AUDIT OF SALMON CLOSURE ZONE COMPLIANCE MONITORING, BEARING SEA POLLOCK FISHERY, 2012

Prepared for

Sea State Inc.
P.O. Box 74
Vashon, WA 98070

Prepared by

Christopher S. Swingley
ABR, Inc.—Environmental Research & Services
P.O. box 80410 Fairbanks, AK 99708

March 2012

Contents

List of Tables

List of Figures

Background

Closure zones were established for the Bering Sea pollock (*Theragra calcogramma*) fishery to ensure that fishing vessels would avoid areas with the potential for substantial bycatch of chum salmon (*Oncorhynchus keta*). Vessel Monitoring System (VMS) units monitored the movement and location of fishing vessels, and fisheries observers and vessel logbooks recorded whether vessels were actively fishing. Sea State, Inc. establishes these closure zones and monitors vessel compliance of these zones using VMS data. In addition to these requirements, The National Oceanic and Atmospheric Administration (NOAA) Fisheries, Alaska Region, requires "an external audit designed to evaluate the accuracy of the approach used by Sea State to monitor compliance" be prepared for the pollock fishery. The audit, which NOAA required be based on an "[e]xamination of a randomly selected subset of vessel/days representing 10% of the catch" was conducted by ABR, Inc.—Environmental Research and Services (hereafter, ABR) for Sea State, Inc. This report presents the analytical methods used to evaluate Sea State's salmon closure zone compliance monitoring, and the results of the audit.

Study Objectives

The objectives of the audit were twofold: (1) assess the compliance of fishing vessels within salmon closure zones by sampling 10% of the 2011 fishing effort, and (2) compare the audit findings with Sea State's conclusions regarding closure violations.

Assumptions

The audit is based upon the following assumptions, which we have not independently verified:

1. Fishing observer data are always correct, and these sources never report non-fishing activity when fishing actually was occurring, or fishing activity when vessels were not fishing.

2. The following data provided by Sea State are free from errors: the table of VMS locations; the tables of observer data indicating haul start and stop times, and catch weights; the tables used to determine coop membership.

3. All coordinates specified in the VMS location tables and vessel closure announcements were in the same horizontal datum, namely World Geodetic System 1984 (WGS1984).

Audit Methods

Subset Selection

The pollock fishery has three major sectors (Cather / Processors, Catcher vessels supplying motherships, and Catcher vesses supplying shoreside fish processors), but all vessels now have fisheries observers on board, so we no longer distinguish between the sectors in our analysis.

Although the NOAA Fisheries requirement stipulated that "vessel/days representing 10% of the catch" were to be audited, we did not interpret this literally because fish catches were not reported by day. Catch was reported for each haul and/or for each individual fishing trip. These catch totals might cover a portion of a day or portions of multiple days. We believe our sampling method, described below, was consistent with the intent of the permit stipulation.

Data collected by fisheries observers provided full coverage for the fishery with start times, stop times, and catch weight for each haul. To randomly select vessel/days representing 10% of the catch, individual hauls were selected without replacement until the total number of hauls exceeded 10% (Appendix 1).

Identification of Candidate Closure Zone Violations

Before performing any analyses on the VMS location data, we verified the closure locations and tier status information by examining all closure notification memos and building closure polygons based on these memos. The dates that a closure applied for each permit cooperative unit (coop) was also recorded from the original memos.

All VMS points (i.e., a 'point' is a specific latitude-longitude coordinate for the fishing vessel) were then passed through a series of geoprocessing operations and database filters to reduce the full set of data down to a limited number of potential closure zone violations.

First, the VMS points were intersected with the dataset of closure polygons (i.e., the geographic area of the closure zones) for all points that were within a closure when the closure was operational. This overlay excluded all points that were outside of closure zones, or were inside zones when the closure was not in effect. Each occurrence of a point within a closure zone resulted in an output table row linking the VMS point with the closure zone.

Next, these intersections of VMS points and closures were reduced by removing all intersections that weren't part of the 10% random sample of trips or hauls we generated earlier. The remaining point / closure intersections represent the list of 'candidate' (i.e. possible) violation points.

