Tilefish Appendixes

Working Paper Appendix A.1
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An overview of the tilefish data collected through the Northeast Fisheries Science Center's Study Fleet project

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Abstract

The last assessment of golden tilefish, *Lopholatilus chamaeleonticeps*, was based on a surplus production model which utilized a commercial catch per unit effort (CPUE) derived from fishing vessel trip reports (VTRs) as an index of abundance. The 2005 Stock Assessment Review Committee (41st SAW, 2005) concluded that "the effort metric (days absent) in the Weighout and VTR CPUE is a crude measure of effort and could be improved by collecting information (number and size of hooks, length of main line, soak time, time of day, depth fished and area fished) on a haul by haul basis and not by a trip basis." In 2007, the Northeast Fisheries Science Center began a cooperative Study Fleet project with the tilefish industry specifically to address the concerns of the 41st SAW. A brief overview of the program and the data collection protocols is presented along with a general overview of the quality of the data collected by the project to date and a cursory examination of the relationships between haul-based effort metrics and catch. The information is intended to inform the 48th Stock Assessment Review Committee on the types of data available from self-reported haul-by-haul data collection programs. Because of the short time series of these data and data quality concerns, their utility to the current assessment is largely limited to informing the assessment (e.g., accuracy of the days absent effort metric and codification of fishing practices). However, this review serves an important first step in determining whether these types of data can be used in future assessments and whether this, or similar studies, should be extended.

Introduction

The golden tilefish, *Lopholatilus chamaeleonticeps* (hereafter referred to as tilefish), fishery in the Mid-Atlantic region is primarily targeted by a small (< 10 vessels) demersal longline fleet with virtually no observer coverage (Appendix Table A.1.1). Furthermore, this stock lacks a fishery independent index of abundance such that the surplus production model used to assess this stock relies entirely on commercial catch per unit effort (CPUE) derived from fishing vessel trip reports (VTRs) as an index of abundance. The 2005 Stock Assessment Review Committee (41st SAW, 2005) concluded that "…the effort metric (days absent) in the Weighout and VTR CPUE is a crude measure of effort and could be improved by collecting information (number and size of hooks, length of main line, soak time, time of day, depth fished and area fished) on a haul by haul basis and not by a trip basis." Beginning in 2007, the NEFSC began a cooperative Study Fleet project with the tilefish industry specifically to address the concerns of the 41st SAW.

The Northeast Fisheries Science Center (NEFSC) has been operating a Study Fleet Program since 2002. The overall objective of the Study Fleet Program is to assemble a fleet of vessels that are "…capable of providing high resolution (haul-by-haul) self-reported data on catch, effort and environmental conditions while conducting "normal" fishing operations" (Palmer et al. 2007). The Program has been involved in numerous fisheries since 2002 including the groundfish, scallop, hagfish, squid and fluke fisheries. In 2007, four longline vessels which target tilefish for all or part of the year were contracted by the NEFSC to collect fine-scale information on fishing effort and catch. Of the four vessels, two held category A permits (full time) and two held category B permits (part time). The small size of the contracted fleet does restrict how much information can be publically released due to the NEFSC's responsibility to protect vessel confidentiality. The first trip recorded by a tilefish vessel occurred in December 2007 and data collections are currently ongoing. In 2008, the first year of full coverage, 42 trips and 642 hauls were recorded. The trips recorded in 2008 accounted for 237.6 mt of landings, representing 32% of the total annual tilefish landings (736 mt; SAW 48 Working Paper A.1.1). Overall, 52 trips and 702 hauls have been recorded through the Study Fleet Program (*through March 1, 2009*).

Data collection protocols

Electronic logbook

Participating tilefish vessels were equipped with the electronic logbook (ELB) software, Fisheries Logbook Data Recording Software (FLDRS). FLDRS collects all of the information currently collected on paper VTRs, but allows fishermen to record effort and catch information for each haul, rather than aggregated to the subtrip level (i.e., one summary report per gear and area fished). FLDRS can be connected to the vessel's global positioning system (GPS) and depth sounder so vessel captains can capture the date, time, position, statistical area and bottom depth of each haul with the click of the mouse button rather than having to enter this information manually. In addition to basic trip information (vessel, captain, date of sailing, port, etc.) captains were asked to estimate the total length of line and number of hooks hauled (Appendix Figure A.1.1). Because of the complexity associated with the setting behavior of tilefish gear (Appendix Figure A.1.2), captains were asked only to record the hauling activity. For each haul recorded, captains had to provide catch estimates (both retained and discarded). During planning meetings with the industry they had commented that hook competition with other species can negatively impact tilefish catch. In an effort to capture this information captains were also asked to estimate the total number of hooks occupied by non-tilefish species (Appendix Figure A.1.3). On review, the hook competition information appeared incomplete, and was therefore not included in this analysis (in 2008 the number of non-tilefish occupied hooks was only recorded for 331 of 642 hauls). On completion of a trip, captains entered the landings information (date landed port landed, species, amount offloaded, dealer, date sold). Captains were allowed to adjust the landings to reflect the true amount of offloaded catch, such that landings were not affected by hailing errors at the haul-level or by missed hauls during the trip.

GPS polling observations

In addition to the self-reported information, FLDRS was configured to poll the vessel's GPS and depth sounder once every 20 seconds to record fine scale information on vessel cruise paths and bottom topography. These data were stored in a file separate from the trip file and were manually collected by Study Fleet field scientists approximately once per month. By using the ELB entered haul times, it was determined that > 90% of the hauling activity occurs between 3.1 km/hr and 10.2 km/hr, whereas only 12% of non-hauling activity occurs in this speed window (Appendix Figure A.1.4). Plotting fishing tracks in a Geographic Information System (GIS), the hauling vs. non-hauling activity could be differentiated with manual post-processing and used to validate the ELB recorded information (Appendix Figure A.1.5). Of the 42 trips recorded in the ELB in 2008, 36 had GPS polling coverage. Failure of the ELB to communicate with the GPS was the primary reason why GPS polling data were unavailable for a particular trip.

Field scientist observations

NEFSC field scientists were present on four of the ELB-recorded trips (total of 51 hauls). The objectives of the field scientists were to: a) provide independent estimates of tilefish catch; and, b) collect biological samples (e.g., length, weight and age) from the tilefish catch. Field scientists did not observe all hauls during a trip nor did they record observations on the amount of fishing effort (e.g., mainline length, number of hooks, bottom depth). Field scientist information can only be used to assess the accuracy of catch estimates and provide biological information on the resulting catch.

Data quality

Overview

The ELB data collected by the tilefish vessels have not previously been analyzed. This analysis represents the first assessment of the quality and utility of these data. It is a critical first step to determine the overall quality of these data and understand how the quality of both the self-reported and electronically recorded (i.e., by GPS and depth sounder) impact their utility for future tilefish stock assessments. Because of the short time series of these data, their utility to the current assessment is largely limited to informing the assessment (e.g., accuracy of the days absent effort metric and codification of fishing practices). However, this review serves an important first step in determining whether these types of data can be used in future assessments and whether this, or similar studies, should be extended. Data quality analyses focused on the quality of the self reported effort metrics (number of hauls, mainline length, number of hooks, soak duration, and fishing depth) and catch estimates.

Effort metrics were primarily validated by comparing the self-reported estimates to estimates obtained from post-processing of the GPS polling information. The post-processing step is an extremely time consuming process taking approximately 4-8 staff hours per trip file depending on the length of the trip and spatial density of the fishing patterns. Due to the time intensive nature of this activity, only 23 of the 36 trips with GPS polling information were post-processed. Unfortunately, all of these trips were from a single vessel so the results of the data quality analysis should not be overly interpreted as indicative of all of the self-reported data. Because of the limited applicability of these data, no statistical tests were performed.

Number of hauls per trip

During preliminary review of the tilefish data it was observed that the sum of individual catches was often much less than the total landings (Appendix Figure A.1.6). This could indicate that either the individual haul hail estimates were consistently low, or not all hauls were recorded in the ELB. Follow-up conversations with vessel captains suggested that the greatest contributor to these discrepancies was missing hauls. Comparison of the number of self-reported hauls per trip to the number estimated from the GPS indicated that hauls do occasionally go unreported in the logbook (Appendix Figure A.1.7). Of the 23 trips examined there was complete agreement in the haul counts on eight trips and no instances of the ELB recording more hauls compared to the GPS analysis. The degree of underestimation in the ELB was variably, but generally less than 5 hauls per trip.

Mainline length hauled

Mainline length was determined from the GPS polling data by calculating the cumulative haversine distance (Sinnott 1984) of all points between the start and ending points of a haul. In general, the ELB estimated mainline length hauled agreed reasonably well with the GPS calculated mainline length, though there was considerable variability and the numerous outliers (Appendix Figure A.1.8).

Number of hooks hauled

There was no way to directly validate the number of hooks self-reported on the ELB, however by comparing these estimates to the GPS calculated mainline length a general understanding of the accuracy of these estimates can be obtained. However, the variability observed in the relationship will be contingent on the accuracy of the self-reported data and the setting hook density (number of hooks per km of line set). There is general agreement between ELB hooks hauled and the GPS calculated mainline length (Appendix Figure A.1.9); however, there is greater spread in the relationship compared to the ELB mainline to GPS mainline comparisons.

Soak duration

GPS soak duration was calculated as the average of the soak durations (time difference between when a particular section of gear was set and when the same section was hauled) from five observations taken along the length of the haul. The soak duration associated with the start haul and end haul was always taken and the intent was that the remaining three observations would be equally spaced out across the haul. The average soak duration and standard deviation were calculated for each haul. The ELB estimates of soak duration were generally higher than those calculated from the GPS polling files (Appendix Figure A.1.10). In conversations with the vessel owners, it could be that this difference is partly attributable to the fact that vessel captains calculate soak duration differently (difference between when the last piece of gear was set and when the last piece of gear was hauled).

There was an interesting trend in the relationship of the standard deviation to the average soak duration (Appendix Figure A.1.11). Two different trends are present, one representing efforts where the gear was hauled in the same direction it was set in (lower ratio of variability to average soak duration), and the other when gear were hauled in the opposite direction from which they were set (higher ratio of variability to average soak duration).

Fishing depth

Because tilefish are caught with bottom tending gear, the fishing depth is the bottom depth. Average fishing depth was calculated from the GPS polling file by calculating the average bottom depth between the start of the haul and the end of the haul. The ELB estimates of bottom depth agreed well with the GPS calculated values, though several outliers exist (Appendix Figure A.1.12).

Catch estimates

ELB-reported catch estimates were compared to the catch estimates recorded by the Study Fleet field scientists. The haul-by-haul difference in reported tilefish catch was generally similar with the median centered near 0 and the spread uniform about the median (Appendix Figure A.1.13). There were three hauls where the ELB estimates were considerably higher than the estimates of the field scientists.

Data quality conclusions

Overall, the self-reported ELB data examined did track the general trends derived from alternate sources (GPS/depth sounder or field scientists). While these conclusions are based on a small subset that was generally limited to a single vessel, they do suggest that the overall quality of the self-reported data are sufficient for use in making general inferences about catch relationships and trends.

