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[via email attachment] 3 February 2012

Daniel Morris
Acting Regional Director, Northeast Region
National Marine Fisheries Service
55 Great Republic Drive
Gloucester, MA 01930-2276

Dear Mr. Morris:

As you know, the Atlantic Large Whale Take Reduction Team has recommended that the Service evaluate measures to reduce the risk of endangered large whale entanglements in the vertical lines of fishing gear using a co-occurrence model. To do so, the Service contracted with Industrial Economics, Inc. to develop this model. The model includes two basic data layers: (1) estimates of the numbers of vertical lines in an area and (2) effort-scaled estimates of the relative abundance of North Atlantic right, humpback, and fin whales (sightings per unit effort, or SPUE). The geographic sampling units for the model are blocks measuring 10 minutes of latitude by 10 minutes of longitude. The undersigned members of the Atlantic Large Whale Take Reduction Team, which includes a majority of the Team members representing the academic and environmental communities, recommend that the National Marine Fisheries Service take the additional steps described below to modify the co-occurrence model to better reflect both entanglement risks for whales and conservation benefits resulting from mitigation measures.

The co-occurrence scores for evaluating risks within each block are computed as the product of the number of vertical lines and the whale SPUE indices, both of which are scaled to an index with a maximum value of 1,000. For developing the whale SPUE index, the team recommended that the model use effort-corrected whale survey data derived from the comprehensive North Atlantic Right Whale Consortium database (curated by Dr. Robert Kenney of the Graduate School of Oceanography at the University of Rhode Island) covering all U.S. waters along the east coast for the period of the past 30 years. This recommendation was adopted and is now used in the model. However, in some blocks with low sampling effort, no whales have been seen—resulting in an SPUE index of zero. When this value is multiplied against any number of vertical lines, the co-occurrence score and indicated risk is therefore zero. Available

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information from opportunistic sightings, whale entanglements, and other sources demonstrate that there are no blocks along the east coast where whales absolutely never can occur and that an absolute zero density of whales in those blocks is therefore unrealistic. Thus, in areas where there are high densities of gear but no on-effort whale sightings and a zero SPUE score, the resulting co-occurrence scores of zero will be misleading. This may result in significant underestimates of both entanglement risk to whales, and reductions in risk from mitigation efforts. In addition, there are blocks where the sampling effort is so low that the SPUE estimate would be unreliable, whether whales were sighted or not. Numerous team members have raised these concerns at several past meetings and recommended that adjustments be made using the existing SPUE data along with other sources of well-documented whale occurrence data to develop values greater than zero in those blocks where low levels of survey effort have yet to produce any whale sightings. To date, those concerns have not yet been resolved and reflected in the model.

At the most recent team meeting (January 2012), the team's consensus was to use the co-occurrence scores rather than the vertical line data alone to evaluate the conservation benefits resulting from vertical line reduction measures. Based on the results of the meeting, that appears to be what will be done. In addition, some members again raised the need to develop SPUE values greater than zero in model blocks with low levels of survey effort and no on-effort whale sightings. No resolution was reached on how to proceed in this regard, but there was no discussion of details or possible methods. At a previous meeting this issue was briefly discussed along the lines of substituting 1's for the 0's across the board, which was admittedly subjective, an overly "broad-brush" approach, and difficult to support scientifically. We would have expected Industrial Economics to have explored options and methods during their modeling exercises, but apparently little or nothing was done on this topic over the intervening year in spite of the recommendation reflected in the meeting summary. The absence of any action thus far to address these weaknesses in the co-occurrence model led one of us (Robert Kenney) to proactively develop a preliminary analysis (attached) that identifies blocks with low levels of sighting effort and proposes a less subjective method for deriving whale occurrence values for some of those blocks. As NMFS acknowledged in the meeting summary, the intent was (and remains) to assess the degree to which zero SPUE estimates are realistic, "since whales are, to some extent, distributed everywhere in the region and the scale should not make it appear with certainty that there are areas where there is no risk of entanglement." The under-signed members of the Atlantic Large Whale Take Reduction Team hereby recommend that the National Marine Fisheries Service take steps to incorporate this method (or an equivalent) into the co-occurrence model and that it then be used to evaluate the entanglement risks and risk-reduction benefits of all vertical line mitigation measures to be considered in the ongoing efforts to amend the Atlantic Large Whale Take Reduction Plan.

Specifically, we recommend that the Service convene a meeting or conference call between scientists on the team, including Dr. Robert Kenney, and staff from the Northeast Fisheries Science Center and Industrial Economics to (1) review and, as appropriate, modify the attached preliminary analysis, and (2) agree on a method to derive substitute SPUE values to be used in the model for blocks in the Northeast Region that currently have low levels of survey effort and zero SPUE values. To maintain a non-biased approach in this matter, this meeting and any agreement on SPUE values appropriate to use in the model should be completed before any values are run through the model for purposes of reevaluating measures proposed to date. Although not directly addressed by the attached analysis, we also urge the Service and Industrial Economics to explore methods for extrapolating whale occurrence values into blocks where there has been no survey effort—to provide quantitative assessment of risk reduction in those areas as well.

The undersigned believe adjustments along the lines described above and in the attached preliminary analysis are essential to provide a more realistic assessment of both entanglement risks and conservation benefits related to vertical line mitigation measures in the Atlantic Large Whale Take Reduction Plan. We also believe that this is a topic that would benefit by a review and discussion by the Atlantic Scientific Review Group, who will be meeting 8–10 February and spending the first day on right whale issues. Given the timing, we have already taken step to place this topic on the ASRG's discussion agenda. We appreciate your consideration of this request and the attached analysis and would be grateful if you would let us know as soon as possible when and where a meeting of relevant scientists would be convenient. If you have any questions, please call or email Dr. Kenney.

Sincerely,

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Attachment

CC: Mary Colligan, NER
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Estimating Minimum SPUE Values for Right and Humpback Whales in Northeast Areas with Low Survey Effort

An Analysis Completed for the Atlantic Large Whale Take Reduction Team

Robert D. Kenney, Ph.D.
University of Rhode Island
Graduate School of Oceanography
Narragansett, RI

31 January 2012

BACKGROUND

At the recent (9–13 January 2012) meeting of the Atlantic Large Whale Take Reduction Team (ALWTRT), a number of questions arose about details of the methodology to be used in assessing the potential risk of entanglement of endangered whales in vertical lines from gillnet and trap/pot fisheries along the U.S. Atlantic coast from Maine to Florida. To analyze this risk, Industrial Economics, Inc. (IEc) has developed a risk-assessment model under contract to the National Marine Fisheries Service (NMFS). The model includes two basic data layers: (1) estimates of the numbers of vertical lines (VL) in an area and (2) effort-scaled estimates of relative abundance of North Atlantic right, humpback, and fin whales (sightings per unit effort, or SPUE). The sampling units for the model were defined spatially (i.e., in blocks measuring 10 minutes of latitude by 10 minutes of longitude) and temporally (i.e., in months across all years). The VL data are derived from multiple sources of federal and state fisheries data, and the SPUE data are derived from pooled 1978–2010 aerial and shipboard survey data archived in a North Atlantic Right Whale Consortium database. Both the VL and SPUE data were scaled as indices with maximum values of 1,000. Within each block and month, a co-occurrence score (CO) is then computed as the product of the VL and SPUE indices, with a maximum possible value of 1,000,000.

The consensus of the Team was that the CO score was the most appropriate metric both for assessing risk and for evaluating relative conservation benefits resulting from alternative proposals to reduce the numbers of vertical lines in different areas. Three inter-related issues or weaknesses with the co-occurrence data were pointed out at the meeting:

(1) The range of effort values (i.e., the number of kilometers of track-line surveyed under conditions within standardized sea state, visibility, and altitude criteria) within a block and month varies widely. There are some cells in the SPUE layer where the effort is so low (even though the data spanned over three decades, from 1978 to 2010) that the SPUE estimate is likely to be unreliable or not representative.

(2) An estimated SPUE value of zero in a cell will result in a CO score of zero regardless of the number of vertical lines estimated in that cell. Given three factors—the relatively sparse nature of the non-zero SPUE distributions, the known presence of whales in cells with SPUE=0 based on opportunistic sighting records and/or tracks of tagged whales, and the recognized capability of whales to easily move through nearly any location within the region—those zero CO values should not be accepted uncritically as convincing evidence for zero risk within a given cell.

(3) Conversely, proposals to significantly reduce the numbers of VLs in areas where SPUE=0 will clearly provide some level of reduction in entanglement risk that will not be captured by the existing model. That is, in those cells where CO scores are 0 because of 0 SPUE values, there will be no way of assessing the risk reduction. Even if draconian reductions were made in VLs, there would be no quantifiable change in CO, and therefore no way to demonstrate any conservation benefit from those reductions. As a related matter, the Team agreed that only counting reductions in lines would not be the optimum way of assessing risk reduction from any given proposal given highly variable densities of whales in any given area. Using CO scores in some blocks and VL values in others is subjective and arbitrary.

GOALS AND OBJECTIVES

It was suggested to the ALWTRT, both at the 2012 meeting and at earlier meetings, that the zero values in the SPUE datasets should be replaced by some very small minimum value so that cells with extremely high VL scores would end up with non-zero CO scores. IEc representatives at the 2012 meeting pointed out that using any arbitrary, across-the-board minimum would be difficult to defend statistically and could weaken the co-occurrence model. The objective of this study was therefore to outline a method for deriving minimum values for SPUE cells where values are currently estimated at 0 based on limited survey effort that: (1) are based on the available data, (2) are not purely arbitrary, (3) will better address the weaknesses pointed out above, and (4) provide a more accurate reflection of both entanglement risks and conservation benefits of proposed management actions in waters off the northeastern United States.

METHODS

The monthly datasets for the Northeast region (including EFFORT and, for all three whale species, number of sightings, number of whales, and SPUE for each 10-minute block and month)

were extracted from the larger dataset (Florida to Nova Scotia) that was provided early in 2011 to IEc, and pooled into a single dataset. The Northeast region was defined as in the IEc model—north of 40°N, east of 72°W, and west of the Hague line). Any 10-minute block that projected visibly on a map over the Hague Line into U.S. jurisdiction was included in its entirety in the analysis. The frequency distribution of EFFORT values was then examined using PROC UNIVARIATE in SAS (SAS for Windows, 64-bit, version 9.2, SAS Institute Inc., Cary, NC). The frequency distributions were also visually examined using PROC CHART to construct "quick and dirty" histograms—first for the full distribution and then for successively smaller subsets at the lowest end. The goal was to objectively define a minimum threshold effort value for a block/month, so that the low-effort blocks could be deleted so as to eliminate the objections stated in item (1) in the Background. The effect of deleting a block is essentially resetting EFFORT to zero and SPUE to undefined (i.e., the black squares in the IEc maps of SPUE or CO).

Similarly, datasets of non-zero SPUE blocks were then created for both right and humpback whales in the Northeast region. The SPUE frequency distributions were examined in PROC UNIVARIATE to look at the bottom ends of the distributions and to begin defining minimum SPUE values that might be used in the CO model. The overall SPUE distributions were examined with the low-effort cells defined above included, and with them deleted, to see if that deletion would have deleterious effects by deleting too many non-zero SPUE values. Additional PROC UNIVARIATE analyses were done on the right whale and humpback datasets by month, and also by season. Seasons were defined using the same aggregations of months used by IEc in their mapping in order to stay consistent (Winter = January–March; Spring = April–June; Summer = July–September; Fall = October–December).

Finally, a draft decision tree was then created that selects a new minimum SPUE value for any cell with an initial zero value, for both right whales and humpbacks separately. The underlying philosophy is that the higher the EFFORT value is for any particular block and month, the more confidence there is in the SPUE estimate. If block/month has relatively high EFFORT, we are more confident that an estimate of SPUE = 0 reliably represents an absence of whales. Conversely, the lower the EFFORT value in a cell, the less likely it is that a zero SPUE value is realistic.

One additional data layer is presumed in the structure of the decision tree—an occurrence (presence/absence) layer for each whale species. The objective here is to include other information on the known occurrence of right whales or humpback whales, based on opportunistic sightings, tracks of tagged whales, or any other type of occurrence records that can be assigned to a 10-minute block and month. Any block/month in which a right whale has ever occurred would be assigned a presence/absence score (P/A) of 1; if none, P/A = 0. The P/A index could conceivably be more complex, e.g., P/A = 0 for no occurrences, P/A = 1 for 1-4 occurrences, and P/A = 2 for 5 or more occurrences (or 0 / 1-2 / 3-9 / 10+). The P/A scores would not be used quantitatively within the decision tree, but only to define decision points, so

the magnitudes of the scores are not important. I will provide, on short notice, a complete set of records from the NARWC database for both right whales and humpbacks to IEc, but they will need to (1) go to other sources for additional data such as tag tracks, entanglement locations, etc., and (2) do the GIS mapping and derive the P/A index values.

