Agenda Item F.6.b
PSMFC Report
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Final Report
Electronic Monitoring Program: Review of the 2012 Season

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Overview/History

In 2012, Pacific States Marine Fisheries Commission (PSMFC) received funds to test the feasibility of using electronic monitoring for catch accounting in the newly implemented Pacific Trawl Rationalization Program within the west coast groundfish fishery. In order to effectively and accurately debit discarded catch from individual fishing quota (IFQ) holder account, the Pacific Fishery Management Council (PFMC) instituted 100% human compliance monitor coverage on all trips for all vessels participating in the IFQ fishery. The cost of this program was regulated to transition from federally subsidized to industry funded over the course of the first 3 years of the program. The industry is interested in finding a less costly and more flexible method to monitor catch and discards at sea. The electronic monitoring project is meant to address some key questions, including; can video monitoring be used effectively to track an individual's catch to be debited from a quota account? And how much would such a program cost the industry as compared to the human compliance monitor program?

The expectation is that the West Coast Groundfish Observer Program (WCGOP) will continue to administer a level of scientific observer coverage to provide stock assessors and other scientists the necessary scientific data for effective management of the various west coast fisheries. This program is not meant to replace scientific observers. This program is solely meant to explore the ability of electronic monitoring systems to capture the at-sea discards of vessels for the purposes of effectively debiting quota accounts throughout the fishing season, therefore replacing the need for 100% at-sea human compliance monitor coverage.

PSMFC contracted with Archipelago Marine Research (AMR) to provide and install electronic monitoring (EM) systems on 11 volunteer fishing vessels (6 whiting and 5 fixed gear), collect data drives from the vessels, provide Electronic Monitoring Interpret™ Pro (EMI) software for converting the raw data into usable catch information, training PSMFC video reviewers, and providing logistical support.

The on-board AMR system includes sensors for drum movement, hydraulic pressure, and GPS locations from which the speed of the vessel is calculated, and 1-4 cameras. A GPS location along with any sensor data was recorded every ten seconds during a trip. Sensor data was recorded at all times that the vessel's power was on. Gaps therefore occurred when in port and the vessel was powered down or the system was turned off manually to prevent the system from draining the vessel's battery when in port. On hake vessels, the system was configured to trigger recording video when the vessel moved outside of a "port area" designated by AMR and continue recording imagery until they returned to port. On fixed gear vessels, systems were configured to trigger recording video when the hydraulic pressure exceeded a threshold that was set by the technician that installed the equipment and was specific to each vessel. Imagery recording would then continue for 20 minutes past the last use of those hydraulics to allow for all catch handling to be captured for each haul.

When the raw sensor and video data were received by PSMFC, annotations were made using the AMR software EMI. Start and end dates, times and locations, for trips and hauls as well as gear and catch information were captured using EMI. The annotation data were imported into a Microsoft Access Database for analysis.

Finalized 2012 at-sea compliance monitoring data were received from the WCGOP for comparison to the video data. Since retained catch is weighed and accounted for by fish dealers at the dock, discards were the main concern for at-sea catch accounting of IFQ species on this project. While analysis of both retained and discarded data are presented in this report, the discard analysis should be more closely scrutinized for this reason.

Fixed Gear

Methods

The electronic monitoring system was installed on 5 volunteer fixed gear vessels fishing IFQ quota out of Morro Bay and Half Moon Bay, California the week of August 21st 2012. All 5 fishing vessels carried the EM system for the remainder of the fishing year. Four of the five vessels fished pot gear solely. One fished both pot and longline gear.

Compliance monitor and video trips were matched using vessel ID and departure date. The quality of the match was then confirmed manually in excel.

Two definitions for fixed gear hauls are presented in the WCGOP manual for the IFQ fishery:

> "A set begins at a buoy and ends at a buoy. The set includes all of the hooks or pots in between the two buoys." (NWFSC 2012, Section 5-8)
>
> "Small pieces of gear with individual buoys are often set haphazardly in a general area or fishing spot. The gear is frequently set and retrieved over and over again, with individual pieces of gear soaking for as little as 5 minutes between retrievals. If each retrieval was considered a set, one day of fishing could have over fifty sets, with each set only having one or two fish caught. Obviously, this would create an unreasonable quantity of paperwork for the amount of data collected. Therefore, individual pieces of gear can be grouped to form a single set using a standard set of criteria." (NWFSC 2012, Section 6-10)

Since strings of gear were distinguishable by the EM system, the former definition was used. It appears the compliance monitor used the second method to define a haul on most of the corresponding trips.

All pot strings had 10 pots or less. On most trips, the haul count in the compliance monitor data was much lower than the count from the video data (Table 1). The number of pots counted on each trip by both programs was very similar (Table 2). This difference in haul definition at the data level led to an inability to assess catch counts at the haul level and thus counts were compared to compliance monitor data at the trip level. All 73 trips monitored electronically had corresponding trips in the compliance monitor data. One trip was missing electronic data entirely.

Of the 73 trips for which electronic data were collected, one had no video data associated with it. The trip was the first trip of the season for this vessel and the problem was resolved before the second trip. On 11 trips, a minimum of one haul during the trip was given a video quality score of "low". The majority of these low scores were not due to equipment failure but due to fisherman or compliance monitor behavior. For this study, fishermen were not given feedback on how to maximize data quality for the video project. Thus, there were instances where the fishermen or the compliance monitors stood with their backs to the camera while sorting, or sorting of catch was conducted out of camera view, which made counting and classifying catch into species groupings impossible.

In this fishery, weights were not directly estimated by the video reviewer. Instead, counts of individual pieces for each species or grouping were recorded. All fish seen on the video were counted by the reviewer including fish that dropped off of the line before being pulled onto the fishing vessel and fish that were damaged or partially eaten. Fish whose fate could not be determined due to being taken or thrown out of camera view or the video ending before fish being put into the hold or discarded were assumed to be retained and recorded as such.

Existing video technology does not allow for effective species identification of difficult to differentiate species such as many rockfishes, thornyheads, or flatfishes. Compliance monitor data therefore contained more species specific information than was possible to collect from the video data. To accommodate this difference, both the compliance monitor and video data were aggregated to a species grouping level for direct comparisons of the counts.

