Density Model for White-Beaked Dolphin (*Lagenorhynchus albirostris*) for the U.S. East Coast: Supplementary Report

Duke University Marine Geospatial Ecology Lab*

Model Version 2.2 - 2015-10-06

Citation

When referencing our methodology or results generally, please cite our open-access article:

Roberts JJ, Best BD, Mannocci L, Fujioka E, Halpin PN, Palka DL, Garrison LP, Mullin KD, Cole TVN, Khan CB, McLellan WM, Pabst DA, Lockhart GG (2016) Habitat-based cetacean density models for the U.S. Atlantic and Gulf of Mexico. Scientific Reports 6: 22615. doi: 10.1038/srep22615

To reference this specific model or Supplementary Report, please cite:

Roberts JJ, Best BD, Mannocci L, Fujioka E, Halpin PN, Palka DL, Garrison LP, Mullin KD, Cole TVN, Khan CB, McLellan WM, Pabst DA, Lockhart GG (2015) Density Model for White-Beaked Dolphin (*Lagenorhynchus albirostris*) for the U.S. East Coast Version 2.2, 2015-10-06, and Supplementary Report. Marine Geospatial Ecology Lab, Duke University, Durham, North Carolina.

Copyright and License

Revision History

Version	Date	Description of changes
1	2014-11-20	Initial version.
2	2015-03-06	Fixed bug that applied the wrong detection function to segments NE_narwss_1999_widgeon_hapo dataset. Refitted model. Updated documentation.
2.1	2015-05-14	Updated calculation of CVs. Switched density rasters to logarithmic breaks. No changes to the model.
2.2	2015-10-06	Updated the documentation. No changes to the model.

*For questions, or to offer feedback about this model or report, please contact Jason Roberts (jason.roberts@duke.edu)

Survey Data

Survey	Period	Length (1000 km)	Hours	Sightings
NEFSC Aerial Surveys	1995-2008	70	412	5
NEFSC NARWSS Harbor Porpoise Survey	1999-1999	6	36	0
NEFSC North Atlantic Right Whale Sighting Survey	1999-2013	432	2330	7
NEFSC Shipboard Surveys	1995-2004	16	1143	0
NJDEP Aerial Surveys	2008-2009	11	60	0
NJDEP Shipboard Surveys	2008-2009	14	836	0
SEFSC Atlantic Shipboard Surveys	1992-2005	28	1731	0
SEFSC Mid Atlantic Tursiops Aerial Surveys	1995-2005	35	196	0
SEFSC Southeast Cetacean Aerial Surveys	1992-1995	8	42	0
UNCW Cape Hatteras Navy Surveys	2011-2013	19	125	0
UNCW Early Marine Mammal Surveys	2002-2002	18	98	0
UNCW Jacksonville Navy Surveys	2009-2013	66	402	0
UNCW Onslow Navy Surveys	2007-2011	49	282	0
UNCW Right Whale Surveys	2005-2008	114	586	0
Virginia Aquarium Aerial Surveys	2012-2014	9	53	0
Total		895	8332	12

Table 2: Survey effort and sightings used in this model. Effort is tallied as the cumulative length of on-effort transects and hours the survey team was on effort. Sightings are the number of on-effort encounters of the modeled species for which a perpendicular sighting distance (PSD) was available. Off effort sightings and those without PSDs were omitted from the analysis.

Season	Months	Length (1000 km)	Hours	Sightings
All_Year	All	897	8332	12

Table 3: Survey effort and on-effort sightings having perpendicular sighting distances.

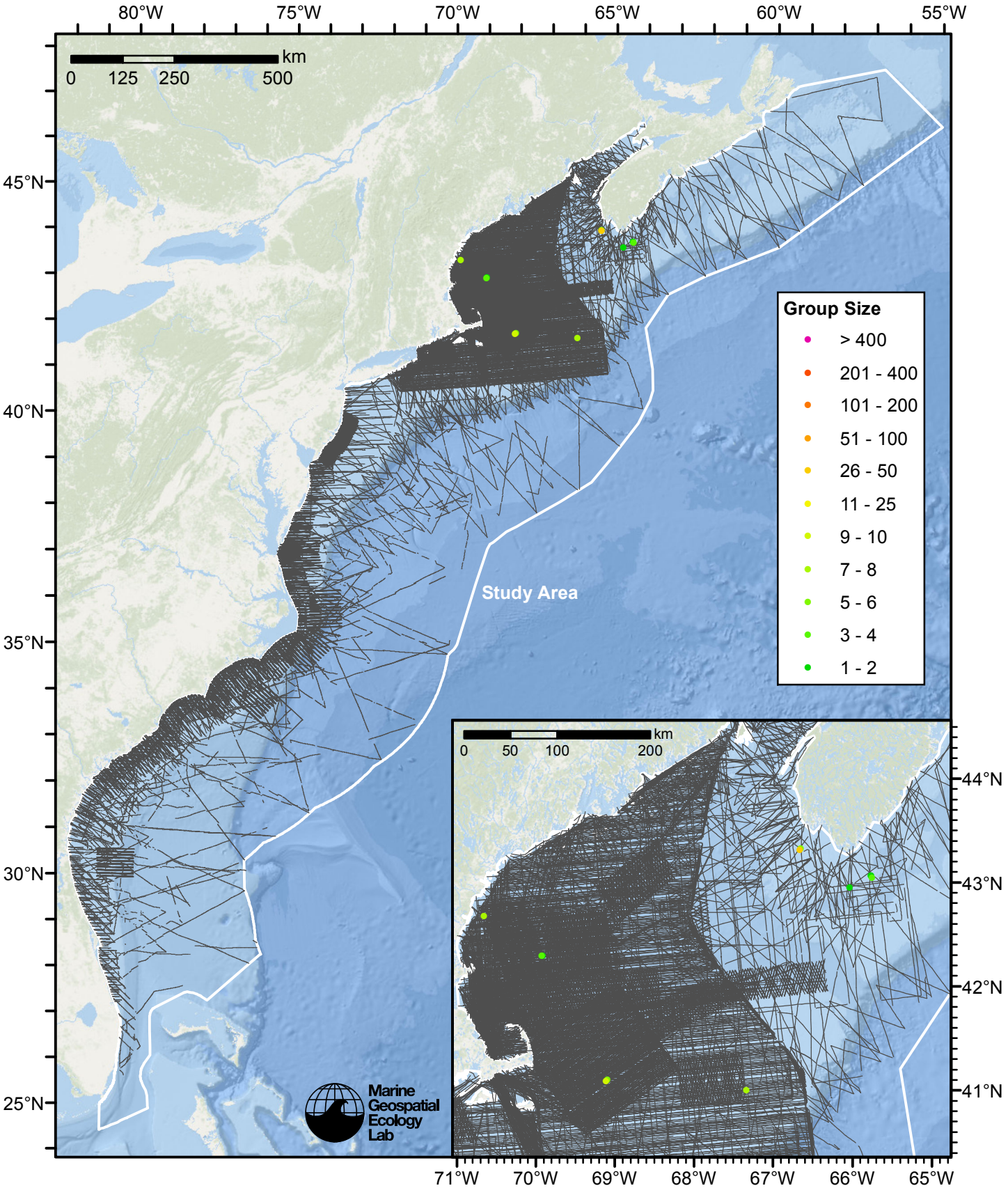

Figure 1: White-beaked dolphin sightings and survey tracklines.

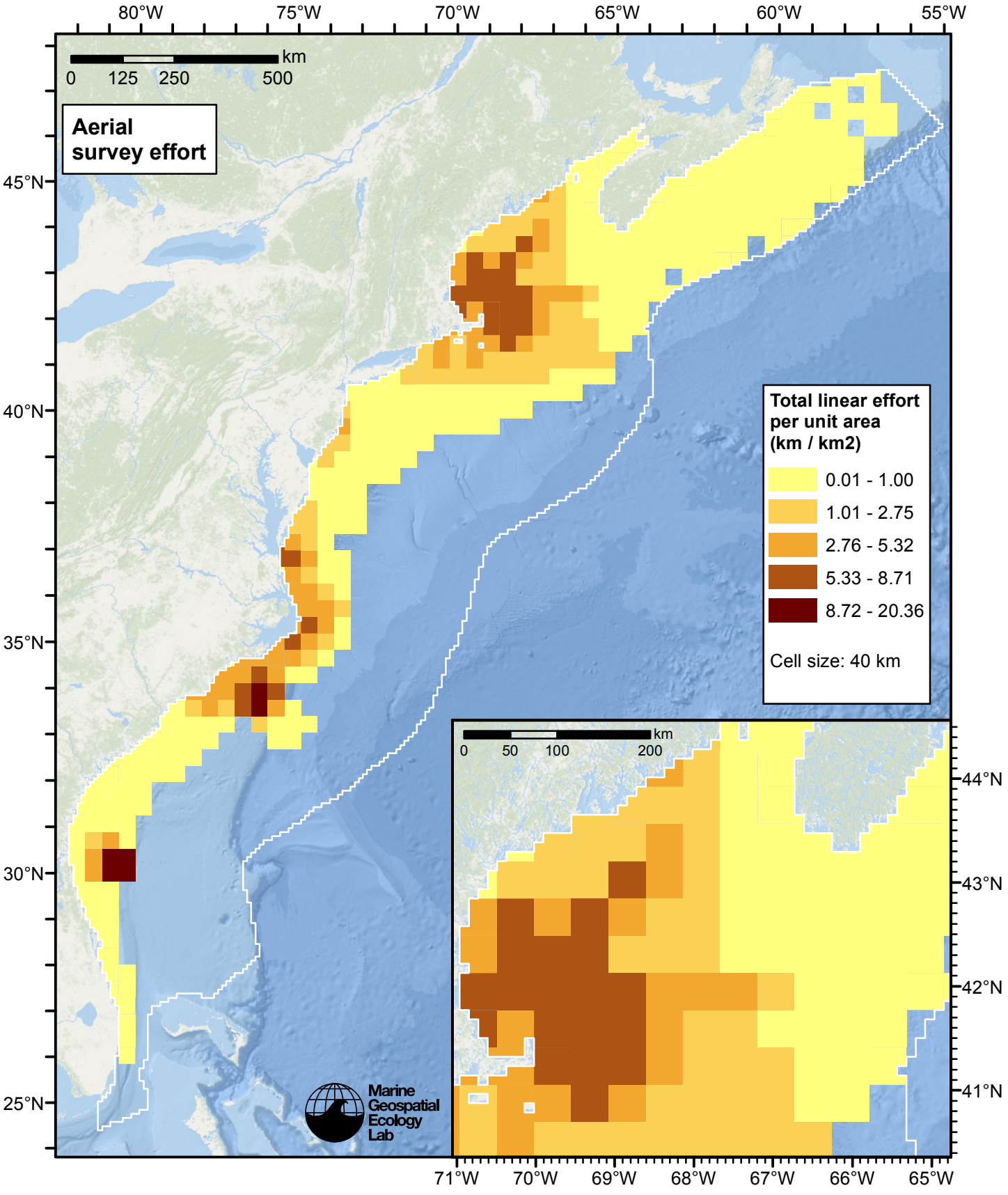

Figure 2: Aerial linear survey effort per unit area.

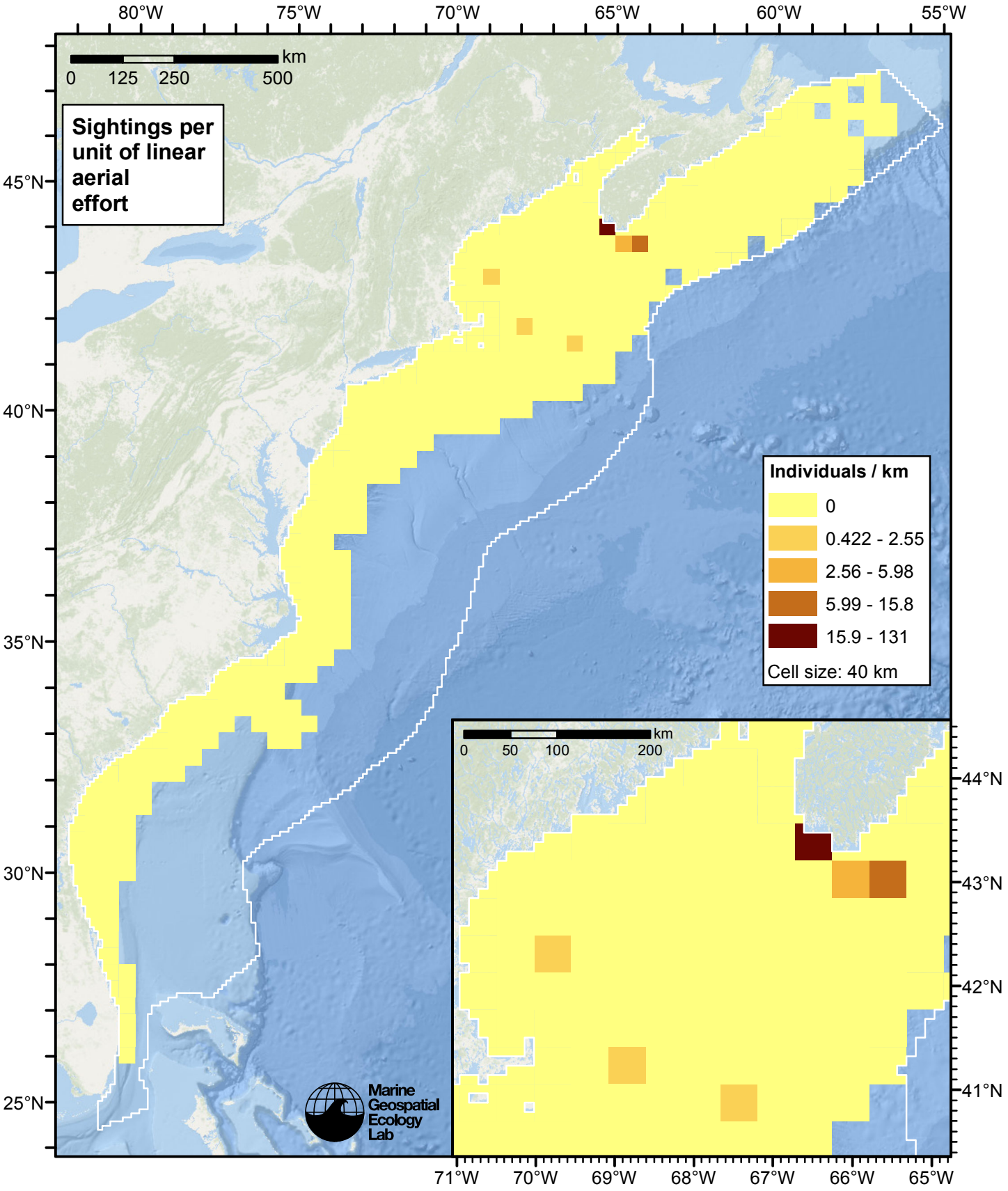

Figure 3: White-beaked dolphin sightings per unit aerial linear survey effort.

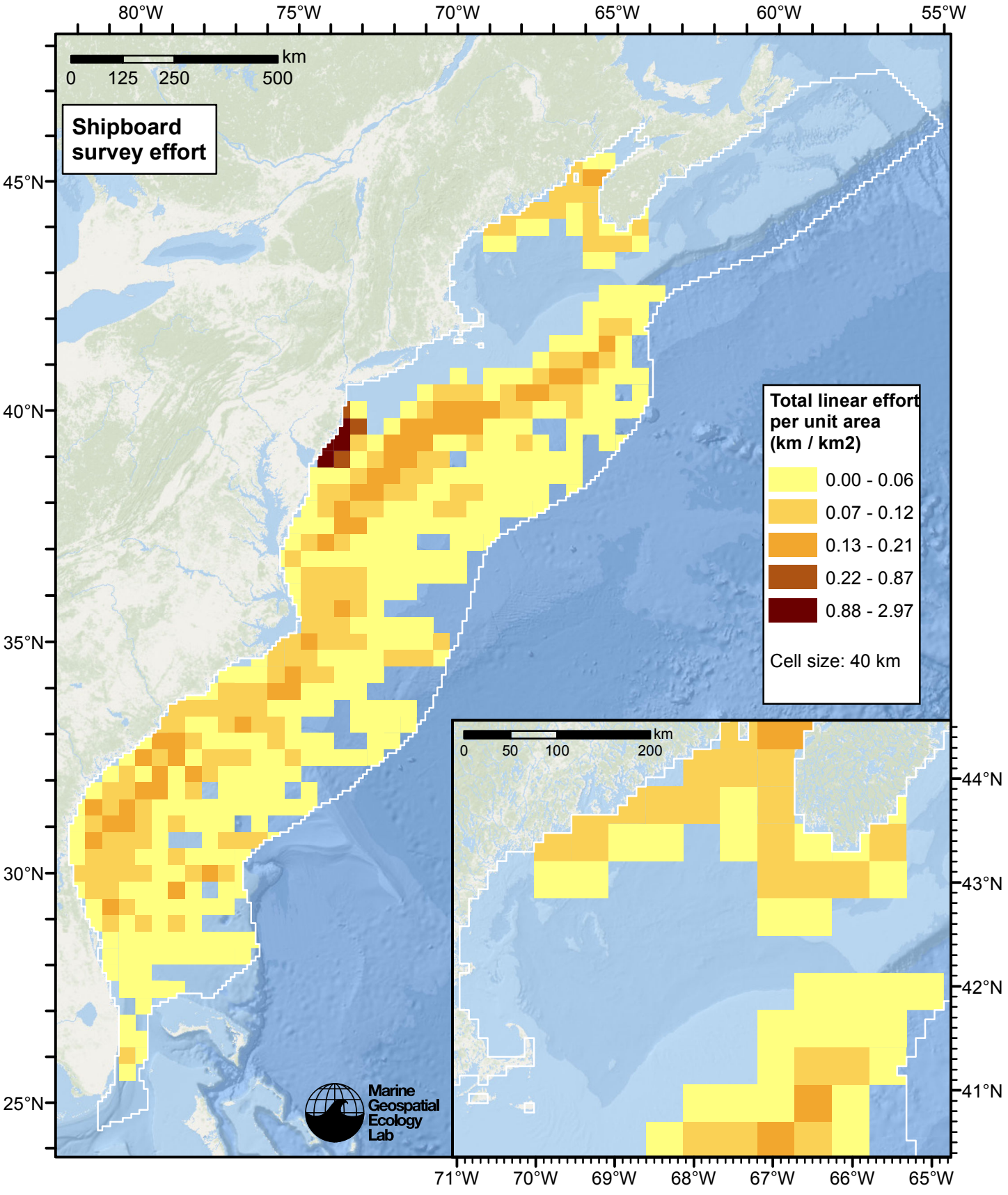

Figure 4: Shipboard linear survey effort per unit area.

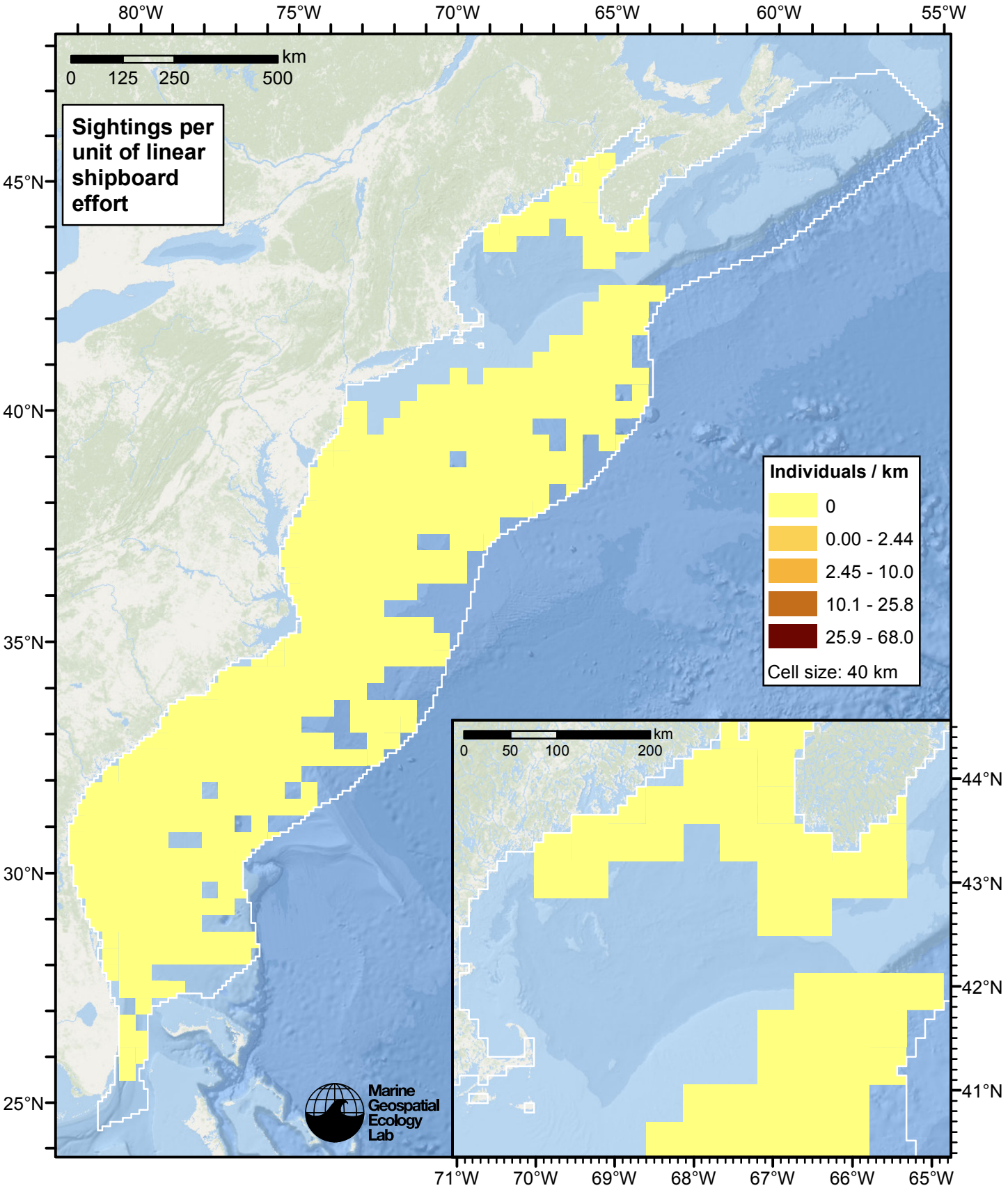

Figure 5: White-beaked dolphin sightings per unit shipboard linear survey effort.

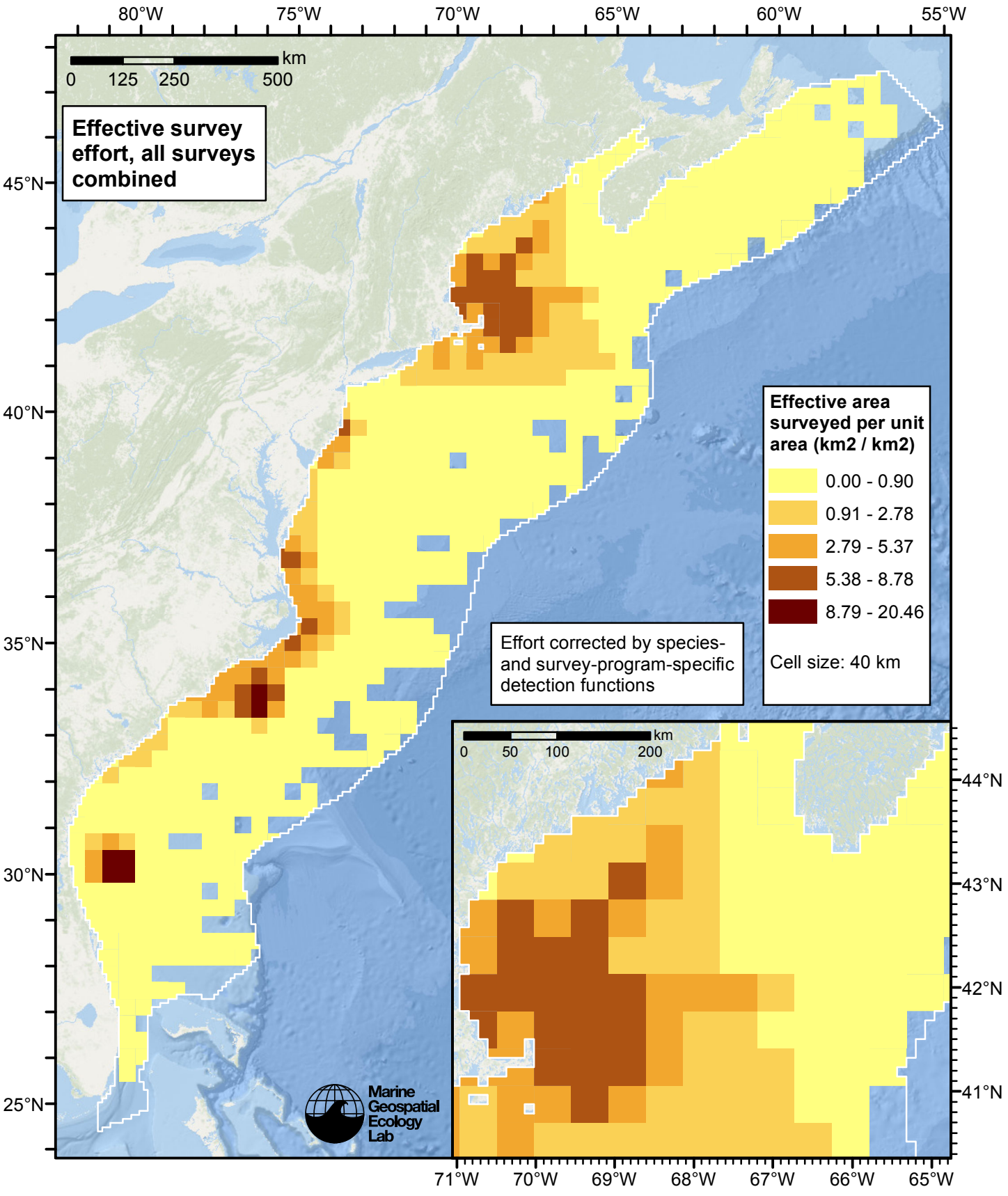

Figure 6: Effective survey effort per unit area, for all surveys combined. Here, effort is corrected by the species- and survey-program-specific detection functions used in fitting the density models.

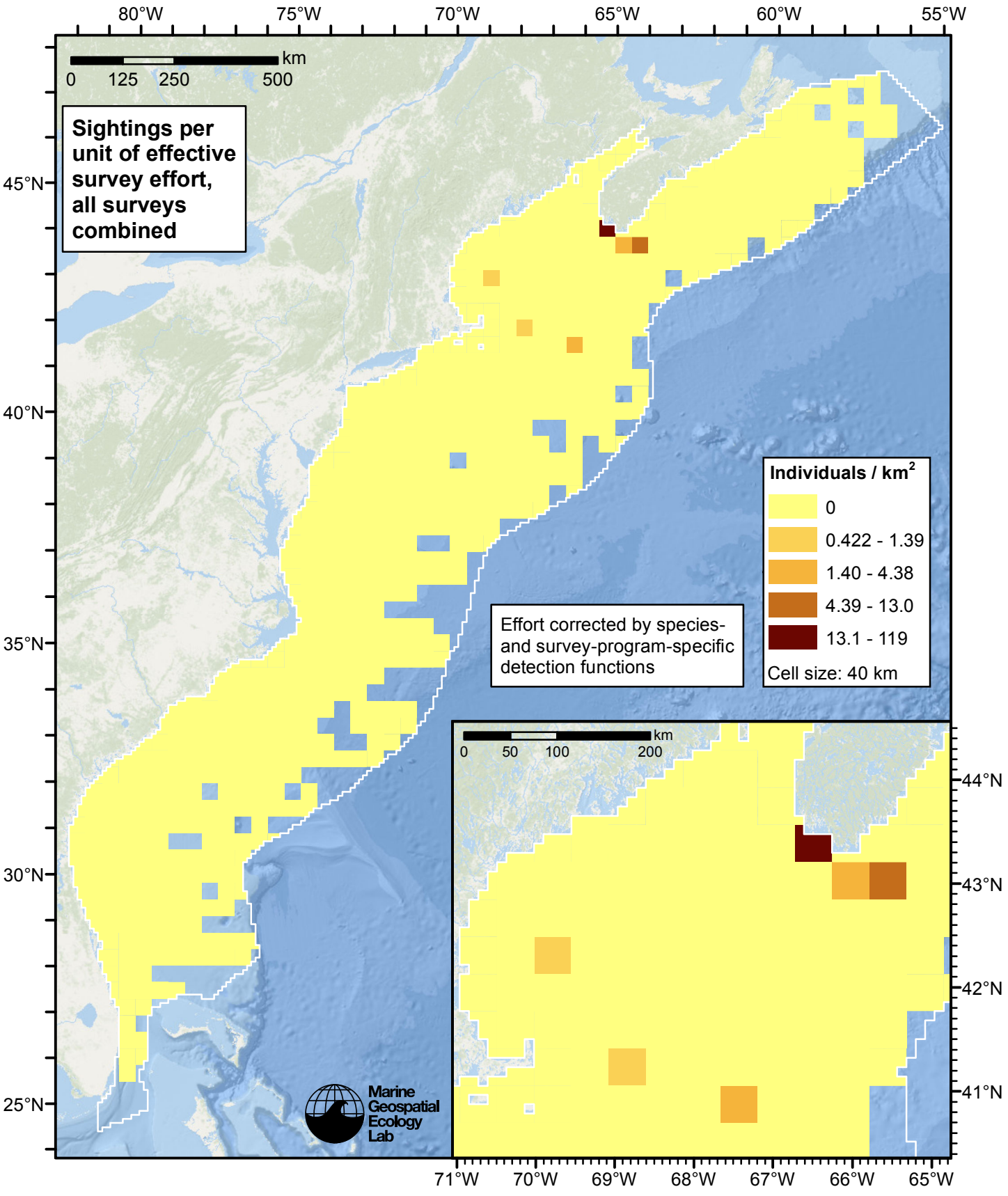

Figure 7: White-beaked dolphin sightings per unit of effective survey effort, for all surveys combined. Here, effort is corrected by the species- and survey-program-specific detection functions used in fitting the density models.

Detection Functions

The detection hierarchy figures below show how sightings from multiple surveys were pooled to try to achieve Buckland et. al's (2001) recommendation that at least 60-80 sightings be used to fit a detection function. Leaf nodes, on the right, usually represent individual surveys, while the hierarchy to the left shows how they have been grouped according to how similar we believed the surveys were to each other in their detection performance.

At each node, the red or green number indicates the total number of sightings below that node in the hierarchy, and is colored green if 70 or more sightings were available, and red otherwise. If a grouping node has zero sightings–i.e. all of the surveys within it had zero sightings–it may be collapsed and shown as a leaf to save space.

Each histogram in the figure indicates a node where a detection function was fitted. The actual detection functions do not appear in this figure; they are presented in subsequent sections. The histogram shows the frequency of sightings by perpendicular sighting distance for all surveys contained by that node. Each survey (leaf node) recieves the detection function that is closest to it up the hierarchy. Thus, for common species, sufficient sightings may be available to fit detection functions deep in the hierarchy, with each function applying to only a few surveys, thereby allowing variability in detection performance between surveys to be addressed relatively finely. For rare species, so few sightings may be available that we have to pool many surveys together to try to meet Buckland's recommendation, and fit only a few coarse detection functions high in the hierarchy.

A blue Proxy Species tag indicates that so few sightings were available that, rather than ascend higher in the hierarchy to a point that we would pool grossly-incompatible surveys together, (e.g. shipboard surveys that used big-eye binoculars with those that used only naked eyes) we pooled sightings of similar species together instead. The list of species pooled is given in following sections.

Shipboard Surveys

Figure 8: Detection hierarchy for shipboard surveys

NEFSC Abel-J Binocular Surveys

Because this taxon was sighted too infrequently to fit a detection function to its sightings alone, we fit a detection function to the pooled sightings of several other species that we believed would exhibit similar detectability. These "proxy species" are listed below.

Reported By Observer	Common Name	n
Delphinus capensis	Long-beaked common dolphin	0
Delphinus delphis	Short-beaked common dolphin	43
Delphinus delphis/Lagenorhynchus acutus	Short-beaked common or Atlantic white-sided dolphin	0
Delphinus delphis/Stenella	Short-beaked common dolphin or Stenella spp.	0
Delphinus delphis/Stenella coeruleoalba	Short-beaked common or striped dolphin	0
Grampus griseus	Risso's dolphin	152
Grampus griseus/Tursiops truncatus	Risso's or Bottlenose dolphin	0
Lagenodelphis hosei	Fraser's dolphin	0
Lagenorhynchus acutus	Atlantic white-sided dolphin	0
Lagenorhynchus albirostris	White-beaked dolphin	0
Lagenorhynchus albirostris/Lagenorhynchus acutus	White-beaked or white-sided dolphin	0
Stenella	Unidentified Stenella	4
Stenella attenuata	Pantropical spotted dolphin	4
Stenella attenuata/frontalis	Pantropical or Atlantic spotted dolphin	0
Stenella clymene	Clymene dolphin	0
Stenella coeruleoalba	Striped dolphin	63
Stenella frontalis	Atlantic spotted dolphin	9
Stenella frontalis/Tursiops truncatus	Atlantic spotted or Bottlenose dolphin	0
Stenella longirostris	Spinner dolphin	1
Steno bredanensis	Rough-toothed dolphin	0
Steno bredanensis/Tursiops truncatus	Bottlenose or rough-toothed dolphin	0
Tursiops truncatus	Bottlenose dolphin	82
Total		358

Table 4: Proxy species used to fit detection functions for NEFSC Abel-J Binocular Surveys. The number of sightings, n, is before truncation.

The sightings were right truncated at 5000m.

Covariate	Description
beaufort	Beaufort sea state.
quality	Survey-specific index of the quality of observation conditions, utilizing relevant factors other than Beaufort sea state (see methods).
size	Estimated size (number of individuals) of the sighted group.

Table 5: Covariates tested in candidate "multi-covariate distance sampling" (MCDS) detection functions.

Key	Adjustment	Order	Covariates	Succeeded	Δ AIC	Mean ESHW (m)
hr			beaufort, size	Yes	0.00	1577
hr			quality, size	Yes	1.35	1558
hr			size	Yes	2.52	1561
hr			quality	Yes	3.94	1586
hr			beaufort, quality	Yes	4.13	1593
hr			beaufort	Yes	4.42	1603
hn	cos	2		Yes	5.28	1504
hr				Yes	5.51	1601
hr	poly	2		Yes	7.06	1551
hr	poly	4		Yes	7.43	1586
hn			beaufort, size	Yes	17.29	1823
hn			beaufort, quality, size	Yes	18.74	1822
hn	cos	3		Yes	20.50	1502
hn			beaufort	Yes	20.71	1817
hn			beaufort, quality	Yes	21.33	1817
hn			quality	Yes	28.71	1823
hn				Yes	29.00	1825
hn			size	Yes	29.10	1825
hn			quality, size	Yes	29.31	1823
hn	herm	4		No		
hr			beaufort, quality, size	No		

Table 6: Candidate detection functions for NEFSC Abel-J Binocular Surveys. The first one listed was selected for the density model.

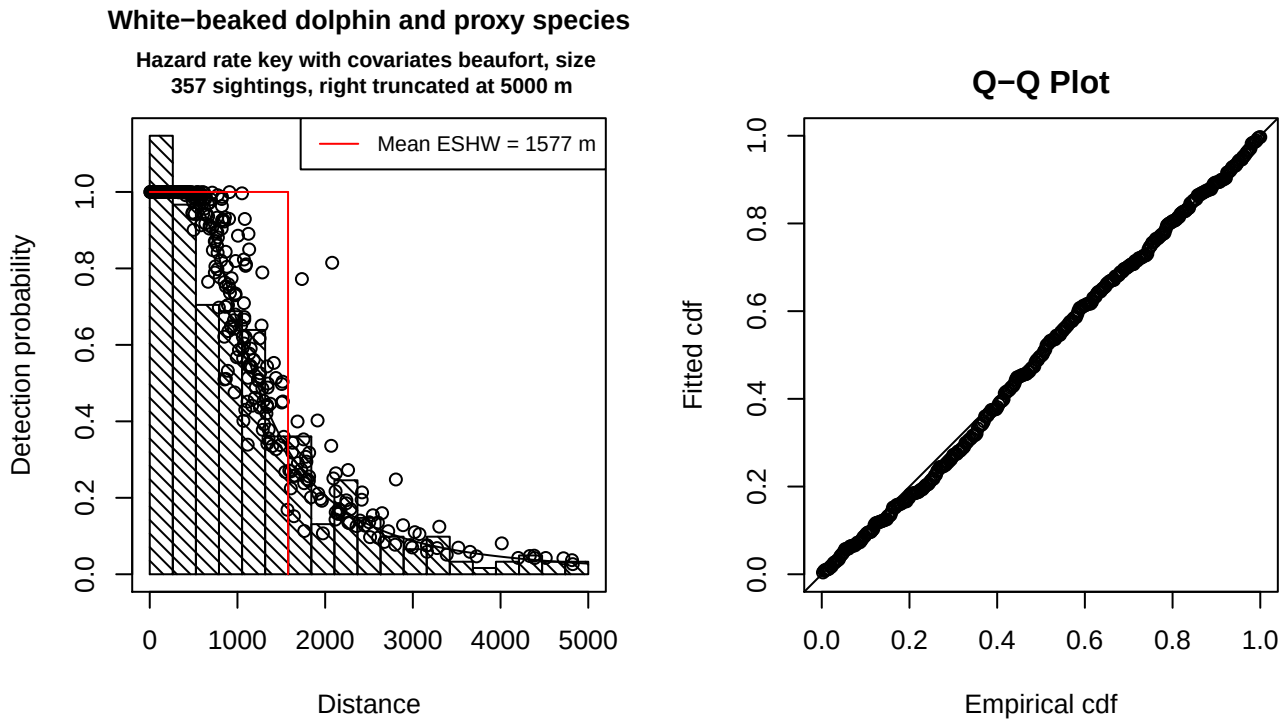

Figure 9: Detection function for NEFSC Abel-J Binocular Surveys that was selected for the density model

Statistical output for this detection function:

```
Summary for ds object
Number of observations :  357
Distance range         :  0  -  5000
AIC                    :  5689.064

Detection function:
 Hazard-rate key function

Detection function parameters
Scale Coefficients:
             estimate         se
(Intercept)  7.4066476 0.28751588
beaufort    -0.1983371 0.10000894
size         0.1366273 0.07421191

Shape parameters:
             estimate         se
(Intercept) 0.8389089 0.09859879

                        Estimate          SE         CV
Average p              0.3078884  0.01882296 0.06113567
N in covered region 1159.5109828 87.51962437 0.07547977
```

Additional diagnostic plots:

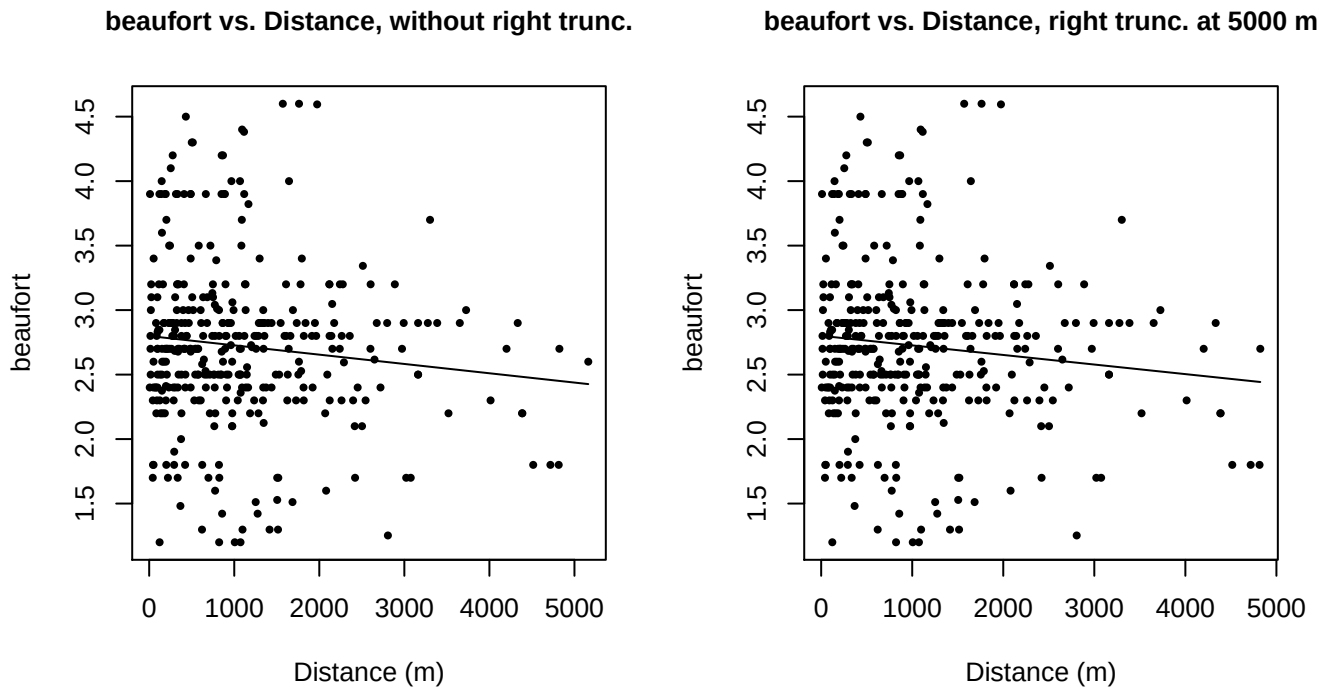

Figure 10: Scatterplots showing the relationship between Beaufort sea state and perpendicular sighting distance, for all sightings (left) and only those not right truncated (right). The line is a simple linear regression.

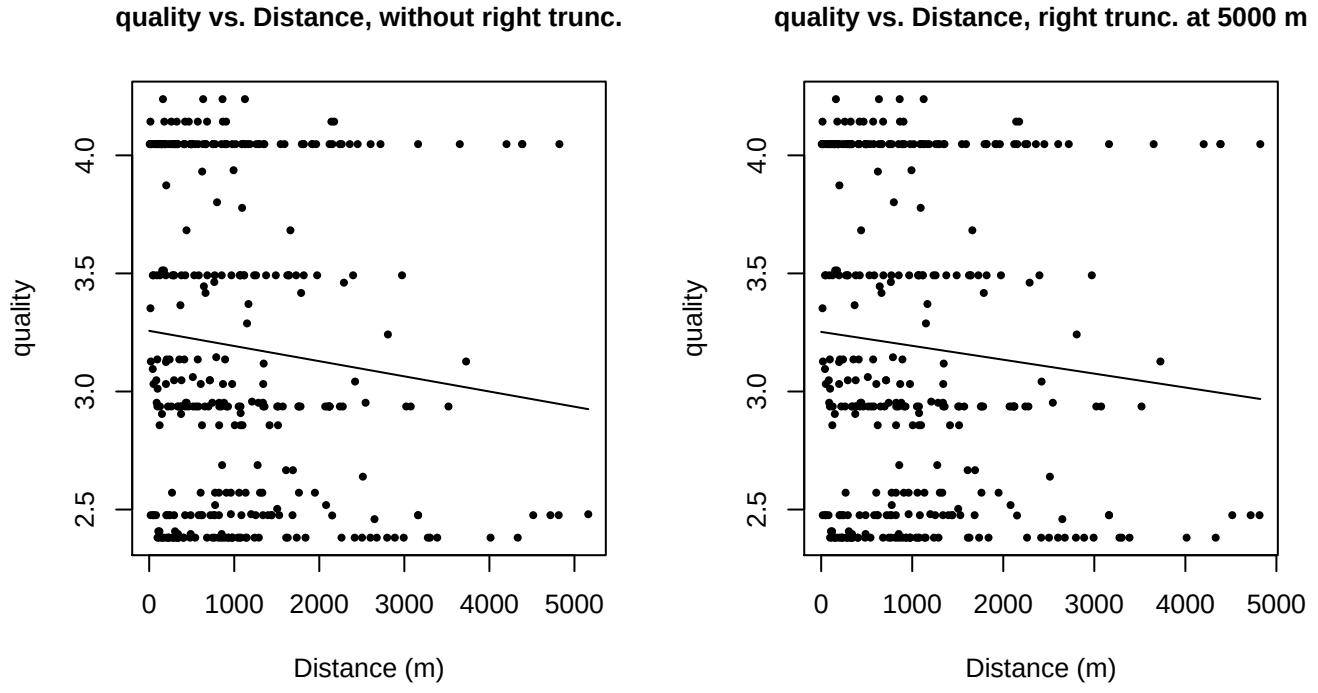

Figure 11: Scatterplots showing the relationship between the survey-specific index of the quality of observation conditions and perpendicular sighting distance, for all sightings (left) and only those not right truncated (right). Low values of the quality index correspond to better observation conditions. The line is a simple linear regression.

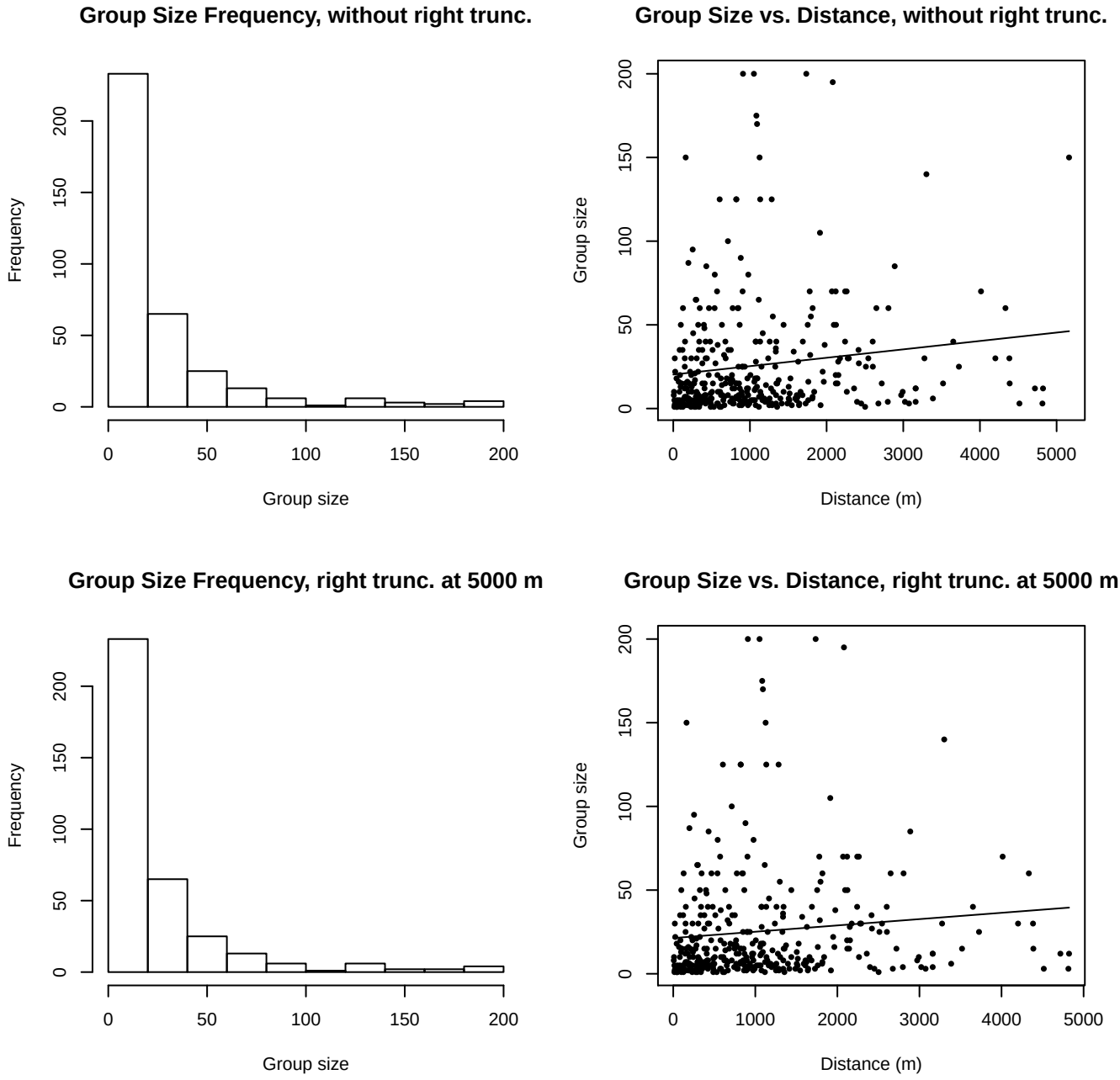

Figure 12: Histograms showing group size frequency and scatterplots showing the relationship between group size and perpendicular sighting distance, for all sightings (top row) and only those not right truncated (bottom row). In the scatterplot, the line is a simple linear regression.

NEFSC Endeavor

Because this taxon was sighted too infrequently to fit a detection function to its sightings alone, we fit a detection function to the pooled sightings of several other species that we believed would exhibit similar detectability. These "proxy species" are listed below.

Reported By Observer	Common Name	n
Delphinus capensis	Long-beaked common dolphin	0
Delphinus delphis	Short-beaked common dolphin	100

Delphinus delphis/Lagenorhynchus acutus	Short-beaked common or Atlantic white-sided dolphin	0
Delphinus delphis/Stenella	Short-beaked common dolphin or Stenella spp.	0
Delphinus delphis/Stenella coeruleoalba	Short-beaked common or striped dolphin	0
Grampus griseus	Risso's dolphin	121
Grampus griseus/Tursiops truncatus	Risso's or Bottlenose dolphin	0
Lagenodelphis hosei	Fraser's dolphin	0
Lagenorhynchus acutus	Atlantic white-sided dolphin	3
Lagenorhynchus albirostris	White-beaked dolphin	0
Lagenorhynchus albirostris/Lagenorhynchus acutus	White-beaked or white-sided dolphin	0
Stenella	Unidentified Stenella	3
Stenella attenuata	Pantropical spotted dolphin	0
Stenella attenuata/frontalis	Pantropical or Atlantic spotted dolphin	0
Stenella clymene	Clymene dolphin	0
Stenella coeruleoalba	Striped dolphin	44
Stenella frontalis	Atlantic spotted dolphin	7
Stenella frontalis/Tursiops truncatus	Atlantic spotted or Bottlenose dolphin	0
Stenella longirostris	Spinner dolphin	0
Steno bredanensis	Rough-toothed dolphin	0
Steno bredanensis/Tursiops truncatus	Bottlenose or rough-toothed dolphin	1
Tursiops truncatus	Bottlenose dolphin	45
Total		324

Table 7: Proxy species used to fit detection functions for NEFSC Endeavor. The number of sightings, n, is before truncation.

The sightings were right truncated at 5000m.

Covariate	Description
beaufort	Beaufort sea state.
quality	Survey-specific index of the quality of observation conditions, utilizing relevant factors other than Beaufort sea state (see methods).
size	Estimated size (number of individuals) of the sighted group.

Table 8: Covariates tested in candidate "multi-covariate distance sampling" (MCDS) detection functions.

Key	Adjustment	Order	Covariates	Succeeded	Δ AIC	Mean ESHW (m)
hn			beaufort	Yes	0.00	1930
hn			beaufort, size	Yes	1.86	1930
hn	cos	3		Yes	2.67	1684
hn				Yes	4.80	1934

hn	cos	2		Yes	5.68	1833
hn			size	Yes	6.54	1934
hn			quality	Yes	6.66	1934
hr			beaufort	Yes	7.56	2068
hn			quality, size	Yes	8.42	1934
hr			beaufort, size	Yes	8.71	2061
hr	poly	4		Yes	10.77	1909
hr				Yes	17.87	2030
hr			size	Yes	19.40	2022
hr			quality	Yes	19.70	2039
hr			quality, size	Yes	21.27	2030
hr	poly	2		Yes	64.80	1002
hn	herm	4		No		
hn			beaufort, quality	No		
hr			beaufort, quality	No		
hn			beaufort, quality, size	No		
hr			beaufort, quality, size	No		

Table 9: Candidate detection functions for NEFSC Endeavor. The first one listed was selected for the density model.

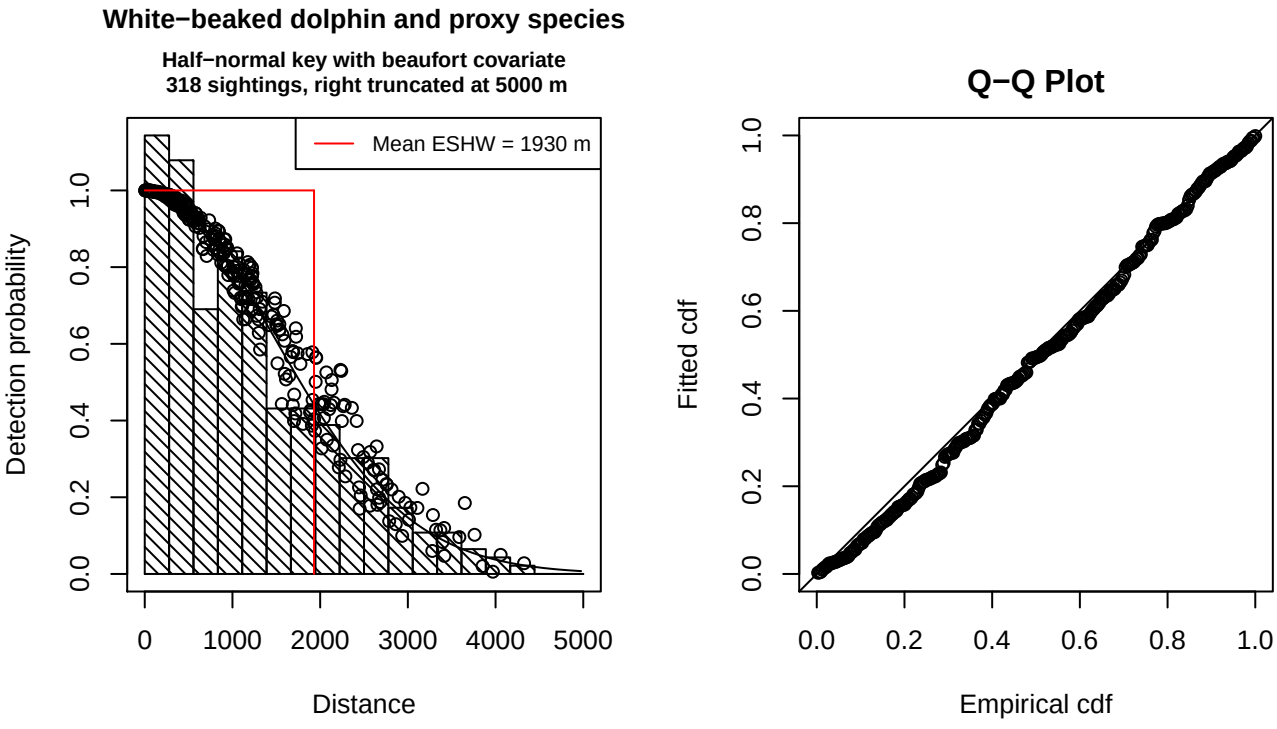

Figure 13: Detection function for NEFSC Endeavor that was selected for the density model

Statistical output for this detection function:

```
Summary for ds object
Number of observations :  318
Distance range         :  0  -  5000
AIC                    :  5123.58

Detection function:
 Half-normal key function

Detection function parameters
Scale Coefficients:
             estimate         se
(Intercept)  7.6304947 0.11974801
beaufort    -0.1208508 0.04145359

                       Estimate          SE         CV
Average p              0.3811258  0.01527091 0.04006791
N in covered region 834.3701363 49.83226006 0.05972441
```

Additional diagnostic plots:

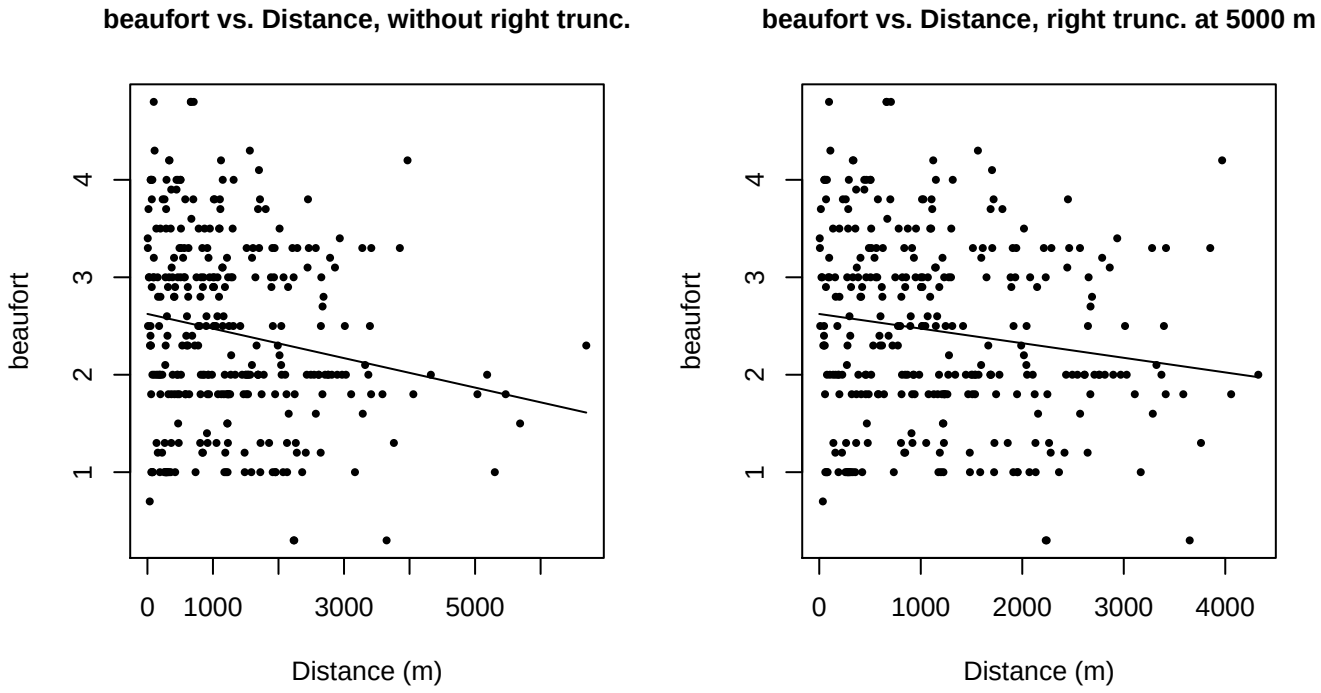

Figure 14: Scatterplots showing the relationship between Beaufort sea state and perpendicular sighting distance, for all sightings (left) and only those not right truncated (right). The line is a simple linear regression.