Use of VTR days absent as a proxy for fishing effort

The 41st SAW (2005) characterized days absent as calculated from the VTR as a "…a crude measure of effort". The availability of more precise and more accurate (particularly when derived from GPS observations) allows the inaccuracy of VTR days absent to be assessed. There are two fundamental questions: 1) does VTR days absent minus one accurately reflect the amount of time spent on the fishing grounds?; and, 2) does this metric track well with alternate effort metrics such as the amount of mainline length fished?

To evaluate the first question, the GPS data were used to determine the total amount of days the vessel spent on the fishing grounds and compare this to the VTR days absent minus one metric. The agreement between the two was highly significant (Appendix Figure A.1.14; $n = 23$, $r = 0.937$, $p < 0.0001$) indicating that the VTR days absent minus one metric accurately reflects the true time spent fishing. When comparing these two metrics to the GPS estimated mainline length fished, the GPS days fished explains a greater degree of the variability in the mainline length hauled ($r^2 = 0.73$) compared to the VTR days absent minus one metric ($r^2 = 0.52$). These results suggests that while the VTR days absent metric accurately reflects the time spent on the fishing grounds and explains some of the variability in mainline length hauled, more precise metrics may offer improvements over the current metric used in the surplus production model.

Catch relationships as a basis for alternate CPUE estimates

SAW 41 (2005) stated that "…the effort metric [used in calculating CPUE]…could be improved by collecting information (number and size of hooks, length of main line, soak time, time of day, depth fished and area fished) on a haul by haul basis." We've taken an exploratory look at the relationship between these alternate haul-based determinants of tilefish catch. Based on the relative accuracy of the self-reported ELB data all recorded haul records (702 hauls recorded between December 1, 2007 and March 1, 2009) were used in these comparisons. The effort metrics examined here are: mainline length, number of hooks, hook density (hooks/km), soak duration, depth and latitude fished. There is a high degree of multicollinearity among these variables which is expected, particularly among those effort metrics that are closely related such as mainline length and number of hooks (Appendix Table A.1.2).

Catch appears most closely related to the number of hooks fished (Appendix Figure A.1.16), with a weaker relationship to the mainline length (Appendix Figure A.1.17), though because of the collinearity between number of hooks and mainline length, it is unclear if this is direct relationship. Interestingly, there is no linear relationship between catch and hook density (Appendix Figure A.1.18); the highest catch rates occur between 200 and 300 hooks/km, but catch rates are lower at densities outside this range. There a weak linear relationship of catch to soak duration (Appendix Figure A.1.19), but again, because of the collinearity of soak duration to both number of hooks and mainline length it is impossible to determine if soak duration is a determinant of catch. There is no linear relationship between catch and depth (Appendix Figure A.1. 20) or latitude (Appendix Figure A.1.21), however catches do appear to be lower at greater depths and lower latitudes. The interpretation of these results is difficult because vessel tended to fish in shallower depths at higher latitudes (Appendix Figure A.1.22).

The length frequency information collected by the field scientists was cursorily examined for trends with respect to depth (Appendix Figure A.1.23) and latitude (Appendix Figure A.1.24). There were significant relationships of size to both of these variables, with latitude explaining a greater degree of the variability in tilefish fork length.

Catch trends over time

Based on the relative strength of the relationship between catch and the number of hooks fished, a CPUE metric was constructed as the catch (live wt. kg) per hook hauled. CPUEs observed in this time series ranged from 0.0 to 1.0 kg/hook. Three different CPUEs trends were examined; 1) using all data across the time series fit with a loess smoother (Appendix Figure A.1.25); 2) using only hauls occurring within a 40 minute square region in the vicinity of Hudson Canyon (Appendix Figure A.1.26); and, 3) using only hauls occurring within a 40 minute square region in the vicinity of Block Canyon (Appendix Figure A.1.26). The area in the vicinity of Hudson Canyon was the most heavily fished area for the duration of the time series, with the Block Canyon region being the second most heavily exploited area. While there is some evidence of declining CPUE in each of the time series, the data are insufficient to draw any conclusions, as the trends are driven by high catches early in the time series and may associated with seasonal effects or some other unknown effect.

Conclusions

The information presented in this working paper is intended to inform the 48th Stock Assessment Review Committee on the types of data available from Study Fleet-like projects focusing on the collection of self-reported haul-by-haul information. The data quality is sufficient to detect relationships and perhaps general trends, but the overall quality of the data can be improved. It should be noted that many of the vessels in the tilefish fleet utilize multiple captains, which increases the time period necessary to familiarize one self with the electronic logbook and data collection protocols. Through closer collaboration with the tilefish industry the quality of these data are likely to improve. Because of the quality of these data, more in depth analyses were not performed, however the results do indicate that the current VTR days absent effort metric does provide a reasonable measure of fishing effort, but that it could be improved on by collecting information at a finer scale.

Acknowledgements

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References

41st Northeast Regional Stock Assessment Workshop (41st SAW). 2005. 41st SAW assessment report. US Dep Commer, Northeast Fish Sci Cent Ref Doc. 05-14; 237 p.

Palmer MC, Wigley SE, Hoey JJ, Palmer J 2007. An evaluation of the Northeast Region's Study Fleet Pilot Program and electronic logbook (ELB) system: Phases I and II. NOAA Tech. Memo. NMFS-NE-204. 79 p.

Palmer MC. 2008. Calculation of distance traveled by fishing vessels using GPS positional data: A theoretical evaluation of the sources of error. Fish Res. 89:57-64.

Sinnott RW. 1984. Virtues of the Haversine. Sky and Telescope 68:159.

Tables

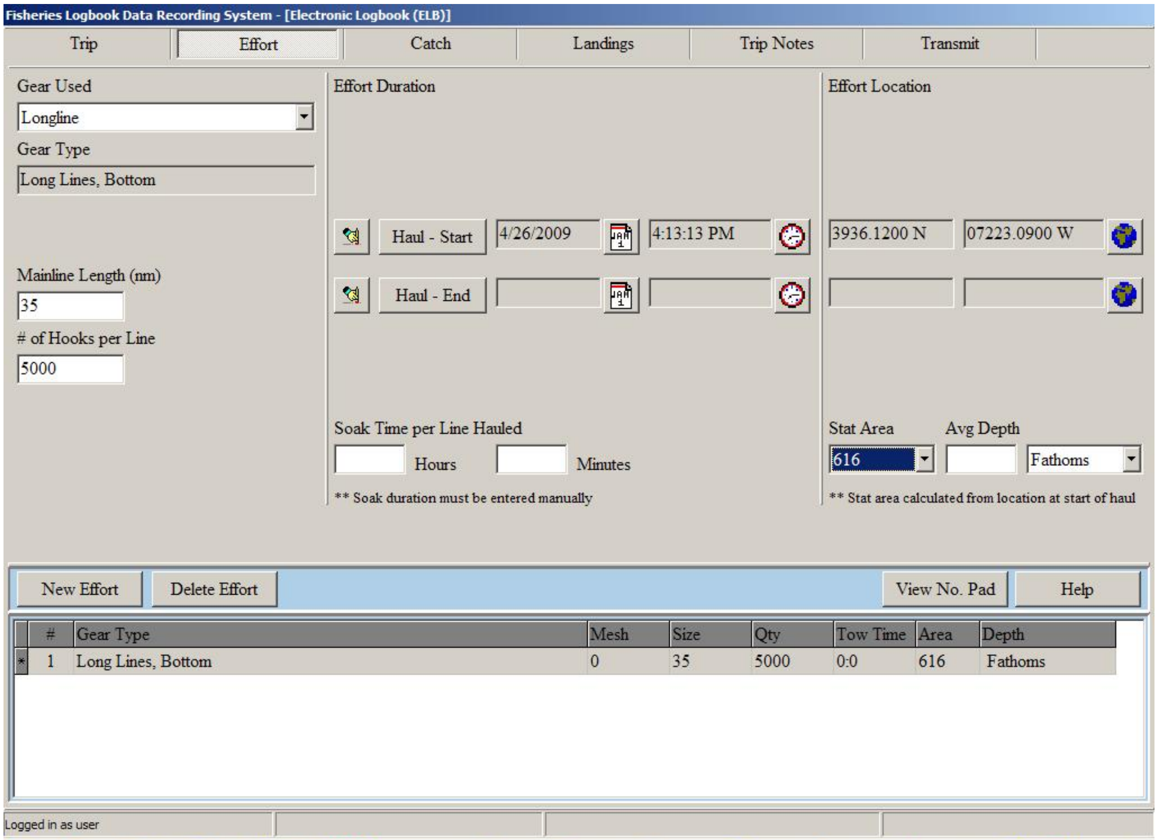
Appendix Table A.1.1. Number of directed tilefish trips (longline gear only) observed by the Northeast Fisheries Observer Program by year.

Year	Number of directed tilefish trips observed (*longline gear only*)
1992	1
2004	1
2005	4
2006	4
2007	2
2008	1

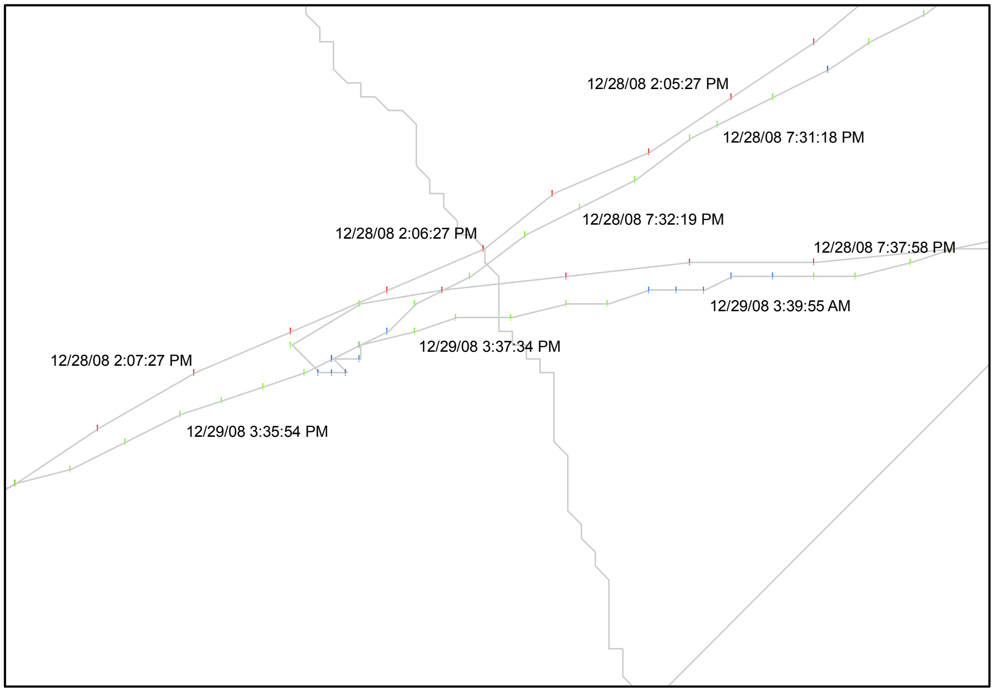
Appendix Table A.1.2. Correlation matrix of tilefish catch and effort metrics from data reported by captains using the electronic logbook. Relationships significant at the $p < 0.05$ are shown in bold.