RESULTS

EFFORT

After creating the Northeast dataset from the larger one, there were 7,417 10x10-minute blocks and months with a least a minimal amount of valid survey effort (defined as track segments completed with at least one observer formally on watch, Beaufort sea state of 4 or lower, visibility at least 2 nautical miles, and aircraft altitude below 1200 feet). EFFORT within a block and month ranged from 0.1 to 16,125.8 km, with a mean of 145.9. (Appendix A includes the detailed SAS output from the UNIVARIATE procedure.) The frequency distribution was significantly non-normal ($P < 0.01$), extremely variable (CV = 353%), and highly skewed, with an extremely long upper tail (Fig. 1). The quantile values for the distribution also show its extreme skewness:

99%	95%	90%	75%	median	25%	10%	5%	1%
1661.7	416.6	236.3	112.5	61.6	30.9	13.9	8.97	1.86

Plotting a histogram of only the bottom three-quarters of the distribution shows it still to be skewed toward the lower end (Fig. 2). Plotting only the lower half of EFFORT distribution begins to show some interesting structure, with a substantial peak in EFFORT with values of 12–15 km (Fig. 3). That peak is still prominent in the >13 km class when plotting only values less than the 10th percentile (Fig. 4). There is a logical explanation for that peak. The 10x10-minute blocks in the Northeast study area measure 18.52 km north-south (10 n.mi., given that the nautical mile is defined as 1 minute of latitude). The east-west dimensions of the blocks vary, because of the curvature of the Earth's surface and the convergence of longitude lines as you go farther north—from 13.15 km at the northern end, to 13.67 km in the center, and to14.17 km at the southern end. The peaks in the 12–15 km class in Fig. 3 and the 13–13.9 km class in Fig. 4 represent blocks with one complete east-west track across. The NEFSC broad-scale surveys follow east-west tracklines. Other surveys would typically cross blocks at angles, resulting in variable trackline lengths within individual blocks. It therefore seems a reasonable option to select 13 km, slightly lower than the 10th percentile of the EFFORT distribution, as the threshold value. No additional structure is visible when plotting only the bottom 5% of the frequency distribution (Fig. 5).

[text continues on page 9, following Fig. 5]

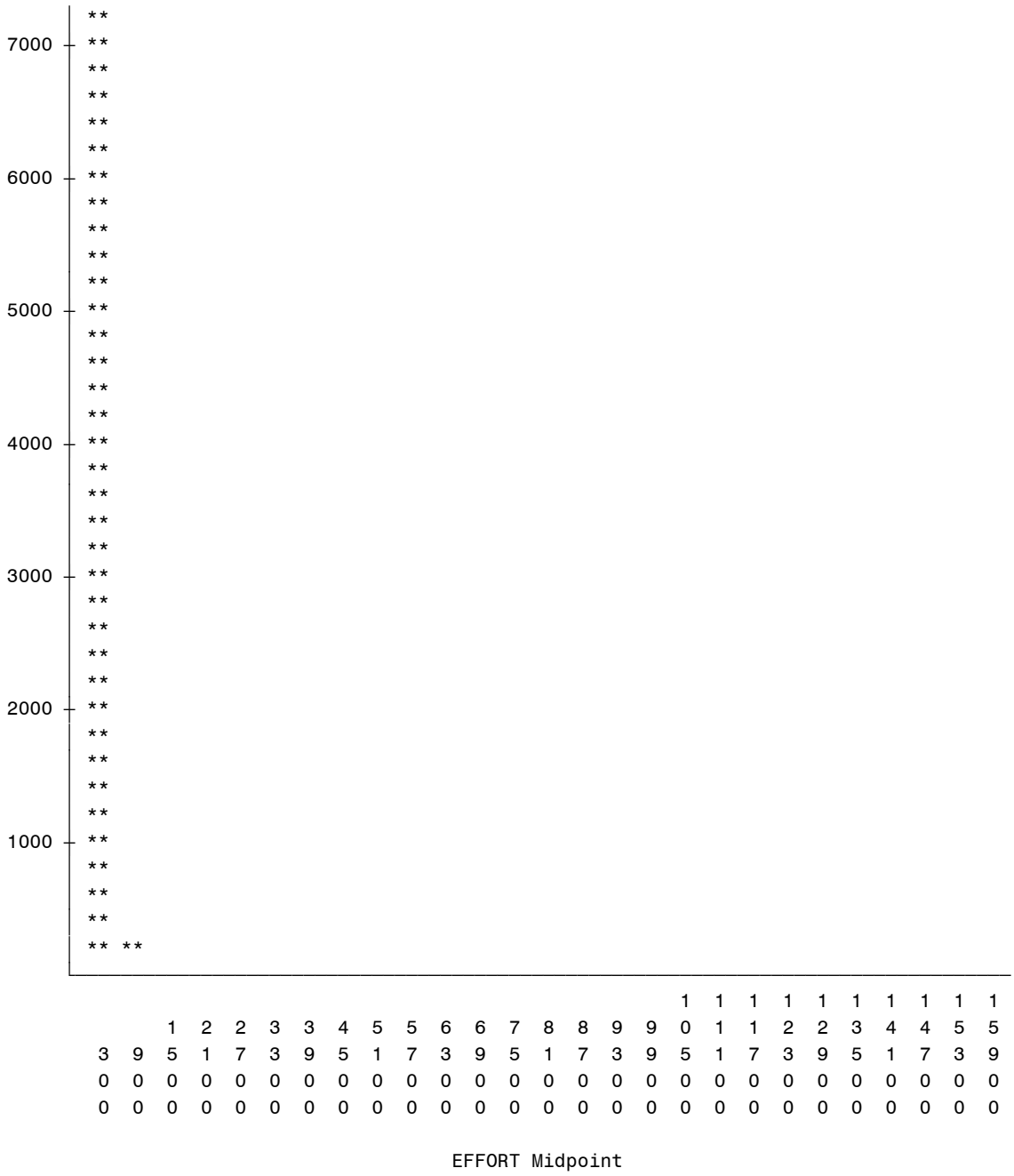

Figure 1: SAS PROC CHART histogram of the frequency distribution of EFFORT by 10x10-minute block and month (N = 7,417). There are data out in the upper tail of the distribution, but the frequencies are too low to show at the scale plotted here.

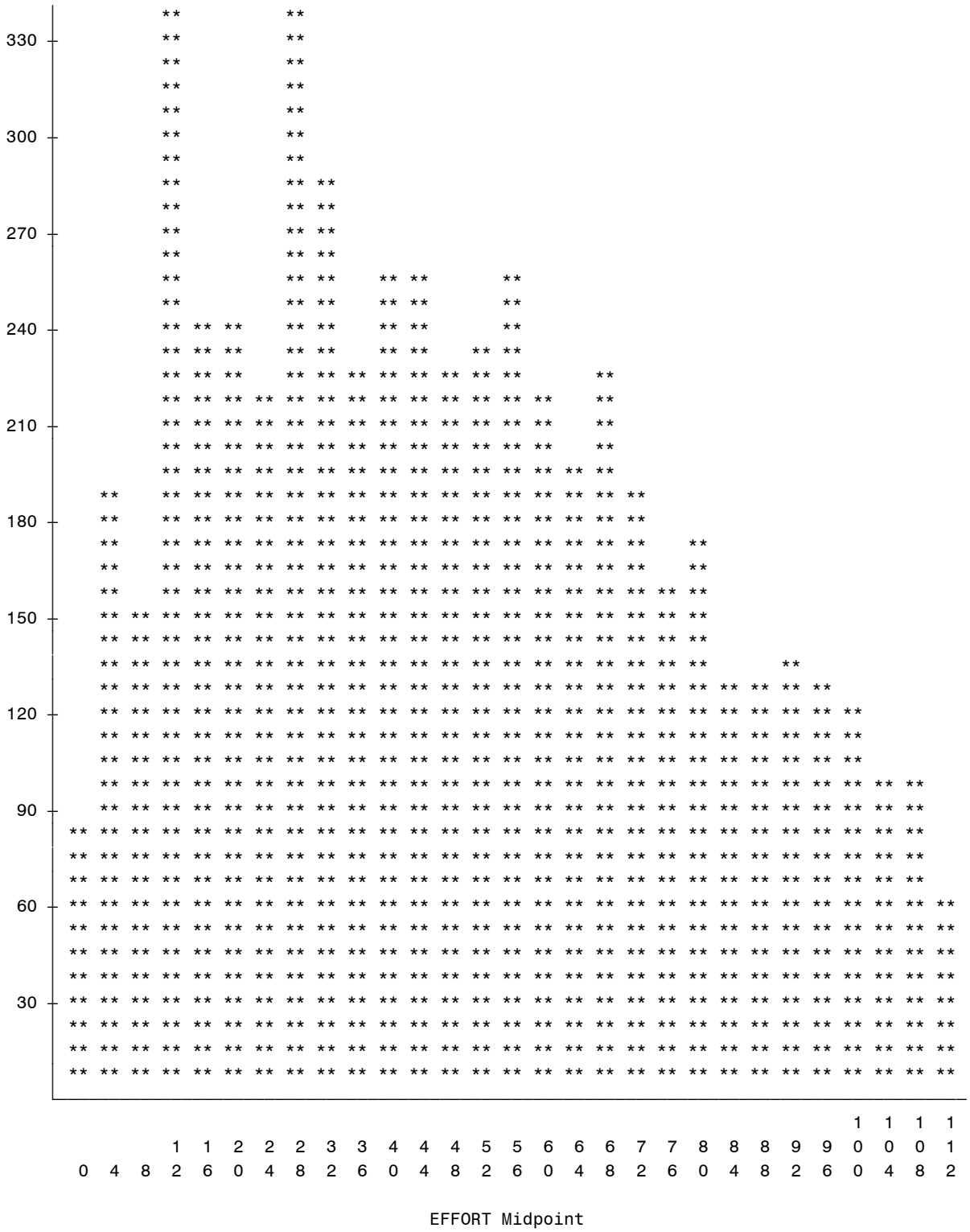

Figure 2: SAS PROC CHART histogram of the frequency distribution of EFFORT by 10x10-minute block and month, including only the lower three-fourths of the distribution.

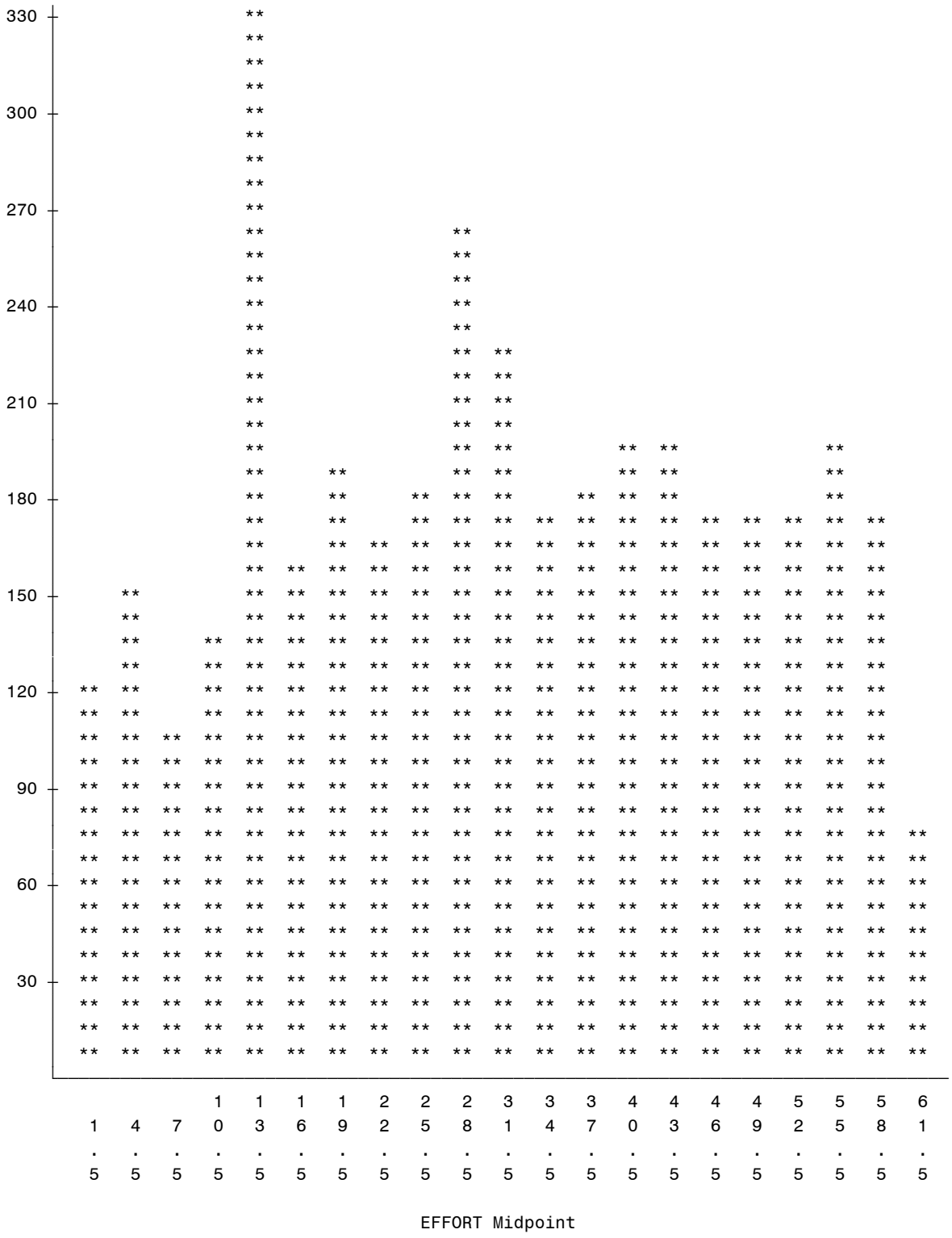

Figure 3: SAS PROC CHART histogram of the frequency distribution of EFFORT by 10x10-minute block and month, including only the lower half of the distribution.