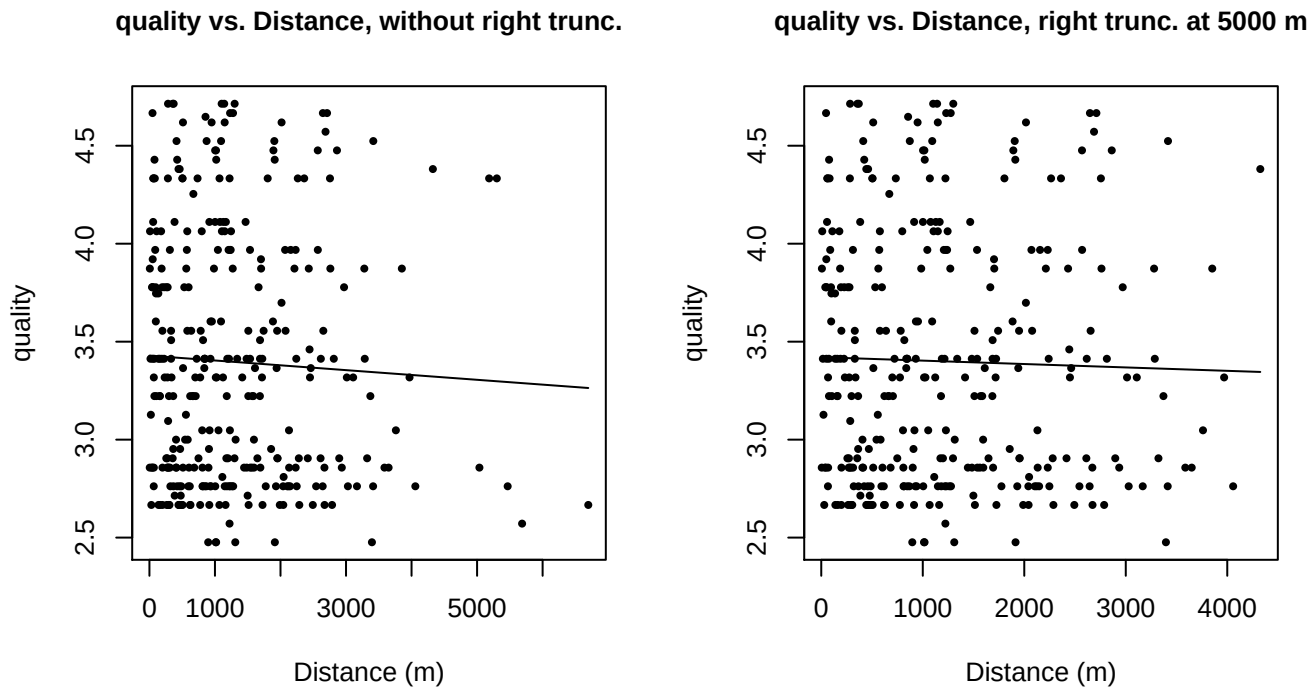

Figure 15: Scatterplots showing the relationship between the survey-specific index of the quality of observation conditions and perpendicular sighting distance, for all sightings (left) and only those not right truncated (right). Low values of the quality index correspond to better observation conditions. The line is a simple linear regression.

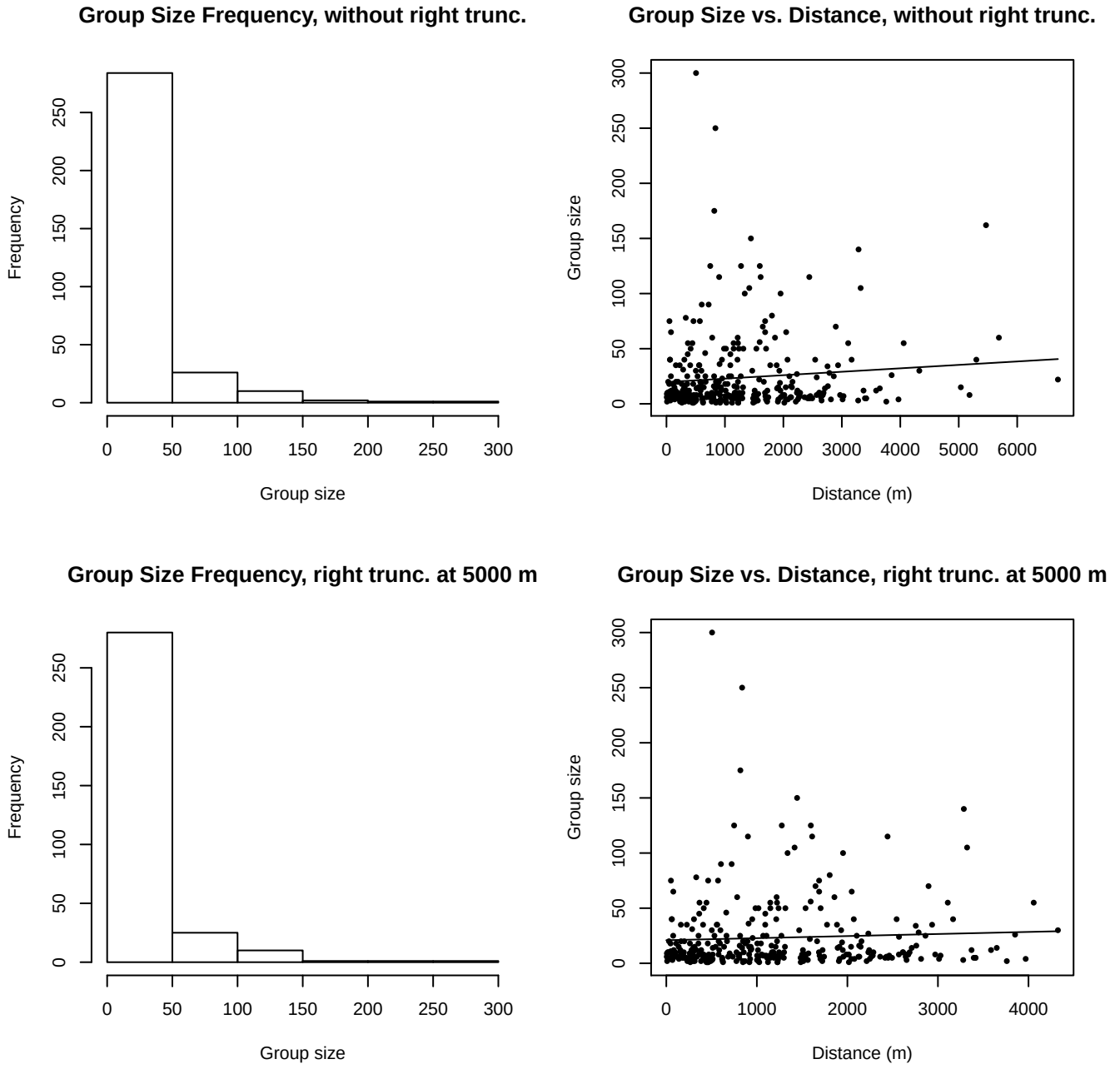

Figure 16: Histograms showing group size frequency and scatterplots showing the relationship between group size and perpendicular sighting distance, for all sightings (top row) and only those not right truncated (bottom row). In the scatterplot, the line is a simple linear regression.

NEFSC Pelican

Because this taxon was sighted too infrequently to fit a detection function to its sightings alone, we fit a detection function to the pooled sightings of several other species that we believed would exhibit similar detectability. These "proxy species" are listed below.

Reported By Observer	Common Name	n
Delphinus capensis	Long-beaked common dolphin	0
Delphinus delphis	Short-beaked common dolphin	30

Delphinus delphis/Lagenorhynchus acutus	Short-beaked common or Atlantic white-sided dolphin	0
Delphinus delphis/Stenella	Short-beaked common dolphin or Stenella spp.	1
Delphinus delphis/Stenella coeruleoalba	Short-beaked common or striped dolphin	0
Grampus griseus	Risso's dolphin	79
Grampus griseus/Tursiops truncatus	Risso's or Bottlenose dolphin	1
Lagenodelphis hosei	Fraser's dolphin	0
Lagenorhynchus acutus	Atlantic white-sided dolphin	0
Lagenorhynchus albirostris	White-beaked dolphin	0
Lagenorhynchus albirostris/Lagenorhynchus acutus	White-beaked or white-sided dolphin	0
Stenella	Unidentified Stenella	3
Stenella attenuata	Pantropical spotted dolphin	0
Stenella attenuata/frontalis	Pantropical or Atlantic spotted dolphin	0
Stenella clymene	Clymene dolphin	0
Stenella coeruleoalba	Striped dolphin	30
Stenella frontalis	Atlantic spotted dolphin	9
Stenella frontalis/Tursiops truncatus	Atlantic spotted or Bottlenose dolphin	0
Stenella longirostris	Spinner dolphin	0
Steno bredanensis	Rough-toothed dolphin	0
Steno bredanensis/Tursiops truncatus	Bottlenose or rough-toothed dolphin	0
Tursiops truncatus	Bottlenose dolphin	50
Total		203

Table 10: Proxy species used to fit detection functions for NEFSC Pelican. The number of sightings, n, is before truncation.

The sightings were right truncated at 4000m.

Covariate	Description
beaufort	Beaufort sea state.
size	Estimated size (number of individuals) of the sighted group.

Table 11: Covariates tested in candidate "multi-covariate distance sampling" (MCDS) detection functions.

Key	Adjustment	Order	Covariates	Succeeded	Δ AIC	Mean ESHW (m)
hr			beaufort, size	Yes	0.00	1405
hr			size	Yes	7.20	1311
hr			beaufort	Yes	7.25	1403
hn			beaufort, size	Yes	8.79	1619
hr	poly	4		Yes	11.78	1180
hr	poly	2		Yes	11.96	1142

hn	cos	3		Yes	14.21	1252
hn			size	Yes	15.02	1620
hn	cos	2		Yes	15.51	1358
hr				Yes	16.02	1231
hn			beaufort	Yes	18.43	1610
hn				Yes	22.69	1616
hn	herm	4		No		

Table 12: Candidate detection functions for NEFSC Pelican. The first one listed was selected for the density model.

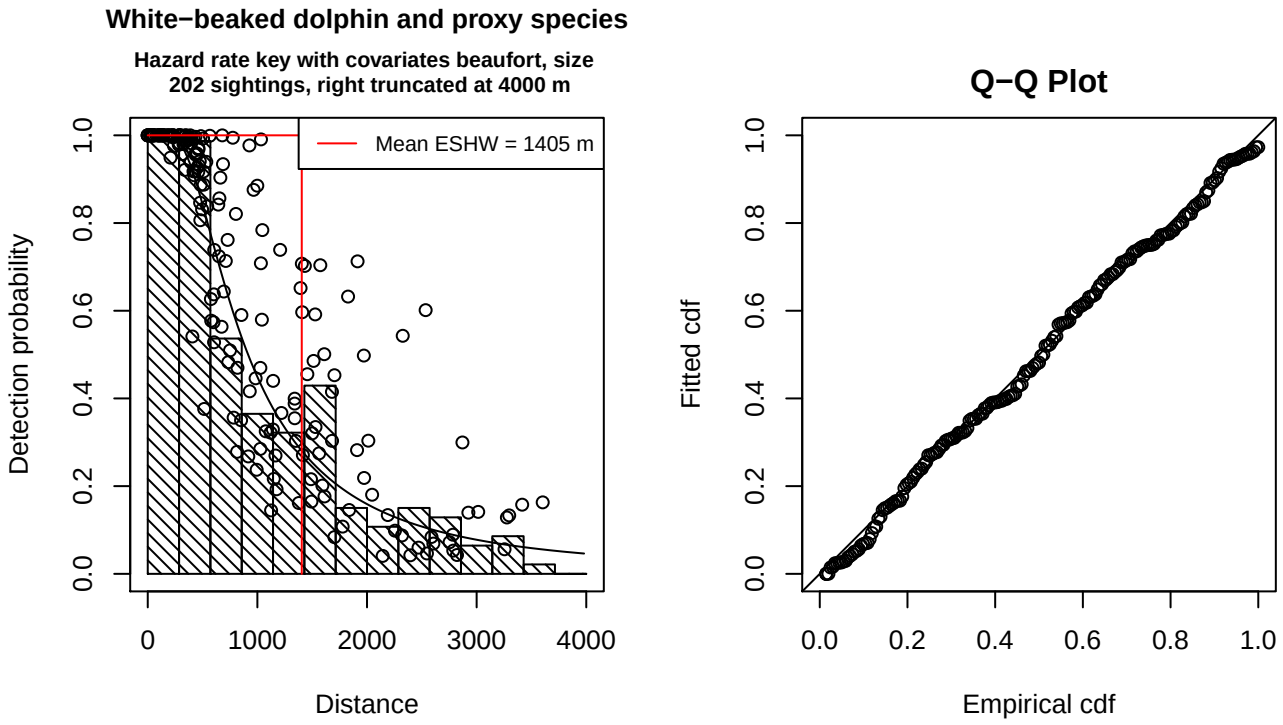

Figure 17: Detection function for NEFSC Pelican that was selected for the density model

Statistical output for this detection function:

```
Summary for ds object
Number of observations :  202
Distance range         :  0  -  4000
AIC                    :  3161.875

Detection function:
 Hazard-rate key function

Detection function parameters
Scale Coefficients:
             estimate        se
(Intercept)  7.5661728 0.3373193
beaufort    -0.4174589 0.1318753
```

```
size         0.4251734 0.1773940

Shape parameters:
             estimate        se
(Intercept) 0.7201716 0.1414403

                        Estimate          SE         CV
Average p             0.3096997  0.03001707 0.09692314
N in covered region 652.2447463 74.41565270 0.11409161
```

Additional diagnostic plots:

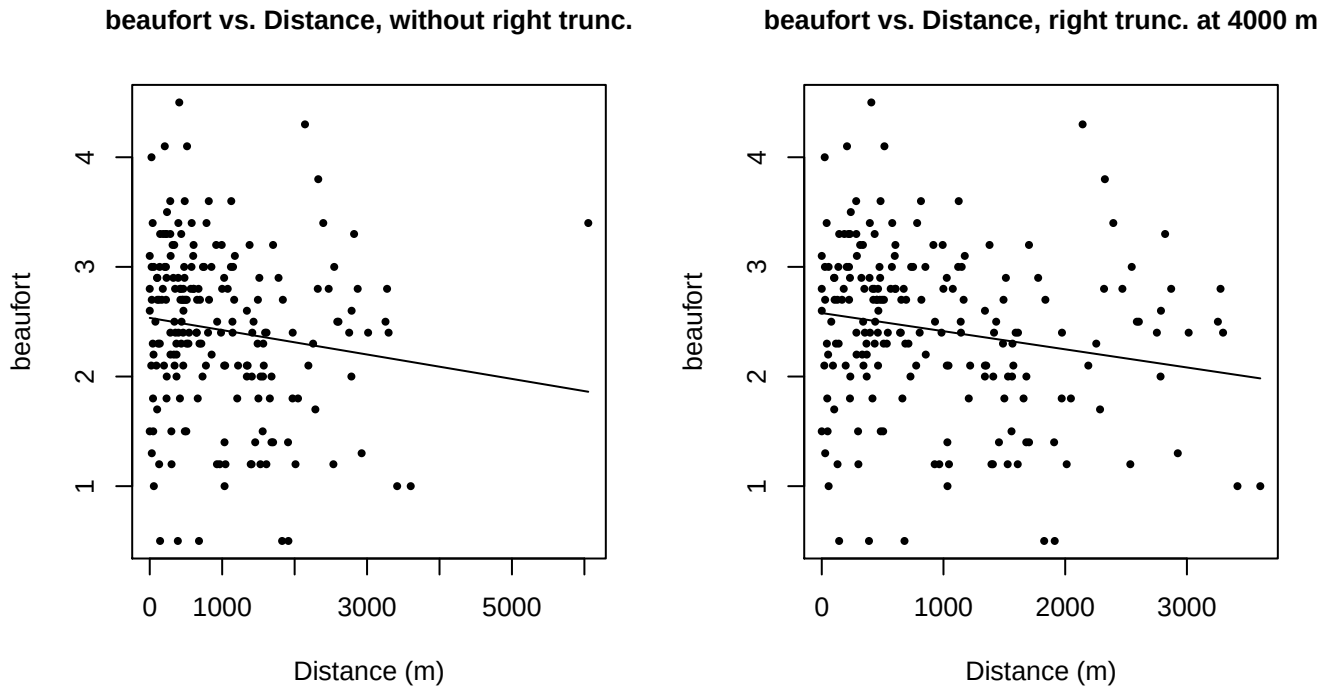

Figure 18: Scatterplots showing the relationship between Beaufort sea state and perpendicular sighting distance, for all sightings (left) and only those not right truncated (right). The line is a simple linear regression.

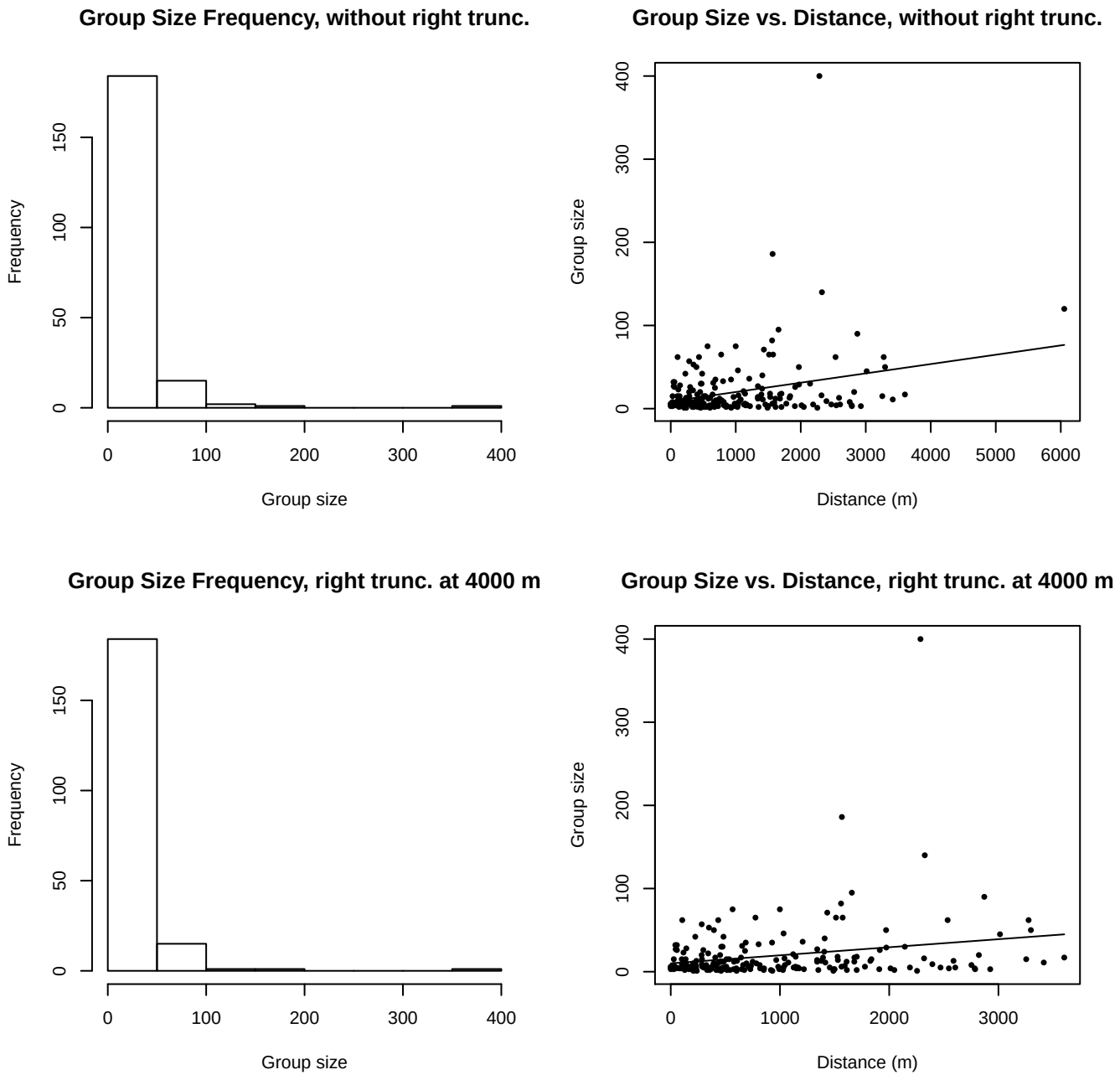

Figure 19: Histograms showing group size frequency and scatterplots showing the relationship between group size and perpendicular sighting distance, for all sightings (top row) and only those not right truncated (bottom row). In the scatterplot, the line is a simple linear regression.

SEFSC Oregon II

Because this taxon was sighted too infrequently to fit a detection function to its sightings alone, we fit a detection function to the pooled sightings of several other species that we believed would exhibit similar detectability. These "proxy species" are listed below.

Reported By Observer	Common Name	n
Delphinus capensis	Long-beaked common dolphin	0
Delphinus delphis	Short-beaked common dolphin	2

Delphinus delphis/Lagenorhynchus acutus	Short-beaked common or Atlantic white-sided dolphin	0
Delphinus delphis/Stenella	Short-beaked common dolphin or Stenella spp.	0
Delphinus delphis/Stenella coeruleoalba	Short-beaked common or striped dolphin	0
Grampus griseus	Risso's dolphin	156
Grampus griseus/Tursiops truncatus	Risso's or Bottlenose dolphin	0
Lagenodelphis hosei	Fraser's dolphin	3
Lagenorhynchus acutus	Atlantic white-sided dolphin	0
Lagenorhynchus albirostris	White-beaked dolphin	0
Lagenorhynchus albirostris/Lagenorhynchus acutus	White-beaked or white-sided dolphin	0
Stenella	Unidentified Stenella	17
Stenella attenuata	Pantropical spotted dolphin	347
Stenella attenuata/frontalis	Pantropical or Atlantic spotted dolphin	0
Stenella clymene	Clymene dolphin	44
Stenella coeruleoalba	Striped dolphin	48
Stenella frontalis	Atlantic spotted dolphin	242
Stenella frontalis/Tursiops truncatus	Atlantic spotted or Bottlenose dolphin	0
Stenella longirostris	Spinner dolphin	38
Steno bredanensis	Rough-toothed dolphin	22
Steno bredanensis/Tursiops truncatus	Bottlenose or rough-toothed dolphin	0
Tursiops truncatus	Bottlenose dolphin	490
Total		1409

Table 13: Proxy species used to fit detection functions for SEFSC Oregon II. The number of sightings, n, is before truncation.

The sightings were right truncated at 5000m.

Covariate	Description
beaufort	Beaufort sea state.
quality	Survey-specific index of the quality of observation conditions, utilizing relevant factors other than Beaufort sea state (see methods).
size	Estimated size (number of individuals) of the sighted group.

Table 14: Covariates tested in candidate "multi-covariate distance sampling" (MCDS) detection functions.

Key	Adjustment	Order	Covariates	Succeeded	Δ AIC	Mean ESHW (m)
hr			beaufort, size	Yes	0.00	807
hr			quality, size	Yes	4.77	771
hr			size	Yes	40.78	712
hr			beaufort, quality	Yes	52.03	579

hr			quality	Yes	77.42	536
hr			beaufort	Yes	89.47	513
hr	poly	4		Yes	96.59	501
hr	poly	2		Yes	103.38	525
hr				Yes	121.28	461
hn	cos	3		Yes	341.53	1351
hn	cos	2		Yes	345.64	1510
hn			beaufort, quality, size	Yes	393.07	1951
hn			quality, size	Yes	417.71	1946
hn			beaufort, size	Yes	440.00	1977
hn			beaufort, quality	Yes	454.31	1929
hn			size	Yes	465.37	1968
hn			quality	Yes	465.95	1932
hn			beaufort	Yes	518.70	1941
hn				Yes	529.51	1944
hn	herm	4		No		
hr			beaufort, quality, size	No		

Table 15: Candidate detection functions for SEFSC Oregon II. The first one listed was selected for the density model.

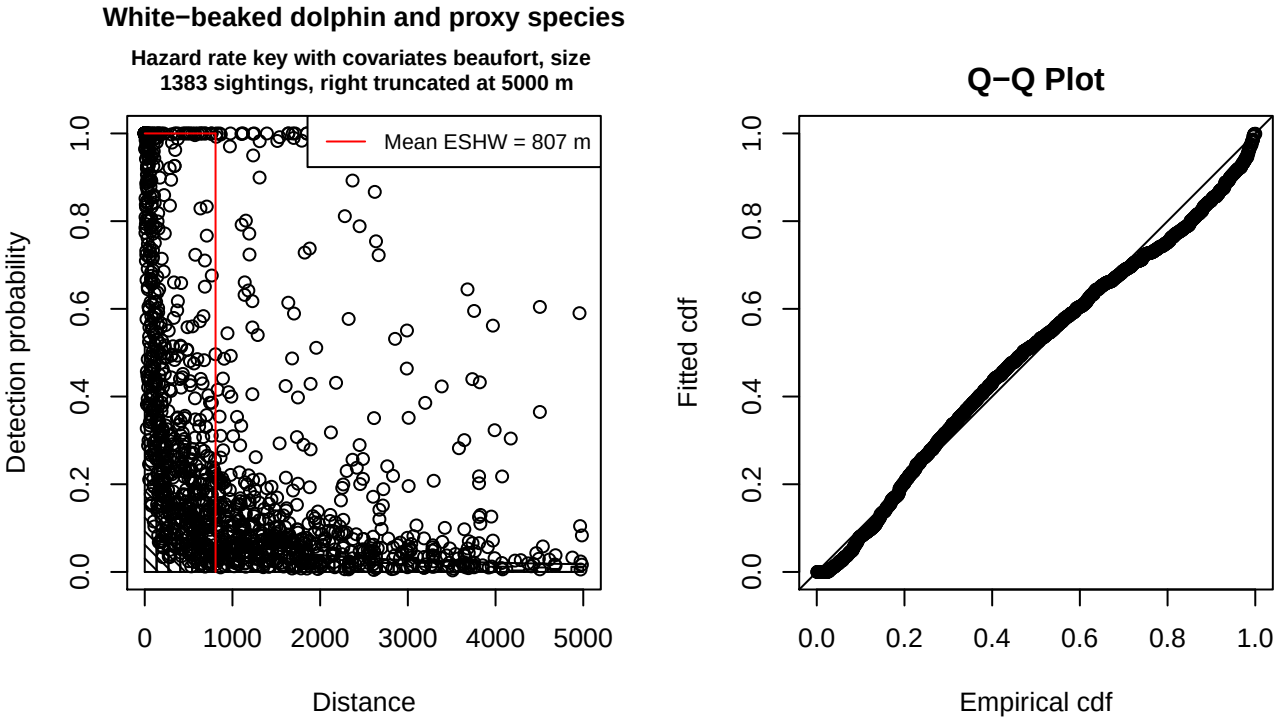

Figure 20: Detection function for SEFSC Oregon II that was selected for the density model

Statistical output for this detection function:

```
Summary for ds object
Number of observations :  1383
Distance range         :  0  -  5000
AIC                    :  21780.64

Detection function:
 Hazard-rate key function

Detection function parameters
Scale Coefficients:
              estimate         se
(Intercept)  5.2365302 0.21037652
beaufort    -0.5641442 0.06785362
size         2.0803998 0.20713158

Shape parameters:
            estimate         se
(Intercept)        0 0.03476077

                         Estimate           SE        CV
Average p            6.366213e-02 6.540950e-03 0.1027447
N in covered region 2.172406e+04 2.309731e+03 0.1063213
```

Additional diagnostic plots:

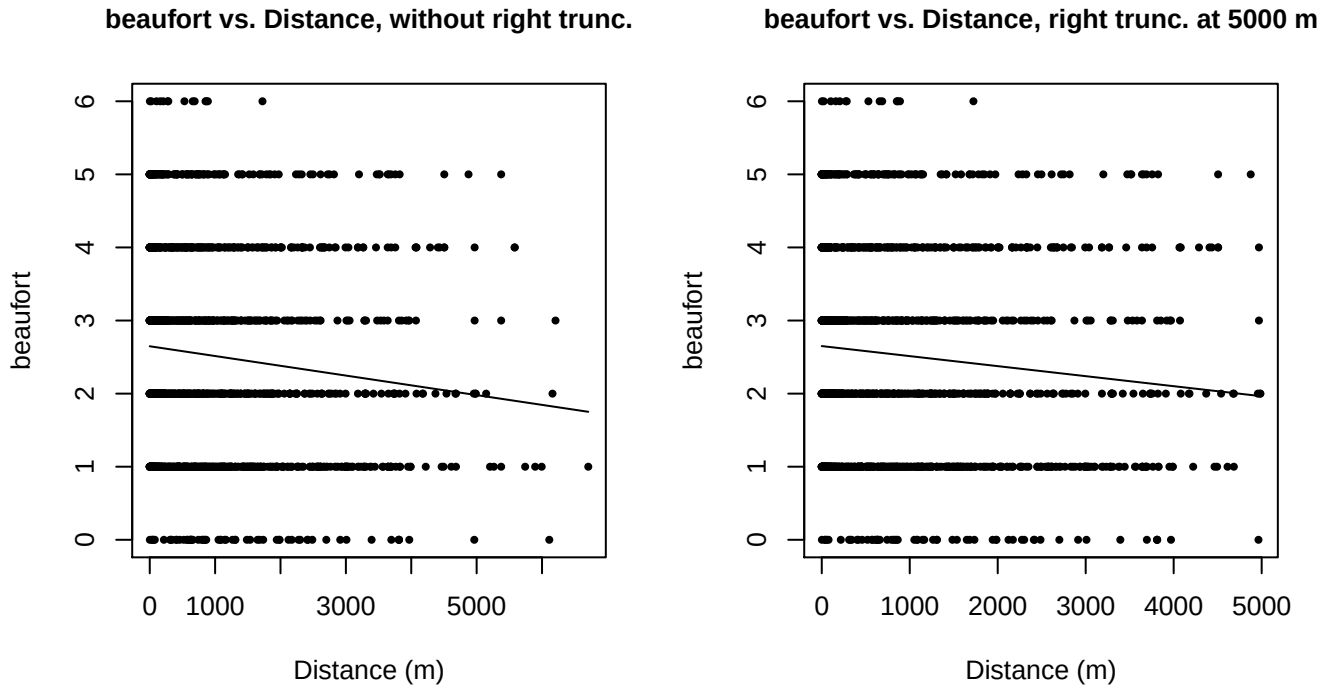

Figure 21: Scatterplots showing the relationship between Beaufort sea state and perpendicular sighting distance, for all sightings (left) and only those not right truncated (right). The line is a simple linear regression.

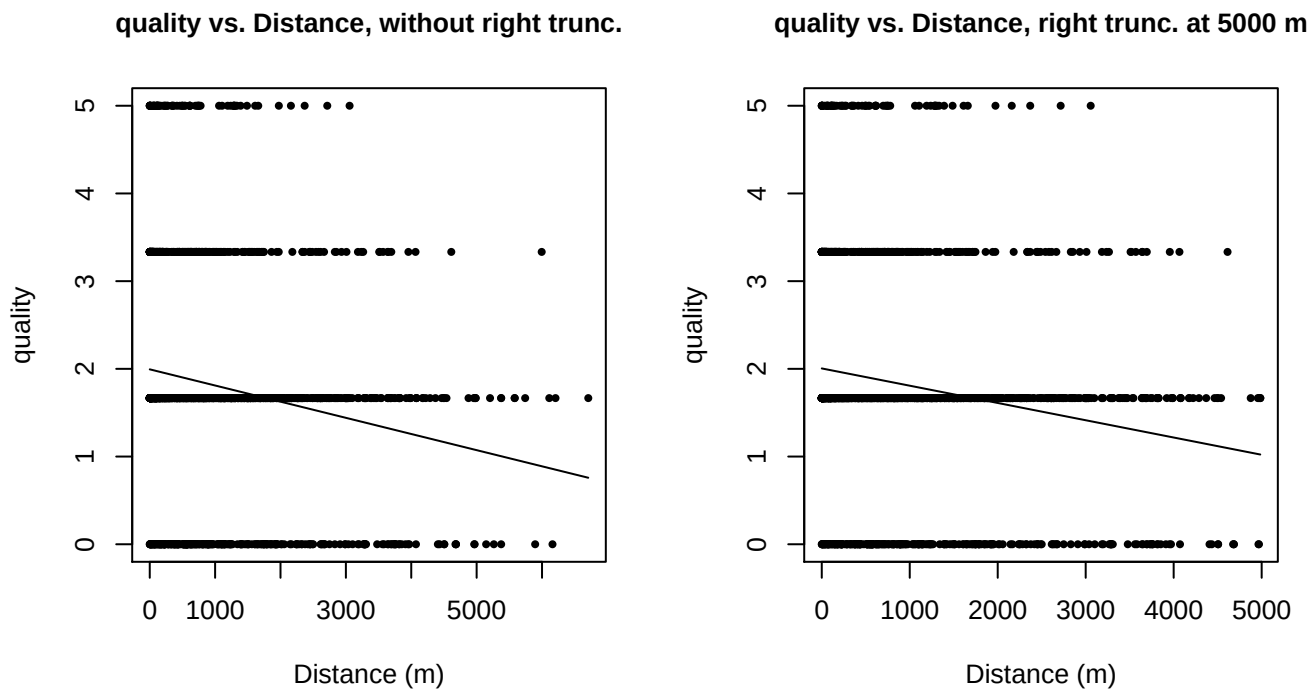

Figure 22: Scatterplots showing the relationship between the survey-specific index of the quality of observation conditions and perpendicular sighting distance, for all sightings (left) and only those not right truncated (right). Low values of the quality index correspond to better observation conditions. The line is a simple linear regression.

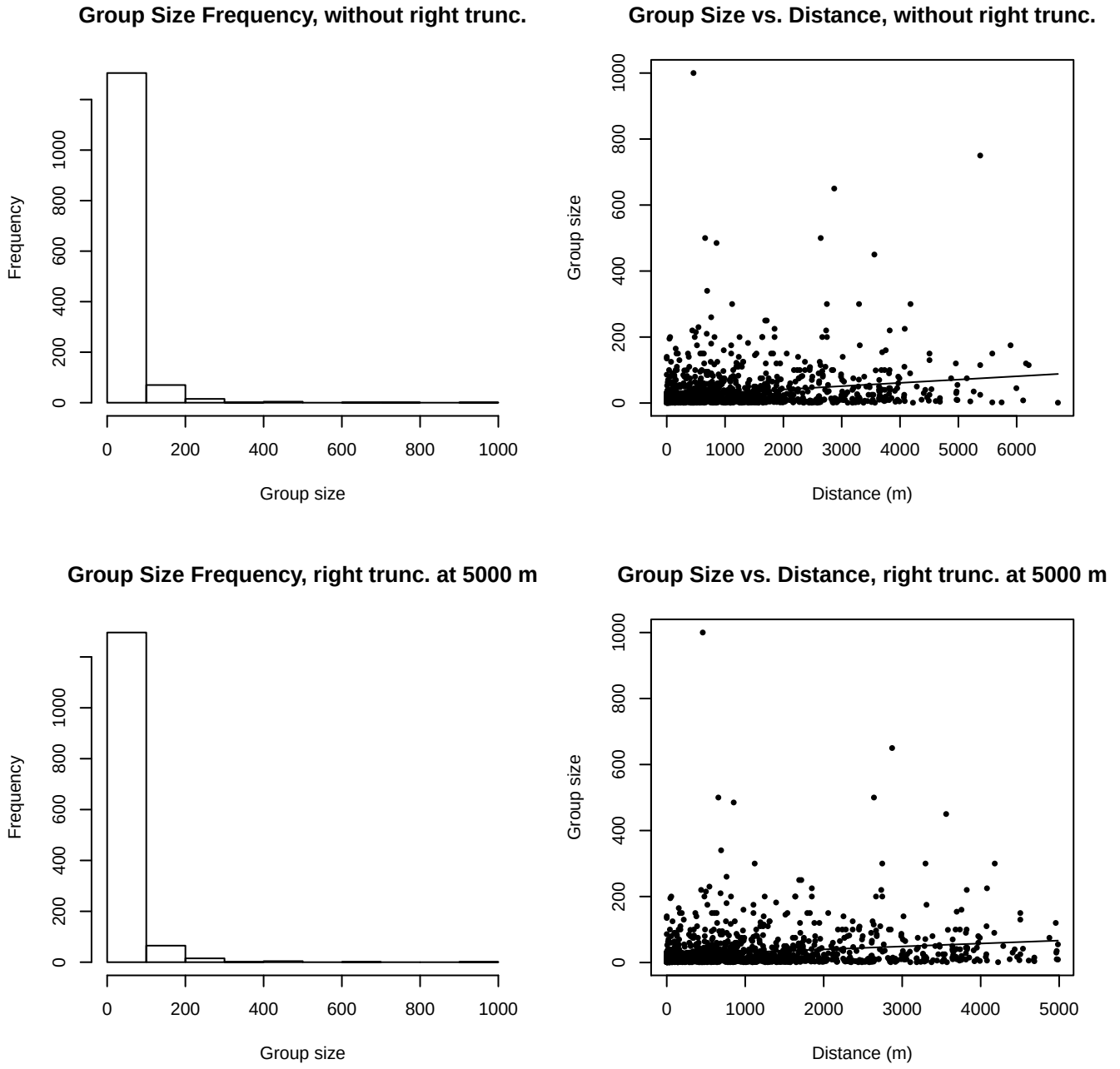

Figure 23: Histograms showing group size frequency and scatterplots showing the relationship between group size and perpendicular sighting distance, for all sightings (top row) and only those not right truncated (bottom row). In the scatterplot, the line is a simple linear regression.

NJ-DEP Hugh R. Sharp

Because this taxon was sighted too infrequently to fit a detection function to its sightings alone, we fit a detection function to the pooled sightings of several other species that we believed would exhibit similar detectability. These "proxy species" are listed below.

Reported By Observer	Common Name	n
Delphinus capensis	Long-beaked common dolphin	0
Delphinus delphis	Short-beaked common dolphin	19

Delphinus delphis/Lagenorhynchus acutus	Short-beaked common or Atlantic white-sided dolphin	0
Delphinus delphis/Stenella	Short-beaked common dolphin or Stenella spp.	0
Delphinus delphis/Stenella coeruleoalba	Short-beaked common or striped dolphin	0
Grampus griseus	Risso's dolphin	0
Grampus griseus/Tursiops truncatus	Risso's or Bottlenose dolphin	0
Lagenodelphis hosei	Fraser's dolphin	0
Lagenorhynchus acutus	Atlantic white-sided dolphin	0
Lagenorhynchus albirostris	White-beaked dolphin	0
Lagenorhynchus albirostris/Lagenorhynchus acutus	White-beaked or white-sided dolphin	0
Stenella	Unidentified Stenella	0
Stenella attenuata	Pantropical spotted dolphin	0
Stenella attenuata/frontalis	Pantropical or Atlantic spotted dolphin	0
Stenella clymene	Clymene dolphin	0
Stenella coeruleoalba	Striped dolphin	0
Stenella frontalis	Atlantic spotted dolphin	0
Stenella frontalis/Tursiops truncatus	Atlantic spotted or Bottlenose dolphin	0
Stenella longirostris	Spinner dolphin	0
Steno bredanensis	Rough-toothed dolphin	0
Steno bredanensis/Tursiops truncatus	Bottlenose or rough-toothed dolphin	0
Tursiops truncatus	Bottlenose dolphin	160
Total		179

Table 16: Proxy species used to fit detection functions for NJ-DEP Hugh R. Sharp. The number of sightings, n, is before truncation.

The sightings were right truncated at 4000m.

Covariate	Description
beaufort	Beaufort sea state.
quality	Survey-specific index of the quality of observation conditions, utilizing relevant factors other than Beaufort sea state (see methods).
size	Estimated size (number of individuals) of the sighted group.

Table 17: Covariates tested in candidate "multi-covariate distance sampling" (MCDS) detection functions.

Key	Adjustment	Order	Covariates	Succeeded	Δ AIC	Mean ESHW (m)
hr			beaufort, size	Yes	0.00	1377
hr			beaufort, quality, size	Yes	1.75	1369
hr			beaufort	Yes	3.38	1206
hr			beaufort, quality	Yes	4.50	1230

hr	poly	4		Yes	5.11	915
hn	cos	3		Yes	8.26	1264
hr			size	Yes	8.29	1080
hn			beaufort, size	Yes	8.82	1847
hr			quality, size	Yes	9.44	1024
hr	poly	2		Yes	10.14	978
hr				Yes	11.84	803
hr			quality	Yes	12.63	823
hn			beaufort	Yes	13.51	1797
hn	cos	2		Yes	19.72	1521
hn			quality, size	Yes	20.75	1842
hn			size	Yes	21.08	1838
hn			quality	Yes	24.69	1812
hn				Yes	24.83	1815
hn	herm	4		No		
hn			beaufort, quality	No		
hn			beaufort, quality, size	No		

Table 18: Candidate detection functions for NJ-DEP Hugh R. Sharp. The first one listed was selected for the density model.

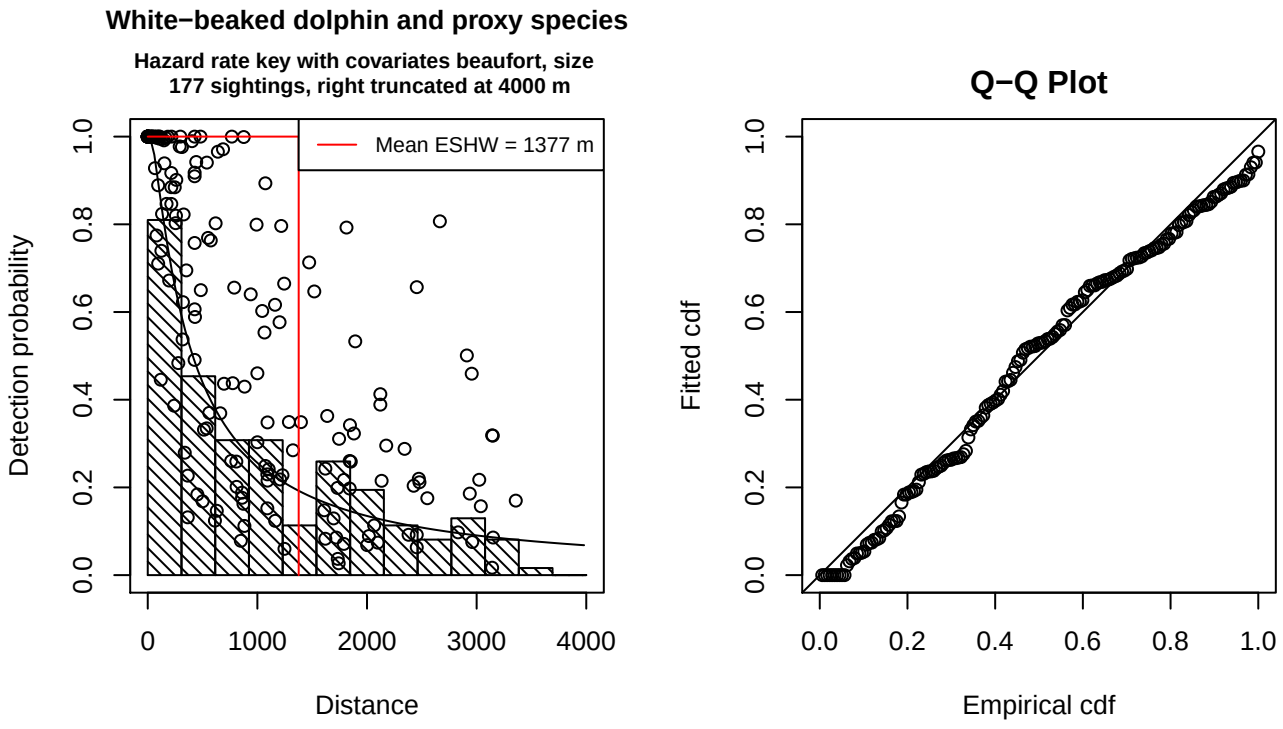

Figure 24: Detection function for NJ-DEP Hugh R. Sharp that was selected for the density model

Statistical output for this detection function:

```
Summary for ds object
Number of observations :  177
Distance range         :  0  -  4000
AIC                    :  2801.518

Detection function:
 Hazard-rate key function

Detection function parameters
Scale Coefficients:
              estimate        se
(Intercept)  6.9376906 0.4645111
beaufort    -0.5811025 0.1584283
size         0.9312215 0.3687349

Shape parameters:
             estimate       se
(Intercept) 0.2435139 0.154517

                        Estimate           SE        CV
Average p              0.2205363   0.04259245 0.1931313
N in covered region 802.5890737 165.26700704 0.2059173
```

Additional diagnostic plots:

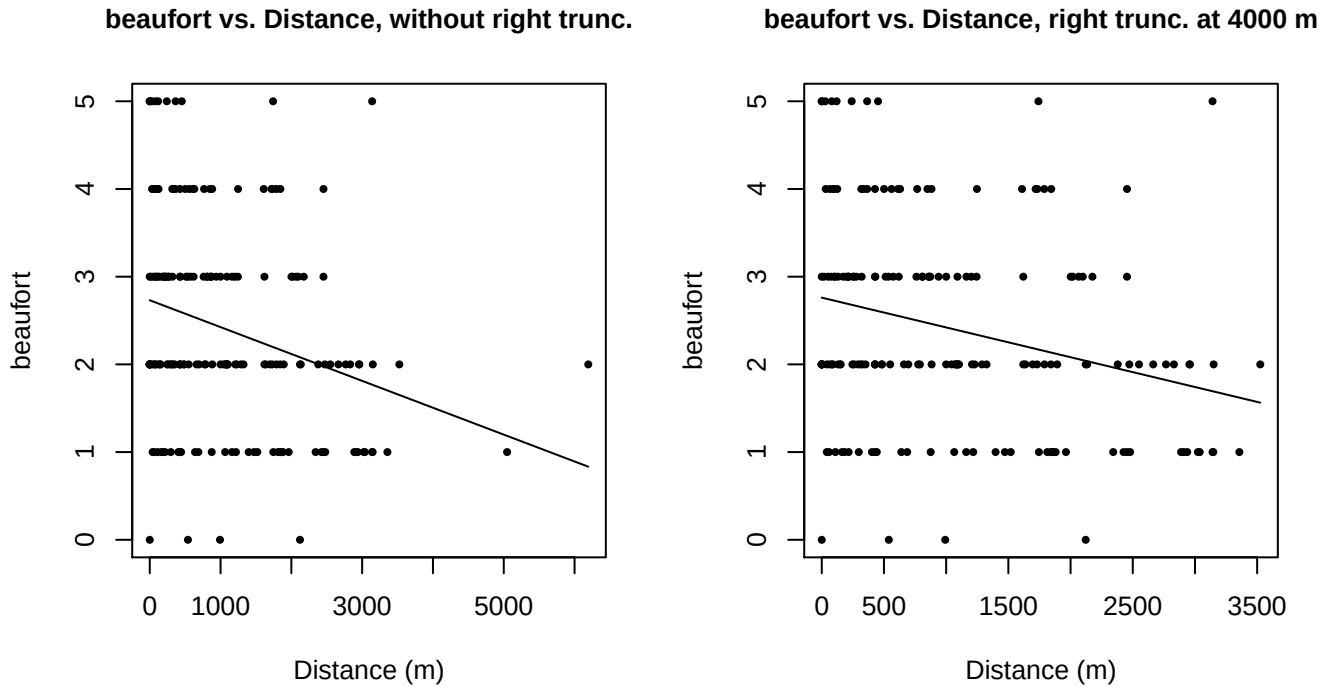

Figure 25: Scatterplots showing the relationship between Beaufort sea state and perpendicular sighting distance, for all sightings (left) and only those not right truncated (right). The line is a simple linear regression.

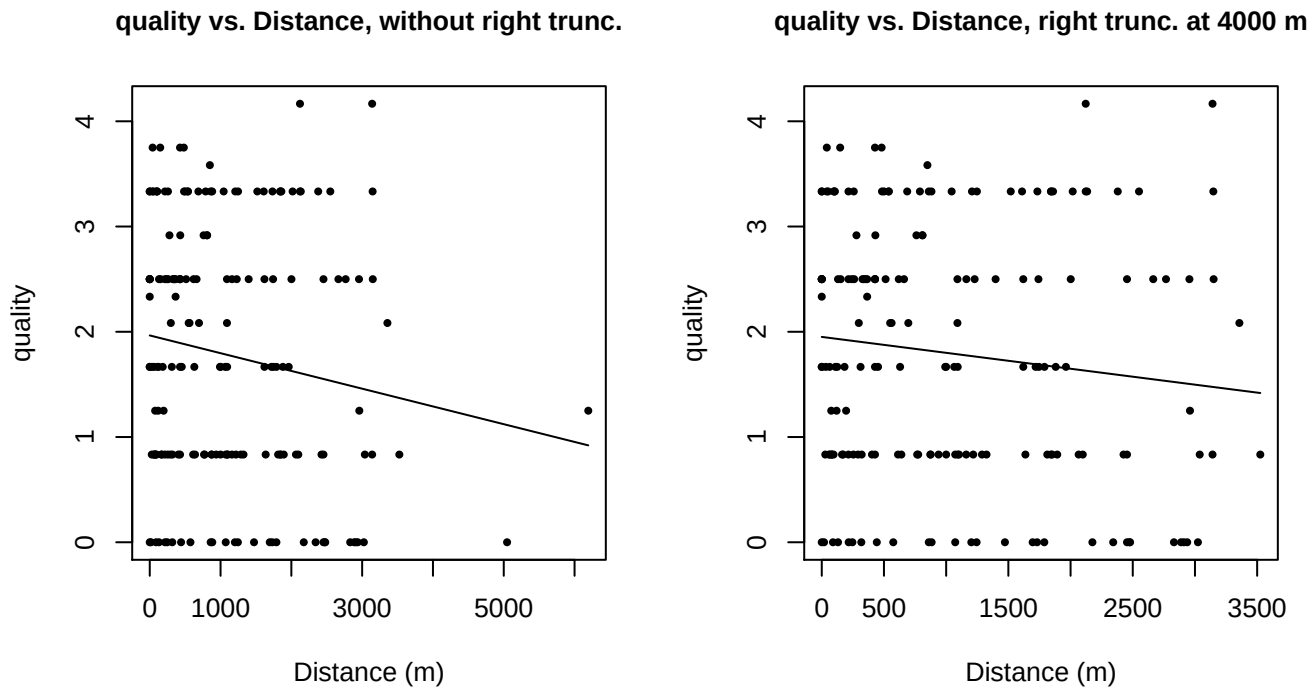

Figure 26: Scatterplots showing the relationship between the survey-specific index of the quality of observation conditions and perpendicular sighting distance, for all sightings (left) and only those not right truncated (right). Low values of the quality index correspond to better observation conditions. The line is a simple linear regression.

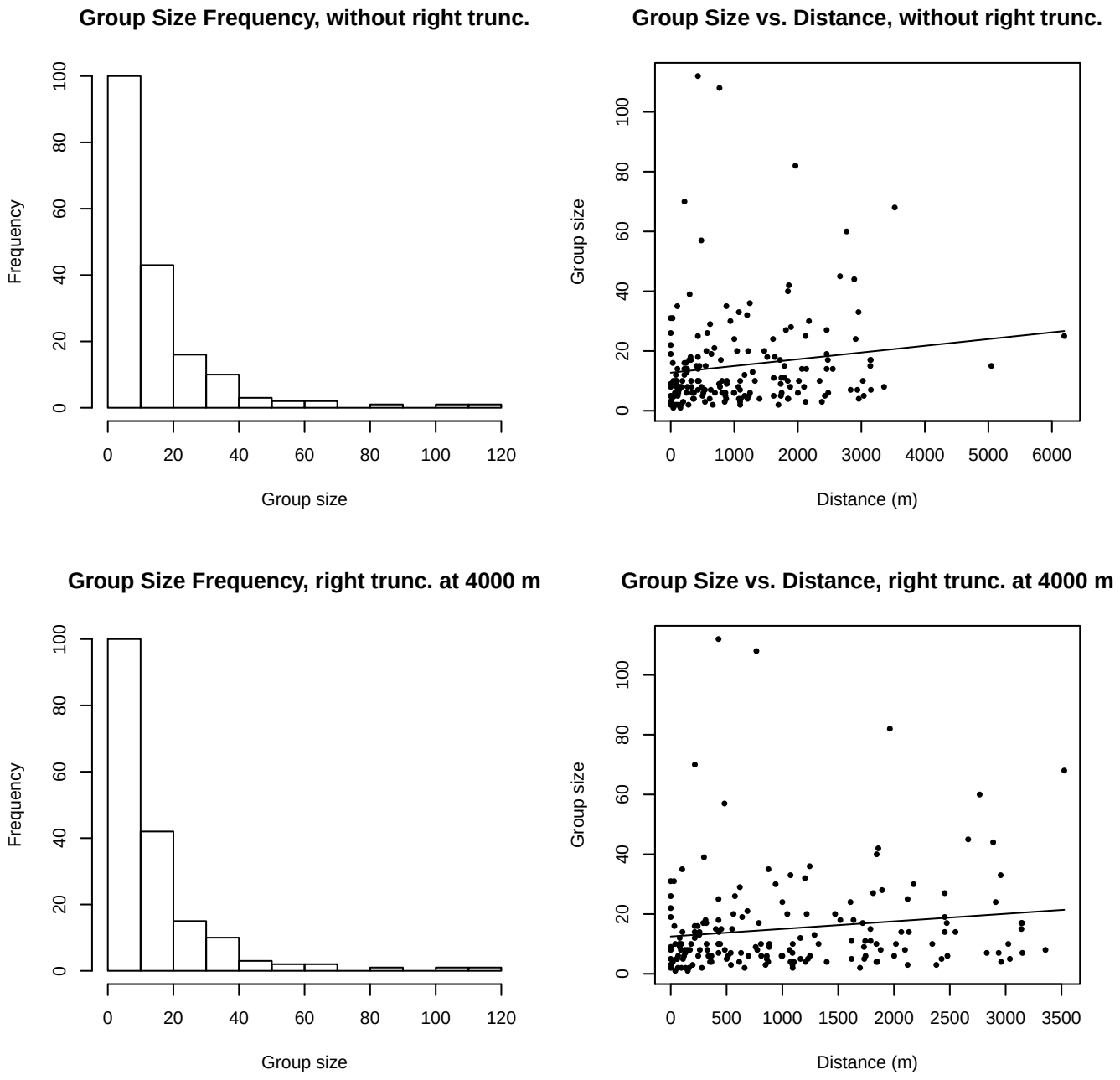

Figure 27: Histograms showing group size frequency and scatterplots showing the relationship between group size and perpendicular sighting distance, for all sightings (top row) and only those not right truncated (bottom row). In the scatterplot, the line is a simple linear regression.

SEFSC Gordon Gunter

Because this taxon was sighted too infrequently to fit a detection function to its sightings alone, we fit a detection function to the pooled sightings of several other species that we believed would exhibit similar detectability. These "proxy species" are listed below.

Reported By Observer	Common Name	n
Delphinus capensis	Long-beaked common dolphin	9
Delphinus delphis	Short-beaked common dolphin	35

Delphinus delphis/Lagenorhynchus acutus	Short-beaked common or Atlantic white-sided dolphin	0
Delphinus delphis/Stenella	Short-beaked common dolphin or Stenella spp.	0
Delphinus delphis/Stenella coeruleoalba	Short-beaked common or striped dolphin	0
Grampus griseus	Risso's dolphin	129
Grampus griseus/Tursiops truncatus	Risso's or Bottlenose dolphin	0
Lagenodelphis hosei	Fraser's dolphin	1
Lagenorhynchus acutus	Atlantic white-sided dolphin	0
Lagenorhynchus albirostris	White-beaked dolphin	0
Lagenorhynchus albirostris/Lagenorhynchus acutus	White-beaked or white-sided dolphin	0
Stenella	Unidentified Stenella	30
Stenella attenuata	Pantropical spotted dolphin	303
Stenella attenuata/frontalis	Pantropical or Atlantic spotted dolphin	0
Stenella clymene	Clymene dolphin	29
Stenella coeruleoalba	Striped dolphin	78
Stenella frontalis	Atlantic spotted dolphin	376
Stenella frontalis/Tursiops truncatus	Atlantic spotted or Bottlenose dolphin	1
Stenella longirostris	Spinner dolphin	24
Steno bredanensis	Rough-toothed dolphin	24
Steno bredanensis/Tursiops truncatus	Bottlenose or rough-toothed dolphin	0
Tursiops truncatus	Bottlenose dolphin	606
Total		1645

Table 19: Proxy species used to fit detection functions for SEFSC Gordon Gunter. The number of sightings, n, is before truncation.

