2b.

NOAA FISHERIES

Northeast Fisheries Science Center

Rockhopper/Chain Sweep Relative Catch Efficiency Analysis

Michael Martin

Ecosystems Surveys Branch
Northeast Fisheries Science Center
Woods Hole, MA

5/31/2016

Study Motivation:

There is great interest among both NEFSC assessment scientists and stakeholders to better understand the catch efficiency of the standard Bottom Trawl Survey (BTS) fishing gear as this knowledge can serve to improve stock assessments.

Study Goal:

To estimate relative catch efficiency for standard BTS rockhopper sweep for several flatfish species.

Study Design

Gear

- Original design – “underbag” to capture escaped fish

- After consultation with stakeholders and gear manufacturer, decision made to switch to twin trawl study design

- Developed efficient chain sweep – built by Reidar’s (New Bedford, MA) in consultation with stakeholders
  - Specific goal - maximize flatfish catch on sand/mud seafloor (approach efficiency of 1)

Study Operational Goal

- Conduct as many twin trawl tows as possible to allow rockhopper/chain sweep gear efficiency comparison – focus on flatfish species

Study Area and Vessel

- Planned study area – Closed Area II – Georges Bank

- 12 contracted days aboard Karen Elizabeth (10 working days – weather days)

Sampling Effort

- Tows placement objective to maximize catch of target species

- Mimic Bigelow protocols where possible
  - 20 minute tows @ 3 knots
  - Recorded GPS, door spread, depth

- Distance fished – from on bottom to off bottom

- Area swept – door spread x distance fished

Biological sampling

- Sample rockhopper/chain sweep catches independently (2 catches/tow)
- Length all flatfish (random subsampling when numerous fish)
- Weigh scallop and combined skate catch (no length data collected)
- Data collected using FSCS 2.0 – many advantages

Data Analysis

Model fitting

- Modified code from Miller (2013) – Albatross/Bigelow calibration (CJFAS 70:1306-1316)
- Binomial and beta-binomial models
- Best model selected by lowest AIC
- All subsequent figures represent best-fitting model results
- Model fitting conducted for:
  - All data
  - Day and night data separately (significant day/night differences for most species)

Model fitting - continued (tables from Miller (2013))

Table 2. Description of relative catch efficiency (ρ) parameterizations for conditional binomial models fit to data for each species.

Model	log(ρ)	Across-pair effects	Pair-specific random effects
BI_0	β_0	Intercept	None
BI_1	$\beta_0 + \delta_{0,j}$	Intercept	Intercept
BI_2	$\boldsymbol{X}_f^T\boldsymbol{\beta} + \boldsymbol{X}_r^T\boldsymbol{b}$	Intercept and cubic spline smoother of size	None
BI_3	$\boldsymbol{X}_f^T\boldsymbol{\beta} + \boldsymbol{X}_r^T\boldsymbol{b} + \delta_{0,j}$	Intercept and cubic spline smoother of size	Intercept
BI_4	$\boldsymbol{X}_f^T(\boldsymbol{\beta}_f + \boldsymbol{\delta}_j) + \boldsymbol{X}_r^T(\boldsymbol{b} + \boldsymbol{\epsilon}_j)$	Intercept and cubic spline smoother of size	Intercept and cubic spline smoother of size

Table 3. Description of relative catch efficiency (ρ) and dispersion (ϕ) parameterizations for conditional beta-binomial models fit to data for each species.

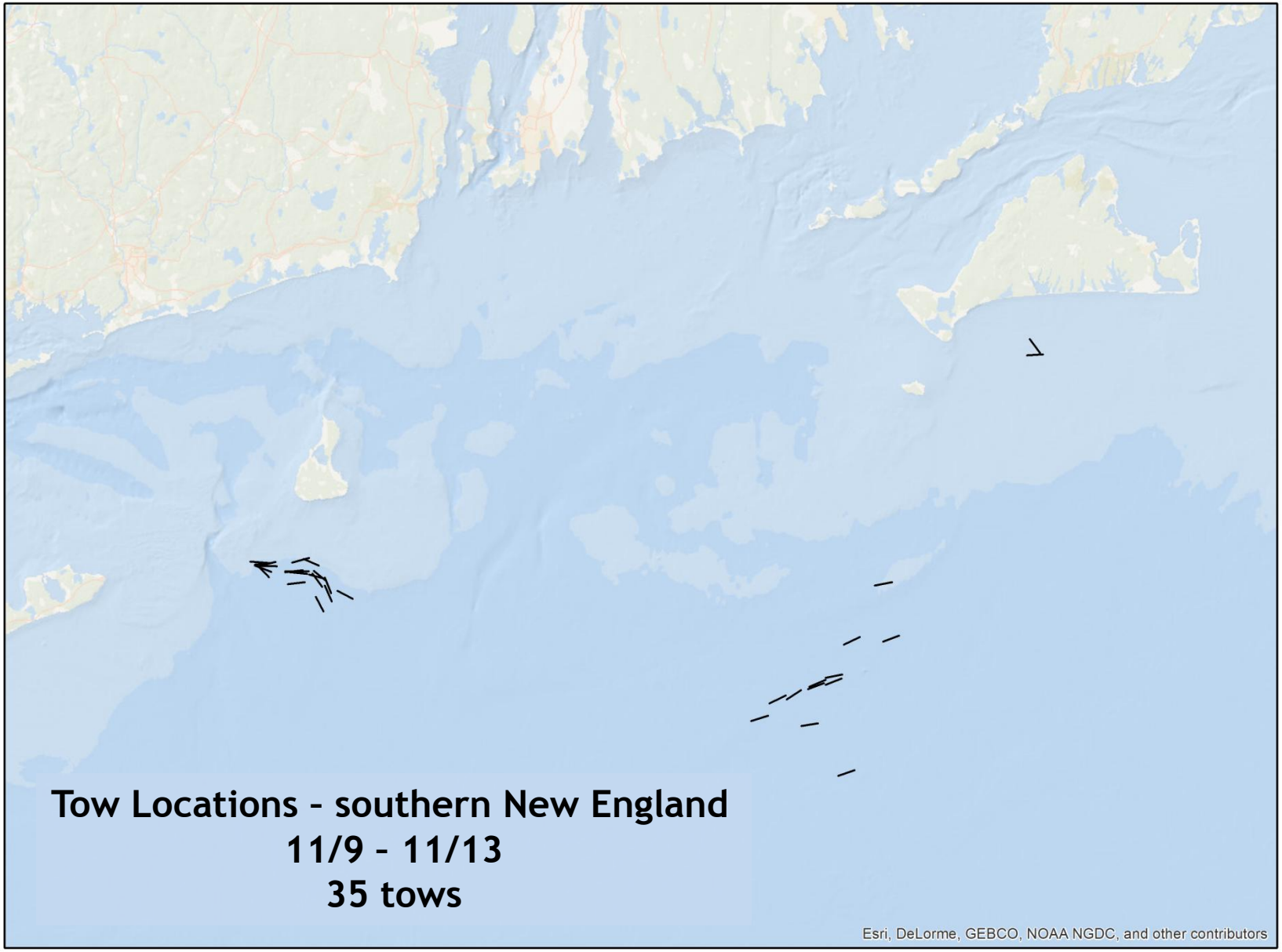
Model	log(ρ)	log(ϕ)	Across-pair effects	Pair-specific random effects
BB_0	β_0	γ_0	Intercepts for mean and dispersion	None
BB_1	$\beta_0 + \delta_{0,j}$	γ_0	Intercepts for mean and dispersion	Intercept for mean
BB_2	$\boldsymbol{X}_f^T\boldsymbol{\beta} + \boldsymbol{X}_r^T\boldsymbol{b}$	γ_0	Mean and dispersion intercepts and cubic-spline smoother of size for mean	None
BB_3	$\boldsymbol{X}_f^T\boldsymbol{\beta} + \boldsymbol{X}_r^T\boldsymbol{b}$	$\boldsymbol{X}_f^T\boldsymbol{\gamma} + \boldsymbol{X}_r^T\boldsymbol{g}$	Intercepts and cubic-spline smoothers of size for mean and dispersion	None
BB_4	$\boldsymbol{X}_f^T\boldsymbol{\beta} + \boldsymbol{X}_r^T\boldsymbol{b} + \delta_{0,j}$	γ_0	Mean and dispersion intercepts and cubic-spline smoother of size for mean	Intercept for mean
BB_5	$\boldsymbol{X}_f^T\boldsymbol{\beta} + \boldsymbol{X}_r^T\boldsymbol{b} + \delta_{0,j}$	$\boldsymbol{X}_f^T\boldsymbol{\gamma} + \boldsymbol{X}_r^T\boldsymbol{g}$	Intercepts and cubic-spline smoothers of size for mean and dispersion	Intercept for mean
BB_6	$\boldsymbol{X}_f^T(\boldsymbol{\beta}_f + \boldsymbol{\delta}_j) + \boldsymbol{X}_r^T(\boldsymbol{b} + \boldsymbol{\epsilon}_j)$	γ_0	Mean and dispersion intercepts and cubic-spline smoother of size for mean	Intercept and cubic spline smoother for mean
BB_7	$\boldsymbol{X}_f^T(\boldsymbol{\beta}_f + \boldsymbol{\delta}_j) + \boldsymbol{X}_r^T(\boldsymbol{b} + \boldsymbol{\epsilon}_j)$	$\boldsymbol{X}_f^T\boldsymbol{\gamma} + \boldsymbol{X}_r^T\boldsymbol{g}$	Intercepts and cubic-spline smoothers of size for mean and dispersion	Intercept and cubic spline smoother for mean

