Final Report for the ICES Science Fund

Principal investigators:

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Dr. Ricardo Amoroso

"Calculating a trawling footprint from Argentina, South Africa and Namibia"

I- Summary

The project fulfilled most of the objectives set out in the ICES Science Fund application. In particular, the project was instrumental to collect process and analyse trawling fisheries data at four large and productive areas of the world: North Benguela Current, South Benguela Current, East Agulhas Current and the Patagonian Shelf. In concert with the data gathered by the project "Trawling Best Practices", we were able to compile the most comprehensive database of trawling intensity in the world (Figure 1). The contribution of this project to the global database was substantial, allowing us to incorporate datasets from developing countries from the southern hemisphere.

The project contemplated three main activities: a meeting with experts in VMS (Vessels Monitoring System) data analysis and two regional training workshops with local experts from Argentina, South Africa and Namibia. Unfortunately, there was no opportunity to hold a similar meeting in South East Asia, although we have built communications so that this may be a future possibility. The first stage of the project was devoted to develop a series of routines in R to read, process, analyse and visualize spatial fisheries data. The regional training workshops served multiple goals: local scientists were able to learn new skills and the project benefited from their knowledge of the local fisheries for an accurate interpretation of the data sets. Despite the fact that each local workshop was tailored to the local types and structure of the data, and the programming level of the participants, we were able to achieve similar results. Below we highlight and illustrate the main results of this project:

1- High-resolution mapping: we were able to develop high-resolution maps (1 km^2 grid) of fishing intensity in four large regions of the world (Figure 2-5). Fishing was highly aggregated, with most of the areas being un-trawled or trawled very lightly. In the case of Argentina, where some large no-take zones are in place, most of the fishing effort was concentrated outside the reserves.

2- Changes in the perception of the footprint with the grid resolution: we were able to show that the scale of the analysis may distort the estimate of the footprint (Figure 6) when fishing data are aggregated in large, low-resolution grids.

II- Specific Activities:

Australia workshop:

This meeting was held at CSIRO (Commonwealth Scientific and Industrial Research Organisation, Australia) form September 1st to 5th, 2014. During the meeting, we had the opportunity to discuss protocols and algorithms for VMS data processing and analysis with experts (see List of Participants). In particular we addressed issues regarding:

- Algorithms for data cleaning and filtering
- Flowchart for data processing (Pseudo-code)
- Methods for spatial interpolation
- Fleet stratification

Part of the code used during the regional workshops was written and tested during this meeting.

Argentina workshop:

a) Summary of activities:

This workshop was held at CENPAT (Centro Nacional Patagonico, Argentina) from March 25th to 28th 2015, with the participation of scientists from the Argentine Scientific and Technologic Research Council (CONICET) and technical staff from the Provincial and National Fisheries Secretaries (see list of participants). The goal of the meeting was to analyse the VMS data collected by the federal government of Argentina, together with logbook records, in order to map the trawling footprint and the disturbance frequency on the Argentinean platform. The main topics covered were:

- Introduction to software: a brief introduction to the R programming language and software developed for this project was done during the first day, and continued during the entire workshop.
- Characterisation of the fleets: the Argentina VMS data set comprises a large number of vessels that target a diverse pool of demersal species, for which specific information on the gear characteristics at the vessel level were not available. In order to assign a gear width and type to a VMS ping it was necessary to cluster vessels in homogenous groups and use an average value. We defined 15 different "metiers" according to the target species, gear and vessel size and product-storing features. Specific data (gear width, and towing speed) for each metier was gathered from the literature and through a meeting with a member of the industry.
- Merging of the logbook and VMS data: In normal operations some vessels switch between target species (and consequently gear), depending both on the season and resource abundance. In order to assign a gear type (and corresponding gear width) to each VMS ping, the catch logbook data were merged with the VMS database. Cleaning the logbook database was a lengthy process, given the large number of inconsistencies. However, we were able to consolidate these two databases for the years 2010 and 2013, the two years that were made available to the workshop.