	Tilefish catch (live wt. kg)	Mainline length (km)	Number of hooks	Hook density (hooks/km)	Soak duration (hours)	Bottom depth (m)
Mainline length (km)	**0.589** ***(<0.0001)***					
Number of hooks	**0.607** ***(<0.0001)***	**0.819** ***(<0.0001)***				
Hook density (hooks/km)	-0.053 *(0.158)*	**-0.308** ***(<0.0001)***	**0.208** ***(<0.0001)***			
Soak duration (hours)	**0.447** ***(<0.0001)***	**0.638** ***(<0.0001)***	**0.604** ***(<0.0001)***	0.017 (0.654)		
Bottom depth (m)	-0.060 *(0.115)*	-0.061 *(0.107)*	-0.066 *(0.083)*	0.008 *(0.832)*	-0.011 *(0.772)*	
Latitude (dd)	-0.049 *(0.1972)*	0.008 *(0.8229)*	**0.094** ***(0.0123)***	**0.123** ***(0.0011)***	**-0.189** ***(<0.0001)***	**-0.361** ***(<0.0001)***

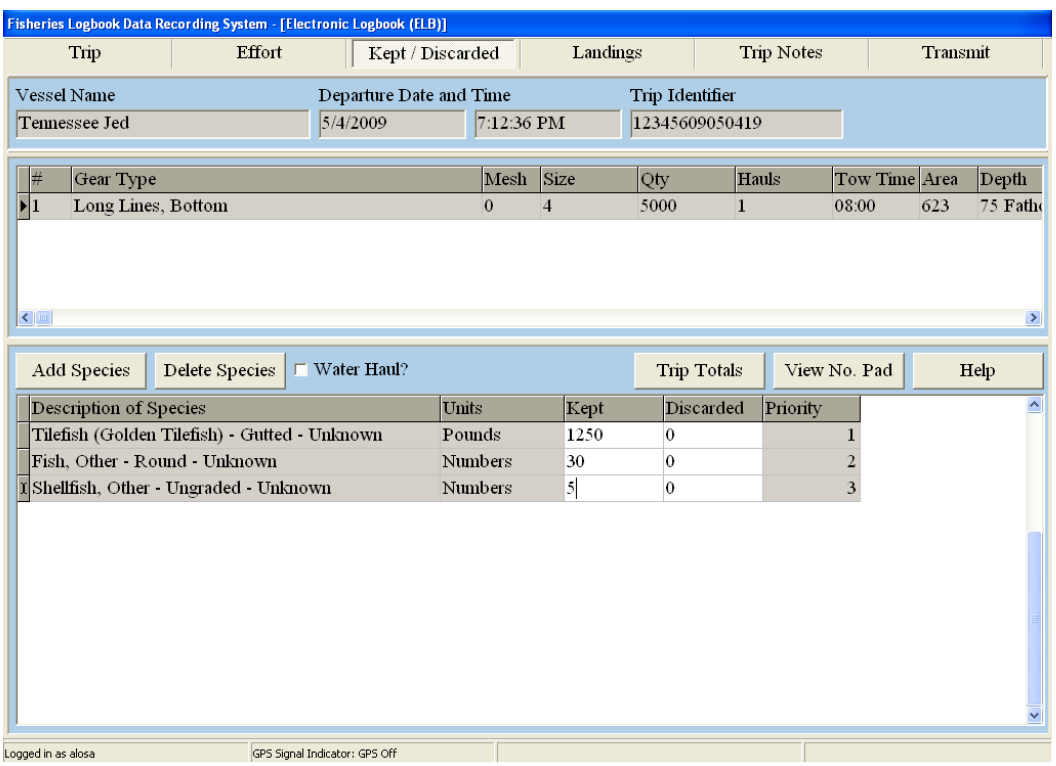
Figures



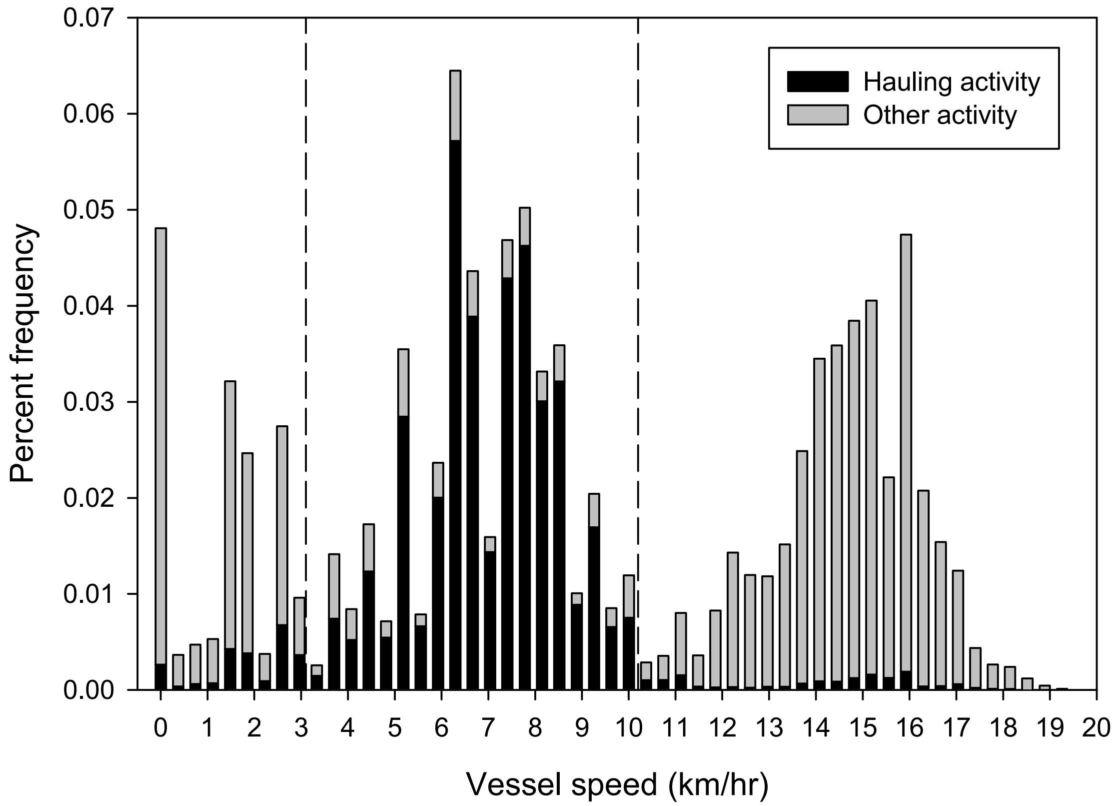
Appendix Figure A.1.1. A screen shot of the Fisheries Logbook Data Recording Software (FLDRS) effort data entry screen. This screen shot is similar to that used by tilefish vessel captains to record information on the gear hauled.



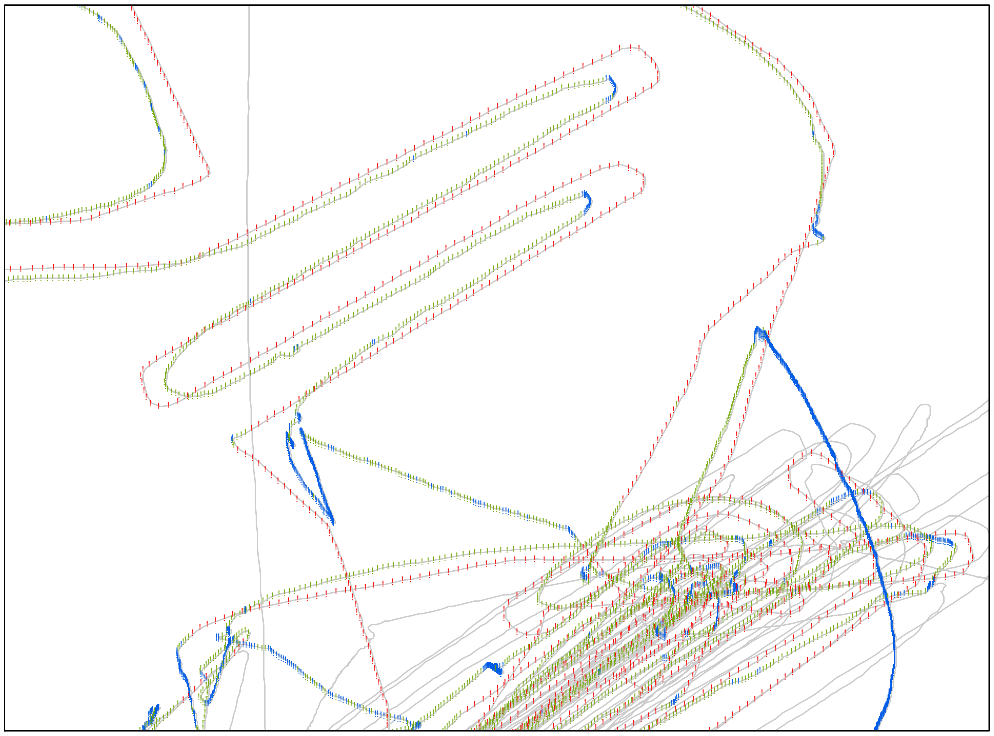
Appendix Figure A.1.2. Example of a tilefish haul where line is hauled from two separate setting events. The 12/29 haul includes gear set on 12/28 around 2:00 PM and also gear set around 7:30 PM. Spatial reference information is intentionally not shown to protect the confidentiality of the vessel data.