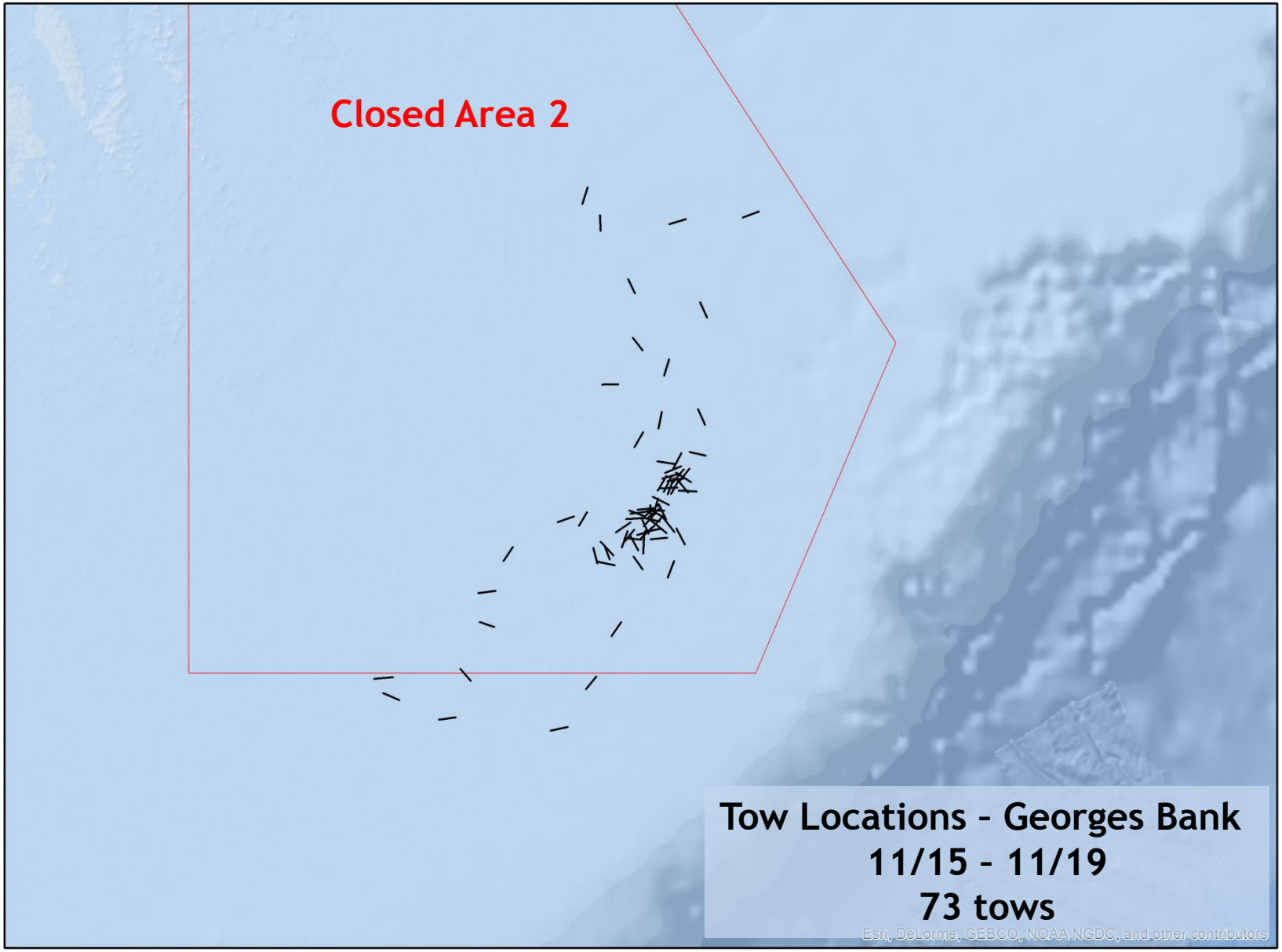
Results

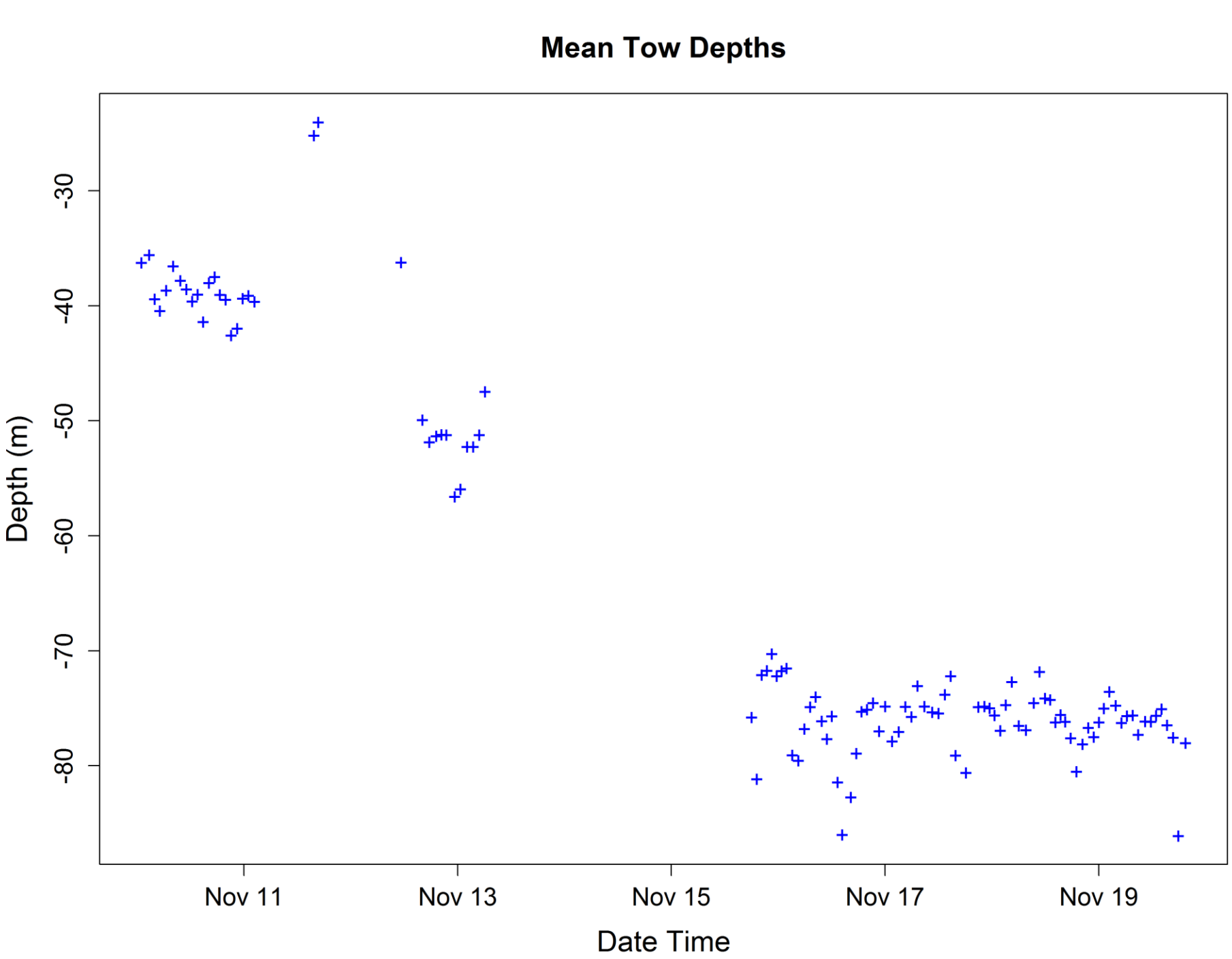
- Weather impeded progress first few day – prevented earlier transit to Georges Bank study area