Ten of the trips included at least one haul where compliance monitor data were expanded to the haul level due to subsampling of the haul. Since these numbers were not true counts, we excluded them from the count comparison. Unfortunately, even if only one haul of a trip was expanded, the whole trip had to be removed due to the inability to compare at the haul level.

Retained and discarded counts of fish were compared to compliance monitor data at the trip and species grouping level. Rockfish and thornyheads were combined into one grouping due to the difficulty to differentiate them on video. Results for the IFQ groupings sablefish, rockfish + thornyheads, and flatfish are reported in this document.

Since only one vessel used longline gear, results could not be reported by fixed gear types (pot vs. longline) due to confidentiality rules. Both pot and longline gears were therefore reported on the same figures. Counts of fish on trips where both gears were used were aggregated together into one value for the trip.

Results

For the three groups reported, sablefish, rockfish + thornyheads, and flatfish, compliance monitor catch counts overall and on a trip bases tended to be greater than video counts for both retained and discarded catch (Table 3, Figures 1-3).

Despite the pattern that compliance monitor total counts were generally greater, the minimum, maximum, mean and median counts per trip were very similar and counts were generally qualitatively similar. Discards of IFQ fish were consistently low, with median discard per trip falling at zero or 1 fish for all three groupings (Table 3).

The similarity of counts between the compliance monitor and video data and pattern of compliance monitor counts being on average larger than video counts is demonstrated in figures 1-3.

Discussion

Video counts of fish were similar to the compliance monitor counts at the trip and species group level in the fixed gear fishery. This indicates that the video is generally seeing the fish that the compliance monitor is seeing. The video system is not yet able to assess weights of fish, or species of rockfish, thornyheads or flatfish. Weights and species are important, since quotas are given to quota holders in weight of IFQ species or grouping. If the EM system cannot assess weight of discards and the species of discard, it would be impossible to accurately debit a fisherman's quota or assess accuracy of logbooks. PSMFC is working with the Alaska Fisheries Science Center to develop methods to resolve these issues moving forward.

Communication with fishermen will be more immediate in the future when behavioral changes need to be made to improve data quality, such as sorting fish one or two at a time so that the viewer can get an accurate count, or ensuring that discards take place within camera view.

Hake

Methods

The electronic monitoring system was installed on 6 volunteer hake trawl vessels fishing IFQ quota out of Newport and Astoria, Oregon the week of May 9th 2012. All 6 fishing vessels carried the EM system for the remainder of the fishing year and made both shoreside and mothership deliveries.

Retained catch, or catch transferred to the mothership, was calculated by video reviewers by counting the number of straps of the codend that contained fish. This number was then multiplied by an estimated weight per strap to get the total weight of retained fish in the codend.

Compliance monitors are advised to use skipper hailed weights recorded in the vessel's logbook for retained catch when they are available and to make individual estimates of the catch only when a vessel logbook is not available (Ryan Shama, personal communication, March 19, 2013).

There were two categories of discards; selective and nonselective. A selective discard was recorded if the deckhands deliberately removed a fish or group of fish from the haul. An example of a selective discard is a 300 pound shark that was pulled aside when the net came up. Nonselective discards were discards that were not deliberately sorted. Examples or nonselective discards are spillage out of the mouth of the codend as the deckhands tied the net off for transfer to a mothership, or fish that were gilled in the net and were then hosed off the deck of the vessel. Nonselective discard weights were recorded based on qualitative volume estimates.

Compliance monitor and video trips were initially matched using vessel ID and departure date. The quality of the match was then confirmed manually in excel. Hauls were then matched based on order within individual fishing days. For example, haul 3 of a fishing day in the compliance monitor data was matched to haul 3 of the same fishing day in the previously matched trip in the video data. This was necessary since there could be multiple hauls in a day and the haul times did not match exactly. Again, the quality of the match was confirmed manually in excel, and adjustments were made where necessary. Adjustments were only necessary if a time gap occurred in the electronic data that led to the EM system missing a haul, a haul occurred near the midnight time mark causing a different date in each of the datasets or if the EM data recorded a net cleaning where the observer data did not.

Of the 172 trips monitored electronically, 169 trips had corresponding trips in the compliance monitor data. Of the three that did not, two were NOAA research trips and one was a short trip where the vessel left the dock and conducted a single net cleaning haul before returning to port. Of all the hake trips, 15 were mothership catcher-vessel trips and 154 were shoreside delivery hake trips. One trip in the dataset included one mothership delivery haul and the catch from the remaining hauls of the trip was stored onboard and delivered shoreside.

41 trips were missing electronic data entirely, 31 of which came from one vessel. Three were the last three trips of the year for a different vessel. Two were at the end of a data drive suggesting the drive on the vessel was full and had not been replaced in a timely fashion. The last 5 occurred between recordings on a trip suggesting the box had been disconnected or the skipper forgot to switch the box on for a particular trip.

Most hauls had corresponding hauls in the compliance monitor data. It was therefore possible to compare catch at the haul level.

16 trips were classified as problem trips. On these trips, a minimum of one haul during the trip was given a video quality score of “low”. The majority of these low scores were due to poor deck lighting, camera angles, or water on the lens of the camera.

Official haul level catch amounts delivered to motherships were available from NORPAC data in PacFIN. Since fish tickets are not available for this fishery, the NORPAC dataset is the best estimate for total catch amounts delivered from the catcher vessels to the motherships. The delivered catch weight was calculated by taking the NORPAC official total catch weight which includes all species, and deducting the WCGOP discard amount, which was made on the catcher vessels prior to codend transfer.

Official trip level landed weights were available for the shoreside deliveries from the state landing receipts in PacFIN. These were matched based on vessel ID and return date. All hauls or trips had corresponding official retained catch amounts.

To address concerns voiced in the PFMC Electronic Monitoring Workshop about quality of EM discard estimation with night light versus day light, hauls brought on board in day light and night light were differentiated in the figures where possible. Hauls brought onboard between 6 AM and 6 PM were labeled day hauls, and hauls brought onboard between 6 PM and 6 AM the next day were labeled night hauls.

