OLSPS Marine

Evidence of spatial competition between hake deep-sea trawls and longline sets, an overview

by

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1 Background

Hake/BG1 proposes that there are a number of unsettled scientific issues which need to be addressed before the impact of increases in the TAC allocations to hake longlining (as proposed in Government Gazette, 2021) on the resource and the fishery can be said to have been assessed. One of these issues is that there may be spatial interactions between the two gear types, trawls vs longlines. These interactions may be competitive, implying that where and when there are longline sets, there are few trawls and vice versa. In 2017, in order to reduce and manage potential conflict, the South African Longline Hake Association (SAHLLA) and the South African Deep Sea Trawling Association (SADSTIA) signed a code of conduct. The provisions in this agreement include the following: "If another vessel is already about to deploy its gear or already fishing, the later vessel must immediately select another area and repeat the process". The concern here is that if trawl skippers are prevented from setting their trawl at a preferred location and time because of the presence of static gear, i.e. a longline set(s), trawl CPUE is less than it would otherwise have been.

Two of the main implications of such a process and its impacts are, for the trawl fishery,

(a) potential for lower TACs from the Operational Management Plan (OMP) than might otherwise have been the case, and

(b) an increase in operational costs per ton of trawled hake.

However, a number of factors need to be confirmed before one can conclude that such a reduction in CPUE is occurring and, if such a reduction is occurring, whether it has a material impact. These are the following:

1. To demonstrate that the potential for competition is present, i.e. that the two fisheries overlap in space and time such that there could be competition between them.

2. That at an operationally meaningful time scale and spatial scale there is competition for space to fish, viz. there is a negative relationship between the amount of effort for the two gear types.
3. That the competition referred to above causes reduced CPUE levels in one or both fisheries
4. That the reduction in CPUE levels referred to above it sufficiently large to be a concern for further escalation of the extent of competition, as may occur if more of the TAC is allocated for hake longlining operations.

Two additional technical papers have been prepared on this topic, viz. HAKE/P3 and HAKE/P4. These papers address the possibilities (1) and (2) described above, and contain the following results:

- HAKE/P3 – this document presents a number of high level data summaries which suggests that the degree of overlap between the two fisheries is sufficient to suggest that there could be spatial competition between the two fisheries.
- HAKE/P4 – this document carries out more detailed analyses and shows that at operationally meaningful temporal and spatial scales, there is evidence of a negative relationship between the number of trawls and the number of sets.

Neither of these documents has quantified the cost of the negative spatial interaction that is highlighted in HAKE/P4, i.e. they do not address points (3) and (4) listed above. The intention is that the International Panel of 2022 will be asked for guidance as to how best to assess and quantify (3) and (4). The content of HAKE/P3 and P4 is as follows.

HAKE/P3 carries out a first analysis of the longline and deep-sea trawl CPUE datasets to determine whether the spatial overlap between the two fisheries is such that the potential for spatial competition and conflict exists. The document shows that there have been important changes in the distribution of hake longline effort between 1994 and 2021. These can be seen in the composite figure here, Figure 3. From a peak in 2006 the number of sets on the South Coast (as defined in HAKE/P3) declines to a very low level by about 2015 and remains very low. The number of sets on the West Coast increases from 2010 to reach a plateau by 2014 which persists until 2021. **Error! Reference source not found.** of HAKE/P3 (Top panel LHS) shows the point in time that a code of conduct between SADSTIA and SAHLLA was signed to regulate competition for space to fish at sea. The timing of this code of conduct appears to be a logical result of an increase in recent years (at that time) of a large shift in longline effort from the South Coast to the West Coast. The shift itself appears to be congruent with CPUE trends shown in Figure 2, taken from HAKE/P3. These illustrate declines in hake longline CPUE which may have driven the relocation of longline fishing further west in search of improved catch rates, although input from the hake longlining fishery is that this was not the case.