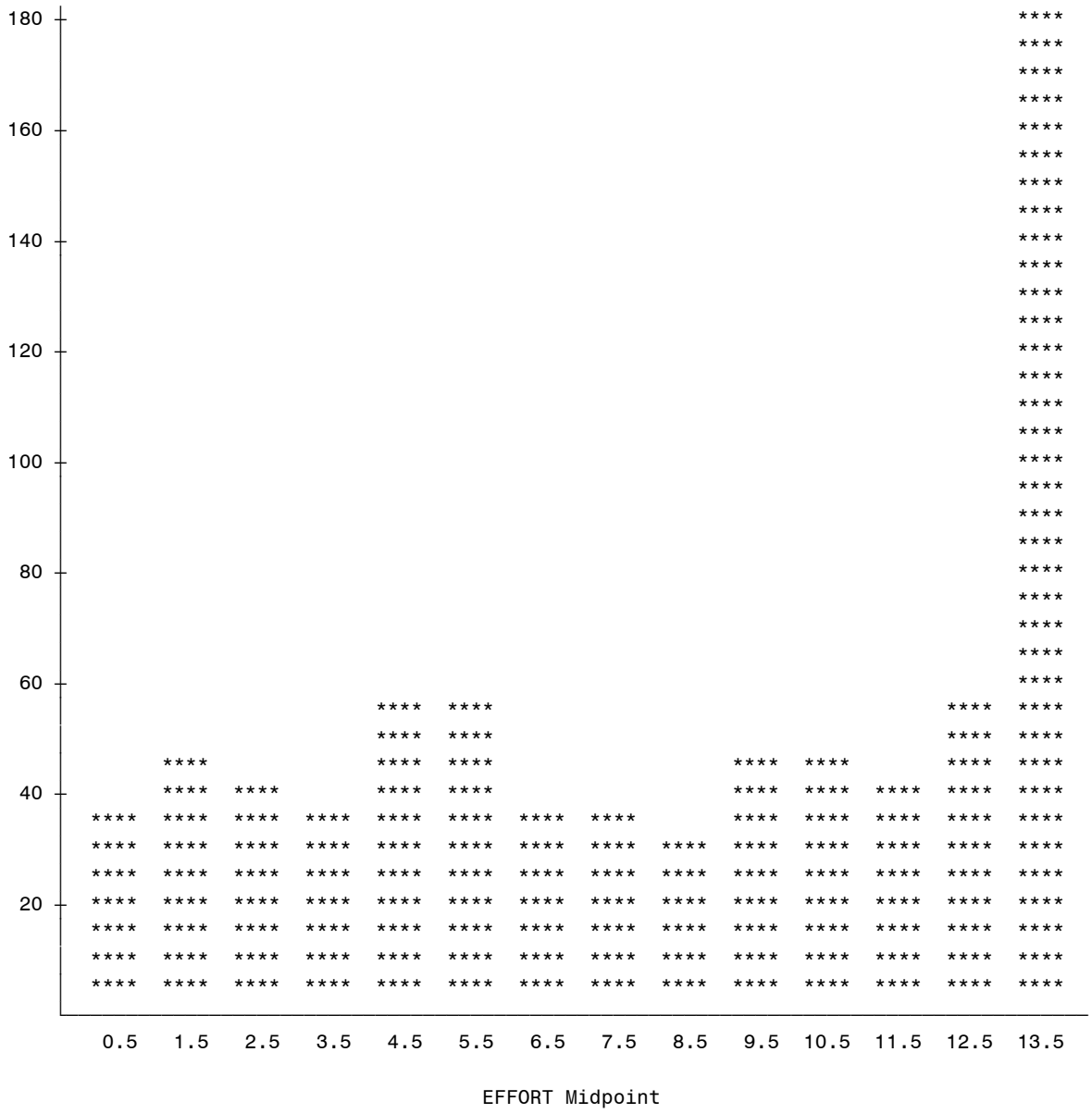

Figure 4: SAS PROC CHART histogram of the frequency distribution of EFFORT by 10x10-minute block and month, including only the lowest tenth of the distribution.

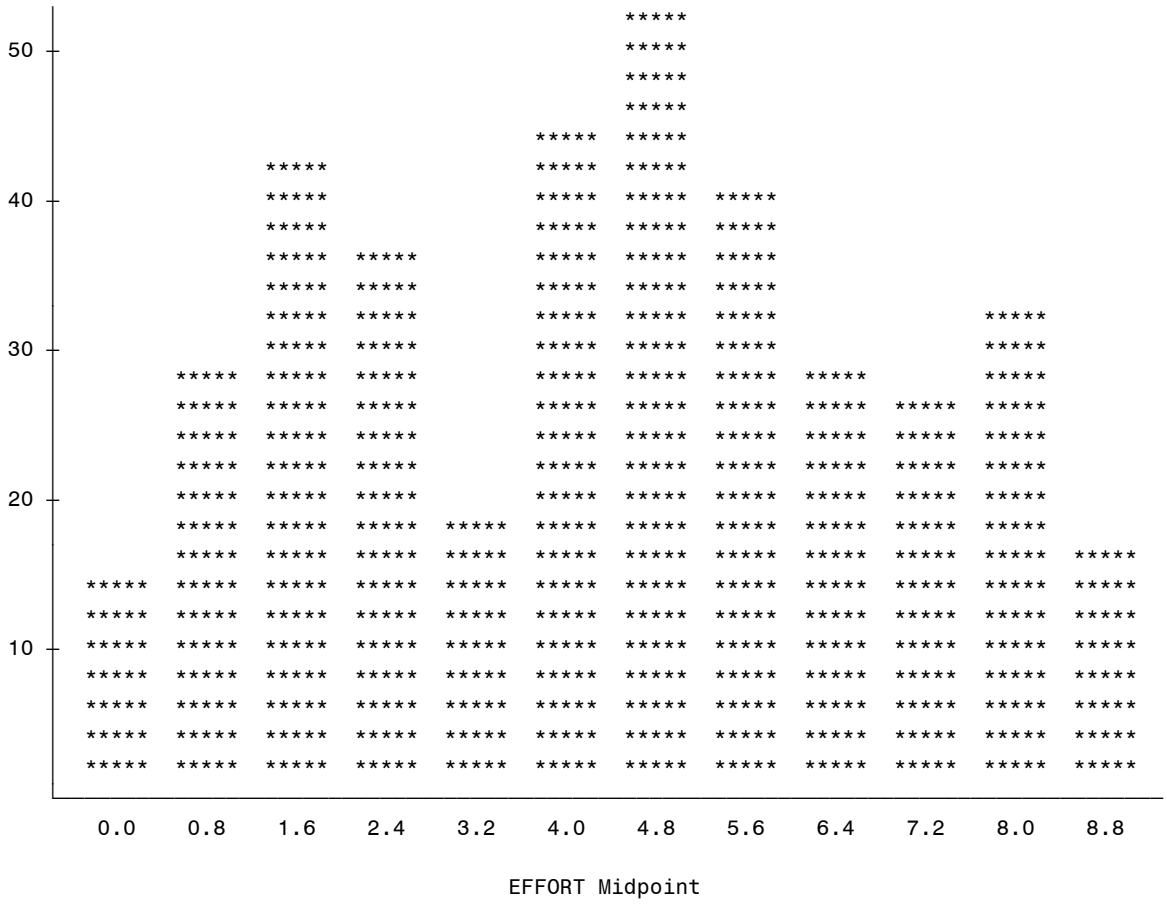

Figure 5: SAS PROC CHART histogram of the frequency distribution of EFFORT by 10x10-minute block and month, including only the lowest 5% of the distribution.

Deleting all cells with EFFORT < 13 km reduces the size of the dataset from 7,417 to 6,855, or 92.4% of its original size. Table 1 compares the numbers of data records by month before and after deleting the 562 entries with EFFORT < 13. The changes are highest in December–February.

Table 1. Changes in numbers of data records by month from deleting those with EFFORT < 13.

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Before	567	544	625	647	638	643	638	660	651	632	606	566
After	492	464	581	615	603	606	614	610	619	597	567	487
Change	75	80	44	32	35	37	24	50	32	35	39	79

SPUE

Of the 7,417 data records (10-minute blocks by month), 619 contained SPUE values over 0 for right whales, and 1,014 had non-zero humpback whale SPUE values. After deleting all records with EFFORT < 13 km, the number of non-zero SPUE values did not change for right whales, and decreased by 4 for humpbacks—to 1,010. For comparative purposes, the number of records with non-zero SPUE for fin whales changed from 1,411 to 1,409 when the low-EFFORT cells were deleted. The numbers of non-zero blocks by month, after the deletion, for each species are shown in Table 2 below.

Table 2. Numbers of 10x10-minute blocks with SPUE > 0 for each of the three endangered whale species after deleting those with EFFORT < 13.

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Right	29	36	57	118	121	101	58	4	10	26	31	28
Humpback	21	11	50	116	162	169	117	76	84	89	73	42
Fin	43	43	58	145	209	188	183	124	114	148	91	63

Overall, right whale SPUE ranged from a minimum of 0.26 to a maximum of 582.8 whales per 1000 km of survey effort. Table 3 shows the summarized results overall and by month and season; the detailed SAS outputs are included in the appendices specified in the table legend. Minimum values by month ranged from 0.26 in January to 11.22 in August (when right whales were seen on surveys in only four blocks in the Northeast study area). Seasonal minima were: 0.26 in winter, 0.74 in spring, 3.14 in summer, and 3.43 in fall. The numbers of blocks occupied tended to be highest in winter and spring, and lowest in summer and fall, suggesting that the higher SPUEs in the latter seasons are more an indication of increased aggregation rather than increased abundance.

Humpback whale SPUE overall ranged from a minimum of 0.13 to a maximum of 331.2 whales per 1000 km of survey effort, and the minimum and maximum values remained the same before and after the four non-zero blocks with EFFORT < 13 were deleted. Table 4 shows the summarized results overall and by month and season; the detailed SAS outputs are included in the appendices specified in the table legend. Minimum values by month ranged from 0.13 in February to 3.61 in October. Seasonal minima were: 0.13 in winter, 0.24 in spring, 1.52 in summer, and 1.68 in fall. The numbers of blocks occupied tended to be lowest in winter, highest in spring, and intermediate in summer and fall, a pattern much different than for right whales. This is more indicative of a three-season occupancy of Northeast feeding habitats.

Table 3. Summarized univariate statistical results for records with right whale SPUE > 0, for all data combined, by month, and by season. The summary of the data quantiles here concentrates on the lower end of the frequency distribution. The full analytical outputs are included in Appendices B (all data), D (by month), and E (by season).

Period	N	Mean	Min.	1%	5%	10%	25%	Med.	75%	Max.
ALL	619	23.93	0.26	0.89	2.51	3.52	6.24	13.66	30.45	582.8
JAN	29	54.31	0.26	0.26	1.44	3.33	7.36	17.49	39.86	582.8
FEB	36	17.20	0.38	0.38	0.75	1.15	5.36	9.73	26.72	80.92
MAR	57	20.25	0.94	0.94	3.28	3.83	5.49	12.50	24.36	144.1
APR	118	18.20	1.67	1.71	3.41	4.30	6.93	11.47	20.43	160.1
MAY	121	21.03	0.74	0.74	1.20	2.38	4.63	11.71	27.24	165.1
JUN	101	22.75	1.43	1.44	2.39	3.02	5.23	16.72	36.00	85.50
JUL	58	32.66	3.14	3.14	3.56	4.30	9.85	21.36	38.31	223.8
AUG	4	27.92	11.22	11.22	11.22	11.22	13.07	20.80	42.77	58.86
SEP	10	25.72	5.16	5.16	5.156	5.82	6.49	10.83	19.66	107.5
OCT	26	14.66	3.55	3.55	4.09	4.59	6.59	10.86	17.00	43.09
NOV	31	25.14	3.43	3.43	4.68	6.34	8.68	14.93	31.85	98.53
DEC	28	37.73	5.80	5.80	5.82	7.27	14.94	22.20	50.34	142.0
WIN	122	27.45	0.26	0.38	1.44	3.83	5.53	12.16	28.47	582.8
SPR	340	20.56	0.74	0.89	1.98	3.01	5.46	12.41	27.26	165.1
SUM	72	31.43	3.14	3.14	4.17	5.16	9.90	19.30	38.00	223.8
FAL	85	26.08	3.43	3.43	4.68	5.82	8.97	16.99	33.00	142.0

Table 4. Summarized univariate statistical results for records with humpback whale SPUE > 0, for all data combined (both with and without the four records with EFFORT < 13, ALL1 and ALL2, respectively), by month, and by season. The summary of the data quantiles here concentrates on the lower end of the frequency distribution. The full analytical outputs are included in Appendices C (all data), F (by month), and G (by season).

