data in order to make it comparable and facilitate its use in the development of EFFDIS.

It was also discussed that the EFFDIS estimations rely on species composition information (for key target species). This is problematic when applying to by-catch species since the composition is biased towards target species and there are in-consistent historical trends in this bias. GCS is hoping to address this issue using cross-validation although non-random bias remains a complicated problem. The Sub-Committee also requested the addition of southern Bluefin tuna catch information into the estimation of EFFDIS.

Due to the fact that by-catch information is usually recorded on a set by set basis for purse seine, this unit of effort would be the most appropriate for use as the effort metric in the EFFDIS dataset for this gear. It is not, however, the most frequently reported unit of effort for purse seines, and thus GCS will have to evaluate the practicality of using this metric.

The Sub-committee also discussed the proposal by the 2013 Working group on stock assessment methods (WGSAM) regarding the additional gears that should be included in the EFFDIS estimation. Previously, it was requested that estimations be done for both purse seine and baitboat fleets. It was pointed out, however, that EFFDIS is only used to assess the fishing impacts of ICCAT fleets on by-catch species, and since by-catch in baitboat fisheries is minimal, there is no point in conducting this exercise for that gear. It was thus agreed that GCS should focus on the more important longline and purse seine estimations under the current contract.

The Sub-Committee also suggested that, when examining 'fleet profiles' for the purse seine fleet, instead of just separating the effort into 'FAD' or 'Free school fishing', an additional category, namely the Ghanaian purse seine/baitboat cooperative fishery should be considered. This is due to the different catchability apparent for this fleet due to the close cooperation in fishing operations between these two gear types and the sharing of catch, which could bias effort estimates. It was suggested that Ghanaian scientists should be consulted to fully explore this unique sector.

## Timeline

The contract between GCS and ICCAT was formally signed by Driss Meski on 26 May 2015. The project is on track to fulfill all Deliverables within the total 6 months allotted. The original agreed Timetable is duplicated below (Table 1) with comments on progress.

*Table 1. EFFDIS project workplan*

|  |  |  |
| --- | --- | --- |
| Date (2015) | Work | Progress |
| May | Contractor to visit ICCAT | Dr Beare visited ICCAT HQ, Madrid, 24-29 May 2015 and existing methods were reviewed. |
| May | Develop methods for a single longline (LL) fleet | 'Strawman' methodology for Chinese Taipei LL developed. |
| 8-12 Jun | Present methodology for LL at SC ECO, Madrid. | 'Strawman' methodology for Chinese Taipei LL developed and presented at SG ECO meeting by Dr Kell. |
| Jun | Develop methods single baitboat (BB) fleet. | In progress |
| Jun | Develop methods for single purse-seine (PS) fleet. | In progress |
| Jul | Expand methods to produce a global estimate with variance. | Global estimates produced for LL, PS and BB to follow shortly. |
| Jul | Seek feedback on methodology from ICCAT Secretariat. Get method approved. | Feedback has been sought and method approved. |
| 27 – 31 Jul | Attend Blue shark stock assessment session. Provide progress report | Dr Beare attended Blue shark assessment meeting in Lisbon between 26 and 31 July. Feedback was largely positive. |
| Aug | Build online spatial, relational, spatial database | Beta version of database built and online, see <http://134.213.29.249/effdis/># |
| Aug | Document methodology, produce Manual and User Guides. | In progress |
| Sept | Write SCRS paper presenting the EFFDIS estimates with method descriptions. | In progress |
| 21 - 25 Sep | Attend Species group meetings and present methods in Madrid. | In progress |
| Oct | Respond to feedback from SCRS and finalize all deliverables. | In progress |

## Data, servers, and version control

An Ubuntu cloud server with a static IP address (134.213.29.249, effdis-tuna-cc1) has been set up by ICCAT specifically for the current project. GCS has also set up a PostGIS enabled PostgreSQL server on this machine where all data related to the project are being stored. The database can be accessed directly from the command line of any unix machine with PostgreSQL installed (psql -h 134.213.29.249 -d effdis -U postgres) or with ODBC via R.

The effdis-tuna-cc1 server also hosts the online geographic information system being trialled for the EFFDIS project by GCS (<http://134.213.29.249/effdis/>#). All scripts (R, Rmarkdown, Shell, PHP) developed by the project are being backed up on GitHub (<https://github.com/bearedo/effdis>). Furthermore all reports and presentations are being done with Rmarkdown, linked to GitHub. This should all facilitate any future modification and updating.

## Exploratory data analysis

### Data screening

Once the RODBC library is installed and the /etc/odbc.ini file modified to include the effdis database the data can be accessed via R according to the following.

Here is an example of counting the numbers of times each effort type has been recorded in the Task II data for longliners. The table illustrates the problems with these data. Brazil, for example, only supplies 'NO. HOOKS' (9380) while Belize has supplied both 'NO. HOOKS' and 'D.FISH'. Many flags have also supplied no effort data with their Task II submissions.