Other Tables and Figures presented in HAKE/P3 provide additional outputs which show, for example (see Figure 3 here) that the number of hooks in use in the fishery increased substantially over time, and that fishing depth (see Figure 3 here) also increased over time. Both of these processes increase the potential for conflict between the two fisheries.

HAKE/P3 therefore confirms that at a high level, there is potential for conflict between the two fisheries, and also that changes in the dynamics of the hake longline fishery are such that the conditions for conflict have been enhanced since about 2015, due to the increase in the number of hook and the length of longline sets, as well as an increase in the spatial overlap between the two fisheries both positionally and as confirmed separately by overlap in the depth of fishing.

HAKE/P4 goes beyond the level of analysis in HAKE/P3 to determine whether there is evidence that the nature of the trawl vs longline interaction is such that at an operationally meaningful temporal and spatial scale, the competition for space is such that where and when there are more longline sets, fewer trawls take place and vice versa. The document uses a K-means clustering algorithm or alternatively a simple binning procedure to define spatial clusters that have dimensions of tens of kilometres. Figure 1, bottom panel, shows the 200 cluster case, after application of the data trimming procedure described in HAKE/P4 – this involves eliminating unimportant clusters which jointly comprise less catch than other clusters and less than 5% of the catch in total. These clusters are analysed day by day in the fishery for the period 2015 to 2020 to determine the relationship between the number of longline sets and the number of trawls. The results show, across different ways of defining spatial areas, that there is a negative relationship between the number of trawls and the number of longline sets, at the level of Cluster_Day, or Bin_Day – see Table 1 and Figure 4. This suggests that the two gear types compete for space to fish, such that the presence of effort for one of the gear types is associated with a reduction in the amount of effort deployed for the other gear type. One cannot conclude the direction of causality simply, viz. it is not clear whether setting longline gear causes a reduction in trawl effort in an area on a particular day, or alternatively whether setting trawl gear causes a reduction in the longline effort in an area. It is however relevant that the static nature of longline gear means that while the gear is set, no trawl can cross the longline across its entire length, which is now greater than 20 km in length, on average. On the other hand, trawls do not occupy area in the same way and a longline set can wait for a trawler to pass before setting. Once set, longline gear occupies the space for the duration of the soak time, typically 6-8 hours.

These results all point to a competitive relationship for space to fish between the two fisheries, trawl vs longline. They do not quantify what impact this competition may have on the trawl or the longline CPUE levels, and this is the next piece of work that is needed.

2 Acknowledgements

To DFFE for the provision of the hake longline and hake deep-sea trawl data.

3 References

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Government Gazette, 2021. Draft Policy on the Allocation and Management of Hake Longline Fishery: 2021 (September).