Period	N	Mean	Min.	1%	5%	10%	25%	Med.	75%	Max.
ALL1	1014	31.36	0.13	0.58	1.83	3.53	7.39	16.63	34.84	331.2
ALL2	1010	31.06	0.13	0.58	1.84	3.52	7.31	16.52	34.65	331.2
JAN	21	27.38	0.34	0.34	0.58	1.16	4.16	10.36	38.17	123.7
FEB	11	6.10	0.13	0.13	0.13	0.17	0.18	2.69	4.38	33.28
MAR	50	12.04	0.17	0.17	0.28	0.56	3.17	7.96	17.03	65.63
APR	116	17.39	0.24	0.66	1.55	2.15	4.73	9.33	23.46	144.1
MAY	162	24.04	0.60	0.61	1.36	2.13	5.22	11.26	27.08	263.0
JUN	169	28.48	0.92	0.99	1.52	3.12	6.49	16.20	34.07	175.7
JUL	117	42.04	2.56	2.84	4.76	5.84	10.63	21.96	46.35	331.2
AUG	76	60.88	1.83	1.83	7.14	11.27	21.89	40.26	75.97	317.0
SEP	84	33.73	1.52	1.52	6.70	7.27	10.27	18.13	35.09	232.9
OCT	89	38.72	3.61	3.61	4.71	6.59	11.31	20.61	44.77	525.1
NOV	73	35.04	3.56	3.56	4.33	7.16	10.34	22.75	42.08	242.3
DEC	42	24.94	1.68	1.68	2.73	3.98	8.49	14.98	34.82	187.0
WIN	82	15.17	0.13	0.13	0.23	0.52	2.95	7.66	17.62	123.7
SPR	447	23.99	0.24	0.71	1.52	2.36	5.34	13.55	28.08	263.0
SUM	277	44.58	1.52	2.56	5.52	7.09	12.08	22.99	53.69	331.2
FAL	204	34.57	1.68	2.73	3.99	6.59	1.30	20.59	38.92	252.1

Decision Tree

A proposed, straw-man decision tree is shown in Figure 6. The first step in the process would be to delete all the records with EFFORT < 13 km. Thereafter the process would go forward separately for each species. The second step is to partition the remaining records into SPUE > 0 and SPUE = 0. The non-zero SPUE blocks would remain unchanged, while the zero blocks would follow a more complicated set of pathways defined by successively decreasing EFFORT (i.e., decreasing confidence in the zero SPUE estimate), as well as by presence/absence of whales as shown by the broader occurrence data. The cut-points used in the tree as shown are the median, first quartile, and 10th percentile values of the EFFORT distribution (Appendix A). As

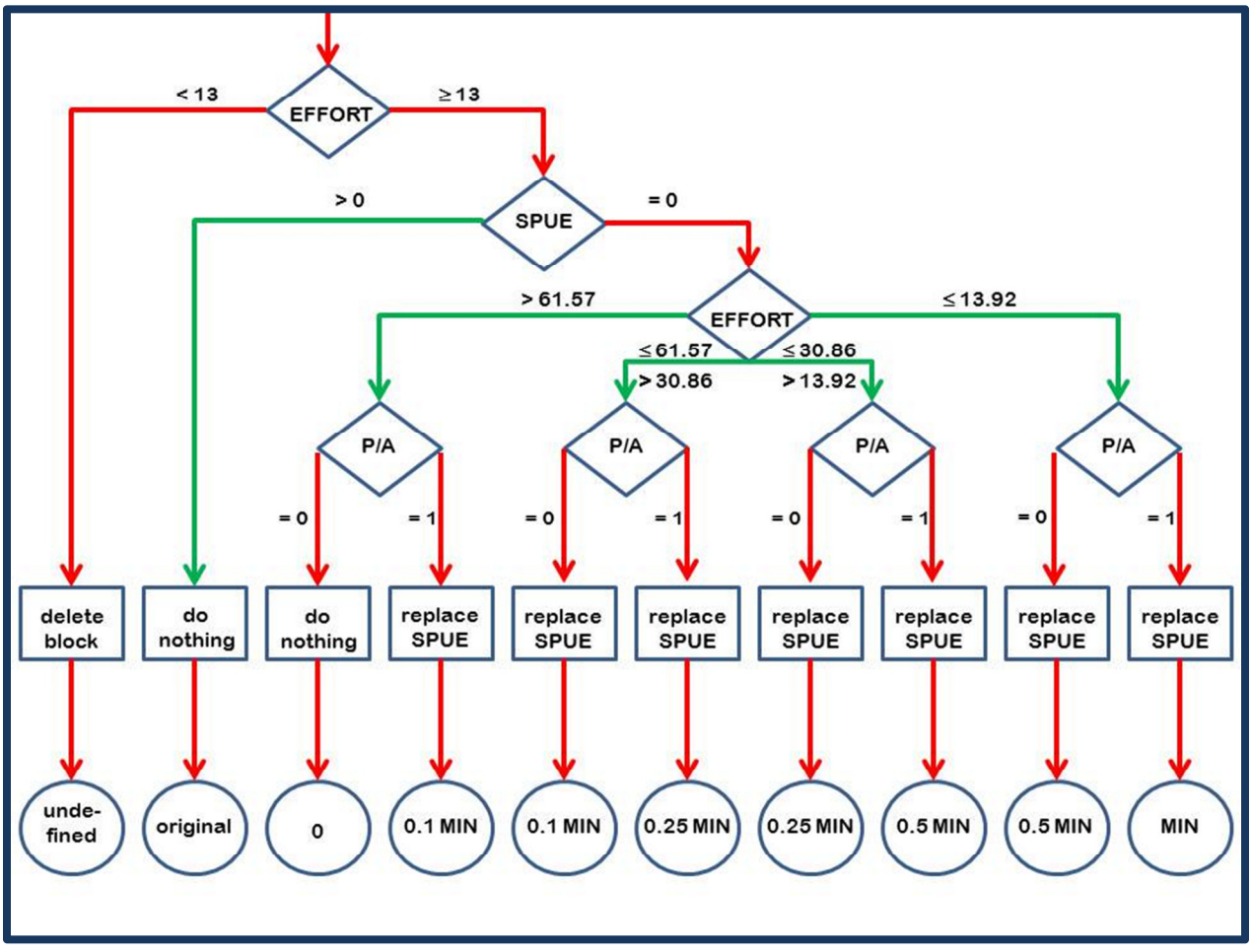

Figure 6. Proposed decision tree for defining minimum SPUE values in 10x10-minute blocks and months in the Northeast with low EFFORT values. The circles across the bottom of the tree are the resulting SPUE values that would be created (or simply kept in the case of the second and third pathways). MIN is the minimum SPUE value for a particular whale species, which could be one value across the board, or different values by season or even by month.

an alternative, one might re-calculate the quantile values of the distribution resulting after deletion of the EFFORT < 13 records (the detailed output of that exercise is in Appendix H). The effect would be to move the cut-points to higher values, especially the 10th percentile. The resulting values would be: median = 66.94, first quartile = 37.59, 10th percentile = 22.25. Table 5 below compares the numbers of data cells following each of the decision pathways (the five green arrows in Fig. 6), for each whale species, under each set of decision criteria.

Table 5. Results of using different quantile partitioning schemes in the decision tree. Trial 1 uses the original frequency distribution of EFFORT to define the quantiles (Appendix A). Trial 2 uses the frequency distribution of EFFORT after the EFFORT < 13 km records have been deleted (Appendix H). The five rows of the table represent the numbers of blocks & months going down each of the green arrows in Figure 6 (from left to right). Each column sums to 6855, the number of records with EFFORT ≥ 13 km.

Criteria	Right Whales		Humpback Whales	
	Trial 1	Trial 2	Trial 1	Trial 2
SPUE > 0	619	619	1010	1010
SPUE = 0 and …				
EFFORT > median	3098	2819	2765	2499
median ≥ EFFORT > Q1	1847	1707	1802	1654
Q1 ≥ EFFORT > 10%ile	1112	1024	1100	1011
EFFORT ≤ 10%ile	179	686	178	681

The base value for resetting the SPUE estimate at the end of each decision pathway in Figure 6 ("MIN") will differ by species, and possibly by time period. The most obvious choice would be the minimum observed value—0.26 for right whales and 0.13 for humpbacks. The minimum SPUE values for right whales and humpbacks are only 0.05% and 0.04% of the respective maxima. Simply for the sake of illustration, the CO score for a block with a maximum possible VL index of 1000 would be 447.7 for the minimum right whale SPUE and 422.5 for the minimum humpback whale SPUE (after scaling to a 0–1000 index). For one of the decision pathways where the final value is 0.1 MIN, those values would decrease by an order of magnitude to 44.8 and 42.3, respectively.

Options for which minimum value or values to use (refer to Tables 3 and 4) would be: the overall species minimum across the board, the monthly minimum values applied to each month separately, the seasonal minimum values applied to the appropriate months, or something

different. Using the overall minimum across the board has the beauty of simplicity. The monthly minima for each species appear to be too widely variable, and some high values likely will result in assigning excessive threshold SPUE estimates in some blocks. Even the seasonal minima appear to be too high to use for calculating new bottom values in some seasons. For right whales, the summer and fall minima are 12 and 13 times the winter minimum—for seasons when the numbers of known occupied blocks in a month are as low as 4 (i.e., the whales are mostly outside of the defined study area). The seasonal variability for humpbacks is almost as marked between winter and summer/fall, but is not as clearly related to whales departing for other habitats. As a starting-point proposal for discussion, my suggestion would be to use either the single minimum value across the board for both species, or:

- For right whales: the winter minimum (0.26) in winter, the spring minimum (0.74) in spring—the season with the most 10-minute blocks occupied and known to be the season of peak occurrence in both Cape Cod Bay and the Great South Channel, and the winter minimum in both summer and fall—when most of the whales are in Canadian waters.
- For humpback whales: the winter minimum (0.13) in winter, and the spring minimum (0.24) in the other three seasons.

NEXT STEPS

I expect that this study will become the basis for a recommendation to NMFS that they and IEc further investigate the minimum SPUE values proposed herein, explore the various options for creating those values, and finally use the updated threshold SPUE values as appropriate in calculating CO scores for the Northeast region. An effective way forward would be for a subset of TRT members to discuss the various options with representatives of NMFS and IEc. The structure and details of the decision tree can be made as simple or complex as necessary or desired. Options to consider could include:

- The minimum allowable EFFORT value.
- The number of EFFORT cut-points, i.e., the fineness of the partitioning of the data down the decision pathways.
- The EFFORT partitioning could be continuous rather than by discrete categories, still presuming that the uppermost half (or some other proportion) is first sent down its own pathway. E.g., presuming a 3-category P/A index, the range of replacement SPUE values might be 0.1–0.5 MIN for P/A = 0, 0.2–1.0 MIN for P/A = 1, and 0.4–2.0 MIN for P/A = 2.
- The number of classes for the presence/absence index. Doing this as a continuous function would not be advisable, given the known biases in the opportunistic data. In addition, the blocks with the highest numbers of opportunistic records would be expected to have SPUE > 0 and not be subject to adjustment.

- The value of the base minimum SPUE value used in computing the new bottoms in the various decision paths.
- The values of the various coefficients used as multipliers of the MIN SPUE value.

As a final caution, in my opinion most or all of the decisions on these various points should be made without regard for the effects on CO scores or distributions. It would be a major mistake to test preliminary results by calculating the CO scores and then adjusting the decision criteria to fit particular outcomes desired by one or another set of stakeholders. In addition, the final decision tree that results should be applied to the entire Northeast region and not to a particular subset of the region based on an *a priori* subjective assessment of relative risk (e.g., only to Lobster Management Area 1).

There is one additional question that the methodology proposed in this analysis does not address; in fact, it makes it worse. There remains some number of 10x10-minute blocks in each month with no survey effort (i.e., EFFORT = 0, SPUE = undefined). The decision tree method does not have any effect on filling in those missing SPUE values, so there will still be blocks where the co-occurrence model provides no quantitative assessment of risk reduction from removing vertical lines. The initial step of deleting all blocks with EFFORT < 13 actually increases the number of missing values (the black squares in IEc's maps of SPUE or CO) by about 8% overall, but more in some months than in others. There are methods for filling in missing data using the data in surrounding locations. One often-used method would be inverse-distance-weighted mean values of the neighboring blocks. This should also be explored in the IEc co-occurrence model, including the distance to search beyond a blank block for values to average, and a minimum weight to determine whether or not to replace any missing value with the IDW mean of its neighbors.

APPENDIX A: SAS PROC UNIVARIATE output, variable = EFFORT

Moments

N	7417	Sum Weights	7417
Mean	145.872987	Sum Observations	1081939.94
Std Deviation	514.641671	Variance	264856.05
Skewness	15.790133	Kurtosis	342.094846
Uncorrected SS	2121998277	Corrected SS	1964172466
Coeff Variation	352.801217	Std Error Mean	5.97572784

Basic Statistical Measures

Location		Variability	
Mean	145.8730	Std Deviation	514.64167
Median	61.5709	Variance	264856
Mode	0.1000	Range	16126
		Interquartile Range	81.59194

Tests for Location: Mu0=0

Test	-Statistic-		-----p Value------	
Student's t	t	24.41092	Pr > |t|	<.0001
Sign	M	3708.5	Pr >= |M|	<.0001
Signed Rank	S	13754827	Pr >= |S|	<.0001

Tests for Normality

Test	--Statistic---		-----p Value------	
Kolmogorov-Smirnov	D	0.388492	Pr > D	<0.0100
Cramer-von Mises	W-Sq	376.9724	Pr > W-Sq	<0.0050
Anderson-Darling	A-Sq	1829.542	Pr > A-Sq	<0.0050

Quantiles (Definition 5)

Quantile	Estimate
100% Max	16125.86174
99%	1661.67942
95%	416.61921
90%	236.31924
75% Q3	112.45478
50% Median	61.57089
25% Q1	30.86284
10%	13.92125
5%	8.97011
1%	1.85574
0% Min	0.10000

APPENDIX B. SAS PROC UNIVARIATE output, variable = RW_SPUE, before and after deleting all blocks with EFFORT < 13 km (both results were exactly the same, not repeated).

Moments

N	619	Sum Weights	619
Mean	23.9381552	Sum Observations	14817.7181
Std Deviation	35.2989823	Variance	1246.01815
Skewness	7.8030818	Kurtosis	105.353454
Uncorrected SS	1124748.05	Corrected SS	770039.216
Coeff Variation	147.459075	Std Error Mean	1.41878589

Basic Statistical Measures

Location		Variability	
Mean	23.93816	Std Deviation	35.29898
Median	13.65942	Variance	1246
Mode	.	Range	582.51913
		Interquartile Range	24.20246

Tests for Location: Mu0=0

Test	-Statistic-		-----p Value------	
Student's t	t	16.87228	Pr > |t|	<.0001
Sign	M	309.5	Pr >= |M|	<.0001
Signed Rank	S	95945	Pr >= |S|	<.0001

Tests for Normality

Test	--Statistic---		-----p Value------	
Shapiro-Wilk	W	0.511554	Pr < W	<0.0001
Kolmogorov-Smirnov	D	0.252281	Pr > D	<0.0100
Cramer-von Mises	W-Sq	11.61659	Pr > W-Sq	<0.0050
Anderson-Darling	A-Sq	62.75717	Pr > A-Sq	<0.0050

Quantiles (Definition 5)

Quantile	Estimate
100% Max	582.780014
99%	145.569577
95%	76.881409
90%	54.315657
75% Q3	30.447050
50% Median	13.659420
25% Q1	6.244594
10%	3.524987
5%	2.510532
1%	0.894114
0% Min	0.260879

APPENDIX C. SAS PROC UNIVARIATE output, variable = HW_SPUE, before and after deleting all blocks with EFFORT < 13 km.