The sightings were right truncated at 6000m.

Covariate	Description
beaufort	Beaufort sea state.
size	Estimated size (number of individuals) of the sighted group.

Table 20: Covariates tested in candidate "multi-covariate distance sampling" (MCDS) detection functions.

Key	Adjustment	Order	Covariates	Succeeded	Δ AIC	Mean ESHW (m)
hr			beaufort	Yes	0.00	845
hr			size	Yes	56.50	827
hr	poly	4		Yes	109.59	672
hr	poly	2		Yes	120.70	708
hr				Yes	146.78	605
hn			beaufort, size	Yes	363.66	2358

hn	cos	3		Yes	368.33	1658
hn	cos	2		Yes	369.53	1845
hn			beaufort	Yes	445.88	2329
hn			size	Yes	494.38	2392
hn				Yes	562.91	2351
hn	herm	4		No		
hr			beaufort, size	No		

Table 21: Candidate detection functions for SEFSC Gordon Gunter. The first one listed was selected for the density model.

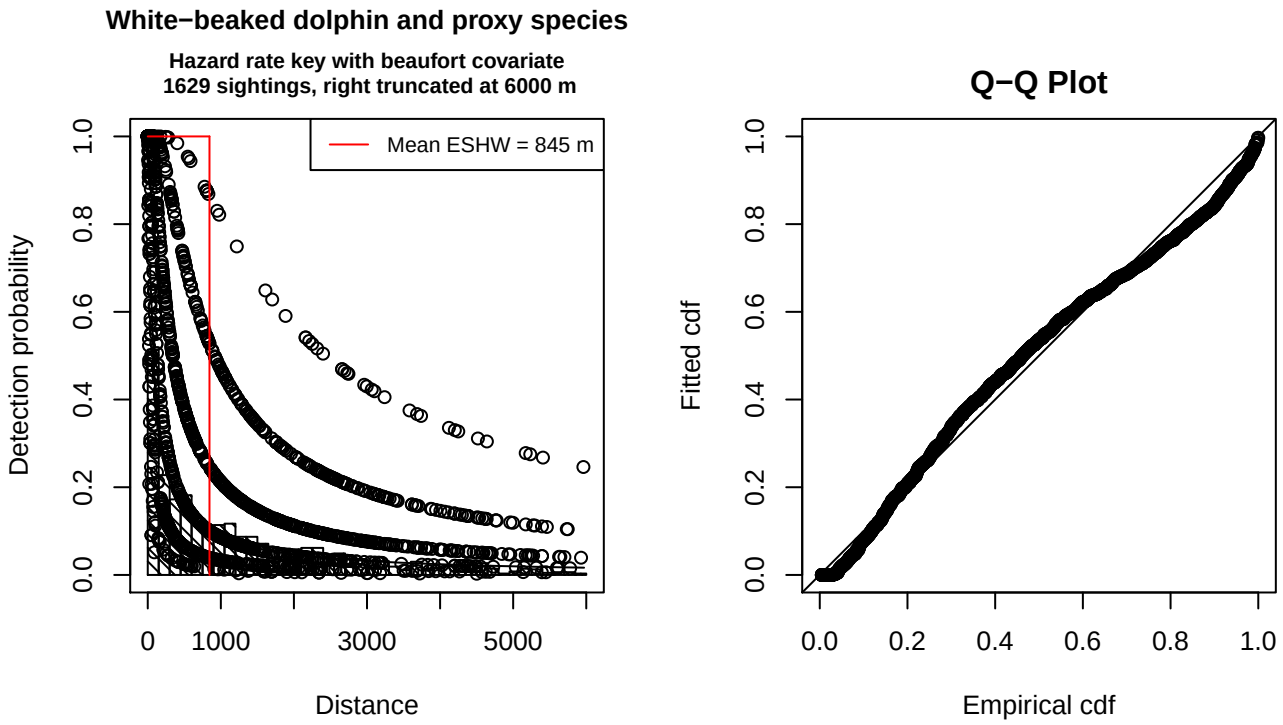

Figure 28: Detection function for SEFSC Gordon Gunter that was selected for the density model

Statistical output for this detection function:

```
Summary for ds object
Number of observations :  1629
Distance range         :  0  -  6000
AIC                    :  26333.8

Detection function:
 Hazard-rate key function

Detection function parameters
Scale Coefficients:
             estimate         se
(Intercept)  7.4292786 0.19090384
beaufort    -0.9782277 0.07236275
```

```
Shape parameters:
            estimate         se
(Intercept)        0 0.03349464

                         Estimate           SE        CV
Average p            6.437877e-02 6.755469e-03 0.1049332
N in covered region 2.530337e+04 2.729041e+03 0.1078529
```

Additional diagnostic plots:

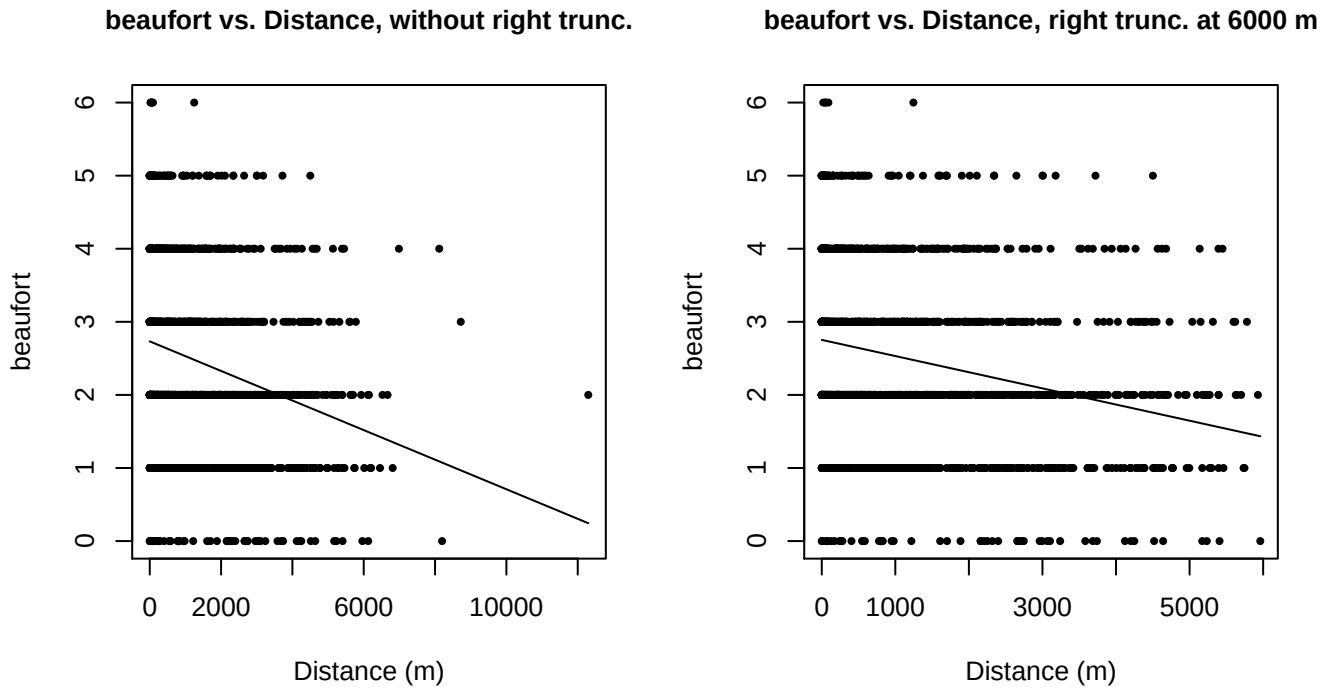

Figure 29: Scatterplots showing the relationship between Beaufort sea state and perpendicular sighting distance, for all sightings (left) and only those not right truncated (right). The line is a simple linear regression.

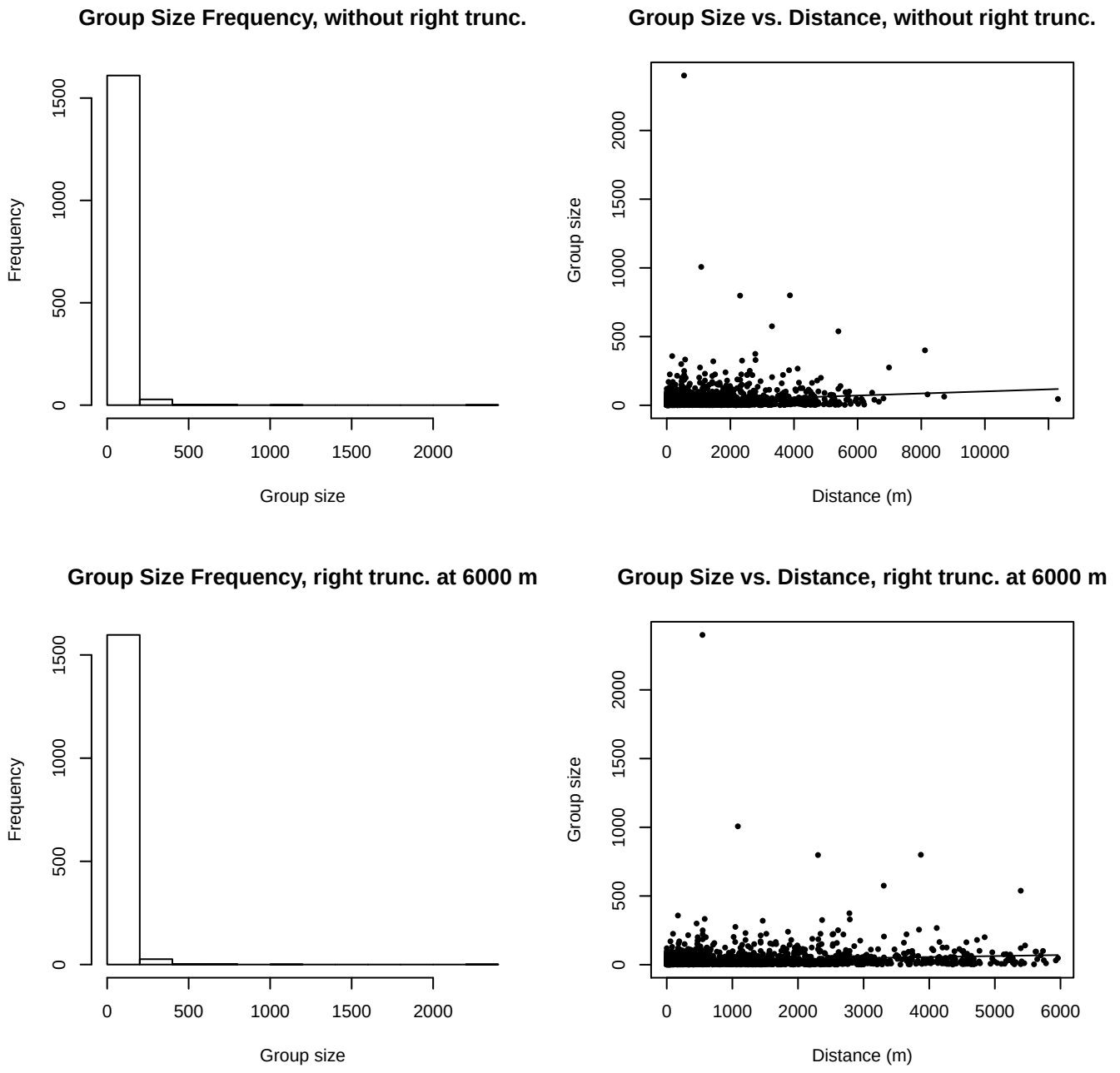

Figure 30: Histograms showing group size frequency and scatterplots showing the relationship between group size and perpendicular sighting distance, for all sightings (top row) and only those not right truncated (bottom row). In the scatterplot, the line is a simple linear regression.

Naked Eye Surveys

Because this taxon was sighted too infrequently to fit a detection function to its sightings alone, we fit a detection function to the pooled sightings of several other species that we believed would exhibit similar detectability. These "proxy species" are listed below.

Reported By Observer	Common Name	n
Delphinus capensis	Long-beaked common dolphin	0
Delphinus delphis	Short-beaked common dolphin	255

Delphinus delphis/Lagenorhynchus acutus	Short-beaked common or Atlantic white-sided dolphin	0
Delphinus delphis/Stenella	Short-beaked common dolphin or Stenella spp.	0
Delphinus delphis/Stenella coeruleoalba	Short-beaked common or striped dolphin	72
Grampus griseus	Risso's dolphin	9
Grampus griseus/Tursiops truncatus	Risso's or Bottlenose dolphin	0
Lagenodelphis hosei	Fraser's dolphin	0
Lagenorhynchus acutus	Atlantic white-sided dolphin	102
Lagenorhynchus albirostris	White-beaked dolphin	36
Lagenorhynchus albirostris/Lagenorhynchus acutus	White-beaked or white-sided dolphin	4
Stenella	Unidentified Stenella	0
Stenella attenuata	Pantropical spotted dolphin	0
Stenella attenuata/frontalis	Pantropical or Atlantic spotted dolphin	0
Stenella clymene	Clymene dolphin	0
Stenella coeruleoalba	Striped dolphin	48
Stenella frontalis	Atlantic spotted dolphin	0
Stenella frontalis/Tursiops truncatus	Atlantic spotted or Bottlenose dolphin	0
Stenella longirostris	Spinner dolphin	0
Steno bredanensis	Rough-toothed dolphin	0
Steno bredanensis/Tursiops truncatus	Bottlenose or rough-toothed dolphin	0
Tursiops truncatus	Bottlenose dolphin	41
Total		567

Table 22: Proxy species used to fit detection functions for Naked Eye Surveys. The number of sightings, n, is before truncation.

The sightings were right truncated at 1300m.

Covariate	Description
beaufort	Beaufort sea state.
size	Estimated size (number of individuals) of the sighted group.

Table 23: Covariates tested in candidate "multi-covariate distance sampling" (MCDS) detection functions.

Key	Adjustment	Order	Covariates	Succeeded	Δ AIC	Mean ESHW (m)
hr			beaufort, size	Yes	0.00	350
hr			size	Yes	5.76	352
hr			beaufort	Yes	8.03	326
hr	poly	2		Yes	9.77	281
hr	poly	4		Yes	12.40	307
hr				Yes	15.22	330

hn	cos	2		Yes	24.51	385
hn	cos	3		Yes	33.35	352
hn			size	Yes	58.26	486
hn			beaufort, size	Yes	58.62	487
hn				Yes	78.39	479
hn			beaufort	Yes	78.83	478
hn	herm	4		No		

Table 24: Candidate detection functions for Naked Eye Surveys. The first one listed was selected for the density model.

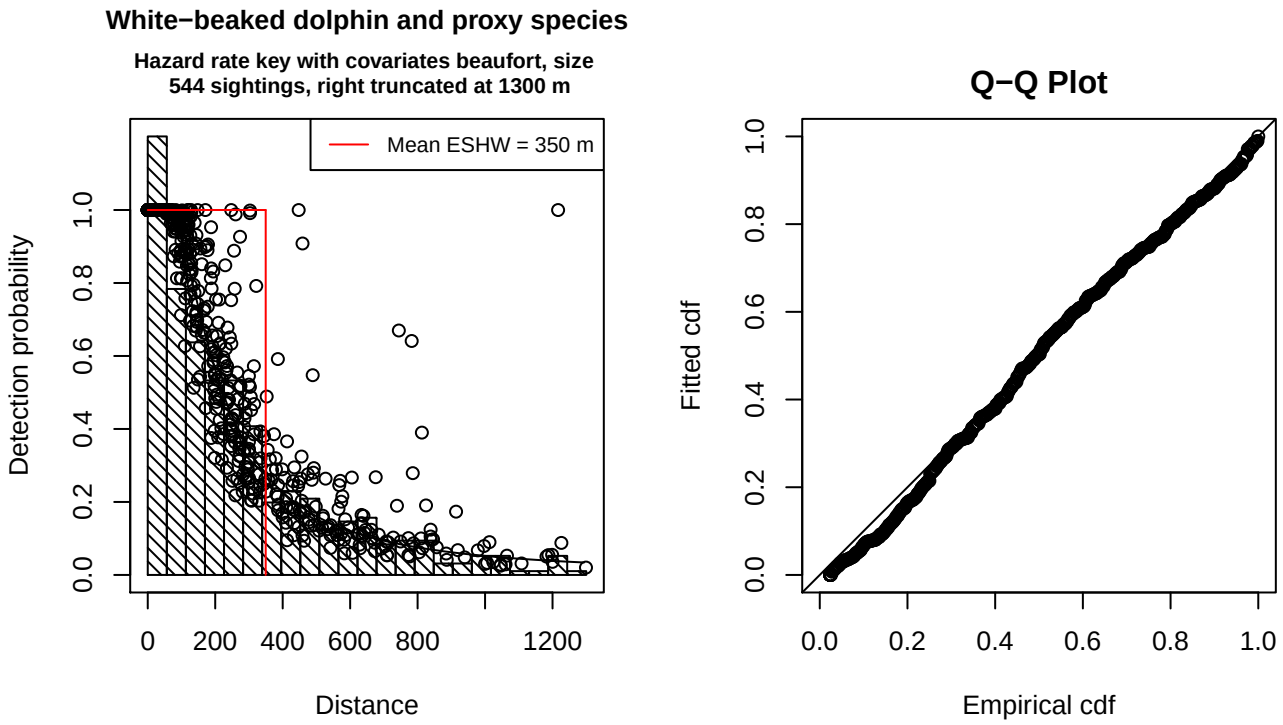

Figure 31: Detection function for Naked Eye Surveys that was selected for the density model

Statistical output for this detection function:

```
Summary for ds object
Number of observations :  544
Distance range         :  0  -  1300
AIC                    :  7176.773

Detection function:
 Hazard-rate key function

Detection function parameters
Scale Coefficients:
             estimate         se
(Intercept)  5.4832964 0.18390295
beaufort    -0.1613519 0.05731217
```

```
size         0.4285522 0.13370410

Shape parameters:
             estimate         se
(Intercept) 0.5903231 0.07541553

                        Estimate           SE         CV
Average p               0.247145   0.01545852 0.06254840
N in covered region 2201.137384 160.79366256 0.07305026
```

Additional diagnostic plots:

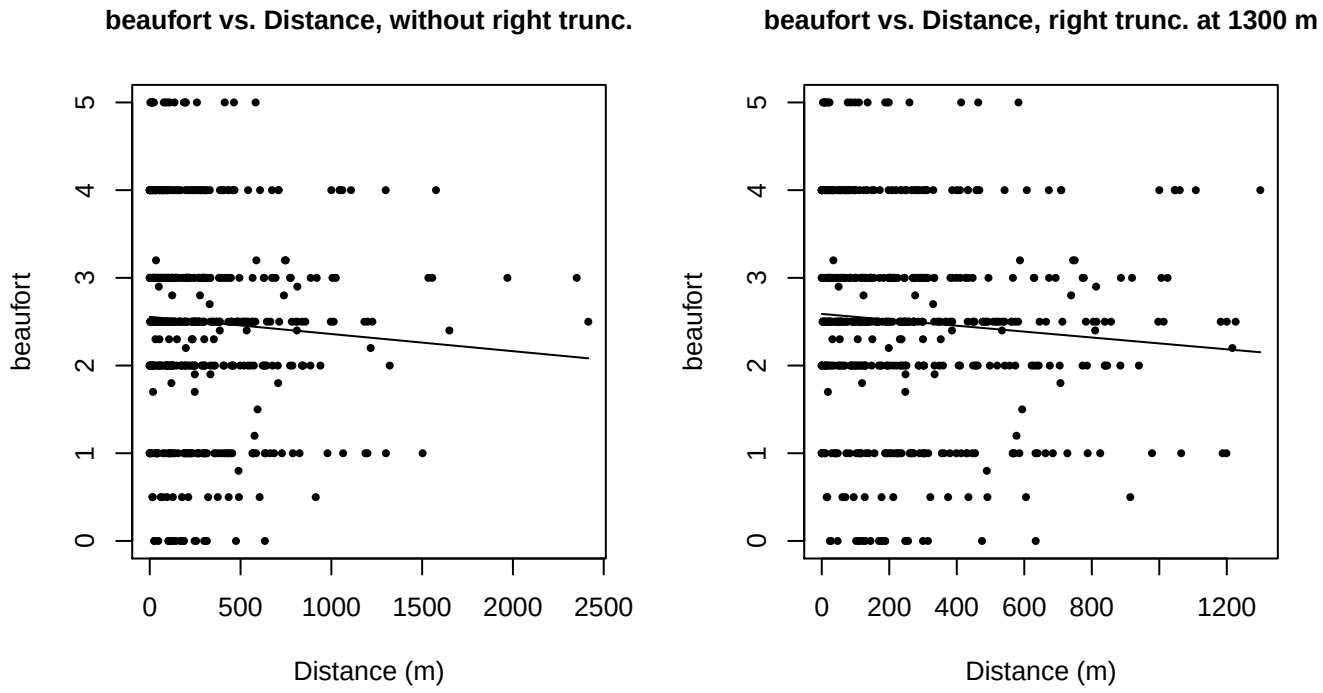

Figure 32: Scatterplots showing the relationship between Beaufort sea state and perpendicular sighting distance, for all sightings (left) and only those not right truncated (right). The line is a simple linear regression.

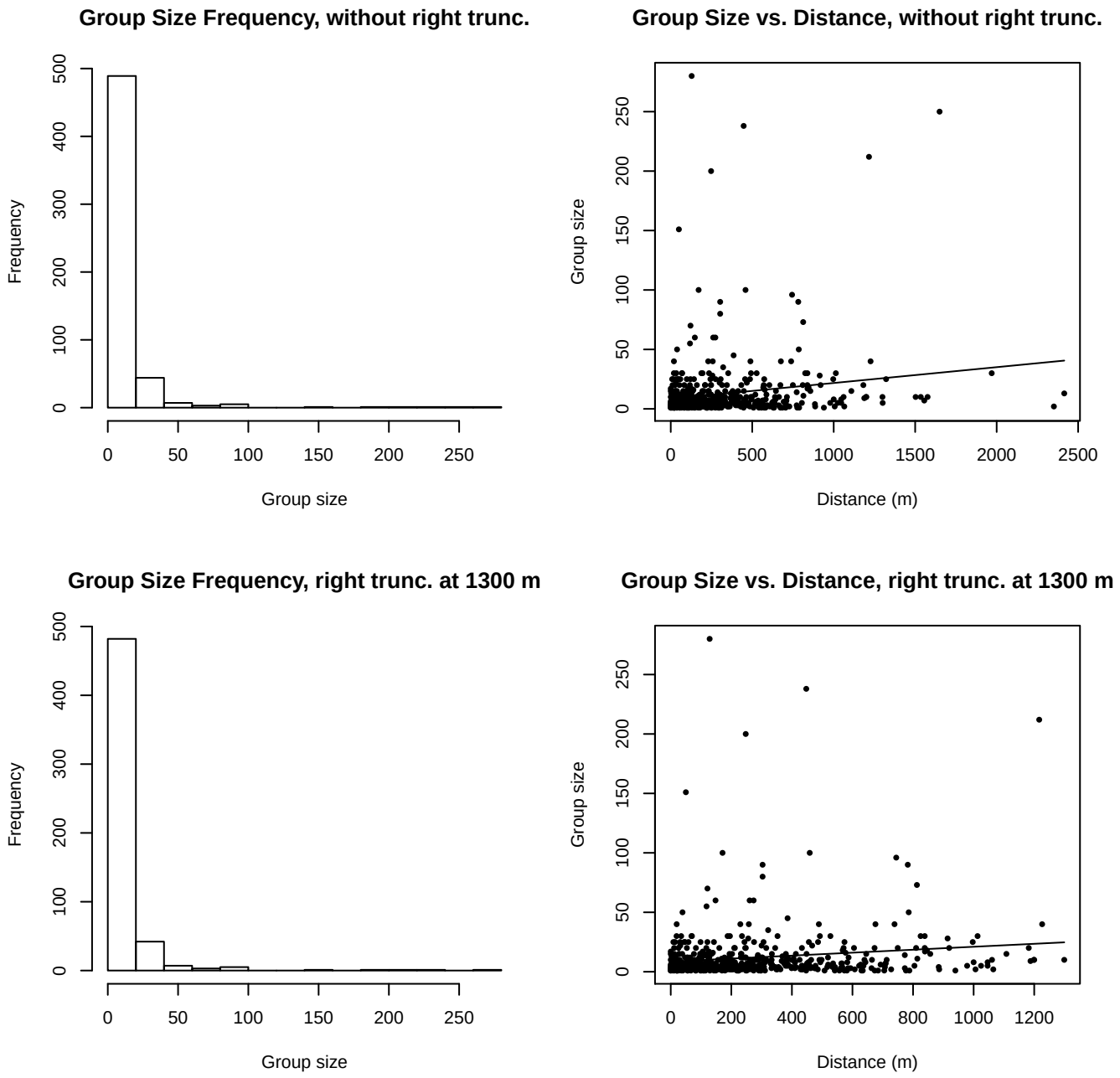

Figure 33: Histograms showing group size frequency and scatterplots showing the relationship between group size and perpendicular sighting distance, for all sightings (top row) and only those not right truncated (bottom row). In the scatterplot, the line is a simple linear regression.

CODA

Because this taxon was sighted too infrequently to fit a detection function to its sightings alone, we fit a detection function to the pooled sightings of several other species that we believed would exhibit similar detectability. These "proxy species" are listed below.

Reported By Observer	Common Name	n
Delphinus capensis	Long-beaked common dolphin	0
Delphinus delphis	Short-beaked common dolphin	113

Delphinus delphis/Lagenorhynchus acutus	Short-beaked common or Atlantic white-sided dolphin	0
Delphinus delphis/Stenella	Short-beaked common dolphin or Stenella spp.	0
Delphinus delphis/Stenella coeruleoalba	Short-beaked common or striped dolphin	29
Grampus griseus	Risso's dolphin	2
Grampus griseus/Tursiops truncatus	Risso's or Bottlenose dolphin	0
Lagenodelphis hosei	Fraser's dolphin	0
Lagenorhynchus acutus	Atlantic white-sided dolphin	14
Lagenorhynchus albirostris	White-beaked dolphin	0
Lagenorhynchus albirostris/Lagenorhynchus acutus	White-beaked or white-sided dolphin	0
Stenella	Unidentified Stenella	0
Stenella attenuata	Pantropical spotted dolphin	0
Stenella attenuata/frontalis	Pantropical or Atlantic spotted dolphin	0
Stenella clymene	Clymene dolphin	0
Stenella coeruleoalba	Striped dolphin	32
Stenella frontalis	Atlantic spotted dolphin	0
Stenella frontalis/Tursiops truncatus	Atlantic spotted or Bottlenose dolphin	0
Stenella longirostris	Spinner dolphin	0
Steno bredanensis	Rough-toothed dolphin	0
Steno bredanensis/Tursiops truncatus	Bottlenose or rough-toothed dolphin	0
Tursiops truncatus	Bottlenose dolphin	22
Total		212

Table 25: Proxy species used to fit detection functions for CODA. The number of sightings, n, is before truncation.

The sightings were right truncated at 1300m.

Covariate	Description
beaufort	Beaufort sea state.
quality	Survey-specific index of the quality of observation conditions, utilizing relevant factors other than Beaufort sea state (see methods).
size	Estimated size (number of individuals) of the sighted group.

Table 26: Covariates tested in candidate "multi-covariate distance sampling" (MCDS) detection functions.

Key	Adjustment	Order	Covariates	Succeeded	Δ AIC	Mean ESHW (m)
hr			quality, size	Yes	0.00	261
hr			quality	Yes	3.19	269
hr			beaufort, size	Yes	4.09	247
hr			size	Yes	4.85	238

hr			beaufort	Yes	7.89	249
hr	poly	2		Yes	8.54	199
hr				Yes	9.85	238
hr	poly	4		Yes	10.46	214
hn	cos	2		Yes	19.33	346
hn	cos	3		Yes	34.78	326
hn			quality	Yes	47.65	438
hn			quality, size	Yes	47.93	438
hn			size	Yes	51.89	440
hn				Yes	52.41	441
hn			beaufort, size	Yes	52.81	440
hn			beaufort	Yes	53.20	440
hn	herm	4		No		
hn			beaufort, quality	No		
hr			beaufort, quality	No		
hn			beaufort, quality, size	No		
hr			beaufort, quality, size	No		

Table 27: Candidate detection functions for CODA. The first one listed was selected for the density model.

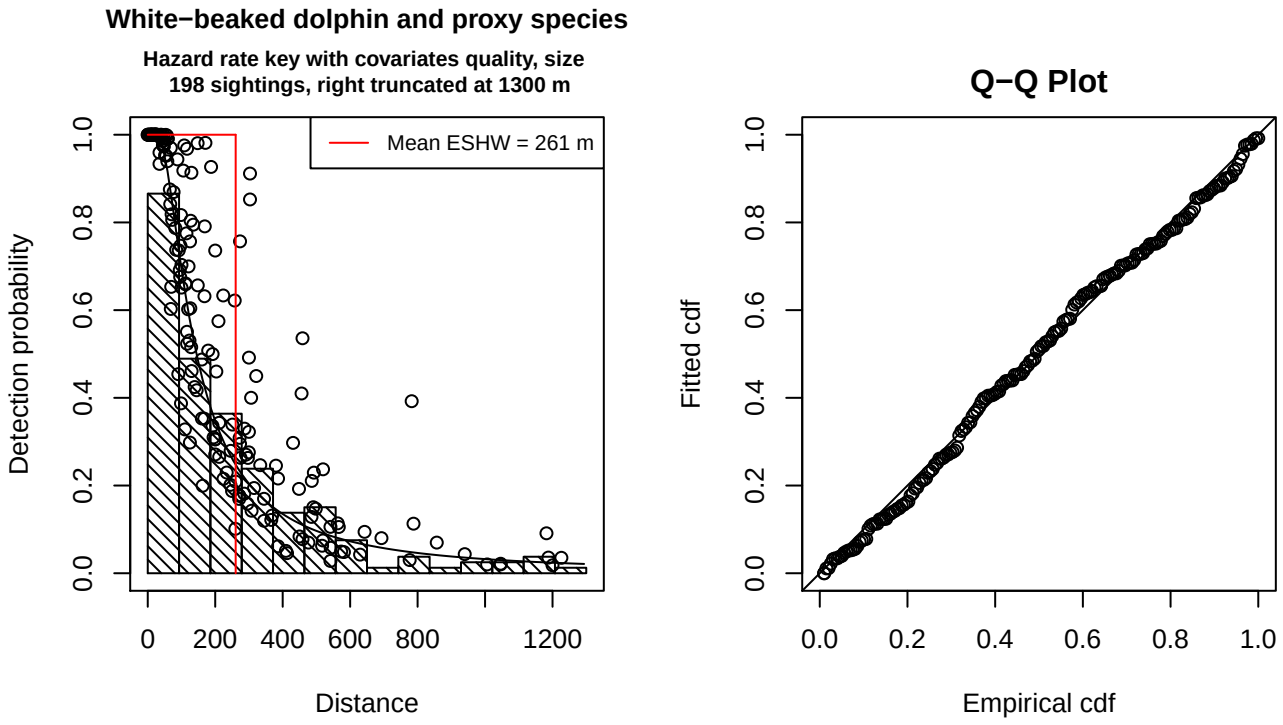

Figure 34: Detection function for CODA that was selected for the density model

Statistical output for this detection function:

```
Summary for ds object
Number of observations :  198
Distance range         :  0  -  1300
AIC                    :  2557.925

Detection function:
 Hazard-rate key function

Detection function parameters
Scale Coefficients:
             estimate         se
(Intercept)  5.3846705 0.32986699
quality     -0.2499530 0.09909297
size         0.2319583 0.13885126

Shape parameters:
             estimate        se
(Intercept) 0.5121523 0.1063675

                         Estimate           SE        CV
Average p               0.1774326   0.02046823 0.1153578
N in covered region 1115.9169012 147.95242555 0.1325837
```

Additional diagnostic plots:

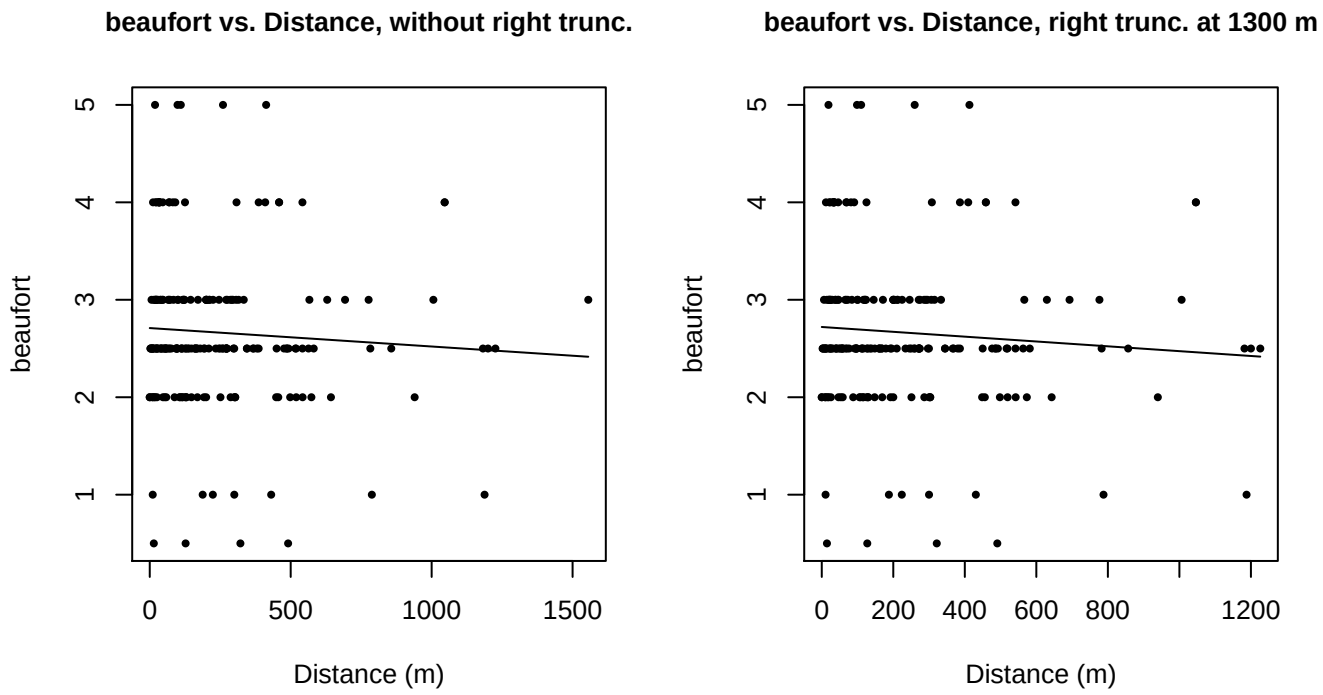

Figure 35: Scatterplots showing the relationship between Beaufort sea state and perpendicular sighting distance, for all sightings (left) and only those not right truncated (right). The line is a simple linear regression.

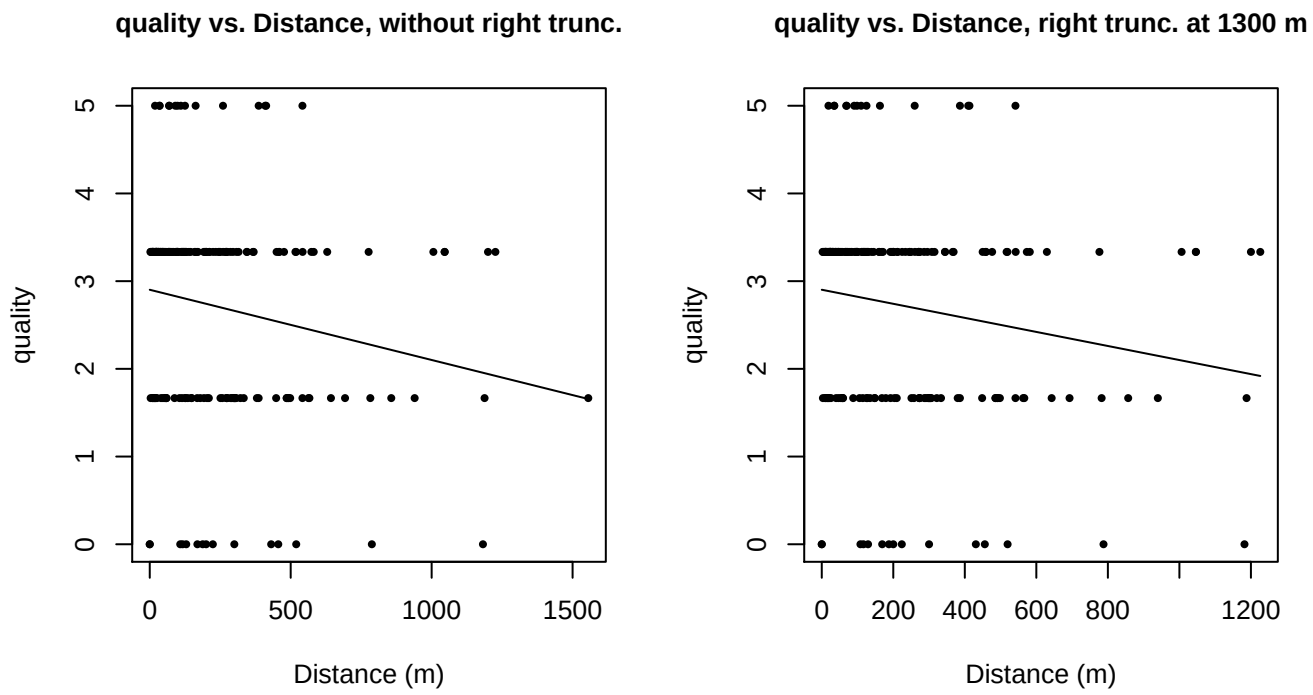

Figure 36: Scatterplots showing the relationship between the survey-specific index of the quality of observation conditions and perpendicular sighting distance, for all sightings (left) and only those not right truncated (right). Low values of the quality index correspond to better observation conditions. The line is a simple linear regression.

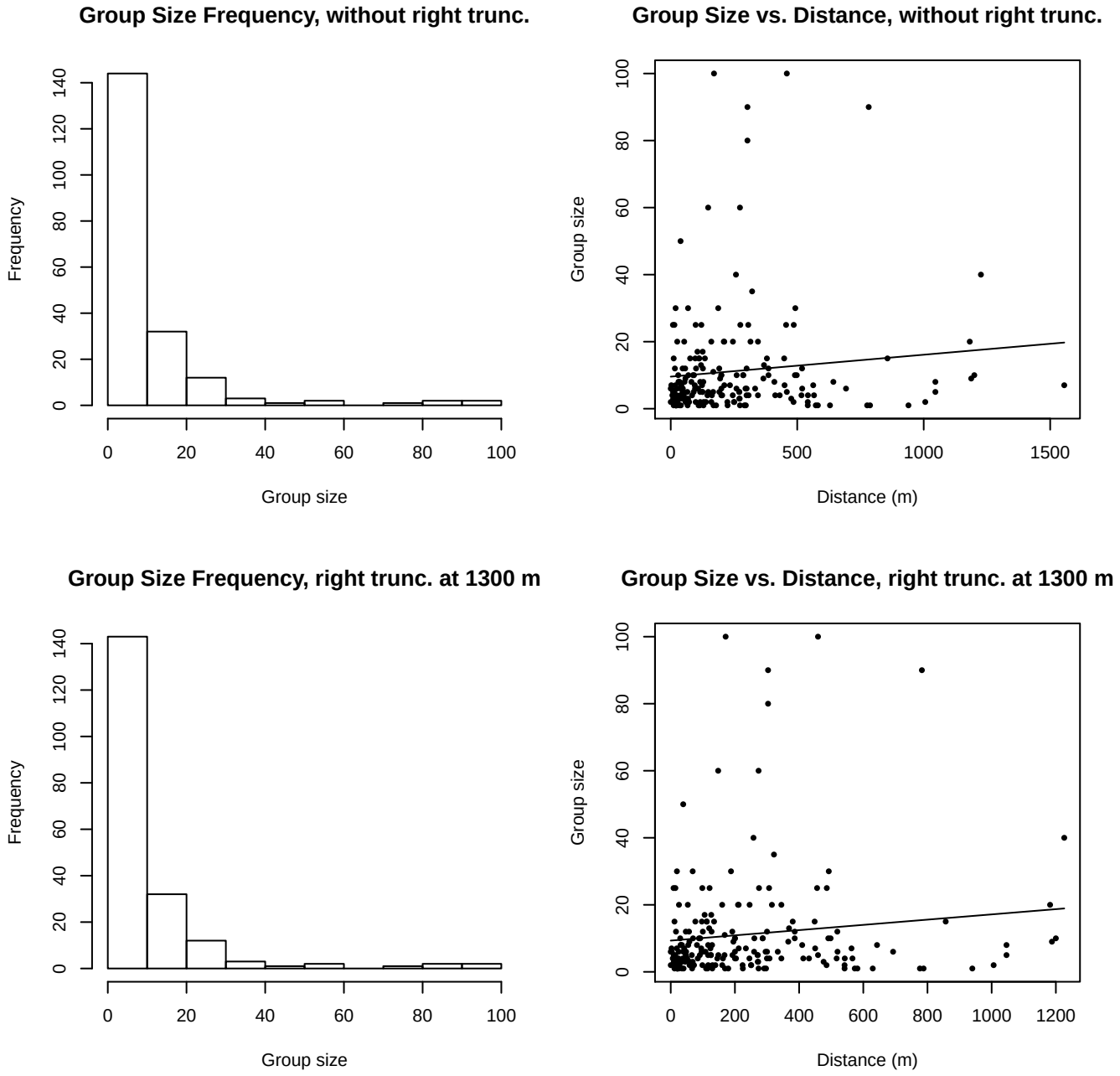

Figure 37: Histograms showing group size frequency and scatterplots showing the relationship between group size and perpendicular sighting distance, for all sightings (top row) and only those not right truncated (bottom row). In the scatterplot, the line is a simple linear regression.

SCANS II Shipboard

Because this taxon was sighted too infrequently to fit a detection function to its sightings alone, we fit a detection function to the pooled sightings of several other species that we believed would exhibit similar detectability. These "proxy species" are listed below.

Reported By Observer	Common Name	n
Delphinus capensis	Long-beaked common dolphin	0
Delphinus delphis	Short-beaked common dolphin	114

Delphinus delphis/Lagenorhynchus acutus	Short-beaked common or Atlantic white-sided dolphin	0
Delphinus delphis/Stenella	Short-beaked common dolphin or Stenella spp.	0
Delphinus delphis/Stenella coeruleoalba	Short-beaked common or striped dolphin	28
Grampus griseus	Risso's dolphin	7
Grampus griseus/Tursiops truncatus	Risso's or Bottlenose dolphin	0
Lagenodelphis hosei	Fraser's dolphin	0
Lagenorhynchus acutus	Atlantic white-sided dolphin	42
Lagenorhynchus albirostris	White-beaked dolphin	32
Lagenorhynchus albirostris/Lagenorhynchus acutus	White-beaked or white-sided dolphin	4
Stenella	Unidentified Stenella	0
Stenella attenuata	Pantropical spotted dolphin	0
Stenella attenuata/frontalis	Pantropical or Atlantic spotted dolphin	0
Stenella clymene	Clymene dolphin	0
Stenella coeruleoalba	Striped dolphin	4
Stenella frontalis	Atlantic spotted dolphin	0
Stenella frontalis/Tursiops truncatus	Atlantic spotted or Bottlenose dolphin	0
Stenella longirostris	Spinner dolphin	0
Steno bredanensis	Rough-toothed dolphin	0
Steno bredanensis/Tursiops truncatus	Bottlenose or rough-toothed dolphin	0
Tursiops truncatus	Bottlenose dolphin	19
Total		250

Table 28: Proxy species used to fit detection functions for SCANS II Shipboard. The number of sightings, n, is before truncation.

The sightings were right truncated at 1000m.

Covariate	Description
beaufort	Beaufort sea state.
quality	Survey-specific index of the quality of observation conditions, utilizing relevant factors other than Beaufort sea state (see methods).
size	Estimated size (number of individuals) of the sighted group.

Table 29: Covariates tested in candidate "multi-covariate distance sampling" (MCDS) detection functions.

Key	Adjustment	Order	Covariates	Succeeded	Δ AIC	Mean ESHW (m)
hn			size	Yes	0.00	462
hn	cos	2		Yes	0.73	361
hn			beaufort, size	Yes	1.47	463
hn			quality, size	Yes	1.78	462

hr				Yes	2.50	379
hr			quality	Yes	4.03	380
hr	poly	4		Yes	4.10	372
hr	poly	2		Yes	4.20	370
hr			beaufort	Yes	4.22	378
hr			quality, size	Yes	6.03	380
hn	cos	3		Yes	10.41	376
hn				Yes	14.12	455
hn			beaufort	Yes	15.37	456
hn			quality	Yes	15.43	455
hn	herm	4		Yes	15.69	454
hn			beaufort, quality	Yes	17.33	456
hr			size	No		
hr			beaufort, quality	No		
hr			beaufort, size	No		
hn			beaufort, quality, size	No		
hr			beaufort, quality, size	No		

Table 30: Candidate detection functions for SCANS II Shipboard. The first one listed was selected for the density model.

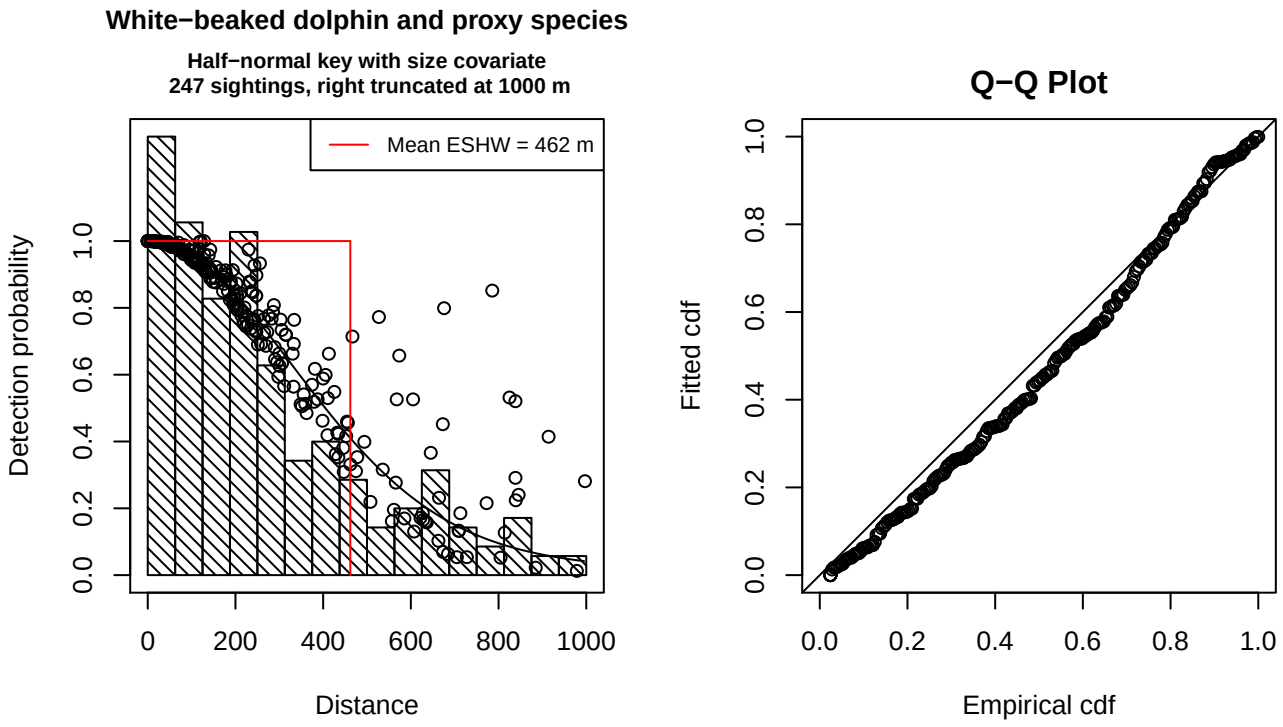

Figure 38: Detection function for SCANS II Shipboard that was selected for the density model

Statistical output for this detection function:

```
Summary for ds object
Number of observations :  247
Distance range         :  0  -  1000
AIC                    :  3245.813

Detection function:
 Half-normal key function

Detection function parameters
Scale Coefficients:
             estimate         se
(Intercept) 5.6435356 0.06781568
size        0.6259412 0.18560451

                       Estimate          SE         CV
Average p              0.4405241  0.01935102 0.04392728
N in covered region 560.6958131 36.68734001 0.06543181
```

Additional diagnostic plots:

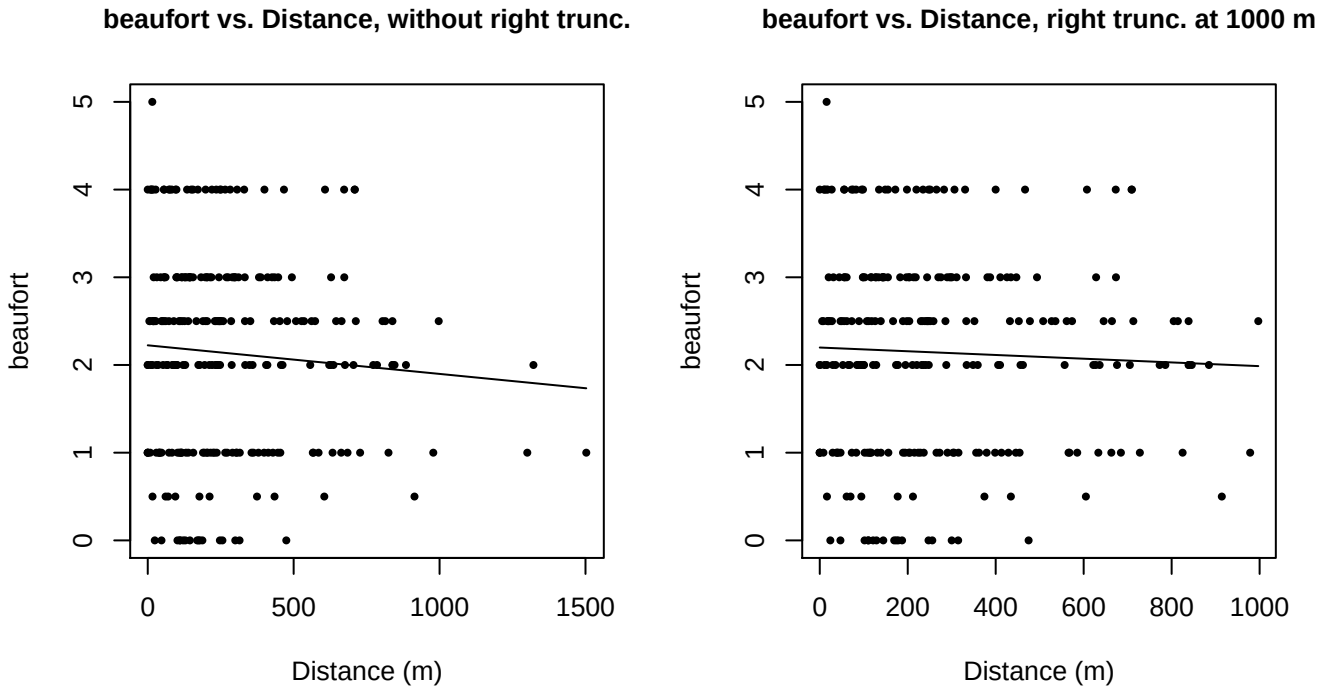

Figure 39: Scatterplots showing the relationship between Beaufort sea state and perpendicular sighting distance, for all sightings (left) and only those not right truncated (right). The line is a simple linear regression.

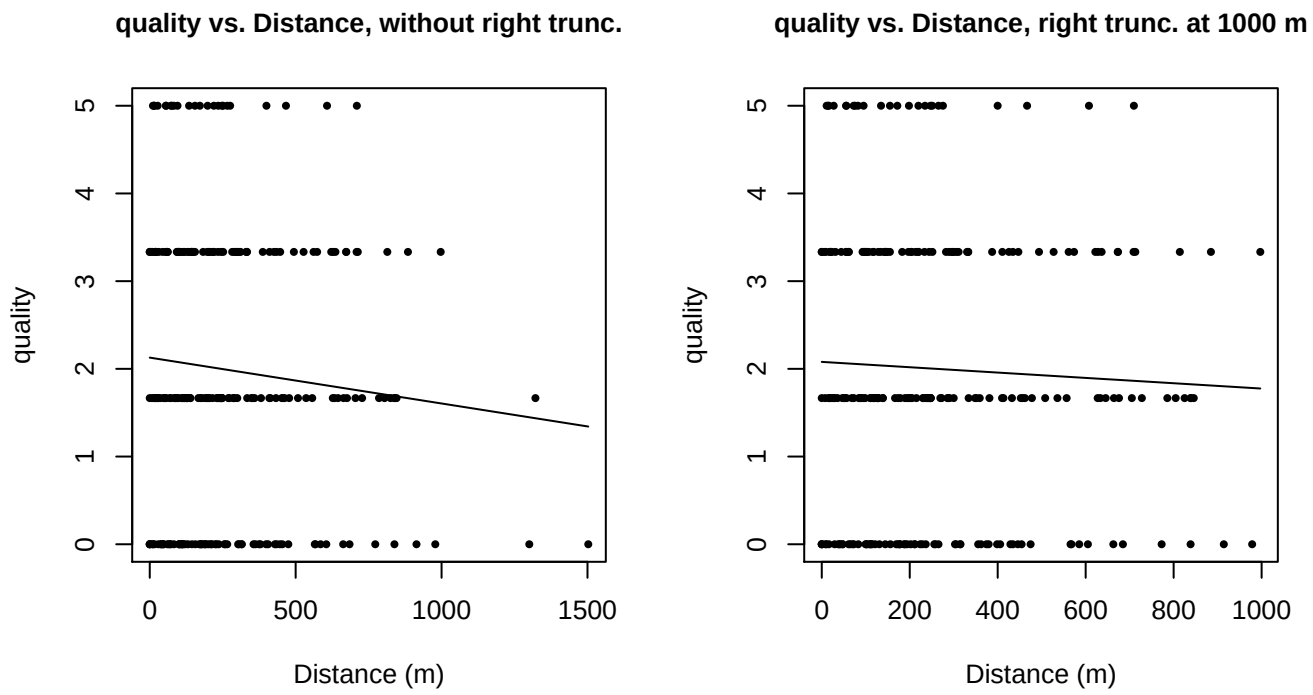

Figure 40: Scatterplots showing the relationship between the survey-specific index of the quality of observation conditions and perpendicular sighting distance, for all sightings (left) and only those not right truncated (right). Low values of the quality index correspond to better observation conditions. The line is a simple linear regression.

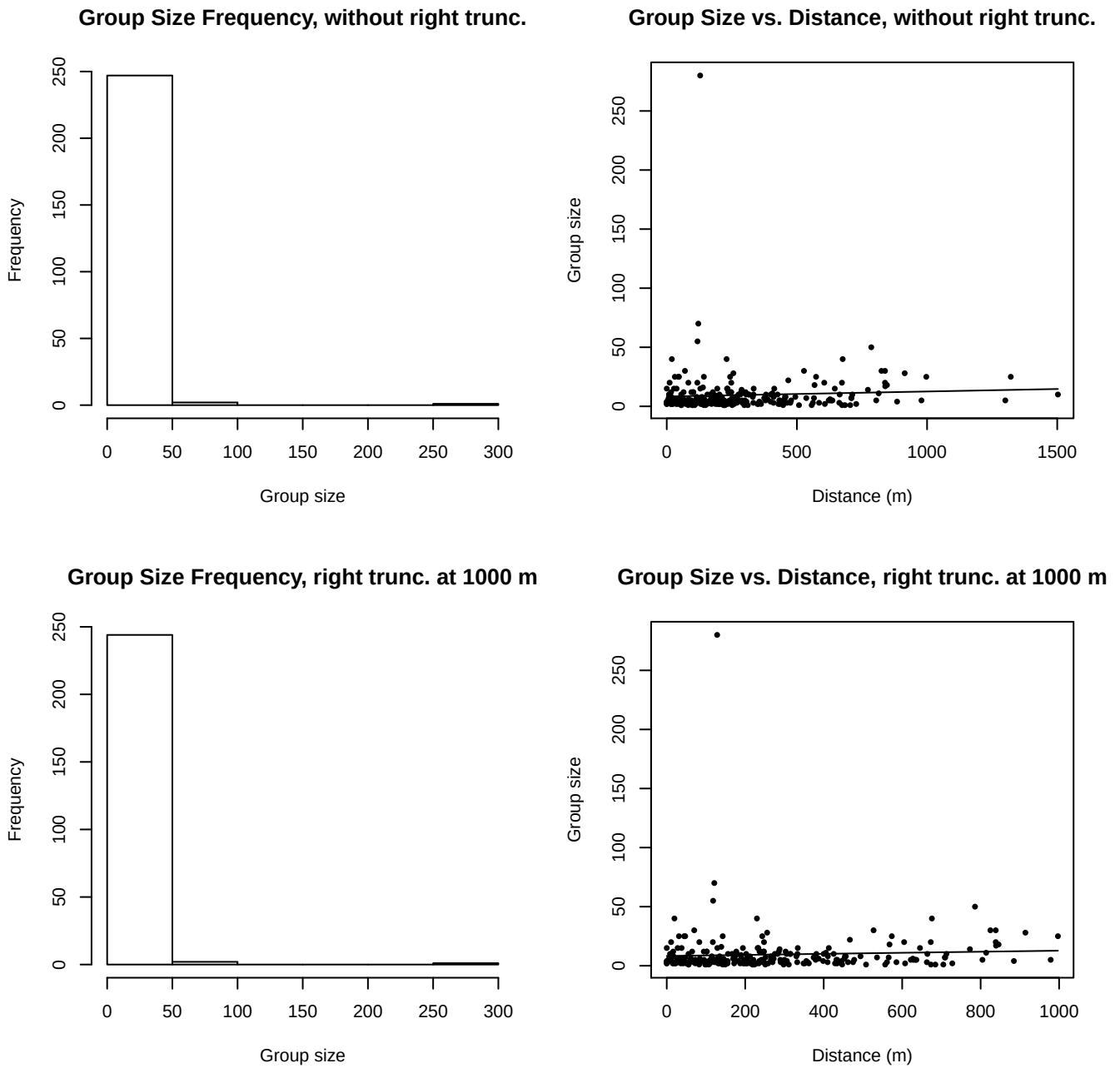

Figure 41: Histograms showing group size frequency and scatterplots showing the relationship between group size and perpendicular sighting distance, for all sightings (top row) and only those not right truncated (bottom row). In the scatterplot, the line is a simple linear regression.