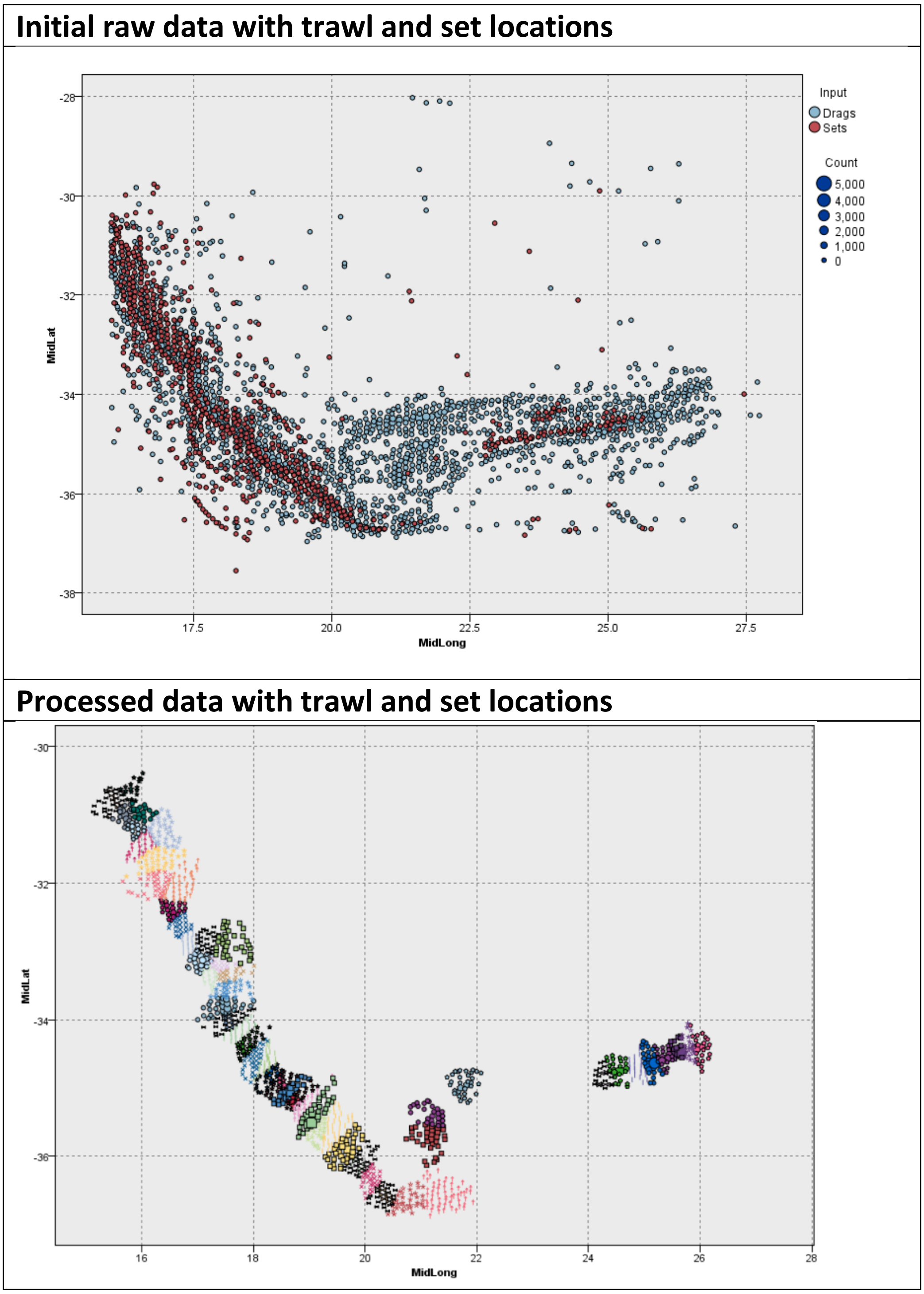

Figure 1. Top panel- A scatter plot of the location of offshore trawls and hake longline sets by the mid-point of the fishing event over all years. Bottom panel - For 2015 to 2020 only, following a run of the K-means algorithm with 200 clusters, after data trimming – only those clusters that make up 95% of the catch over all years are shown. .