*Table 2. Effort type sampling by flag in EFFDIS Task II database*

|  |  |  |
| --- | --- | --- |
| flag | effort\_type | no\_records |
| Belize | D.FISH | 485 |
| Belize | NO.HOOKS | 629 |
| Brasil | NO.HOOKS | 9380 |
| China P.R. | NO.HOOKS | 1225 |
| China P.R. | -none- | 43 |
| Chinese Taipei | NO.HOOKS | 37789 |
| Cuba | NO.HOOKS | 2298 |
| EU.España | NO.HOOKS | 19721 |
| EU.España | -none- | 3150 |
| EU.Malta | D.FISH | 3657 |
| EU.Malta | NO.HOOKS | 203 |
| EU.Malta | -none- | 432 |
| EU.Portugal | NO.HOOKS | 1692 |
| EU.Portugal | -none- | 2753 |
| EU.Portugal | NO.TRIPS | 13 |
| Japan | NO.HOOKS | 34770 |
| Korea Rep. | NO.HOOKS | 9390 |
| Maroc | NO.HOOKS | 70 |
| Maroc | -none- | 12 |
| Mexico | NO.HOOKS | 521 |
| Mexico | NO.SETS | 12 |
| Mexico | SUC.SETS | 61 |
| Namibia | NO.HOOKS | 861 |
| Namibia | -none- | 6 |
| Other | D.AT SEA | 51 |
| Other | D.FISH | 295 |
| Other | NO.HOOKS | 8674 |
| Other | -none- | 1399 |
| Other | NO.SETS | 286 |
| Other | NO.TRIPS | 65 |
| Other | SUC.D.FI | 4 |
| Panama | NO.HOOKS | 547 |
| Philippines | NO.HOOKS | 497 |
| Philippines | -none- | 804 |
| South Africa | D.AT SEA | 10 |
| South Africa | D.FISH | 13 |
| South Africa | NO.BOATS | 3 |
| South Africa | NO.HOOKS | 1510 |
| South Africa | -none- | 4 |
| St. Vincent and Grenadines | NO.HOOKS | 1112 |
| St. Vincent and Grenadines | -none- | 1 |
| Trinidad and Tobago | NO.HOOKS | 84 |
| Trinidad and Tobago | NO.TRIPS | 12 |
| Uruguay | NO.HOOKS | 1919 |
| Uruguay | -none- | 17 |
| U.S.A. | NO.HOOKS | 78698 |
| U.S.S.R. | D.FISH | 61 |
| U.S.S.R. | NO.HOOKS | 166 |
| U.S.S.R. | -none- | 26 |
| Vanuatu | NO.HOOKS | 19083 |
| Venezuela | NO.HOOKS | 18588 |

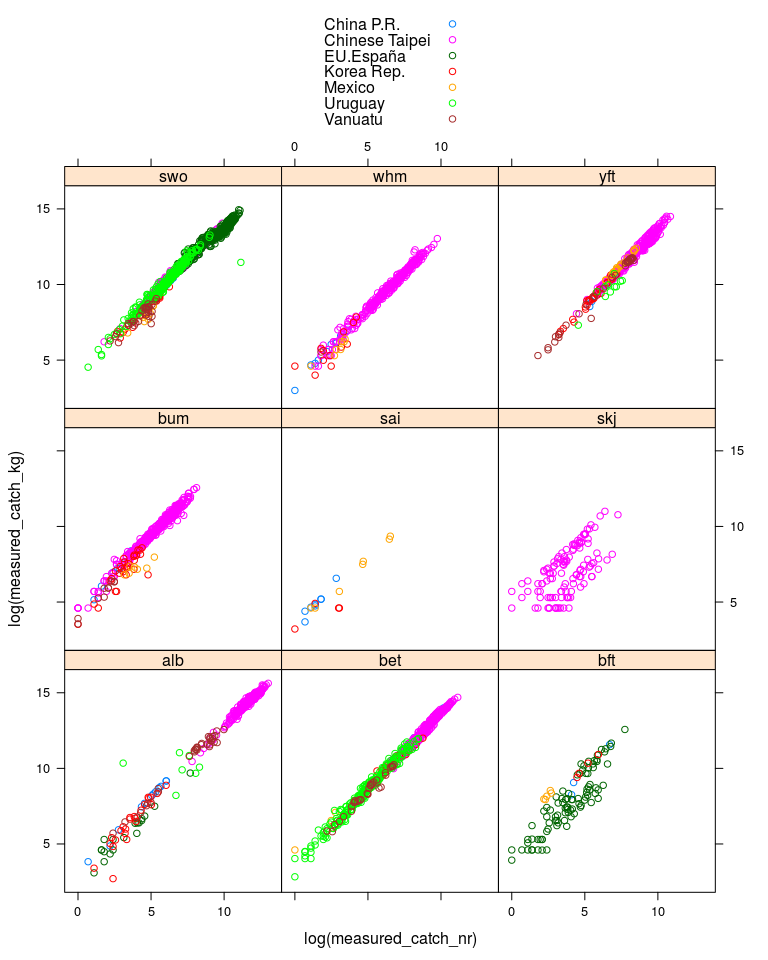
After examining this table GCS made the decision to examine records with 'NO. HOOKS' and remove all other rows. Similarly there are 3346 data recorded with catch unit '--' (Table 3) and these data were also perforce removed from subsequent analyses.