Results

Mothership Catcher Vessels

Discard

The video data contained a larger number of discard events than the compliance monitor data, and those discard events were estimated by the video to be larger than the compliance monitor estimate (Table 4 and Figure 4). Most discard events were very small. The relationship of video to compliance monitor discard estimates was consistent regardless of whether the haul was retrieved in night-time or day-time lighting.

Retained

Retained catch estimated by the video compared to the compliance monitor data and the official catch data from NORPAC had very similar patterns (Figure 5). Again, the relationship of video to compliance monitor discard estimates was consistent regardless of whether the haul was retrieved in night-time or day-time lighting. The relationship between video and compliance monitor retained estimates fell across the video = compliance monitor/NORPAC reference line. Video retained catch estimates tended to be higher than compliance monitor estimates on loads smaller than 50,000 pounds, and tended to be lower than compliance monitor estimates on loads larger than 50,000 pounds (Figure 5).

Shoreside Hake

Discard

The video data contained a larger number of discard events than the compliance monitor data. The total amount of discarded weight captured by the video was estimated to be almost double the discarded weight captured by the compliance monitor (Table 4). Most discard events were very small (Figure 6). Only six observations of discards occurred during the night and all were from the compliance monitor dataset. There were only 9 hauls where discards were recorded in both datasets.

Retained

Retained catch estimated by the video compared to the compliance monitor data and the official catch data on fish tickets from PacFIN had very similar patterns (Figure 7). In both cases the trend line qualitatively tracked the video = compliance monitor reference line closely with the line hovering just above the reference line.

Discussion

Mothership Catcher Vessels

For the mothership catcher vessel fishery, video retained catch estimates tended to be higher than compliance monitor estimates on loads smaller than 50,000 pounds, and tended to be lower than compliance monitor estimates on loads larger than 50,000 pounds (Figure 5). Vessels targeting hake use different codends when fishing with the intent to deliver to motherships than if the intent is to deliver to shoreside processors. No information was obtained from the vessels about the capacity of their nets or the dimensions of their vessel to aid in catch estimation from the camera view prior to video reviewing. Obtaining this information would likely help with the accuracy of estimation of retained catch weight in codends.

Discard events were much more abundant in the video data than in the compliance monitor data for this fishery. The majority of the discard events recorded in the video data were of a magnitude smaller than 2000 pounds. This suggests that compliance monitors were not recording discards in most instances when the magnitude was considered small. There were five large discard events above 2000 pounds, ranging from 5000 to 16000 pounds not reported in the compliance monitor data. All five of these events were net bleeds due to the codend being over full making it impossible to tie the codend off prior to transfer to the mothership.

Shoreside Hake

The shoreside hake retained weights were on average (using the trend line as a gauge) accurate but had variability when assessing at the trip level (Figure 7). This was likely due to vessel to vessel variability of nets and codend capacity and the lack of information about each vessel that the video reviewers had available to them when estimating catch. Measurements like width and depth of trawl alley, estimated catch weight when codend is full and the vessel's hold capacity would assist video reviewers in their catch estimates. Therefore, the variability in the accuracy of estimation of retained catch is not necessarily due to a shortfall of the EM system, but rather could likely be resolved by providing additional information from skippers about their vessels to video reviewers.

The discarded catch estimates were more variable with only 9 of the 38 total discard observations in both datasets overlapping (Table 4). Most of the discard observations were only detected in one of the two datasets. The magnitude of most of these discard events were generally small at less than 2000 pounds (Figure 6). There were four discard events that were larger than 2000 pounds that were recorded by the video but not the compliance monitor. Two of these were blowout panel discards prior to the net boarding the vessel. The other two were due to deck washing of fish. The one discard event recorded in the compliance monitor data but not in the video data that was larger than 2000 pounds was also a deck washing event. The blowout panel events recorded by the video reviewer but not the compliance monitor resurfaces the regulatory question: when is a fish considered caught? It is clear that video can detect and quantify these discard events if needed for catch accounting. The deck washing events indicate a difficulty for the video reviewer to assess whether fish are being washed into a hold

(retained) or off the vessel (discard). This may be resolved by adjustment of camera angles, or changes in fisher behavior.

Acknowledgements

We would like to thank the owners, skippers, and crew of the 11 volunteer fishing vessels for volunteering and helping this project move forward. We would like to thank the West Coast Groundfish Observer Program for providing data for this report.

References

Northwest Fisheries Science Center (NWFSC). 2012. West Coast Groundfish Observer Program 2013 Catch Shares Training Manual. West Coast Groundfish Observer Program. NWFSC, 2725 Montlake Blvd. East, Seattle, Washington, 98112.

Tables

Table 1. Summary of data including: number of vessels, number of trips, data quality of trips, trip length, number of hauls, video data quality of hauls, and reason for low video data quality.

Number of Vessels	Fixed Gear	Mothership Catcher Vessel	Shoreside Hake
Total	5	6	6

Trips

Number of Trips			
Compliance Monitor	74	17	193
Video	73	15	154

Trip Data Quality			
Low Video Quality (at least one haul on trip had low video quality)	11	3	15
No Video Data Recorded	1	1	10
Compliance Monitor Data Expanded - Trips not included in comparison	10	0	0
One or both ends of trip based on timegap	10	3	6
No Data Quality Problems	41	8	123

Sea Days Per Trip			
Minimum	1	4	1
Median	1	12	3
Mean	1	12	3
Maximum	3	18	5
Total	105	178	402

Hauls

Number of Hauls			
Compliance Monitor	289	313	396
Video	879	307	393

Haul Video Data Quality			
High	619	185	263
Medium	205	87	94
Low	49	33	19
No Video	6	2	17

Low Haul Video Data Quality Reason			
Camera Failure - No data	0	0	1
Corrupt Video Files	1	0	2
Crew Catch Handling - Not in Camera View	34	0	0
Poor Image Quality - Glare	1	0	0
Poor Image Quality - Night Lighting	6	7	15
Poor Image Quality - Poor Camera Angles	4	24	1
Poor Image Quality - Water Spots	0	2	0
No Reason Given	1	0	0
Unclosed Video Files	2	0	0
Total	49	33	19

Table 2. Comparison of number of pots counted per trip by compliance monitor and video.