- 108 representative tows (45 day, 63 night)

- Seven species with adequate data for analysis:
  - yellowtail flounder
  - winter flounder
  - windowpane
  - fluke
  - fourspot flounder
  - Gulf Stream flounder
  - monkfish

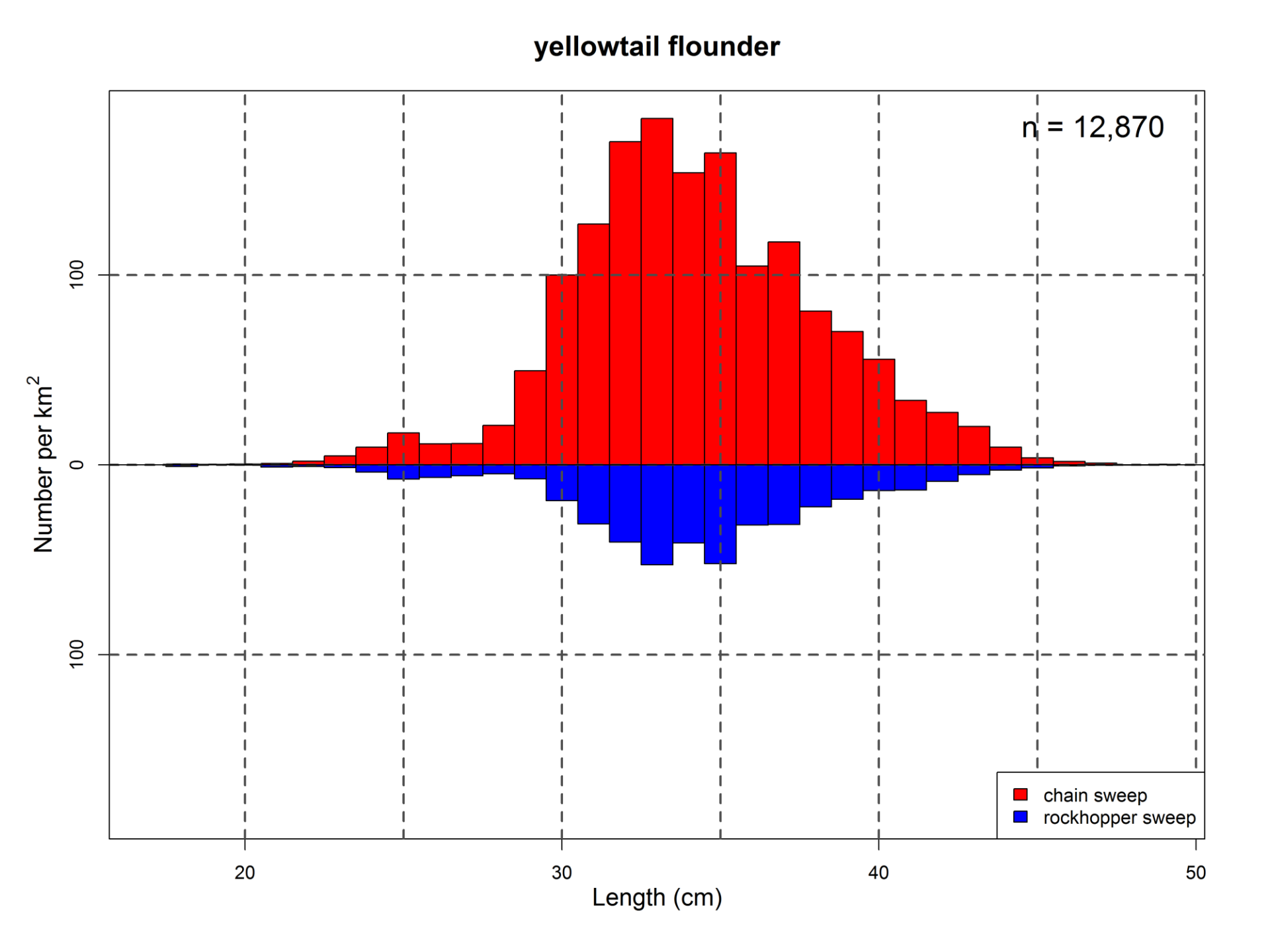

Tow Locations – southern New England
11/9 – 11/13
35 tows
Esri, DeLorme, GEBCO, NOAA NGDC, and other contributors