*Table 3. Catch unit sampling by flag in EFFDIS Task II database*

|  |  |
| --- | --- |
| catchunit | no\_records |
| -- | 3346 |
| kg | 94379 |
| nr | 151702 |

### Catch weights versus numbers

Another problem with the Task II data is the fact that some countries report catches by total weight, some by total numbers and some by both. The data for countries that have reported both weights and numbers were extracted and examined. The relationships between them proved to be highly linear (Figure 1).



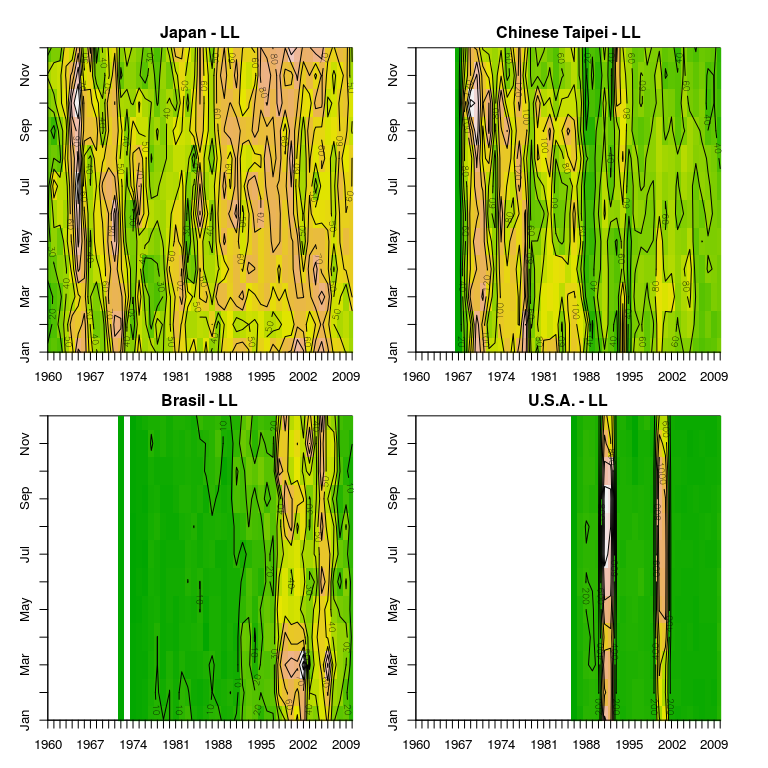
On the basis of Figure 1 we decided to model the relationship between numbers and weights and use the parameters to impute weights for Task II where total numbers only were supplied. A stepwise model selection procedure resulted in the model summarised below (Table 4). The model fits the data well and the = 90%. Note: that when the bootstrap error variance estimation is done this process will need to be included.

*Table 4. Linear model summarising the relationship between weights and numbers for countries that sent both to ICCAT for the Task II database*

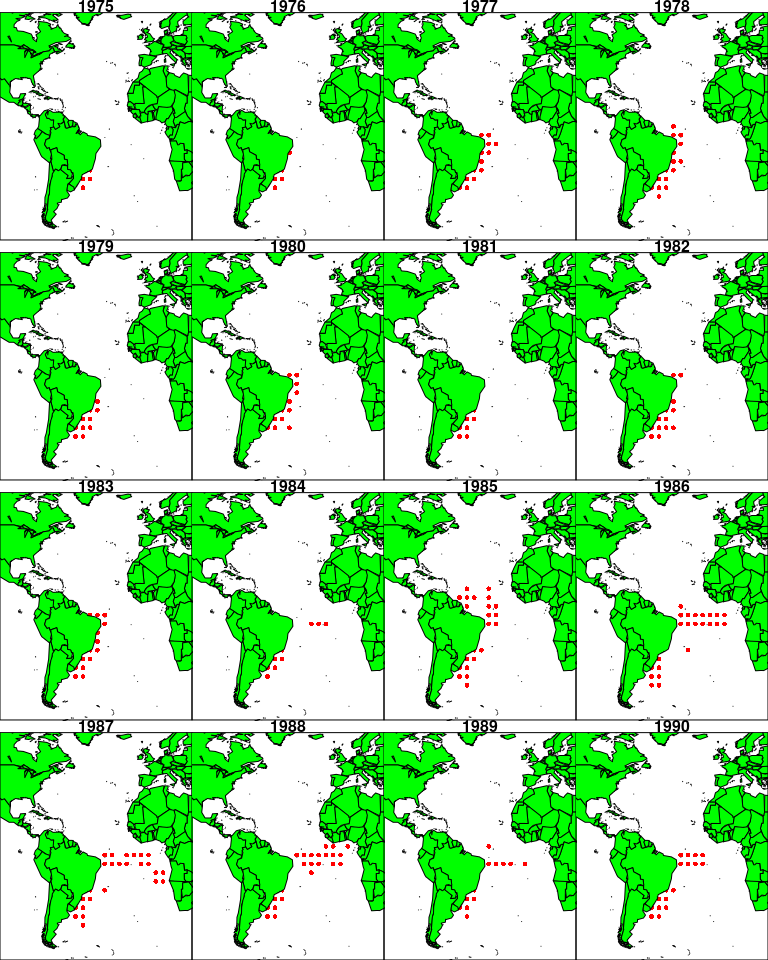
|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Estimate | Std. Error | t value | Pr(>|t|) |
| **measured\_catch\_nr** | 15 | 0.06 | 260 | 0 |
| **trend** | 69 | 14 | 5 | 5e-07 |
| **speciesbet** | 96371 | 6344 | 15 | 2e-51 |
| **speciesbft** | 15782 | 6415 | 2 | 0.01 |
| **speciesbum** | 23320 | 6412 | 4 | 3e-04 |
| **speciessai** | 14591 | 6415 | 2 | 0.02 |
| **speciesskj** | 14876 | 6415 | 2 | 0.02 |
| **speciesswo** | 2e+05 | 6262 | 38 | 9e-295 |
| **specieswhm** | 19229 | 6406 | 3 | 0.003 |
| **speciesyft** | 67542 | 6366 | 11 | 4e-26 |
| **flagnameChinese Taipei** | 33767 | 14398 | 2 | 0.02 |
| **flagnameEU.España** | 26414 | 13813 | 2 | 0.06 |
| **flagnameKorea Rep.** | -28747 | 15915 | -2 | 0.07 |
| **flagnameMexico** | -25234 | 17230 | -1 | 0.1 |
| **flagnameUruguay** | -26004 | 13921 | -2 | 0.06 |
| **flagnameVanuatu** | -35296 | 15468 | -2 | 0.02 |
| **(Intercept)** | -59789 | 17064 | -4 | 5e-04 |