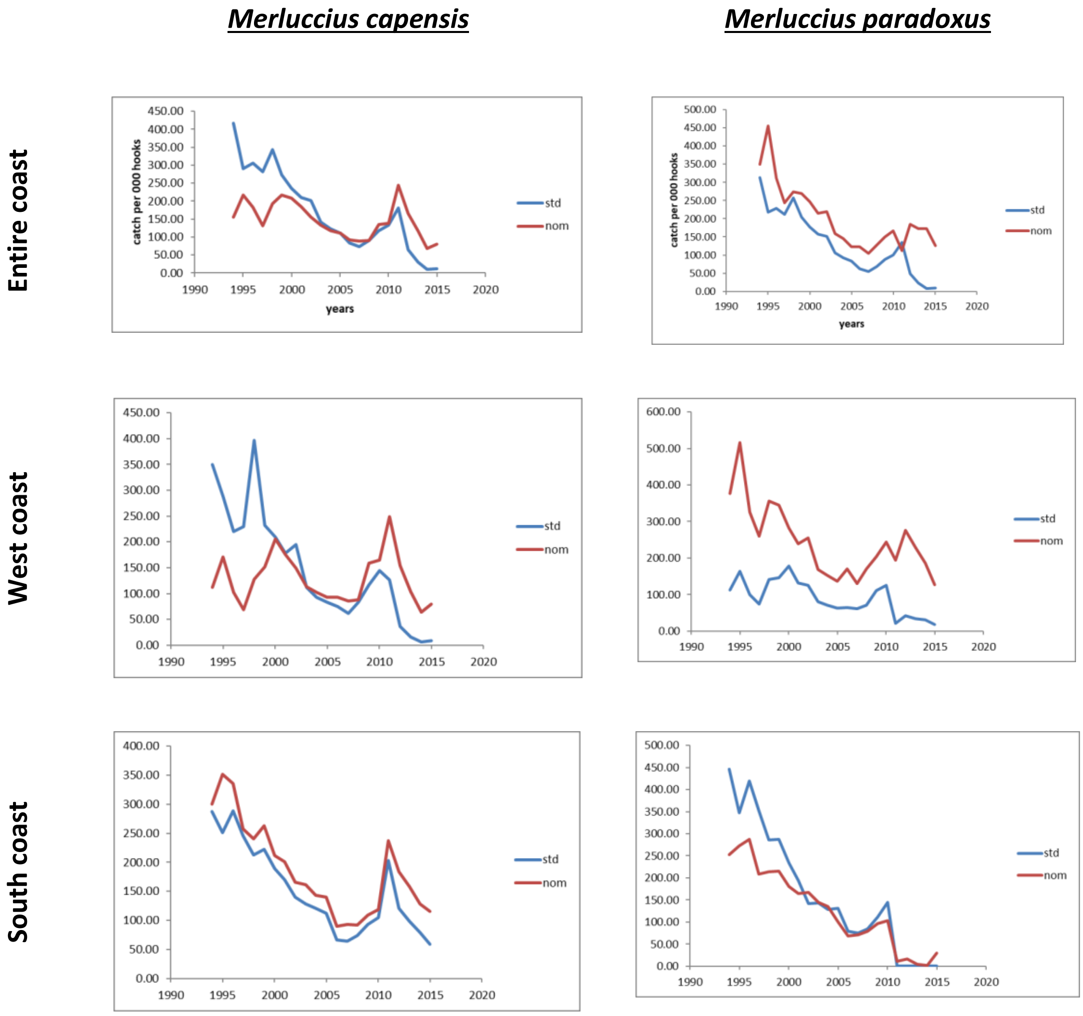

Figure 2. CPUE trends in the hake longline fishery based on Somhlaba et al (2016). Units: kg / ‘000 Hooks ((source: Somhlaba et al, 2016)).