Pot counts	Video	Compliance Monitor
Minimum	12	12
Median	37	38
Mean	47	48
Maximum	140	140
Total	3,376	3,448

Table 3. Comparison of counts of fish per trip of three broad IFQ groups by compliance monitor and video.

	Sablefish		**Rockfish and Thornyheads**		**Flatfish**	
Discarded	**Video**	**Compliance Monitor**	**Video**	**Compliance Monitor**	**Video**	**Compliance Monitor**
Minimum	0	0	0	0	0	0
Median	1	2	0	1	0	0
Mean	6	7	2	3	2	2
Maximum	52	58	28	31	12	12
Total	401	405	139	175	109	123
Retained						
Minimum	42	42	0	0	0	0
Median	463	513	1	1	0	0
Mean	605	628	51	55	1	1
Maximum	3,143	3,108	380	414	7	9
Total	37,530	38,948	3,155	3,397	51	70

Table 4. Summary of number of discard events (haul counts) in the compliance monitor and video data, and the catch weight that they represent in the mothership catcher vessel and shoreside hake fisheries.

	Mothership Catcher Vessel		Shoreside Hake	
Total Number of Discard Events in Each Dataset	**Number of Discard Events**	**Discard (lbs)**	**Number of Discard Events**	**Discard (lbs)**
Compliance Monitor	26	29,650	22	77,189
Video	140	136,742	25	134,931
Hauls with Discards in the Compliance Monitor Dataset but not the Video Dataset				
Compliance Monitor	4	5,000	13	12,059
Hauls with Discards in the Video Dataset but not the Compliance Monitor Dataset				
Video	118	83,902	16	55,931
Hauls with Discards in both the Video and Compliance Monitor Datasets				
	22		9	
Compliance Monitor		24,650		65,130
Video		52,840		79,000

Figures

Figure 1. Fixed Gear Fishery. Comparison of compliance monitor and video total counts of: a. discarded and b. retained sablefish aggregated to the trip level. Each point represents a trip. Trips where compliance monitor expansions were applied were removed from the plots. The dashed line is the video = compliance monitor line. If video and compliance monitor counts agreed for a trip, the point for that trip would fall on the dashed line. The solid line is a fitted trend line to give a snapshot of the relationship between the two datasets. If the trend line falls below the video = compliance monitor line, compliance monitor counts tend to be larger than video counts. If the trend line falls above the video = compliance monitor line, compliance monitor counts tend to be smaller than video counts.

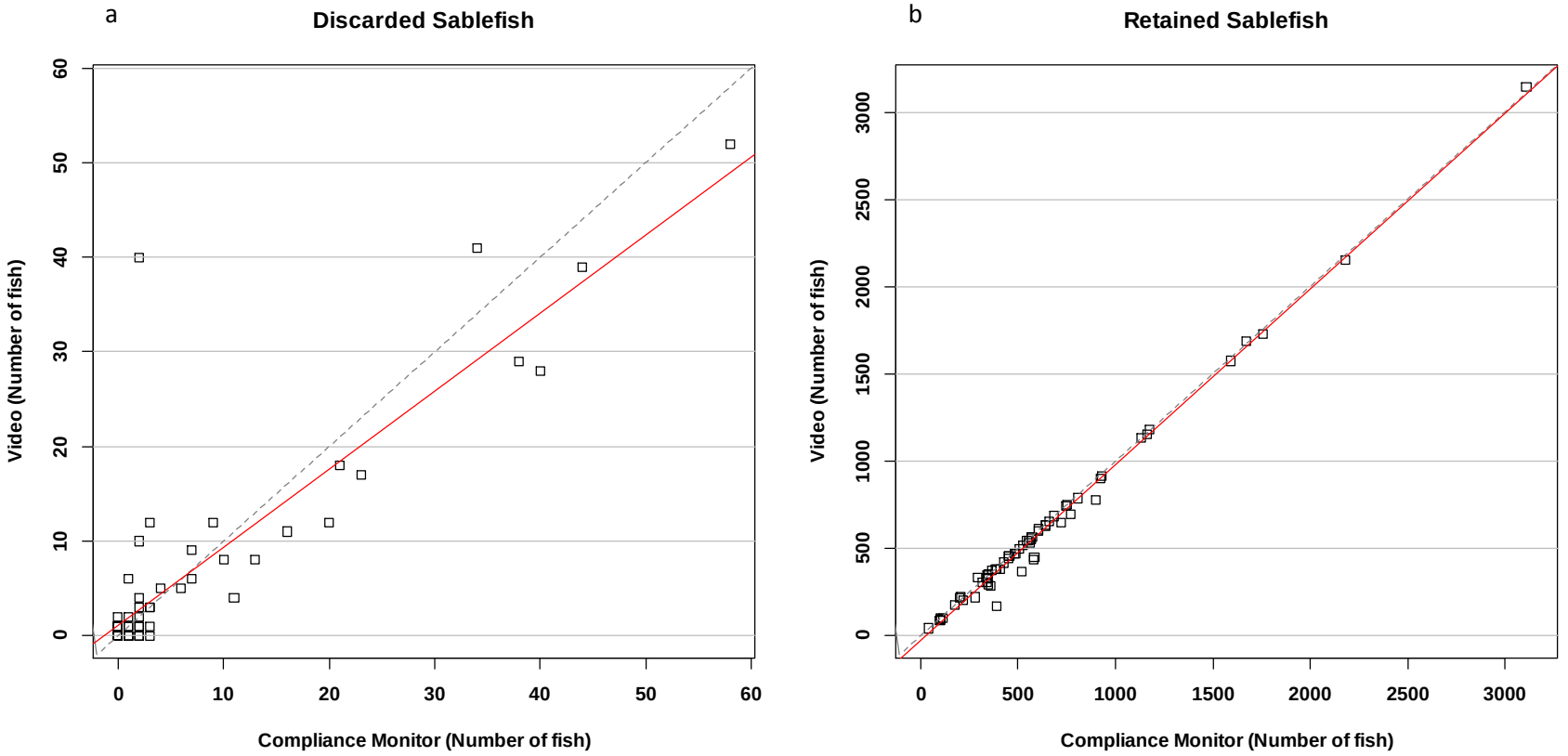


Figure 2. Fixed Gear Fishery. Comparison of compliance monitor and video total counts of a. discarded and b. retained rockfish and thornyheads aggregated to the trip level. Each point represents a trip. Trips where compliance monitor expansions were applied were removed from the plots. The dashed line is the video = compliance monitor line. If video and compliance monitor counts agreed for a trip, the point for that trip would fall on the dashed line. The solid line is a fitted trend line to give a snapshot of the relationship between the two datasets. If the trend line falls below the video = compliance monitor line, compliance monitor counts tend to be larger than video counts. If the trend line falls above the video = compliance monitor line, compliance monitor counts tend to be smaller than video counts.