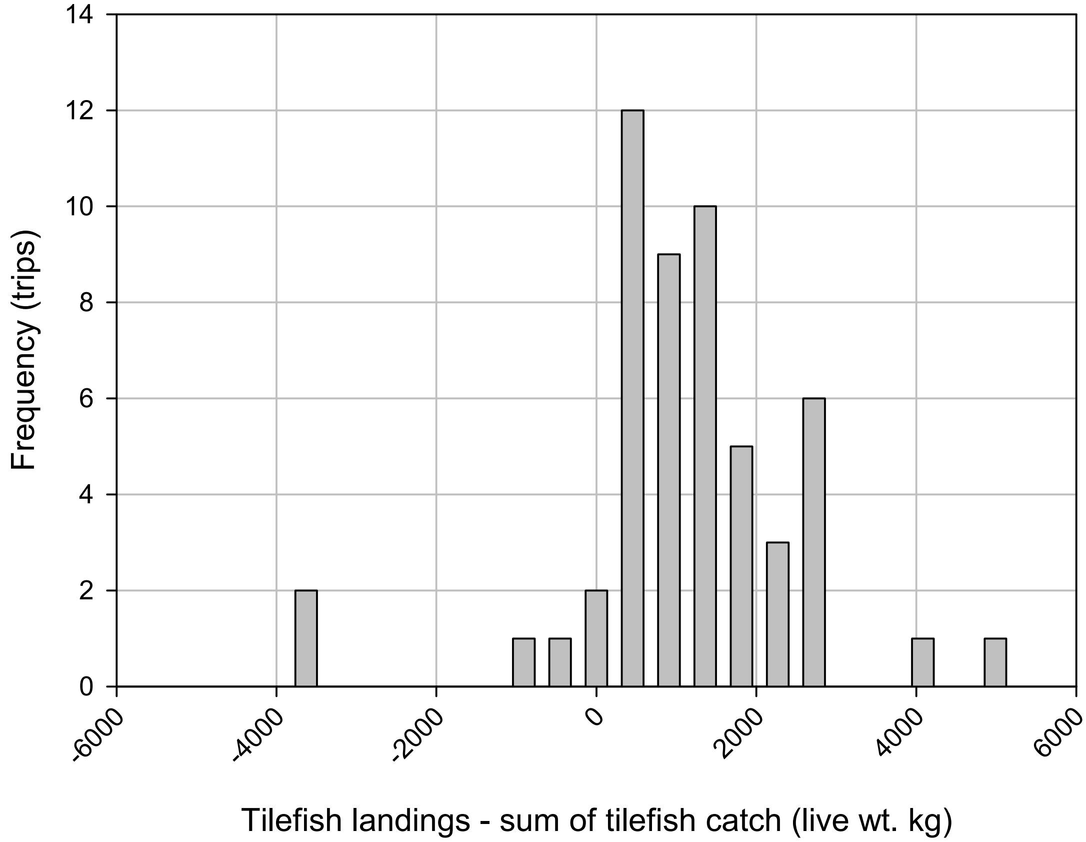
Appendix Figure A.1.3. A screen shot of the Fisheries Logbook Data Recording Software (FLDRS) catch data entry screen. This screen shot is similar to that used by tilefish vessel captains to record information on the fish caught for each haul.



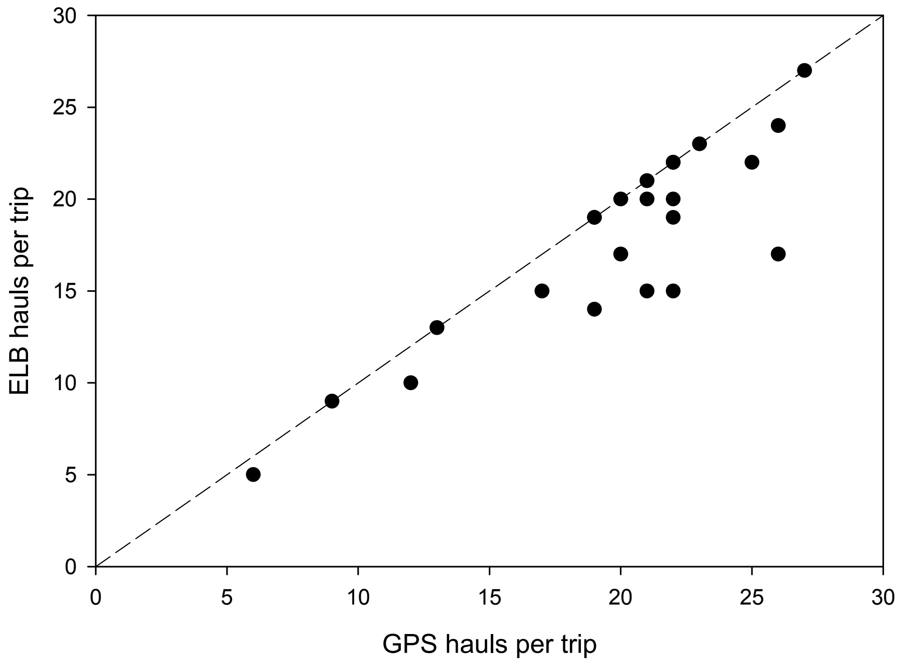
Appendix Figure A.1.4. Percent frequency distribution of recorded tilefish vessel speeds divided into hauling and other activity. The dashed lines (3.1 km/hr and 10.2 km/hr) indicate the speed window where >90% of the hauling activity occurs.



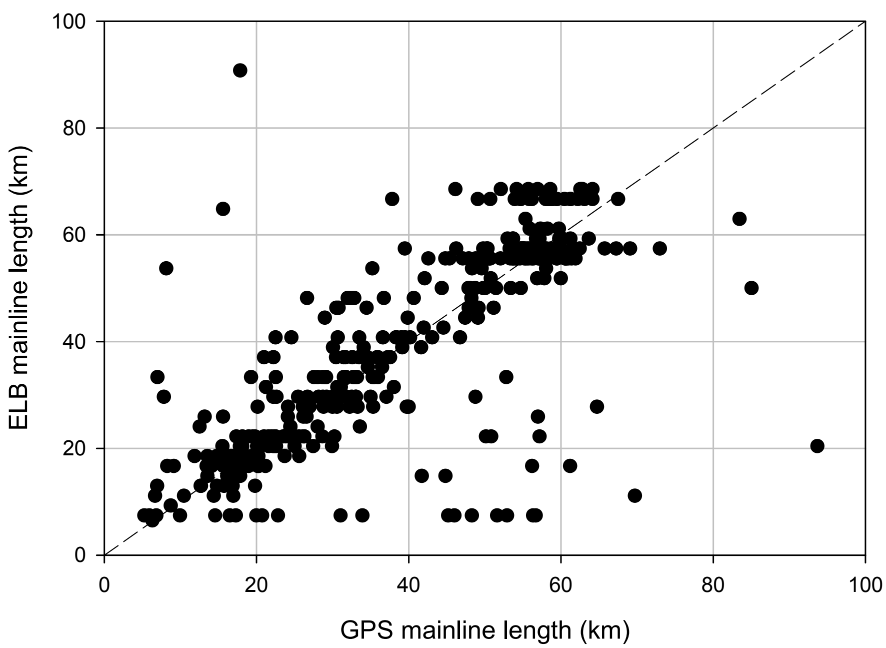
Appendix Figure A.1.5. Example of a global positioning system (GPS) polling file collected from a tilefish vessel. The cruise track is color coded based on vessel speed (blue < 1.7 knots, 1.7 ≥ green ≤ 5.5 knots, red > 5.5 knots). Spatial reference information is intentionally not shown to protect the confidentiality of the vessel data.



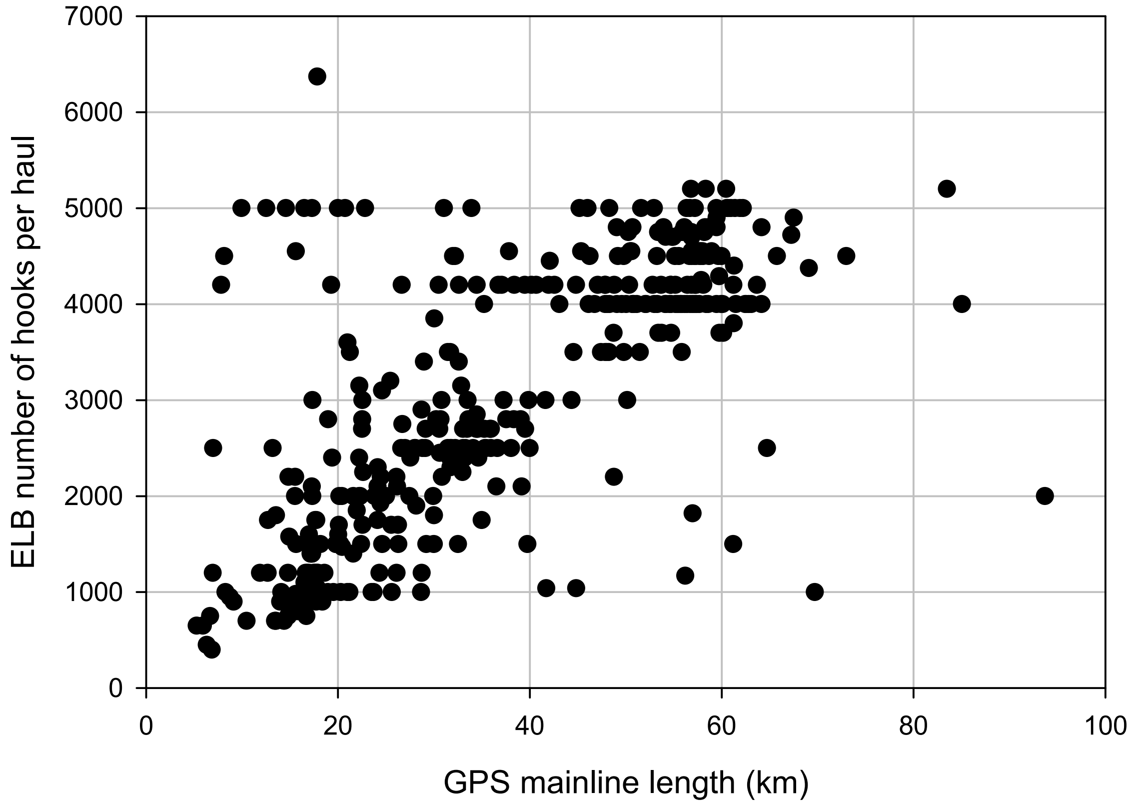
Appendix Figure A.1.6. Frequency distribution of the difference between the amount of landed tilefish and the sum of the individual haul hail weights for a trip. Positive values indicate more landed catch than recorded for the individual hauls, negative values indicates that there was more catch hailed than actually landed.



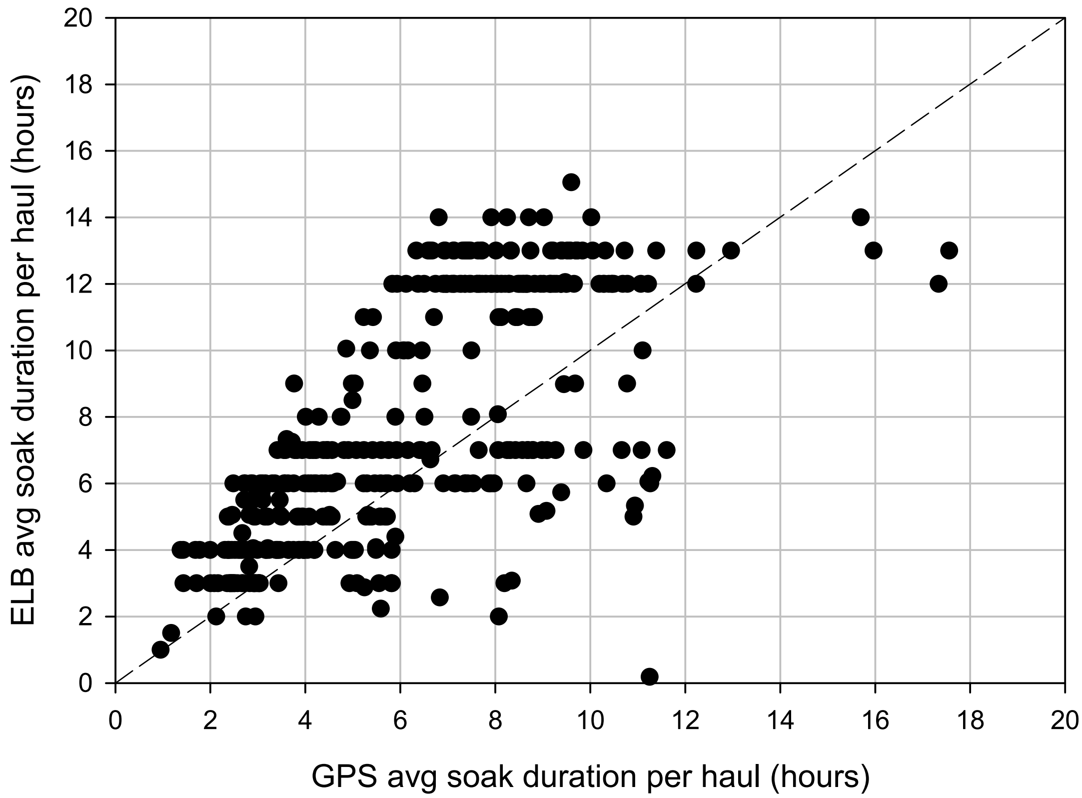
Appendix Figure A.1.7. The number of hauls recorded by the captain in the electronic logbook (ELB) compared to the number of hauls estimated from analysis of the global positioning system (GPS) polling file. The dashed line indicates the 1:1 identity line.