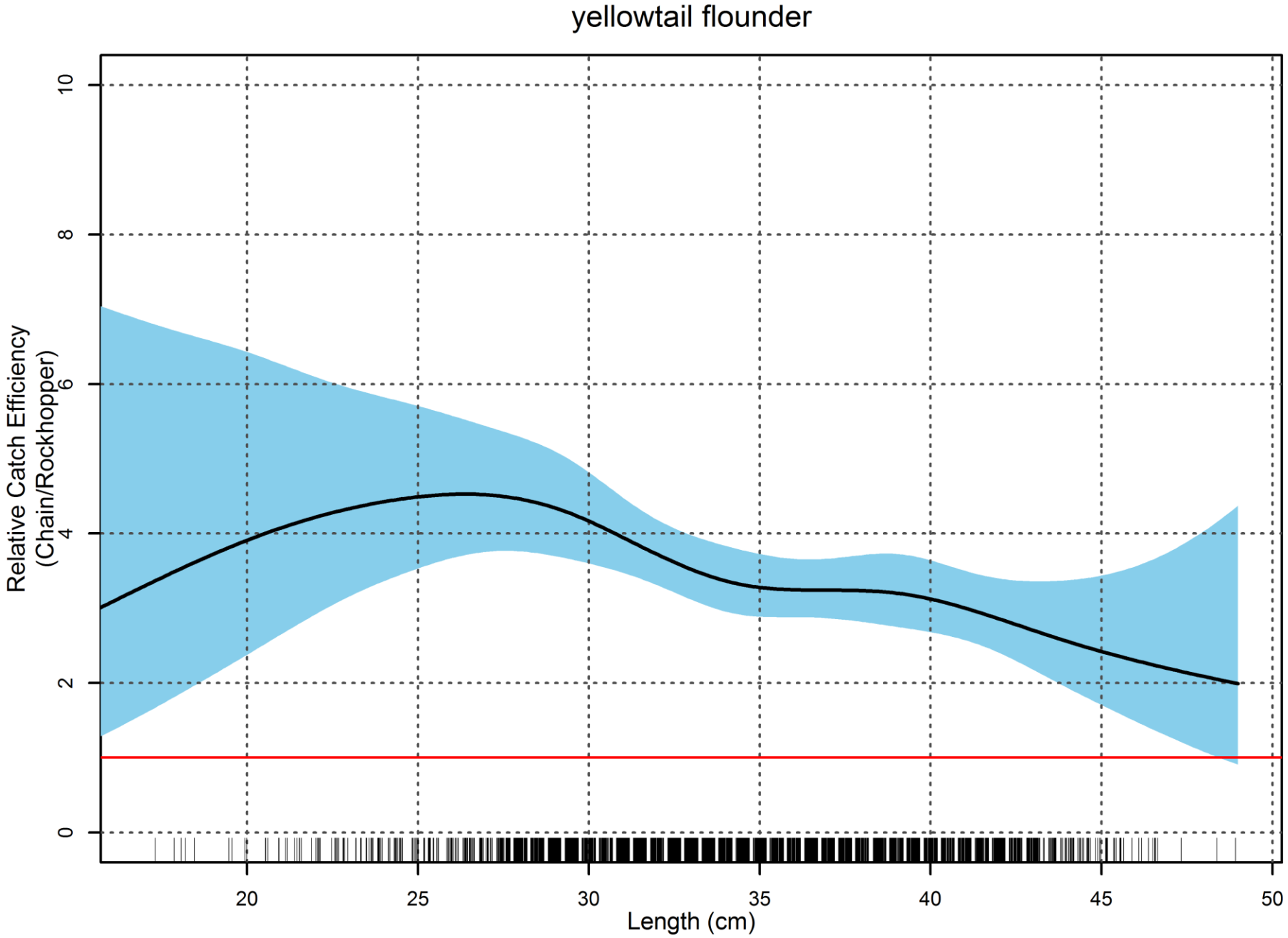

Closed Area 2
Tow Locations - Georges Bank
11/15 - 11/19
73 tows
Esri, DeLorme, GEBCO, NOAA NGDC, and other contributors

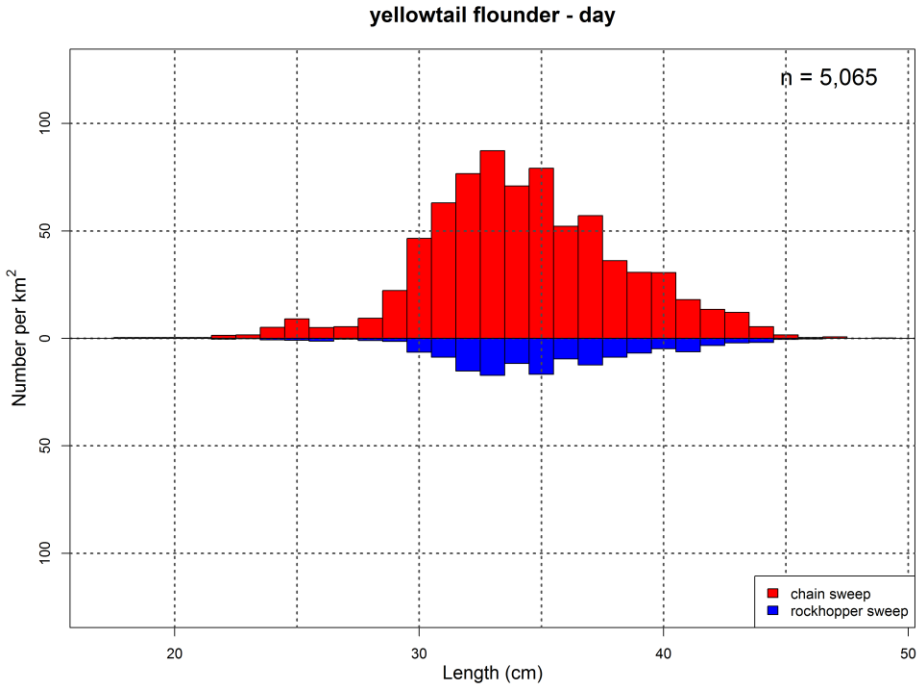

Mean Tow Depths
Depth (m)
-30
-40
-50
-60
-70
-80
Nov 11
Nov 13
Nov 15
Nov 17
Nov 19
Date Time

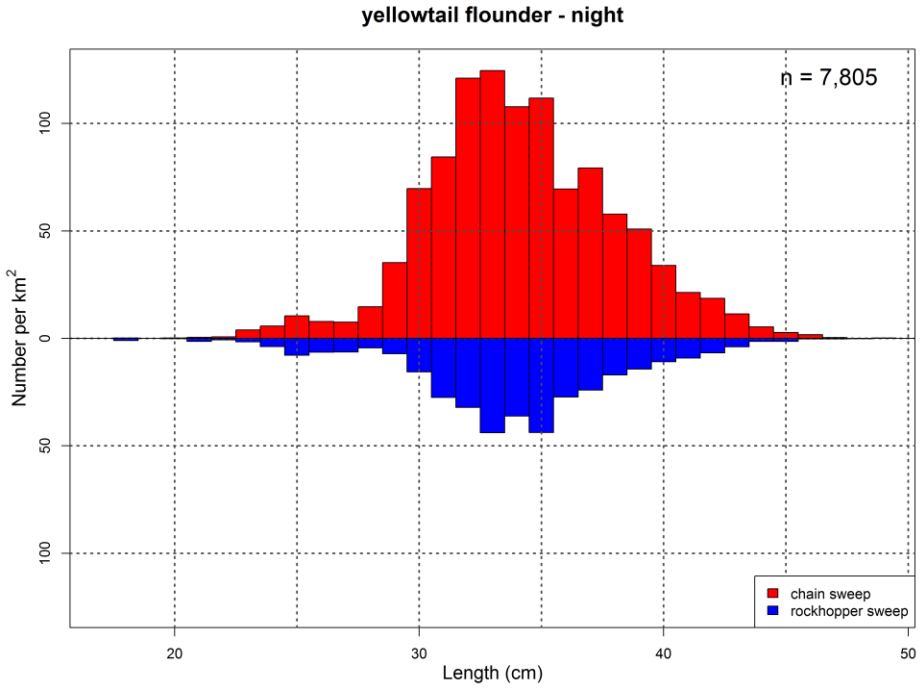
Data Summary

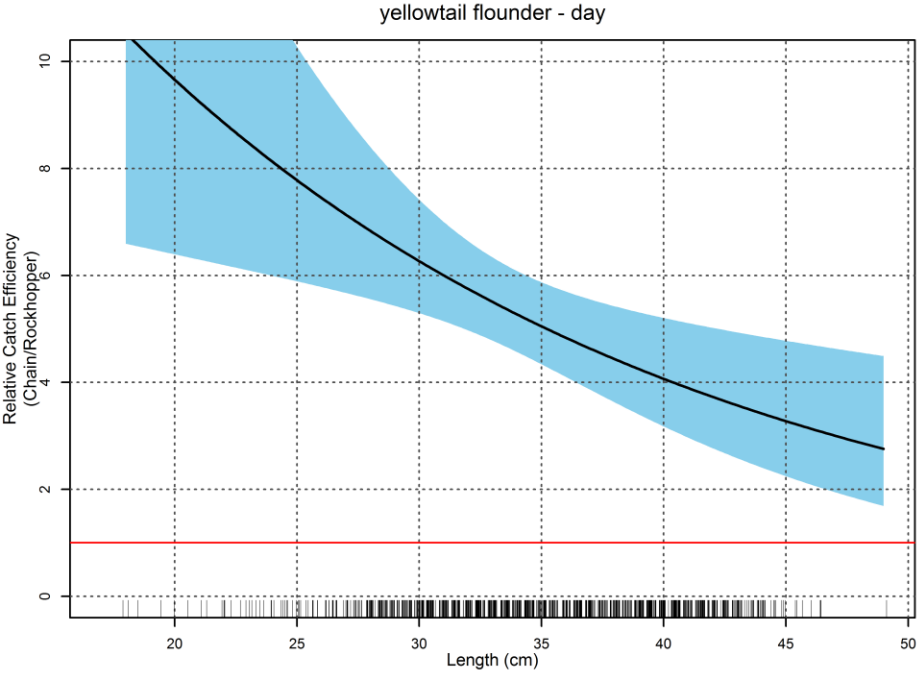
Species	Day/Night	Number of Pairs	Number Caught	Number Lengthed	Best Model
yellowtail flounder	all	93	12,870	9,985	BB4
yellowtail flounder	day	37	5,065	3,742	BI4
yellowtail flounder	night	56	7,805	6,243	BB4
windowpane	all	108	4,914	4,864	BI3
windowpane	day	45	1,778	1,778	BI1
windowpane	night	63	3,136	3,086	BB1
winter flounder	all	47	1,809	1,809	BI3
winter flounder	day	20	859	859	BI2
winter flounder	night	27	950	950	BI2
fluke	all	63	2,582	2,582	BI2
fluke	day	29	791	791	BI1
fluke	night	34	1,791	1,791	BI2
fourspot flounder	all	108	14,558	9,802	BB7
fourspot flounder	day	45	5,769	3,489	BB4
fourspot flounder	night	63	8,789	6,313	BB4
Gulf Stream flounder	all	90	7,433	4,202	BB7
Gulf Stream flounder	day	35	1,973	1,436	BI3
Gulf Stream flounder	night	55	5,460	2,766	BB1
monkfish	all	108	3,673	3,594	BI3
monkfish	day	45	975	975	BI2
monkfish	night	63	2,698	2,619	BI3