Aerial Surveys

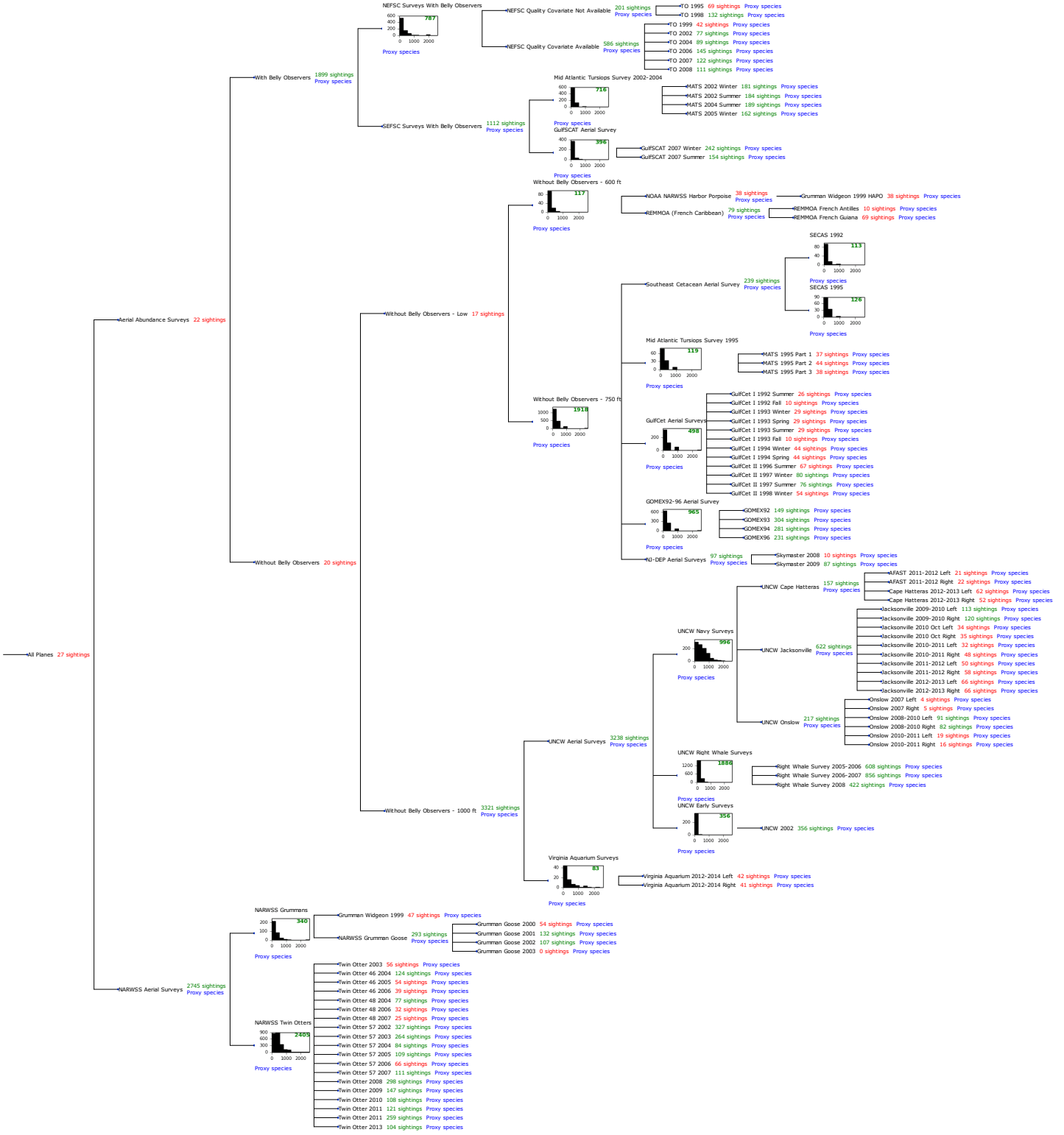

Figure 42: Detection hierarchy for aerial surveys

NEFSC Surveys With Belly Observers

Because this taxon was sighted too infrequently to fit a detection function to its sightings alone, we fit a detection function to the pooled sightings of several other species that we believed would exhibit similar detectability. These "proxy species" are

listed below.

Reported By Observer	Common Name	n
Delphinus capensis	Long-beaked common dolphin	0
Delphinus delphis	Short-beaked common dolphin	311
Delphinus delphis/Lagenorhynchus acutus	Short-beaked common or Atlantic white-sided dolphin	0
Delphinus delphis/Stenella	Short-beaked common dolphin or Stenella spp.	0
Delphinus delphis/Stenella coeruleoalba	Short-beaked common or striped dolphin	0
Grampus griseus	Risso's dolphin	148
Grampus griseus/Tursiops truncatus	Risso's or Bottlenose dolphin	0
Lagenodelphis hosei	Fraser's dolphin	0
Lagenorhynchus acutus	Atlantic white-sided dolphin	220
Lagenorhynchus albirostris	White-beaked dolphin	5
Lagenorhynchus albirostris/Lagenorhynchus acutus	White-beaked or white-sided dolphin	0
Stenella	Unidentified Stenella	0
Stenella attenuata	Pantropical spotted dolphin	0
Stenella attenuata/frontalis	Pantropical or Atlantic spotted dolphin	0
Stenella clymene	Clymene dolphin	0
Stenella coeruleoalba	Striped dolphin	2
Stenella frontalis	Atlantic spotted dolphin	2
Stenella frontalis/Tursiops truncatus	Atlantic spotted or Bottlenose dolphin	0
Stenella longirostris	Spinner dolphin	0
Steno bredanensis	Rough-toothed dolphin	0
Steno bredanensis/Tursiops truncatus	Bottlenose or rough-toothed dolphin	0
Tursiops truncatus	Bottlenose dolphin	99
Total		787

Table 31: Proxy species used to fit detection functions for NEFSC Surveys With Belly Observers. The number of sightings, n, is before truncation.

The sightings were right truncated at 1000m.

Covariate	Description
beaufort	Beaufort sea state.
size	Estimated size (number of individuals) of the sighted group.

Table 32: Covariates tested in candidate "multi-covariate distance sampling" (MCDS) detection functions.

Key	Adjustment	Order	Covariates	Succeeded	Δ AIC	Mean ESHW (m)

hr			size	Yes	0.00	380
hr	poly	4		Yes	18.20	354
hr				Yes	20.16	359
hr	poly	2		Yes	20.32	350
hn	cos	2		Yes	20.44	311
hn			size	Yes	25.50	370
hn	cos	3		Yes	37.76	322
hn				Yes	43.60	364
hn	herm	4		No		
hn			beaufort	No		
hr			beaufort	No		
hn			beaufort, size	No		
hr			beaufort, size	No		

Table 33: Candidate detection functions for NEFSC Surveys With Belly Observers. The first one listed was selected for the density model.

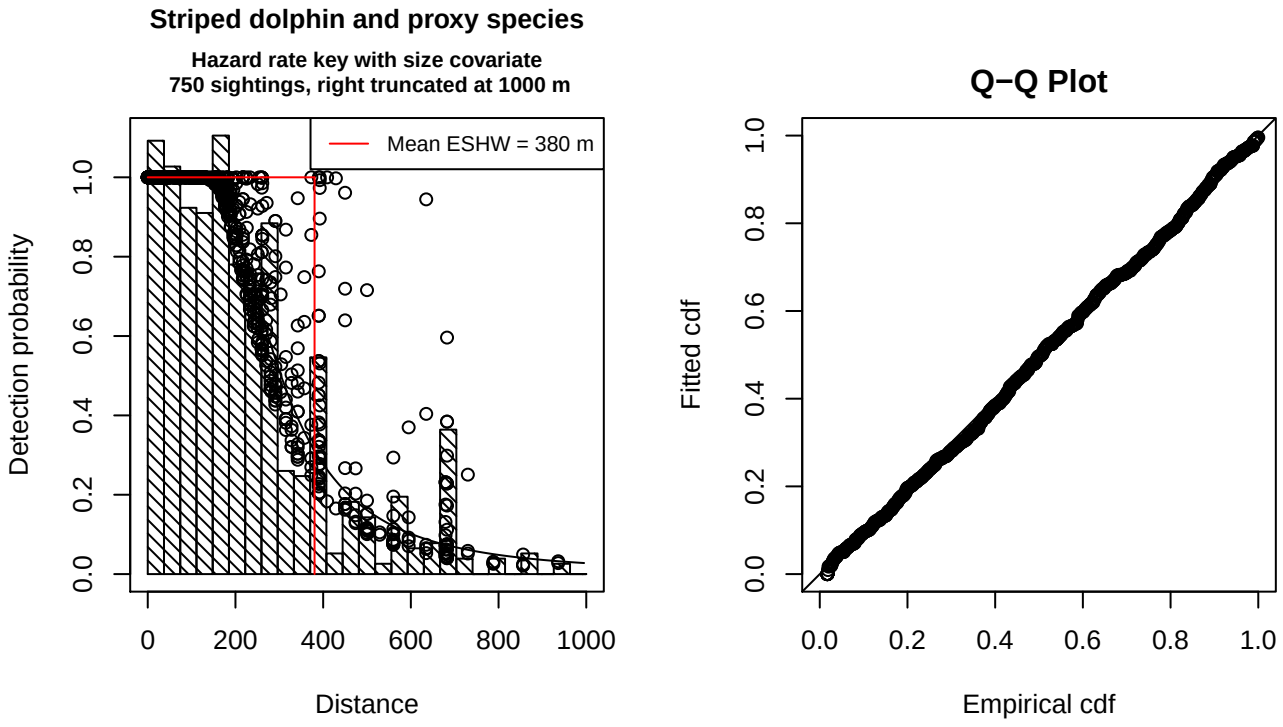

Figure 43: Detection function for NEFSC Surveys With Belly Observers that was selected for the density model

Statistical output for this detection function:

```
Summary for ds object
Number of observations :  750
```

```
Distance range         :  0  -  1000
AIC                    :  9547.646

Detection function:
 Hazard-rate key function

Detection function parameters
Scale Coefficients:
             estimate         se
(Intercept) 5.4723434 0.05875063
size        0.4897148 0.09093801

Shape parameters:
            estimate         se
(Intercept) 1.119312 0.06987572

                         Estimate          SE         CV
Average p                0.3611765  0.01276499 0.03534280
N in covered region 2076.5469236 95.75679628 0.04611348
```

Additional diagnostic plots:

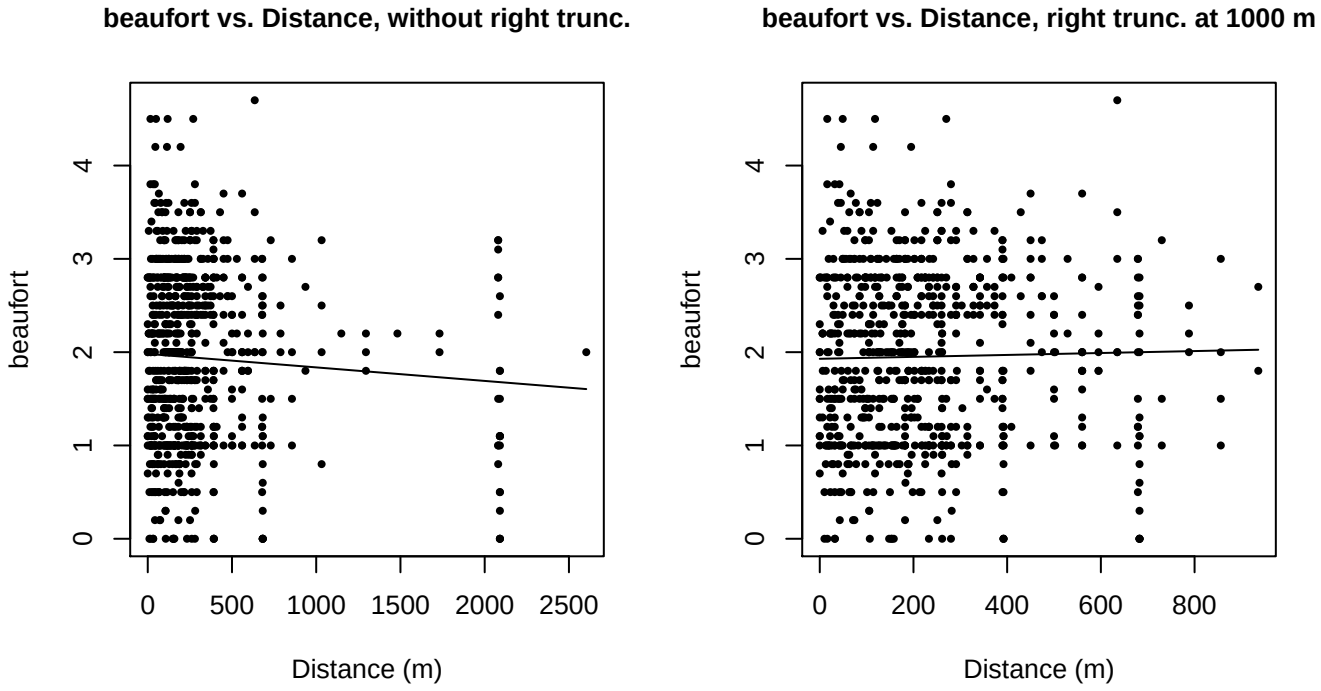

Figure 44: Scatterplots showing the relationship between Beaufort sea state and perpendicular sighting distance, for all sightings (left) and only those not right truncated (right). The line is a simple linear regression.

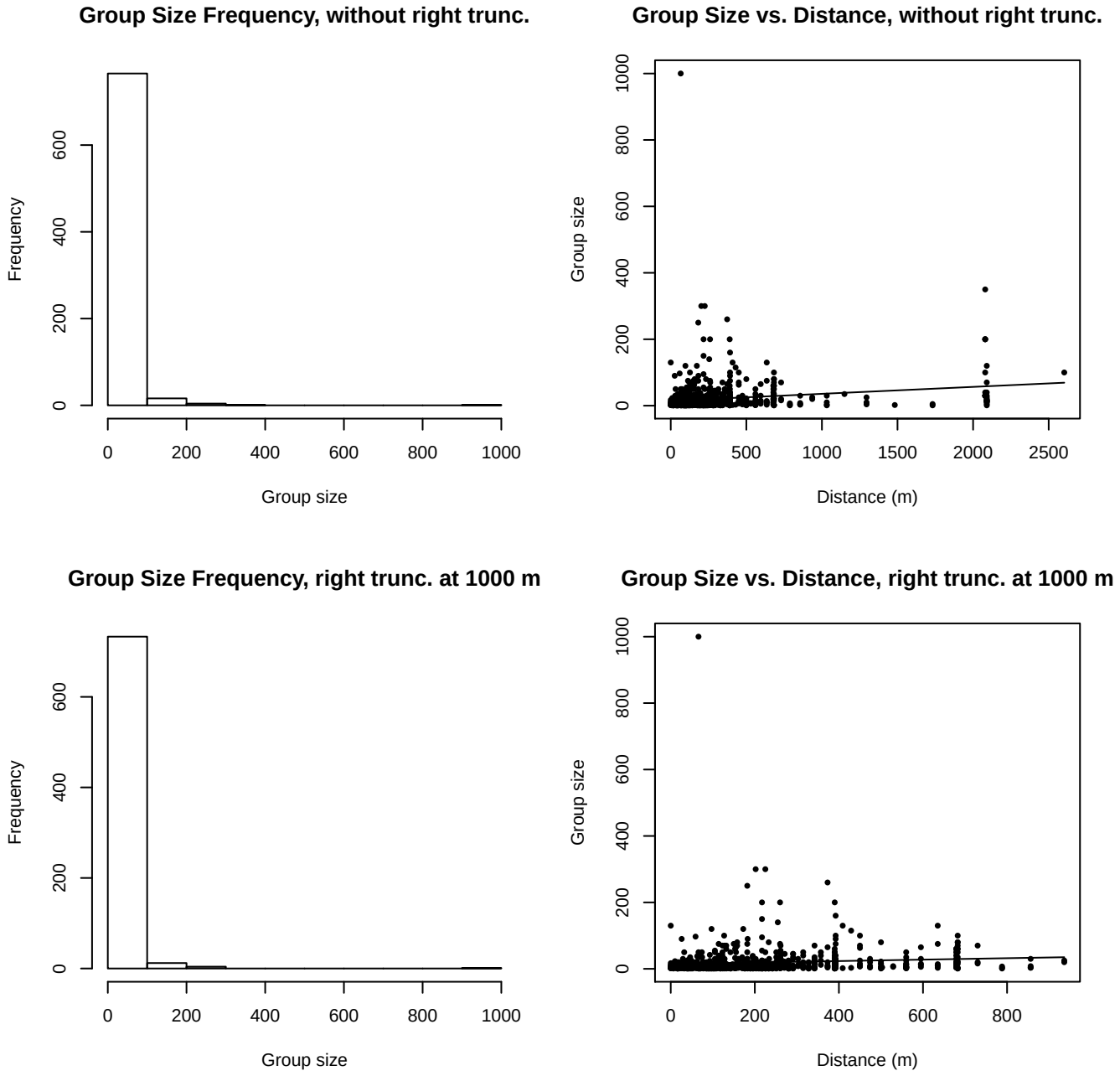

Figure 45: Histograms showing group size frequency and scatterplots showing the relationship between group size and perpendicular sighting distance, for all sightings (top row) and only those not right truncated (bottom row). In the scatterplot, the line is a simple linear regression.

Mid Atlantic Tursiops Survey 2002-2004

Because this taxon was sighted too infrequently to fit a detection function to its sightings alone, we fit a detection function to the pooled sightings of several other species that we believed would exhibit similar detectability. These "proxy species" are listed below.

Reported By Observer	Common Name	n
Delphinus capensis	Long-beaked common dolphin	0
Delphinus delphis	Short-beaked common dolphin	3

Delphinus delphis/Lagenorhynchus acutus	Short-beaked common or Atlantic white-sided dolphin	0
Delphinus delphis/Stenella	Short-beaked common dolphin or Stenella spp.	0
Delphinus delphis/Stenella coeruleoalba	Short-beaked common or striped dolphin	0
Grampus griseus	Risso's dolphin	0
Grampus griseus/Tursiops truncatus	Risso's or Bottlenose dolphin	0
Lagenodelphis hosei	Fraser's dolphin	0
Lagenorhynchus acutus	Atlantic white-sided dolphin	0
Lagenorhynchus albirostris	White-beaked dolphin	0
Lagenorhynchus albirostris/Lagenorhynchus acutus	White-beaked or white-sided dolphin	0
Stenella	Unidentified Stenella	4
Stenella attenuata	Pantropical spotted dolphin	2
Stenella attenuata/frontalis	Pantropical or Atlantic spotted dolphin	0
Stenella clymene	Clymene dolphin	1
Stenella coeruleoalba	Striped dolphin	0
Stenella frontalis	Atlantic spotted dolphin	107
Stenella frontalis/Tursiops truncatus	Atlantic spotted or Bottlenose dolphin	0
Stenella longirostris	Spinner dolphin	0
Steno bredanensis	Rough-toothed dolphin	0
Steno bredanensis/Tursiops truncatus	Bottlenose or rough-toothed dolphin	0
Tursiops truncatus	Bottlenose dolphin	599
Total		716

Table 34: Proxy species used to fit detection functions for Mid Atlantic Tursiops Survey 2002-2004. The number of sightings, n, is before truncation.

The sightings were right truncated at 1296m. The vertical sighting angles were heaped at 10 degree increments, so the candidate detection functions were fitted using linear bins scaled accordingly.

Covariate	Description
beaufort	Beaufort sea state.
quality	Survey-specific index of the quality of observation conditions, utilizing relevant factors other than Beaufort sea state (see methods).
size	Estimated size (number of individuals) of the sighted group.

Table 35: Covariates tested in candidate "multi-covariate distance sampling" (MCDS) detection functions.

Key	Adjustment	Order	Covariates	Succeeded	Δ AIC	Mean ESHW (m)
hr			beaufort, size	Yes	0.00	325
hr			beaufort	Yes	7.24	320
hr			size	Yes	15.12	325

hr				Yes	19.50	320
hr	poly	4		Yes	21.50	320
hr	poly	2		Yes	21.50	320
hn			beaufort, size	Yes	24.60	291
hn			beaufort, quality, size	Yes	26.60	291
hn	cos	2		Yes	30.33	279
hn			beaufort	Yes	31.06	289
hn			beaufort, quality	Yes	33.06	289
hn			size	Yes	40.68	292
hn	cos	3		Yes	41.28	267
hn			quality, size	Yes	42.58	292
hn				Yes	44.72	289
hn			quality	Yes	46.63	289
hn	herm	4		Yes	46.67	289
hr			quality	No		
hr			beaufort, quality	No		
hr			quality, size	No		
hr			beaufort, quality, size	No		

Table 36: Candidate detection functions for Mid Atlantic Tursiops Survey 2002-2004. The first one listed was selected for the density model.

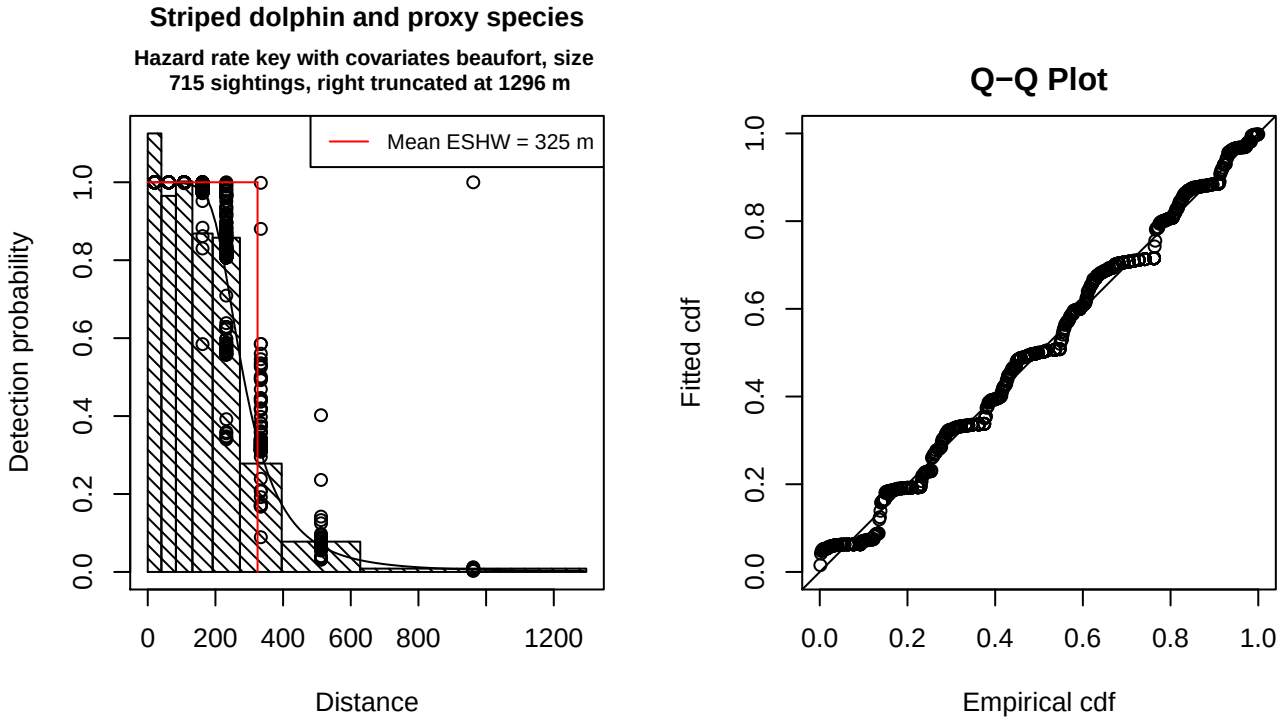

Figure 46: Detection function for Mid Atlantic Tursiops Survey 2002-2004 that was selected for the density model

Statistical output for this detection function:

```
Summary for ds object
Number of observations :  715
Distance range         :  0  -  1296
AIC                    :  2772.625

Detection function:
 Hazard-rate key function

Detection function parameters
Scale Coefficients:
              estimate         se
(Intercept)  5.7367970 0.06707586
beaufort    -0.1711625 0.03979058
size         0.3020980 0.11348684

Shape parameters:
            estimate         se
(Intercept) 1.410835 0.06851877

                        Estimate           SE         CV
Average p              0.2429646 7.460291e-03 0.03070526
N in covered region 2942.8157278 1.320027e+02 0.04485592
```

Additional diagnostic plots:

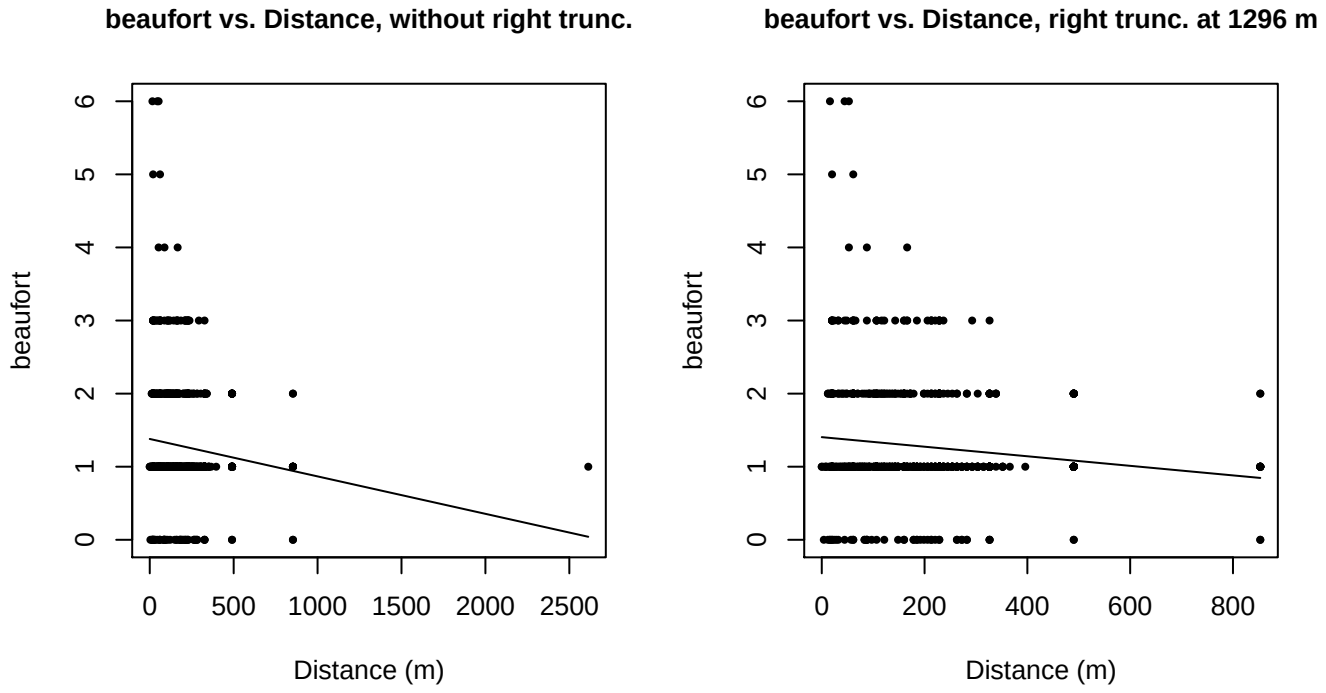

Figure 47: Scatterplots showing the relationship between Beaufort sea state and perpendicular sighting distance, for all sightings (left) and only those not right truncated (right). The line is a simple linear regression.

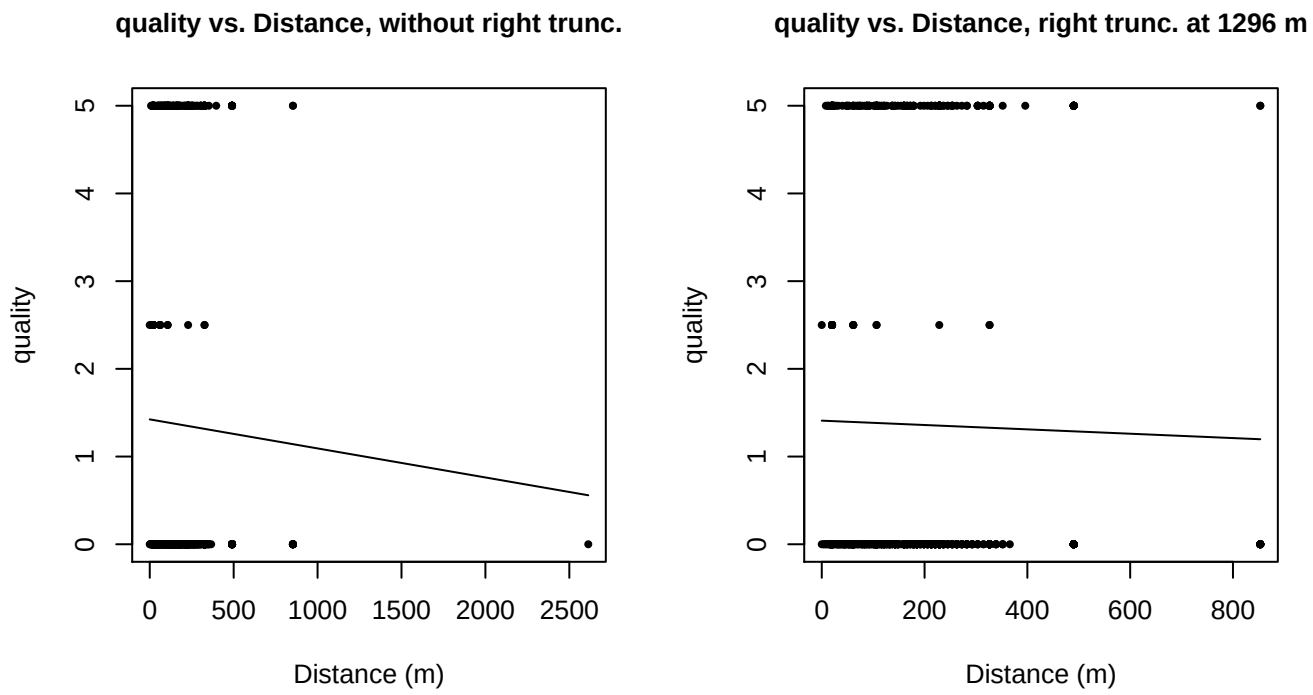

Figure 48: Scatterplots showing the relationship between the survey-specific index of the quality of observation conditions and perpendicular sighting distance, for all sightings (left) and only those not right truncated (right). Low values of the quality index correspond to better observation conditions. The line is a simple linear regression.

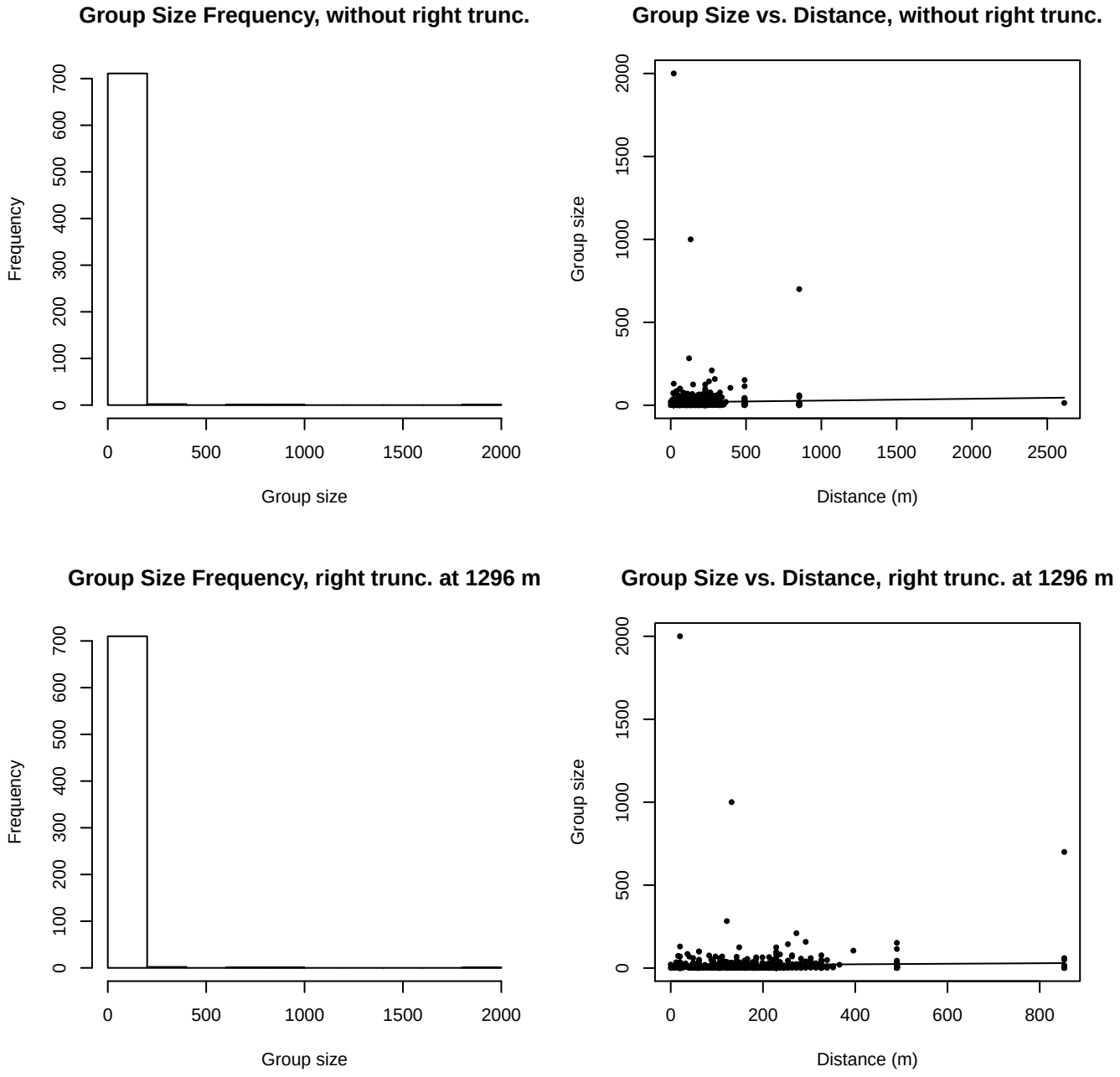

Figure 49: Histograms showing group size frequency and scatterplots showing the relationship between group size and perpendicular sighting distance, for all sightings (top row) and only those not right truncated (bottom row). In the scatterplot, the line is a simple linear regression.

GulfSCAT Aerial Survey

Because this taxon was sighted too infrequently to fit a detection function to its sightings alone, we fit a detection function to the pooled sightings of several other species that we believed would exhibit similar detectability. These "proxy species" are listed below.

Reported By Observer	Common Name	n
Delphinus capensis	Long-beaked common dolphin	0
Delphinus delphis	Short-beaked common dolphin	0

Delphinus delphis/Lagenorhynchus acutus	Short-beaked common or Atlantic white-sided dolphin	0
Delphinus delphis/Stenella	Short-beaked common dolphin or Stenella spp.	0
Delphinus delphis/Stenella coeruleoalba	Short-beaked common or striped dolphin	0
Grampus griseus	Risso's dolphin	0
Grampus griseus/Tursiops truncatus	Risso's or Bottlenose dolphin	0
Lagenodelphis hosei	Fraser's dolphin	0
Lagenorhynchus acutus	Atlantic white-sided dolphin	0
Lagenorhynchus albirostris	White-beaked dolphin	0
Lagenorhynchus albirostris/Lagenorhynchus acutus	White-beaked or white-sided dolphin	0
Stenella	Unidentified Stenella	0
Stenella attenuata	Pantropical spotted dolphin	0
Stenella attenuata/frontalis	Pantropical or Atlantic spotted dolphin	0
Stenella clymene	Clymene dolphin	0
Stenella coeruleoalba	Striped dolphin	0
Stenella frontalis	Atlantic spotted dolphin	15
Stenella frontalis/Tursiops truncatus	Atlantic spotted or Bottlenose dolphin	0
Stenella longirostris	Spinner dolphin	0
Steno bredanensis	Rough-toothed dolphin	0
Steno bredanensis/Tursiops truncatus	Bottlenose or rough-toothed dolphin	0
Tursiops truncatus	Bottlenose dolphin	381
Total		396

Table 37: Proxy species used to fit detection functions for GulfSCAT Aerial Survey. The number of sightings, n, is before truncation.

The sightings were right truncated at 400m.

Covariate	Description
beaufort	Beaufort sea state.
quality	Survey-specific index of the quality of observation conditions, utilizing relevant factors other than Beaufort sea state (see methods).
size	Estimated size (number of individuals) of the sighted group.

Table 38: Covariates tested in candidate "multi-covariate distance sampling" (MCDS) detection functions.

Key	Adjustment	Order	Covariates	Succeeded	Δ AIC	Mean ESHW (m)
hn	herm	4		Yes	0.00	218
hn	cos	2		Yes	0.09	221
hn				Yes	0.90	199
hn			size	Yes	2.21	199

hn	cos	3		Yes	2.37	209
hr	poly	2		Yes	2.39	218
hr	poly	4		Yes	2.47	223
hr				Yes	4.46	230
hr			size	Yes	5.04	232
hn			beaufort	No		
hr			beaufort	No		
hn			quality	No		
hr			quality	No		
hn			beaufort, quality	No		
hr			beaufort, quality	No		
hn			beaufort, size	No		
hr			beaufort, size	No		
hn			quality, size	No		
hr			quality, size	No		
hn			beaufort, quality, size	No		
hr			beaufort, quality, size	No		

Table 39: Candidate detection functions for GulfSCAT Aerial Survey. The first one listed was selected for the density model.

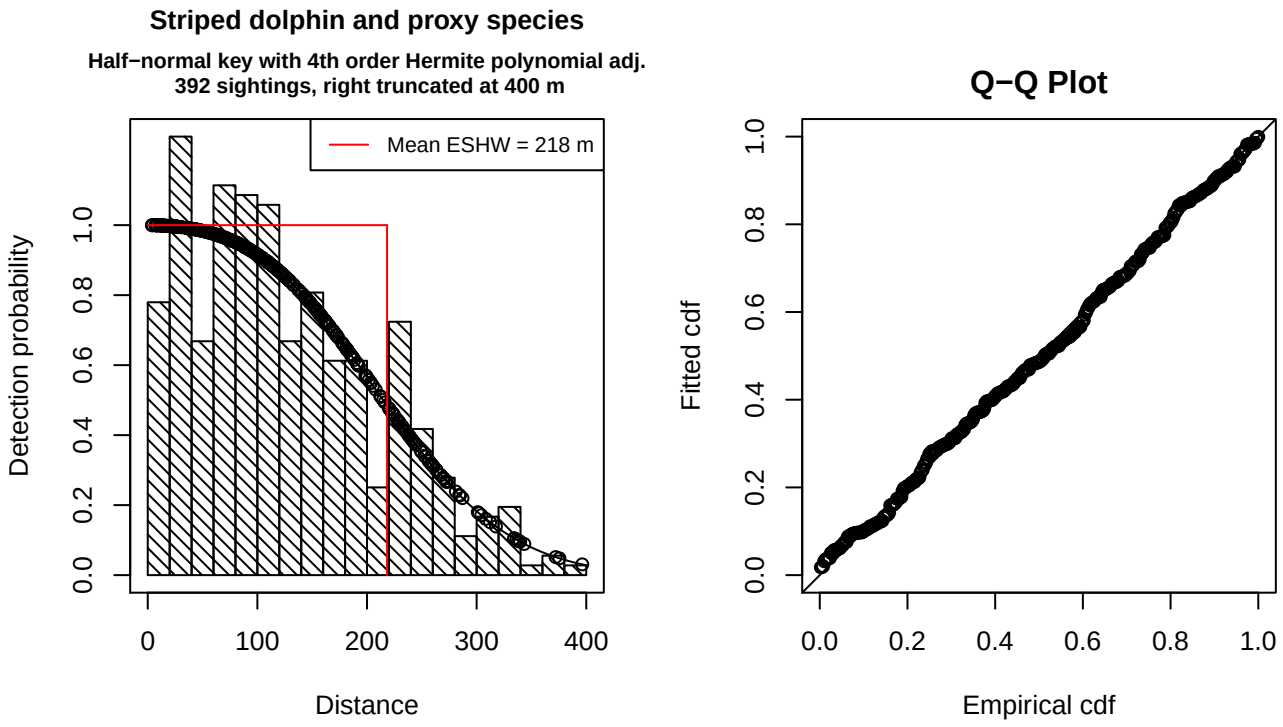

Figure 50: Detection function for GulfSCAT Aerial Survey that was selected for the density model

Statistical output for this detection function:

```
Summary for ds object
Number of observations :  392
Distance range         :  0  -  400
AIC                    :  4505.917

Detection function:
 Half-normal key function with Hermite polynomial adjustment term of order 4

Detection function parameters
Scale Coefficients:
            estimate         se
(Intercept) 4.855664 0.07416788

Adjustment term parameter(s):
                 estimate         se
herm, order 4 -0.04125508 0.01270725


Monotonicity constraints were enforced.
                       Estimate          SE         CV
Average p              0.5457491  0.04201236 0.07698108
N in covered region 718.2787706 60.45880788 0.08417179

Monotonicity constraints were enforced.
```

Additional diagnostic plots:

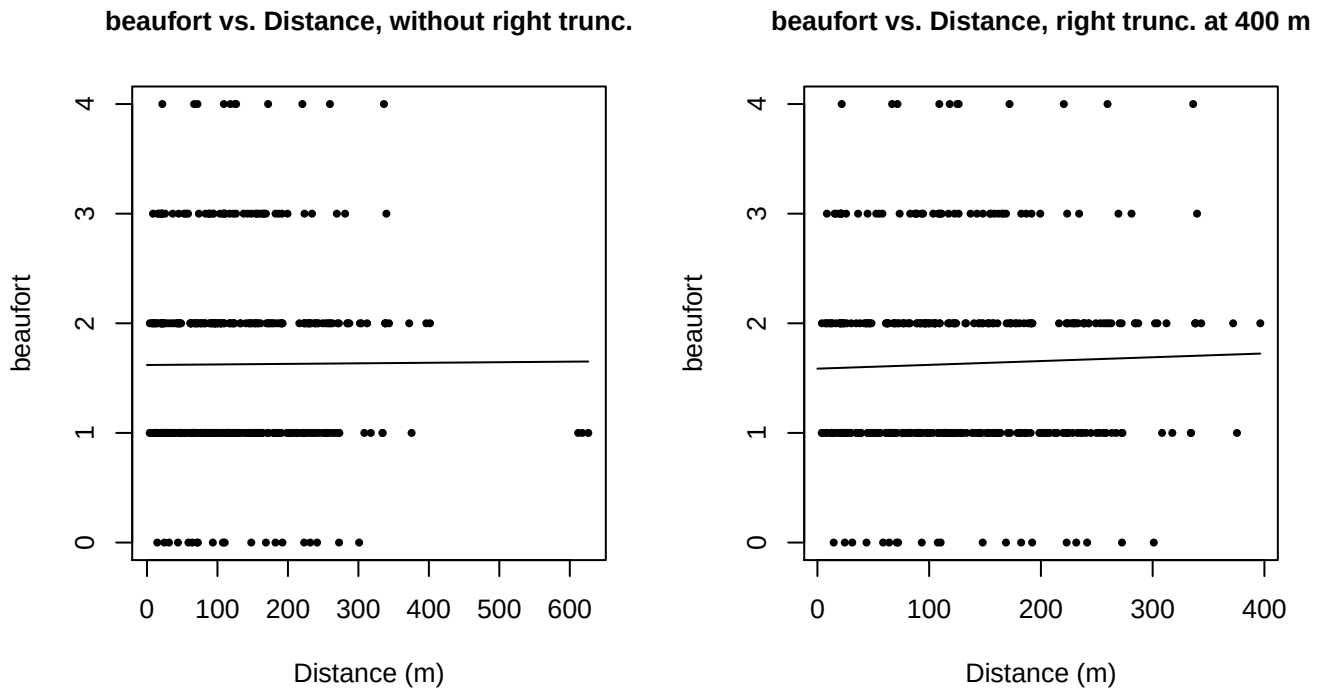

Figure 51: Scatterplots showing the relationship between Beaufort sea state and perpendicular sighting distance, for all sightings (left) and only those not right truncated (right). The line is a simple linear regression.

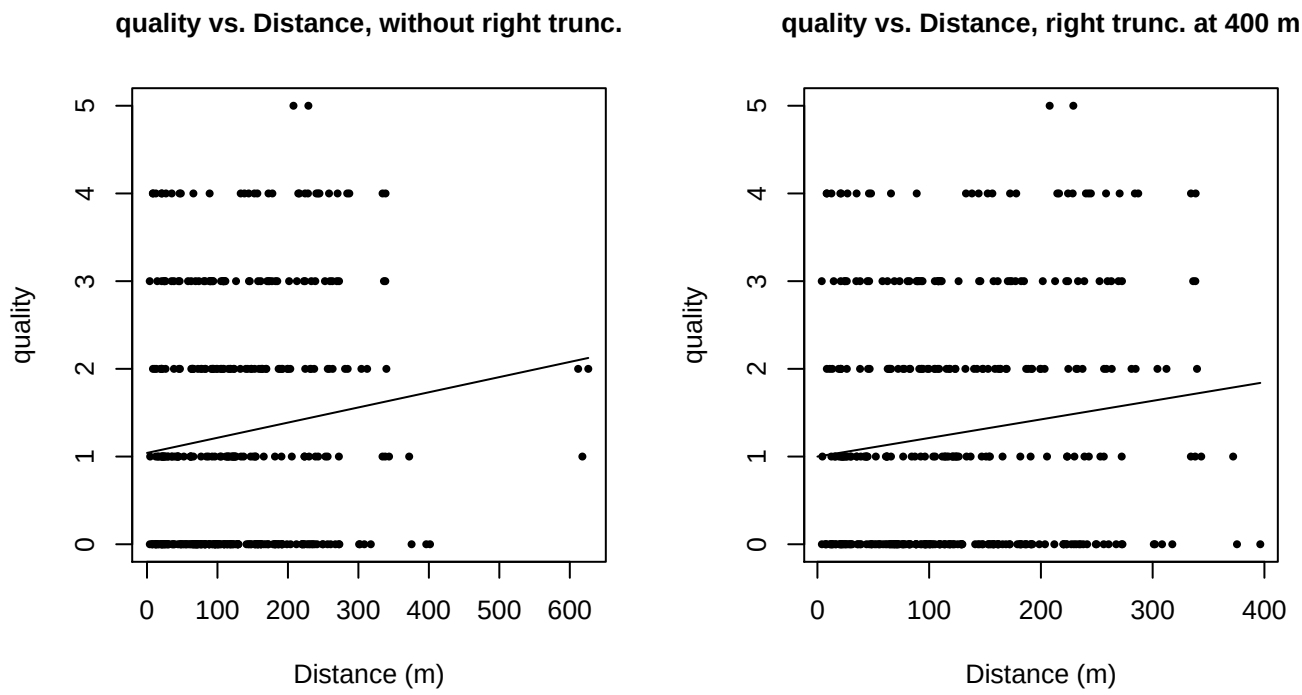

Figure 52: Scatterplots showing the relationship between the survey-specific index of the quality of observation conditions and perpendicular sighting distance, for all sightings (left) and only those not right truncated (right). Low values of the quality index correspond to better observation conditions. The line is a simple linear regression.

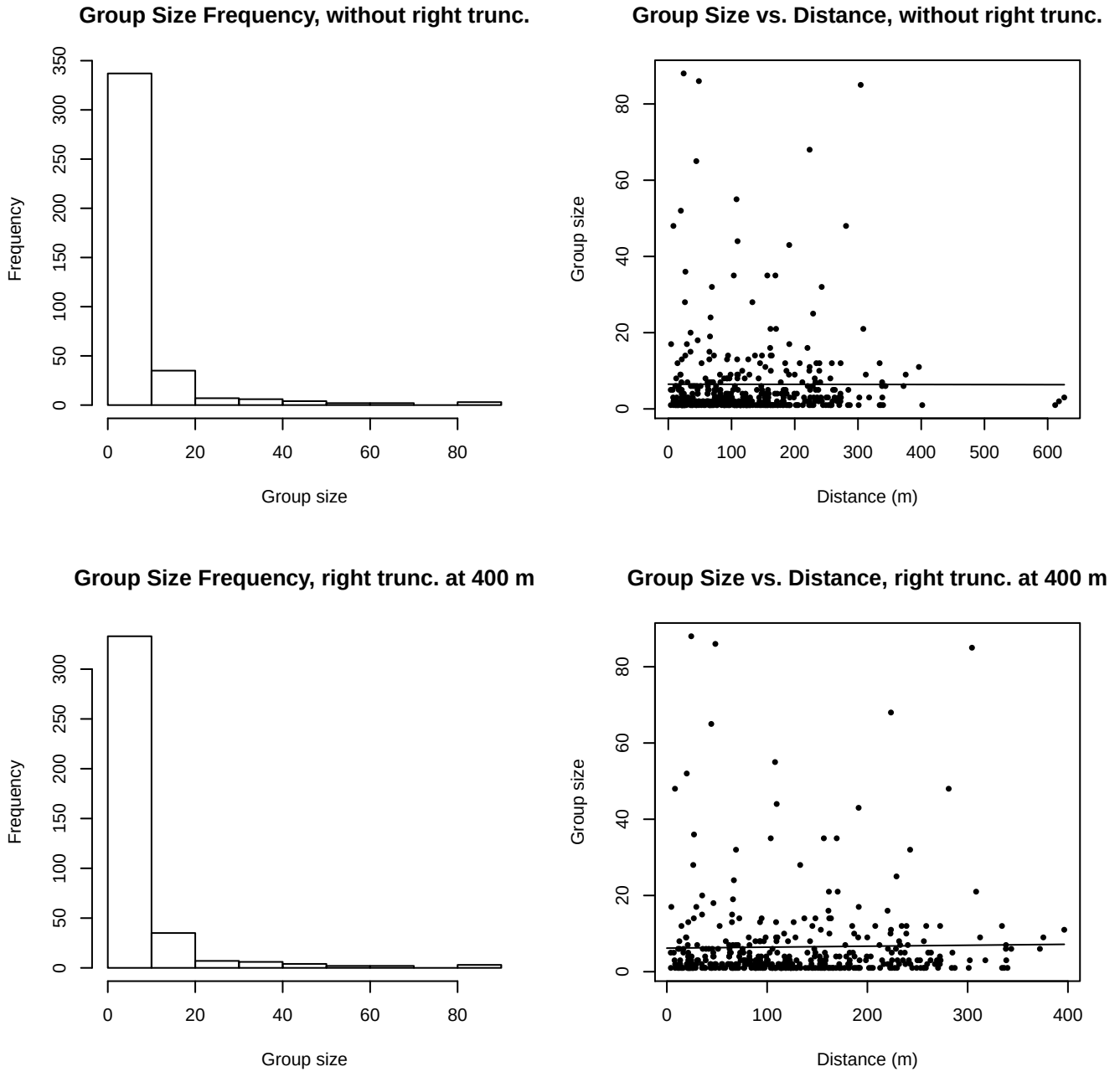

Figure 53: Histograms showing group size frequency and scatterplots showing the relationship between group size and perpendicular sighting distance, for all sightings (top row) and only those not right truncated (bottom row). In the scatterplot, the line is a simple linear regression.

Without Belly Observers - 600 ft

Because this taxon was sighted too infrequently to fit a detection function to its sightings alone, we fit a detection function to the pooled sightings of several other species that we believed would exhibit similar detectability. These "proxy species" are listed below.

Reported By Observer	Common Name	n
Delphinus capensis	Long-beaked common dolphin	0
Delphinus delphis	Short-beaked common dolphin	5

Delphinus delphis/Lagenorhynchus acutus	Short-beaked common or Atlantic white-sided dolphin	0
Delphinus delphis/Stenella	Short-beaked common dolphin or Stenella spp.	0
Delphinus delphis/Stenella coeruleoalba	Short-beaked common or striped dolphin	0
Grampus griseus	Risso's dolphin	3
Grampus griseus/Tursiops truncatus	Risso's or Bottlenose dolphin	0
Lagenodelphis hosei	Fraser's dolphin	4
Lagenorhynchus acutus	Atlantic white-sided dolphin	31
Lagenorhynchus albirostris	White-beaked dolphin	0
Lagenorhynchus albirostris/Lagenorhynchus acutus	White-beaked or white-sided dolphin	0
Stenella	Unidentified Stenella	0
Stenella attenuata	Pantropical spotted dolphin	4
Stenella attenuata/frontalis	Pantropical or Atlantic spotted dolphin	0
Stenella clymene	Clymene dolphin	0
Stenella coeruleoalba	Striped dolphin	0
Stenella frontalis	Atlantic spotted dolphin	0
Stenella frontalis/Tursiops truncatus	Atlantic spotted or Bottlenose dolphin	0
Stenella longirostris	Spinner dolphin	0
Steno bredanensis	Rough-toothed dolphin	0
Steno bredanensis/Tursiops truncatus	Bottlenose or rough-toothed dolphin	0
Tursiops truncatus	Bottlenose dolphin	70
Total		117

Table 40: Proxy species used to fit detection functions for Without Belly Observers - 600 ft. The number of sightings, n, is before truncation.

The sightings were right truncated at 600m.

Covariate	Description
beaufort	Beaufort sea state.
size	Estimated size (number of individuals) of the sighted group.

Table 41: Covariates tested in candidate "multi-covariate distance sampling" (MCDS) detection functions.

Key	Adjustment	Order	Covariates	Succeeded	Δ AIC	Mean ESHW (m)
hn				Yes	0.00	273
hr				Yes	0.47	313
hn	cos	3		Yes	0.63	294
hn	cos	2		Yes	1.46	297
hn			beaufort	Yes	1.82	273
hn	herm	4		Yes	1.85	280

hn			size	Yes	1.98	273
hr	poly	4		Yes	2.01	305
hr			beaufort	Yes	2.15	308
hr	poly	2		Yes	2.38	298
hn			beaufort, size	Yes	3.80	273
hr			size	No		
hr			beaufort, size	No		

Table 42: Candidate detection functions for Without Belly Observers - 600 ft. The first one listed was selected for the density model.