- Developing speed filters to identify fishing operations: when analysing VMS data it is critical to identify those pings that correspond to a fishing operation. We decomposed the modes of the speed distribution frequency distribution for each metier in order to estimate the lower and upper speed limits that characterize fishing operations.
- Interpolation and gridding: the filtered data was gridded and interpolated using the code developed during this project, which combines several spatial libraries and ad-hoc functions to handle vectorial and raster data. This code was made available to local experts. As part of this activity the fishing effort was overlapped with bathymetric data.
- Visualization: we used the code developed in this project to map the distribution of the fishing intensity and frequency.
- Summary statistics: we reviewed methods to calculate summary statistics of trawling impact. We calculated the proportion of the area trawled at different intensities assuming both a Poisson and a uniform distribution of fishing activities within a cell. This summary statistics were reported at the regional level, but also for two depth strata: 0-200m and 200-1000m depth.

b) Additional work and future perspectives:

In terms of the project, there are still some ongoing activities, most importantly the assessment of the degree of coverage of the VMS data relative to the total catch/effort. This job is being conducted by Dr. Ana Parma and Dr. Ricardo Amoroso.

After the meeting, Dr. Ricardo Amoroso did a public presentation about the TBP project and the preliminary results obtained during the workshop at CENPAT. This talk, which was primarily targeted to local researchers and students, was very well received and triggered a productive conversation between the members of the project and local scientist.

Dr. Ana Parma, a member of the TBP project, has a student conducting research on the distribution of the shrimp fleet within the San Jorge Gulf, a very important area for conservation and industrial activities. We expect to continue to cooperate with her laboratory in analysing high-resolution data of fishing activities.

South Africa workshop

a) Summary of activities:

This workshop was held at DAFF (Agriculture Forestry and Fisheries ,Cape Town, South Africa) from May 20th – 22nd, 2015 with the participation of members of the Namibian and South Africa Ministries of Fisheries (see list of participants) and industry members representatives. During this meeting we developed a series of activities aimed to map the trawling footprint and the disturbance frequency at the Benguela and Aghullas current eco-regions. The main topics covered were:

- Introduction to the software: a brief introduction to the R programming language and software developed for this project was done during the first day, and continued during the entire workshop.

- Database merging: although the Namibian and South Africa trawling fisheries mostly target the same species (*Merluccius capensis* and *M. paradoxus*) the databases maintained by each country are quite dissimilar. In order to minimize ad-hoc data processing it was necessary to merge the two national databases. Each country records tow by tow information. Unfortunately the amount of data available for the workshop from Namibia was incomplete, and more work remains to be done in the future.
- Database Cleaning: We discussed and programmed specific filters to identify problematic data. Whenever possible, data were corrected at the meeting. Otherwise records were flagged and shared the problems with the local database administrators. Industry members contacted their skippers during the meeting to collect information on the gear width used in the operations. This allowed us to use vessel-by-vessel gear width data for swept-area calculations (with a few exceptions, for which the average gear width was used).
- Interpolation and gridding: after using proper filters we used the code developed during the project to grid and interpolate data. We reviewed and compared results of different methods to calculate the distance between start and end positions of a tow positions, and its implications for swept-area calculations. As in Argentina, we overlapped trawling intensity with bathymetric data.
- Visualization: we used the code developed in this project to map the distribution of the fishing intensity and frequency of disturbance.
- Summary statistics: we covered the same topics as in Argentina.

b) Additional work and future perspectives:

After the workshop, Dr. Ricardo Amoroso continued working with Tracey Fairweather regarding specific issues related to the extension of the footprint in South Africa. The Marine Stewardship Council has certified the South African hake fishery, which is a strong incentive to continue developing sustainable fishing practices. As part of management toolkit, South Africa has frozen their historical footprint, with a strong commitment by the industry to keep their operations within those boundaries. The work after the workshop aimed to estimate the area of the "frozen footprint" that is currently being fished and temporal changes in the distribution of the fleets. It is expected that this information will be used by South Africa as part of the scientific input required to decide the location of new marine protected areas.