BEFORE:

Moments

N	1014	Sum Weights	1014
Mean	31.3355945	Sum Observations	31774.2928
Std Deviation	42.7482284	Variance	1827.41103
Skewness	3.0864667	Kurtosis	11.8341831
Uncorrected SS	2846833.73	Corrected SS	1851167.38
Coeff Variation	136.420671	Std Error Mean	1.34245317

Basic Statistical Measures

Location		Variability	
Mean	31.33559	Std Deviation	42.74823
Median	16.62772	Variance	1827
Mode	.	Range	331.09887
		Interquartile Range	27.44564

Tests for Location: Mu0=0

Test	-Statistic-		-----p Value------	
Student's t	t	23.34204	Pr > |t|	<.0001
Sign	M	507	Pr >= |M|	<.0001
Signed Rank	S	257302.5	Pr >= |S|	<.0001

Tests for Normality

Test	--Statistic---		-----p Value------	
Shapiro-Wilk	W	0.644691	Pr < W	<0.0001
Kolmogorov-Smirnov	D	0.232699	Pr > D	<0.0100
Cramer-von Mises	W-Sq	20.14379	Pr > W-Sq	<0.0050
Anderson-Darling	A-Sq	107.2598	Pr > A-Sq	<0.0050

Quantiles (Definition 5)

Quantile	Estimate
100% Max	331.228814
99%	217.102061
95%	118.478474
90%	78.518096
75% Q3	34.837529
50% Median	16.627720
25% Q1	7.391887
10%	3.527870
5%	1.831634
1%	0.581027
0% Min	0.129941

AFTER:

Moments

N	1010	Sum Weights	1010
Mean	31.0597238	Sum Observations	31370.321
Std Deviation	42.5489035	Variance	1810.40919
Skewness	3.12851522	Kurtosis	12.161448
Uncorrected SS	2801056.38	Corrected SS	1826702.87
Coeff Variation	136.990605	Std Error Mean	1.33883694

Basic Statistical Measures

Location		Variability	
Mean	31.05972	Std Deviation	42.54890
Median	16.51575	Variance	1810
Mode	.	Range	331.09887
		Interquartile Range	27.34134

Tests for Location: Mu0=0

Test	-Statistic-		-----p Value------	
Student's t	t	23.19903	Pr > |t|	<.0001
Sign	M	505	Pr >= |M|	<.0001
Signed Rank	S	255277.5	Pr >= |S|	<.0001

Tests for Normality

Test	--Statistic---		-----p Value------	
Shapiro-Wilk	W	0.640603	Pr < W	<0.0001
Kolmogorov-Smirnov	D	0.233637	Pr > D	<0.0100
Cramer-von Mises	W-Sq	20.22653	Pr > W-Sq	<0.0050
Anderson-Darling	A-Sq	107.7219	Pr > A-Sq	<0.0050

Quantiles (Definition 5)

Quantile	Estimate
100% Max	331.228814
99%	217.102061
95%	116.681613
90%	76.361067
75% Q3	34.646820
50% Median	16.515750
25% Q1	7.305477
10%	3.518826
5%	1.831634
1%	0.581027
0% Min	0.129941

APPENDIX D. SAS PROC UNIVARIATE output, variable = RW_SPUE, by month.

MONTH=1

Moments

N	29	Sum Weights	29
Mean	54.3125362	Sum Observations	1575.06355
Std Deviation	113.324999	Variance	12842.5554
Skewness	3.99974937	Kurtosis	17.8220188
Uncorrected SS	445137.248	Corrected SS	359591.552
Coeff Variation	208.653484	Std Error Mean	21.043924

Basic Statistical Measures

Location		Variability	
Mean	54.31254	Std Deviation	113.32500
Median	17.48647	Variance	12843
Mode	.	Range	582.51913
		Interquartile Range	32.50063

Tests for Location: Mu0=0

Test	-Statistic-		-----p Value------	
Student's t	t	2.580913	Pr > |t|	0.0154
Sign	M	14.5	Pr >= |M|	<.0001
Signed Rank	S	217.5	Pr >= |S|	<.0001

Tests for Normality

Test	--Statistic---		-----p Value------	
Shapiro-Wilk	W	0.470132	Pr < W	<0.0001
Kolmogorov-Smirnov	D	0.343341	Pr > D	<0.0100
Cramer-von Mises	W-Sq	1.065456	Pr > W-Sq	<0.0050
Anderson-Darling	A-Sq	5.421121	Pr > A-Sq	<0.0050

Quantiles (Definition 5)

Quantile	Estimate
100% Max	582.780014
99%	582.780014
95%	205.702752
90%	184.614139
75% Q3	39.856999
50% Median	17.486474
25% Q1	7.356374
10%	3.329293
5%	1.437864
1%	0.260879
0% Min	0.260879

MONTH=2

Moments

N	36	Sum Weights	36
Mean	17.198136	Sum Observations	619.132897
Std Deviation	17.3649385	Variance	301.54109
Skewness	1.934826	Kurtosis	4.62729157
Uncorrected SS	21201.8699	Corrected SS	10553.9381
Coeff Variation	100.969887	Std Error Mean	2.89415642

Basic Statistical Measures

Location		Variability	
Mean	17.19814	Std Deviation	17.36494
Median	9.73138	Variance	301.54109
Mode	.	Range	80.53603
		Interquartile Range	21.36618

Tests for Location: Mu0=0

Test	-Statistic-		-----p Value------	
Student's t	t	5.942366	Pr > |t|	<.0001
Sign	M	18	Pr >= |M|	<.0001
Signed Rank	S	333	Pr >= |S|	<.0001

Tests for Normality

Test	--Statistic---		-----p Value------	
Shapiro-Wilk	W	0.793638	Pr < W	<0.0001
Kolmogorov-Smirnov	D	0.226355	Pr > D	<0.0100
Cramer-von Mises	W-Sq	0.358459	Pr > W-Sq	<0.0050
Anderson-Darling	A-Sq	2.164546	Pr > A-Sq	<0.0050

Quantiles (Definition 5)

Quantile	Estimate
100% Max	80.916554
99%	80.916554
95%	61.373635
90%	34.969864
75% Q3	26.722486
50% Median	9.731378
25% Q1	5.356301
10%	1.148524
5%	0.751993
1%	0.380524
0% Min	0.380524

MONTH=3

Moments

N	57	Sum Weights	57
Mean	20.2497356	Sum Observations	1154.23493
Std Deviation	23.7936556	Variance	566.138045
Skewness	3.09044325	Kurtosis	12.8506726
Uncorrected SS	55076.6826	Corrected SS	31703.7305
Coeff Variation	117.501068	Std Error Mean	3.15154667

Basic Statistical Measures

Location		Variability	
Mean	20.24974	Std Deviation	23.79366
Median	12.50190	Variance	566.13804
Mode	.	Range	143.13862
		Interquartile Range	18.86336

Tests for Location: Mu0=0

Test	-Statistic-		-----p Value------	
Student's t	t	6.425333	Pr > |t|	<.0001
Sign	M	28.5	Pr >= |M|	<.0001
Signed Rank	S	826.5	Pr >= |S|	<.0001

Tests for Normality

Test	--Statistic---		-----p Value------	
Shapiro-Wilk	W	0.681288	Pr < W	<0.0001
Kolmogorov-Smirnov	D	0.210689	Pr > D	<0.0100
Cramer-von Mises	W-Sq	0.832518	Pr > W-Sq	<0.0050
Anderson-Darling	A-Sq	4.708164	Pr > A-Sq	<0.0050

Quantiles (Definition 5)

Quantile	Estimate
100% Max	144.074669
99%	144.074669
95%	70.209455
90%	45.707102
75% Q3	24.358259
50% Median	12.501902
25% Q1	5.494903
10%	3.829491
5%	3.275806
1%	0.936052
0% Min	0.936052

MONTH=4

Moments

N	118	Sum Weights	118
Mean	18.1983058	Sum Observations	2147.40008
Std Deviation	20.5373523	Variance	421.78284
Skewness	3.7312742	Kurtosis	20.2574008
Uncorrected SS	88427.6355	Corrected SS	49348.5922
Coeff Variation	112.853101	Std Error Mean	1.89061653

Basic Statistical Measures

Location		Variability	
Mean	18.19831	Std Deviation	20.53735
Median	11.47264	Variance	421.78284
Mode	.	Range	158.40784
		Interquartile Range	13.49170

Tests for Location: Mu0=0

Test	-Statistic-		-----p Value------	
Student's t	t	9.625593	Pr > |t|	<.0001
Sign	M	59	Pr >= |M|	<.0001
Signed Rank	S	3510.5	Pr >= |S|	<.0001

Tests for Normality

Test	--Statistic---		-----p Value------	
Shapiro-Wilk	W	0.644337	Pr < W	<0.0001
Kolmogorov-Smirnov	D	0.223412	Pr > D	<0.0100
Cramer-von Mises	W-Sq	2.000003	Pr > W-Sq	<0.0050
Anderson-Darling	A-Sq	10.62133	Pr > A-Sq	<0.0050

Quantiles (Definition 5)

Quantile	Estimate
100% Max	160.08097
99%	95.74710
95%	55.03782
90%	42.31443
75% Q3	20.42588
50% Median	11.47264
25% Q1	6.93417
10%	4.29771
5%	3.41103
1%	1.70658
0% Min	1.67313

MONTH=5

Moments

N	121	Sum Weights	121
Mean	21.0295394	Sum Observations	2544.57426
Std Deviation	26.3513347	Variance	694.392842
Skewness	2.54831841	Kurtosis	8.40266939
Uncorrected SS	136838.366	Corrected SS	83327.141
Coeff Variation	125.306286	Std Error Mean	2.39557588

Basic Statistical Measures

Location		Variability	
Mean	21.02954	Std Deviation	26.35133
Median	11.70516	Variance	694.39284
Mode	.	Range	164.32003
		Interquartile Range	22.61034

Tests for Location: Mu0=0

Test		-Statistic-	-----p Value------	
Student's t	t	8.77849	Pr > |t|	<.0001
Sign	M	60.5	Pr >= |M|	<.0001
Signed Rank	S	3690.5	Pr >= |S|	<.0001

Tests for Normality

Test	--Statistic---		-----p Value------	
Shapiro-Wilk	W	0.713114	Pr < W	<0.0001
Kolmogorov-Smirnov	D	0.22064	Pr > D	<0.0100
Cramer-von Mises	W-Sq	1.841935	Pr > W-Sq	<0.0050
Anderson-Darling	A-Sq	10.24403	Pr > A-Sq	<0.0050

Quantiles (Definition 5)

Quantile	Estimate
100% Max	165.058138
99%	109.974851
95%	78.361088
90%	55.332390
75% Q3	27.238940
50% Median	11.705157
25% Q1	4.628597
10%	2.384078
5%	1.202926
1%	0.744836
0% Min	0.738107

MONTH=6

Moments

N	101	Sum Weights	101
Mean	22.745611	Sum Observations	2297.30671
Std Deviation	21.1307648	Variance	446.509222
Skewness	1.14936514	Kurtosis	0.70564343
Uncorrected SS	96904.567	Corrected SS	44650.9222
Coeff Variation	92.9004053	Std Error Mean	2.10258969

Basic Statistical Measures

Location		Variability	
Mean	22.74561	Std Deviation	21.13076
Median	16.72324	Variance	446.50922
Mode	.	Range	84.07329
		Interquartile Range	30.77244

Tests for Location: Mu0=0

Test	-Statistic-		-----p Value------	
Student's t	t	10.8179	Pr > |t|	<.0001
Sign	M	50.5	Pr >= |M|	<.0001
Signed Rank	S	2575.5	Pr >= |S|	<.0001

Tests for Normality

Test	--Statistic---		-----p Value------	
Shapiro-Wilk	W	0.861488	Pr < W	<0.0001
Kolmogorov-Smirnov	D	0.156516	Pr > D	<0.0100
Cramer-von Mises	W-Sq	0.717609	Pr > W-Sq	<0.0050
Anderson-Darling	A-Sq	4.350839	Pr > A-Sq	<0.0050

Quantiles (Definition 5)

Quantile	Estimate
100% Max	85.50048
99%	84.53487
95%	63.02433
90%	51.56834
75% Q3	36.00208
50% Median	16.72324
25% Q1	5.22964
10%	3.02242
5%	2.39468
1%	1.43679
0% Min	1.42719

MONTH=7

Moments

N	58	Sum Weights	58
Mean	32.6567632	Sum Observations	1894.09227
Std Deviation	36.938689	Variance	1364.46674
Skewness	3.07305743	Kurtosis	12.8450822
Uncorrected SS	139629.527	Corrected SS	77774.6043
Coeff Variation	113.111911	Std Error Mean	4.85028748

Basic Statistical Measures

Location		Variability	
Mean	32.65676	Std Deviation	36.93869
Median	21.35518	Variance	1364
Mode	.	Range	220.69668
		Interquartile Range	28.46464