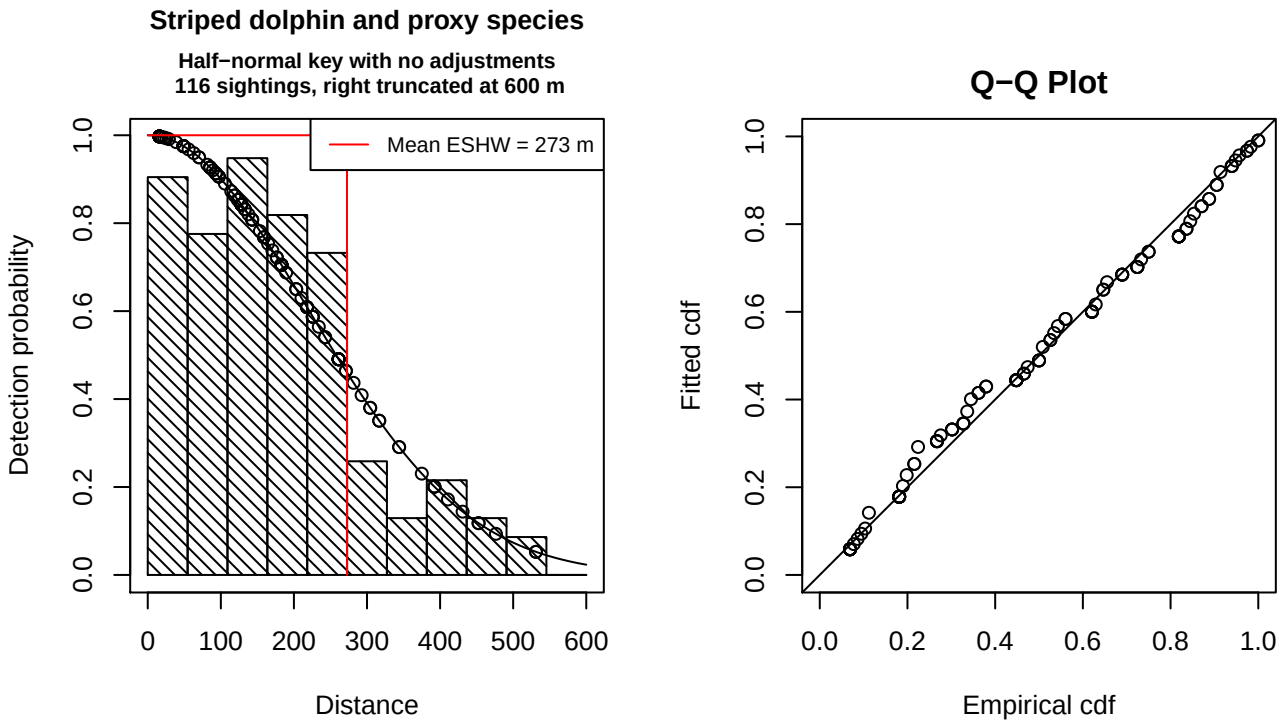

Figure 54: Detection function for Without Belly Observers - 600 ft that was selected for the density model

Statistical output for this detection function:

```
Summary for ds object
Number of observations :  116
Distance range         :  0  -  600
AIC                    :  1413.111

Detection function:
 Half-normal key function

Detection function parameters
Scale Coefficients:
            estimate         se
(Intercept) 5.388383 0.07654643
```

```
                      Estimate          SE         CV
Average p             0.4543498  0.03299346 0.07261686
N in covered region 255.3098755 25.50172372 0.09988538
```

Additional diagnostic plots:

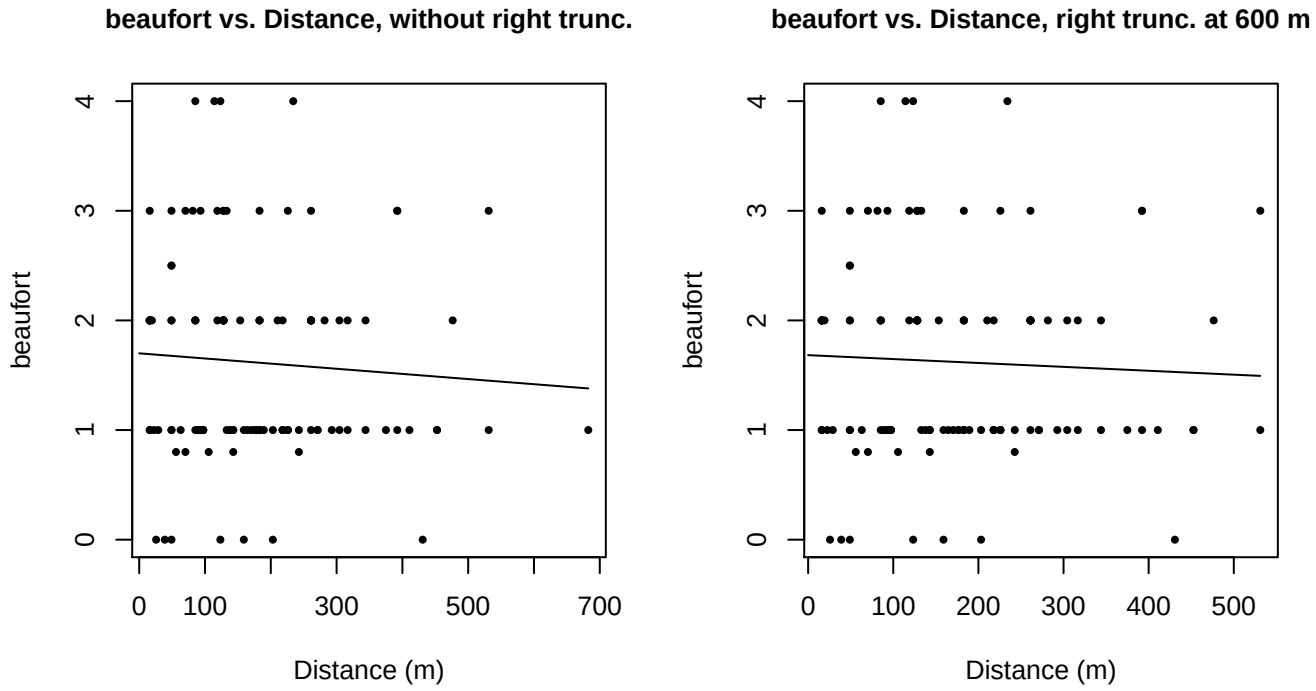

Figure 55: Scatterplots showing the relationship between Beaufort sea state and perpendicular sighting distance, for all sightings (left) and only those not right truncated (right). The line is a simple linear regression.

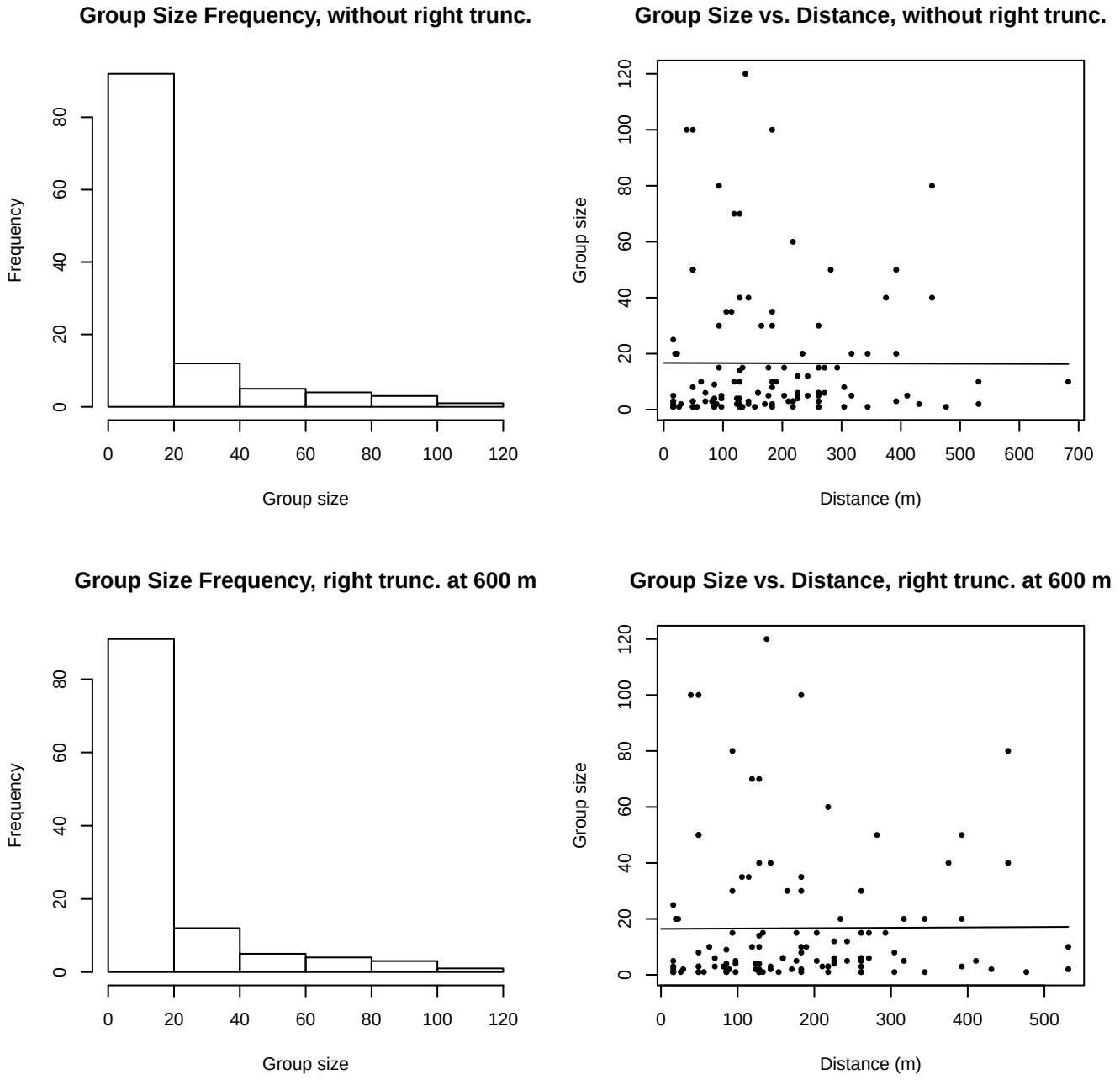

Figure 56: Histograms showing group size frequency and scatterplots showing the relationship between group size and perpendicular sighting distance, for all sightings (top row) and only those not right truncated (bottom row). In the scatterplot, the line is a simple linear regression.

Without Belly Observers - 750 ft

Because this taxon was sighted too infrequently to fit a detection function to its sightings alone, we fit a detection function to the pooled sightings of several other species that we believed would exhibit similar detectability. These "proxy species" are listed below.

Reported By Observer	Common Name	n
Delphinus capensis	Long-beaked common dolphin	0
Delphinus delphis	Short-beaked common dolphin	5

Delphinus delphis/Lagenorhynchus acutus	Short-beaked common or Atlantic white-sided dolphin	0
Delphinus delphis/Stenella	Short-beaked common dolphin or Stenella spp.	0
Delphinus delphis/Stenella coeruleoalba	Short-beaked common or striped dolphin	0
Grampus griseus	Risso's dolphin	75
Grampus griseus/Tursiops truncatus	Risso's or Bottlenose dolphin	0
Lagenodelphis hosei	Fraser's dolphin	2
Lagenorhynchus acutus	Atlantic white-sided dolphin	0
Lagenorhynchus albirostris	White-beaked dolphin	0
Lagenorhynchus albirostris/Lagenorhynchus acutus	White-beaked or white-sided dolphin	0
Stenella	Unidentified Stenella	14
Stenella attenuata	Pantropical spotted dolphin	94
Stenella attenuata/frontalis	Pantropical or Atlantic spotted dolphin	0
Stenella clymene	Clymene dolphin	12
Stenella coeruleoalba	Striped dolphin	17
Stenella frontalis	Atlantic spotted dolphin	82
Stenella frontalis/Tursiops truncatus	Atlantic spotted or Bottlenose dolphin	0
Stenella longirostris	Spinner dolphin	11
Steno bredanensis	Rough-toothed dolphin	9
Steno bredanensis/Tursiops truncatus	Bottlenose or rough-toothed dolphin	0
Tursiops truncatus	Bottlenose dolphin	1597
Total		1918

Table 43: Proxy species used to fit detection functions for Without Belly Observers - 750 ft. The number of sightings, n, is before truncation.

The sightings were right truncated at 1296m. The vertical sighting angles were heaped at 10 degree increments, so the candidate detection functions were fitted using linear bins scaled accordingly.

Covariate	Description
beaufort	Beaufort sea state.
quality	Survey-specific index of the quality of observation conditions, utilizing relevant factors other than Beaufort sea state (see methods).
size	Estimated size (number of individuals) of the sighted group.

Table 44: Covariates tested in candidate "multi-covariate distance sampling" (MCDS) detection functions.

Key	Adjustment	Order	Covariates	Succeeded	Δ AIC	Mean ESHW (m)
hr			size	Yes	0.00	392
hr				Yes	8.40	388
hr	poly	2		Yes	10.38	388

hr	poly	4		Yes	10.38	388
hn	cos	2		Yes	39.35	354
hn	cos	3		Yes	59.72	342
hn			size	Yes	81.81	402
hn				Yes	95.30	401
hn	herm	4		Yes	96.81	401
hr			beaufort	No		
hn			beaufort	No		
hr			quality	No		
hn			quality	No		
hr			beaufort, quality	No		
hn			beaufort, quality	No		
hr			beaufort, size	No		
hn			beaufort, size	No		
hr			quality, size	No		
hn			quality, size	No		
hr			beaufort, quality, size	No		
hn			beaufort, quality, size	No		

Table 45: Candidate detection functions for Without Belly Observers - 750 ft. The first one listed was selected for the density model.

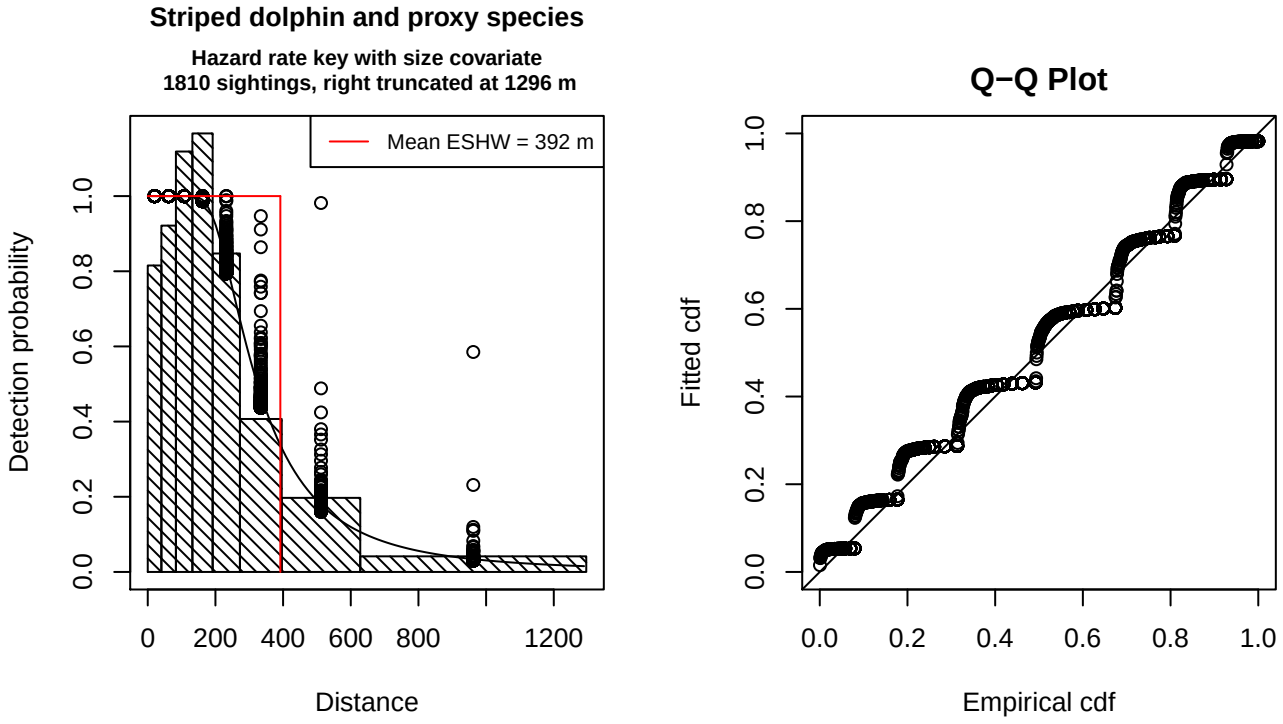

Figure 57: Detection function for Without Belly Observers - 750 ft that was selected for the density model

Statistical output for this detection function:

```
Summary for ds object
Number of observations :  1810
Distance range         :  0  -  1296
AIC                    :  7378.672

Detection function:
 Hazard-rate key function

Detection function parameters
Scale Coefficients:
             estimate         se
(Intercept) 5.6088057 0.03890075
size        0.1034633 0.02841209

Shape parameters:
            estimate         se
(Intercept) 1.023516 0.04368421

                         Estimate           SE         CV
Average p              0.2999988 7.471092e-03 0.02490374
N in covered region 6033.3566458 1.915759e+02 0.03175279
```

Additional diagnostic plots:

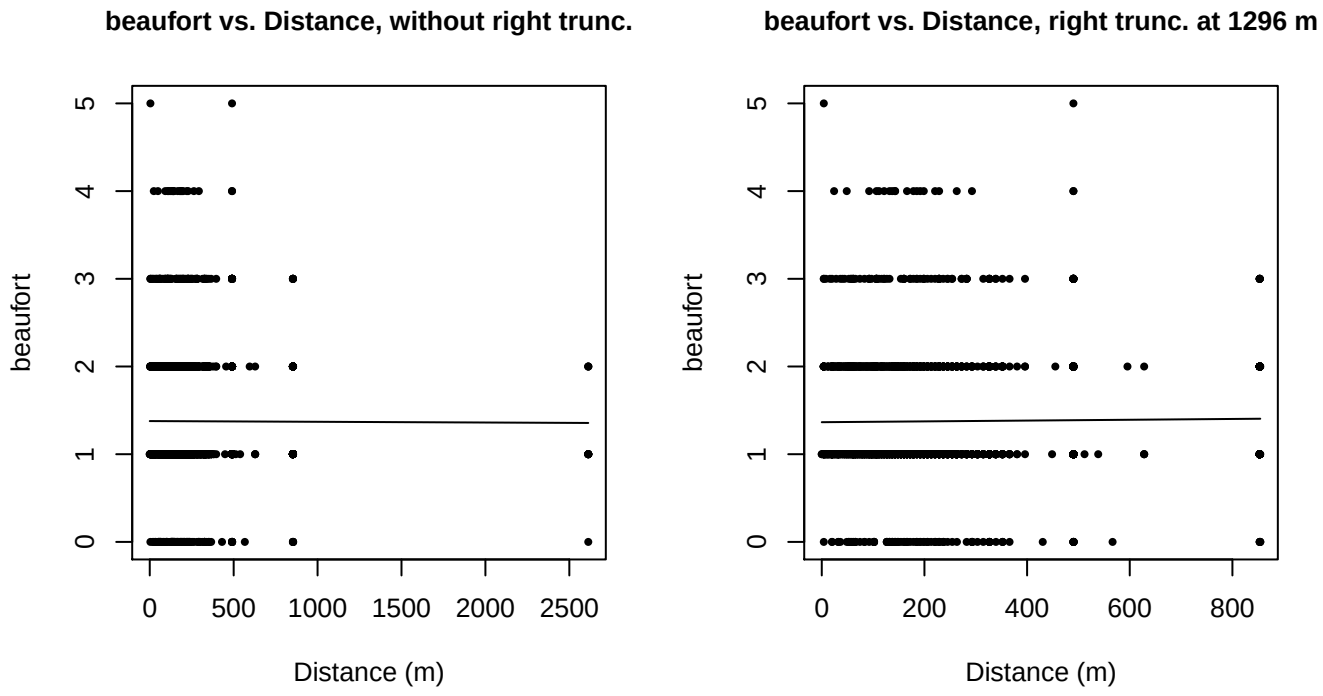

Figure 58: Scatterplots showing the relationship between Beaufort sea state and perpendicular sighting distance, for all sightings (left) and only those not right truncated (right). The line is a simple linear regression.

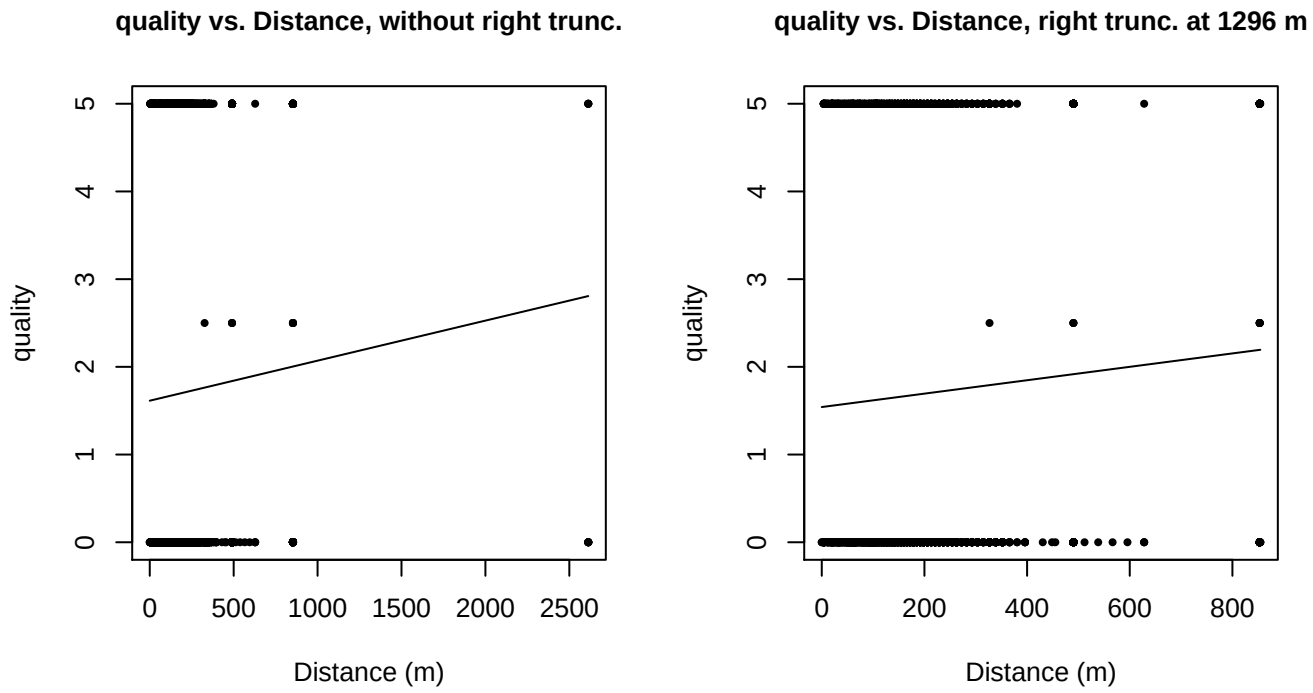

Figure 59: Scatterplots showing the relationship between the survey-specific index of the quality of observation conditions and perpendicular sighting distance, for all sightings (left) and only those not right truncated (right). Low values of the quality index correspond to better observation conditions. The line is a simple linear regression.

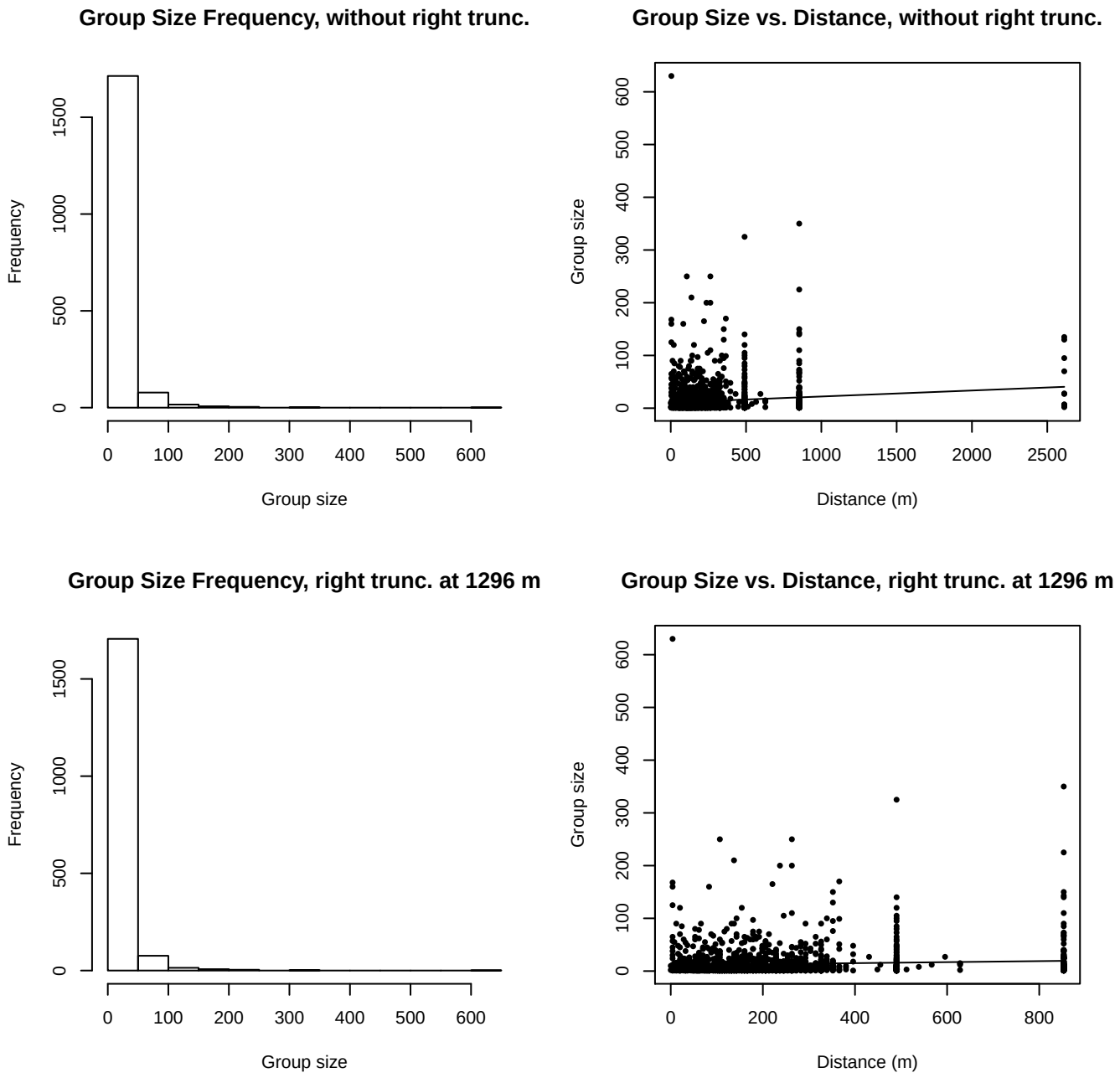

Figure 60: Histograms showing group size frequency and scatterplots showing the relationship between group size and perpendicular sighting distance, for all sightings (top row) and only those not right truncated (bottom row). In the scatterplot, the line is a simple linear regression.

SE_secas92

Because this taxon was sighted too infrequently to fit a detection function to its sightings alone, we fit a detection function to the pooled sightings of several other species that we believed would exhibit similar detectability. These "proxy species" are listed below.

Reported By Observer	Common Name	n
Delphinus capensis	Long-beaked common dolphin	0
Delphinus delphis	Short-beaked common dolphin	0

Delphinus delphis/Lagenorhynchus acutus	Short-beaked common or Atlantic white-sided dolphin	0
Delphinus delphis/Stenella	Short-beaked common dolphin or Stenella spp.	0
Delphinus delphis/Stenella coeruleoalba	Short-beaked common or striped dolphin	0
Grampus griseus	Risso's dolphin	0
Grampus griseus/Tursiops truncatus	Risso's or Bottlenose dolphin	0
Lagenodelphis hosei	Fraser's dolphin	0
Lagenorhynchus acutus	Atlantic white-sided dolphin	0
Lagenorhynchus albirostris	White-beaked dolphin	0
Lagenorhynchus albirostris/Lagenorhynchus acutus	White-beaked or white-sided dolphin	0
Stenella	Unidentified Stenella	1
Stenella attenuata	Pantropical spotted dolphin	0
Stenella attenuata/frontalis	Pantropical or Atlantic spotted dolphin	0
Stenella clymene	Clymene dolphin	0
Stenella coeruleoalba	Striped dolphin	0
Stenella frontalis	Atlantic spotted dolphin	9
Stenella frontalis/Tursiops truncatus	Atlantic spotted or Bottlenose dolphin	0
Stenella longirostris	Spinner dolphin	0
Steno bredanensis	Rough-toothed dolphin	0
Steno bredanensis/Tursiops truncatus	Bottlenose or rough-toothed dolphin	0
Tursiops truncatus	Bottlenose dolphin	103
Total		113

Table 46: Proxy species used to fit detection functions for SE_secas92. The number of sightings, n, is before truncation.

The sightings were right truncated at 900m. Due to a reduced frequency of sightings close to the trackline that plausibly resulted from the behavior of the observers and/or the configuration of the survey platform, the sightings were left truncted as well. Sightings closer than 40 m to the trackline were omitted from the analysis, and it was assumed that the the area closer to the trackline than this was not surveyed. This distance was estimated by inspecting histograms of perpendicular sighting distances. The vertical sighting angles were heaped at 10 degree increments, so the candidate detection functions were fitted using linear bins scaled accordingly.

Covariate	Description
beaufort	Beaufort sea state.
size	Estimated size (number of individuals) of the sighted group.

Table 47: Covariates tested in candidate "multi-covariate distance sampling" (MCDS) detection functions.

Key	Adjustment	Order	Covariates	Succeeded	Δ AIC	Mean ESHW (m)
hr			beaufort	Yes	0.00	249
hr			beaufort, size	Yes	1.98	254

hr			size	Yes	15.77	257
hr				Yes	18.01	216
hn	cos	2		Yes	19.23	189
hr	poly	2		Yes	20.01	216
hr	poly	4		Yes	22.44	187
hn			beaufort	Yes	35.20	260
hn				Yes	41.73	264
hn	cos	3		Yes	41.97	219
hn	herm	4		Yes	43.30	264
hn			size	No		
hn			beaufort, size	No		

Table 48: Candidate detection functions for SE_secas92. The first one listed was selected for the density model.

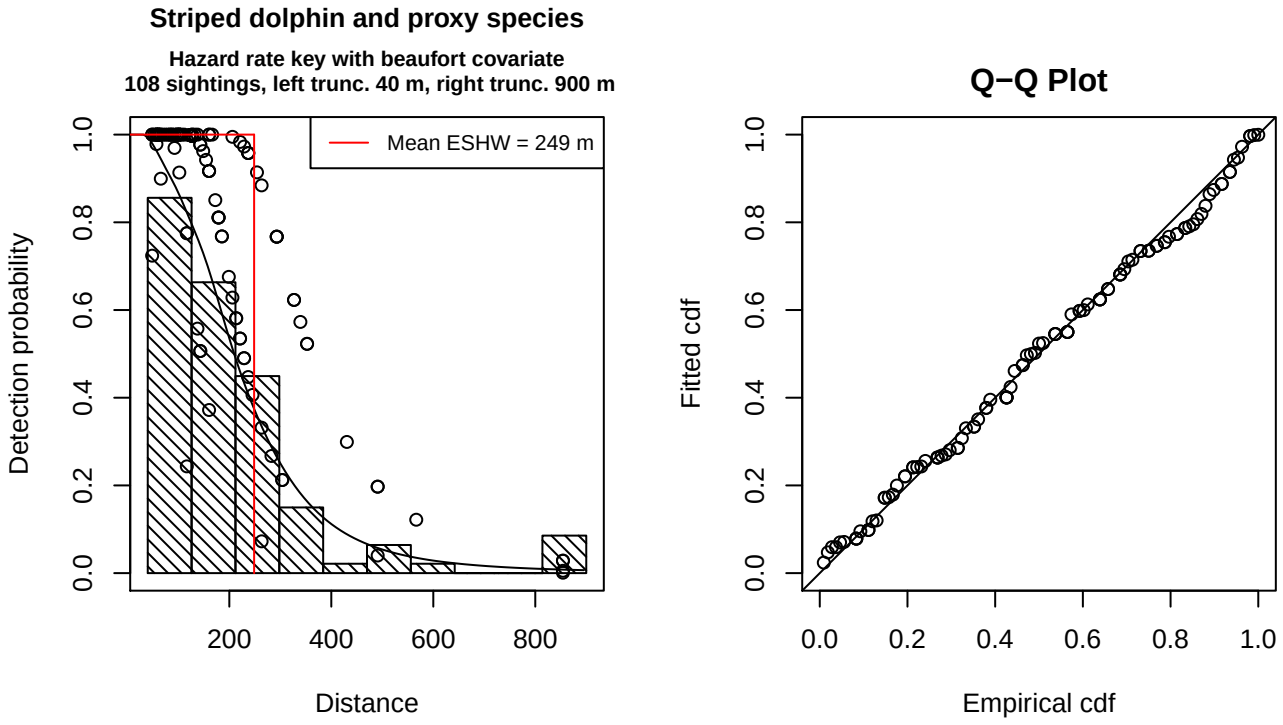

Figure 61: Detection function for SE_secas92 that was selected for the density model

Statistical output for this detection function:

```
Summary for ds object
Number of observations :  108
Distance range         :  40  -  900
AIC                    :  1288.381

Detection function:
 Hazard-rate key function
```

```
Detection function parameters
Scale Coefficients:
             estimate         se
(Intercept)  5.7829497 0.12346060
beaufort    -0.4573296 0.09973202

Shape parameters:
            estimate        se
(Intercept) 1.299333 0.1172672

                       Estimate          SE        CV
Average p              0.2208124  0.03796305 0.1719244
N in covered region 489.1028683 94.44375144 0.1930959
```

Additional diagnostic plots:

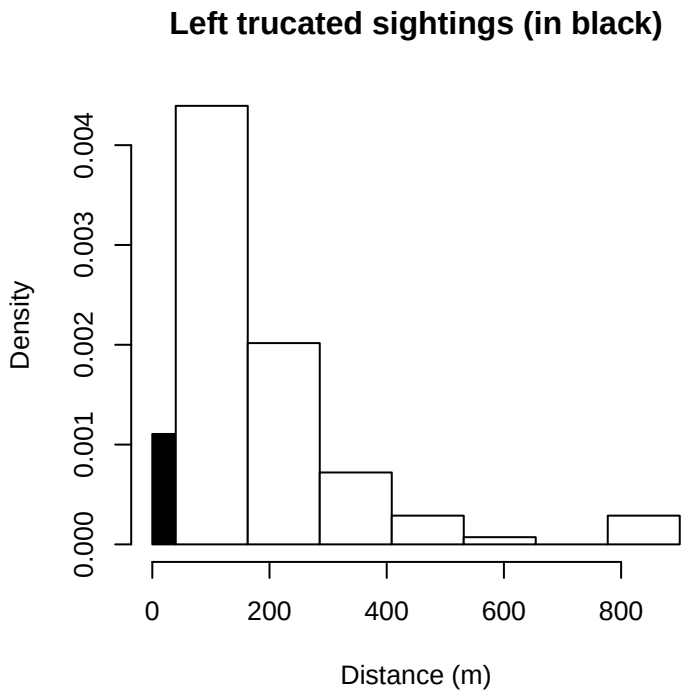

Figure 62: Density of sightings by perpendicular distance for SE_secas92. Black bars on the left show sightings that were left truncated.

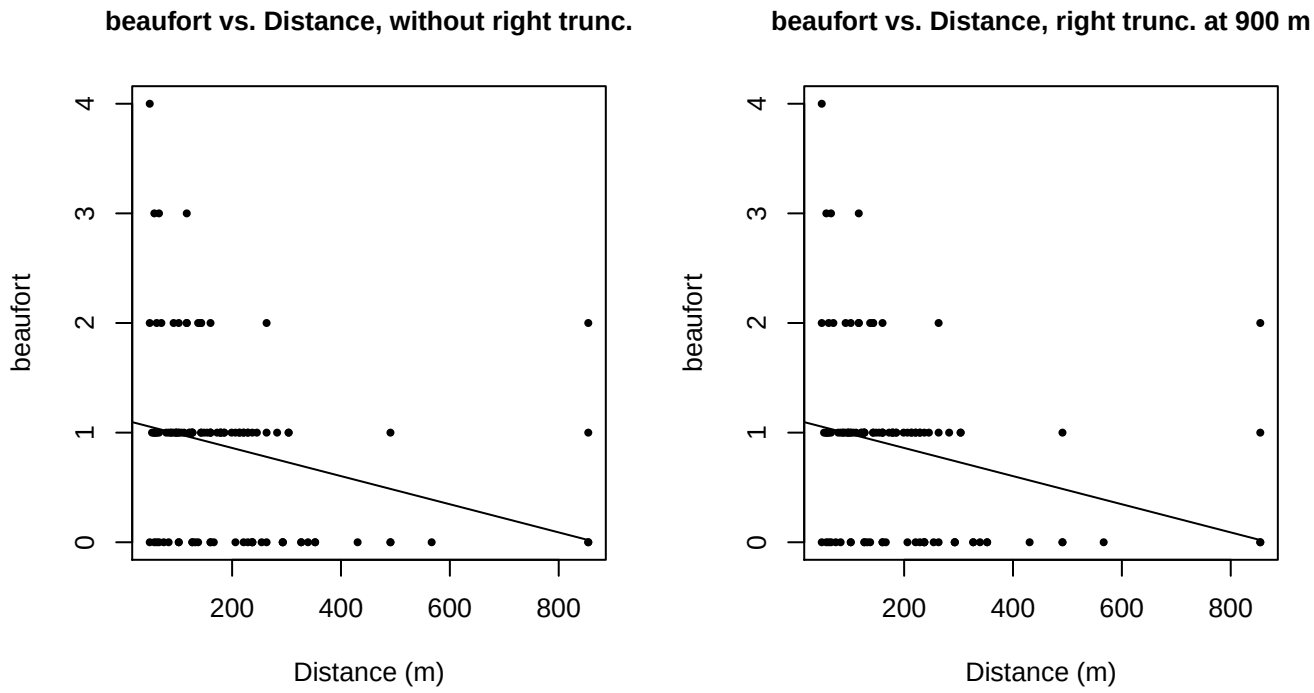

Figure 63: Scatterplots showing the relationship between Beaufort sea state and perpendicular sighting distance, for all sightings (left) and only those not right truncated (right). The line is a simple linear regression.

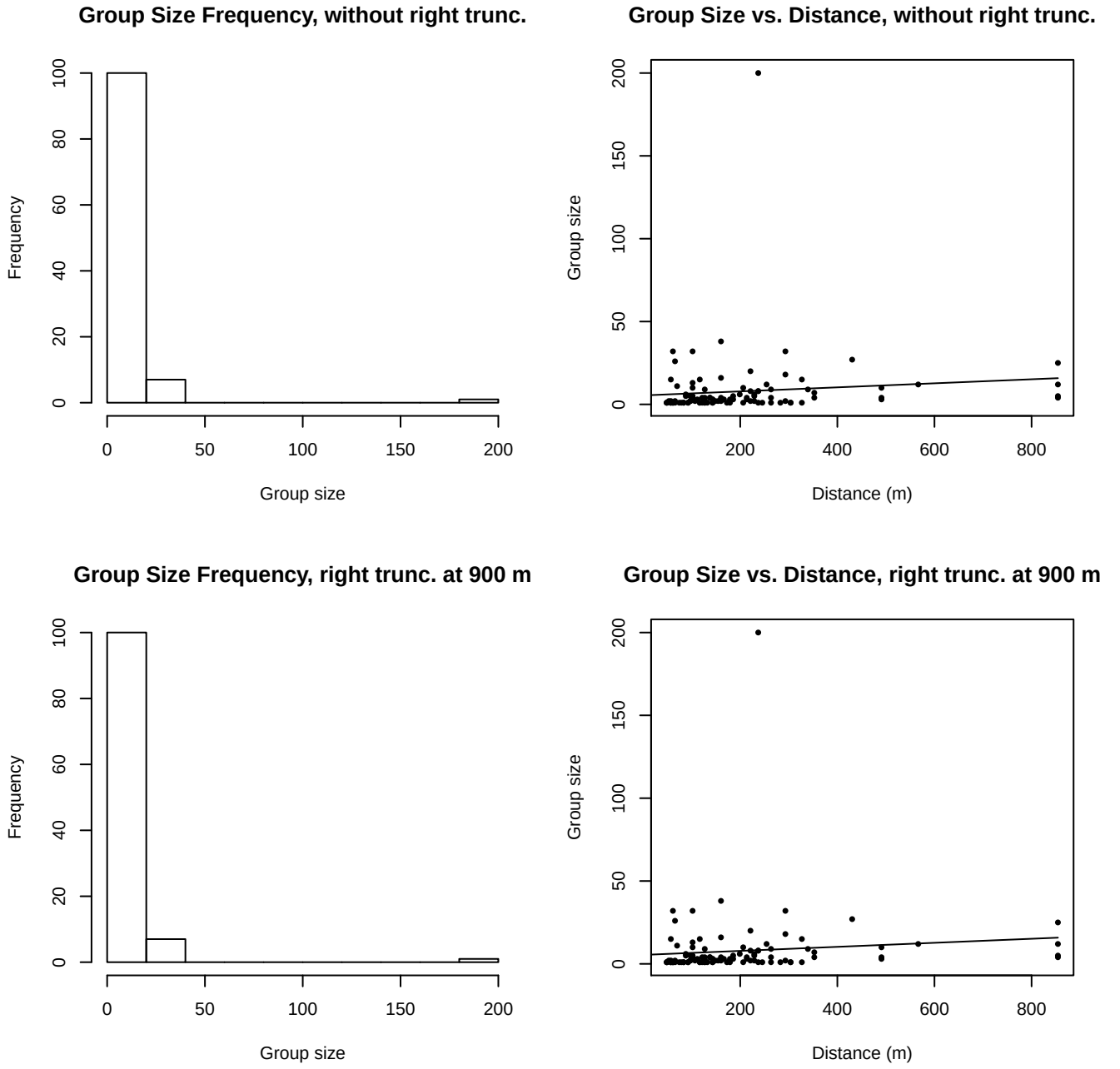

Figure 64: Histograms showing group size frequency and scatterplots showing the relationship between group size and perpendicular sighting distance, for all sightings (top row) and only those not right truncated (bottom row). In the scatterplot, the line is a simple linear regression.

SE_secas95

Because this taxon was sighted too infrequently to fit a detection function to its sightings alone, we fit a detection function to the pooled sightings of several other species that we believed would exhibit similar detectability. These "proxy species" are listed below.

Reported By Observer	Common Name	n
Delphinus capensis	Long-beaked common dolphin	0
Delphinus delphis	Short-beaked common dolphin	0

Delphinus delphis/Lagenorhynchus acutus	Short-beaked common or Atlantic white-sided dolphin	0
Delphinus delphis/Stenella	Short-beaked common dolphin or Stenella spp.	0
Delphinus delphis/Stenella coeruleoalba	Short-beaked common or striped dolphin	0
Grampus griseus	Risso's dolphin	0
Grampus griseus/Tursiops truncatus	Risso's or Bottlenose dolphin	0
Lagenodelphis hosei	Fraser's dolphin	0
Lagenorhynchus acutus	Atlantic white-sided dolphin	0
Lagenorhynchus albirostris	White-beaked dolphin	0
Lagenorhynchus albirostris/Lagenorhynchus acutus	White-beaked or white-sided dolphin	0
Stenella	Unidentified Stenella	2
Stenella attenuata	Pantropical spotted dolphin	0
Stenella attenuata/frontalis	Pantropical or Atlantic spotted dolphin	0
Stenella clymene	Clymene dolphin	0
Stenella coeruleoalba	Striped dolphin	1
Stenella frontalis	Atlantic spotted dolphin	10
Stenella frontalis/Tursiops truncatus	Atlantic spotted or Bottlenose dolphin	0
Stenella longirostris	Spinner dolphin	0
Steno bredanensis	Rough-toothed dolphin	0
Steno bredanensis/Tursiops truncatus	Bottlenose or rough-toothed dolphin	0
Tursiops truncatus	Bottlenose dolphin	113
Total		126

Table 49: Proxy species used to fit detection functions for SE_secas95. The number of sightings, n, is before truncation.

The sightings were right truncated at 900m. The vertical sighting angles were heaped at 10 degree increments, so the candidate detection functions were fitted using linear bins scaled accordingly.

Covariate	Description
beaufort	Beaufort sea state.
quality	Survey-specific index of the quality of observation conditions, utilizing relevant factors other than Beaufort sea state (see methods).
size	Estimated size (number of individuals) of the sighted group.

Table 50: Covariates tested in candidate "multi-covariate distance sampling" (MCDS) detection functions.

Key	Adjustment	Order	Covariates	Succeeded	Δ AIC	Mean ESHW (m)
hr			quality	Yes	0.00	361
hr				Yes	1.17	370
hr	poly	2		Yes	3.17	370

hr	poly	4		Yes	3.17	370
hn			quality	Yes	3.44	351
hn				Yes	4.36	352
hn	cos	3		Yes	5.36	390
hn			beaufort, quality	Yes	5.41	351
hn	cos	2		Yes	5.97	333
hn	herm	4		Yes	6.17	351
hn			beaufort	Yes	6.35	352
hr			beaufort	No		
hn			size	No		
hr			size	No		
hr			beaufort, quality	No		
hn			beaufort, size	No		
hr			beaufort, size	No		
hn			quality, size	No		
hr			quality, size	No		
hn			beaufort, quality, size	No		
hr			beaufort, quality, size	No		

Table 51: Candidate detection functions for SE_secas95. The first one listed was selected for the density model.

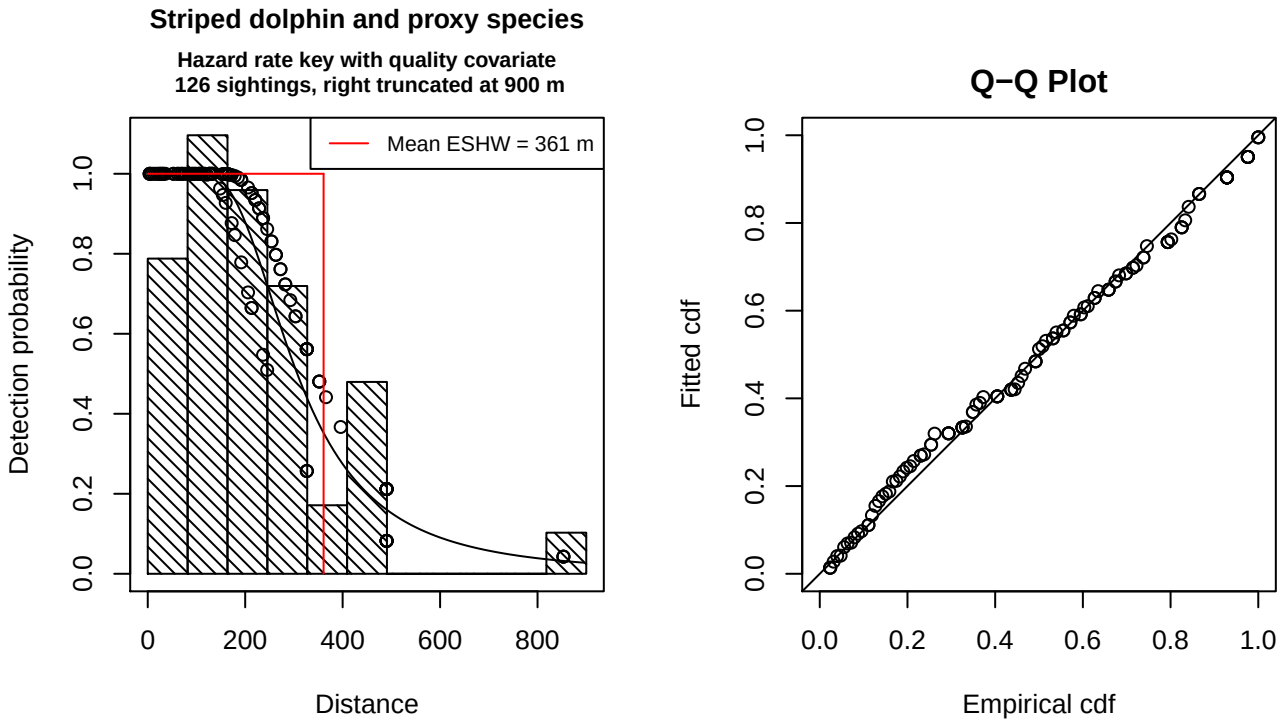

Figure 65: Detection function for SE_secas95 that was selected for the density model

Statistical output for this detection function:

```
Summary for ds object
Number of observations :  126
Distance range         :  0  -  900
AIC                    :  1599.263

Detection function:
 Hazard-rate key function

Detection function parameters
Scale Coefficients:
               estimate         se
(Intercept)  5.72521560 0.13241064
quality     -0.06684612 0.03458459

Shape parameters:
            estimate        se
(Intercept) 1.116802 0.1798011

                        Estimate          SE         CV
Average p              0.3924197  0.03385989 0.08628489
N in covered region 321.0848094 35.66094937 0.11106396
```

Additional diagnostic plots:

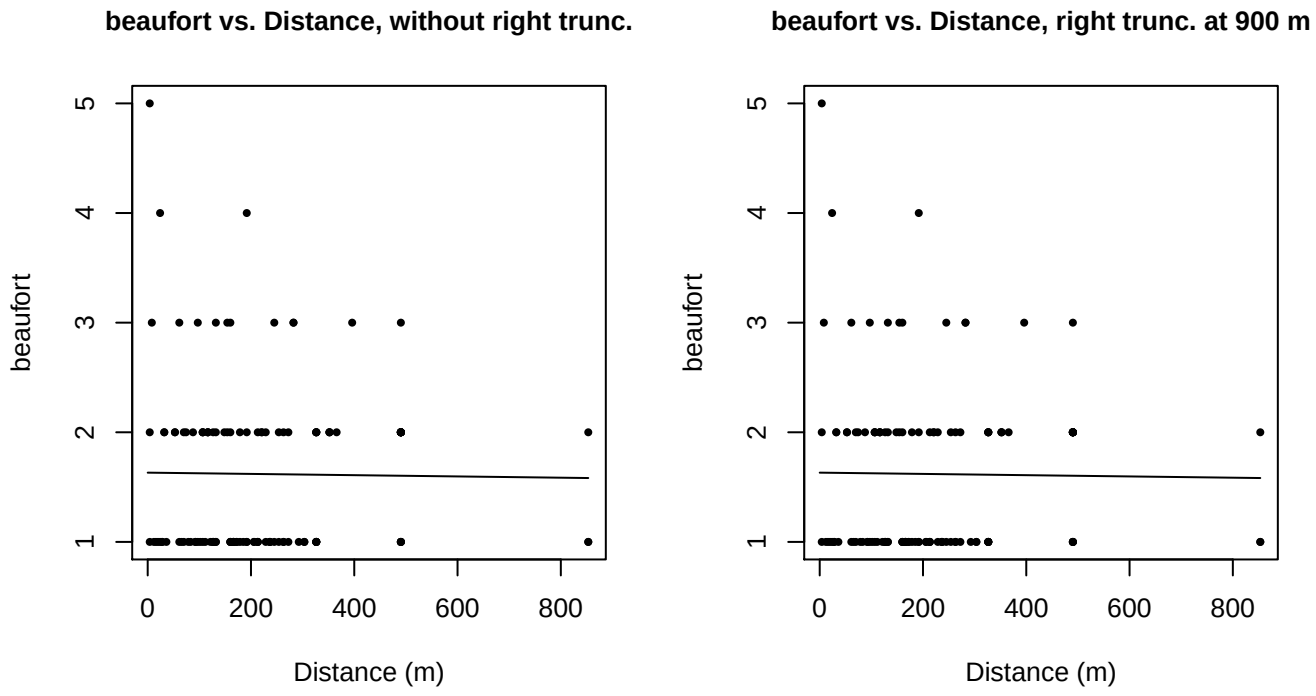

Figure 66: Scatterplots showing the relationship between Beaufort sea state and perpendicular sighting distance, for all sightings (left) and only those not right truncated (right). The line is a simple linear regression.

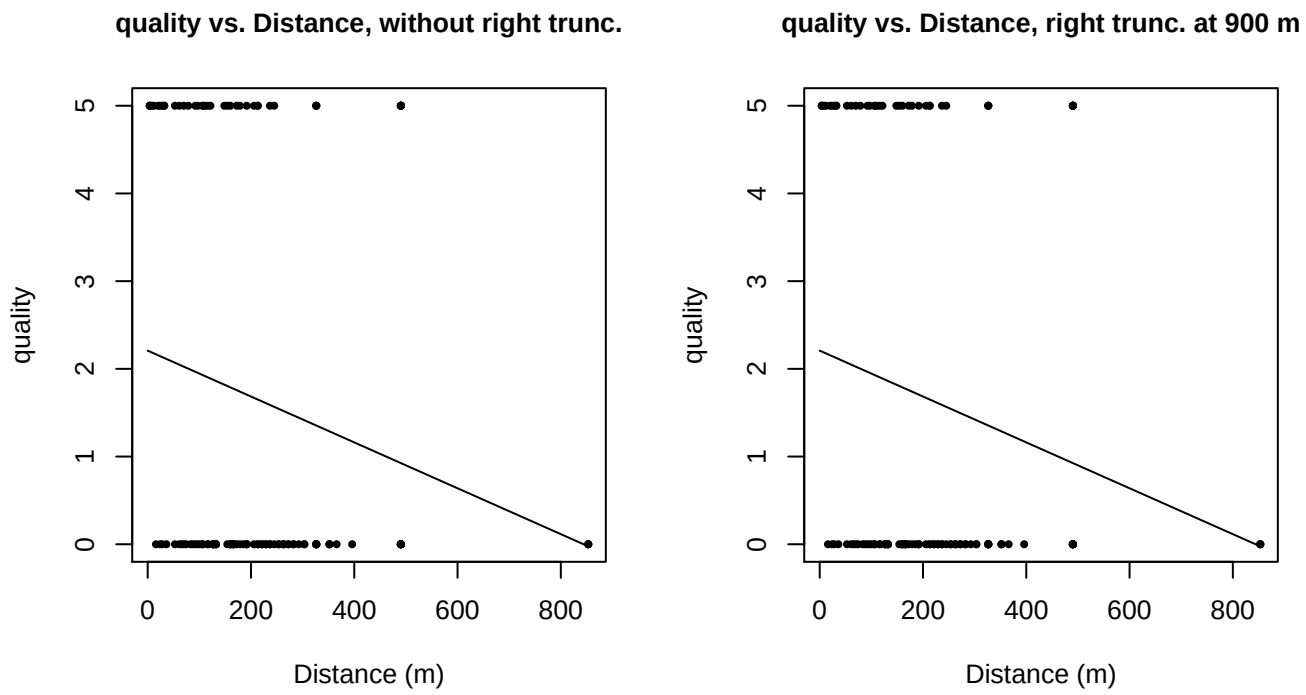

Figure 67: Scatterplots showing the relationship between the survey-specific index of the quality of observation conditions and perpendicular sighting distance, for all sightings (left) and only those not right truncated (right). Low values of the quality index correspond to better observation conditions. The line is a simple linear regression.

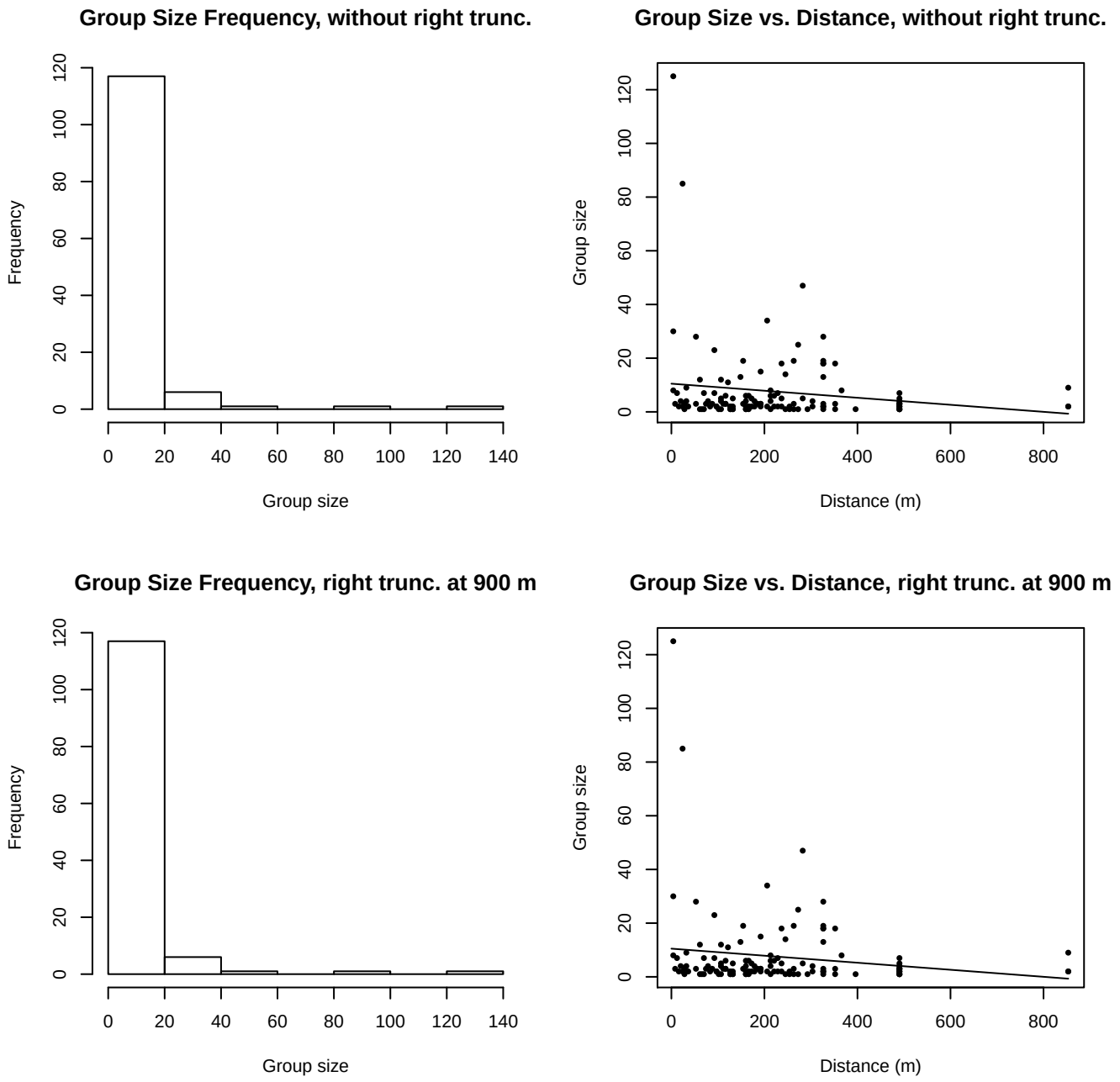

Figure 68: Histograms showing group size frequency and scatterplots showing the relationship between group size and perpendicular sighting distance, for all sightings (top row) and only those not right truncated (bottom row). In the scatterplot, the line is a simple linear regression.