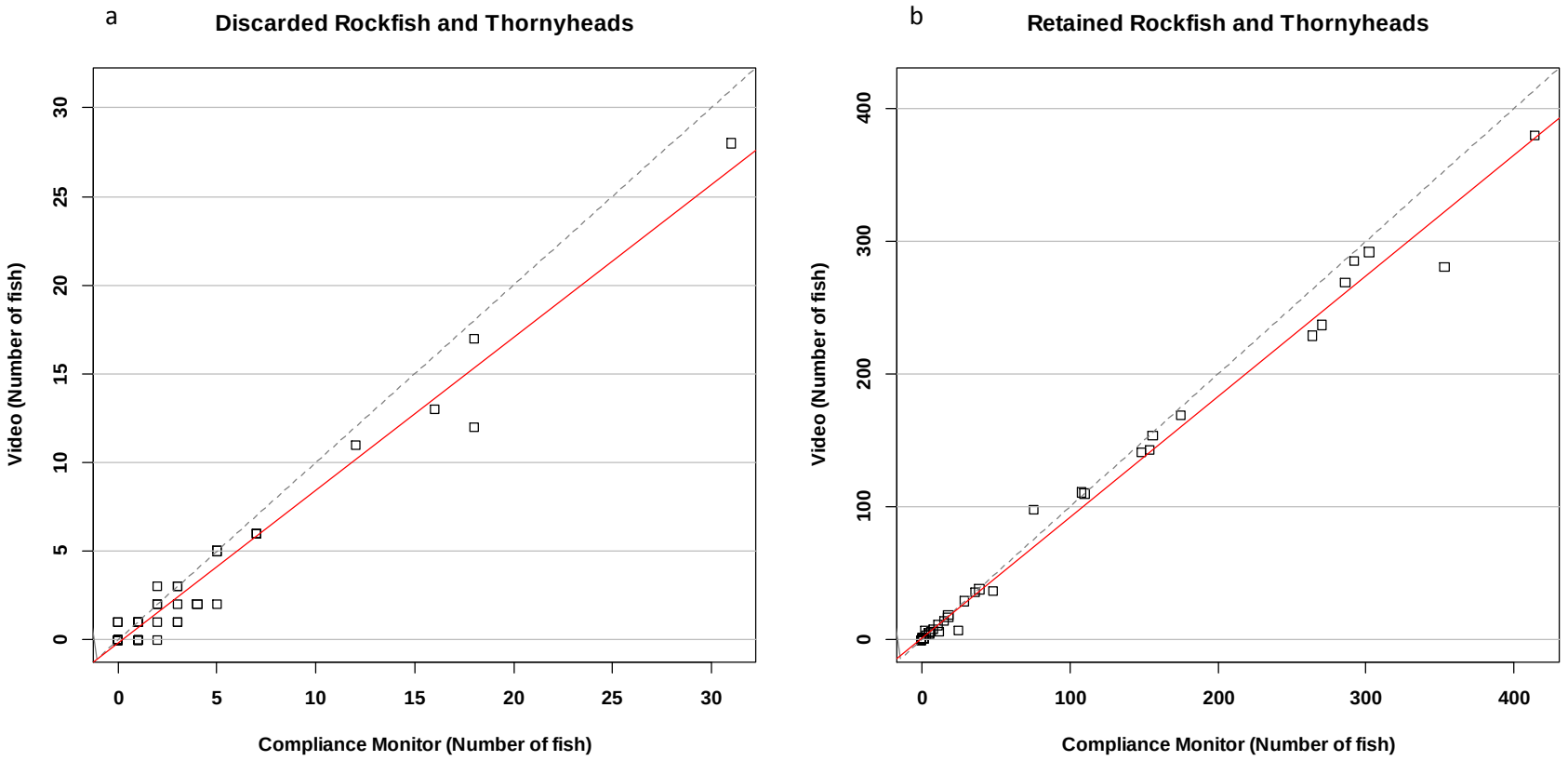


Figure 3. Fixed Gear Fishery. Comparison of compliance monitor and video total counts of a. discarded and b. retained flatfish aggregated to the trip level. Each point represents a trip. Trips where compliance monitor expansions were applied were removed from the plots. The dashed line is the video = compliance monitor line. If video and compliance monitor counts agreed for a trip, the point for that trip would fall on the dashed line. The solid line is a fitted trend line to give a snapshot of the relationship between the two datasets. If the trend line falls below the video = compliance monitor line, compliance monitor counts tend to be larger than video counts. If the trend line falls above the video = compliance monitor line, compliance monitor counts tend to be smaller than video counts.