Fitting linear model: measured\_catch\_kg ~ measured\_catch\_nr + trend + species + flagname

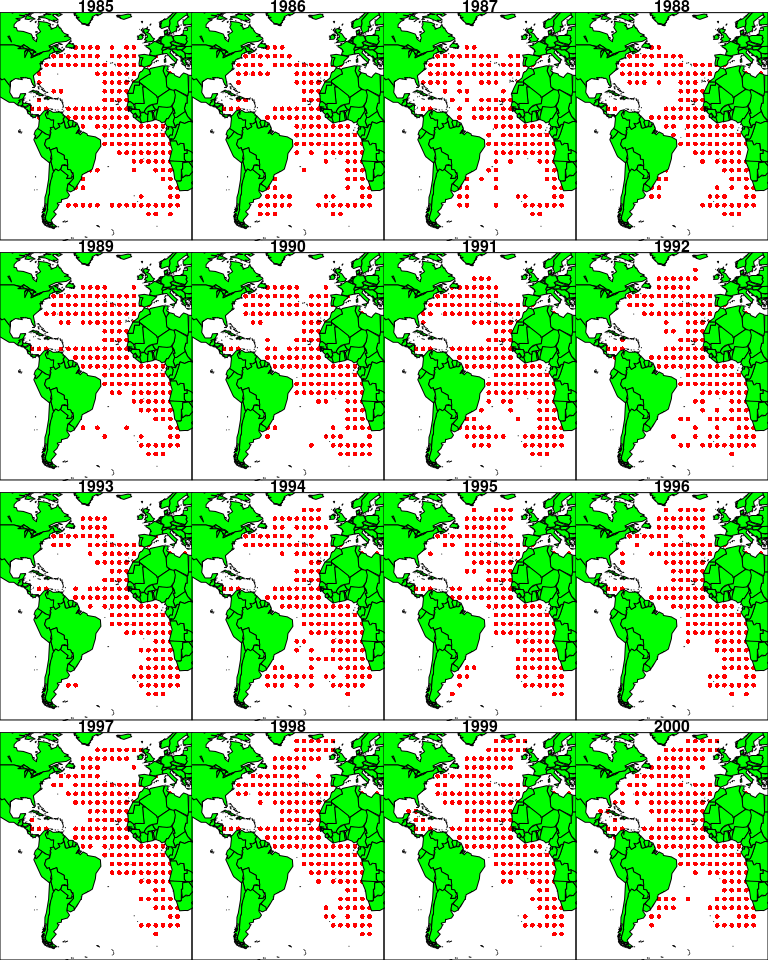
### Sampling by year and month



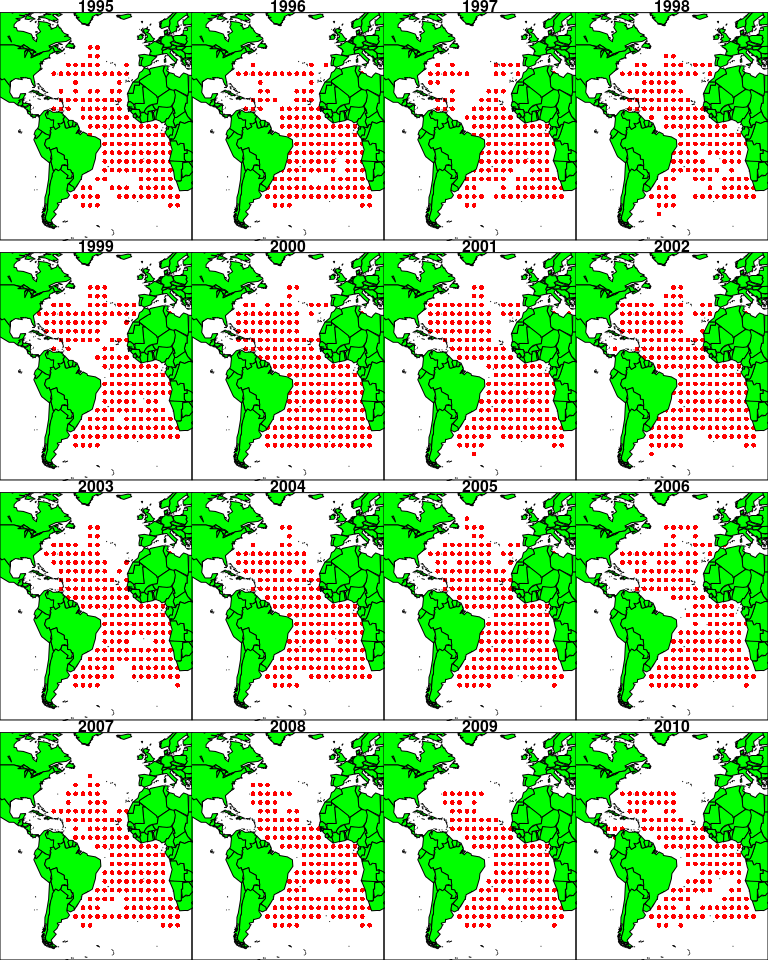