Buffer Filter

There were four data providers for VMS locations: Faria, SkyMate / Nobletec, CLS America, and Thrane and Thrane. We only have information on the accuracy of the Thrane and Thrane system. For these locations we applied a two-stage buffering operation, forming a polygon from each point by adding and subtracting a pair of data trans-

mission error terms (±0.000333 degrees for rounding errors and ±0.000667 degrees for truncation errors) to each location, and then applying a second 30 meter buffer representing the positional accuracy of the satellite locations. For the other three systems, we had no information on how the data was transmitted or the accuracy of individual locations, so we applied a simple 30 meter buffer around each point.

The buffered polygon boundaries around each location point were next compared to closure zone boundaries. When the buffer polygons were partially outside the closure zone of interest, the corresponding points were flagged as "excluded by buffer" and these points were eliminated from further consideration.

Because of the uncertainty surrounding the different systems, we performed an analysis designed to characterize the quality of the data for each system. We made a pass through the data to determine the speed and heading of each vessel from each point to the next point along their path while the vessels were fishing, counting the number of points where speeds exceeds a reasonable threshold (7 knots).

The results of this analysis are not adequate to characterize the accuracy of individual points and was not used in filtering process, but they useful in determining the data quality of each VMS provider.

Tier Status Filter

Location points that still remained as candidate violations were then compared to the tier status reports to determine whether the vessel was exempt from the closure restrictions at the time of the candidate violation. Some closures applied to all vessels, regardless of tier status. Other closures were advisory only, and so technically did not apply to any vessels. The remainder of closures applied to only certain vessels—some vessels were exempt, based on past performance of their coop at avoiding salmon bycatch. Candidate violations that occurred when the vessel was exempt from closure restrictions were flagged as "exempt from closure due to tier status" and excluded from further consideration.

At this point, all remaining observations with observer data were considered closure zone violations. These observations were flagged as "possible violation."

Speed Filter

For those locations that have been flagged as "possible violation," we examined the speed of those locations to identify any locations where the speeds were large enough that they could indicate an inaccurate satellite position, or a vessel that was actually running rather than fishing. We applied the simple speed threshold we developed for our assessment of the 2006 season [MacanderDissing2007]. This is an automated way to filter out many points that clearly corresponded to rapid vessel travel, rather than potential fishing activity.

The speed filter applied several criteria to candidate violations to determine whether they could be excluded on the basis of vessel speed. Locational points met the speed test criteria and were excluded based on a high sustained speed, if they had 1) GPS coordinates, 2) at least 5-min elapsed time from the previous point, 3) at least 5-min elapsed time to the next point, 4) a calculated speed of >5.6 knots from the previous

point, and 5) a calculated speed of >5.6 knots to the next point. Accuracy of the speed filter was able to predict fishing activity correctly for 99.83% of examined points in 2006 [MacanderDissing2007]. The low failure rate of this method is acceptable, especially because visual examination of the points in question is likely to have a similar, if not higher, failure rate.

To develop the data necessary to apply the speed filter, the minimum sustained speed and the time interval to and from successive VMS locations was calculated for all of the trips. Speeds were calculated from the difference in time and the distance between successive VMS locations. These values corresponded to a minimum speed because vessels traveling a zig-zag course between two observations would have a speed higher than the calculated speed. Candidate violations from that met our speed test criteria were flagged as "excluded due to high sustained speed." These data were excluded from further consideration.

Visual Examination

The remaining candidate violations were reviewed manually. In the past, we have noted that some of the points that did not pass the conservative speed test corresponded to non-fishing activity. For example, some points, which were just below the speed threshold, were along a straight line with several other points that did meet the criteria of the speed filter. Points that did not meet the speed test, but which were determined to correspond to running out to the fishing ground (based on visual review), were flagged as "excluded by manual review: vessel running." These data were excluded from further consideration.

Remaining points corresponded to fishing in closure zones, and will be flagged as "possible violation." Violations will be reported to Sea State and the North Pacific Fisheries Management Council (NPFMC). A database containing the relevant attribute data for these violations, and maps for each violation, would be provided to Sea State and NPFMC.