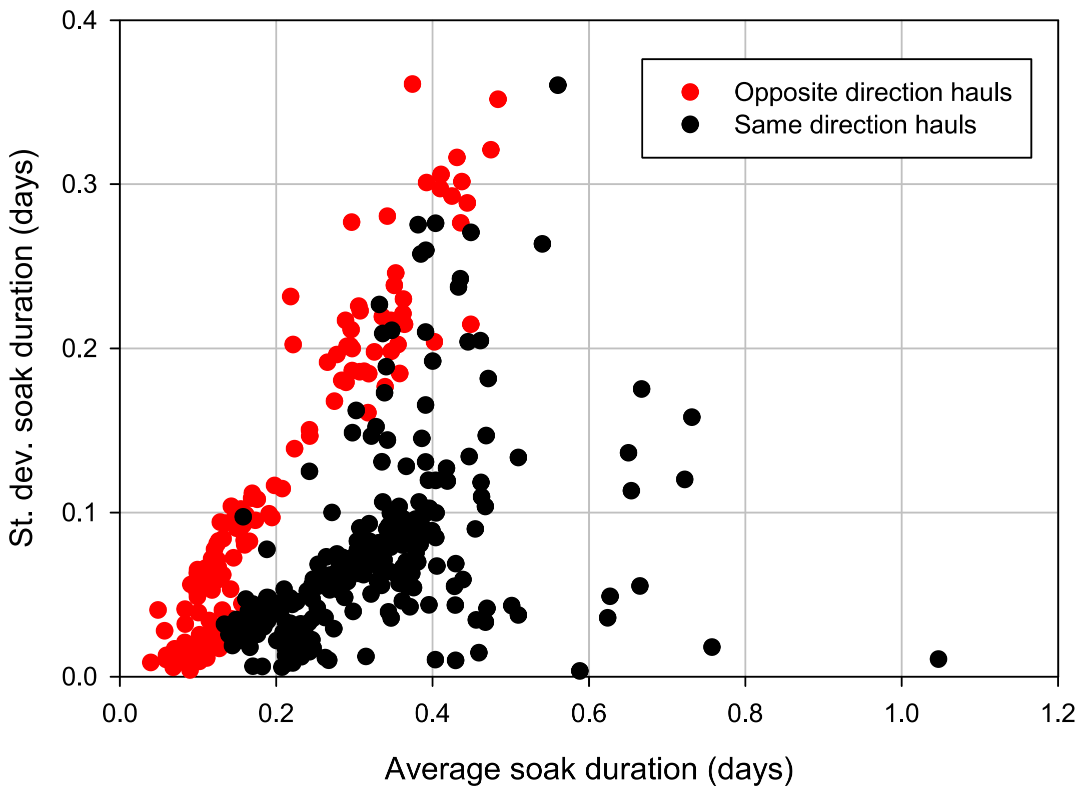
Appendix Figure A.1.8. The captain's estimate of mainline length hauled recorded in the electronic logbook (ELB) compared to the mainline length estimated from analysis of the global positioning system (GPS) polling file. The dashed line indicates the 1:1 identity line.



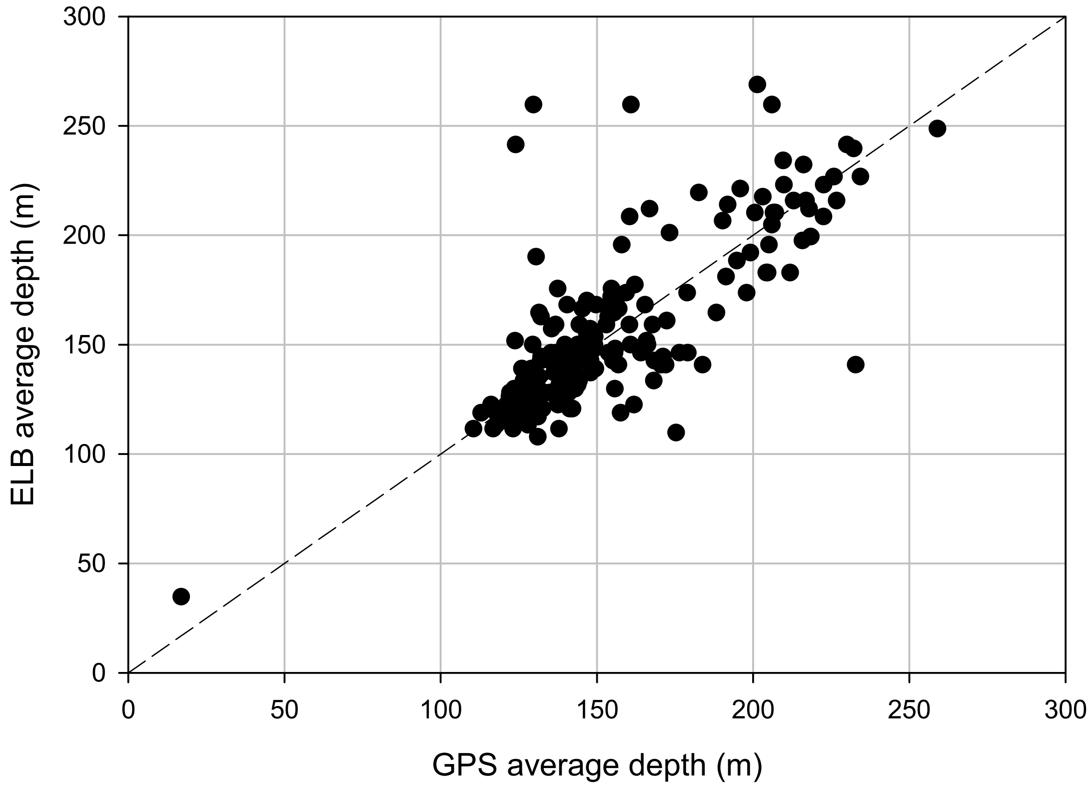
Appendix Figure A.1.9. The captain's estimate of the number of hooks hauled as recorded in the electronic logbook (ELB) compared to the mainline length estimated from analysis of the global positioning system (GPS) polling file.



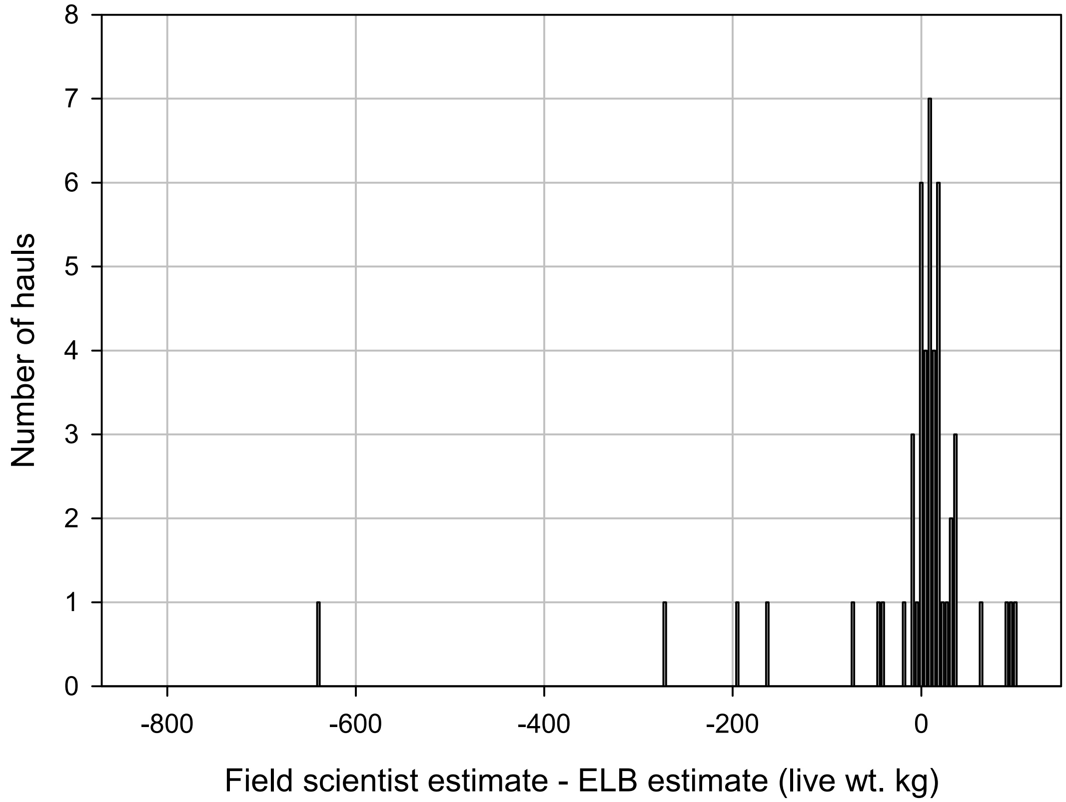
Appendix Figure A.1.10. The captain's estimate of the average soak duration of each haul recorded in the electronic logbook (ELB) compared to the average soak duration estimated from analysis of the global positioning system (GPS) polling file. The dashed line indicates the 1:1 identity line.