Tests for Location: Mu0=0

Test	-Statistic-		-----p Value------	
Student's t	t	6.732954	Pr > |t|	<.0001
Sign	M	29	Pr >= |M|	<.0001
Signed Rank	S	855.5	Pr >= |S|	<.0001

Tests for Normality

Test	--Statistic---		-----p Value------	
Shapiro-Wilk	W	0.695259	Pr < W	<0.0001
Kolmogorov-Smirnov	D	0.212149	Pr > D	<0.0100
Cramer-von Mises	W-Sq	0.672979	Pr > W-Sq	<0.0050
Anderson-Darling	A-Sq	4.078509	Pr > A-Sq	<0.0050

Quantiles (Definition 5)

Quantile	Estimate
100% Max	223.83991
99%	223.83991
95%	84.59972
90%	69.84815
75% Q3	38.31198
50% Median	21.35518
25% Q1	9.84734
10%	4.29835
5%	3.55810
1%	3.14323
0% Min	3.14323

MONTH=8

Moments

N	4	Sum Weights	4
Mean	27.9192867	Sum Observations	111.677147
Std Deviation	21.6528863	Variance	468.847485
Skewness	1.4943337	Kurtosis	2.00458471
Uncorrected SS	4524.48873	Corrected SS	1406.54246
Coeff Variation	77.5552992	Std Error Mean	10.8264432

Basic Statistical Measures

Location		Variability	
Mean	27.91929	Std Deviation	21.65289
Median	20.80086	Variance	468.84749
Mode	.	Range	47.63846
		Interquartile Range	29.69900

Tests for Location: Mu0=0

Test	-Statistic-		-----p Value------	
Student's t	t	2.578805	Pr > |t|	0.0819
Sign	M	2	Pr >= |M|	0.1250
Signed Rank	S	5	Pr >= |S|	0.1250

Tests for Normality

Test	--Statistic---		-----p Value------	
Shapiro-Wilk	W	0.855879	Pr < W	0.2458
Kolmogorov-Smirnov	D	0.272809	Pr > D	>0.1500
Cramer-von Mises	W-Sq	0.064276	Pr > W-Sq	>0.2500
Anderson-Darling	A-Sq	0.377754	Pr > A-Sq	0.2152

Quantiles (Definition 5)

Quantile	Estimate
100% Max	58.8569
99%	58.8569
95%	58.8569
90%	58.8569
75% Q3	42.7688
50% Median	20.8009
25% Q1	13.0698
10%	11.2185
5%	11.2185
1%	11.2185
0% Min	11.2185

MONTH=9

Moments

N	10	Sum Weights	10
Mean	25.7159121	Sum Observations	257.159121
Std Deviation	33.493909	Variance	1121.84194
Skewness	2.09718522	Kurtosis	3.88927808
Uncorrected SS	16709.6588	Corrected SS	10096.5775
Coeff Variation	130.245853	Std Error Mean	10.591704

Basic Statistical Measures

Location		Variability	
Mean	25.71591	Std Deviation	33.49391
Median	10.82660	Variance	1122
Mode	.	Range	102.35820
		Interquartile Range	13.17475

Tests for Location: Mu0=0

Test	-Statistic-		-----p Value------	
Student's t	t	2.42793	Pr > |t|	0.0381
Sign	M	5	Pr >= |M|	0.0020
Signed Rank	S	27.5	Pr >= |S|	0.0020

Tests for Normality

Test	--Statistic---		-----p Value------	
Shapiro-Wilk	W	0.65208	Pr < W	0.0002
Kolmogorov-Smirnov	D	0.371723	Pr > D	<0.0100
Cramer-von Mises	W-Sq	0.312141	Pr > W-Sq	<0.0050
Anderson-Darling	A-Sq	1.595391	Pr > A-Sq	<0.0050

Quantiles (Definition 5)

Quantile	Estimate
100% Max	107.51558
99%	107.51558
95%	107.51558
90%	85.55501
75% Q3	19.66147
50% Median	10.82660
25% Q1	6.48672
10%	5.81853
5%	5.15738
1%	5.15738
0% Min	5.15738

MONTH=10

Moments

N	26	Sum Weights	26
Mean	14.6577084	Sum Observations	381.100419
Std Deviation	11.1009924	Variance	123.232033
Skewness	1.52710466	Kurtosis	1.67560345
Uncorrected SS	8666.85966	Corrected SS	3080.80083
Coeff Variation	75.7348427	Std Error Mean	2.17708373

Basic Statistical Measures

Location		Variability	
Mean	14.65771	Std Deviation	11.10099
Median	10.86398	Variance	123.23203
Mode	.	Range	39.54014
		Interquartile Range	10.40708

Tests for Location: Mu0=0

Test	-Statistic-		-----p Value------	
Student's t	t	6.732726	Pr > |t|	<.0001
Sign	M	13	Pr >= |M|	<.0001
Signed Rank	S	175.5	Pr >= |S|	<.0001

Tests for Normality

Test	--Statistic---		-----p Value------	
Shapiro-Wilk	W	0.813387	Pr < W	0.0003
Kolmogorov-Smirnov	D	0.222939	Pr > D	<0.0100
Cramer-von Mises	W-Sq	0.288877	Pr > W-Sq	<0.0050
Anderson-Darling	A-Sq	1.712793	Pr > A-Sq	<0.0050

Quantiles (Definition 5)

Quantile	Estimate
100% Max	43.08745
99%	43.08745
95%	42.42867
90%	35.17032
75% Q3	16.99697
50% Median	10.86398
25% Q1	6.58989
10%	4.59224
5%	4.09168
1%	3.54732
0% Min	3.54732

MONTH=11

Moments

N	31	Sum Weights	31
Mean	25.143604	Sum Observations	779.451724
Std Deviation	23.6746847	Variance	560.490694
Skewness	1.68751747	Kurtosis	2.48295285
Uncorrected SS	36412.9463	Corrected SS	16814.7208
Coeff Variation	94.1578807	Std Error Mean	4.25209889

Basic Statistical Measures

Location		Variability	
Mean	25.14360	Std Deviation	23.67468
Median	14.93037	Variance	560.49069
Mode	.	Range	95.10801
		Interquartile Range	23.16872

Tests for Location: Mu0=0

Test	-Statistic-		-----p Value------	
Student's t	t	5.913222	Pr > |t|	<.0001
Sign	M	15.5	Pr >= |M|	<.0001
Signed Rank	S	248	Pr >= |S|	<.0001

Tests for Normality

Test	--Statistic---		-----p Value------	
Shapiro-Wilk	W	0.795565	Pr < W	<0.0001
Kolmogorov-Smirnov	D	0.184018	Pr > D	<0.0100
Cramer-von Mises	W-Sq	0.392914	Pr > W-Sq	<0.0050
Anderson-Darling	A-Sq	2.225961	Pr > A-Sq	<0.0050

Quantiles (Definition 5)

Quantile	Estimate
100% Max	98.53440
99%	98.53440
95%	81.65519
90%	60.95860
75% Q3	31.85147
50% Median	14.93037
25% Q1	8.68275
10%	6.34412
5%	4.67714
1%	3.42638
0% Min	3.42638

MONTH=12

Moments

N	28	Sum Weights	28
Mean	37.7330339	Sum Observations	1056.52495
Std Deviation	36.1848696	Variance	1309.34479
Skewness	1.79337815	Kurtosis	2.9412148
Uncorrected SS	75218.2009	Corrected SS	35352.3093
Coeff Variation	95.8970586	Std Error Mean	6.83829758

Basic Statistical Measures

Location		Variability	
Mean	37.73303	Std Deviation	36.18487
Median	22.19895	Variance	1309
Mode	.	Range	136.15301
		Interquartile Range	35.40334

Tests for Location: Mu0=0

Test	-Statistic-		-----p Value------	
Student's t	t	5.517899	Pr > |t|	<.0001
Sign	M	14	Pr >= |M|	<.0001
Signed Rank	S	203	Pr >= |S|	<.0001

Tests for Normality

Test	--Statistic---		-----p Value------	
Shapiro-Wilk	W	0.779233	Pr < W	<0.0001
Kolmogorov-Smirnov	D	0.213711	Pr > D	<0.0100
Cramer-von Mises	W-Sq	0.343753	Pr > W-Sq	<0.0050
Anderson-Darling	A-Sq	2.06099	Pr > A-Sq	<0.0050

Quantiles (Definition 5)

Quantile	Estimate
100% Max	141.95697
99%	141.95697
95%	137.33931
90%	85.99529
75% Q3	50.33924
50% Median	22.19895
25% Q1	14.93590
10%	7.27443
5%	5.82145
1%	5.80396
0% Min	5.80396

APPENDIX E. SAS PROC UNIVARIATE output, variable = RW_SPUE, by season.

SEASON=WINTER

Moments

N	122	Sum Weights	122
Mean	27.4461588	Sum Observations	3348.43138
Std Deviation	59.579395	Variance	3549.70431
Skewness	7.26290684	Kurtosis	63.775509
Uncorrected SS	521415.801	Corrected SS	429514.221
Coeff Variation	217.077353	Std Error Mean	5.39406497

Basic Statistical Measures

Location		Variability	
Mean	27.44616	Std Deviation	59.57939
Median	12.16159	Variance	3550
Mode	.	Range	582.51913
		Interquartile Range	22.94043

Tests for Location: Mu0=0

Test	-Statistic-		-----p Value------	
Student's t	t	5.088214	Pr > |t|	<.0001
Sign	M	61	Pr >= |M|	<.0001
Signed Rank	S	3751.5	Pr >= |S|	<.0001

Tests for Normality

Test	--Statistic---		-----p Value------	
Shapiro-Wilk	W	0.358226	Pr < W	<0.0001
Kolmogorov-Smirnov	D	0.324092	Pr > D	<0.0100
Cramer-von Mises	W-Sq	4.26318	Pr > W-Sq	<0.0050
Anderson-Darling	A-Sq	21.80768	Pr > A-Sq	<0.0050

Quantiles (Definition 5)

Quantile	Estimate
100% Max	582.780014
99%	205.702752
95%	80.268109
90%	52.868155
75% Q3	28.470719
50% Median	12.161590
25% Q1	5.530290
10%	3.829491
5%	1.437864
1%	0.380524
0% Min	0.260879

SEASON=SPRING

Moments

N	340	Sum Weights	340
Mean	20.556709	Sum Observations	6989.28105
Std Deviation	22.9462596	Variance	526.53083
Skewness	2.54080048	Kurtosis	9.45243206
Uncorrected SS	322170.568	Corrected SS	178493.951
Coeff Variation	111.624189	Std Error Mean	1.24443565

Basic Statistical Measures

Location		Variability	
Mean	20.55671	Std Deviation	22.94626
Median	12.41075	Variance	526.53083
Mode	.	Range	164.32003
		Interquartile Range	21.79025

Tests for Location: Mu0=0

Test	-Statistic-		-----p Value------	
Student's t	t	16.5189	Pr > |t|	<.0001
Sign	M	170	Pr >= |M|	<.0001
Signed Rank	S	28985	Pr >= |S|	<.0001

Tests for Normality

Test	--Statistic---		-----p Value------	
Shapiro-Wilk	W	0.743541	Pr < W	<0.0001
Kolmogorov-Smirnov	D	0.193877	Pr > D	<0.0100
Cramer-von Mises	W-Sq	4.164415	Pr > W-Sq	<0.0050
Anderson-Darling	A-Sq	23.17488	Pr > A-Sq	<0.0050

Quantiles (Definition 5)

Quantile	Estimate
100% Max	165.058138
99%	108.117239
95%	64.565776
90%	50.277510
75% Q3	27.255112
50% Median	12.410754
25% Q1	5.464859
10%	3.008974
5%	1.975480
1%	0.894114
0% Min	0.738107

SEASON=SUMMER

Moments

N	72	Sum Weights	72
Mean	31.429563	Sum Observations	2262.92853
Std Deviation	35.5521477	Variance	1263.95521
Skewness	2.96944354	Kurtosis	12.3051174
Uncorrected SS	160863.675	Corrected SS	89740.8196
Coeff Variation	113.116901	Std Error Mean	4.18986079

Basic Statistical Measures

Location		Variability	
Mean	31.42956	Std Deviation	35.55215
Median	19.30415	Variance	1264
Mode	.	Range	220.69668
		Interquartile Range	28.09929

Tests for Location: Mu0=0

Test	-Statistic-		-----p Value------	
Student's t	t	7.501338	Pr > |t|	<.0001
Sign	M	36	Pr >= |M|	<.0001
Signed Rank	S	1314	Pr >= |S|	<.0001

Tests for Normality

Test	--Statistic---		-----p Value------	
Shapiro-Wilk	W	0.704127	Pr < W	<0.0001
Kolmogorov-Smirnov	D	0.213124	Pr > D	<0.0100
Cramer-von Mises	W-Sq	0.888876	Pr > W-Sq	<0.0050
Anderson-Darling	A-Sq	5.149304	Pr > A-Sq	<0.0050

Quantiles (Definition 5)

Quantile	Estimate
100% Max	223.83991
99%	223.83991
95%	84.59972
90%	67.84014
75% Q3	37.99572
50% Median	19.30415
25% Q1	9.89643
10%	5.15738
5%	4.16598
1%	3.14323
0% Min	3.14323

SEASON=FALL

Moments

N	85	Sum Weights	85
Mean	26.0832599	Sum Observations	2217.07709
Std Deviation	27.2705599	Variance	743.683439
Skewness	2.34140211	Kurtosis	6.29750619
Uncorrected SS	120298.007	Corrected SS	62469.4089
Coeff Variation	104.551962	Std Error Mean	2.95790753

Basic Statistical Measures

Location		Variability	
Mean	26.08326	Std Deviation	27.27056
Median	16.98951	Variance	743.68344
Mode	.	Range	138.53059
		Interquartile Range	24.02910

Tests for Location: Mu0=0

Test	-Statistic-		-----p Value------	
Student's t	t	8.818146	Pr > |t|	<.0001
Sign	M	42.5	Pr >= |M|	<.0001
Signed Rank	S	1827.5	Pr >= |S|	<.0001

Tests for Normality

Test	--Statistic---		-----p Value------	
Shapiro-Wilk	W	0.728646	Pr < W	<0.0001
Kolmogorov-Smirnov	D	0.207133	Pr > D	<0.0100
Cramer-von Mises	W-Sq	1.237581	Pr > W-Sq	<0.0050
Anderson-Darling	A-Sq	6.911631	Pr > A-Sq	<0.0050

Quantiles (Definition 5)

Quantile	Estimate
100% Max	141.95697
99%	141.95697
95%	85.11099
90%	59.69861
75% Q3	32.99609
50% Median	16.98951
25% Q1	8.96699
10%	5.82145
5%	4.67714
1%	3.42638
0% Min	3.42638

APPENDIX F. SAS PROC UNIVARIATE output, variable = HW_SPUE, by month.