Comparison with Sea State Determinations

A comparison of the violations reported by ABR was made to those reported by Sea State. All of the location points that were part of ABR's 10% selection were considered in this assessment.

Results and Discussion

Identification of Candidate Closure Zone Violations

Identifying Candidate Violations

The identification of candidate violations was entirely automated, without any interpretation or subjective thresholds (Table 1). This automated approach efficiently reduced the number of points requiring closer examination from 562,155 for the total fishery to the 25 locations that were assessed for potential closure zone violation. Many of the

original set of VMS locations were for vessels not in the fishery, which is why the 10% subset is smaller than would be expected.

Table 1: Number of vessel locations considered at different stages of the closure violation audit, Bering Sea pollock fishery, 2011.

Category	Locations
All VMS Locations	562,155
Select 10% of Hauls or Trips	13,712
Points in Closure when Closed (Candidate Violations)	25
Violations	25

Categorizing Candidate Violations

A small degree of subjectivity is involved in setting the buffer distances and vessel speed thresholds, as well as in the process of reviewing vessel tracks manually. We believe, however, that our approach was cautious, well-documented, and reasonable. After applying the buffers, tier status, speed threshold, and a visual review, the number of candidate violations remained at 25 (Table 2).

Table 2: Results of ABR review of candidate violations of the closure zones, Bering Sea pollock fishery, 2011.

Category	Total
Candidate Violations	25
Excluded by buffer	0
Excluded based on tier status	0
Excluded by speed filter	0
Excluded by visual review	0
Violations	25

We found 25 candidate violations that could not be exonerated by our processes. These locations were for a single vessel, fishing in three chum salmon closure zones that were in effect for their coop (Figures 1, 2, and 3).

Analysis of VMS location systems

Table 3 shows the results of our analysis of the accuracy of each of the VMS location providers. Of primary concern in this result is the high frequency of points from the SkyMate / Nobletec and CLS America systems where the speed calculated from one

point to the next was greater than the likely maximum rate of travel while fishing. In addition, the large difference between mean and median speed, and the high standard deviation of fishing speeds calculated from SkyMate / Nobletec positions is further evidence that the accuracy of the locations from this system are suspect. We recommend the data providers be required to identify the accuracy of their systems, preferably in such a way that the accuracy of individual points can be assessed, and that the reporting interval be more frequent.

Table 3: Speed analysis of four different VMS location providers during fishing activity, Bearing Sea Pollock fishery, 2011.

VMS location system	Average speeds (knots)	Median speed (knots)	Standard deviation	Frequency of high speed locations
Thrane and Thrane	3.28	3.38	1.25	0.22
CLS America	3.90	3.25	2.88	17.82
Faria	3.13	3.29	0.97	0.41
SkyMate / Nobletec	4.93	2.83	25.94	5.97

Comparison with Sea State Determinations

A complete list of candidate violations was compiled and for each candidate violation we identified, our verdict and the verdict of Sea State are listed (Appendix 2). Of the 13,712 candidate locations in our 10% sample, both Sea State and ABR excluded 13,687 positions as potential violations based on their not being in a closure zone when it was closed, or because the vessel belonged to a coop whose tier status meant the closure didn't apply. We found 25 locations for a single vessel fishing in three separate closure zones when the closures were in force for the coop they were a part of, and none of our filters excluded these locations from being violations. Sea State identified the same 25 violating locations.

We found that our verdicts agreed with Sea State's determination in all cases. Our 10% subsample did not identify any errors in Sea State's original determinations, and we did not further investigate locations outside of our subsample.