The Namibian database was incomplete, and there is work in progress in order to fill the gaps in information. In particular, it is necessary to extend the time series of data and include the monkfish fishery. After this, data will be re-analysed and results distributed between the participants.

III- Future Perspectives:

It is expected to continue conducting regional training workshops in other regions of the world. As of today, the fisheries management authorities of Chile have agreed to host a workshop in Valparaiso to analyse the country's trawling fisheries data. We are currently looking for funding to conduct this workshop by the end of the year. Ricardo Amoroso hosted a two-day workshop with Japanese scientists (July 1st -2nd, 2015) at the University of Washington on trawling data analysis. This meeting was instrumental to discuss the aim of the project and the methods currently used for data analysis. The Japanese colleagues will assess the possibility of sharing their database with the project and host a regional workshop in Tokyo.

IV- List of Participants:

Australia Workshop:

- Kathryn Hughes (University of Bangor, UK - Research)
- Ricardo Amoroso (University of Washington, USA - Research)
- Roland Pitcher (CSIRO, Australia – Research)
- Nick Ellis (CSIRO, Australia – Research)
- Wayne Rochester (CSIRO, Australia – Research)
- Mick Haywood (CSIRO, Australia – Research)

Argentina Workshop:

- Ricardo Amoroso (University of Washington- Research)
- Ana Parma (CENPAT- Research)
- Mariana Mazzini (Subsecretaría de Pesca y Acuicultura de Nación- Technical staff)
- María Eva Gongora (UNPSJB y Subsecretaría de Pesca del Chubut -Research)
- Gaston Trobbiani (CENPAT -Research)
- Alejo Irigoyen (CENPAT- Research)
- Noela Sánchez (CENPAT- Research)
- Adrian Morales (Industry)

South Africa Workshop:

- Kathryn Hughes (University of Bangor, UK - Research)
- Ricardo Amoroso (University of Washington, USA - Research)
- Tracey Fairweather (Department of Agriculture Forestry and Fisheries, South Africa - Research)
- Deon Durholtz (Department of Agriculture Forestry and Fisheries, South Africa - Research)
- Paulus Kainge ((MFMR)Namibia - Research)
- Josef Shikeva ((MFMR) Namibia - Research)
- Johannes Kathena ((MFMR) Namibia - Research)
- Lara Atkinson (South African Earth Observation Network (SAEON), South Africa - Research)

- Kerry Sink (South Africa National Biodiversity Institution (SANBI), South Africa - Research)
- Robert Leslie (Department of Agriculture Forestry and Fisheries, South Africa - Research)
- Kirsten DuPlessis (Irvin and Johnson (I&J), South Africa - Industry)
- Calvin Waiman (Irvin and Johnson (I&J), South Africa – Industry)
- Robert Landman (Irvin and Johnson (I&J), South Africa – Industry)
- Johann Augustyn (Secretary, South African Deep Sea Trawling Association (SADSTIA), South Africa – Industry)