Mid Atlantic Tursiops Survey 1995

Because this taxon was sighted too infrequently to fit a detection function to its sightings alone, we fit a detection function to the pooled sightings of several other species that we believed would exhibit similar detectability. These "proxy species" are listed below.

Reported By Observer	Common Name	n
Delphinus capensis	Long-beaked common dolphin	0
Delphinus delphis	Short-beaked common dolphin	0

Delphinus delphis/Lagenorhynchus acutus	Short-beaked common or Atlantic white-sided dolphin	0
Delphinus delphis/Stenella	Short-beaked common dolphin or Stenella spp.	0
Delphinus delphis/Stenella coeruleoalba	Short-beaked common or striped dolphin	0
Grampus griseus	Risso's dolphin	0
Grampus griseus/Tursiops truncatus	Risso's or Bottlenose dolphin	0
Lagenodelphis hosei	Fraser's dolphin	0
Lagenorhynchus acutus	Atlantic white-sided dolphin	0
Lagenorhynchus albirostris	White-beaked dolphin	0
Lagenorhynchus albirostris/Lagenorhynchus acutus	White-beaked or white-sided dolphin	0
Stenella	Unidentified Stenella	0
Stenella attenuata	Pantropical spotted dolphin	0
Stenella attenuata/frontalis	Pantropical or Atlantic spotted dolphin	0
Stenella clymene	Clymene dolphin	0
Stenella coeruleoalba	Striped dolphin	0
Stenella frontalis	Atlantic spotted dolphin	3
Stenella frontalis/Tursiops truncatus	Atlantic spotted or Bottlenose dolphin	0
Stenella longirostris	Spinner dolphin	0
Steno bredanensis	Rough-toothed dolphin	0
Steno bredanensis/Tursiops truncatus	Bottlenose or rough-toothed dolphin	0
Tursiops truncatus	Bottlenose dolphin	116
Total		119

Table 52: Proxy species used to fit detection functions for Mid Atlantic Tursiops Survey 1995. The number of sightings, n, is before truncation.

The sightings were right truncated at 1296m. The vertical sighting angles were heaped at 10 degree increments, so the candidate detection functions were fitted using linear bins scaled accordingly.

Covariate	Description
beaufort	Beaufort sea state.
quality	Survey-specific index of the quality of observation conditions, utilizing relevant factors other than Beaufort sea state (see methods).
size	Estimated size (number of individuals) of the sighted group.

Table 53: Covariates tested in candidate "multi-covariate distance sampling" (MCDS) detection functions.

Key	Adjustment	Order	Covariates	Succeeded	Δ AIC	Mean ESHW (m)
hr				Yes	0.00	416
hr			quality	Yes	1.20	425
hr			size	Yes	1.63	420

hr	poly	4		Yes	2.00	416
hr	poly	2		Yes	2.00	416
hr			quality, size	Yes	3.04	426
hn	cos	2		Yes	3.19	334
hn				Yes	6.62	397
hn			quality	Yes	7.34	397
hn			size	Yes	7.67	397
hn	cos	3		Yes	8.38	376
hn	herm	4		Yes	8.59	397
hn			quality, size	Yes	8.74	397
hr			beaufort	No		
hn			beaufort	No		
hr			beaufort, quality	No		
hn			beaufort, quality	No		
hr			beaufort, size	No		
hn			beaufort, size	No		
hr			beaufort, quality, size	No		
hn			beaufort, quality, size	No		

Table 54: Candidate detection functions for Mid Atlantic Tursiops Survey 1995. The first one listed was selected for the density model.

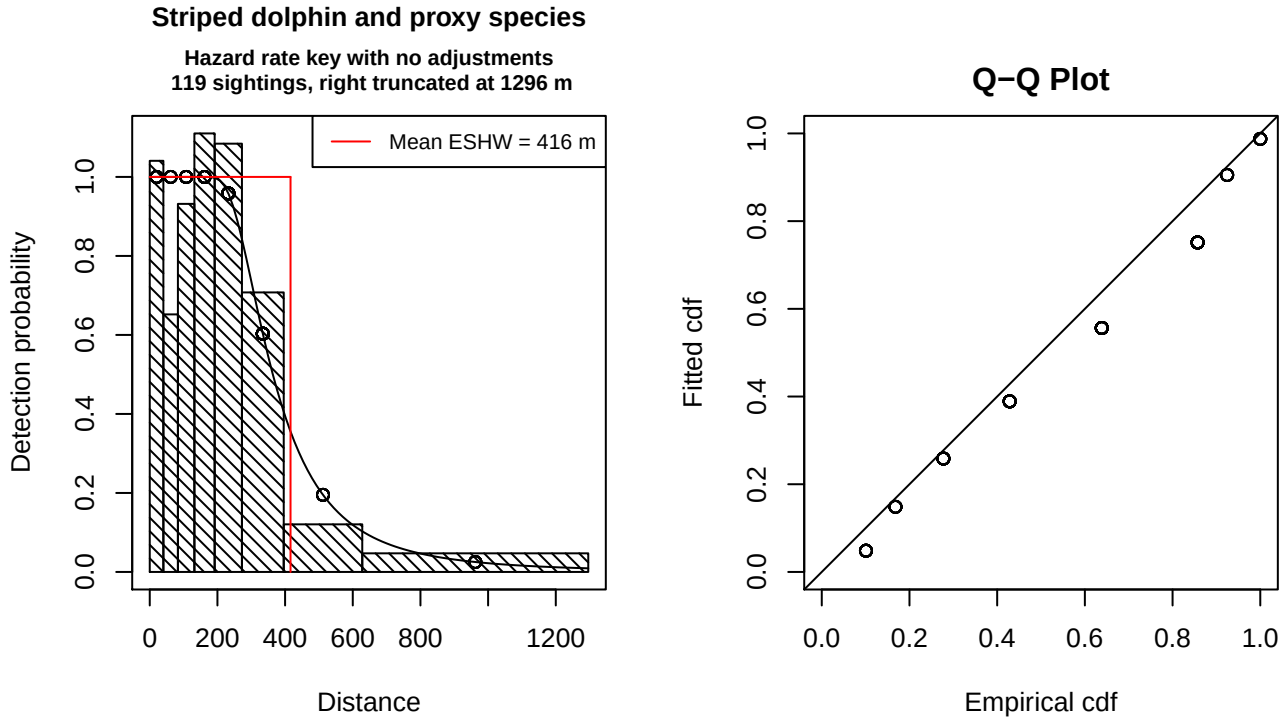

Figure 69: Detection function for Mid Atlantic Tursiops Survey 1995 that was selected for the density model

Statistical output for this detection function:

```
Summary for ds object
Number of observations :  119
Distance range         :  0  -  1296
AIC                    :  481.8113

Detection function:
 Hazard-rate key function

Detection function parameters
Scale Coefficients:
            estimate       se
(Intercept) 5.788509 0.117856

Shape parameters:
            estimate        se
(Intercept)  1.22245 0.1594061

                     Estimate          SE        CV
Average p             0.32101  0.02785003 0.0867575
N in covered region 370.70494 42.64341671 0.1150333
```

Additional diagnostic plots:

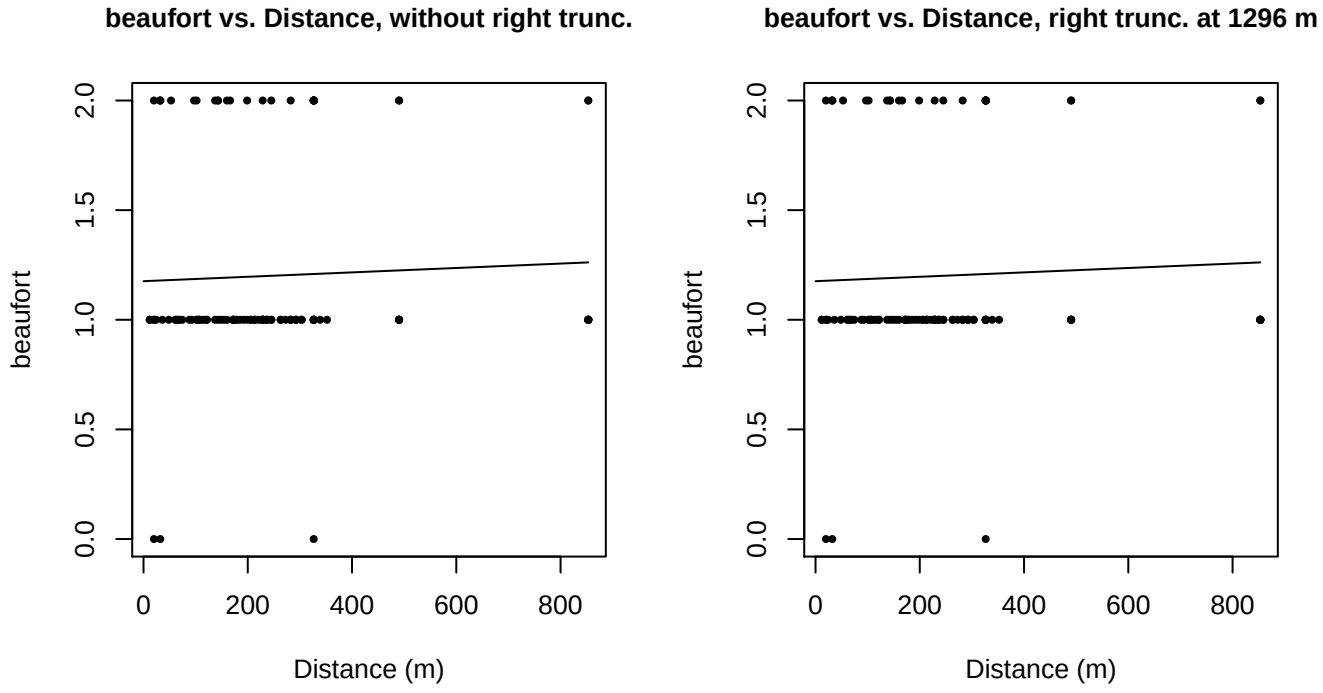

Figure 70: Scatterplots showing the relationship between Beaufort sea state and perpendicular sighting distance, for all sightings (left) and only those not right truncated (right). The line is a simple linear regression.

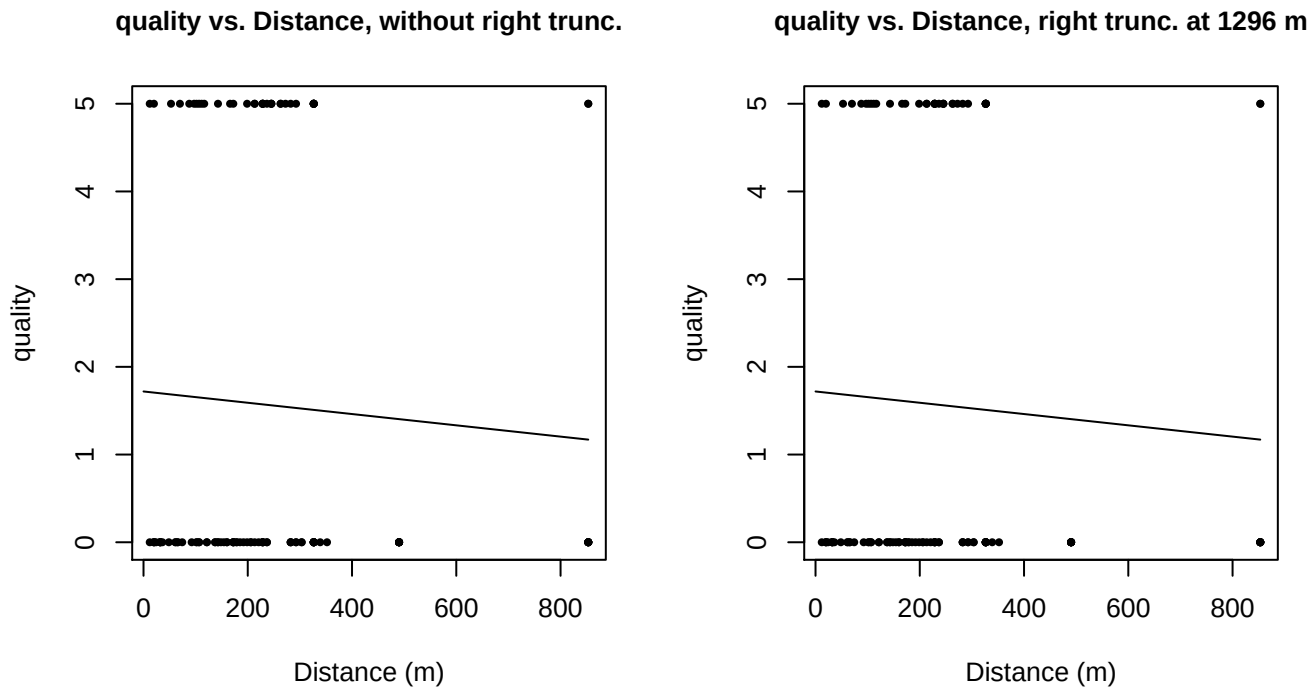

Figure 71: Scatterplots showing the relationship between the survey-specific index of the quality of observation conditions and perpendicular sighting distance, for all sightings (left) and only those not right truncated (right). Low values of the quality index correspond to better observation conditions. The line is a simple linear regression.

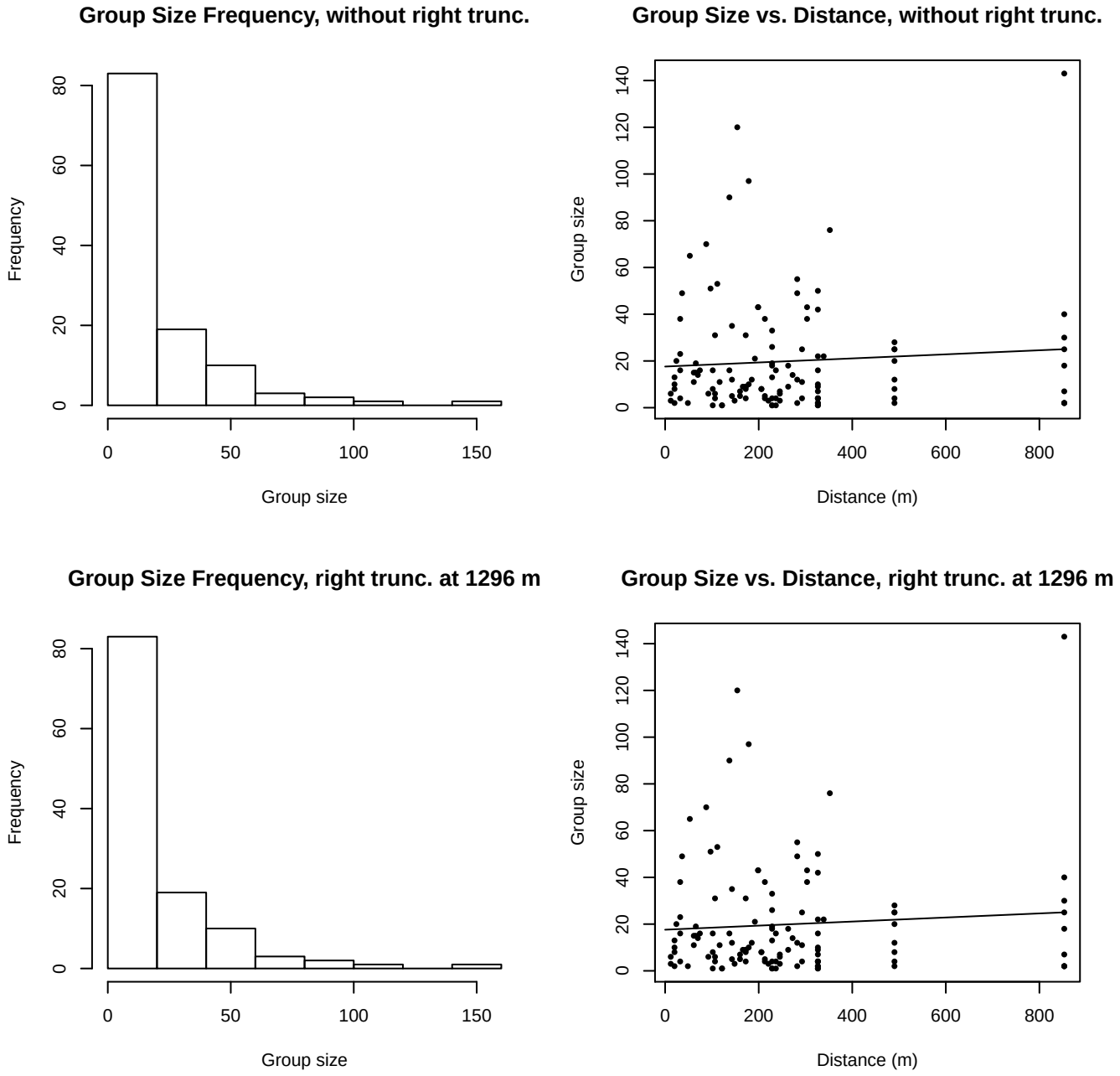

Figure 72: Histograms showing group size frequency and scatterplots showing the relationship between group size and perpendicular sighting distance, for all sightings (top row) and only those not right truncated (bottom row). In the scatterplot, the line is a simple linear regression.

GulfCet Aerial Surveys

Because this taxon was sighted too infrequently to fit a detection function to its sightings alone, we fit a detection function to the pooled sightings of several other species that we believed would exhibit similar detectability. These "proxy species" are listed below.

Reported By Observer	Common Name	n
Delphinus capensis	Long-beaked common dolphin	0
Delphinus delphis	Short-beaked common dolphin	0

Delphinus delphis/Lagenorhynchus acutus	Short-beaked common or Atlantic white-sided dolphin	0
Delphinus delphis/Stenella	Short-beaked common dolphin or Stenella spp.	0
Delphinus delphis/Stenella coeruleoalba	Short-beaked common or striped dolphin	0
Grampus griseus	Risso's dolphin	71
Grampus griseus/Tursiops truncatus	Risso's or Bottlenose dolphin	0
Lagenodelphis hosei	Fraser's dolphin	2
Lagenorhynchus acutus	Atlantic white-sided dolphin	0
Lagenorhynchus albirostris	White-beaked dolphin	0
Lagenorhynchus albirostris/Lagenorhynchus acutus	White-beaked or white-sided dolphin	0
Stenella	Unidentified Stenella	10
Stenella attenuata	Pantropical spotted dolphin	94
Stenella attenuata/frontalis	Pantropical or Atlantic spotted dolphin	0
Stenella clymene	Clymene dolphin	12
Stenella coeruleoalba	Striped dolphin	16
Stenella frontalis	Atlantic spotted dolphin	36
Stenella frontalis/Tursiops truncatus	Atlantic spotted or Bottlenose dolphin	0
Stenella longirostris	Spinner dolphin	11
Steno bredanensis	Rough-toothed dolphin	9
Steno bredanensis/Tursiops truncatus	Bottlenose or rough-toothed dolphin	0
Tursiops truncatus	Bottlenose dolphin	237
Total		498

Table 55: Proxy species used to fit detection functions for GulfCet Aerial Surveys. The number of sightings, n, is before truncation.

The sightings were right truncated at 1296m. The vertical sighting angles were heaped at 10 degree increments, so the candidate detection functions were fitted using linear bins scaled accordingly.

Covariate	Description
beaufort	Beaufort sea state.
quality	Survey-specific index of the quality of observation conditions, utilizing relevant factors other than Beaufort sea state (see methods).
size	Estimated size (number of individuals) of the sighted group.

Table 56: Covariates tested in candidate "multi-covariate distance sampling" (MCDS) detection functions.

Key	Adjustment	Order	Covariates	Succeeded	Δ AIC	Mean ESHW (m)
hr			size	Yes	0.00	402
hr				Yes	1.41	394
hr	poly	2		Yes	3.41	394

hr	poly	4		Yes	3.41	394
hn	cos	2		Yes	4.97	368
hn	cos	3		Yes	10.69	340
hn			size	Yes	31.42	441
hn				Yes	34.80	439
hn	herm	4		Yes	36.57	439
hr			beaufort	No		
hn			beaufort	No		
hr			quality	No		
hn			quality	No		
hr			beaufort, quality	No		
hn			beaufort, quality	No		
hr			beaufort, size	No		
hn			beaufort, size	No		
hr			quality, size	No		
hn			quality, size	No		
hr			beaufort, quality, size	No		
hn			beaufort, quality, size	No		

Table 57: Candidate detection functions for GulfCet Aerial Surveys. The first one listed was selected for the density model.

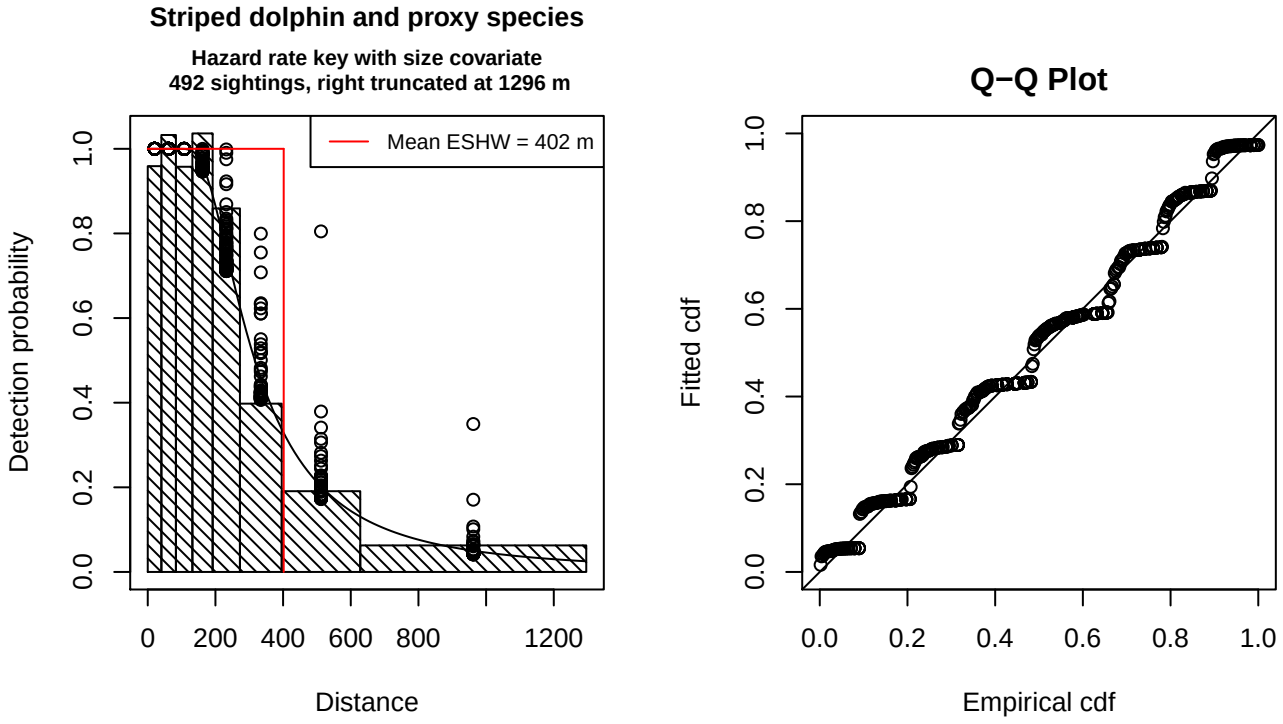

Figure 73: Detection function for GulfCet Aerial Surveys that was selected for the density model

Statistical output for this detection function:

```
Summary for ds object
Number of observations :  492
Distance range         :  0  -  1296
AIC                    :  2031.84

Detection function:
 Hazard-rate key function

Detection function parameters
Scale Coefficients:
             estimate         se
(Intercept) 5.5354386 0.09101914
size        0.1398343 0.06269366

Shape parameters:
             estimate         se
(Intercept) 0.8669391 0.08291978

                         Estimate           SE         CV
Average p                0.3057321   0.01666672 0.05451413
N in covered region 1609.2517747 106.64340484 0.06626894
```

Additional diagnostic plots:

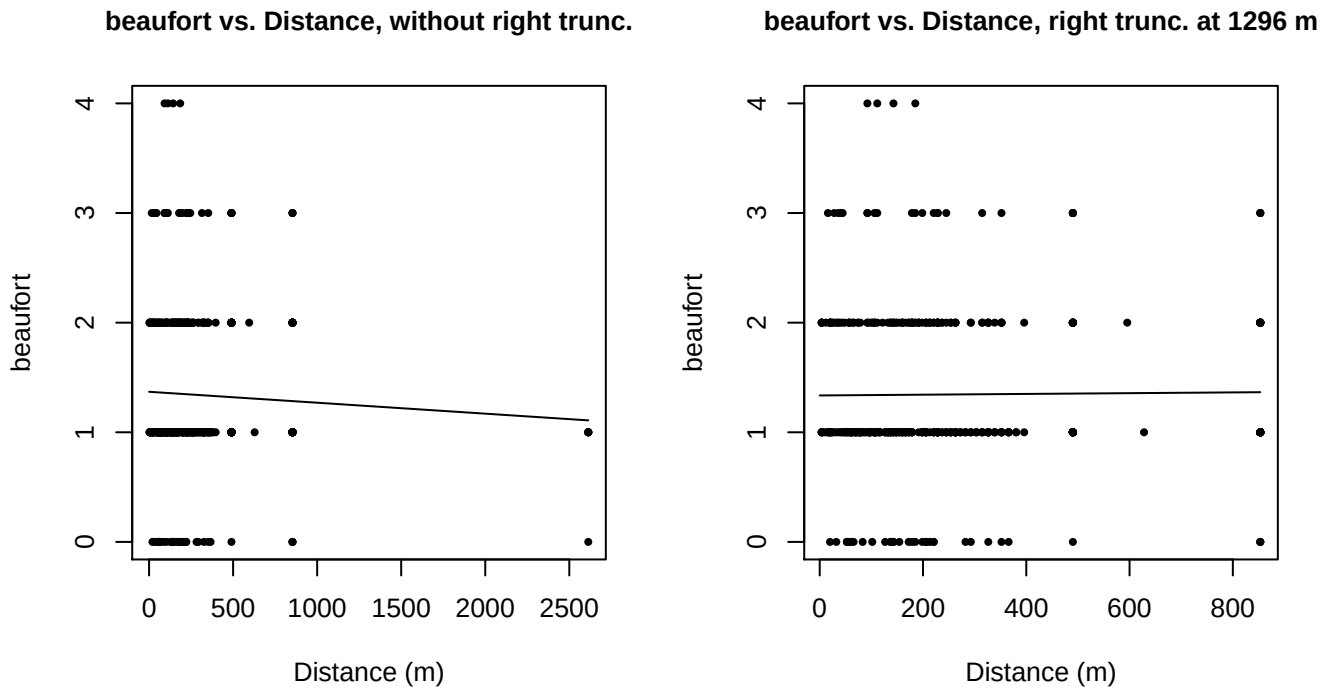

Figure 74: Scatterplots showing the relationship between Beaufort sea state and perpendicular sighting distance, for all sightings (left) and only those not right truncated (right). The line is a simple linear regression.

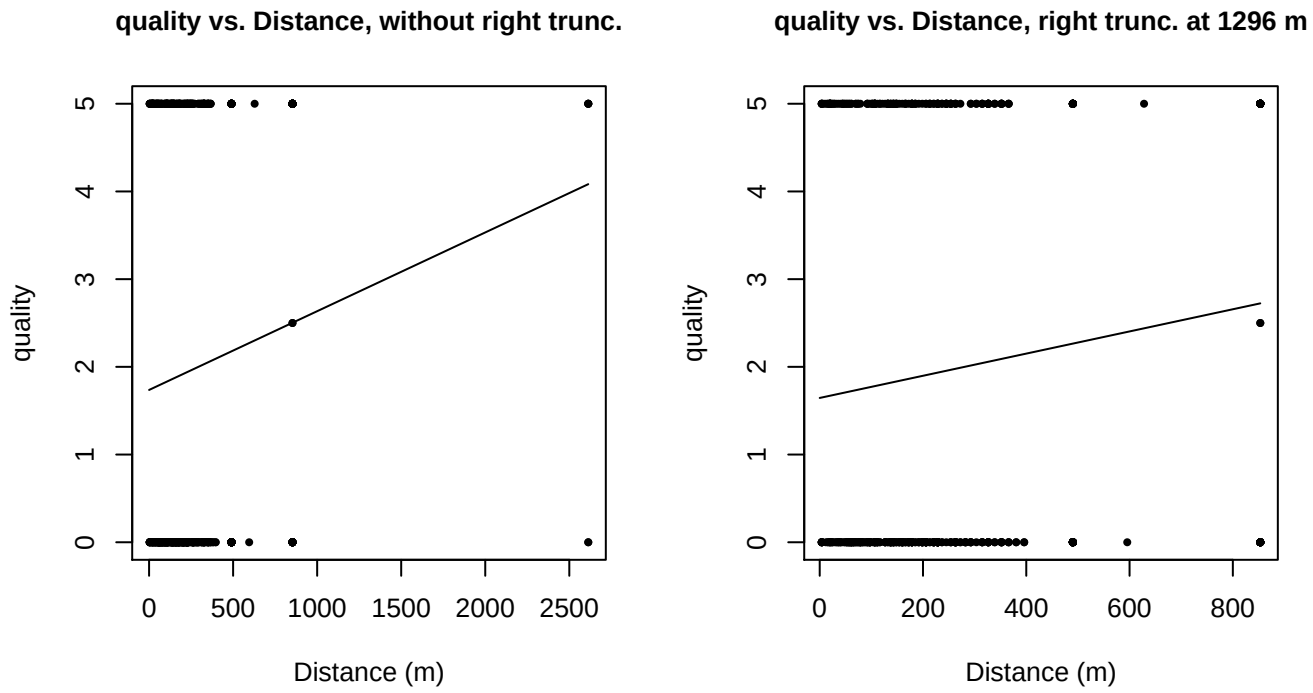

Figure 75: Scatterplots showing the relationship between the survey-specific index of the quality of observation conditions and perpendicular sighting distance, for all sightings (left) and only those not right truncated (right). Low values of the quality index correspond to better observation conditions. The line is a simple linear regression.

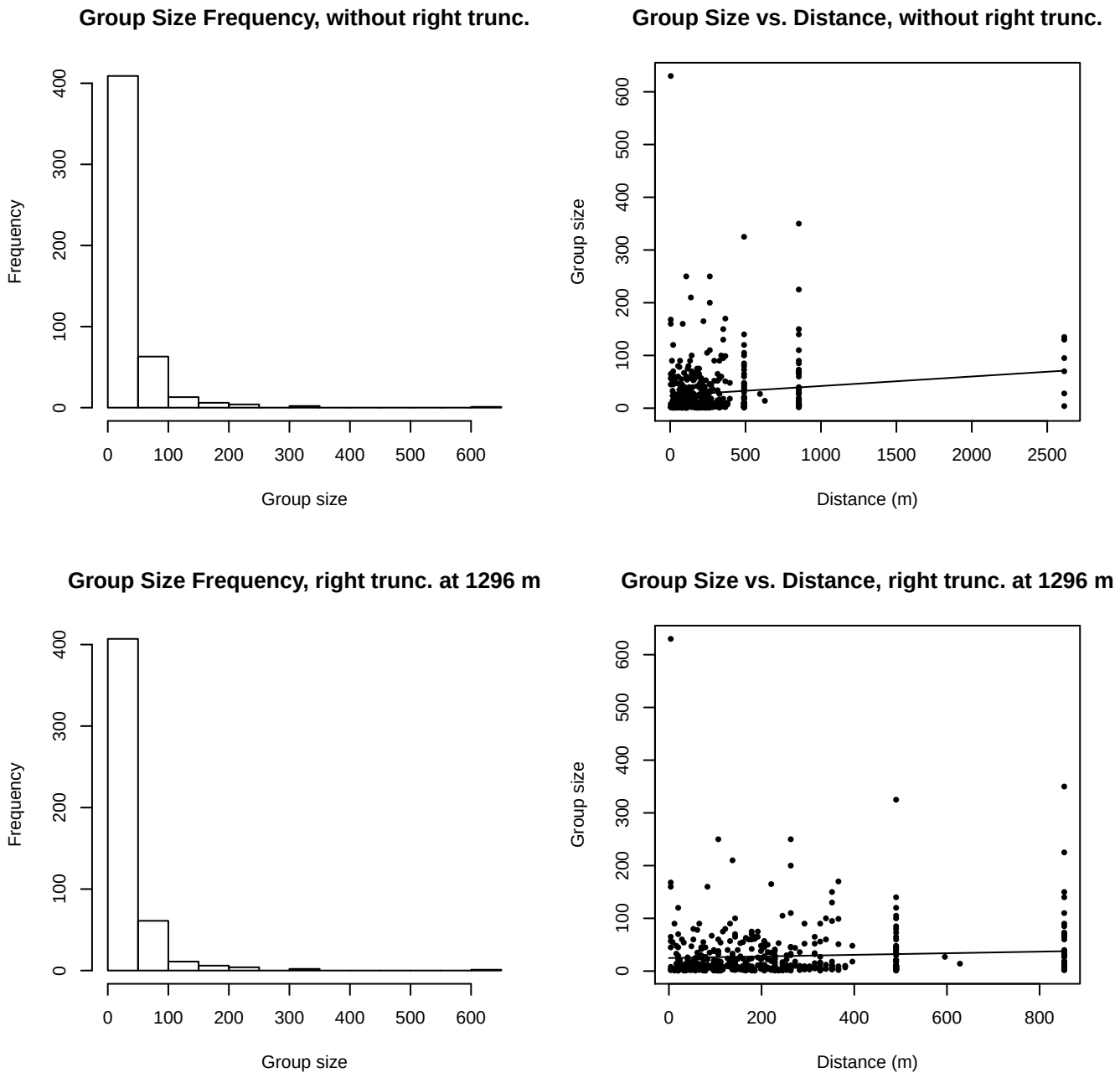

Figure 76: Histograms showing group size frequency and scatterplots showing the relationship between group size and perpendicular sighting distance, for all sightings (top row) and only those not right truncated (bottom row). In the scatterplot, the line is a simple linear regression.

GOMEX92-96 Aerial Survey

Because this taxon was sighted too infrequently to fit a detection function to its sightings alone, we fit a detection function to the pooled sightings of several other species that we believed would exhibit similar detectability. These "proxy species" are listed below.

Reported By Observer	Common Name	n
Delphinus capensis	Long-beaked common dolphin	0
Delphinus delphis	Short-beaked common dolphin	0

Delphinus delphis/Lagenorhynchus acutus	Short-beaked common or Atlantic white-sided dolphin	0
Delphinus delphis/Stenella	Short-beaked common dolphin or Stenella spp.	0
Delphinus delphis/Stenella coeruleoalba	Short-beaked common or striped dolphin	0
Grampus griseus	Risso's dolphin	4
Grampus griseus/Tursiops truncatus	Risso's or Bottlenose dolphin	0
Lagenodelphis hosei	Fraser's dolphin	0
Lagenorhynchus acutus	Atlantic white-sided dolphin	0
Lagenorhynchus albirostris	White-beaked dolphin	0
Lagenorhynchus albirostris/Lagenorhynchus acutus	White-beaked or white-sided dolphin	0
Stenella	Unidentified Stenella	1
Stenella attenuata	Pantropical spotted dolphin	0
Stenella attenuata/frontalis	Pantropical or Atlantic spotted dolphin	0
Stenella clymene	Clymene dolphin	0
Stenella coeruleoalba	Striped dolphin	0
Stenella frontalis	Atlantic spotted dolphin	24
Stenella frontalis/Tursiops truncatus	Atlantic spotted or Bottlenose dolphin	0
Stenella longirostris	Spinner dolphin	0
Steno bredanensis	Rough-toothed dolphin	0
Steno bredanensis/Tursiops truncatus	Bottlenose or rough-toothed dolphin	0
Tursiops truncatus	Bottlenose dolphin	936
Total		965

Table 58: Proxy species used to fit detection functions for GOMEX92-96 Aerial Survey. The number of sightings, n, is before truncation.

The sightings were right truncated at 1296m. Due to a reduced frequency of sightings close to the trackline that plausibly resulted from the behavior of the observers and/or the configuration of the survey platform, the sightings were left truncted as well. Sightings closer than 83 m to the trackline were omitted from the analysis, and it was assumed that the the area closer to the trackline than this was not surveyed. This distance was estimated by inspecting histograms of perpendicular sighting distances. The vertical sighting angles were heaped at 10 degree increments, so the candidate detection functions were fitted using linear bins scaled accordingly.

Covariate	Description
beaufort	Beaufort sea state.
quality	Survey-specific index of the quality of observation conditions, utilizing relevant factors other than Beaufort sea state (see methods).
size	Estimated size (number of individuals) of the sighted group.

Table 59: Covariates tested in candidate "multi-covariate distance sampling" (MCDS) detection functions.

Key	Adjustment	Order	Covariates	Succeeded	Δ AIC	Mean ESHW (m)

hr			size	Yes	0.00	281
hn	cos	3		Yes	4.86	220
hr				Yes	4.90	278
hr	poly	4		Yes	6.90	278
hr	poly	2		Yes	6.90	278
hn	cos	2		Yes	12.08	259
hn			size	Yes	39.54	304
hn				Yes	41.95	304
hn	herm	4		Yes	43.71	304
hr			beaufort	No		
hn			beaufort	No		
hr			quality	No		
hn			quality	No		
hr			beaufort, quality	No		
hn			beaufort, quality	No		
hr			beaufort, size	No		
hn			beaufort, size	No		
hr			quality, size	No		
hn			quality, size	No		
hr			beaufort, quality, size	No		
hn			beaufort, quality, size	No		

Table 60: Candidate detection functions for GOMEX92-96 Aerial Survey. The first one listed was selected for the density model.

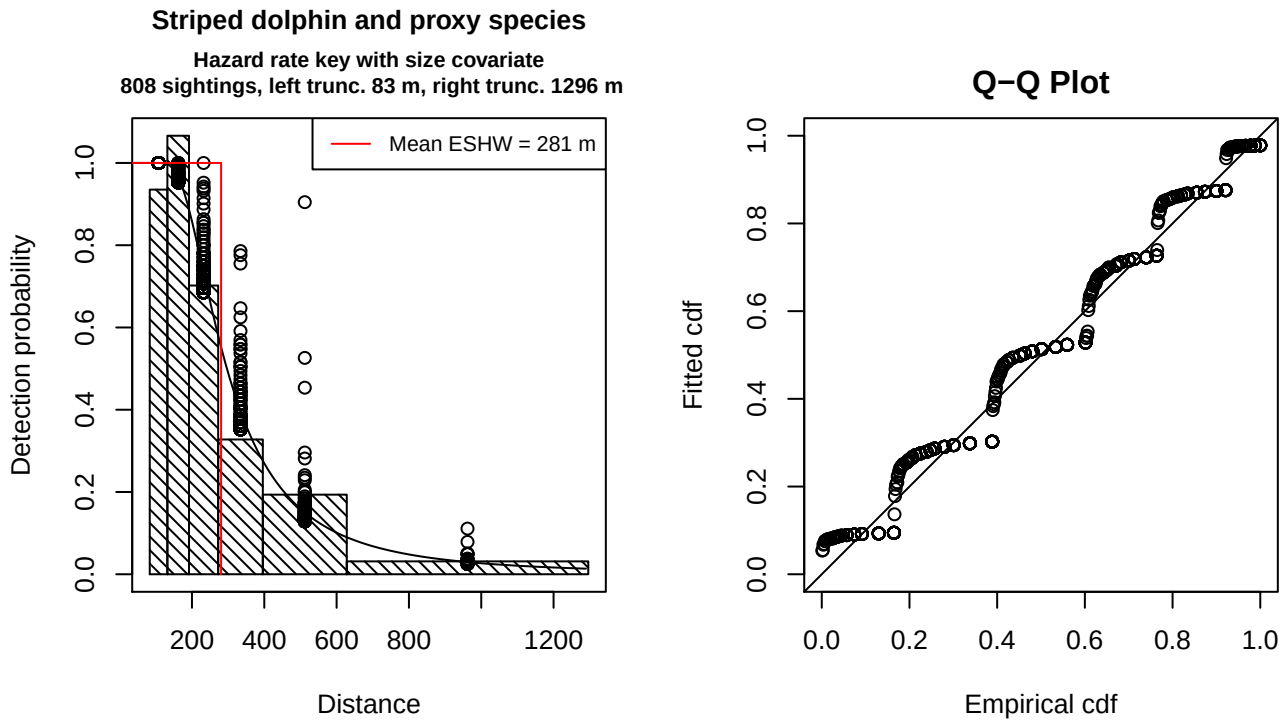

Figure 77: Detection function for GOMEX92-96 Aerial Survey that was selected for the density model

Statistical output for this detection function:

```
Summary for ds object
Number of observations :  808
Distance range         :  83.2036  -  1296
AIC                    :  2832.21

Detection function:
 Hazard-rate key function

Detection function parameters
Scale Coefficients:
             estimate         se
(Intercept) 5.48993350 0.06755593
size        0.09571101 0.04017188

Shape parameters:
             estimate         se
(Intercept) 0.9892248 0.05853657

                         Estimate           SE         CV
Average p                0.2138271   0.01146024 0.05359584
N in covered region 3778.7542797 234.43000362 0.06203896
```

Additional diagnostic plots:

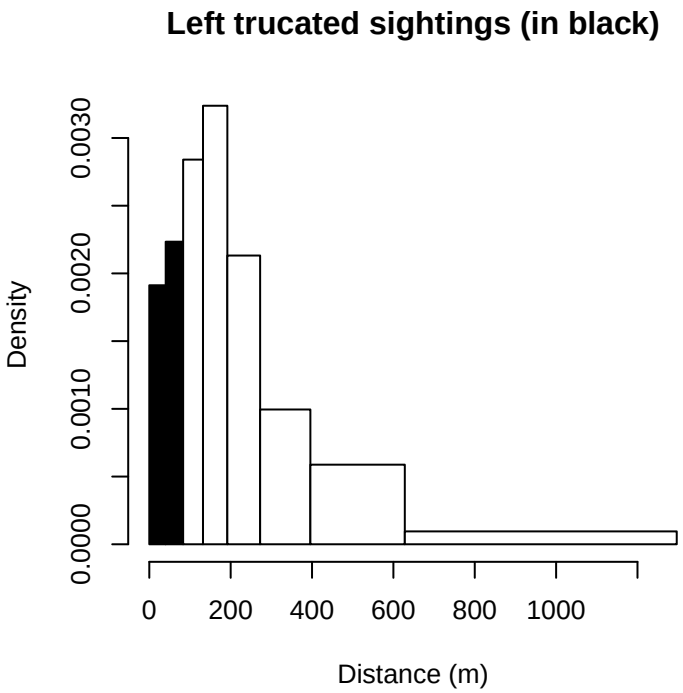

Figure 78: Density of sightings by perpendicular distance for GOMEX92-96 Aerial Survey. Black bars on the left show sightings that were left truncated.

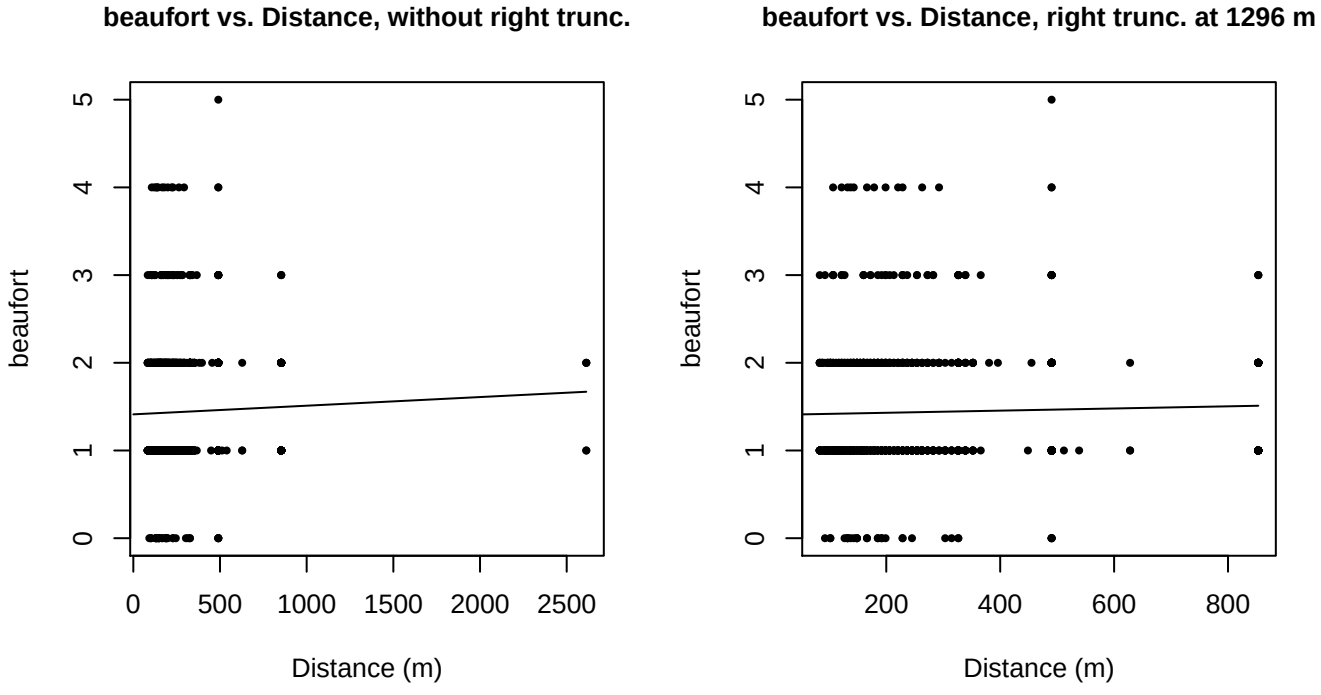

Figure 79: Scatterplots showing the relationship between Beaufort sea state and perpendicular sighting distance, for all sightings (left) and only those not right truncated (right). The line is a simple linear regression.

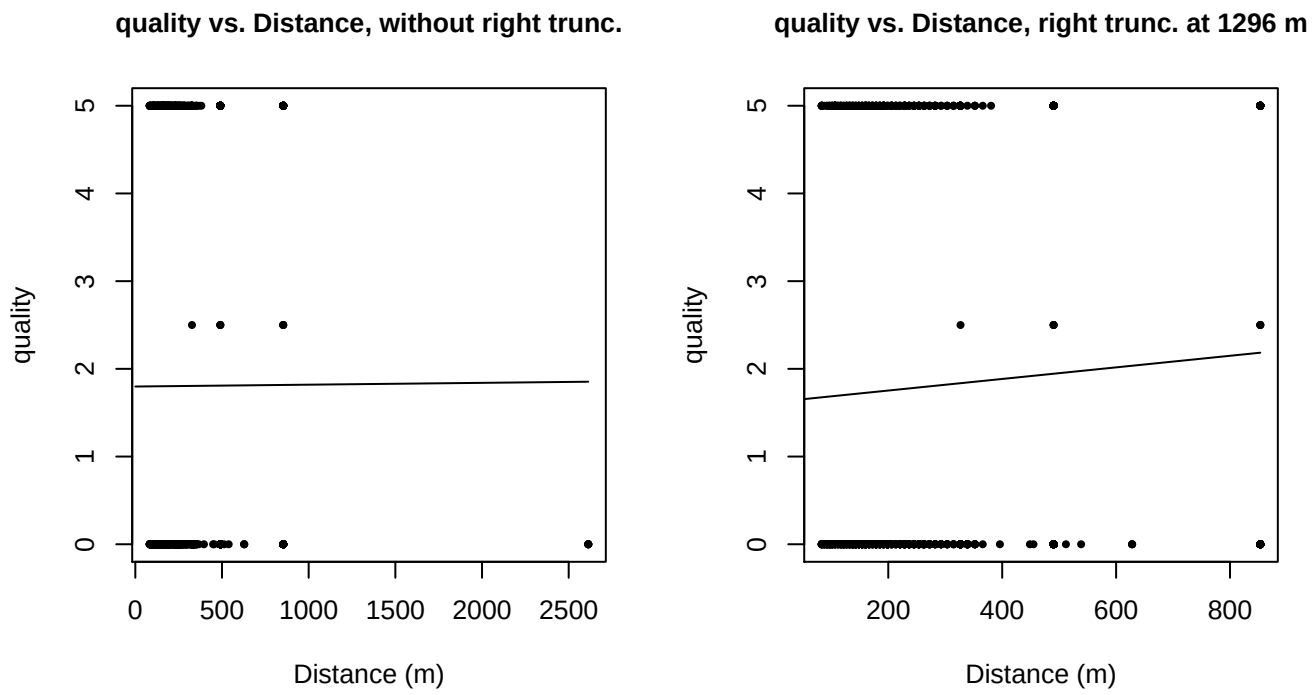

Figure 80: Scatterplots showing the relationship between the survey-specific index of the quality of observation conditions and perpendicular sighting distance, for all sightings (left) and only those not right truncated (right). Low values of the quality index correspond to better observation conditions. The line is a simple linear regression.

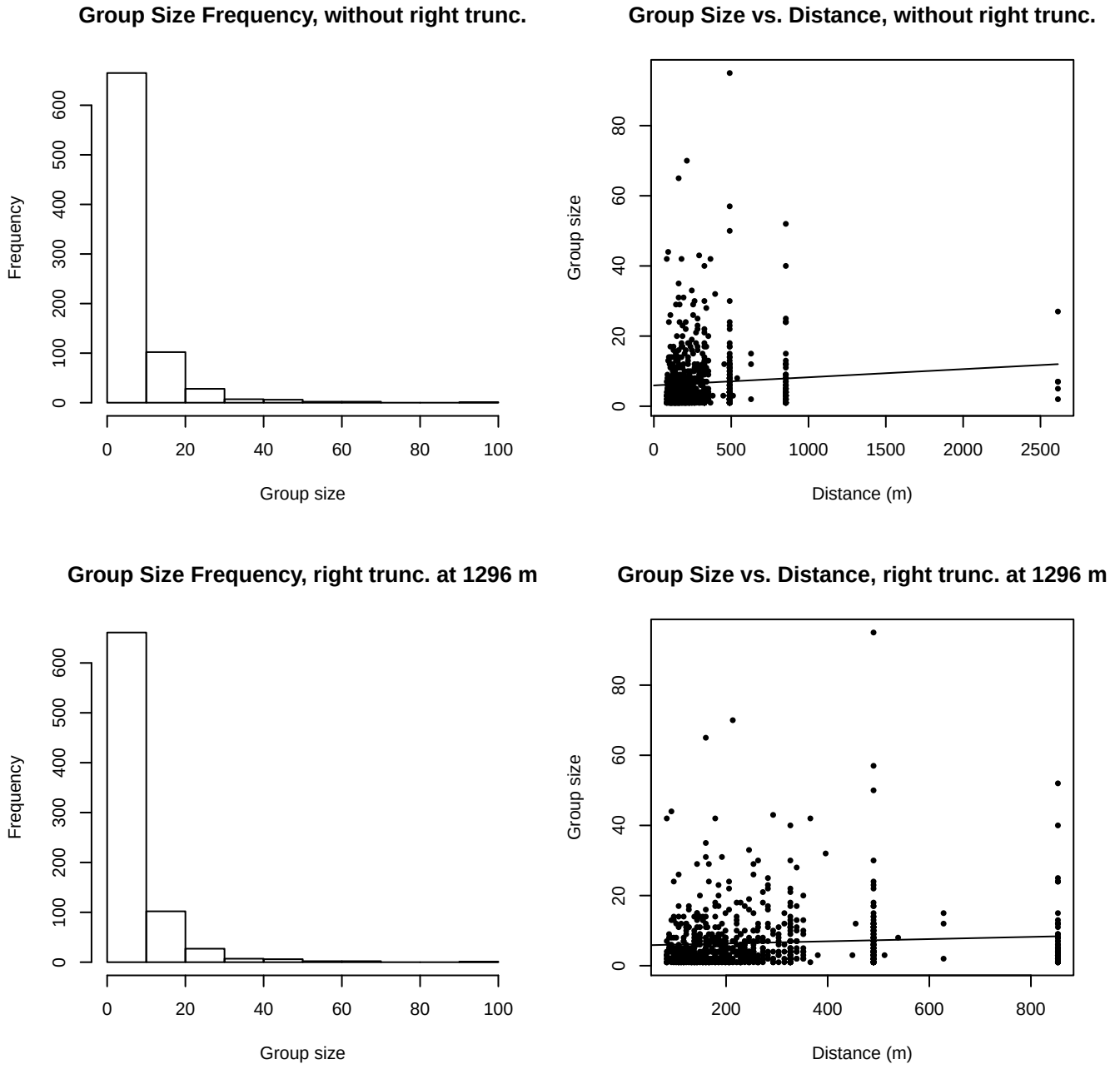

Figure 81: Histograms showing group size frequency and scatterplots showing the relationship between group size and perpendicular sighting distance, for all sightings (top row) and only those not right truncated (bottom row). In the scatterplot, the line is a simple linear regression.

UNCW Navy Surveys

Because this taxon was sighted too infrequently to fit a detection function to its sightings alone, we fit a detection function to the pooled sightings of several other species that we believed would exhibit similar detectability. These "proxy species" are listed below.

Reported By Observer	Common Name	n
Delphinus capensis	Long-beaked common dolphin	0
Delphinus delphis	Short-beaked common dolphin	13

Delphinus delphis/Lagenorhynchus acutus	Short-beaked common or Atlantic white-sided dolphin	0
Delphinus delphis/Stenella	Short-beaked common dolphin or Stenella spp.	0
Delphinus delphis/Stenella coeruleoalba	Short-beaked common or striped dolphin	0
Grampus griseus	Risso's dolphin	56
Grampus griseus/Tursiops truncatus	Risso's or Bottlenose dolphin	0
Lagenodelphis hosei	Fraser's dolphin	1
Lagenorhynchus acutus	Atlantic white-sided dolphin	0
Lagenorhynchus albirostris	White-beaked dolphin	0
Lagenorhynchus albirostris/Lagenorhynchus acutus	White-beaked or white-sided dolphin	0
Stenella	Unidentified Stenella	1
Stenella attenuata	Pantropical spotted dolphin	1
Stenella attenuata/frontalis	Pantropical or Atlantic spotted dolphin	0
Stenella clymene	Clymene dolphin	3
Stenella coeruleoalba	Striped dolphin	3
Stenella frontalis	Atlantic spotted dolphin	341
Stenella frontalis/Tursiops truncatus	Atlantic spotted or Bottlenose dolphin	0
Stenella longirostris	Spinner dolphin	1
Steno bredanensis	Rough-toothed dolphin	9
Steno bredanensis/Tursiops truncatus	Bottlenose or rough-toothed dolphin	0
Tursiops truncatus	Bottlenose dolphin	567
Total		996

Table 61: Proxy species used to fit detection functions for UNCW Navy Surveys. The number of sightings, n, is before truncation.

The sightings were right truncated at 1500m.

Covariate	Description
beaufort	Beaufort sea state.
quality	Survey-specific index of the quality of observation conditions, utilizing relevant factors other than Beaufort sea state (see methods).
size	Estimated size (number of individuals) of the sighted group.

Table 62: Covariates tested in candidate "multi-covariate distance sampling" (MCDS) detection functions.

Key	Adjustment	Order	Covariates	Succeeded	Δ AIC	Mean ESHW (m)
hn			size	Yes	0.00	754
hn			quality, size	Yes	0.22	754
hn			beaufort, size	Yes	1.76	754
hn			beaufort, quality, size	Yes	1.86	755

hn	herm	4		Yes	4.03	787
hn	cos	2		Yes	6.16	795
hn				Yes	6.29	753
hn			quality	Yes	7.23	753
hr	poly	2		Yes	7.54	825
hn	cos	3		Yes	8.04	736
hn			beaufort	Yes	8.24	753
hn			beaufort, quality	Yes	9.14	753
hr	poly	4		Yes	9.77	841
hr			size	Yes	10.22	901
hr			quality, size	Yes	10.94	900
hr			beaufort, size	Yes	12.22	901
hr			beaufort, quality, size	Yes	12.93	900
hr				Yes	16.65	887
hr			quality	Yes	17.70	886
hr			beaufort	No		
hr			beaufort, quality	No		

Table 63: Candidate detection functions for UNCW Navy Surveys. The first one listed was selected for the density model.