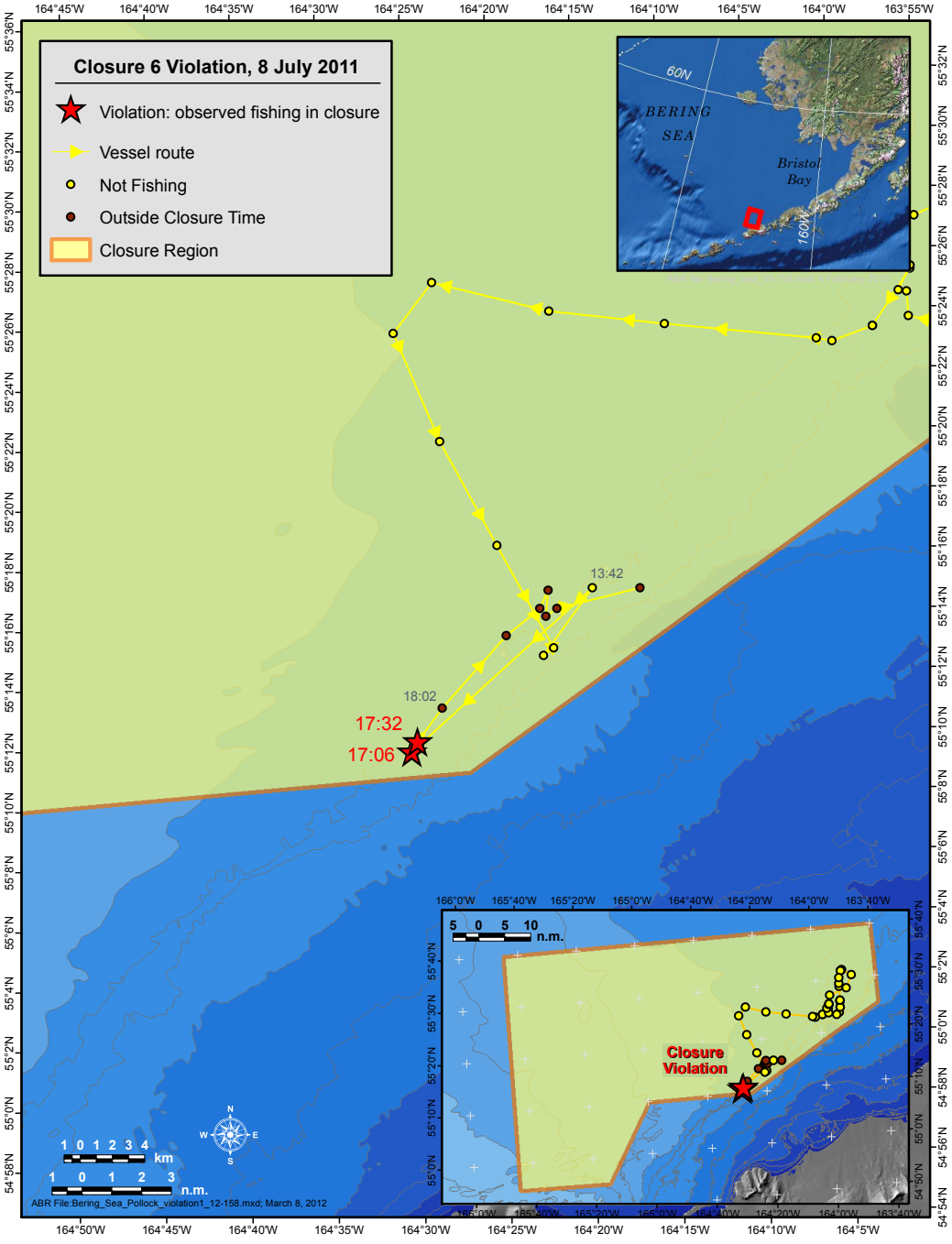

Figure 1: Closure 6 violation

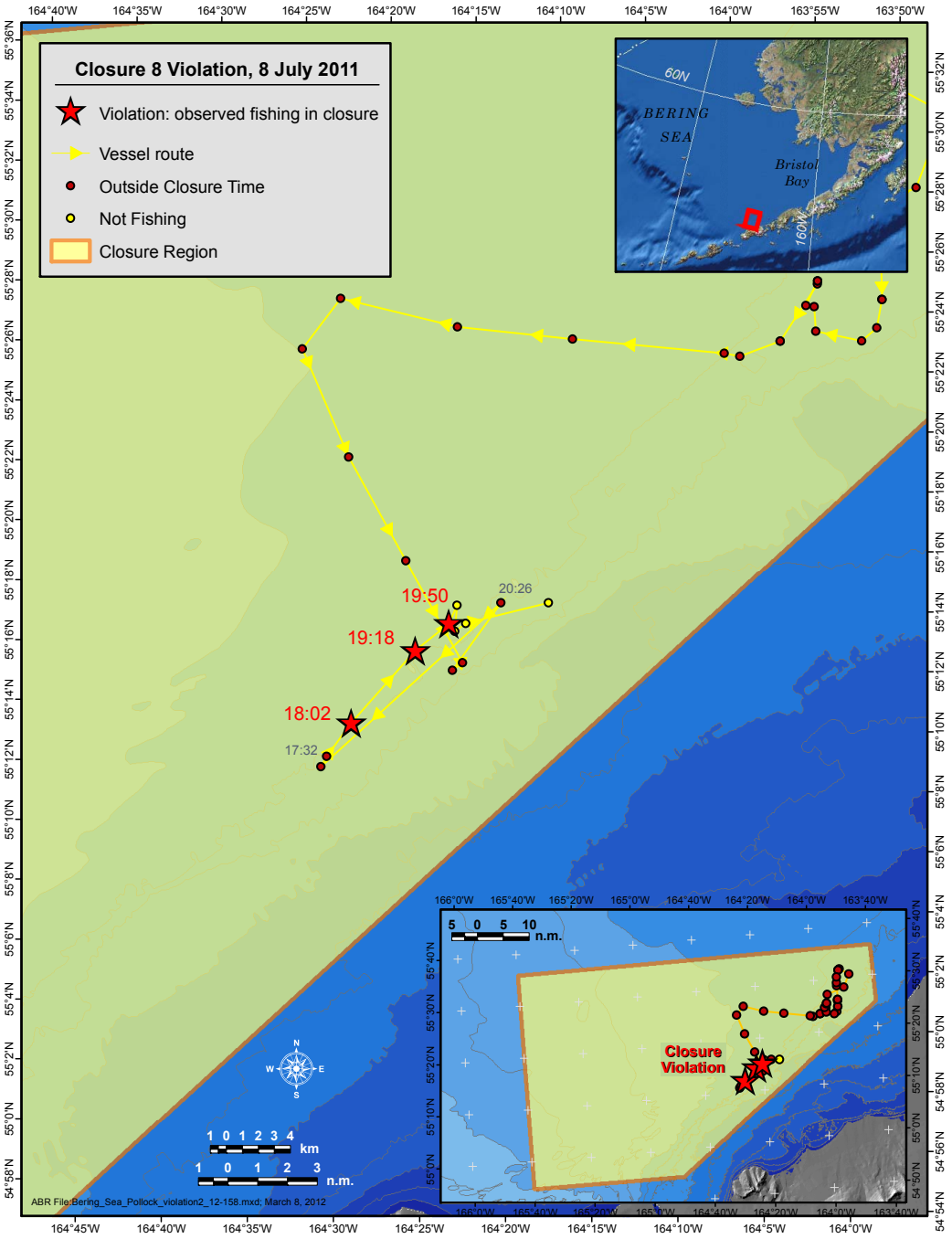

Figure 2: Closure 8 violation

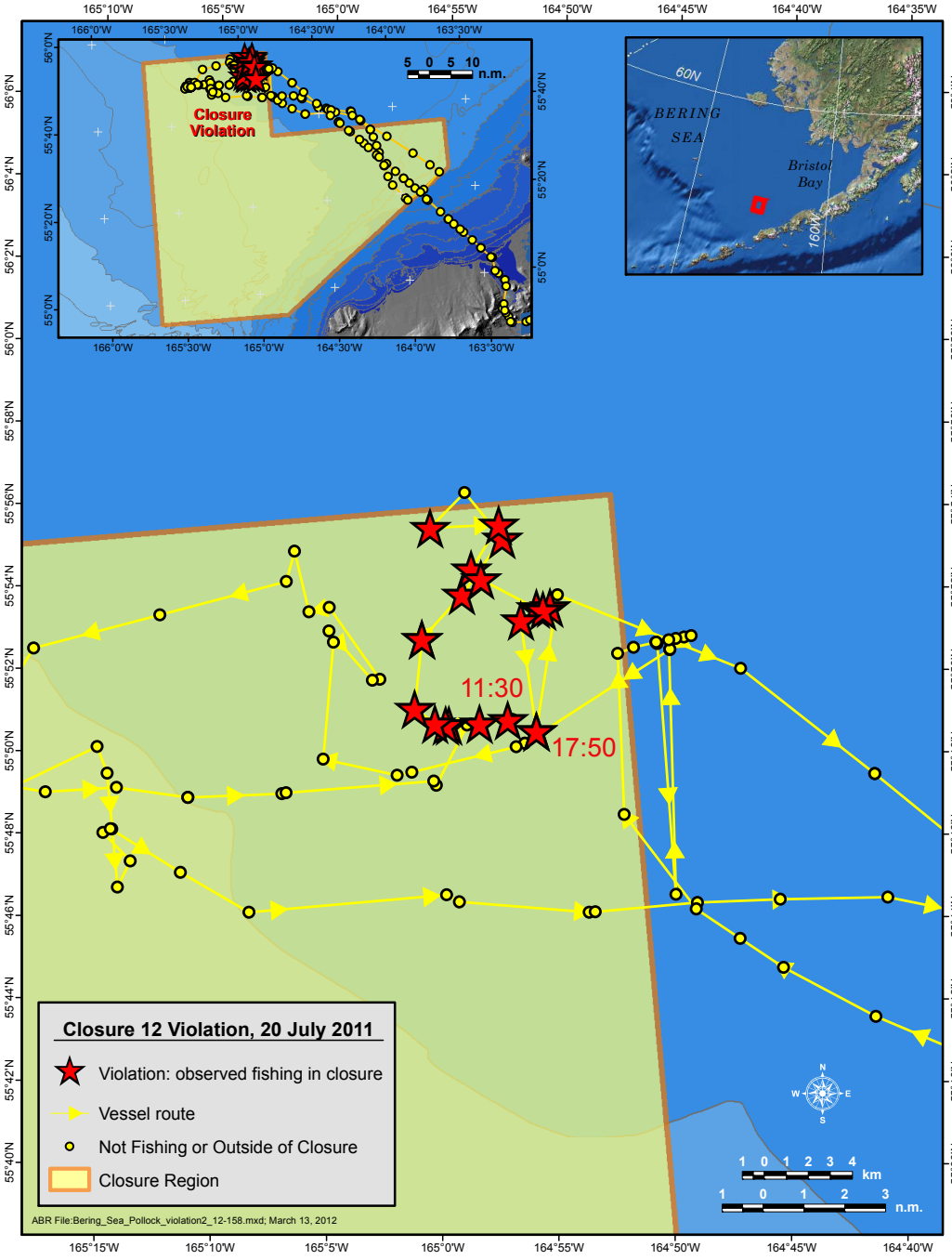

Figure 3: Closure 12 violation

Conclusions

ABR agreed with the determinations of Sea State for the 10% sample that we examined. Of points examined, our determination agreed with Sea State for all 13,712 candidate locations in our subsample. Minor discrepancies in the reason points were excluded were found, but this is because our filtering methods differed. Despite differences in methods, however, there was complete agreement by ABR and Sea State on final verdicts.

With the exception of the closure zone data, which we reconstruct from the closure documents, ABR's assessment was based on our review and processing of data tables developed and provided by Sea State, Inc. As a result, our audit does not systematically assess any errors that might have occurred during Sea State's data compilation process. This could be addressed in the future by extending the compliance audit to include a systematic comparison of raw data (such as the raw VMS files) with Sea State's tables for a fraction of each table.

Literature Cited

[MacanderDissing2007] Macander, M.J. and D, Dissing. 2007. Audit of salmon closure zone compliance monitoring Bering Sea pollock fishery. ABR, Inc.-Environmental Research & Services, Fairbanks, AK, 99708. pp. 48.