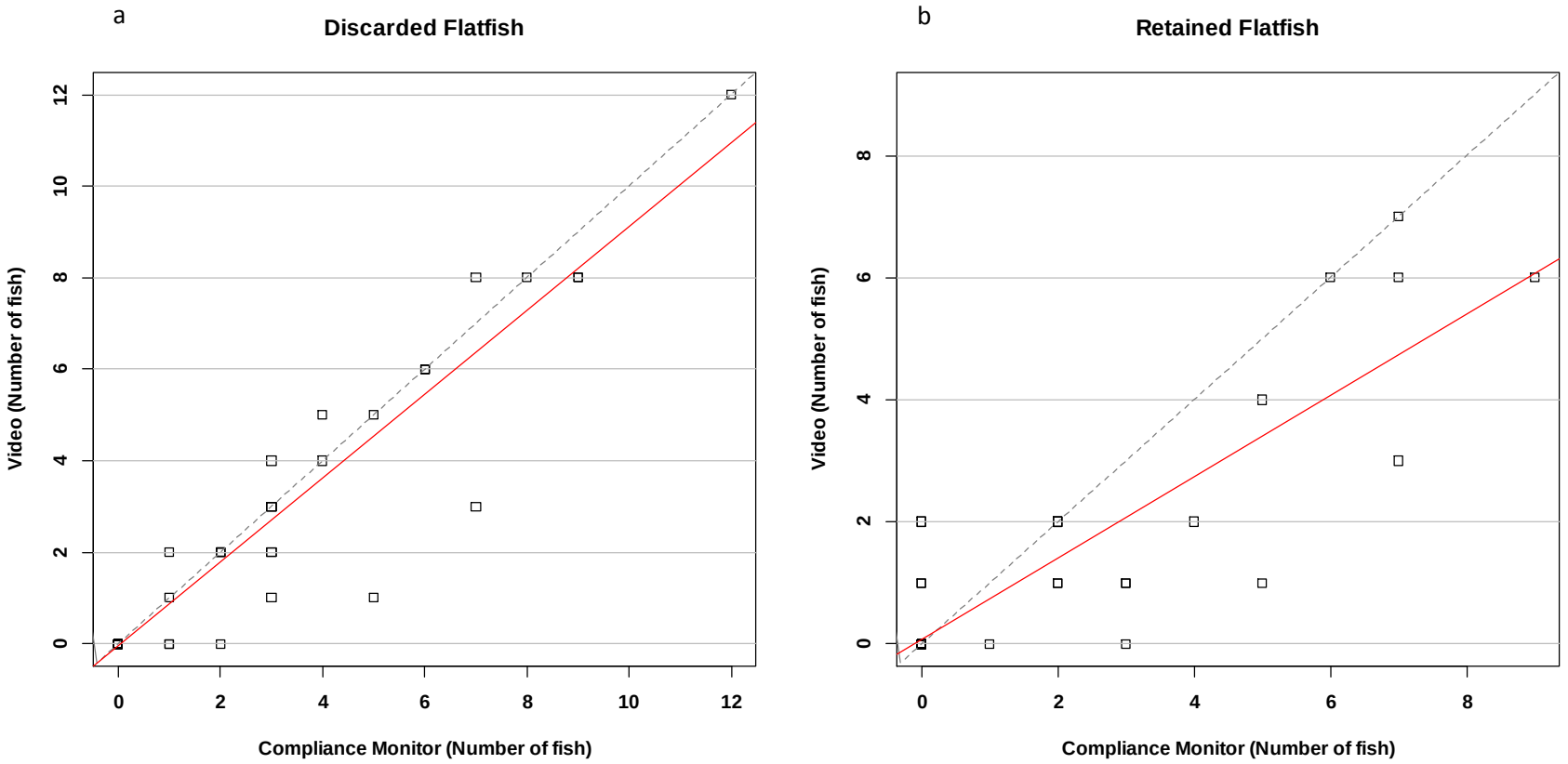
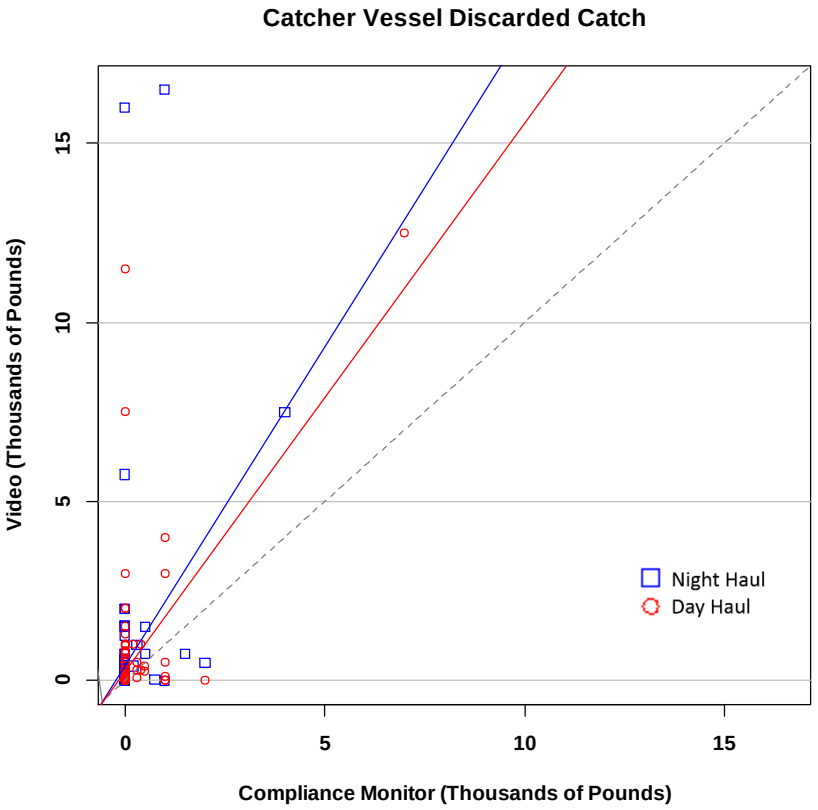


Figure 4. Mothership Catcher Vessel Fishery. Comparison of compliance monitor and video discarded catch weight of all species aggregated to the haul level. Figure b. is the same data as figure a. with different axis scales to show the data clustered in the bottom left corner of figure a. Each point represents a haul. Blue squares represent hauls brought onboard in the dark, red circles represent hauls brought onboard in daylight. The dashed line is the video = compliance monitor line. If video and compliance monitor weights agreed for a haul, the point for that haul would fall on the dashed line. The solid line is a fitted trend line to give a snapshot of the relationship between the two datasets. If the trend line falls below the video = compliance monitor line, compliance monitor weights tend to be larger than video weights. If the trend line falls above the video = compliance monitor line, compliance monitor weights tend to be smaller than video weights.