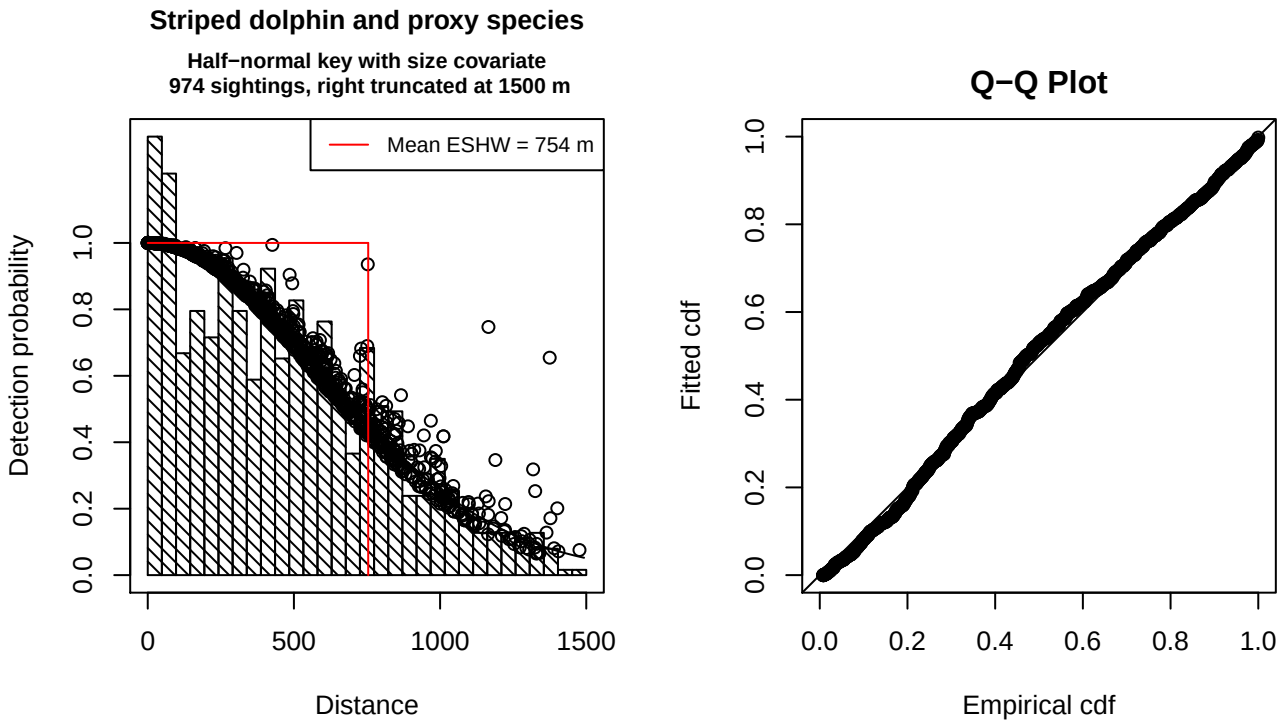

Figure 82: Detection function for UNCW Navy Surveys that was selected for the density model

Statistical output for this detection function:

```
Summary for ds object
Number of observations :  974
Distance range         :  0  -  1500
AIC                    :  13779.06

Detection function:
 Half-normal key function

Detection function parameters
Scale Coefficients:
             estimate         se
(Intercept) 6.3388868 0.04000233
size        0.1172576 0.05082555

                         Estimate          SE         CV
Average p              0.4997021  0.01337788 0.02677171
N in covered region 1949.1611578 68.45627661 0.03512089
```

Additional diagnostic plots:

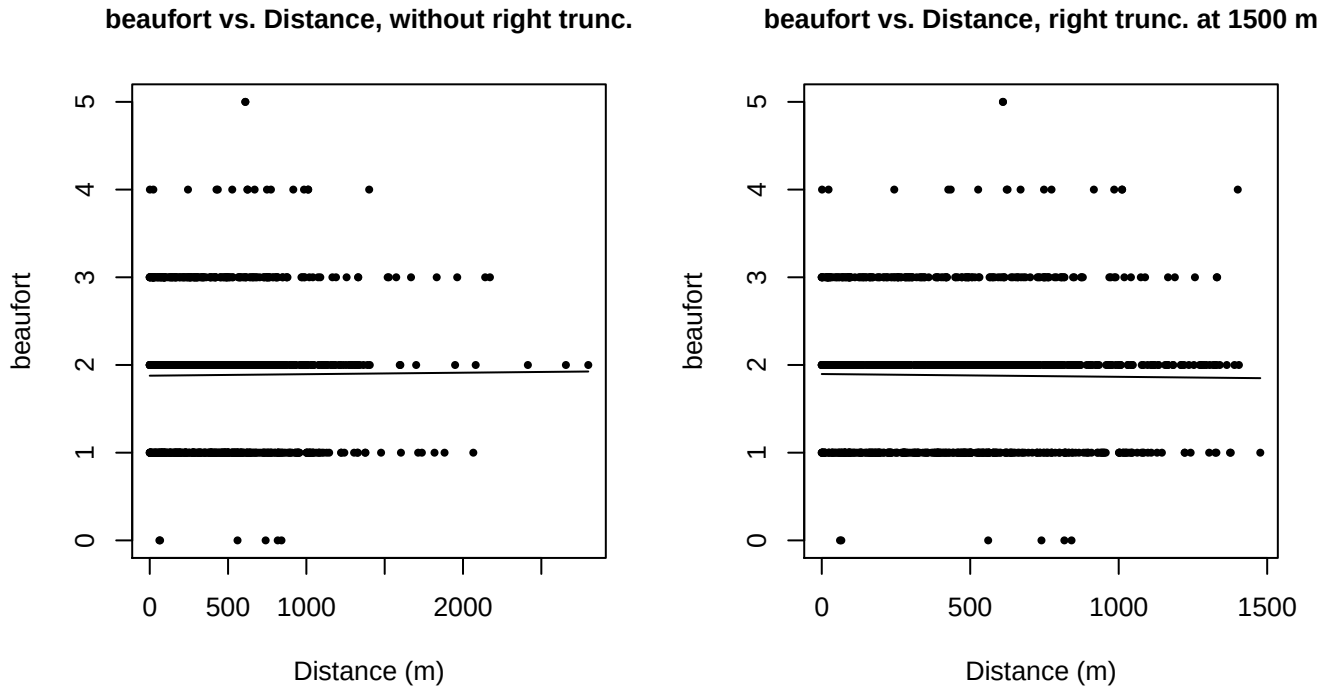

Figure 83: Scatterplots showing the relationship between Beaufort sea state and perpendicular sighting distance, for all sightings (left) and only those not right truncated (right). The line is a simple linear regression.

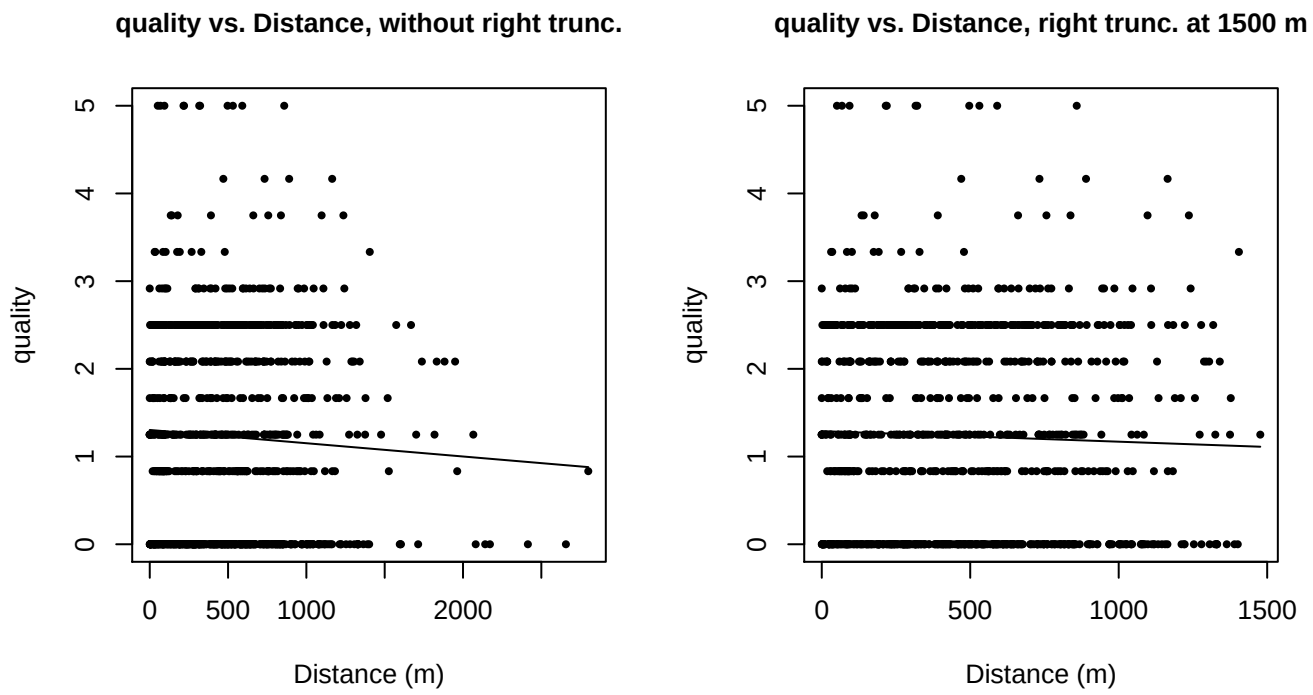

Figure 84: Scatterplots showing the relationship between the survey-specific index of the quality of observation conditions and perpendicular sighting distance, for all sightings (left) and only those not right truncated (right). Low values of the quality index correspond to better observation conditions. The line is a simple linear regression.

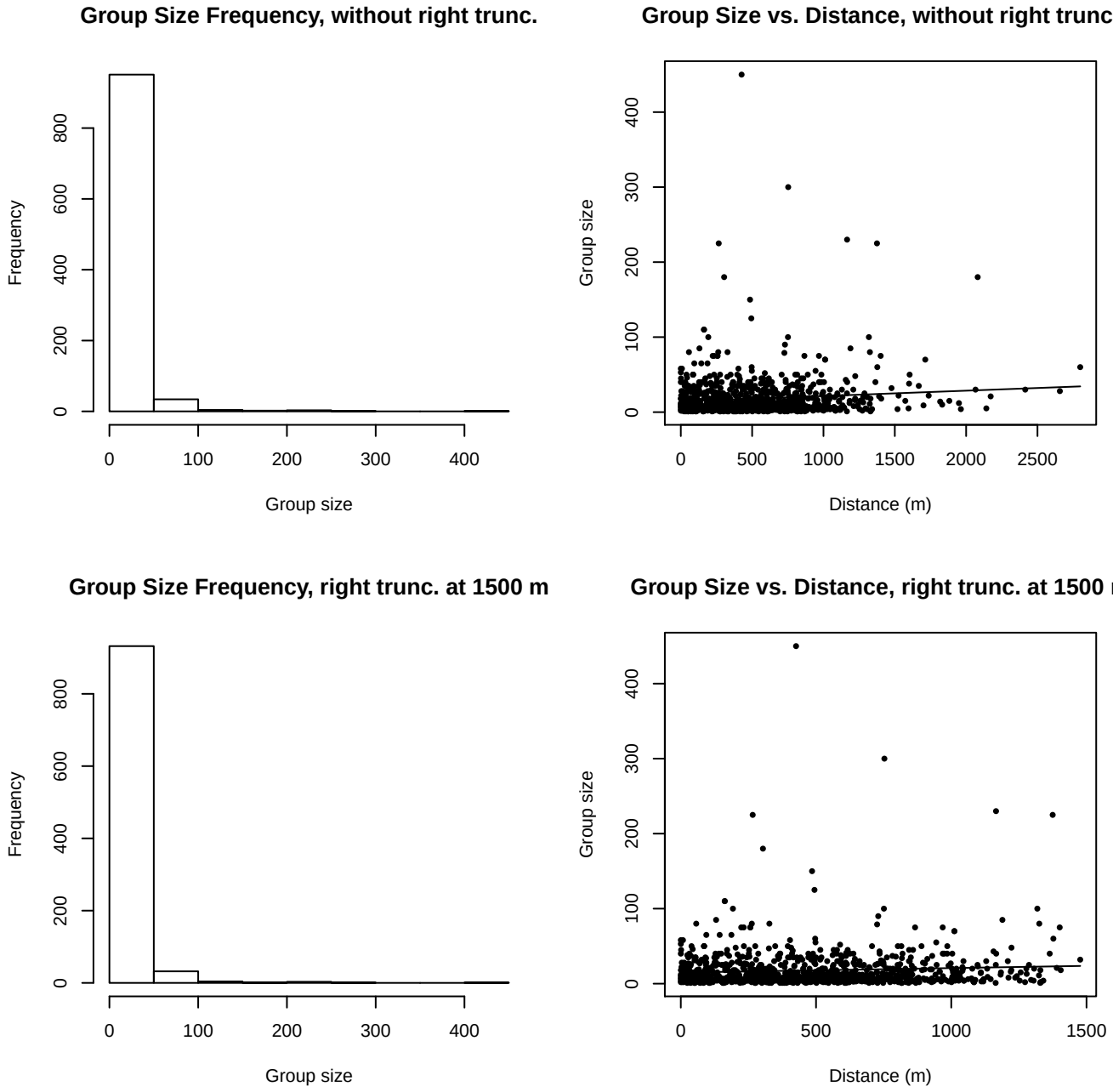

Figure 85: Histograms showing group size frequency and scatterplots showing the relationship between group size and perpendicular sighting distance, for all sightings (top row) and only those not right truncated (bottom row). In the scatterplot, the line is a simple linear regression.

UNCW Right Whale Surveys

Because this taxon was sighted too infrequently to fit a detection function to its sightings alone, we fit a detection function to the pooled sightings of several other species that we believed would exhibit similar detectability. These "proxy species" are listed below.

Reported By Observer	Common Name	n
Delphinus capensis	Long-beaked common dolphin	0
Delphinus delphis	Short-beaked common dolphin	26

Delphinus delphis/Lagenorhynchus acutus	Short-beaked common or Atlantic white-sided dolphin	0
Delphinus delphis/Stenella	Short-beaked common dolphin or Stenella spp.	0
Delphinus delphis/Stenella coeruleoalba	Short-beaked common or striped dolphin	0
Grampus griseus	Risso's dolphin	0
Grampus griseus/Tursiops truncatus	Risso's or Bottlenose dolphin	0
Lagenodelphis hosei	Fraser's dolphin	0
Lagenorhynchus acutus	Atlantic white-sided dolphin	0
Lagenorhynchus albirostris	White-beaked dolphin	0
Lagenorhynchus albirostris/Lagenorhynchus acutus	White-beaked or white-sided dolphin	0
Stenella	Unidentified Stenella	0
Stenella attenuata	Pantropical spotted dolphin	0
Stenella attenuata/frontalis	Pantropical or Atlantic spotted dolphin	0
Stenella clymene	Clymene dolphin	0
Stenella coeruleoalba	Striped dolphin	0
Stenella frontalis	Atlantic spotted dolphin	5
Stenella frontalis/Tursiops truncatus	Atlantic spotted or Bottlenose dolphin	0
Stenella longirostris	Spinner dolphin	0
Steno bredanensis	Rough-toothed dolphin	0
Steno bredanensis/Tursiops truncatus	Bottlenose or rough-toothed dolphin	0
Tursiops truncatus	Bottlenose dolphin	1855
Total		1886

Table 64: Proxy species used to fit detection functions for UNCW Right Whale Surveys. The number of sightings, n, is before truncation.

The sightings were right truncated at 837m. Due to a reduced frequency of sightings close to the trackline that plausibly resulted from the behavior of the observers and/or the configuration of the survey platform, the sightings were left truncted as well. Sightings closer than 111 m to the trackline were omitted from the analysis, and it was assumed that the the area closer to the trackline than this was not surveyed. This distance was estimated by inspecting histograms of perpendicular sighting distances. The vertical sighting angles were heaped at 10 degree increments, so the candidate detection functions were fitted using linear bins scaled accordingly.

Covariate	Description
beaufort	Beaufort sea state.
quality	Survey-specific index of the quality of observation conditions, utilizing relevant factors other than Beaufort sea state (see methods).
size	Estimated size (number of individuals) of the sighted group.

Table 65: Covariates tested in candidate "multi-covariate distance sampling" (MCDS) detection functions.

Key	Adjustment	Order	Covariates	Succeeded	Δ AIC	Mean ESHW (m)

hr			beaufort	Yes	0.00	162
hr			beaufort, size	Yes	1.38	162
hr				Yes	2.22	161
hr	poly	2		Yes	4.22	161
hr	poly	4		Yes	4.22	161
hn	cos	2		Yes	62.20	87
hn				Yes	77.91	103
hn	cos	3		Yes	78.05	117
hn	herm	4		Yes	79.70	103
hn			beaufort	No		
hn			quality	No		
hr			quality	No		
hn			size	No		
hr			size	No		
hn			beaufort, quality	No		
hr			beaufort, quality	No		
hn			beaufort, size	No		
hn			quality, size	No		
hr			quality, size	No		
hn			beaufort, quality, size	No		
hr			beaufort, quality, size	No		

Table 66: Candidate detection functions for UNCW Right Whale Surveys. The first one listed was selected for the density model.

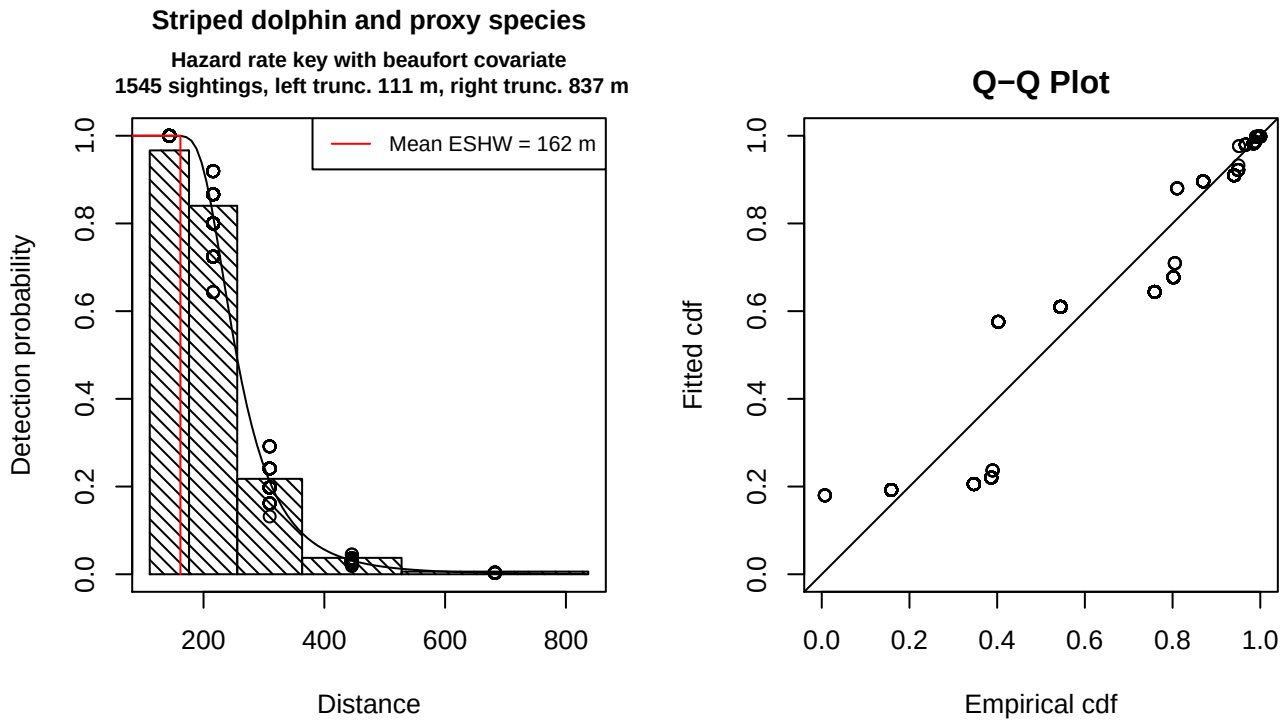

Figure 86: Detection function for UNCW Right Whale Surveys that was selected for the density model

Statistical output for this detection function:

```
Summary for ds object
Number of observations :  1545
Distance range         :  110.9381  -  837
AIC                    :  3681.827

Detection function:
 Hazard-rate key function

Detection function parameters
Scale Coefficients:
               estimate         se
(Intercept)  5.54196336 0.04042409
beaufort    -0.04042406 0.02041452

Shape parameters:
            estimate         se
(Intercept) 1.707667 0.04319172

                         Estimate           SE         CV
Average p               0.1927444   0.00547895 0.02842598
N in covered region 8015.7956844 292.42037285 0.03648052
```

Additional diagnostic plots:

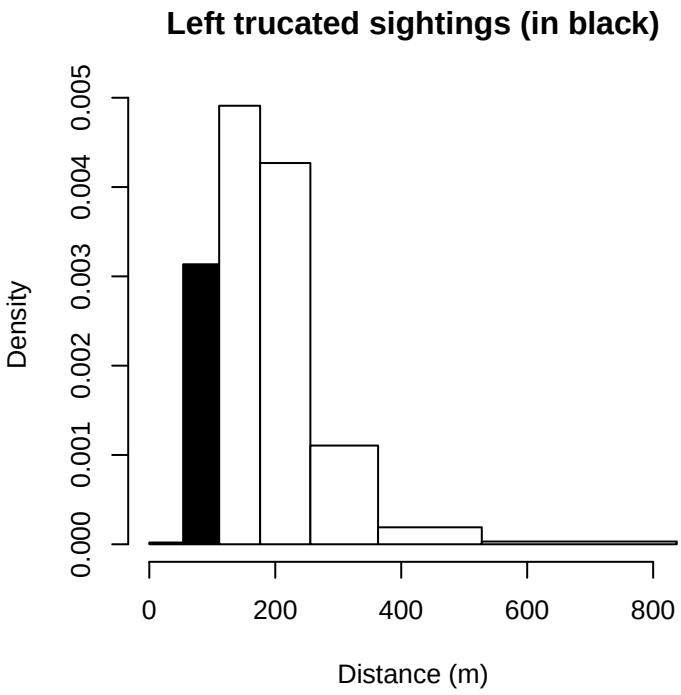

Figure 87: Density of sightings by perpendicular distance for UNCW Right Whale Surveys. Black bars on the left show sightings that were left truncated.

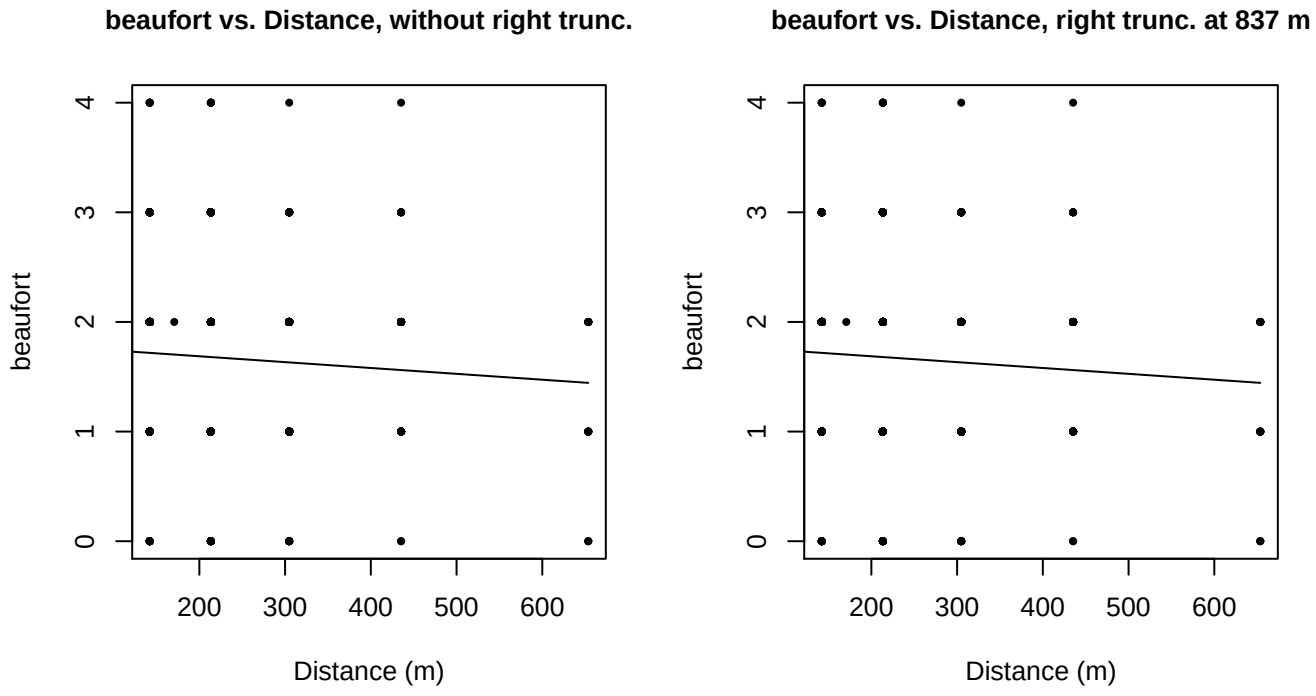

Figure 88: Scatterplots showing the relationship between Beaufort sea state and perpendicular sighting distance, for all sightings (left) and only those not right truncated (right). The line is a simple linear regression.

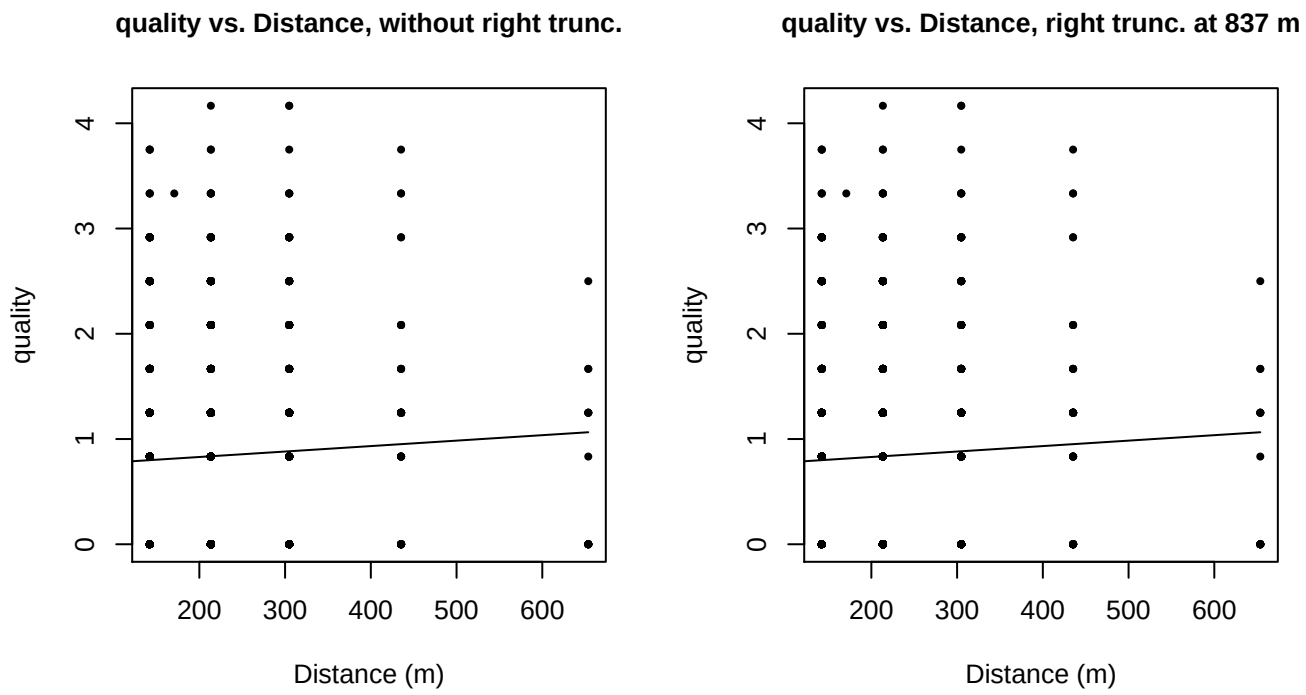

Figure 89: Scatterplots showing the relationship between the survey-specific index of the quality of observation conditions and perpendicular sighting distance, for all sightings (left) and only those not right truncated (right). Low values of the quality index correspond to better observation conditions. The line is a simple linear regression.

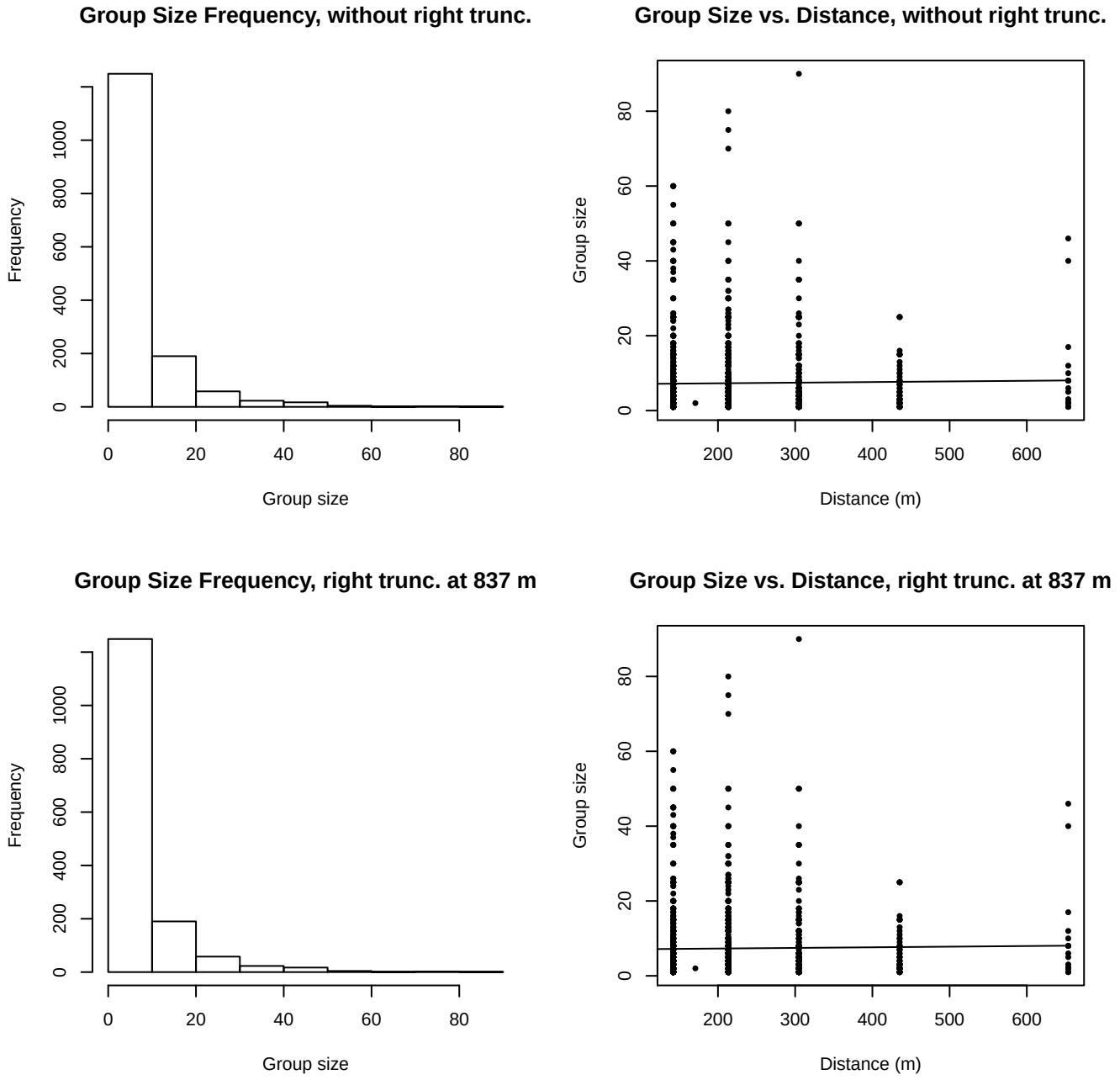

Figure 90: Histograms showing group size frequency and scatterplots showing the relationship between group size and perpendicular sighting distance, for all sightings (top row) and only those not right truncated (bottom row). In the scatterplot, the line is a simple linear regression.

UNCW Early Surveys

Because this taxon was sighted too infrequently to fit a detection function to its sightings alone, we fit a detection function to the pooled sightings of several other species that we believed would exhibit similar detectability. These "proxy species" are listed below.

Reported By Observer	Common Name	n
Delphinus capensis	Long-beaked common dolphin	0
Delphinus delphis	Short-beaked common dolphin	5

Delphinus delphis/Lagenorhynchus acutus	Short-beaked common or Atlantic white-sided dolphin	0
Delphinus delphis/Stenella	Short-beaked common dolphin or Stenella spp.	0
Delphinus delphis/Stenella coeruleoalba	Short-beaked common or striped dolphin	0
Grampus griseus	Risso's dolphin	0
Grampus griseus/Tursiops truncatus	Risso's or Bottlenose dolphin	0
Lagenodelphis hosei	Fraser's dolphin	0
Lagenorhynchus acutus	Atlantic white-sided dolphin	0
Lagenorhynchus albirostris	White-beaked dolphin	0
Lagenorhynchus albirostris/Lagenorhynchus acutus	White-beaked or white-sided dolphin	0
Stenella	Unidentified Stenella	0
Stenella attenuata	Pantropical spotted dolphin	0
Stenella attenuata/frontalis	Pantropical or Atlantic spotted dolphin	0
Stenella clymene	Clymene dolphin	0
Stenella coeruleoalba	Striped dolphin	0
Stenella frontalis	Atlantic spotted dolphin	1
Stenella frontalis/Tursiops truncatus	Atlantic spotted or Bottlenose dolphin	0
Stenella longirostris	Spinner dolphin	0
Steno bredanensis	Rough-toothed dolphin	0
Steno bredanensis/Tursiops truncatus	Bottlenose or rough-toothed dolphin	0
Tursiops truncatus	Bottlenose dolphin	350
Total		356

Table 67: Proxy species used to fit detection functions for UNCW Early Surveys. The number of sightings, n, is before truncation.

The sightings were right truncated at 332m. Due to a reduced frequency of sightings close to the trackline that plausibly resulted from the behavior of the observers and/or the configuration of the survey platform, the sightings were left truncted as well. Sightings closer than 13 m to the trackline were omitted from the analysis, and it was assumed that the the area closer to the trackline than this was not surveyed. This distance was estimated by inspecting histograms of perpendicular sighting distances.

Covariate	Description
beaufort	Beaufort sea state.
quality	Survey-specific index of the quality of observation conditions, utilizing relevant factors other than Beaufort sea state (see methods).
size	Estimated size (number of individuals) of the sighted group.

Table 68: Covariates tested in candidate "multi-covariate distance sampling" (MCDS) detection functions.

Key	Adjustment	Order	Covariates	Succeeded	Δ AIC	Mean ESHW (m)
hn			beaufort	Yes	0.00	158

hn				Yes	2.97	157
hn	herm	4		Yes	4.33	164
hn	cos	2		Yes	4.73	164
hn			quality	Yes	4.80	157
hr	poly	4		Yes	4.86	167
hn	cos	3		Yes	4.95	159
hr	poly	2		Yes	5.37	165
hr			beaufort	Yes	5.57	187
hr				Yes	8.04	173
hr			quality	Yes	9.35	173
hn			size	No		
hr			size	No		
hn			beaufort, quality	No		
hr			beaufort, quality	No		
hn			beaufort, size	No		
hr			beaufort, size	No		
hn			quality, size	No		
hr			quality, size	No		
hn			beaufort, quality, size	No		
hr			beaufort, quality, size	No		

Table 69: Candidate detection functions for UNCW Early Surveys. The first one listed was selected for the density model.

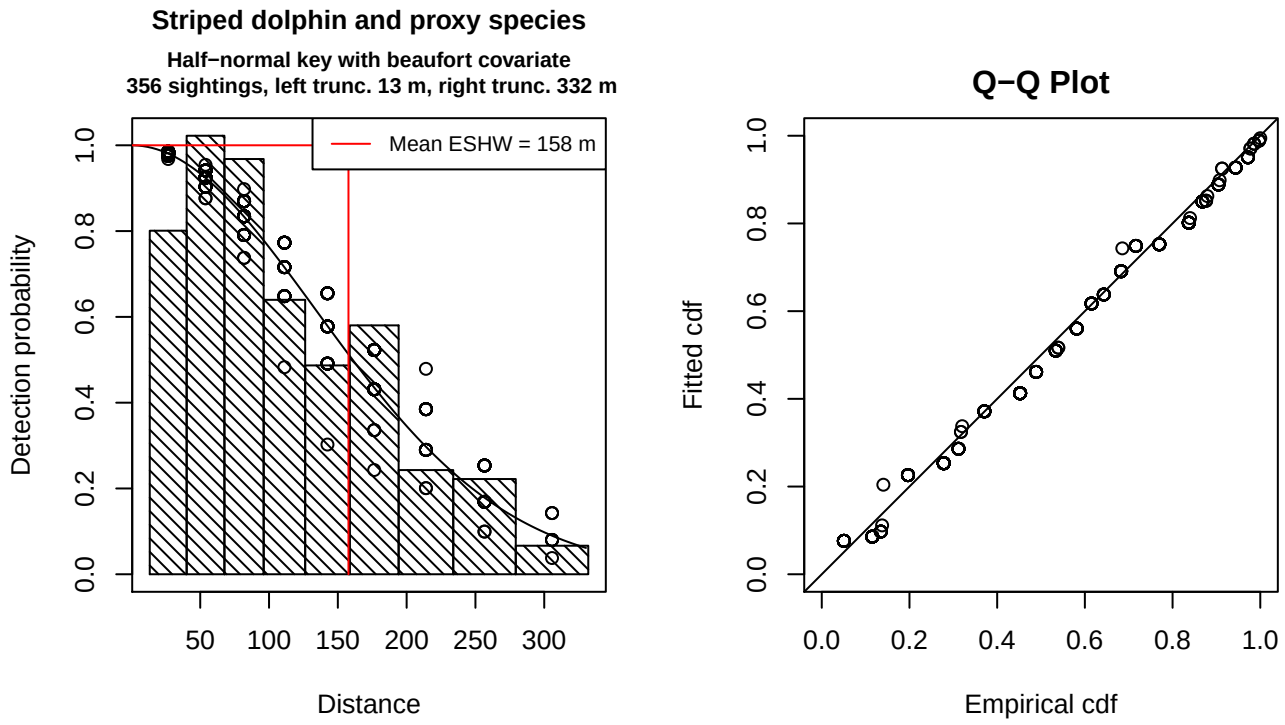

Figure 91: Detection function for UNCW Early Surveys that was selected for the density model

Statistical output for this detection function:

```
Summary for ds object
Number of observations :  356
Distance range         :  13.30786  -  332
AIC                    :  1491.715

Detection function:
 Half-normal key function

Detection function parameters
Scale Coefficients:
             estimate         se
(Intercept)  5.1726896 0.13721406
beaufort    -0.1299227 0.06484242

                      Estimate          SE         CV
Average p             0.4700677  0.02238003 0.04761023
N in covered region 757.3377587 46.49751992 0.06139601
```

Additional diagnostic plots:

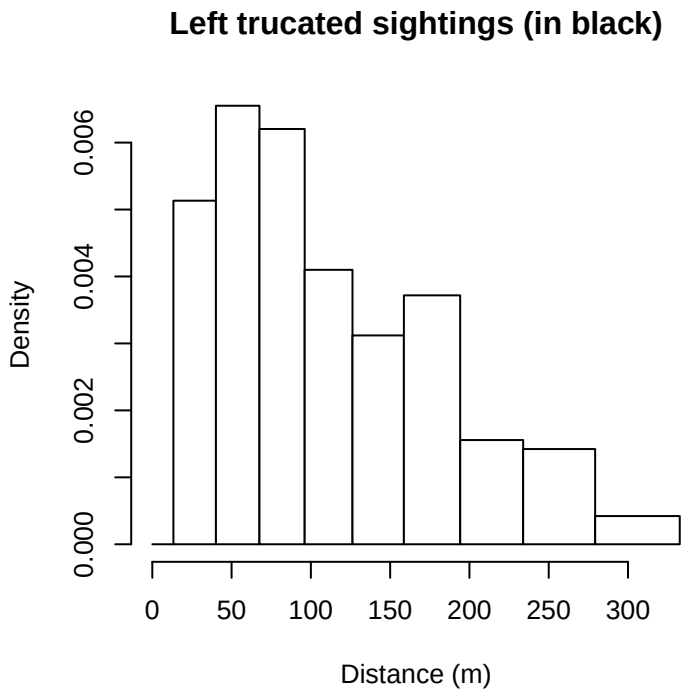

Figure 92: Density of sightings by perpendicular distance for UNCW Early Surveys. Black bars on the left show sightings that were left truncated.

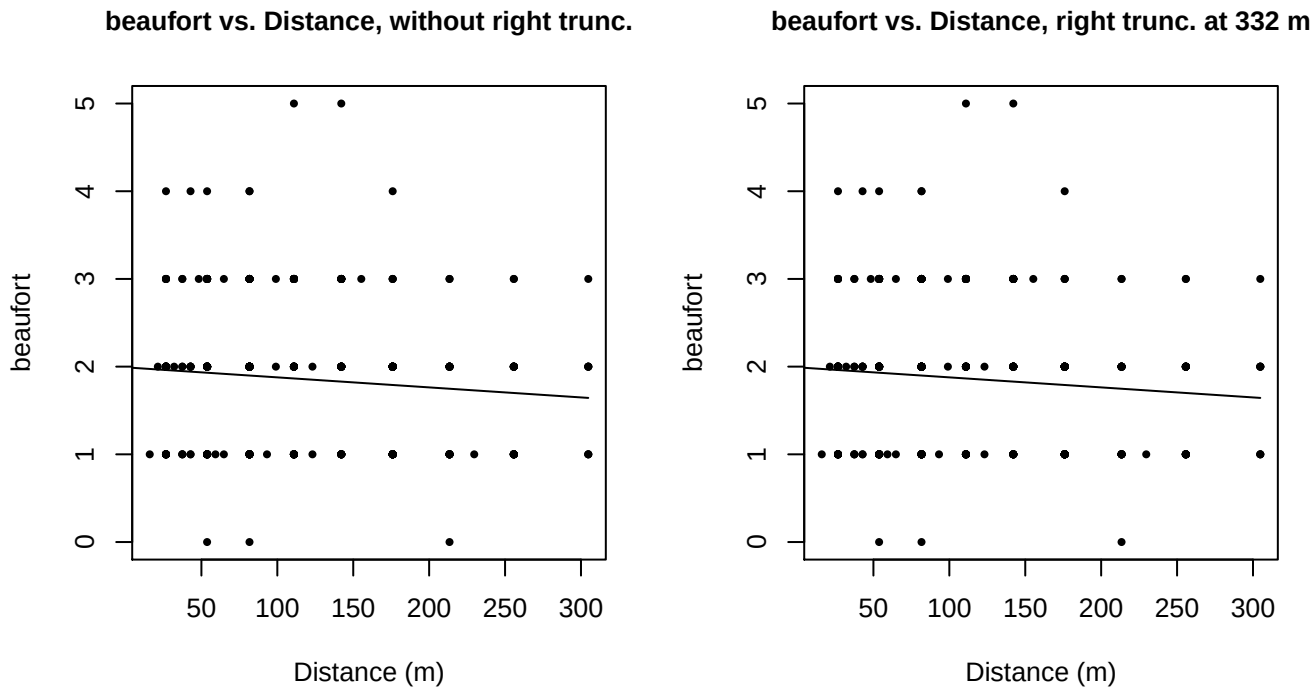

Figure 93: Scatterplots showing the relationship between Beaufort sea state and perpendicular sighting distance, for all sightings (left) and only those not right truncated (right). The line is a simple linear regression.

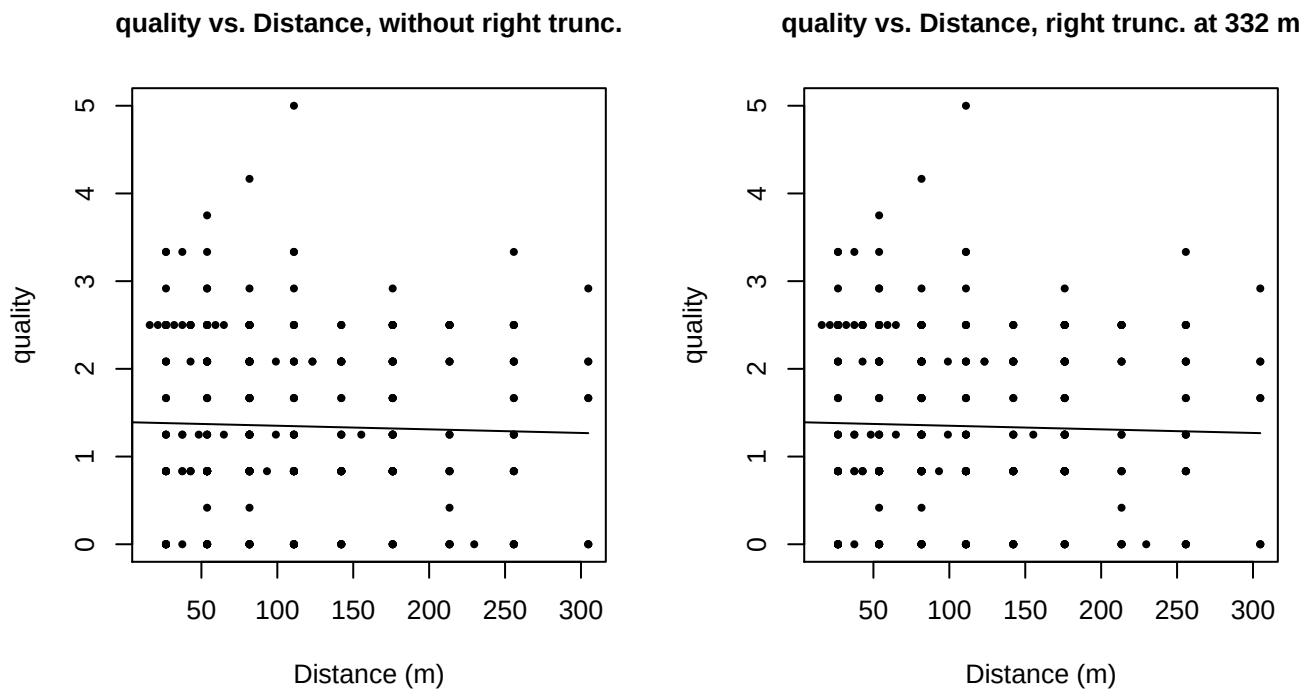

Figure 94: Scatterplots showing the relationship between the survey-specific index of the quality of observation conditions and perpendicular sighting distance, for all sightings (left) and only those not right truncated (right). Low values of the quality index correspond to better observation conditions. The line is a simple linear regression.

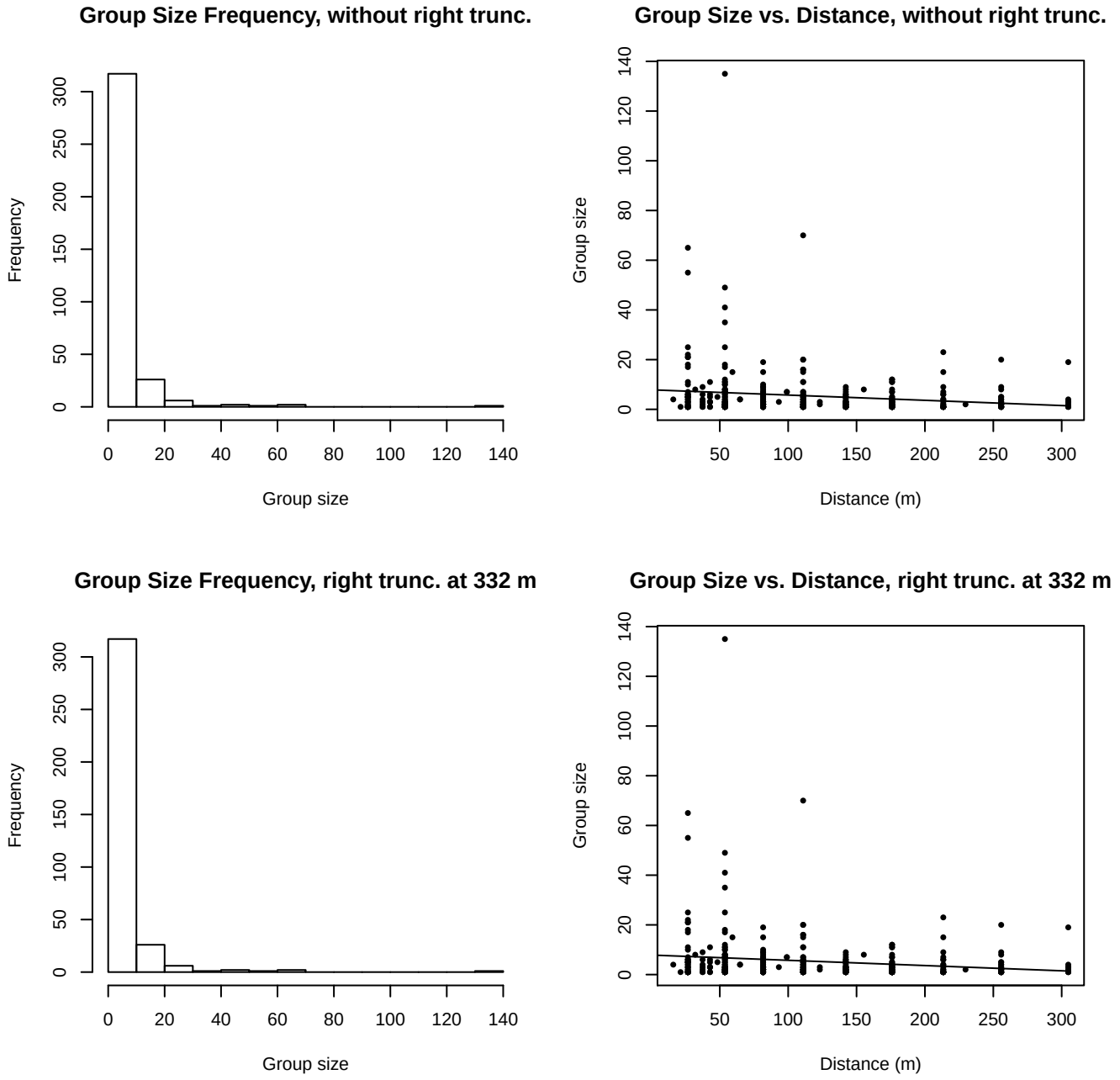

Figure 95: Histograms showing group size frequency and scatterplots showing the relationship between group size and perpendicular sighting distance, for all sightings (top row) and only those not right truncated (bottom row). In the scatterplot, the line is a simple linear regression.

Virginia Aquarium Surveys

Because this taxon was sighted too infrequently to fit a detection function to its sightings alone, we fit a detection function to the pooled sightings of several other species that we believed would exhibit similar detectability. These "proxy species" are listed below.

Reported By Observer	Common Name	n
Delphinus capensis	Long-beaked common dolphin	0
Delphinus delphis	Short-beaked common dolphin	16

Delphinus delphis/Lagenorhynchus acutus	Short-beaked common or Atlantic white-sided dolphin	0
Delphinus delphis/Stenella	Short-beaked common dolphin or Stenella spp.	0
Delphinus delphis/Stenella coeruleoalba	Short-beaked common or striped dolphin	0
Grampus griseus	Risso's dolphin	0
Grampus griseus/Tursiops truncatus	Risso's or Bottlenose dolphin	0
Lagenodelphis hosei	Fraser's dolphin	0
Lagenorhynchus acutus	Atlantic white-sided dolphin	0
Lagenorhynchus albirostris	White-beaked dolphin	0
Lagenorhynchus albirostris/Lagenorhynchus acutus	White-beaked or white-sided dolphin	0
Stenella	Unidentified Stenella	0
Stenella attenuata	Pantropical spotted dolphin	0
Stenella attenuata/frontalis	Pantropical or Atlantic spotted dolphin	0
Stenella clymene	Clymene dolphin	0
Stenella coeruleoalba	Striped dolphin	0
Stenella frontalis	Atlantic spotted dolphin	0
Stenella frontalis/Tursiops truncatus	Atlantic spotted or Bottlenose dolphin	0
Stenella longirostris	Spinner dolphin	0
Steno bredanensis	Rough-toothed dolphin	0
Steno bredanensis/Tursiops truncatus	Bottlenose or rough-toothed dolphin	0
Tursiops truncatus	Bottlenose dolphin	67
Total		83

Table 70: Proxy species used to fit detection functions for Virginia Aquarium Surveys. The number of sightings, n, is before truncation.

The sightings were right truncated at 1500m.

Covariate	Description
beaufort	Beaufort sea state.
quality	Survey-specific index of the quality of observation conditions, utilizing relevant factors other than Beaufort sea state (see methods).
size	Estimated size (number of individuals) of the sighted group.

Table 71: Covariates tested in candidate "multi-covariate distance sampling" (MCDS) detection functions.

Key	Adjustment	Order	Covariates	Succeeded	Δ AIC	Mean ESHW (m)
hr			quality, size	Yes	0.00	413
hr			quality	Yes	2.75	381
hr			size	Yes	2.86	408
hr				Yes	5.08	379

hr	poly	4		Yes	7.07	377
hr	poly	2		Yes	7.08	379
hn	cos	2		Yes	8.57	438
hn			quality, size	Yes	10.48	567
hn	cos	3		Yes	11.42	404
hn			quality	Yes	11.94	549
hn			beaufort, quality, size	Yes	12.28	569
hn			beaufort, quality	Yes	13.90	549
hn			beaufort, size	Yes	17.69	567
hn			beaufort	Yes	18.02	563
hn				Yes	18.13	562
hn			size	Yes	18.73	562
hn	herm	4		No		
hr			beaufort	No		
hr			beaufort, quality	No		
hr			beaufort, size	No		
hr			beaufort, quality, size	No		

Table 72: Candidate detection functions for Virginia Aquarium Surveys. The first one listed was selected for the density model.

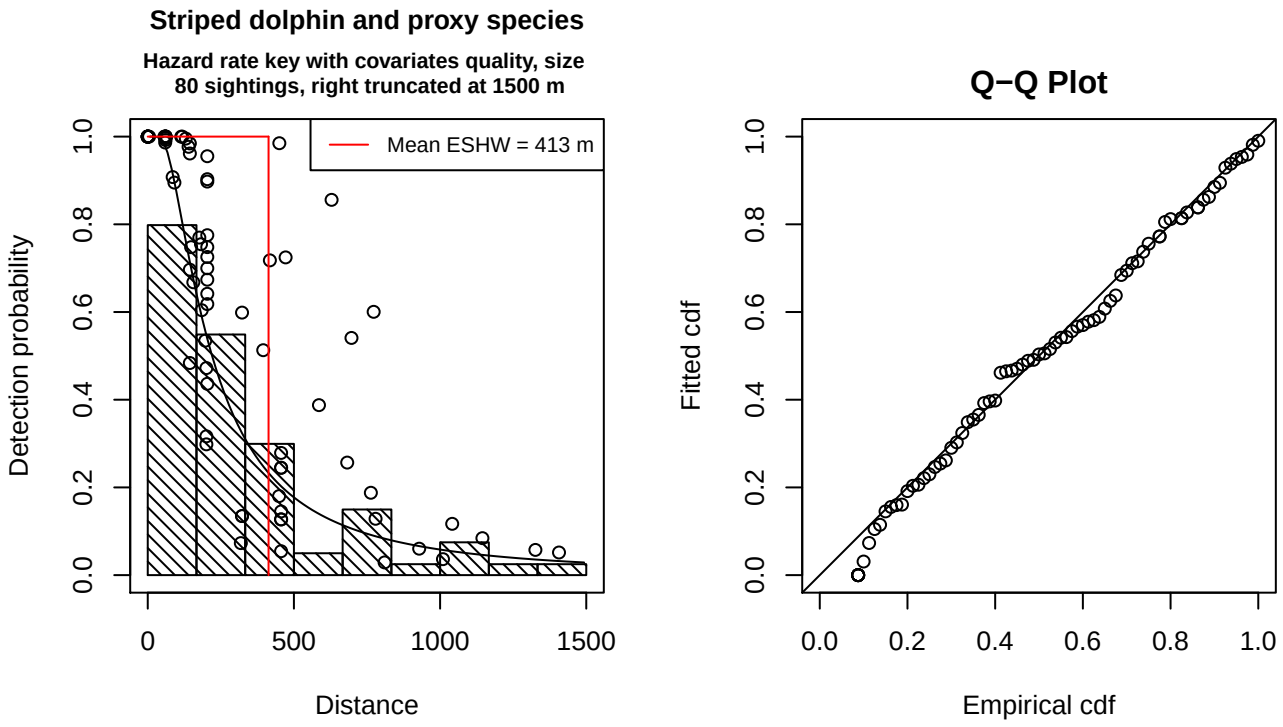

Figure 96: Detection function for Virginia Aquarium Surveys that was selected for the density model

Statistical output for this detection function:

```
Summary for ds object
Number of observations :  80
Distance range         :  0  -  1500
AIC                    :  1076.058

Detection function:
 Hazard-rate key function

Detection function parameters
Scale Coefficients:
              estimate        se
(Intercept)  5.6518239 0.3734155
quality     -0.3758731 0.1494911
size         0.3255962 0.2331376

Shape parameters:
             estimate        se
(Intercept) 0.6332354 0.1825191

                       Estimate          SE        CV
Average p             0.2217122  0.03813113 0.1719848
N in covered region 360.8280660 72.14728675 0.1999492
```

Additional diagnostic plots:

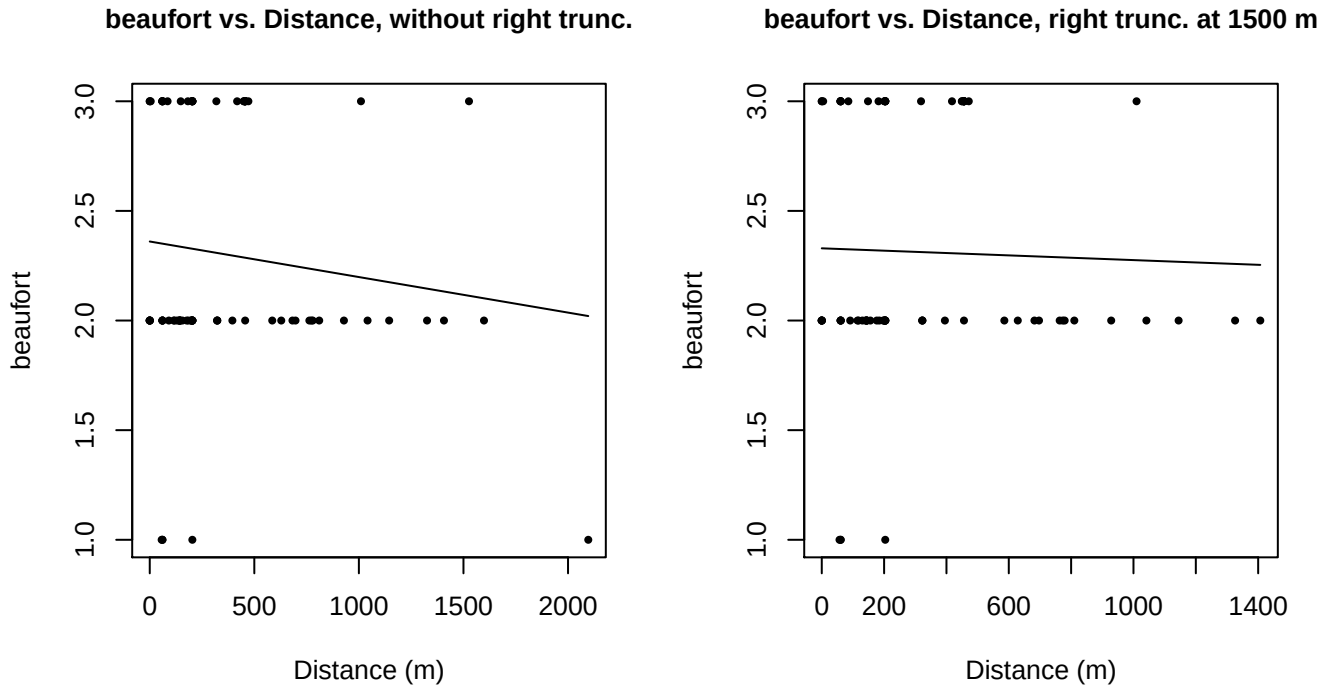

Figure 97: Scatterplots showing the relationship between Beaufort sea state and perpendicular sighting distance, for all sightings (left) and only those not right truncated (right). The line is a simple linear regression.