MONTH=1

Moments

N	21	Sum Weights	21
Mean	27.3821804	Sum Observations	575.025789
Std Deviation	34.6543486	Variance	1200.92388
Skewness	1.56192605	Kurtosis	1.65150167
Uncorrected SS	39763.9375	Corrected SS	24018.4776
Coeff Variation	126.558032	Std Error Mean	7.56219885

Basic Statistical Measures

Location		Variability	
Mean	27.38218	Std Deviation	34.65435
Median	10.35902	Variance	1201
Mode	.	Range	123.35132
		Interquartile Range	34.00453

Tests for Location: Mu0=0

Test	-Statistic-		-----p Value------	
Student's t	t	3.620928	Pr > |t|	0.0017
Sign	M	10.5	Pr >= |M|	<.0001
Signed Rank	S	115.5	Pr >= |S|	<.0001

Tests for Normality

Test	--Statistic---		-----p Value------	
Shapiro-Wilk	W	0.754969	Pr < W	0.0001
Kolmogorov-Smirnov	D	0.315394	Pr > D	<0.0100
Cramer-von Mises	W-Sq	0.411747	Pr > W-Sq	<0.0050
Anderson-Darling	A-Sq	2.139958	Pr > A-Sq	<0.0050

Quantiles (Definition 5)

Quantile	Estimate
100% Max	123.694189
99%	123.694189
95%	82.126045
90%	78.866375
75% Q3	38.166148
50% Median	10.359023
25% Q1	4.161616
10%	1.158904
5%	0.581027
1%	0.342872
0% Min	0.342872

MONTH=2

Moments

N	11	Sum Weights	11
Mean	6.098482	Sum Observations	67.083302
Std Deviation	9.94394314	Variance	98.8820052
Skewness	2.47825547	Kurtosis	6.28008434
Uncorrected SS	1397.92636	Corrected SS	988.820052
Coeff Variation	163.056038	Std Error Mean	2.99821167

Basic Statistical Measures

Location		Variability	
Mean	6.098482	Std Deviation	9.94394
Median	2.687041	Variance	98.88201
Mode	.	Range	33.15114
		Interquartile Range	4.20148

Tests for Location: Mu0=0

Test	-Statistic-		-----p Value------	
Student's t	t	2.03404	Pr > |t|	0.0693
Sign	M	5.5	Pr >= |M|	0.0010
Signed Rank	S	33	Pr >= |S|	0.0010

Tests for Normality

Test	--Statistic---		-----p Value------	
Shapiro-Wilk	W	0.63068	Pr < W	<0.0001
Kolmogorov-Smirnov	D	0.386633	Pr > D	<0.0100
Cramer-von Mises	W-Sq	0.327194	Pr > W-Sq	<0.0050
Anderson-Darling	A-Sq	1.725952	Pr > A-Sq	<0.0050

Quantiles (Definition 5)

Quantile	Estimate
100% Max	33.281077
99%	33.281077
95%	33.281077
90%	15.071855
75% Q3	4.383831
50% Median	2.687041
25% Q1	0.182355
10%	0.172161
5%	0.129941
1%	0.129941
0% Min	0.129941

MONTH=3

Moments

N	50	Sum Weights	50
Mean	12.0434733	Sum Observations	602.173664
Std Deviation	12.6076218	Variance	158.952127
Skewness	2.08503111	Kurtosis	5.88825395
Uncorrected SS	15040.9167	Corrected SS	7788.65423
Coeff Variation	104.684267	Std Error Mean	1.78298697

Basic Statistical Measures

Location		Variability	
Mean	12.04347	Std Deviation	12.60762
Median	7.96415	Variance	158.95213
Mode	.	Range	65.45928
		Interquartile Range	13.85576

Tests for Location: Mu0=0

Test	-Statistic-		-----p Value------	
Student's t	t	6.754661	Pr > |t|	<.0001
Sign	M	25	Pr >= |M|	<.0001
Signed Rank	S	637.5	Pr >= |S|	<.0001

Tests for Normality

Test	--Statistic---		-----p Value------	
Shapiro-Wilk	W	0.803821	Pr < W	<0.0001
Kolmogorov-Smirnov	D	0.173158	Pr > D	<0.0100
Cramer-von Mises	W-Sq	0.421274	Pr > W-Sq	<0.0050
Anderson-Darling	A-Sq	2.478784	Pr > A-Sq	<0.0050

Quantiles (Definition 5)

Quantile	Estimate
100% Max	65.629433
99%	65.629433
95%	35.457431
90%	28.233028
75% Q3	17.030622
50% Median	7.964149
25% Q1	3.174858
10%	0.555507
5%	0.282192
1%	0.170151
0% Min	0.170151

MONTH=4

Moments

N	116	Sum Weights	116
Mean	17.389895	Sum Observations	2017.22783
Std Deviation	22.035105	Variance	485.545855
Skewness	3.16372878	Kurtosis	13.1016573
Uncorrected SS	90917.1534	Corrected SS	55837.7733
Coeff Variation	126.712122	Std Error Mean	2.04590814

Basic Statistical Measures

Location		Variability	
Mean	17.38990	Std Deviation	22.03511
Median	9.32983	Variance	485.54585
Mode	.	Range	143.83386
		Interquartile Range	18.72503

Tests for Location: Mu0=0

Test	-Statistic-		-----p Value------	
Student's t	t	8.499842	Pr > |t|	<.0001
Sign	M	58	Pr >= |M|	<.0001
Signed Rank	S	3393	Pr >= |S|	<.0001

Tests for Normality

Test	--Statistic---		-----p Value------	
Shapiro-Wilk	W	0.664398	Pr < W	<0.0001
Kolmogorov-Smirnov	D	0.218327	Pr > D	<0.0100
Cramer-von Mises	W-Sq	1.864709	Pr > W-Sq	<0.0050
Anderson-Darling	A-Sq	10.34299	Pr > A-Sq	<0.0050

Quantiles (Definition 5)

Quantile	Estimate
100% Max	144.072875
99%	121.339987
95%	59.819731
90%	36.457695
75% Q3	23.458003
50% Median	9.329832
25% Q1	4.732977
10%	2.148739
5%	1.554511
1%	0.655212
0% Min	0.239018

MONTH=5

Moments

N	162	Sum Weights	162
Mean	24.0426201	Sum Observations	3894.90445
Std Deviation	36.5346995	Variance	1334.78427
Skewness	3.66899665	Kurtosis	16.9736275
Uncorrected SS	308543.975	Corrected SS	214900.267
Coeff Variation	151.958062	Std Error Mean	2.87043709

Basic Statistical Measures

Location		Variability	
Mean	24.04262	Std Deviation	36.53470
Median	11.25746	Variance	1335
Mode	.	Range	262.40013
		Interquartile Range	21.85683

Tests for Location: Mu0=0

Test	-Statistic-		-----p Value------	
Student's t	t	8.375944	Pr > |t|	<.0001
Sign	M	81	Pr >= |M|	<.0001
Signed Rank	S	6601.5	Pr >= |S|	<.0001

Tests for Normality

Test	--Statistic---		-----p Value------	
Shapiro-Wilk	W	0.58456	Pr < W	<0.0001
Kolmogorov-Smirnov	D	0.260568	Pr > D	<0.0100
Cramer-von Mises	W-Sq	3.759538	Pr > W-Sq	<0.0050
Anderson-Darling	A-Sq	19.9683	Pr > A-Sq	<0.0050

Quantiles (Definition 5)

Quantile	Estimate
100% Max	263.002317
99%	221.643042
95%	101.007228
90%	53.856551
75% Q3	27.081036
50% Median	11.257462
25% Q1	5.224202
10%	2.129723
5%	1.358736
1%	0.611124
0% Min	0.602182

MONTH=6

Moments

N	169	Sum Weights	169
Mean	28.4805938	Sum Observations	4813.22035
Std Deviation	33.7516281	Variance	1139.1724
Skewness	2.05390959	Kurtosis	4.32813836
Uncorrected SS	328464.337	Corrected SS	191380.963
Coeff Variation	118.507459	Std Error Mean	2.59627909

Basic Statistical Measures

Location		Variability	
Mean	28.48059	Std Deviation	33.75163
Median	16.20142	Variance	1139
Mode	.	Range	174.79009
		Interquartile Range	27.58352

Tests for Location: Mu0=0

Test	-Statistic-		-----p Value------	
Student's t	t	10.96977	Pr > |t|	<.0001
Sign	M	84.5	Pr >= |M|	<.0001
Signed Rank	S	7182.5	Pr >= |S|	<.0001

Tests for Normality

Test	--Statistic---		-----p Value------	
Shapiro-Wilk	W	0.738333	Pr < W	<0.0001
Kolmogorov-Smirnov	D	0.223633	Pr > D	<0.0100
Cramer-von Mises	W-Sq	2.770024	Pr > W-Sq	<0.0050
Anderson-Darling	A-Sq	15.02698	Pr > A-Sq	<0.0050

Quantiles (Definition 5)

Quantile	Estimate
100% Max	175.703484
99%	174.366319
95%	100.630739
90%	85.126029
75% Q3	34.070168
50% Median	16.201424
25% Q1	6.486646
10%	3.119105
5%	1.522046
1%	0.986027
0% Min	0.913396

MONTH=7

Moments

N	117	Sum Weights	117
Mean	42.0385789	Sum Observations	4918.51373
Std Deviation	54.9631862	Variance	3020.95184
Skewness	2.85293095	Kurtosis	9.89811086
Uncorrected SS	557197.742	Corrected SS	350430.414
Coeff Variation	130.744634	Std Error Mean	5.08134837

Basic Statistical Measures

Location		Variability	
Mean	42.03858	Std Deviation	54.96319
Median	21.95545	Variance	3021
Mode	.	Range	328.67332
		Interquartile Range	35.71819

Tests for Location: Mu0=0

Test	-Statistic-		-----p Value------	
Student's t	t	8.273115	Pr > |t|	<.0001
Sign	M	58.5	Pr >= |M|	<.0001
Signed Rank	S	3451.5	Pr >= |S|	<.0001

Tests for Normality

Test	--Statistic---		-----p Value------	
Shapiro-Wilk	W	0.661979	Pr < W	<0.0001
Kolmogorov-Smirnov	D	0.244479	Pr > D	<0.0100
Cramer-von Mises	W-Sq	2.283435	Pr > W-Sq	<0.0050
Anderson-Darling	A-Sq	12.06559	Pr > A-Sq	<0.0050

Quantiles (Definition 5)

Quantile	Estimate
100% Max	331.22881
99%	277.62645
95%	148.64174
90%	106.87026
75% Q3	46.35175
50% Median	21.95545
25% Q1	10.63356
10%	5.83934
5%	4.76115
1%	2.84392
0% Min	2.55550

MONTH=8

Moments

N	76	Sum Weights	76
Mean	60.8835168	Sum Observations	4627.14727
Std Deviation	63.5541032	Variance	4039.12403
Skewness	2.03384406	Kurtosis	4.23030183
Uncorrected SS	584651.301	Corrected SS	302934.302
Coeff Variation	104.386387	Std Error Mean	7.29015561

Basic Statistical Measures

Location		Variability	
Mean	60.88352	Std Deviation	63.55410
Median	40.25671	Variance	4039
Mode	.	Range	315.15136
		Interquartile Range	54.07848

Tests for Location: Mu0=0

Test	-Statistic-		-----p Value------	
Student's t	t	8.35147	Pr > |t|	<.0001
Sign	M	38	Pr >= |M|	<.0001
Signed Rank	S	1463	Pr >= |S|	<.0001

Tests for Normality

Test	--Statistic---		-----p Value------	
Shapiro-Wilk	W	0.7583	Pr < W	<0.0001
Kolmogorov-Smirnov	D	0.224856	Pr > D	<0.0100
Cramer-von Mises	W-Sq	1.077573	Pr > W-Sq	<0.0050
Anderson-Darling	A-Sq	6.045639	Pr > A-Sq	<0.0050

Quantiles (Definition 5)

Quantile	Estimate
100% Max	316.98177
99%	316.98177
95%	211.01978
90%	163.16776
75% Q3	75.96842
50% Median	40.25671
25% Q1	21.88994
10%	11.26523
5%	7.14221
1%	1.83041
0% Min	1.83041

MONTH=9

Moments

N	84	Sum Weights	84
Mean	33.3731953	Sum Observations	2803.3484
Std Deviation	42.877596	Variance	1838.48824
Skewness	3.04592229	Kurtosis	9.92082789
Uncorrected SS	246151.218	Corrected SS	152594.524
Coeff Variation	128.479145	Std Error Mean	4.67832927