a



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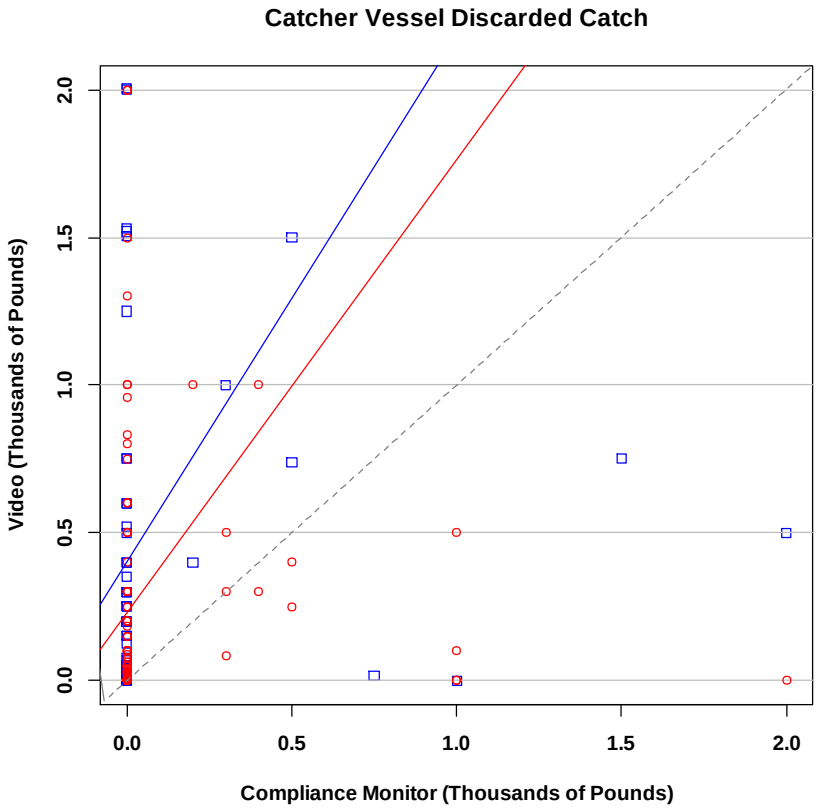

Figure 5. Mothership Catcher Vessel Fishery. Comparison of video retained catch weight to: a. compliance monitor and b. official catch from NORPAC retained catch weight of all species aggregated to the haul level. Each point represents a haul. Blue squares represent hauls brought onboard in the dark, red circles represent hauls brought onboard in daylight. The dashed line is the video = compliance monitor line. If video and compliance monitor weights agreed for a haul, the point for that haul would fall on the dashed line. The solid line is a fitted trend line to give a snapshot of the relationship between the two datasets. If the trend line falls below the video = compliance monitor line, compliance monitor or official weights tend to be larger than video weights. If the trend line falls above the video = compliance monitor line, compliance monitor or official weights tend to be smaller than video weights.