## Sampling in space by year - Brazil



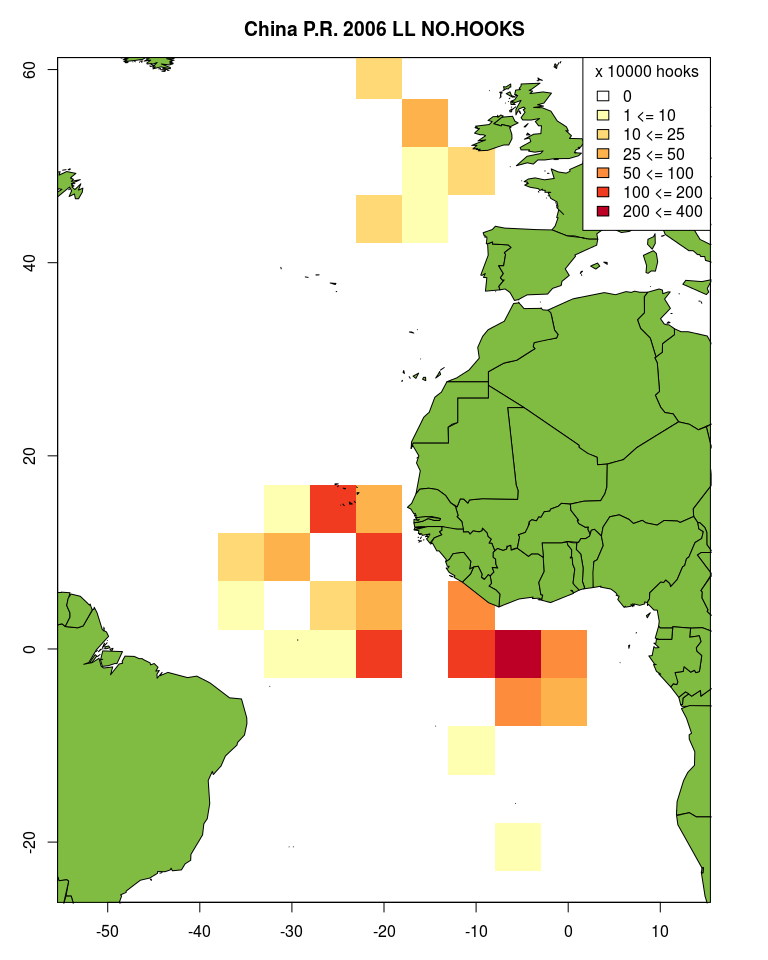
## Sampling in space by year - Japan

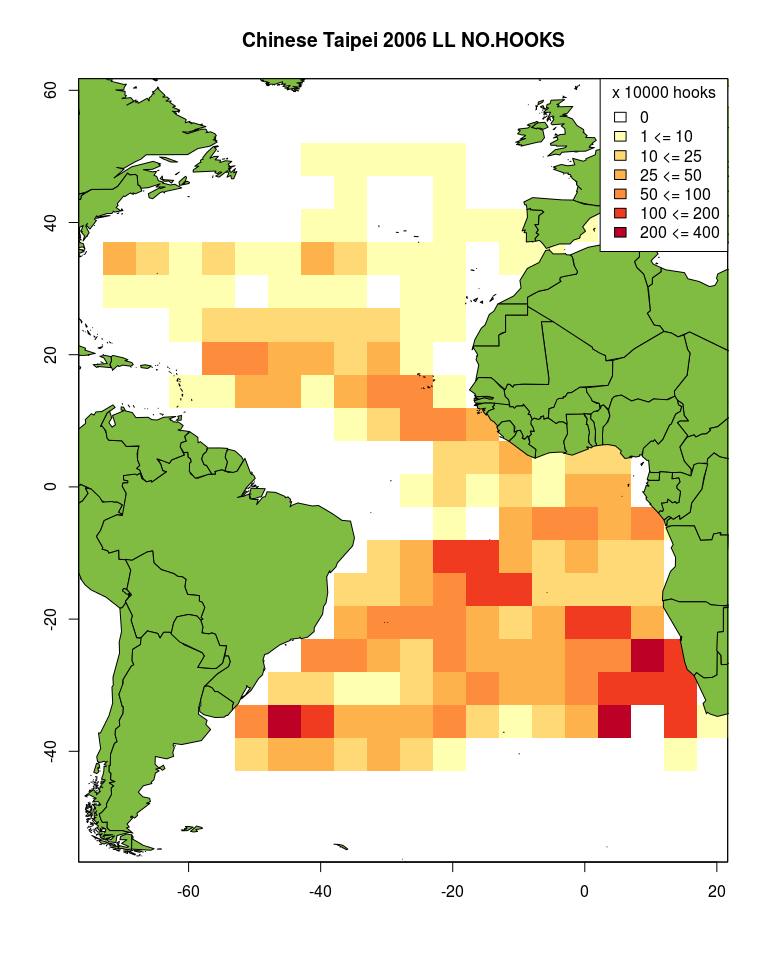


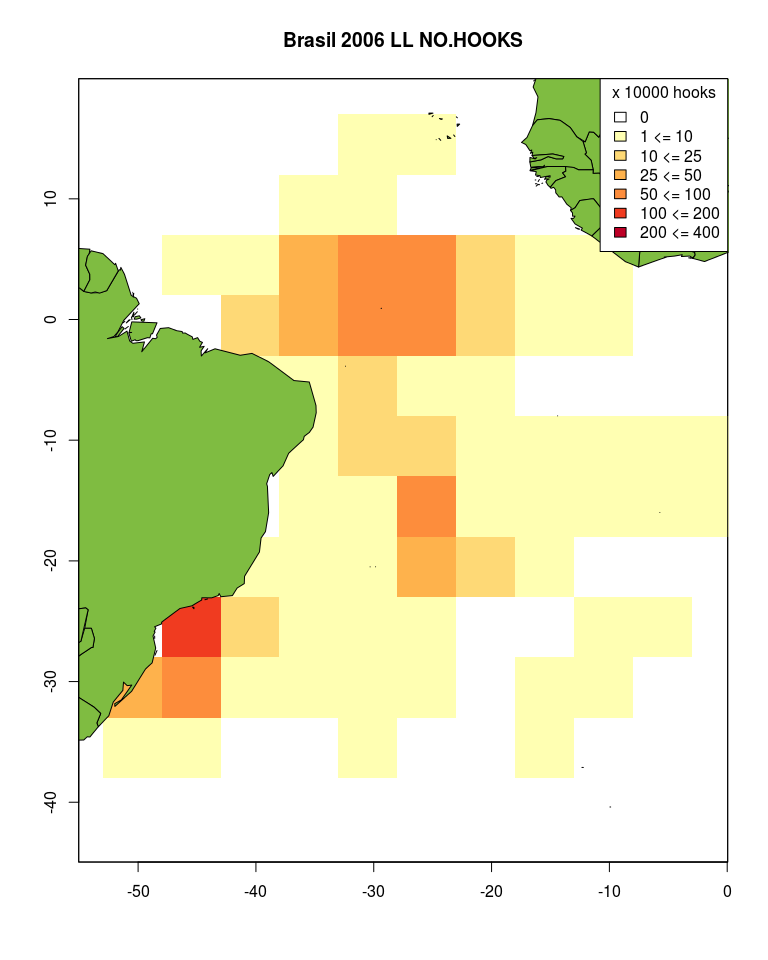
## Sampling in space by year - Chinese Taipei