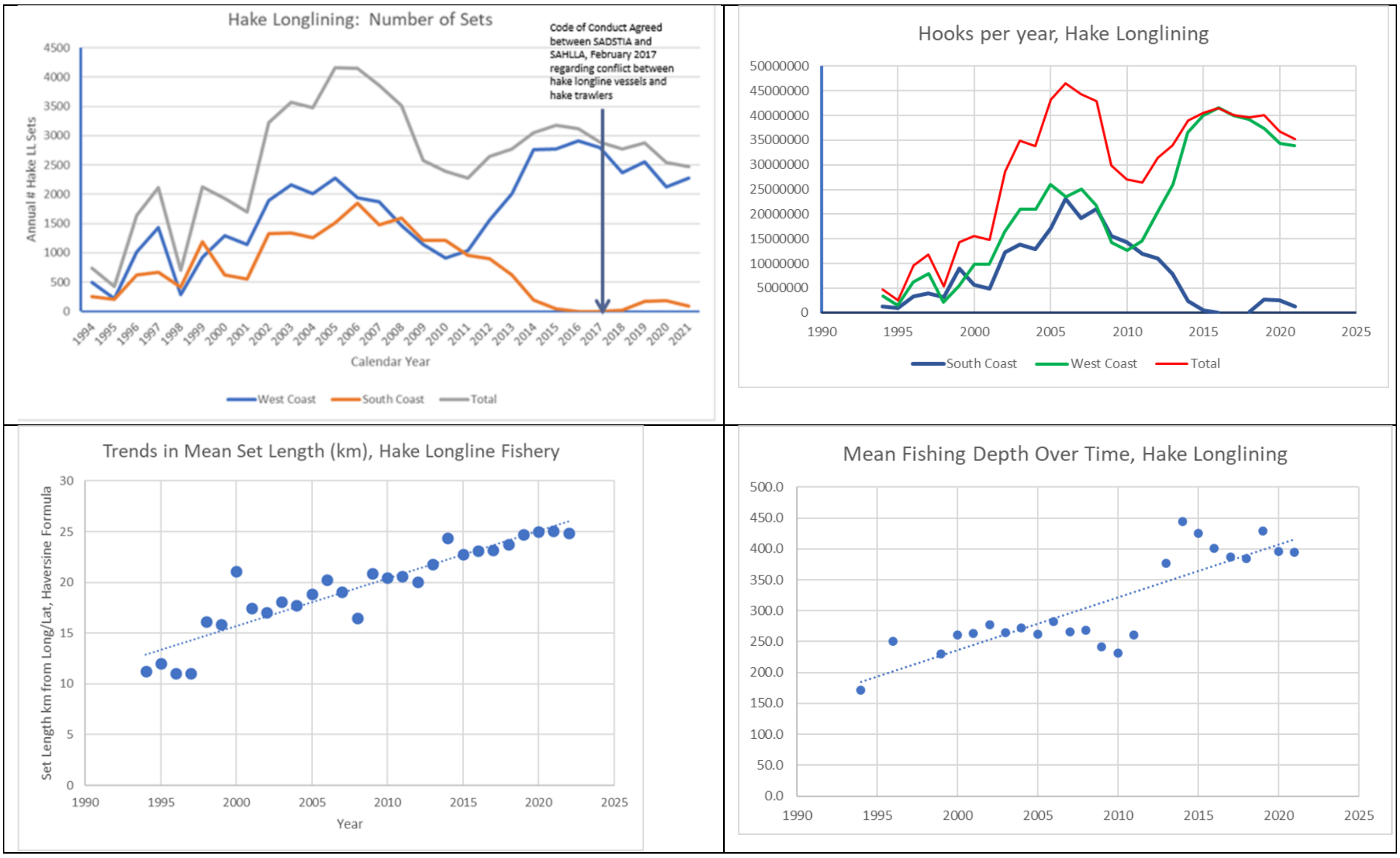

Figure 3. Various trends in the longline fishery. Top LHS panel shows trends in the total annual number of sets split between the West and the South Coasts, and in total. Top RHS panel shows trends in the total number of hooks per year, again split between the West and the South Coasts, and in total. Bottom LHS shows the trend in the mean set length per annum in the hake longline fishery. Bottom RHS panel shows the trend in the mean fishing depth per annum in the hake longline fishery.

Table 1. GLM based estimates of the slope of the covariate 'number of sets (n(SETS))' when the dependent variable is the number of drags (n(DRAGS)). For these analyses a record represents a single Cluster_Day or Bin_Day combination which is a record because there was at least one drag or one set in that Cluster_Day or Bin_Day. For either of the Cluster_Day only, or Cluster then Bin_Day data preparation and spatial definitions, the data are first reduced to the highest ranked (by green weight catch) clusters which make up 95% of the total hake catch over the period 2015 to 2020 inclusive. This involves 121(or 74 or 50) clusters when the K-means algorithm used a predefined and fixed number of 500 (or 300 or 200) clusters. GLMs were run using either the 'identity' or 'log'-link functions, and the explanatory variable is either (a) n(SETS) and K-means clusters or (b) only n(SETS). Two bin width options were explored when implementing the Bin_Days step, either 0.2 degrees or 0.05 degrees (where a degree at the applicable latitude is approximately 100 km), but only for the 200 and 500 cluster options.