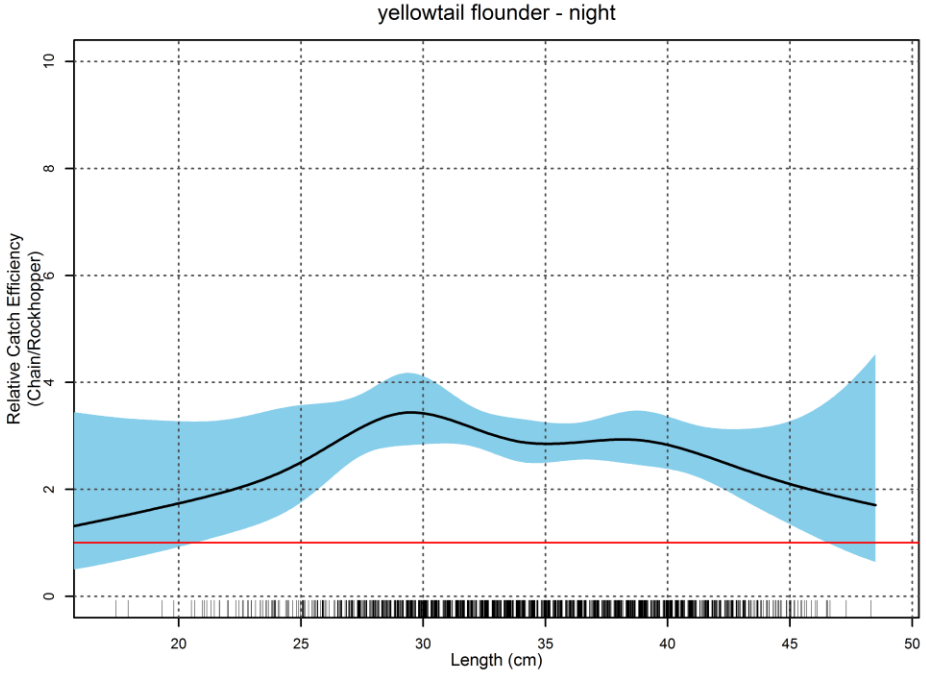

yellowtail flounder
n = 12,870
Number per km2
100
0
100
20
30
40
50
Length (cm)
chain sweep
rockhopper sweep

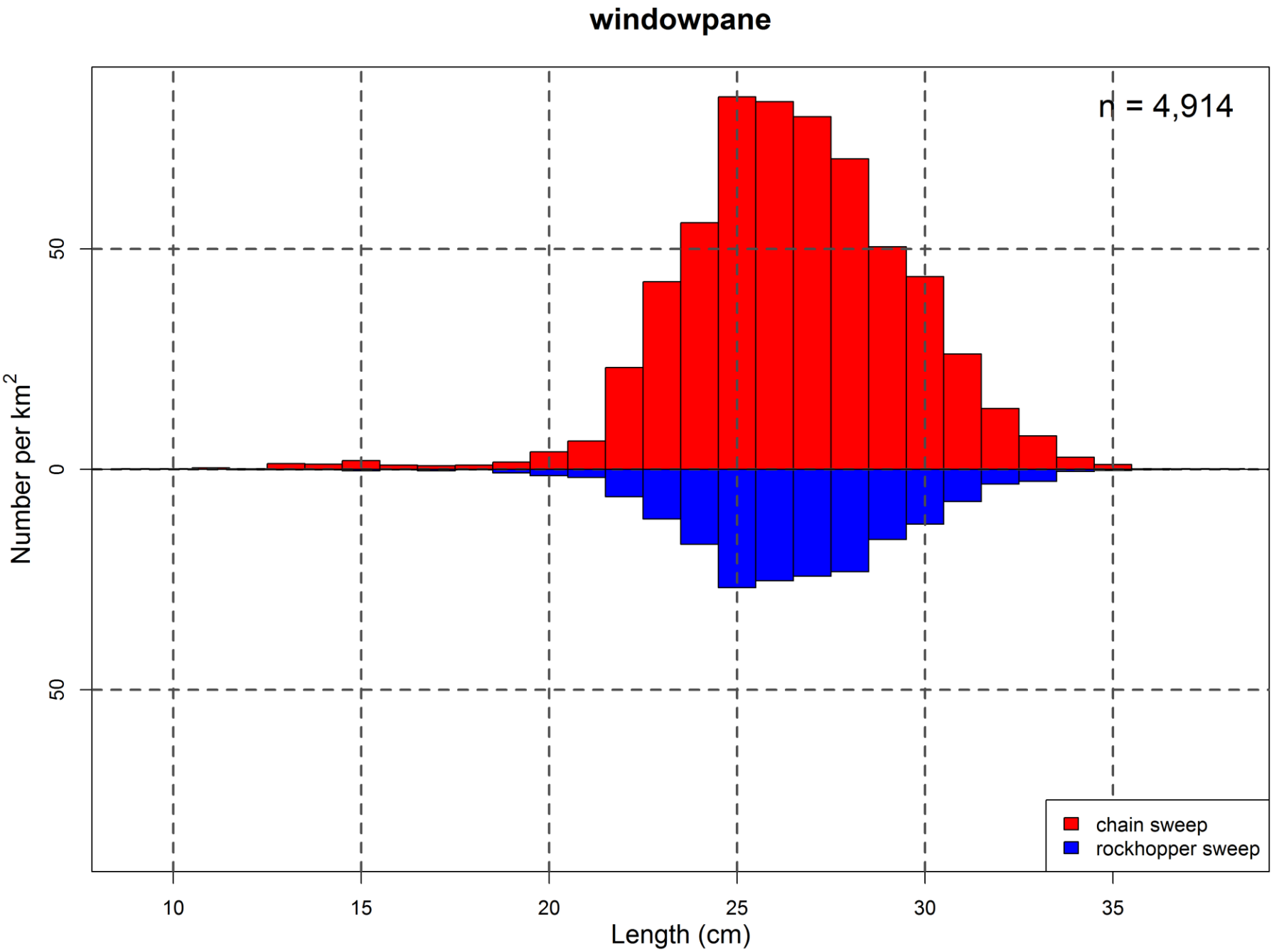

yellowtail flounder
Relative Catch Efficiency
(Chain/Rockhopper)
0
2
4
6
8
10
20
25
30
35
40
45
50
Length (cm)