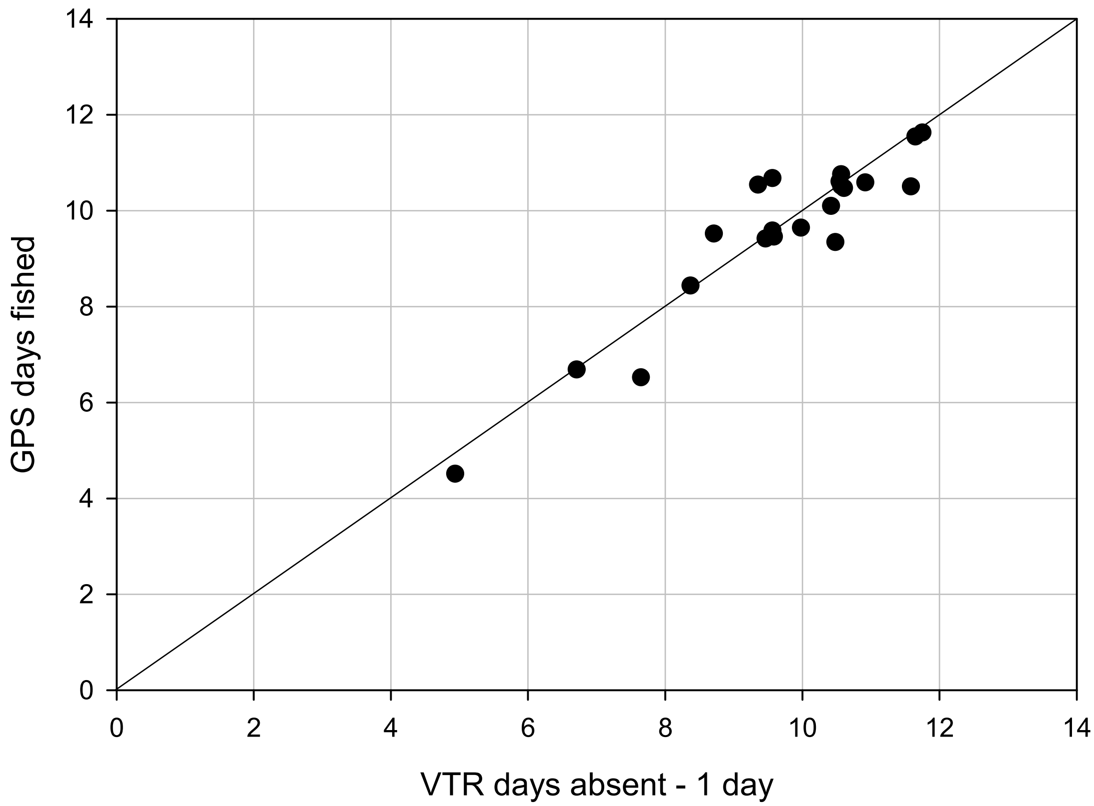
Appendix Figure A.1.11. Comparison of the amount of variability in haul soak times to the overall average soak time for the individual haul. Data points in red represent hauls that were hauled in the opposite direction from which they were set and the points in black represent hauls that were hauled in the same direction they were set.



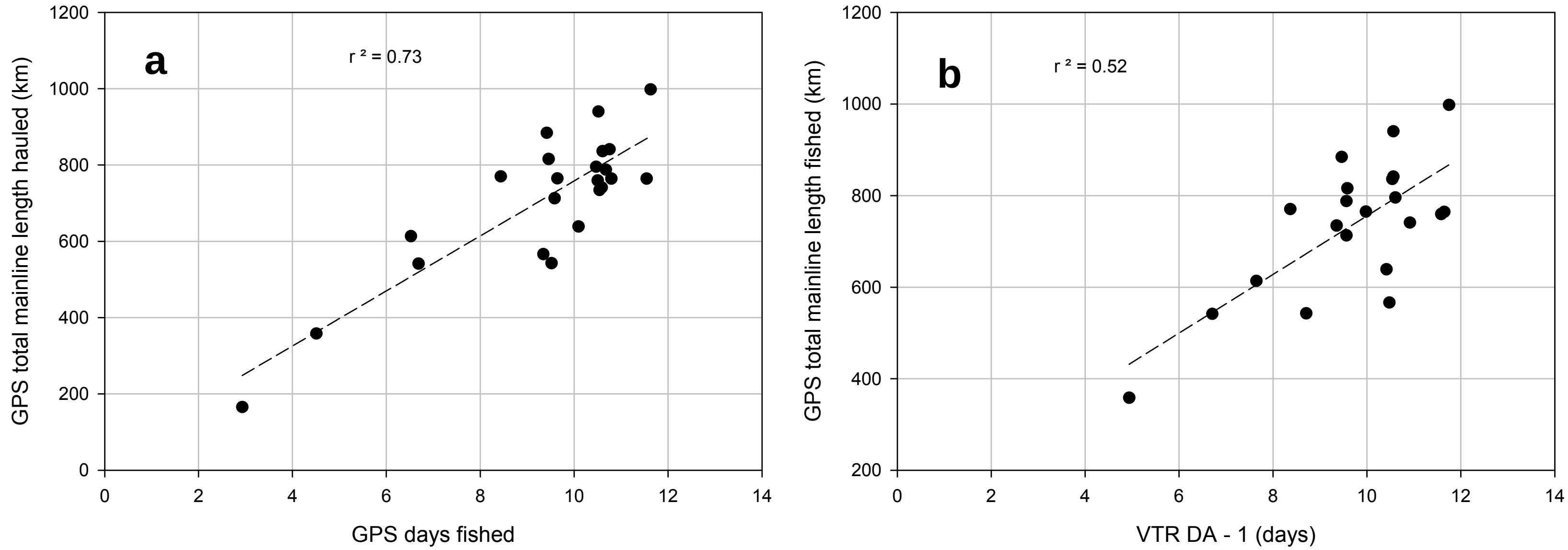
Appendix Figure A.1.12. The captain's estimate of the fishing depth of each haul recorded in the electronic logbook (ELB) compared to the average haul depth (m) estimated from analysis of the global positioning system (GPS) polling file.



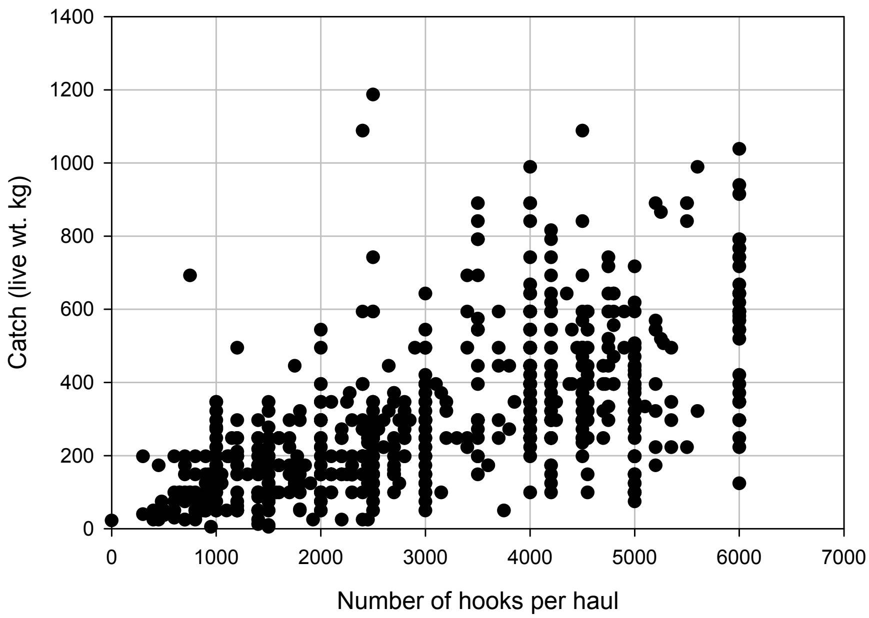
Appendix Figure A.1.13. Frequency distribution of the difference between the captain's haul-level hail weights and those estimated by Study Fleet field scientists. The compared weights span three different trips on three different vessels.



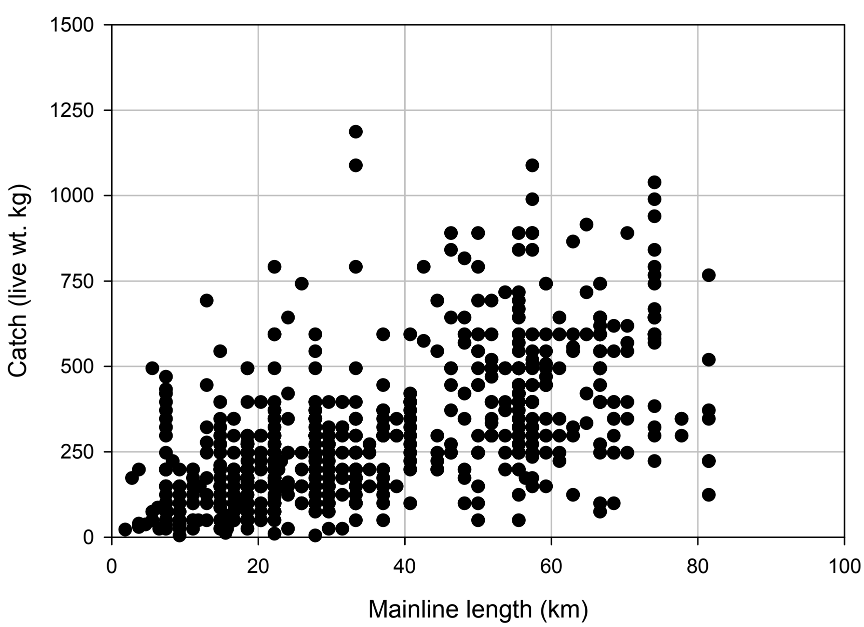
Appendix Figure A.1.14. Relationship between the total number of days fished as determined from analysis of global positioning system (GPS) data and the effort metric used is the surplus production model, the total days absent minus one calculated from the vessel trip reports (VTR).



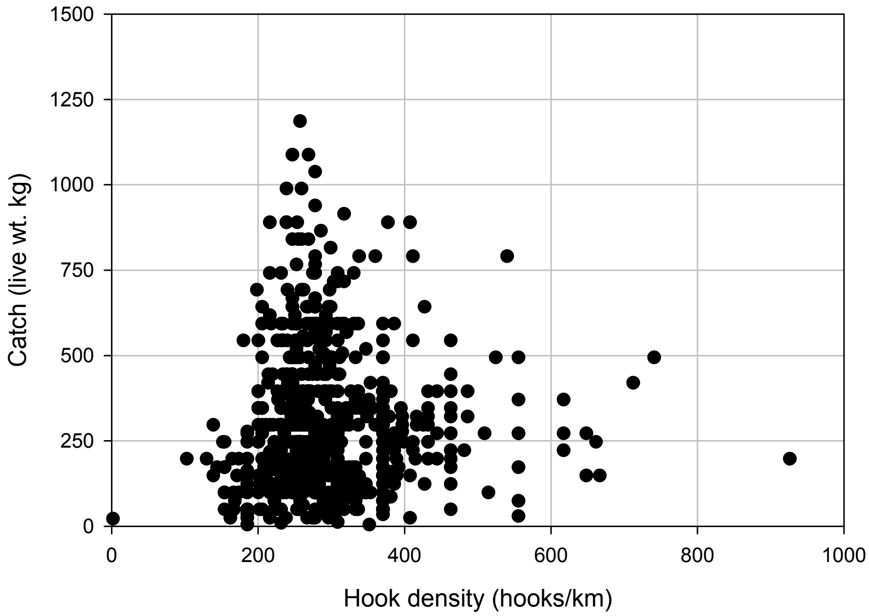
Appendix Figure A.1.15. Relationship between the total mainline length fished per trip as calculated from analysis of global positioning system (GPS) data and the total number of days fished (a) and the total days absent minus one calculated from the vessel trip reports (VTR; b).