Model	# Clusters	# Clusters, 95% of Catch	Lat/Long Bins; Bin width in degrees	# Cluster_Days in Analysis	# Bin_Days in Analysis	Transformation	Explanatory variable (Dependent variable - n(DRAGS))	n(SET) parameter estimate in transformed domain	95% Range
GLM	500	121	n/a	90110	n/a	None	n(SETS), K-means cluster	-0.748	(-0.777, -0.719)
GLM	500	121	n/a	90110	n/a	Natural Log	n(SETS), K-means cluster	-0.788	(-0.834, -0.742)
GLM	500	121	n/a	90110	n/a	None	n(SETS)	-0.823	(-0.850, -0.796)
GLM	500	121	n/a	90110	n/a	Natural Log	n(SETS)	-0.931	(-0.983, -0.880)
GLM	300	74	n/a	72077	n/a	None	n(SETS), K-means cluster	-0.669	(-0.706, -0.631)
GLM	300	74	n/a	72077	n/a	Natural Log	n(SETS), K-means cluster	-0.424	(-0.456, -0.392)
GLM	300	74	n/a	72077	n/a	None	n(SETS)	-0.720	(-0.756, -0.683)
GLM	300	74	n/a	72077	n/a	Natural Log	n(SETS)	-0.525	(-0.562, -0.487)
GLM	200	50	n/a	59637	n/a	None	n(SETS), K-means cluster	-0.649	(-0.693, -0.605)
GLM	200	50	n/a	59637	n/a	Natural Log	n(SETS), K-means cluster	-0.327	(-0.354, -0.299)
GLM	200	50	n/a	59637	n/a	None	n(SETS)	-0.775	(-0.818, -0.732)
GLM	200	50	n/a	59637	n/a	Natural Log	n(SETS)	-0.427	(-0.458, -0.395)
GLM	500	121	0.2	90110	58512	None	n(SETS)	-0.790	(-0.830, -0.750)
GLM	500	121	0.2	90110	58512	Natural Log	n(SETS)	-0.894	(-0.966, -0.821)
GLM	500	121	0.05	90110	131005	None	n(SETS)	-0.940	(-0.954, -0.925)
GLM	500	121	0.05	90110	131005	Natural Log	n(SETS)	-3.000	(-3.284, -2.715)
GLM	200	121	0.2	59637	86635	None	n(SETS)	-0.829	(-0.861, -0.797)
GLM	200	121	0.2	59637	86635	Natural Log	n(SETS)	-0.893	(-0.949, -0.838)
GLM	200	121	0.05	59637	168969	None	n(SETS)	-0.934	(-0.945, -0.923)
GLM	200	121	0.05	59637	168969	Natural Log	n(SETS)	-3.100	(-3.343, -2.865)