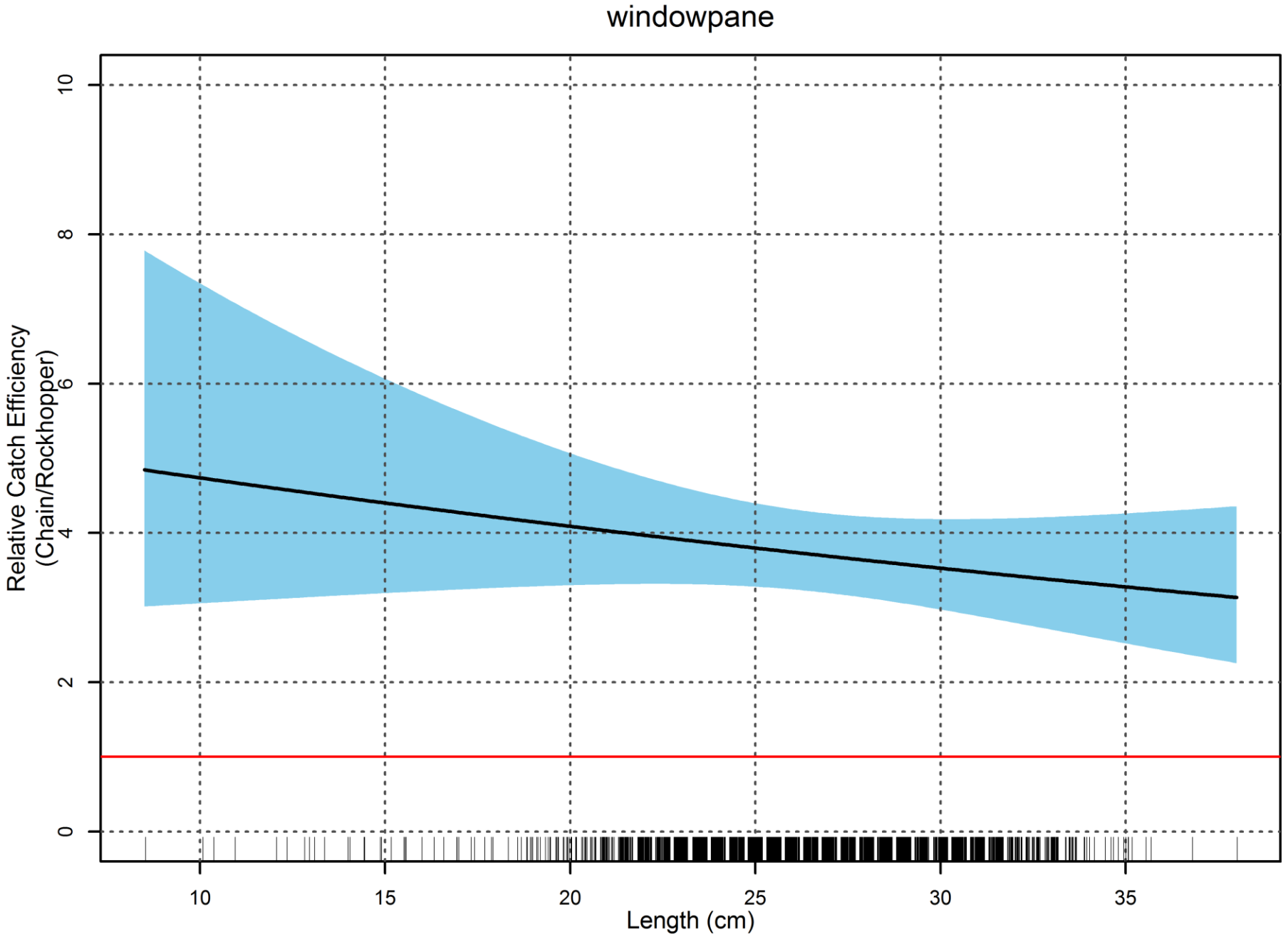

yellowtail flounder - day
n = 5,065
Number per km2
Length (cm)
chain sweep
rockhopper sweep

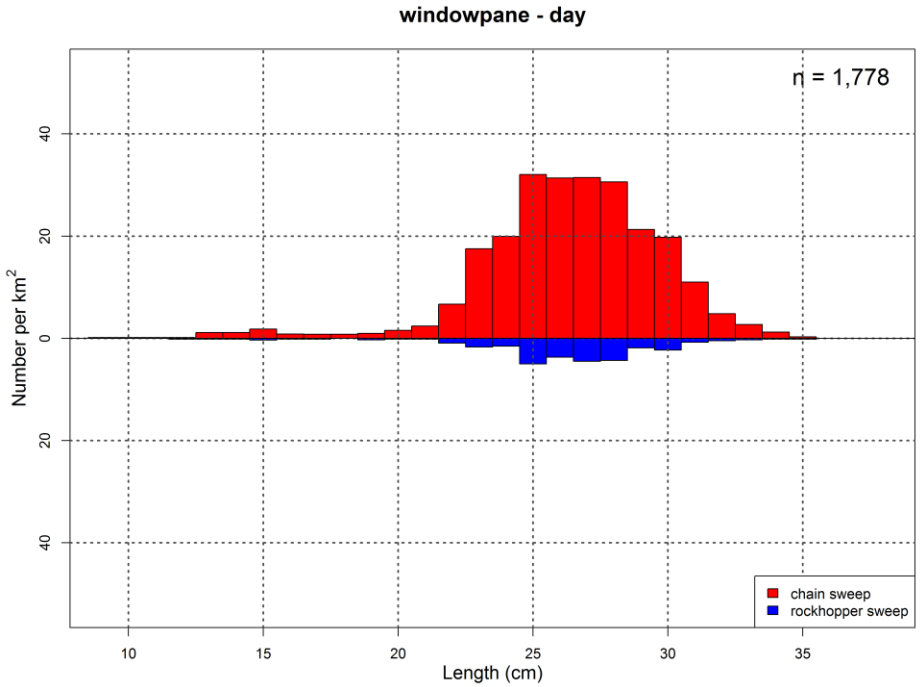

yellowtail flounder - night
n = 7,805
Number per km2
Length (cm)
chain sweep
rockhopper sweep

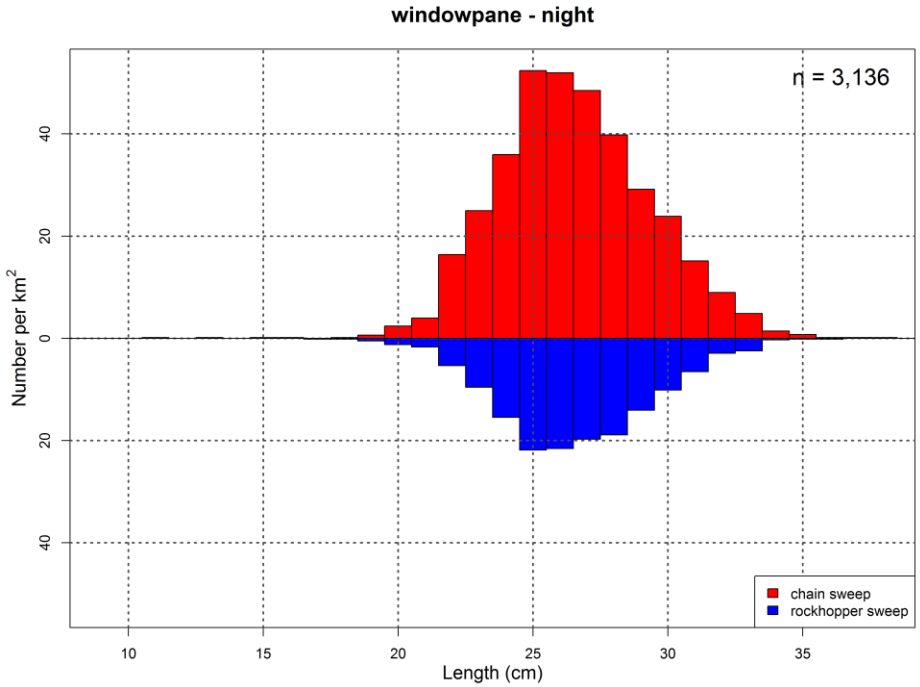

yellowtail flounder - day
Relative Catch Efficiency
(Chain/Rockhopper)
Length (cm)