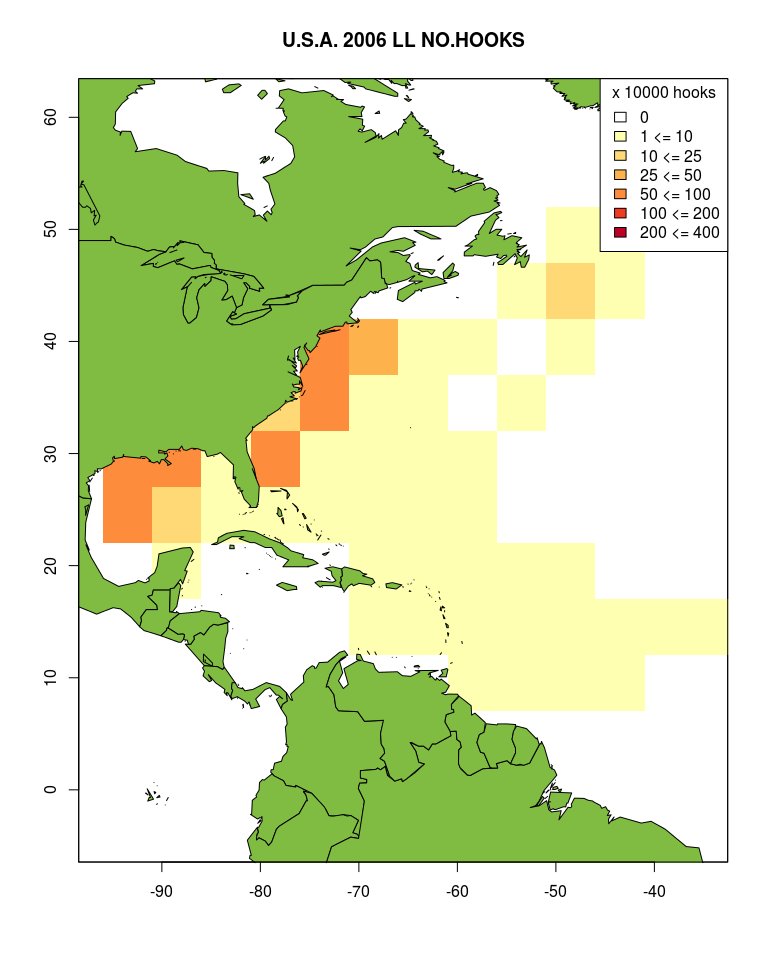


## No of hooks by year and location

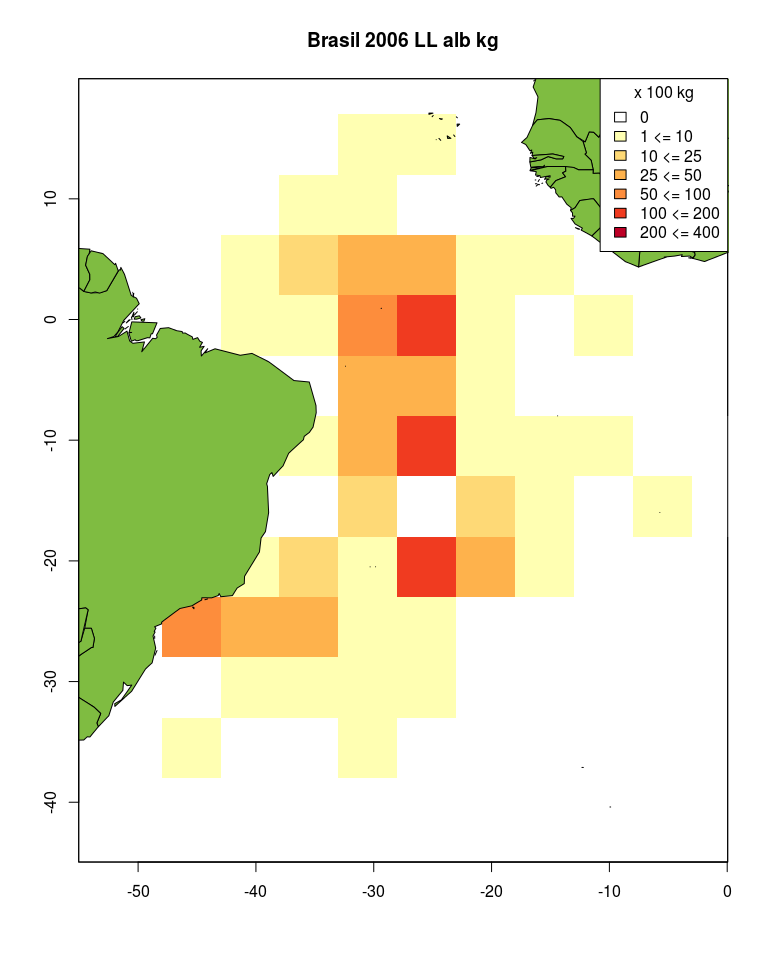