IV- Figures

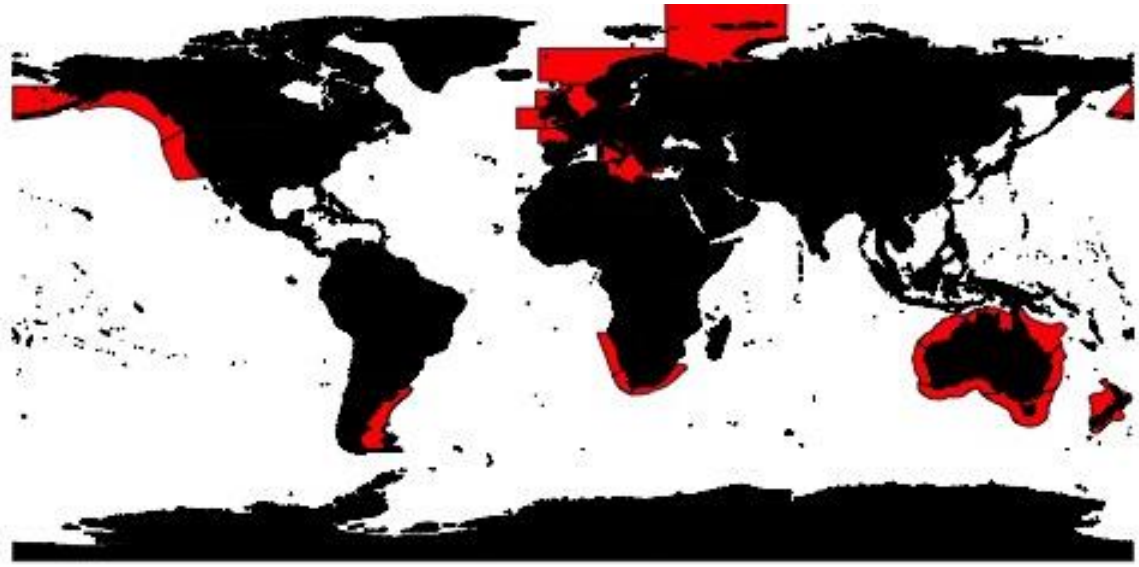

Figure 1: Regions of the world covered by this project and TBP project.

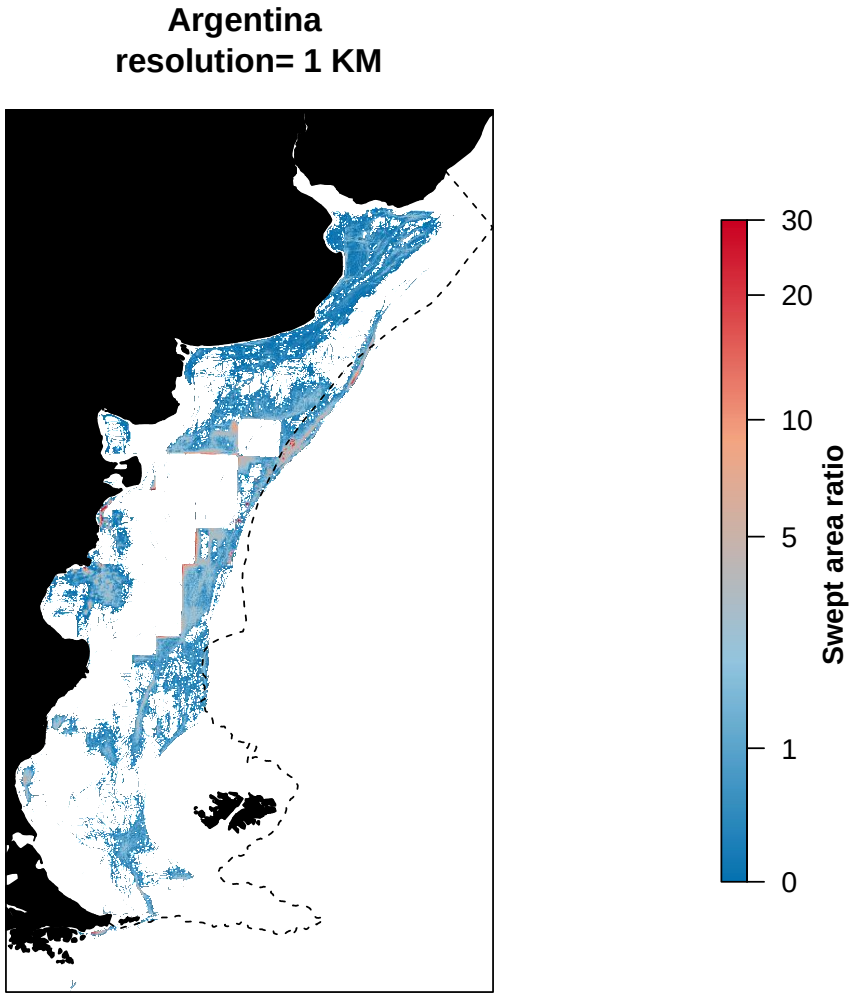

Figure 2: High resolution map of fishing intensity in the Argentina Sea.