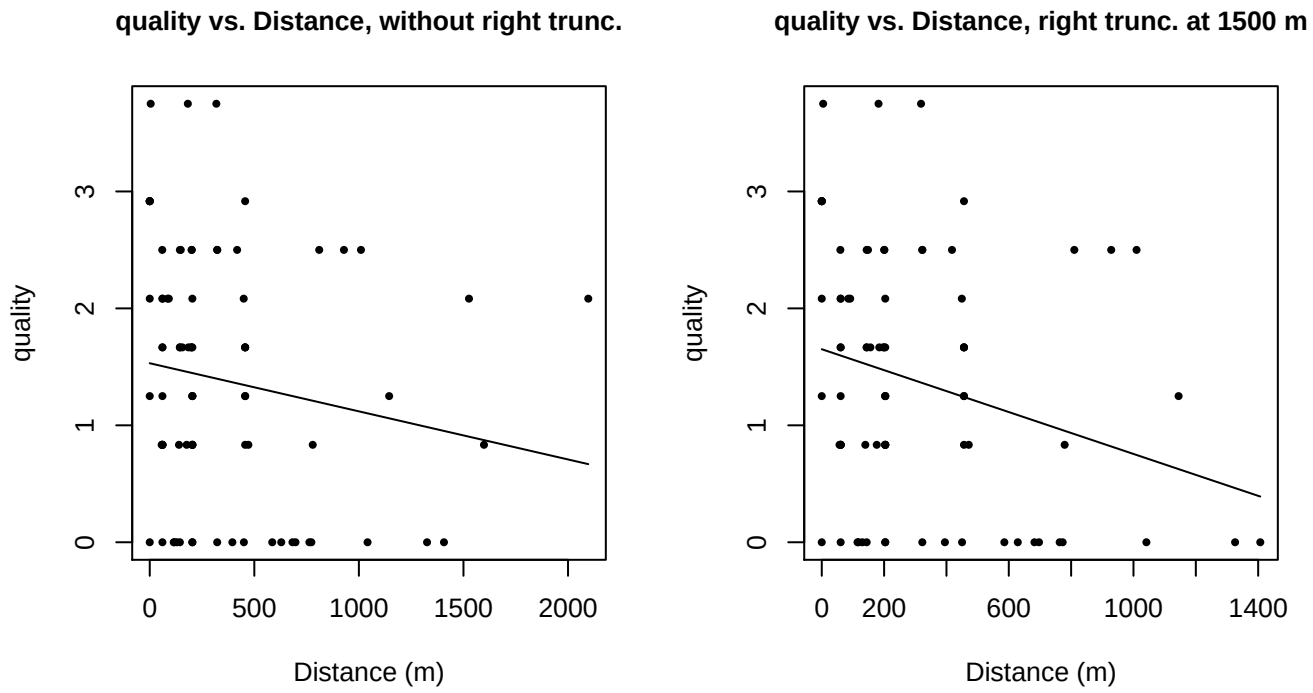

Figure 98: Scatterplots showing the relationship between the survey-specific index of the quality of observation conditions and perpendicular sighting distance, for all sightings (left) and only those not right truncated (right). Low values of the quality index correspond to better observation conditions. The line is a simple linear regression.

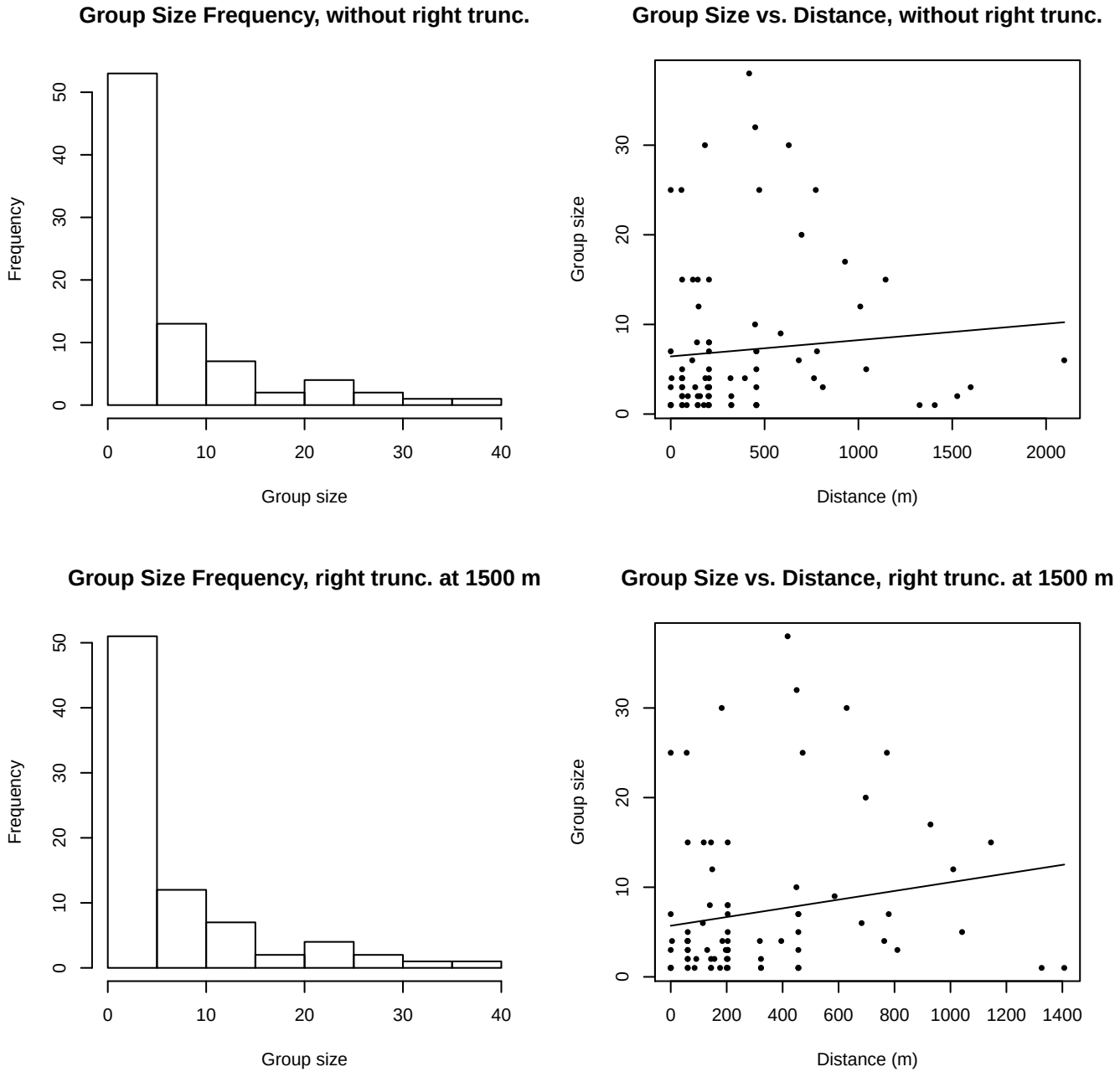

Figure 99: Histograms showing group size frequency and scatterplots showing the relationship between group size and perpendicular sighting distance, for all sightings (top row) and only those not right truncated (bottom row). In the scatterplot, the line is a simple linear regression.

NARWSS Grummans

Because this taxon was sighted too infrequently to fit a detection function to its sightings alone, we fit a detection function to the pooled sightings of several other species that we believed would exhibit similar detectability. These "proxy species" are listed below.

Reported By Observer	Common Name	n
Delphinus capensis	Long-beaked common dolphin	0
Delphinus delphis	Short-beaked common dolphin	42

Delphinus delphis/Lagenorhynchus acutus	Short-beaked common or Atlantic white-sided dolphin	0
Delphinus delphis/Stenella	Short-beaked common dolphin or Stenella spp.	0
Delphinus delphis/Stenella coeruleoalba	Short-beaked common or striped dolphin	0
Grampus griseus	Risso's dolphin	0
Grampus griseus/Tursiops truncatus	Risso's or Bottlenose dolphin	0
Lagenodelphis hosei	Fraser's dolphin	0
Lagenorhynchus acutus	Atlantic white-sided dolphin	288
Lagenorhynchus albirostris	White-beaked dolphin	3
Lagenorhynchus albirostris/Lagenorhynchus acutus	White-beaked or white-sided dolphin	0
Stenella	Unidentified Stenella	0
Stenella attenuata	Pantropical spotted dolphin	0
Stenella attenuata/frontalis	Pantropical or Atlantic spotted dolphin	0
Stenella clymene	Clymene dolphin	0
Stenella coeruleoalba	Striped dolphin	1
Stenella frontalis	Atlantic spotted dolphin	0
Stenella frontalis/Tursiops truncatus	Atlantic spotted or Bottlenose dolphin	0
Stenella longirostris	Spinner dolphin	0
Steno bredanensis	Rough-toothed dolphin	0
Steno bredanensis/Tursiops truncatus	Bottlenose or rough-toothed dolphin	0
Tursiops truncatus	Bottlenose dolphin	6
Total		340

Table 73: Proxy species used to fit detection functions for NARWSS Grummans. The number of sightings, n, is before truncation.

The sightings were right truncated at 800m. Due to a reduced frequency of sightings close to the trackline that plausibly resulted from the behavior of the observers and/or the configuration of the survey platform, the sightings were left truncted as well. Sightings closer than 107 m to the trackline were omitted from the analysis, and it was assumed that the the area closer to the trackline than this was not surveyed. This distance was estimated by inspecting histograms of perpendicular sighting distances.

Covariate	Description
beaufort	Beaufort sea state.
quality	Survey-specific index of the quality of observation conditions, utilizing relevant factors other than Beaufort sea state (see methods).
size	Estimated size (number of individuals) of the sighted group.

Table 74: Covariates tested in candidate "multi-covariate distance sampling" (MCDS) detection functions.

Key	Adjustment	Order	Covariates	Succeeded	Δ AIC	Mean ESHW (m)
hr			quality, size	Yes	0.00	235

hr			size	Yes	5.95	231
hr			beaufort, size	Yes	7.81	233
hr			quality	Yes	11.76	213
hn			size	Yes	14.26	231
hn			quality, size	Yes	14.51	233
hn			beaufort, size	Yes	16.23	231
hr				Yes	20.06	203
hr	poly	4		Yes	21.78	200
hr			beaufort	Yes	22.05	204
hr	poly	2		Yes	22.06	203
hn				Yes	33.54	223
hn			quality	Yes	33.86	223
hn	cos	3		Yes	34.13	179
hn	herm	4		Yes	35.13	222
hn	cos	2		No		
hn			beaufort	No		
hn			beaufort, quality	No		
hr			beaufort, quality	No		
hn			beaufort, quality, size	No		
hr			beaufort, quality, size	No		

Table 75: Candidate detection functions for NARWSS Grummans. The first one listed was selected for the density model.

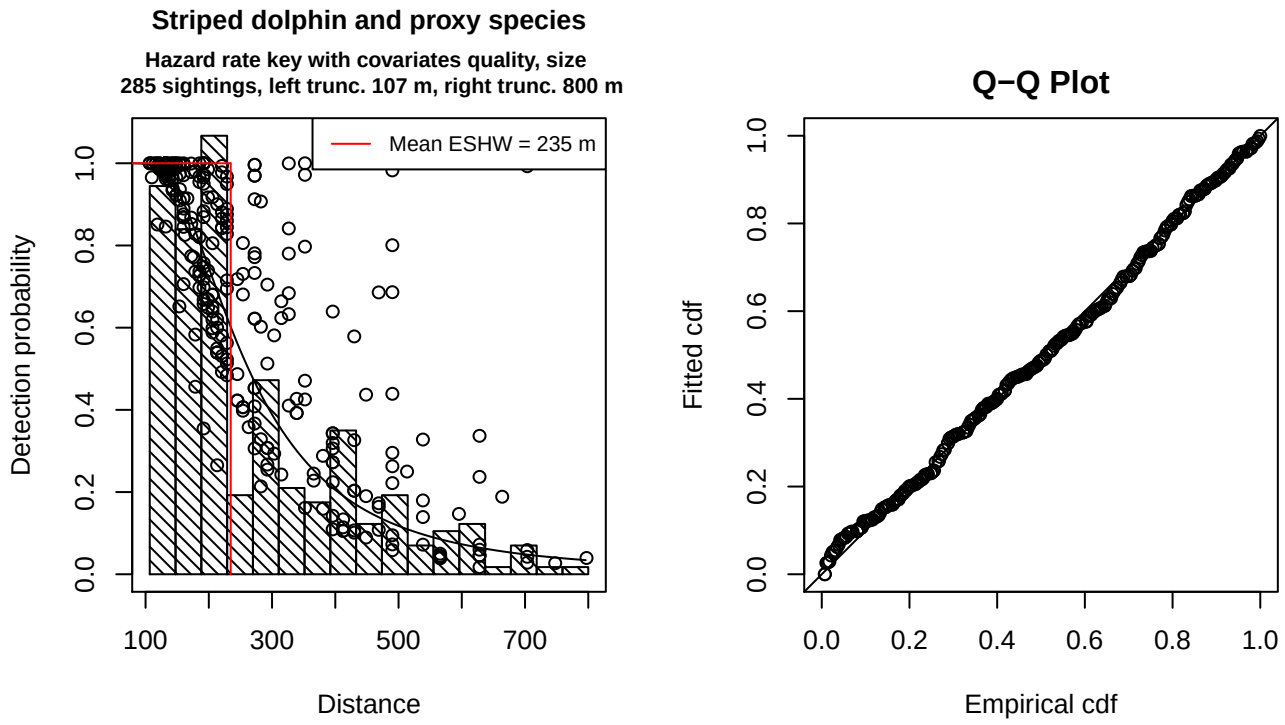

Figure 100: Detection function for NARWSS Grummans that was selected for the density model

Statistical output for this detection function:

```
Summary for ds object
Number of observations :  285
Distance range         :  106.5979  -  800
AIC                    :  3450.827

Detection function:
 Hazard-rate key function

Detection function parameters
Scale Coefficients:
             estimate         se
(Intercept)  5.5620259 0.12398130
quality     -0.2408179 0.09290192
size         0.2953779 0.09400126

Shape parameters:
            estimate        se
(Intercept) 1.119906 0.1056045

                         Estimate           SE        CV
Average p               0.2541682   0.03062592 0.1204947
N in covered region 1121.3045461 147.37019002 0.1314274
```

Additional diagnostic plots:

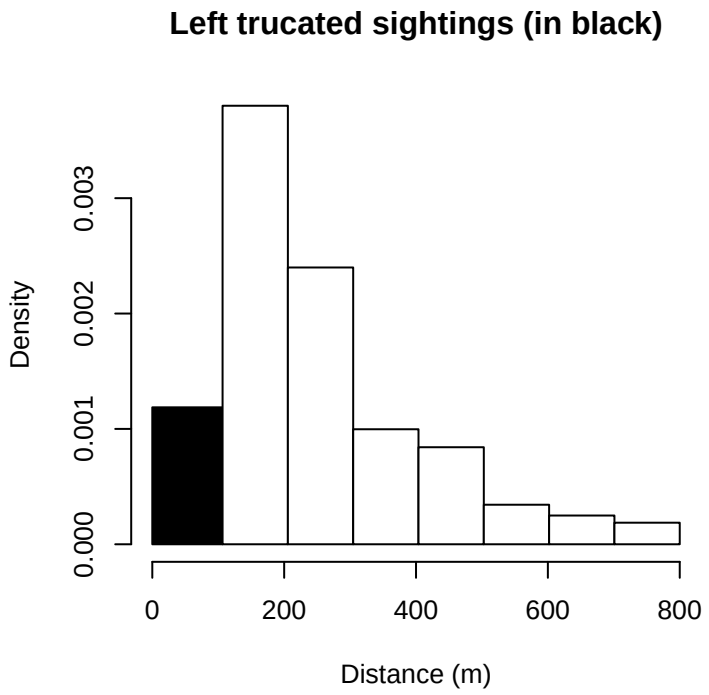

Figure 101: Density of sightings by perpendicular distance for NARWSS Grummans. Black bars on the left show sightings that were left truncated.

Figure 102: Scatterplots showing the relationship between Beaufort sea state and perpendicular sighting distance, for all sightings (left) and only those not right truncated (right). The line is a simple linear regression.

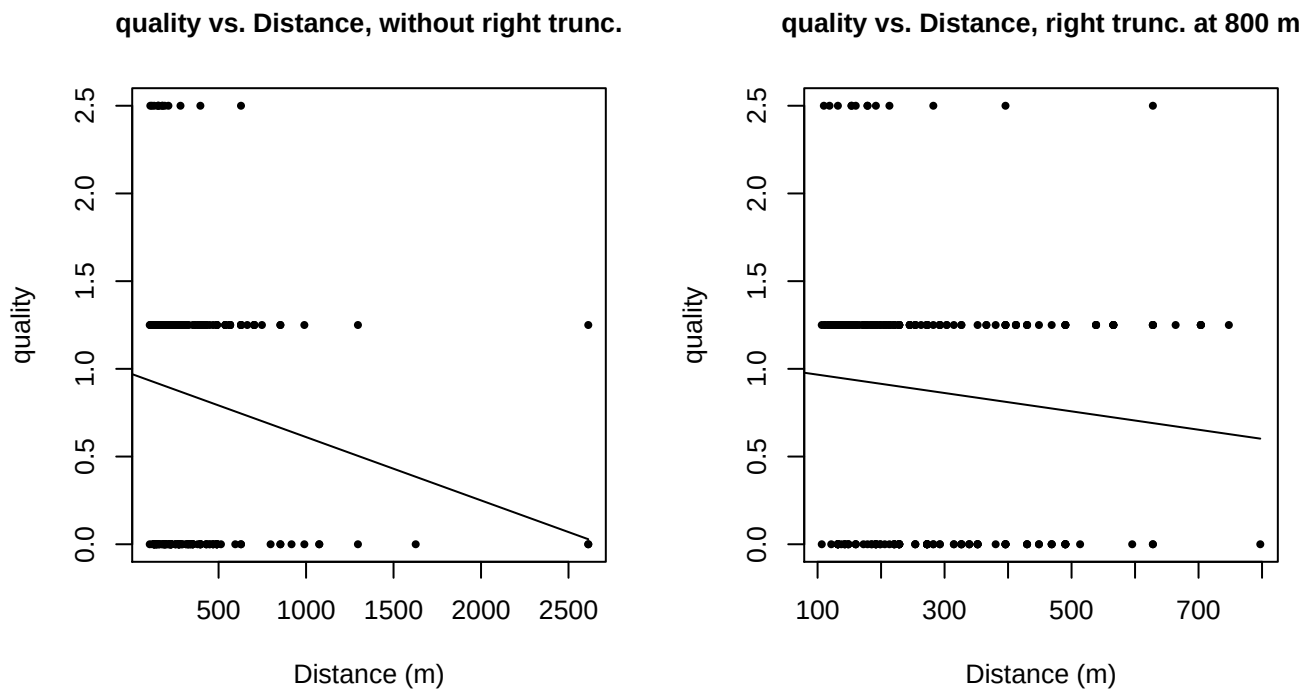

Figure 103: Scatterplots showing the relationship between the survey-specific index of the quality of observation conditions and perpendicular sighting distance, for all sightings (left) and only those not right truncated (right). Low values of the quality index correspond to better observation conditions. The line is a simple linear regression.

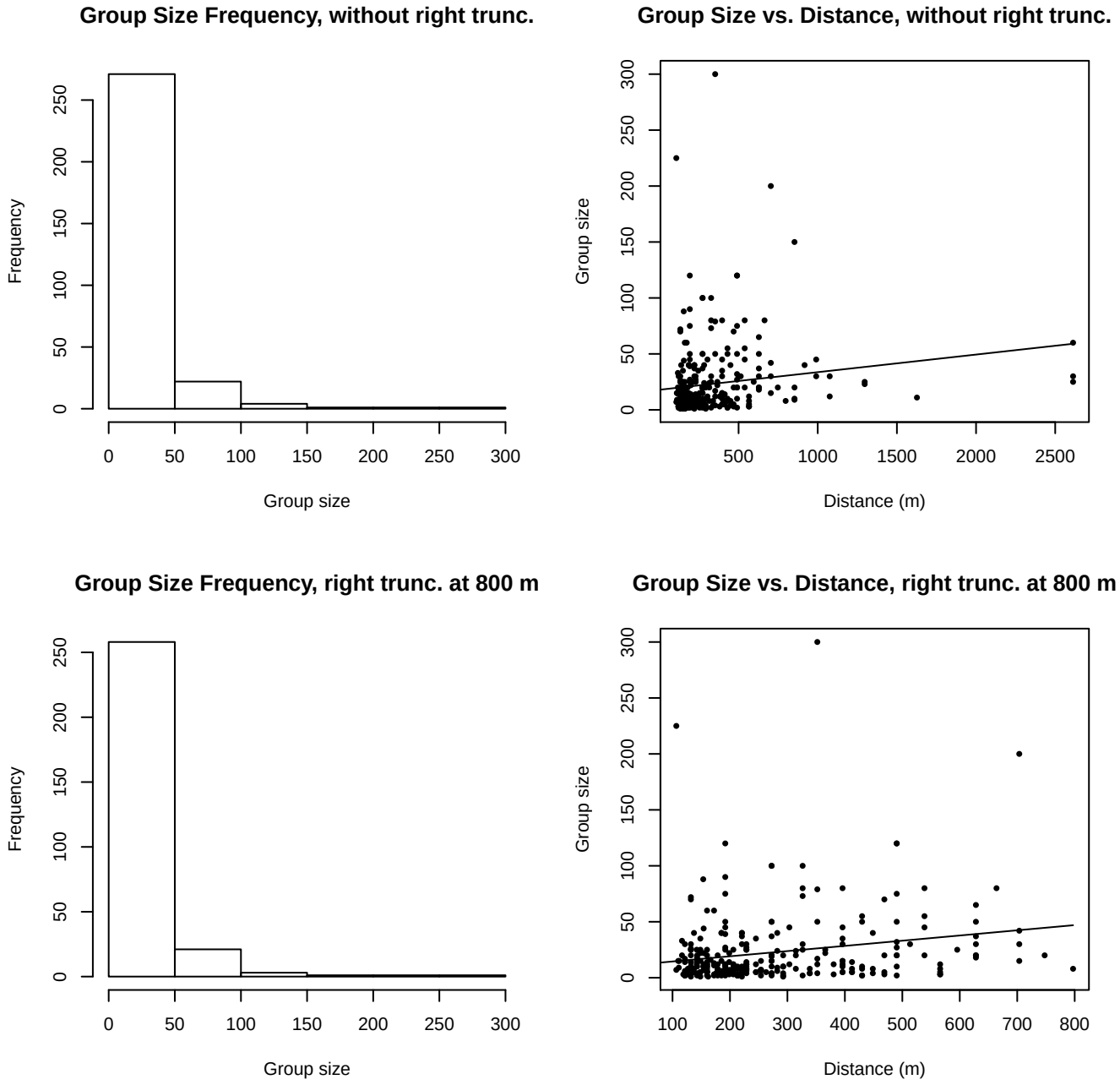

Figure 104: Histograms showing group size frequency and scatterplots showing the relationship between group size and perpendicular sighting distance, for all sightings (top row) and only those not right truncated (bottom row). In the scatterplot, the line is a simple linear regression.

NARWSS Twin Otters

Because this taxon was sighted too infrequently to fit a detection function to its sightings alone, we fit a detection function to the pooled sightings of several other species that we believed would exhibit similar detectability. These "proxy species" are listed below.

Reported By Observer	Common Name	n
Delphinus capensis	Long-beaked common dolphin	0
Delphinus delphis	Short-beaked common dolphin	539

Delphinus delphis/Lagenorhynchus acutus	Short-beaked common or Atlantic white-sided dolphin	0
Delphinus delphis/Stenella	Short-beaked common dolphin or Stenella spp.	0
Delphinus delphis/Stenella coeruleoalba	Short-beaked common or striped dolphin	0
Grampus griseus	Risso's dolphin	86
Grampus griseus/Tursiops truncatus	Risso's or Bottlenose dolphin	0
Lagenodelphis hosei	Fraser's dolphin	0
Lagenorhynchus acutus	Atlantic white-sided dolphin	1732
Lagenorhynchus albirostris	White-beaked dolphin	4
Lagenorhynchus albirostris/Lagenorhynchus acutus	White-beaked or white-sided dolphin	0
Stenella	Unidentified Stenella	1
Stenella attenuata	Pantropical spotted dolphin	0
Stenella attenuata/frontalis	Pantropical or Atlantic spotted dolphin	0
Stenella clymene	Clymene dolphin	0
Stenella coeruleoalba	Striped dolphin	4
Stenella frontalis	Atlantic spotted dolphin	0
Stenella frontalis/Tursiops truncatus	Atlantic spotted or Bottlenose dolphin	0
Stenella longirostris	Spinner dolphin	0
Steno bredanensis	Rough-toothed dolphin	0
Steno bredanensis/Tursiops truncatus	Bottlenose or rough-toothed dolphin	0
Tursiops truncatus	Bottlenose dolphin	39
Total		2405

Table 76: Proxy species used to fit detection functions for NARWSS Twin Otters. The number of sightings, n, is before truncation.

The sightings were right truncated at 2500m. Due to a reduced frequency of sightings close to the trackline that plausibly resulted from the behavior of the observers and/or the configuration of the survey platform, the sightings were left truncted as well. Sightings closer than 160 m to the trackline were omitted from the analysis, and it was assumed that the the area closer to the trackline than this was not surveyed. This distance was estimated by inspecting histograms of perpendicular sighting distances. The vertical sighting angles were heaped at 10 degree increments up to 80 degrees and 1 degree increments thereafter, so the candidate detection functions were fitted using linear bins scaled accordingly.

Covariate	Description
beaufort	Beaufort sea state.
quality	Survey-specific index of the quality of observation conditions, utilizing relevant factors other than Beaufort sea state (see methods).
size	Estimated size (number of individuals) of the sighted group.

Table 77: Covariates tested in candidate "multi-covariate distance sampling" (MCDS) detection functions.

Key	Adjustment	Order	Covariates	Succeeded	Δ AIC	Mean ESHW (m)

hr			beaufort, size	Yes	0.00	470
hr			size	Yes	5.29	463
hr			quality, size	Yes	7.11	463
hr	poly	2		Yes	9.16	430
hr	poly	4		Yes	10.71	442
hr			beaufort	Yes	17.46	464
hr				Yes	22.55	458
hr			quality	Yes	24.49	458
hn	cos	2		Yes	33.82	434
hn	cos	3		Yes	54.89	361
hn			beaufort, size	Yes	162.73	517
hn			size	Yes	162.85	518
hn			quality, size	Yes	164.00	518
hn			beaufort, quality, size	Yes	164.45	517
hn			beaufort	Yes	185.34	516
hn				Yes	186.28	516
hn	herm	4		Yes	186.91	516
hn			beaufort, quality	Yes	187.34	516
hn			quality	Yes	188.03	516
hr			beaufort, quality	No		
hr			beaufort, quality, size	No		

Table 78: Candidate detection functions for NARWSS Twin Otters. The first one listed was selected for the density model.

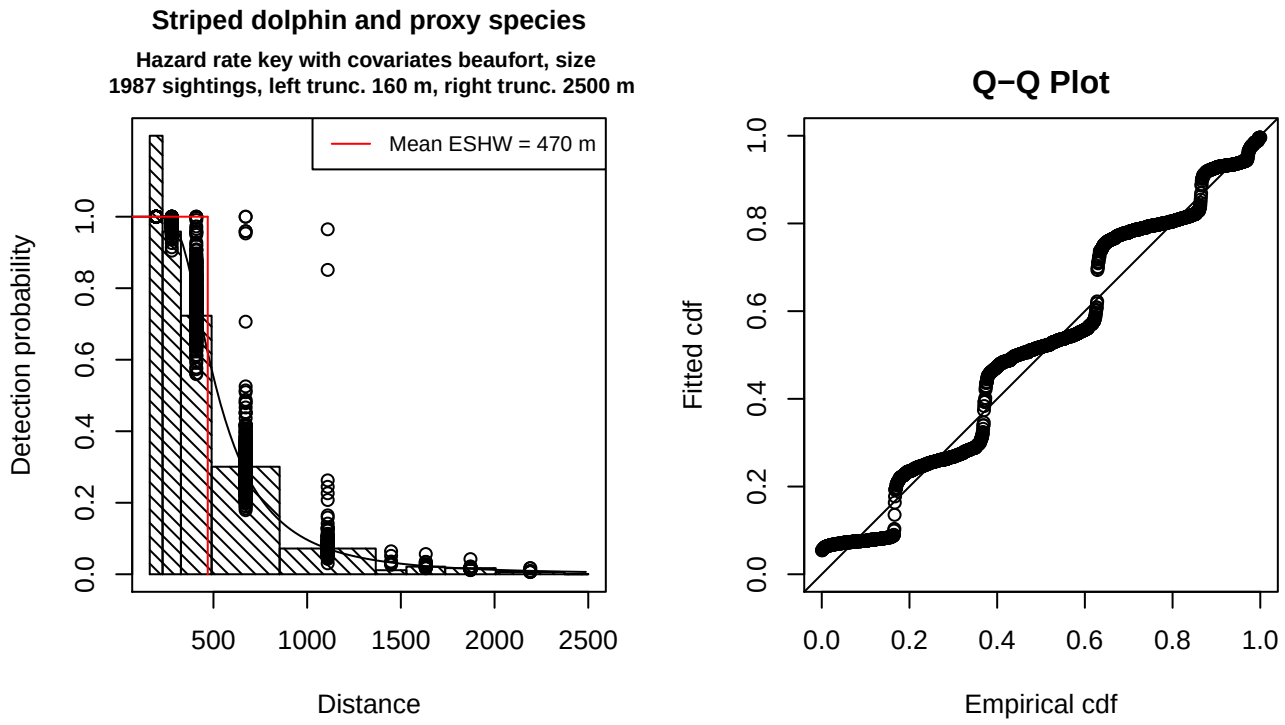

Figure 105: Detection function for NARWSS Twin Otters that was selected for the density model

Statistical output for this detection function:

```
Summary for ds object
Number of observations :  1987
Distance range         :  160.0674  -  2500
AIC                    :  6745.856

Detection function:
 Hazard-rate key function

Detection function parameters
Scale Coefficients:
               estimate         se
(Intercept)  6.26395198 0.06468196
beaufort    -0.07274292 0.02643651
size         0.08974254 0.02445737

Shape parameters:
            estimate        se
(Intercept) 1.110483 0.0356417

                        Estimate           SE         CV
Average p           1.845364e-01 5.774489e-03 0.03129187
N in covered region 1.076752e+04 4.016208e+02 0.03729928
```

Additional diagnostic plots:

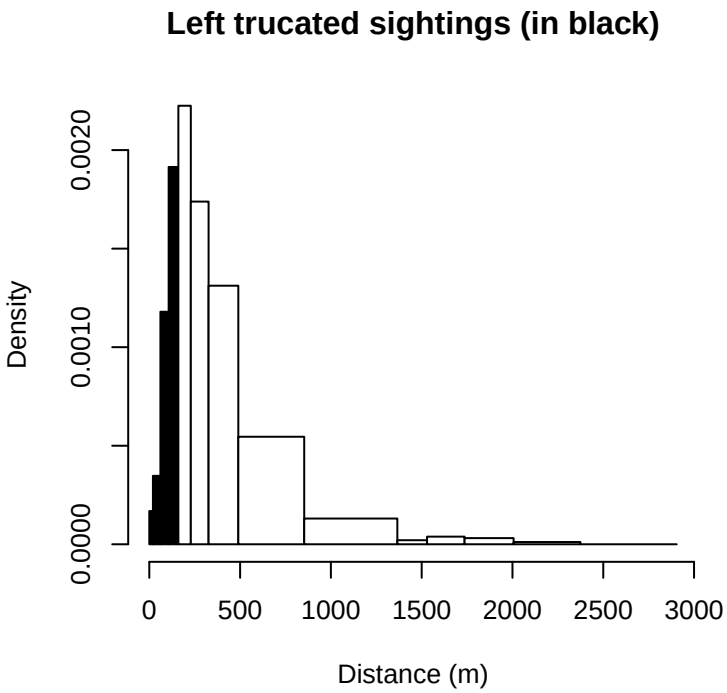

Figure 106: Density of sightings by perpendicular distance for NARWSS Twin Otters. Black bars on the left show sightings that were left truncated.

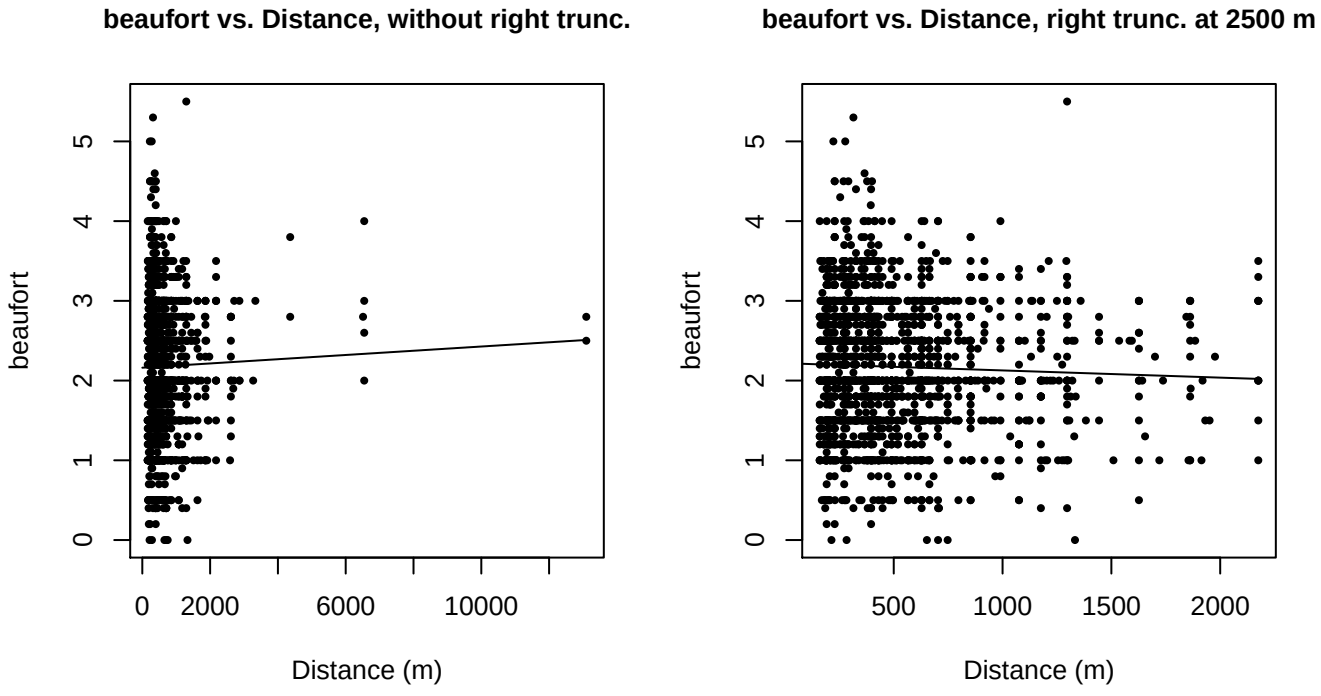

Figure 107: Scatterplots showing the relationship between Beaufort sea state and perpendicular sighting distance, for all sightings (left) and only those not right truncated (right). The line is a simple linear regression.

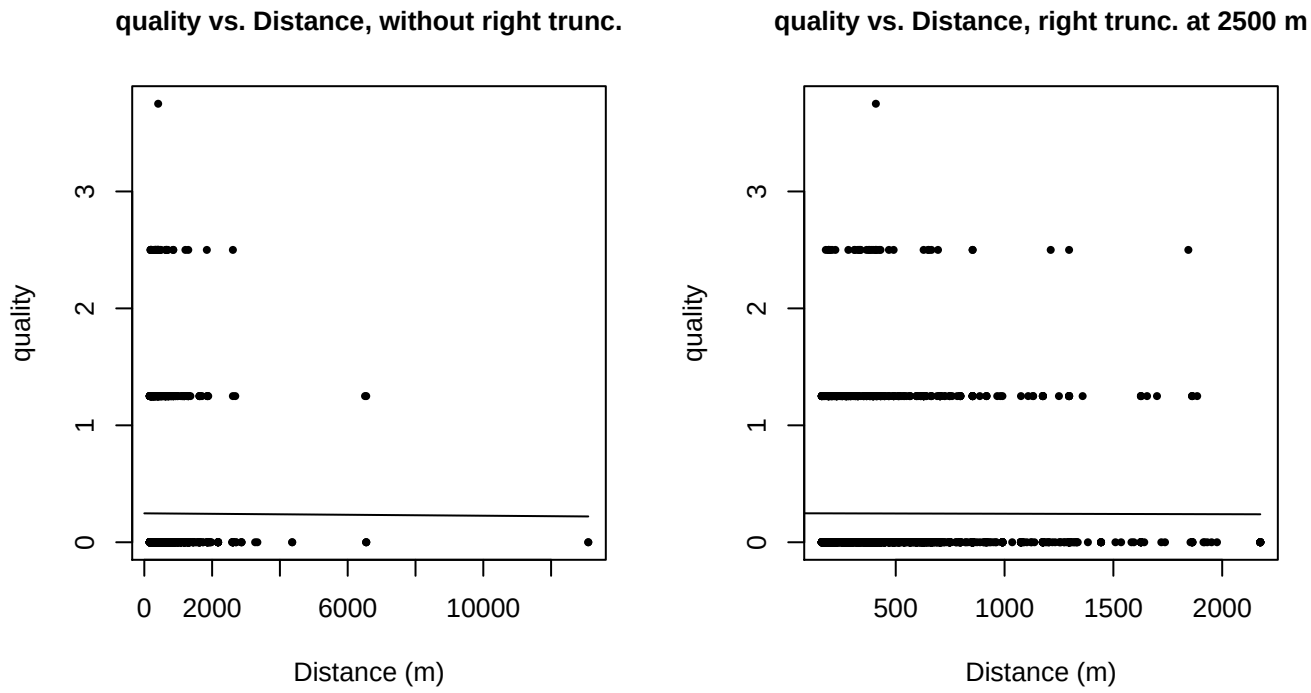

Figure 108: Scatterplots showing the relationship between the survey-specific index of the quality of observation conditions and perpendicular sighting distance, for all sightings (left) and only those not right truncated (right). Low values of the quality index correspond to better observation conditions. The line is a simple linear regression.

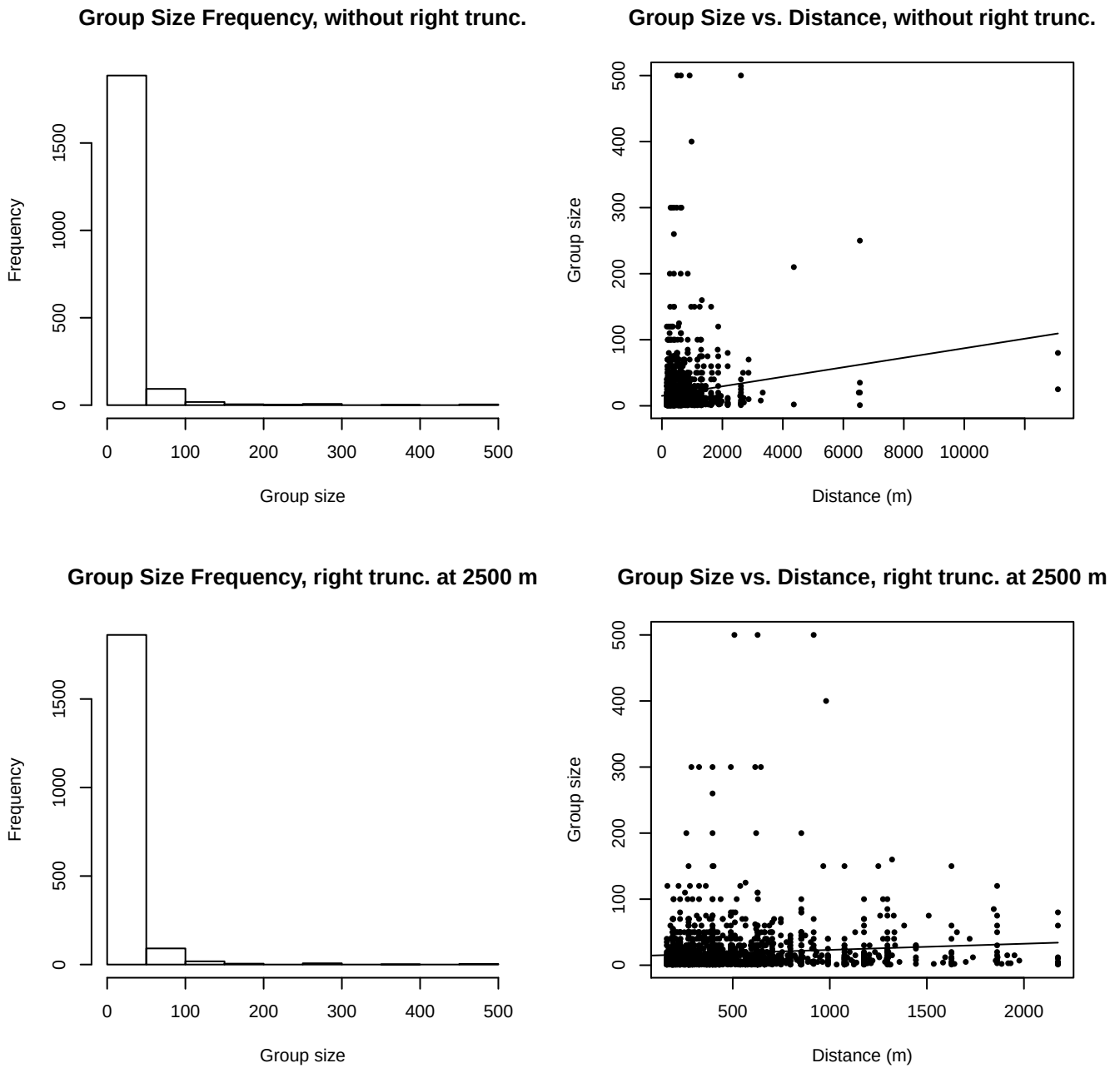

Figure 109: Histograms showing group size frequency and scatterplots showing the relationship between group size and perpendicular sighting distance, for all sightings (top row) and only those not right truncated (bottom row). In the scatterplot, the line is a simple linear regression.

g(0) Estimates

Platform	Surveys	Group Size	*g(0)*	Biases Addressed	Source
Shipboard	All	1-20	0.856	Perception	Barlow and Forney (2007)
		>20	0.970	Perception	Barlow and Forney (2007)
Aerial	All	1-5	0.43	Both	Palka (2006)
		>5	0.960	Both	Carretta et al. (2000)

Table 79: Estimates of *g(0)* used in this density model.

No species-specific g(0) estimates were published for any of the shipboard surveys available to us. Instead, we utilized Barlow and Forney's (2007) estimates for delphinids, produced from several years of dual-team surveys that used bigeye binoculars and similar protocols to the surveys in our study. This study provided separate estimates for small and large groups, but pooled sightings of several species together to provide a generic estimate for all delphinids, due to sample-size limitations. Their estimate accounted for perception bias but not availability bias; dive times for dolphins are short enough that availability bias is not expected to be significant for dolphins observed from shipboard surveys. In any case, no sightings of the species modeled here were sighted by shipboard surveys within the east coast study area, so the choice of g(0) has a negligible effect on the final abundance estimate for that study area.

For aerial surveys, we were unable to locate species-specific g(0) estimates in the literature. For small groups, defined here as 1-5 individuals, we used Palka's (2006) estimate of g(0) for groups of 1-5 small cetaceans, estimated from two years of aerial surveys using the Hiby (1999) circle-back method. This estimate accounted for both availability and perception bias, but pooled sightings of several species together to provide a generic estimate for all delphinids, due to sample-size limitations. For large groups, defined here as greater than 5 individuals, Palka (2006) assumed that g(0) was 1. When we discussed this with NOAA SWFSC reviewers, they agreed that it was safe to assume that the availability bias component of g(0) was 1 but insisted that perception bias should be slightly less than 1, because it was possible to miss large groups. We agreed to take a conservative approach and obtained our g(0) for large groups from Carretta et al. (2000), who estimated g(0) for both small and large groups of delphinids. We used Carretta et al.'s g(0) estimate for groups of 1-25 individuals (0.960), rather than their larger one for more than 25 individuals (0.994), to account for the fact that we were using Palka's definition of large groups as those with more than 5 individuals.

Density Model

In the western North Atlantic, white-beaked dolphins are a cool-water species that occurs from southern New England to southern Greenland and the Davis Strait (Waring et al. 2007). The literature reports that during the 1970s, white-beaked dolphins switched habitats with Atlantic white-sided dolphins, with white-beaked dolphins moving from on-shelf to off-shelf, and Atlantic white-sided dolphins moving from off-shelf to on-shelf, possibly due to changes in the abundance of prey species (Kenney et al. 1996, Waring et al. 2007). The surveys utilized in our study were conducted after the habitat switch, from 1992-2014, and reported over 2000 sightings of white-sided dolphins. These were concentrated in the Gulf of Maine and southern New England, with comparatively few reported on the continental slope, consistent with the literature reports of their post-switch habitat. The surveys reported only 12 sightings of white-beaked dolphins, which all occurred on the continental shelf. This finding of low abundance on the shelf agrees with the reported habitat switch, but the lack of white-beaked dolphin sightings off-shelf may not.

Although total survey effort was concentrated over the continental shelf in the Gulf of Maine and southern New England and relatively low in off-shelf waters (Fig. 6), high shipboard effort occurred along the continental slope of Georges Bank (Fig. 4). It seems unlikely that if white-beaked dolphins were historically present in high densities on the shelf in the Gulf of Maine and southern New England and simply moved off-shelf, no sightings would have been reported by any off-shelf survey. To investigate the possibility of off-shelf presence further, we consulted the OBIS-SEAMAP database (last accessed October 6, 2015). Although this database includes opportunistic sightings and therefore does not provide a systematic, effort-corrected view of species distributions, we noted that in the western North Atlantic, the southernmost off-shelf sighting of white-beaked dolphins occurred at 51 N, while relatively numerous sightings occurred on the shelf from southern Labrador to southern New

England, with the southernmost on-shelf sighting occurring off North Carolina, at 36 N. Several sightings were reported along the shelf-break, including the North Carolina sighting, which occurred at in water 395m deep.

Given the presence of on-shelf sightings, both in our systematic survey data and in the OBIS-SEAMAP database, and the total lack of off-shelf sightings south of 51 N in either data source, we concluded that currently white-beaked dolphins likely occupy only the shelf and shelf-break waters of our study area. With so few sightings, we could not model density from habitat-based predictors, and instead estimated mean density over the area we believed they typically occupy. We defined this region to be the shelf waters north of Cape Hatteras, based on the southernmost sighting occurring in North Carolina. We extended the outer limit of this area to the 500m isobath to encompass the upper shelf break and slope.

It is possible that off-shelf abundance of white-beaked dolphins might be discovered with additional off-shelf surveying, particularly in the northern part of our study area (e.g. off the Scotian Shelf). Should that happen, we would consider revising our model to include off-shelf waters.

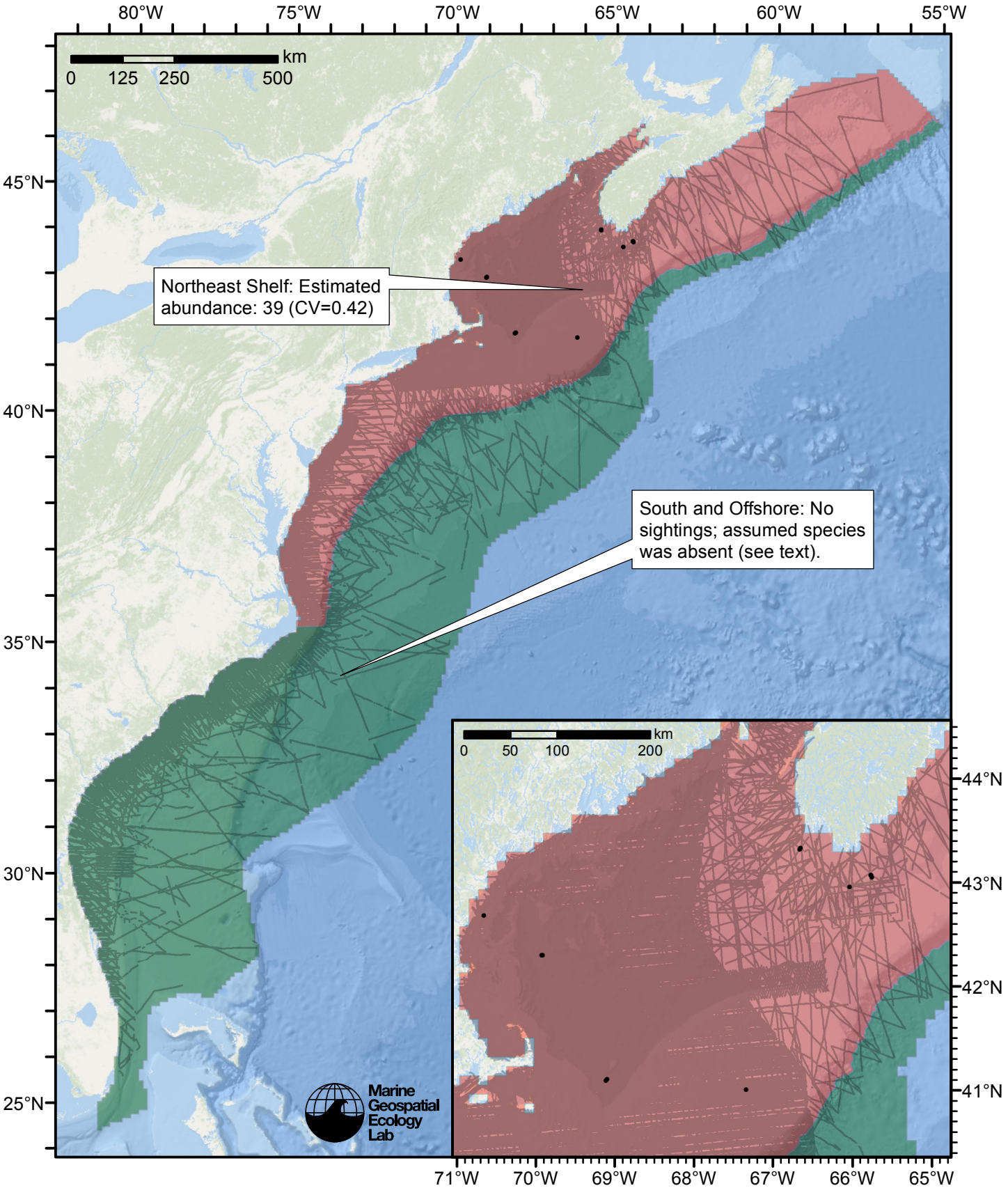

Figure 110: White-beaked dolphin density model schematic. All sightings are shown, including those that were truncated when detection functions were fitted. The coefficient of variation (CV) underestimates the true uncertainty of our estimate, as it only incorporated the uncertainty of the GAM stage of our model. Other sources of uncertainty include the detection functions and g(0) estimates. It was not possible to incorporate these into our CV without undertaking a computationally-prohibitive bootstrap; we hope to attempt that in a future version of our model.

Abundance Estimates

Dates	Model or study	Estimated abundance	CV	Assumed g(0)=1	In our models
1995-2014	Our model	39	0.42	No	
August 2006	Southern Gulf of Maine to Bay of Fundy and Gulf of St. Lawrence (Waring et al. 2014)	2003	0.94	No	Yes

Table 80: Estimated mean abundance within the study area for our model and independent estimates from NOAA and/or the scientific literature. The Dates column gives the dates to which the estimates apply. For our model, these are the years for survey data were available. Our coefficient of variation (CV) estimates are probably too low, as they only incorporated the uncertainty of the GAM stage of our models. Other sources of uncertainty include the detection functions and g(0) estimates. It was not possible to incorporate these into our CVs without undertaking a computationally-prohibitive bootstrap; we hope to attempt that in a future version of our models. The Assumed g(0)=1 column specifies whether the abundance estimate assumed that detection was certain along the survey trackline. Studies that assumed this did not correct for availability or perception bias, and therefore underestimated abundance. The In our models column specifies whether the survey data from the study was also used in our models. If not, the study provides a completely independent estimate of abundance. Note that our abundance estimates are averaged over the whole year, while the other estimates apply to specific months or seasons. Please see the Discussion section below for our evaluation of our models compared to the other estimates.

Discussion

Our stratified model predicted a total mean abundance of 39 over the modeled area during the study period, reflecting the rarity of white-beaked dolphins. NOAA's only abundance estimate came from a 2006 aerial survey of the Gulf of Maine and Scotian Shelf, in which five sightings occurred off southern Nova Scotia on August 17 and 18, 2006, yielding an estimate of 2003 white-beaked dolphins (CV=0.94) for the surveyed area (Waring et al. 2007). NOAA did not sight white-beaked dolphins on any other marine mammal abundance surveys conducted between 1995-2008. Two additional sightings occurred during the 2010-2014 AMAPPS survey program, but as of this writing (October 6, 2015), NOAA had not issued a new stock assessment report (even the 2015 draft reports available at this time did not include a new report for white-beaked dolphin).

In total, these data suggest that white-beaked dolphins occur over the continental shelf and shelf break of the study area, but rarely. They may only be present in particular years, perhaps based to prey availability. Our density and abundance estimate was very low, as it averaged all data available in the northeast U.S. during the 1995-2013 period, and included effort extending south to Cape Hatteras based on a historical sighting, effectively diluting the sightings reported in the northeast. NOAA's estimate was much higher, but was based on a particular year that white-beaked dolphins were sighted, and did not account for their total absence in other years. We conclude that our study provides a better long-term average of density and abundance, but NOAA's provides a more precautionary estimate, indicative of the density and abundance that can occur in particular years.

References

Barlow J, Forney KA (2007) Abundance and density of cetaceans in the California Current ecosystem. Fish. Bull. 105: 509-526.

Carretta JV, Lowry MS, Stinchcomb CE, Lynn MS, Cosgrove RE (2000) Distribution and abundance of marine mammals at San Clemente Island and surrounding offshore waters: results from aerial and ground surveys in 1998 and 1999. Administrative Report LJ-00-02, available from Southwest Fisheries Science Center, P.O. Box 271, La Jolla, CA USA 92038. 44 p.

Hiby L (1999) The objective identification of duplicate sightings in aerial survey for porpoise. In: Marine Mammal Survey and Assessment Methods (Garner GW, Amstrup SC, Laake JL, Manly BFJ, McDonald LL, Robertson DG, eds.). Balkema, Rotterdam, pp. 179-189.

Kenney RD, Payne PM, Heinemann DW, Winn HE (1996) Shifts in Northeast shelf cetacean distributions relative to trends in Gulf of Maine/Georges Bank finfish abundance. In: The Northeast Shelf Ecosystem: Assessment, Sustainability, and Management. Blackwell Science, Cambridge, MA. pp. 169-196.

Palka DL (2006) Summer Abundance Estimates of Cetaceans in US North Atlantic Navy Operating Areas. US Dept Commer, Northeast Fish Sci Cent Ref Doc. 06-03: 41 p.

Waring GT, Josephson E, Fairfield-Walsh CP, Maze-Foley K, eds. (2007) U.S. Atlantic and Gulf of Mexico Marine Mammal Stock Assessments – 2007. NOAA Tech Memo NMFS NE 205; 415 p.

Waring GT, Josephson E, Maze-Foley K, Rosel PE, eds. (2014) U.S. Atlantic and Gulf of Mexico Marine Mammal Stock Assessments – 2013. NOAA Tech Memo NMFS NE 228; 464 p.