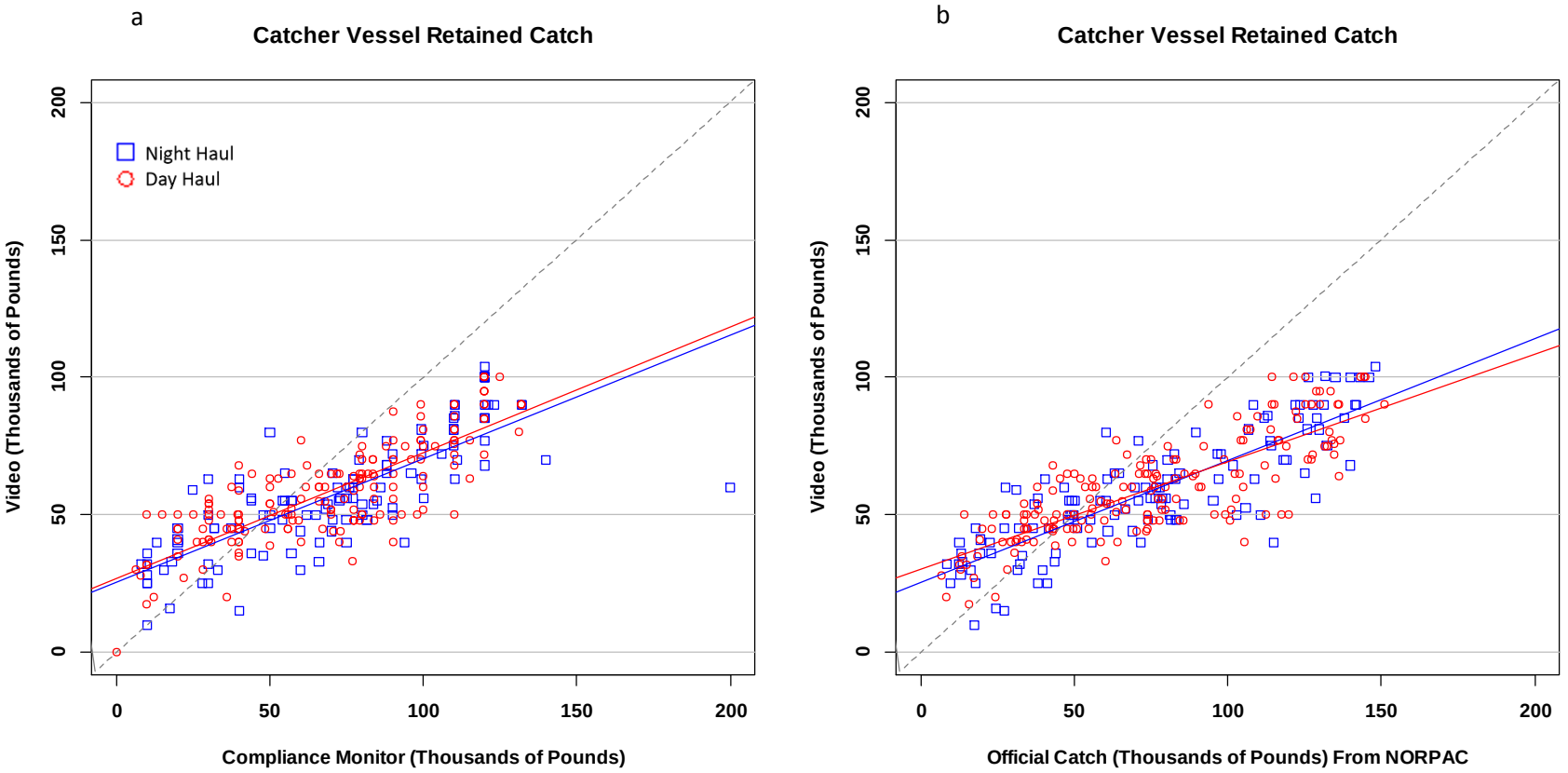

Figure 6. Shoreside Hake Fishery. Comparison of compliance monitor and video discarded catch weight of all species aggregated to the haul level. Figure b. is the same data as figure a. with different axis scales to show the data clustered in the bottom left corner of figure a. Each point represents a haul. Blue squares represent hauls brought onboard in the dark, red circles represent hauls brought onboard in daylight. The dashed line is the video = compliance monitor line. If video and compliance monitor weights agreed for a haul, the point for that haul would fall on the dashed line. If the data point falls below the video = compliance monitor line, compliance monitor weights are larger than video weights for that haul. If the data point falls above the video = compliance monitor line, compliance monitor weights tend to be smaller than video weights for that haul.

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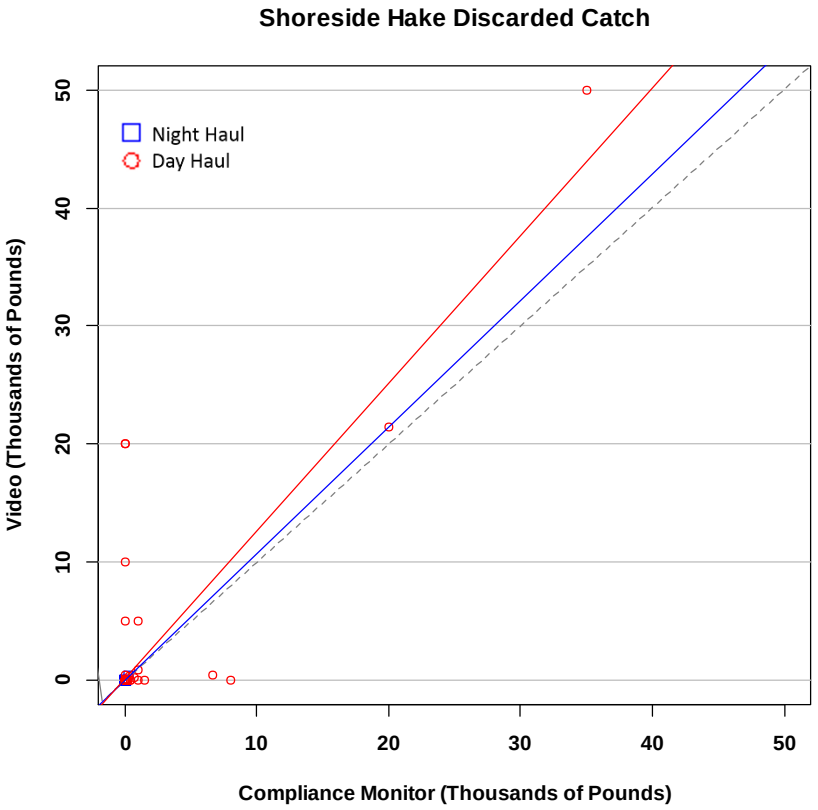

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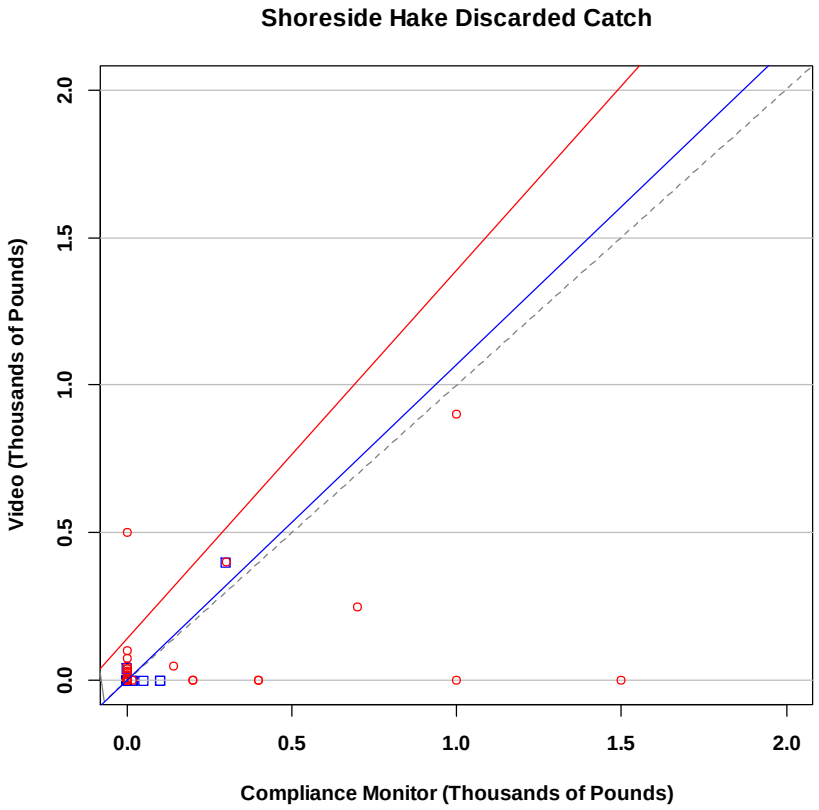

Figure 7. Shoreside Hake Fishery. Comparison of video retained catch weight to: a. compliance monitor and b. official fish ticket or landing receipt retained catch weight of all species aggregated to the trip level. Each point represents a trip. The dashed line is the video = compliance monitor line. If video and compliance monitor weights agreed for a trip, the point for that trip would fall on the dashed line. The solid line is a fitted trend line to give a snapshot of the relationship between the two datasets. If the trend line falls below the video = compliance monitor line, compliance monitor or fish ticket weights tend to be larger than video weights. If the trend line falls above the video = compliance monitor line, compliance monitor or fish ticket weights tend to be smaller than video weights.