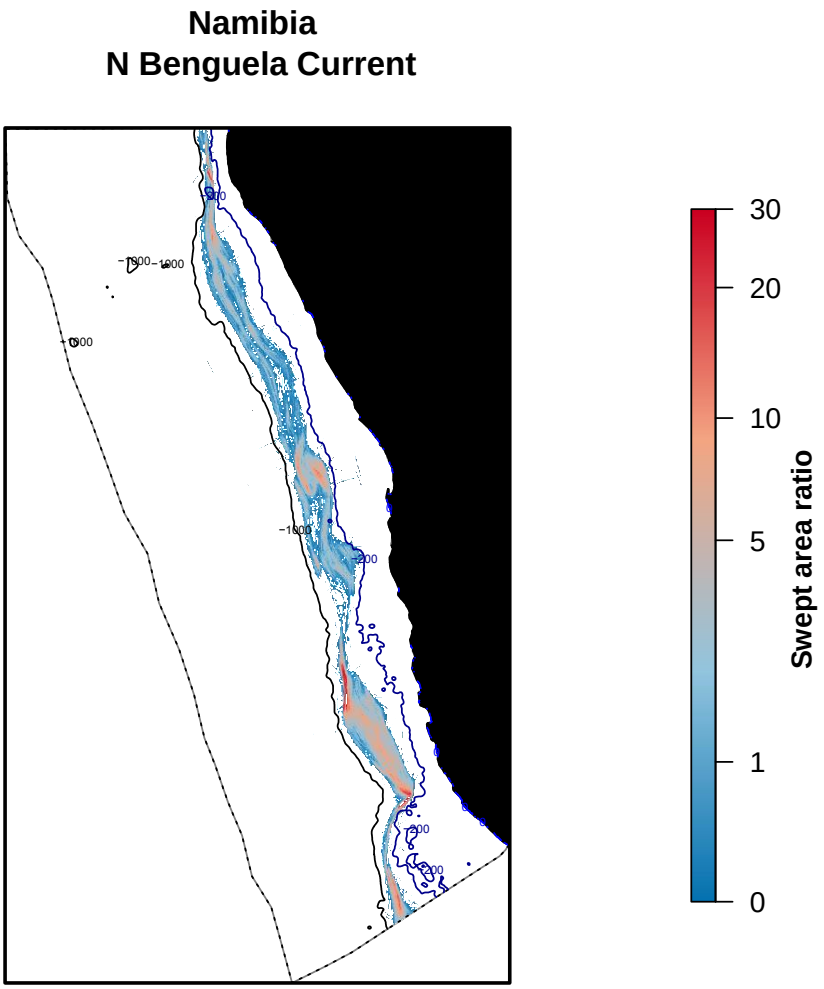

Figure 3: High resolution mapping of fishing intensity.