Basic Statistical Measures

Location		Variability	
Mean	33.37320	Std Deviation	42.87760
Median	18.12605	Variance	1838
Mode	.	Range	231.37057
		Interquartile Range	24.82800

Tests for Location: Mu0=0

Test	-Statistic-		-----p Value------	
Student's t	t	7.133571	Pr > |t|	<.0001
Sign	M	42	Pr >= |M|	<.0001
Signed Rank	S	1785	Pr >= |S|	<.0001

Tests for Normality

Test	--Statistic---		-----p Value------	
Shapiro-Wilk	W	0.60832	Pr < W	<0.0001
Kolmogorov-Smirnov	D	0.250465	Pr > D	<0.0100
Cramer-von Mises	W-Sq	1.910579	Pr > W-Sq	<0.0050
Anderson-Darling	A-Sq	10.45527	Pr > A-Sq	<0.0050

Quantiles (Definition 5)

Quantile	Estimate
100% Max	232.89373
99%	232.89373
95%	104.81999
90%	73.07631
75% Q3	35.09357
50% Median	18.12605
25% Q1	10.26556
10%	7.27213
5%	6.70285
1%	1.52316
0% Min	1.52316

MONTH=10

Moments

N	89	Sum Weights	89
Mean	38.7235274	Sum Observations	3446.39394
Std Deviation	48.9892478	Variance	2399.9464
Skewness	2.58648194	Kurtosis	6.95461696
Uncorrected SS	344651.813	Corrected SS	211195.283
Coeff Variation	126.510292	Std Error Mean	5.19284988

Basic Statistical Measures

Location		Variability	
Mean	38.72353	Std Deviation	48.98925
Median	20.61054	Variance	2400
Mode	.	Range	248.45100
		Interquartile Range	33.46925

Tests for Location: Mu0=0

Test	-Statistic-		-----p Value------	
Student's t	t	7.457086	Pr > |t|	<.0001
Sign	M	44.5	Pr >= |M|	<.0001
Signed Rank	S	2002.5	Pr >= |S|	<.0001

Tests for Normality

Test	--Statistic---		-----p Value------	
Shapiro-Wilk	W	0.657197	Pr < W	<0.0001
Kolmogorov-Smirnov	D	0.266955	Pr > D	<0.0100
Cramer-von Mises	W-Sq	1.923805	Pr > W-Sq	<0.0050
Anderson-Darling	A-Sq	10.30004	Pr > A-Sq	<0.0050

Quantiles (Definition 5)

Quantile	Estimate
100% Max	252.05948
99%	252.05948
95%	160.30068
90%	91.86442
75% Q3	44.77475
50% Median	20.61054
25% Q1	11.30550
10%	6.58989
5%	4.71430
1%	3.60848
0% Min	3.60848

MONTH=11

Moments

N	73	Sum Weights	73
Mean	35.0367736	Sum Observations	2557.68447
Std Deviation	42.4635614	Variance	1803.15404
Skewness	3.01201817	Kurtosis	10.5779506
Uncorrected SS	219440.103	Corrected SS	129827.091
Coeff Variation	121.197122	Std Error Mean	4.96998394

Basic Statistical Measures

Location		Variability	
Mean	35.03677	Std Deviation	42.46356
Median	22.75136	Variance	1803
Mode	.	Range	238.78130
		Interquartile Range	31.73853

Tests for Location: Mu0=0

Test	-Statistic-		-----p Value------	
Student's t	t	7.049675	Pr > |t|	<.0001
Sign	M	36.5	Pr >= |M|	<.0001
Signed Rank	S	1350.5	Pr >= |S|	<.0001

Tests for Normality

Test	--Statistic---		-----p Value------	
Shapiro-Wilk	W	0.65168	Pr < W	<0.0001
Kolmogorov-Smirnov	D	0.22928	Pr > D	<0.0100
Cramer-von Mises	W-Sq	1.236488	Pr > W-Sq	<0.0050
Anderson-Darling	A-Sq	7.18001	Pr > A-Sq	<0.0050

Quantiles (Definition 5)

Quantile	Estimate
100% Max	242.34320
99%	242.34320
95%	141.16889
90%	63.91812
75% Q3	42.08058
50% Median	22.75136
25% Q1	10.34205
10%	7.15559
5%	4.33314
1%	3.56190
0% Min	3.56190

MONTH=12

Moments

N	42	Sum Weights	42
Mean	24.9428055	Sum Observations	1047.59783
Std Deviation	30.7253473	Variance	944.046966
Skewness	3.83420977	Kurtosis	18.9052713
Uncorrected SS	64835.9545	Corrected SS	38705.9256
Coeff Variation	123.183205	Std Error Mean	4.74102401

Basic Statistical Measures

Location		Variability	
Mean	24.94281	Std Deviation	30.72535
Median	14.97920	Variance	944.04697
Mode	.	Range	185.29282
		Interquartile Range	26.33592

Tests for Location: Mu0=0

Test	-Statistic-		-----p Value------	
Student's t	t	5.261059	Pr > |t|	<.0001
Sign	M	21	Pr >= |M|	<.0001
Signed Rank	S	451.5	Pr >= |S|	<.0001

Tests for Normality

Test	--Statistic---		-----p Value------	
Shapiro-Wilk	W	0.611597	Pr < W	<0.0001
Kolmogorov-Smirnov	D	0.224504	Pr > D	<0.0100
Cramer-von Mises	W-Sq	0.673235	Pr > W-Sq	<0.0050
Anderson-Darling	A-Sq	3.92566	Pr > A-Sq	<0.0050

Quantiles (Definition 5)

Quantile	Estimate
100% Max	186.97444
99%	186.97444
95%	63.87875
90%	54.96322
75% Q3	34.82375
50% Median	14.97920
25% Q1	8.48784
10%	3.98217
5%	2.72994
1%	1.68162
0% Min	1.68162

APPENDIX G. SAS PROC UNIVARIATE output, variable = HW_SPUE, by season.

SEASON=WINTER

Moments

N	82	Sum Weights	82
Mean	15.1741799	Sum Observations	1244.28276
Std Deviation	21.4653928	Variance	460.763088
Skewness	2.81576186	Kurtosis	9.2793858
Uncorrected SS	56202.7806	Corrected SS	37321.8101
Coeff Variation	141.459986	Std Error Mean	2.37045608

Basic Statistical Measures

Location		Variability	
Mean	15.17418	Std Deviation	21.46539
Median	7.66309	Variance	460.76309
Mode	.	Range	123.56425
		Interquartile Range	14.66501

Tests for Location: Mu0=0

Test	-Statistic-		-----p Value------	
Student's t	t	6.401376	Pr > |t|	<.0001
Sign	M	41	Pr >= |M|	<.0001
Signed Rank	S	1701.5	Pr >= |S|	<.0001

Tests for Normality

Test	--Statistic---		-----p Value------	
Shapiro-Wilk	W	0.660579	Pr < W	<0.0001
Kolmogorov-Smirnov	D	0.241695	Pr > D	<0.0100
Cramer-von Mises	W-Sq	1.584801	Pr > W-Sq	<0.0050
Anderson-Darling	A-Sq	8.683462	Pr > A-Sq	<0.0050

Quantiles (Definition 5)

Quantile	Estimate
100% Max	123.694189
99%	123.694189
95%	65.629433
90%	35.457431
75% Q3	17.617894
50% Median	7.663092
25% Q1	2.952887
10%	0.515412
5%	0.225418
1%	0.129941
0% Min	0.129941

SEASON=SPRING

Moments

N	447	Sum Weights	447
Mean	23.9940775	Sum Observations	10725.3526
Std Deviation	32.4825073	Variance	1055.11328
Skewness	3.08000223	Kurtosis	12.662336
Uncorrected SS	727925.465	Corrected SS	470580.524
Coeff Variation	135.377188	Std Error Mean	1.53636988

Basic Statistical Measures

Location		Variability	
Mean	23.99408	Std Deviation	32.48251
Median	13.54781	Variance	1055
Mode	.	Range	262.76330
		Interquartile Range	22.54368

Tests for Location: Mu0=0

Test	-Statistic-		-----p Value------	
Student's t	t	15.61738	Pr > |t|	<.0001
Sign	M	223.5	Pr >= |M|	<.0001
Signed Rank	S	50064	Pr >= |S|	<.0001

Tests for Normality

Test	--Statistic---		-----p Value------	
Shapiro-Wilk	W	0.653115	Pr < W	<0.0001
Kolmogorov-Smirnov	D	0.233483	Pr > D	<0.0100
Cramer-von Mises	W-Sq	8.638684	Pr > W-Sq	<0.0050
Anderson-Darling	A-Sq	46.51862	Pr > A-Sq	<0.0050

Quantiles (Definition 5)

Quantile	Estimate
100% Max	263.002317
99%	144.072875
95%	98.272187
90%	59.819731
75% Q3	28.081184
50% Median	13.547814
25% Q1	5.537503
10%	2.356832
5%	1.522046
1%	0.714876
0% Min	0.239018

SEASON=SUMMER

Moments

N	277	Sum Weights	277
Mean	44.5812614	Sum Observations	12349.0094
Std Deviation	55.0844491	Variance	3034.29653
Skewness	2.59425083	Kurtosis	7.59915401
Uncorrected SS	1388000.26	Corrected SS	837465.843
Coeff Variation	123.559647	Std Error Mean	3.30970378

Basic Statistical Measures

Location		Variability	
Mean	44.58126	Std Deviation	55.08445
Median	22.98547	Variance	3034
Mode	.	Range	329.70566
		Interquartile Range	41.60719

Tests for Location: Mu0=0

Test	-Statistic-		-----p Value------	
Student's t	t	13.46986	Pr > |t|	<.0001
Sign	M	138.5	Pr >= |M|	<.0001
Signed Rank	S	19251.5	Pr >= |S|	<.0001

Tests for Normality

Test	--Statistic---		-----p Value------	
Shapiro-Wilk	W	0.682151	Pr < W	<0.0001
Kolmogorov-Smirnov	D	0.217339	Pr > D	<0.0100
Cramer-von Mises	W-Sq	5.141498	Pr > W-Sq	<0.0050
Anderson-Darling	A-Sq	27.80585	Pr > A-Sq	<0.0050

Quantiles (Definition 5)

Quantile	Estimate
100% Max	331.22881
99%	277.62645
95%	173.03697
90%	104.81999
75% Q3	53.68837
50% Median	22.98547
25% Q1	12.08118
10%	7.09228
5%	5.51638
1%	2.55550
0% Min	1.52316

SEASON=FALL

Moments

N	204	Sum Weights	204
Mean	34.5670404	Sum Observations	7051.67624
Std Deviation	43.5591604	Variance	1897.40046
Skewness	2.90850242	Kurtosis	9.29510938
Uncorrected SS	628927.871	Corrected SS	385172.293
Coeff Variation	126.013566	Std Error Mean	3.04975124

Basic Statistical Measures

Location		Variability	
Mean	34.56704	Std Deviation	43.55916
Median	20.58982	Variance	1897
Mode	.	Range	250.37786
		Interquartile Range	28.62076

Tests for Location: Mu0=0

Test	-Statistic-		-----p Value------	
Student's t	t	11.33438	Pr > |t|	<.0001
Sign	M	102	Pr >= |M|	<.0001
Signed Rank	S	10455	Pr >= |S|	<.0001

Tests for Normality

Test	--Statistic---		-----p Value------	
Shapiro-Wilk	W	0.641326	Pr < W	<0.0001
Kolmogorov-Smirnov	D	0.225884	Pr > D	<0.0100
Cramer-von Mises	W-Sq	3.999889	Pr > W-Sq	<0.0050
Anderson-Darling	A-Sq	22.17986	Pr > A-Sq	<0.0050

Quantiles (Definition 5)

Quantile	Estimate
100% Max	252.05948
99%	216.67745
95%	127.11922
90%	67.16094
75% Q3	38.92002
50% Median	20.58982
25% Q1	10.29926
10%	6.58989
5%	3.98856
1%	2.72994
0% Min	1.68162

APPENDIX H: SAS PROC UNIVARIATE output, variable = EFFORT, with all records having EFFORT < 13 km deleted

Moments

N	6855	Sum Weights	6855
Mean	157.287392	Sum Observations	1078205.07
Std Deviation	533.71554	Variance	284852.278
Skewness	15.2554205	Kurtosis	318.520449
Uncorrected SS	2121965578	Corrected SS	1952377513
Coeff Variation	339.325061	Std Error Mean	6.44623478

Basic Statistical Measures

Location		Variability	
Mean	157.2874	Std Deviation	533.71554
Median	66.9407	Variance	284852
Mode	.	Range	16113
		Interquartile Range	82.88266

Tests for Location: Mu0=0

Test	-Statistic-		-----p Value------	
Student's t	t	24.39989	Pr > |t|	<.0001
Sign	M	3427.5	Pr >= |M|	<.0001
Signed Rank	S	11749470	Pr >= |S|	<.0001

Tests for Normality

Test	--Statistic---		-----p Value------	
Kolmogorov-Smirnov	D	0.393452	Pr > D	<0.0100
Cramer-von Mises	W-Sq	350.4963	Pr > W-Sq	<0.0050
Anderson-Darling	A-Sq	1698.351	Pr > A-Sq	<0.0050

Quantiles (Definition 5)

Quantile	Estimate
100% Max	16125.8617
99%	1753.0419
95%	440.9185
90%	250.7168
75% Q3	120.4695
50% Median	66.9407
25% Q1	37.5868
10%	22.2468
5%	16.2288
1%	13.4278
0% Min	13.0071