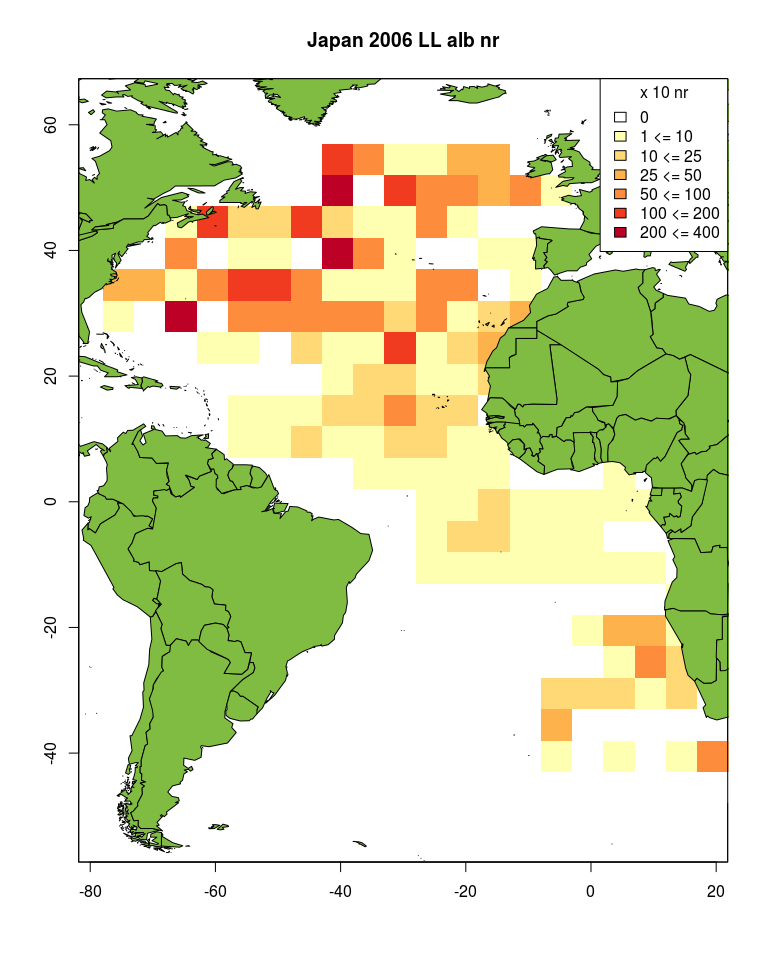
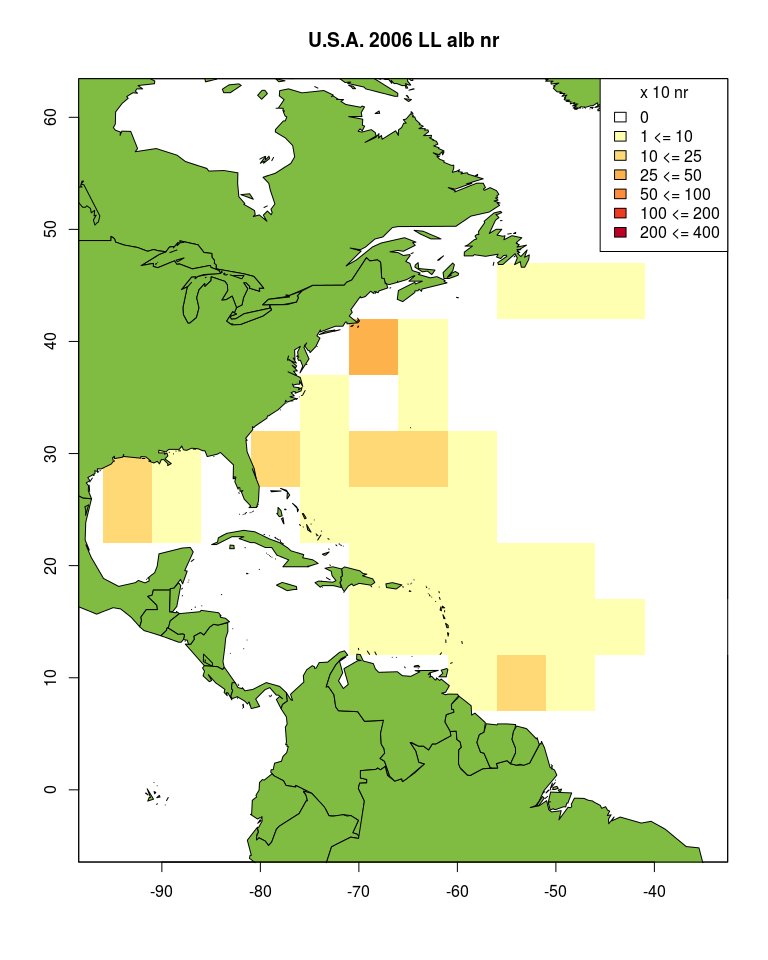