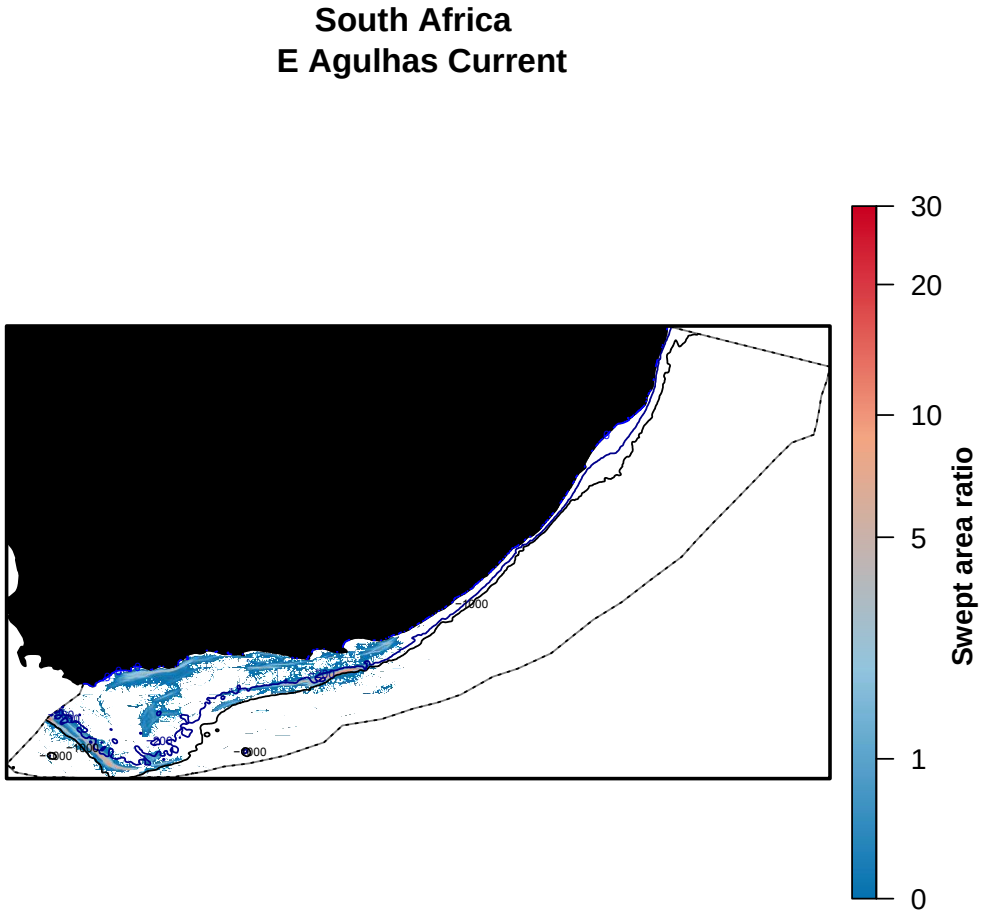

Figure 4: High resolution mapping of fishing intensity.