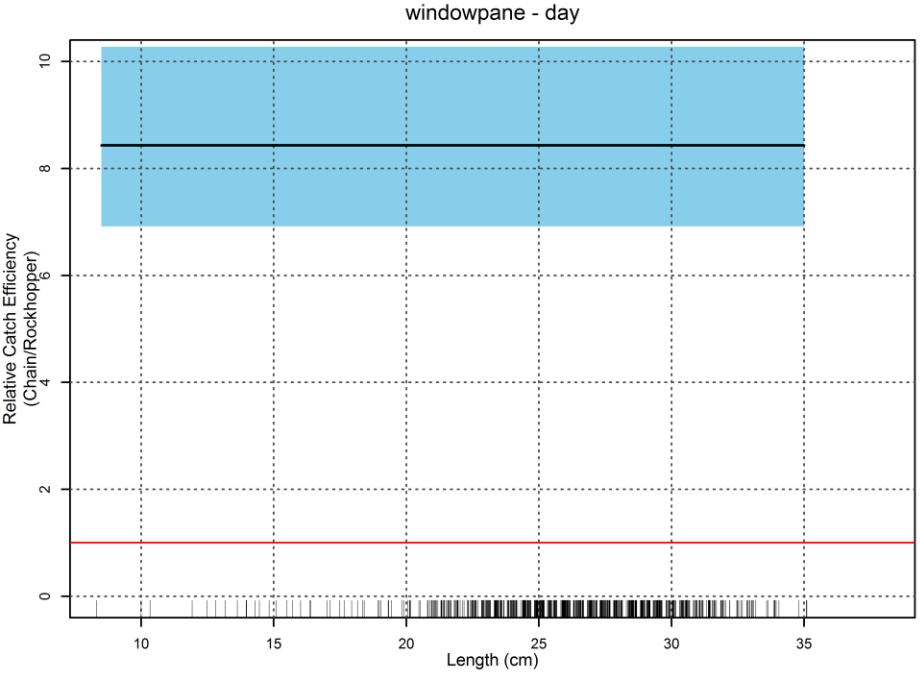

yellowtail flounder - night
Relative Catch Efficiency
(Chain/Rockhopper)
Length (cm)

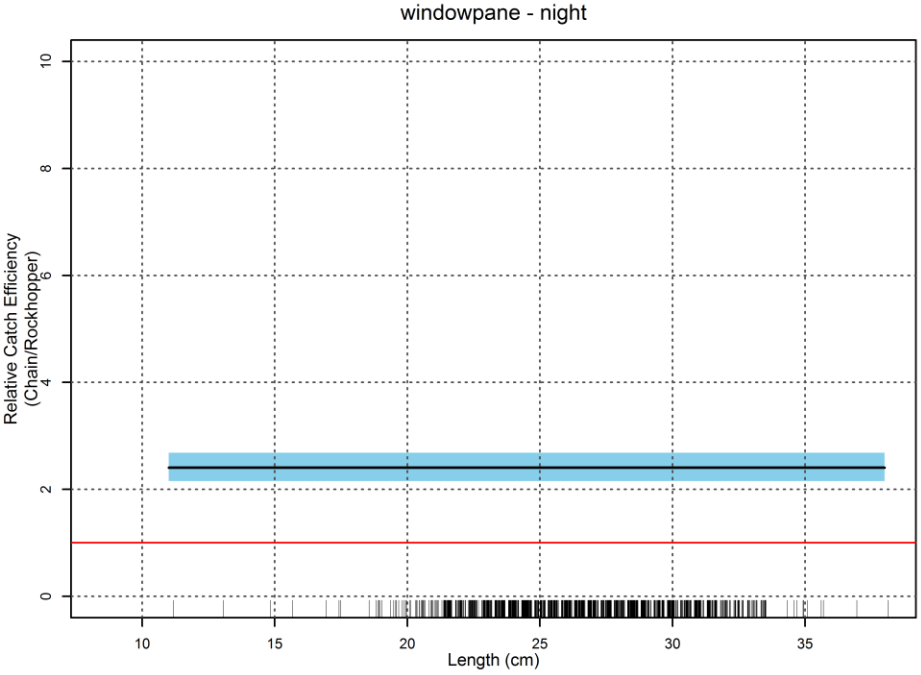

windowpane
n = 4,914
50
0
50
Number per km2
10
15
20
25
30
35
Length (cm)
chain sweep
rockhopper sweep

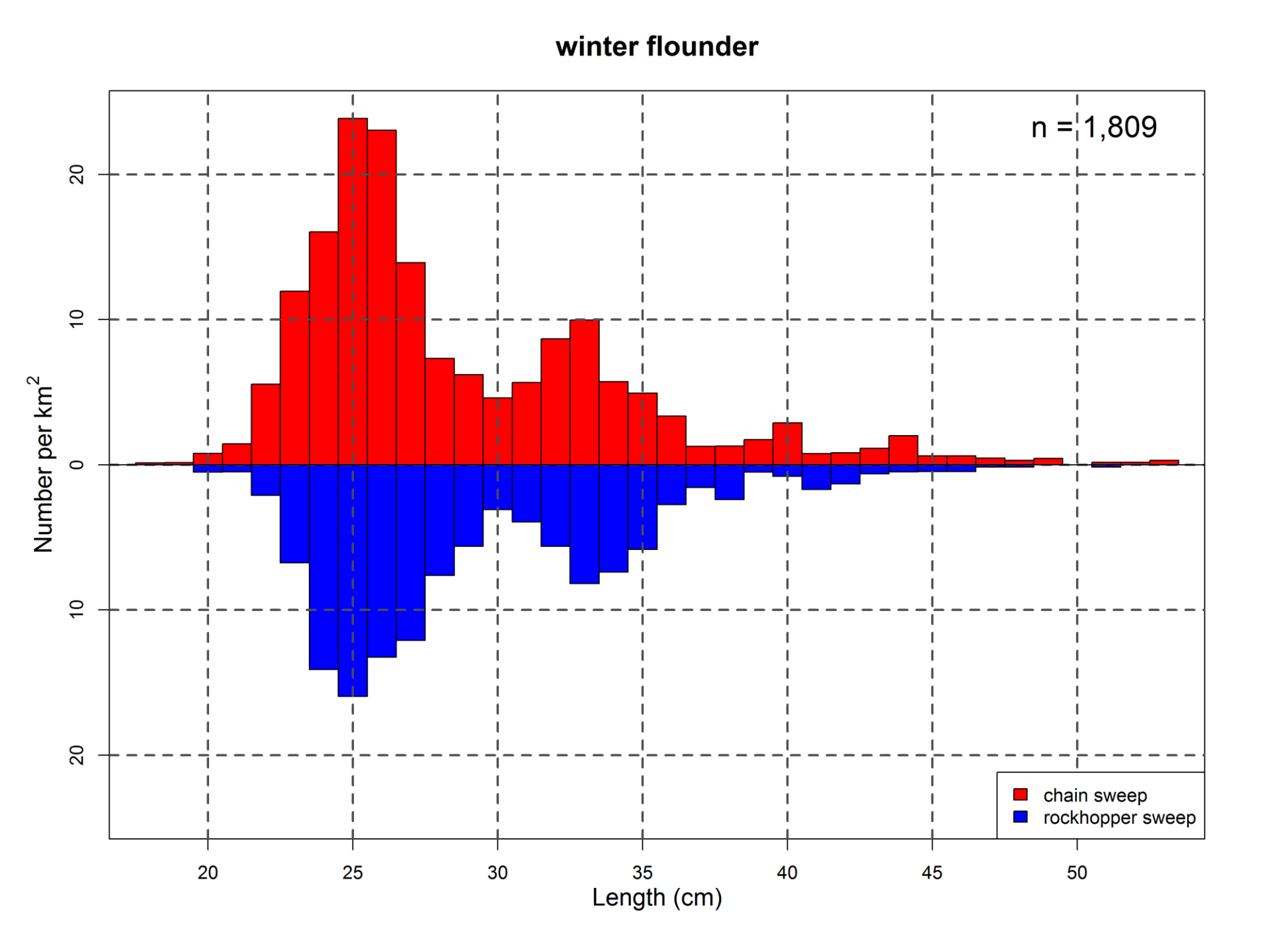

windowpane
Relative Catch Efficiency
(Chain/Rockhopper)
0
2
4
6
8
10
10
15
20
25
30
35
Length (cm)