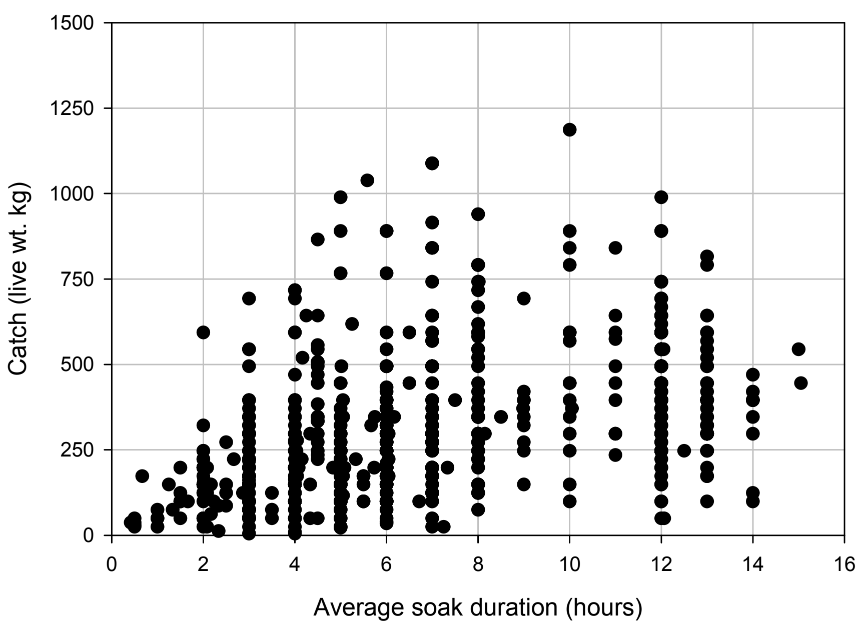
Appendix Figure A.1.16. Tilefish catch (kg live wt.) as a function of the number of hooks fished per haul. Tilefish catches are reported at the haul level by the vessel captains in the electronic logbook.



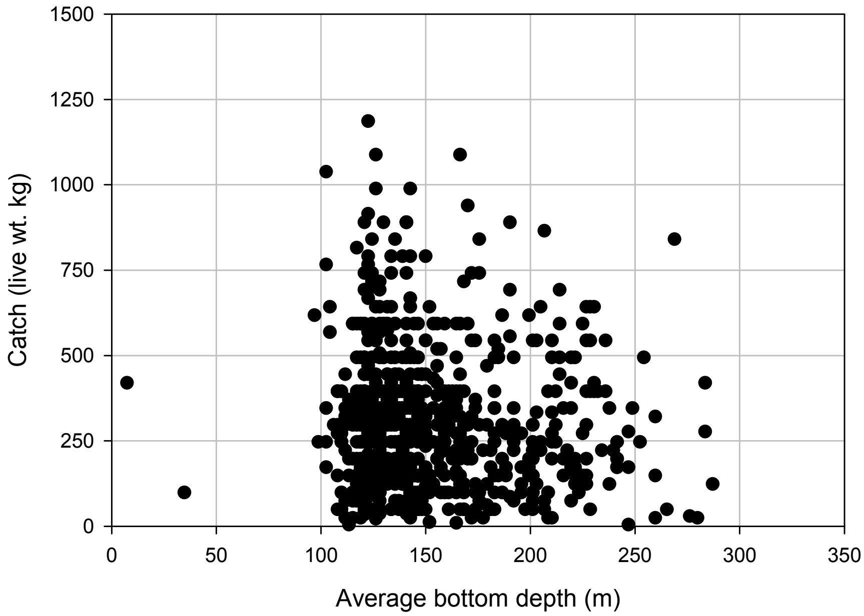
Appendix Figure A.1.17. Tilefish catch (kg live wt.) as a function of mainline length (km). Tilefish catches are reported at the haul level by the vessel captains in the electronic logbook.



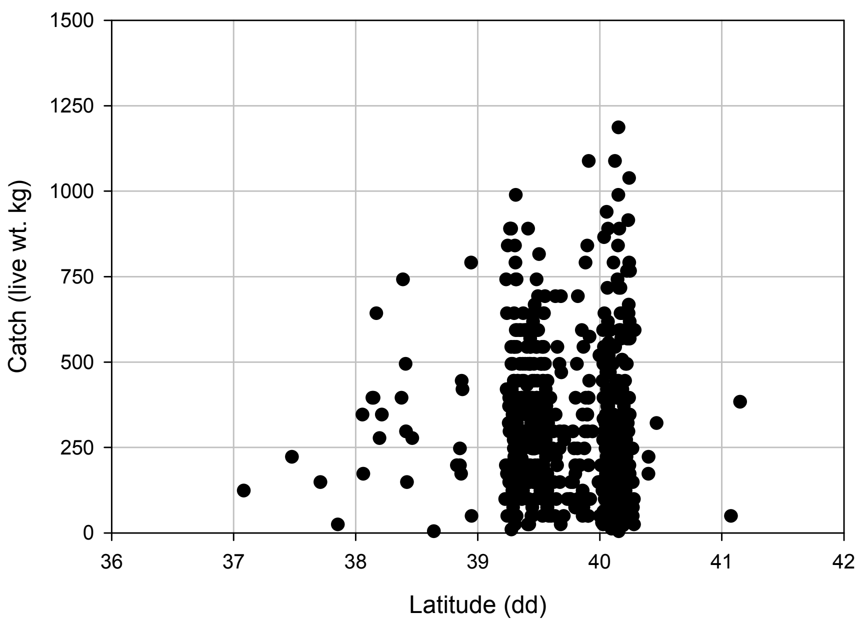
Appendix Figure A.1.18. Tilefish catch (kg live wt.) as a function of hook density (hooks/km). Tilefish catches are reported at the haul level by the vessel captains in the electronic logbook.



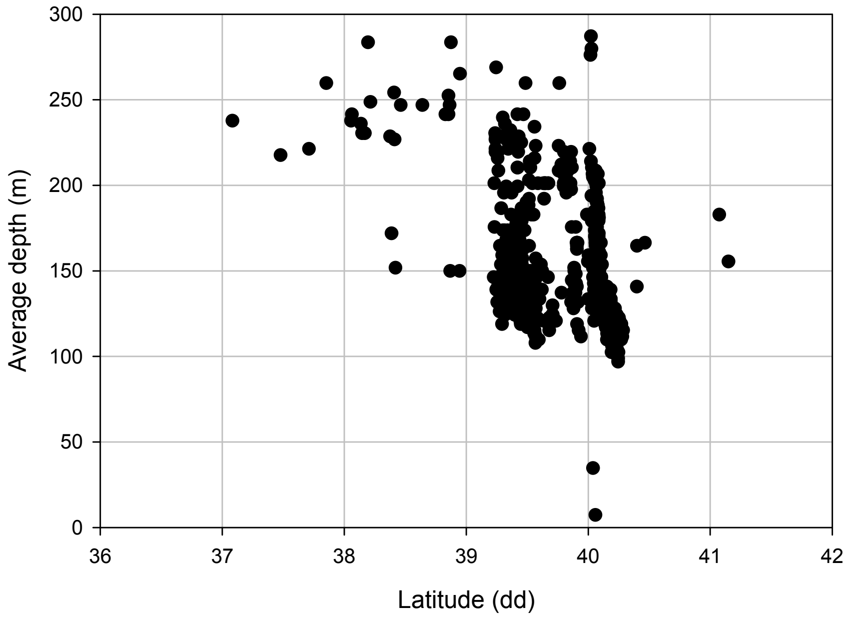
Appendix Figure A.1.19. Tilefish catch (kg live wt.) as a function of average soak duration (hours). Tilefish catches are reported at the haul level by the vessel captains in the electronic logbook.



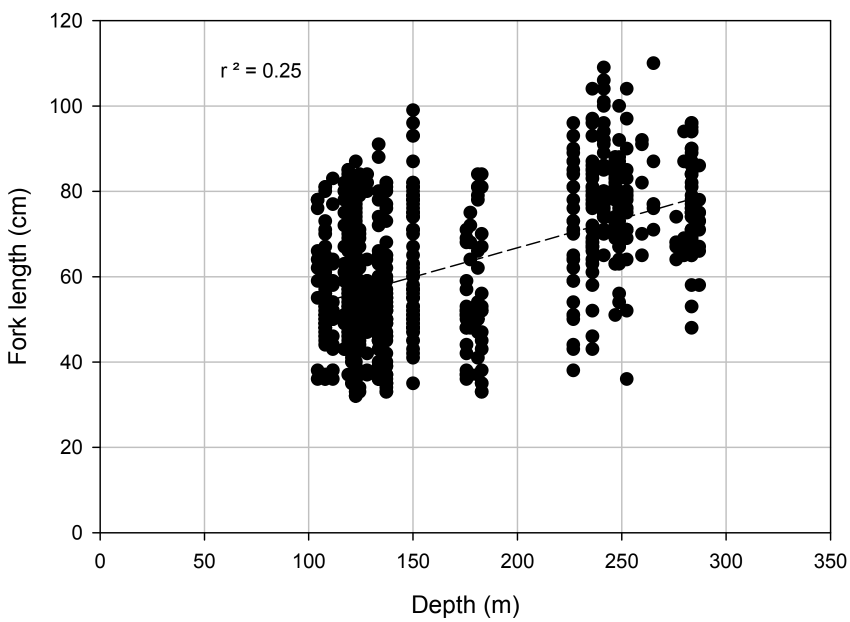
Appendix Figure A.1.20. Tilefish catch (kg live wt.) as a function of bottom depth (m). Tilefish catches are reported at the haul level by the vessel captains in the electronic logbook.



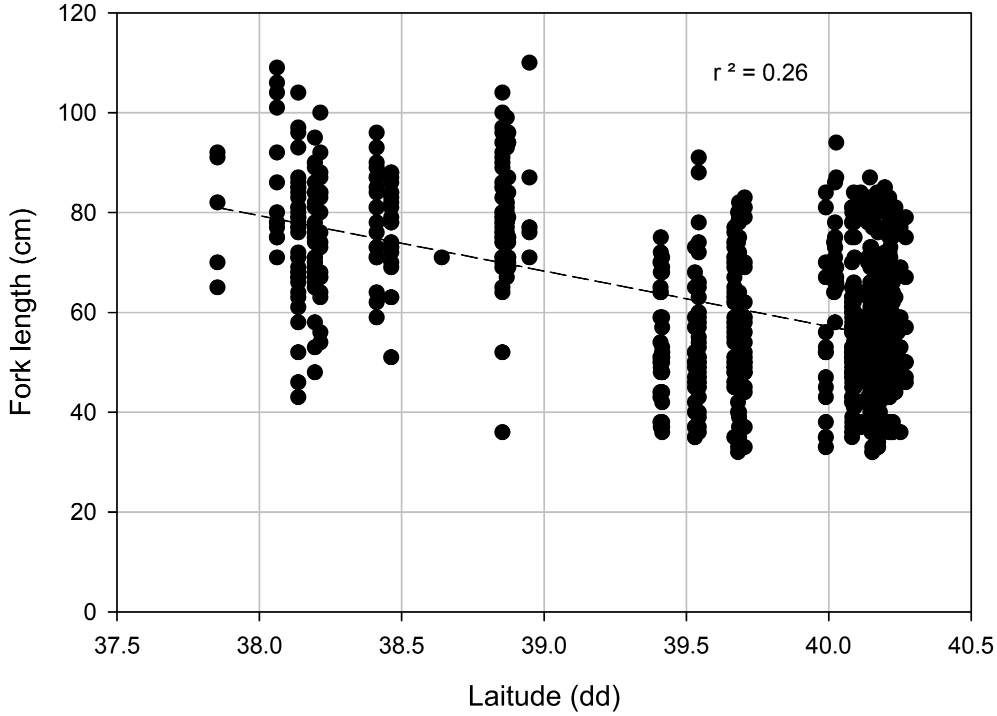
Appendix Figure A.1.21. Tilefish catch (kg live wt.) as a function of latitude (decimal degrees, dd). Tilefish catches are reported at the haul level by the vessel captains in the electronic logbook.