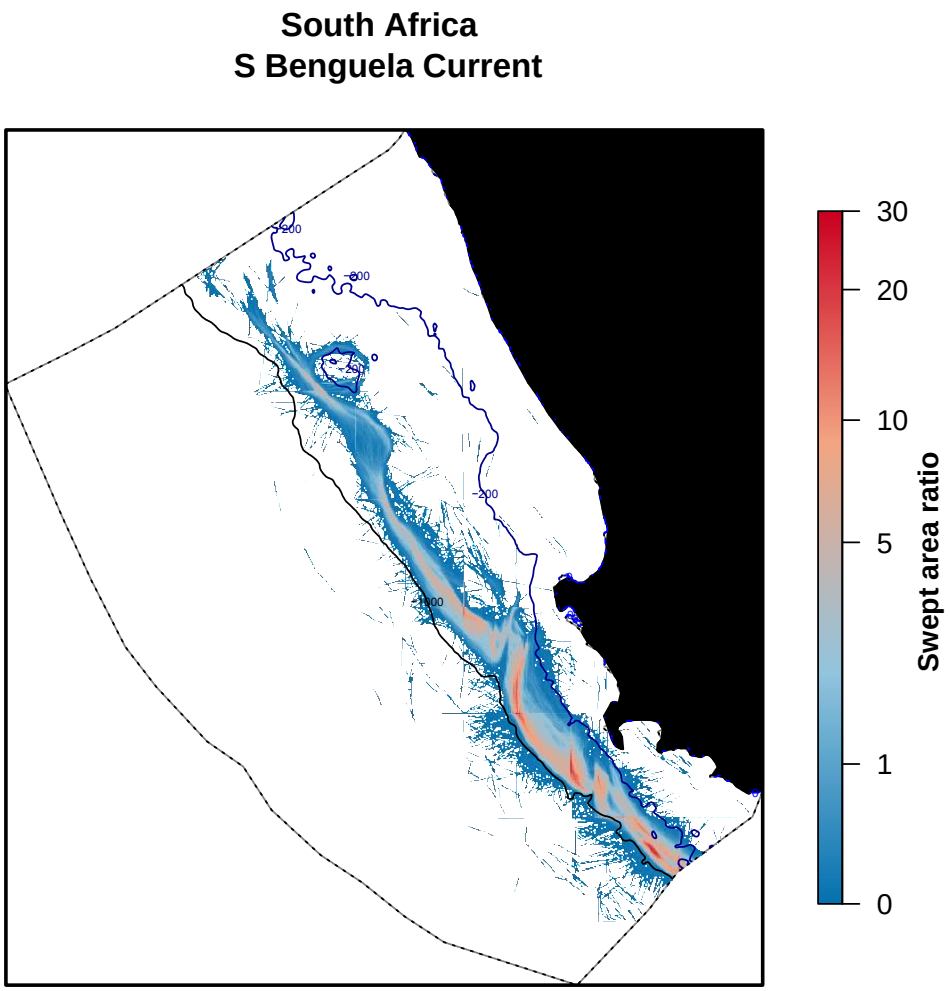

Figure 5: High resolution mapping of fishing intensity.

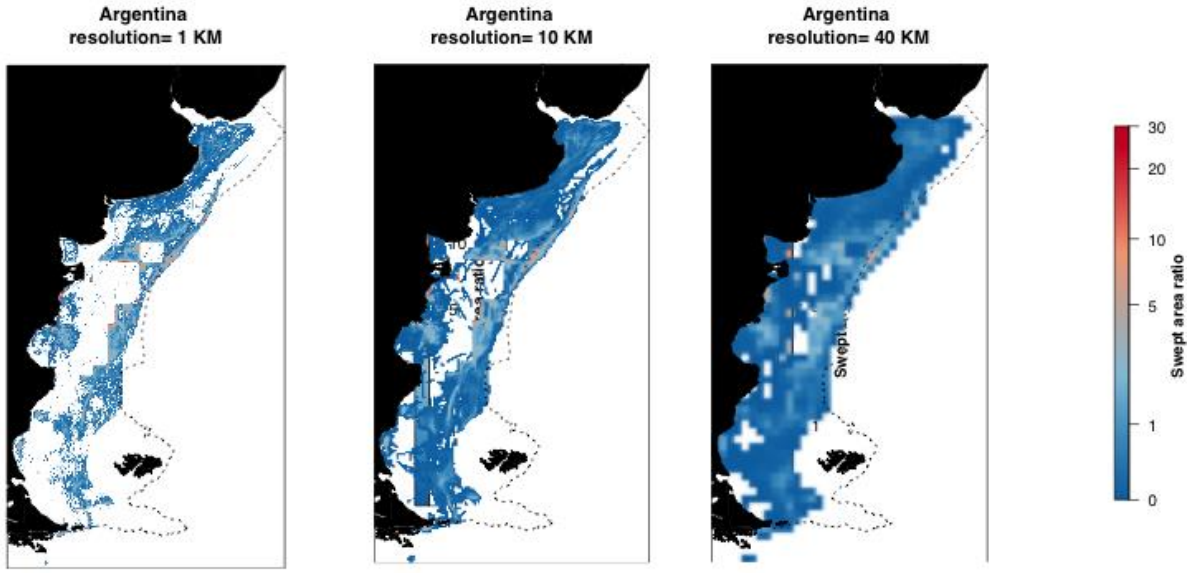

Figure 6: Distortion of the trawling footprint with decreasing grid resolution.