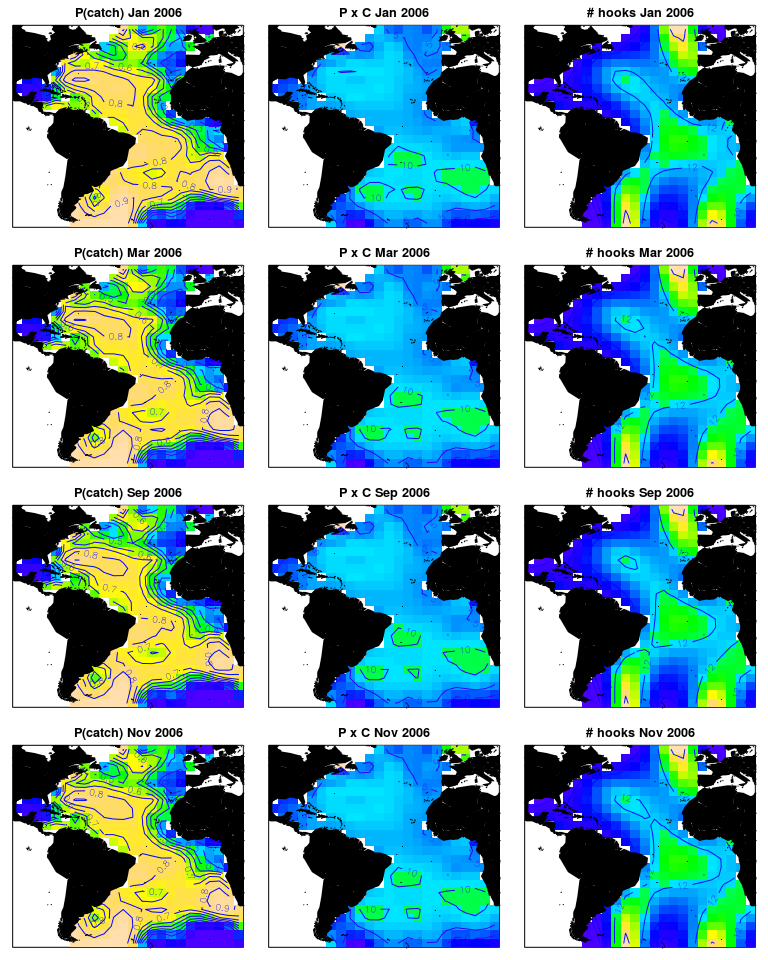




## Weight of albacore caught by year and location - China P.R.

## Regression modeling



## Presentations

## Postgresql and PostGIS server

# Conclusions