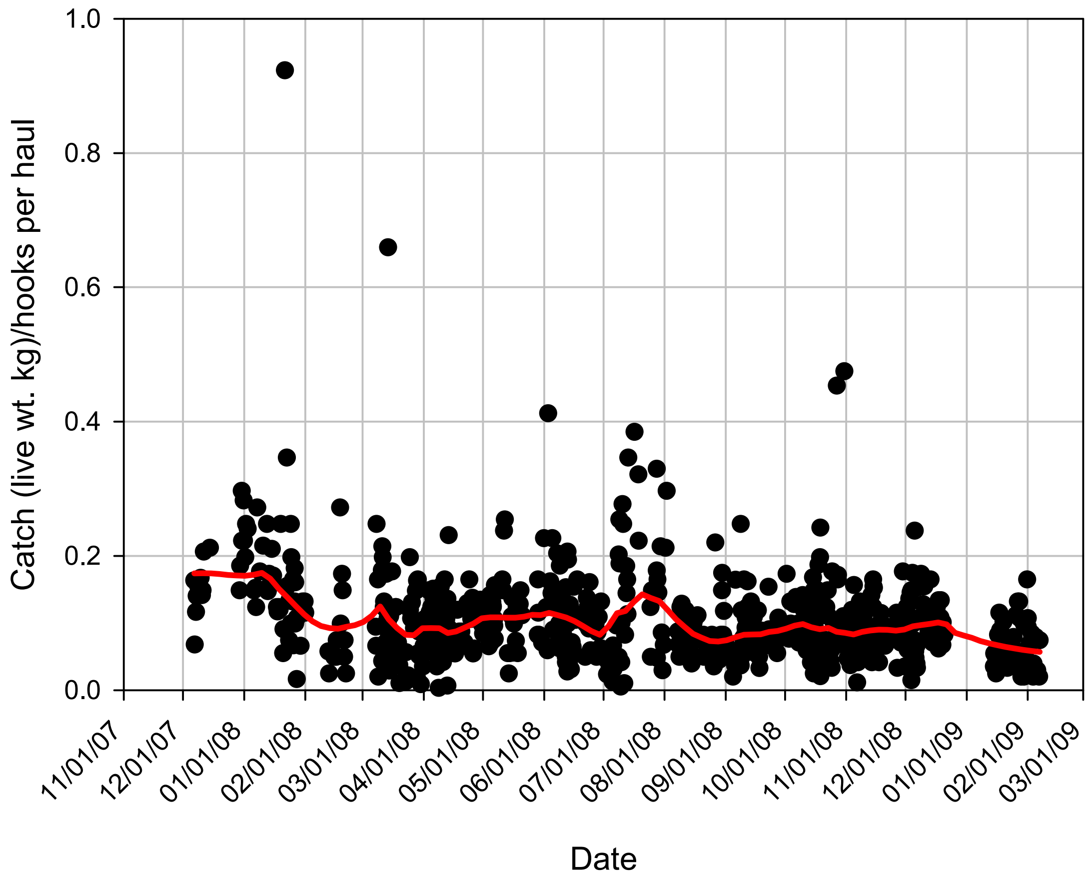
Appendix Figure A.1.22. Bottom depth fished (m) as a function of latitude (decimal degrees, dd).



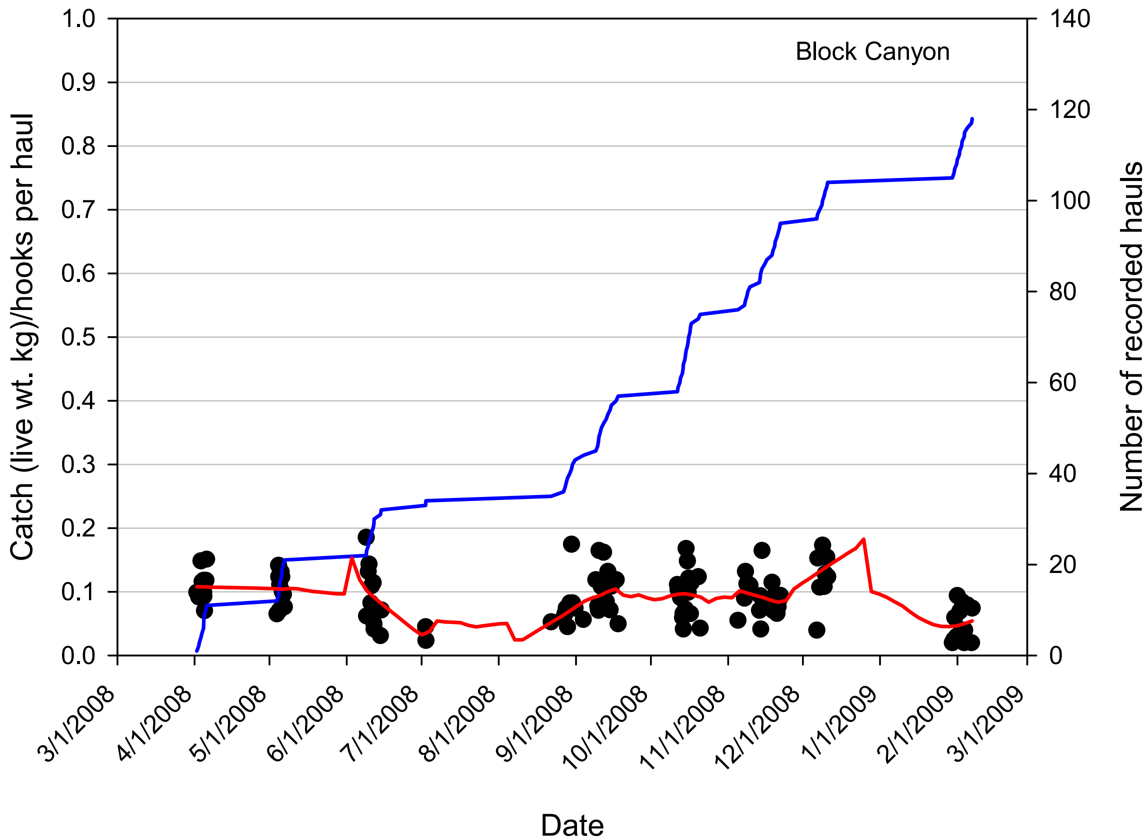
Appendix Figure A.1.23. Tilefish fork length (cm) as a function of bottom depth fished (m).



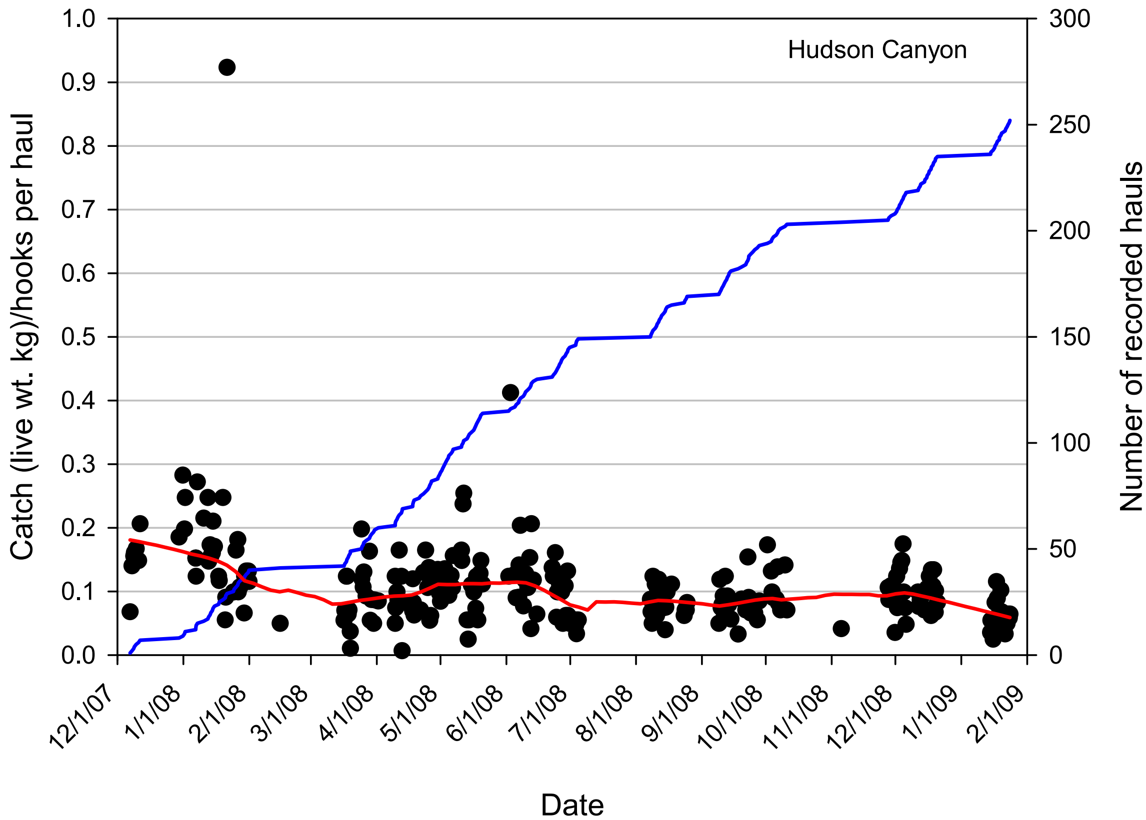
Appendix Figure A.1.24. Tilefish fork length (cm) as a function of the latitude fished (decimal degrees, dd).



Appendix Figure A.1.25. Tilefish haul-level catch (kg live wt.) over time (all data). The red line represents a loess smoothed trend of the time series.



Appendix Figure A.1.26. Tilefish haul-level catch (kg live wt.) over time in the vicinity of Block Canyon. The red line represents a loess smoothed trend of the time series.



Appendix Figure A.1.27. Tilefish haul-level catch (kg live wt.) over time in the vicinity of Hudson Canyon. The red line represents a loess smoothed trend of the time series.