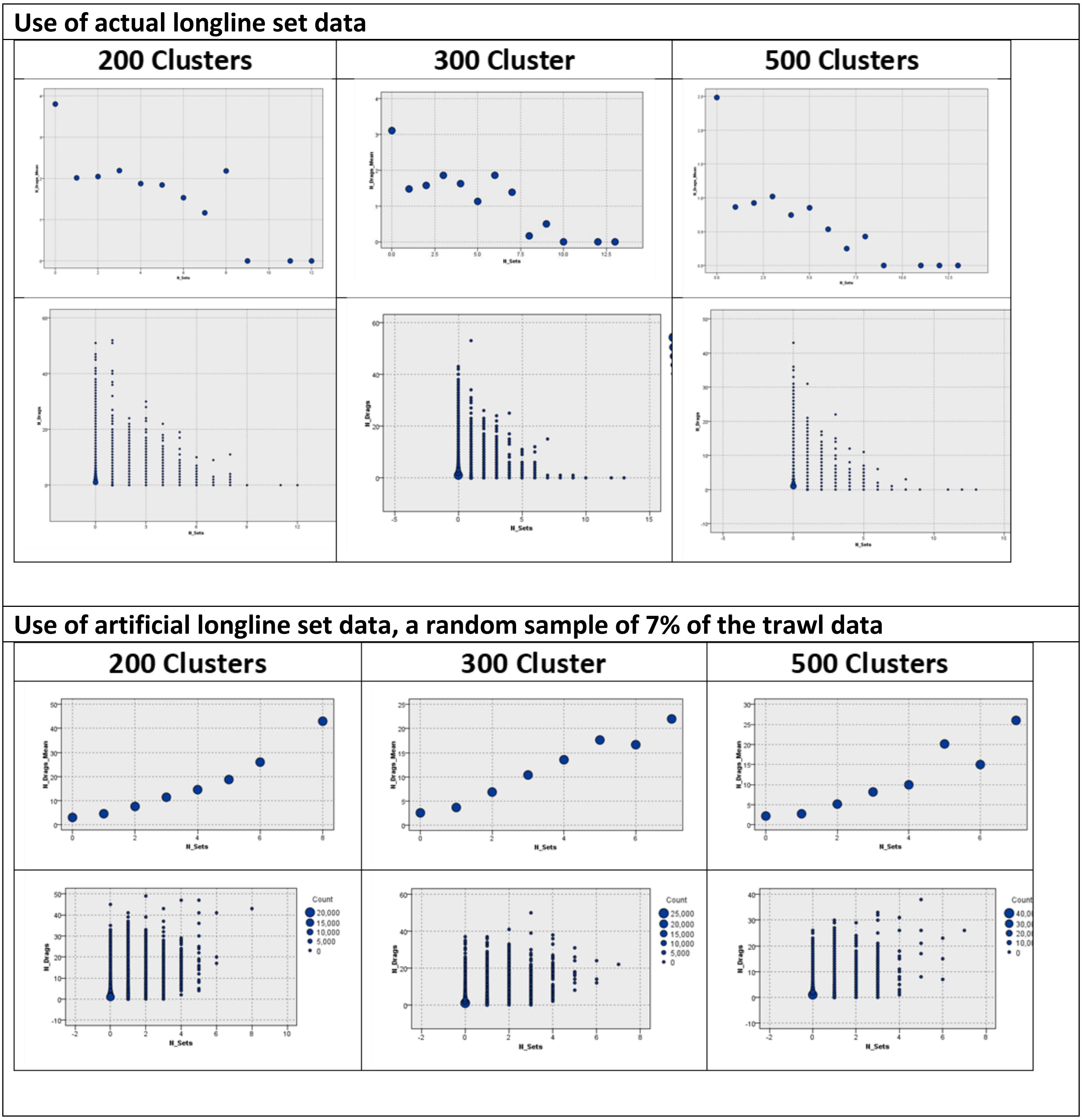

Figure 4. Top panel: For the 200, 300 and the 500 cluster cases, a plot of the number of drags (n(DRAGS)) vs the number of sets (n(SETS)) at the resolution of Cluster_Days. Bottom panel: For the 200, 300 and the 500 cluster cases, a plot of the number of drags (n(DRAGS)) vs the number of sets (n(SETS)) at the resolution of Cluster_Days, **where for this case the sets are a random selection of 7% of the trawls and the true longline set level information has been excluded from the calculations**. As stated the top half of each of the two panels show the average number of drags on the y axis for given 'numbers of sets' to clarify the average relationship. The bottom panels show all cases, except that larger dots represent more than one value (where a value is a Cluster_Day) as indicated by the legend.