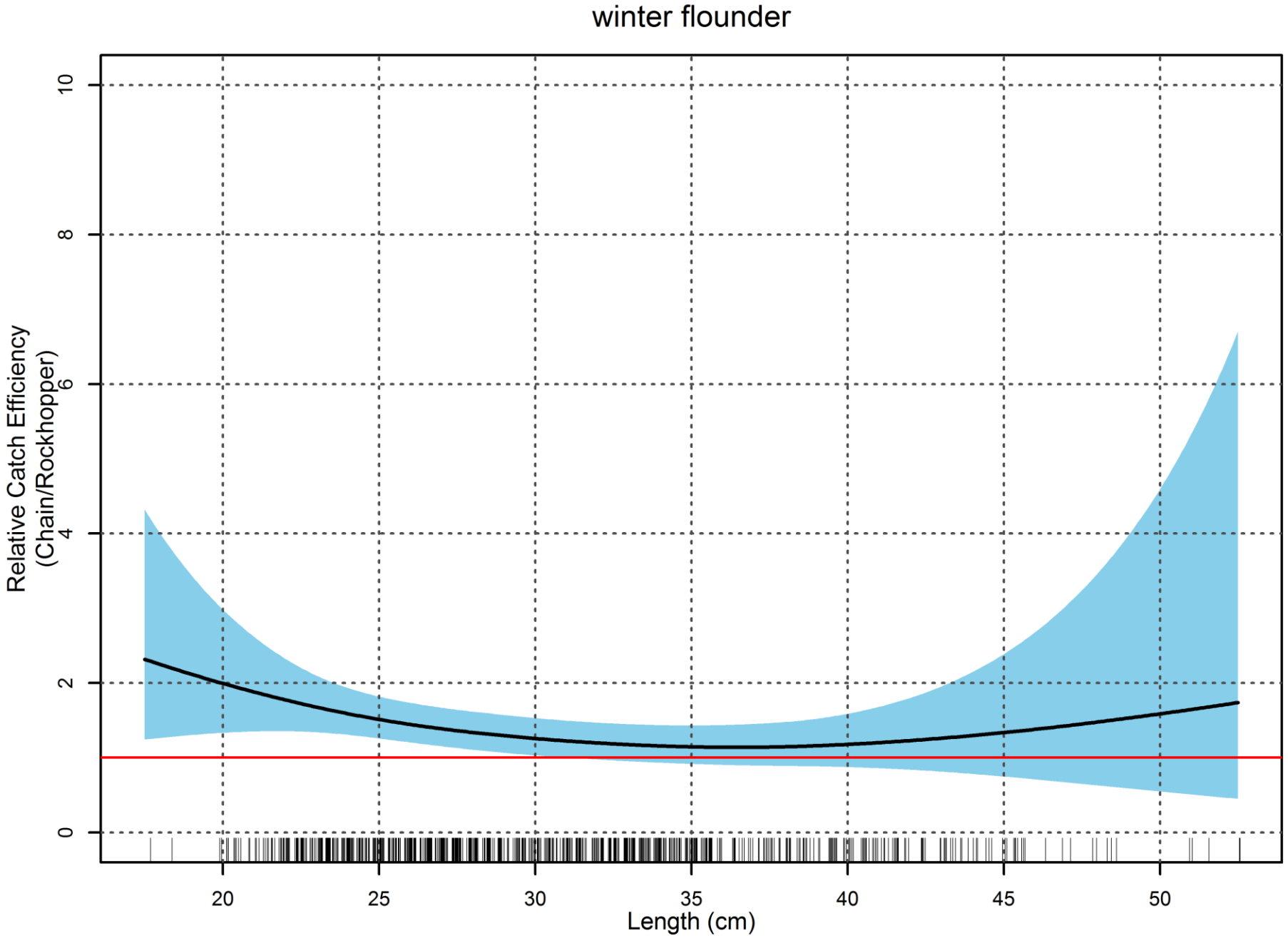

windowpane - day
n = 1,778
Number per km2
Length (cm)
chain sweep
rockhopper sweep

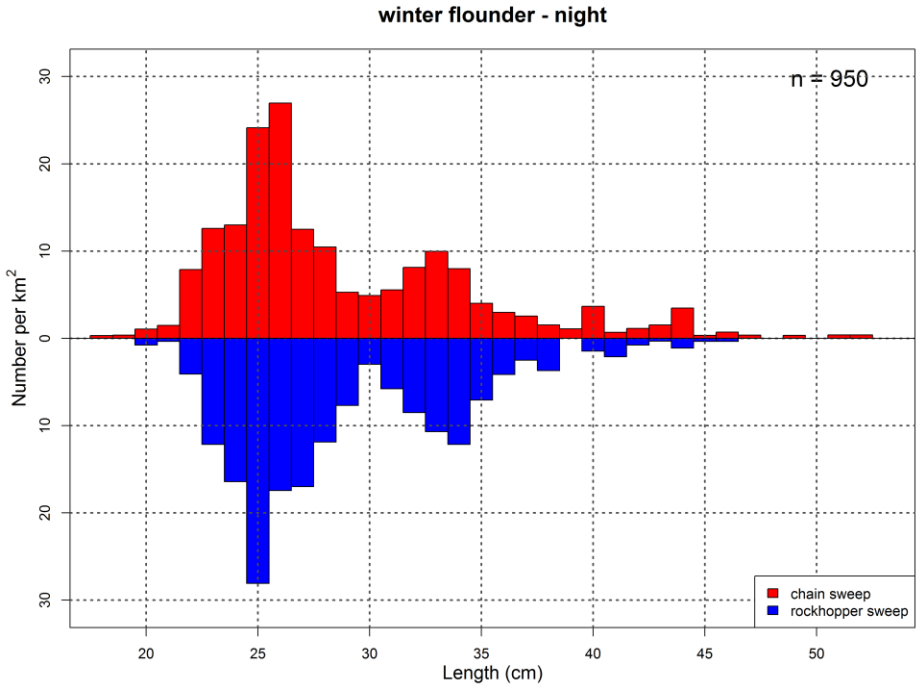

windowpane - night
n = 3,136
Number per km2
Length (cm)
chain sweep
rockhopper sweep

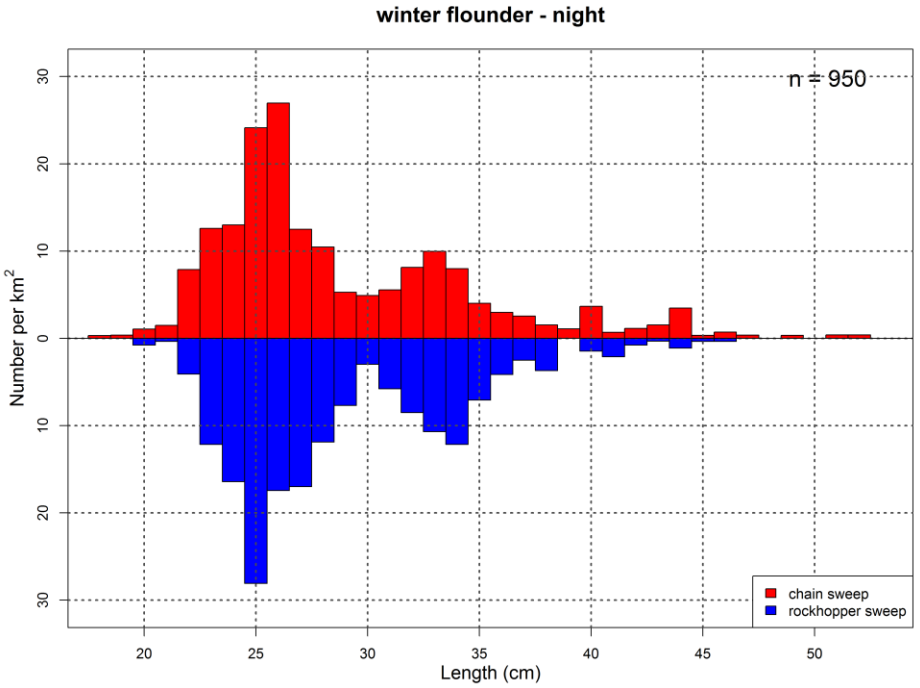

windowpane - day
Relative Catch Efficiency
(Chain/Rockhopper)
Length (cm)

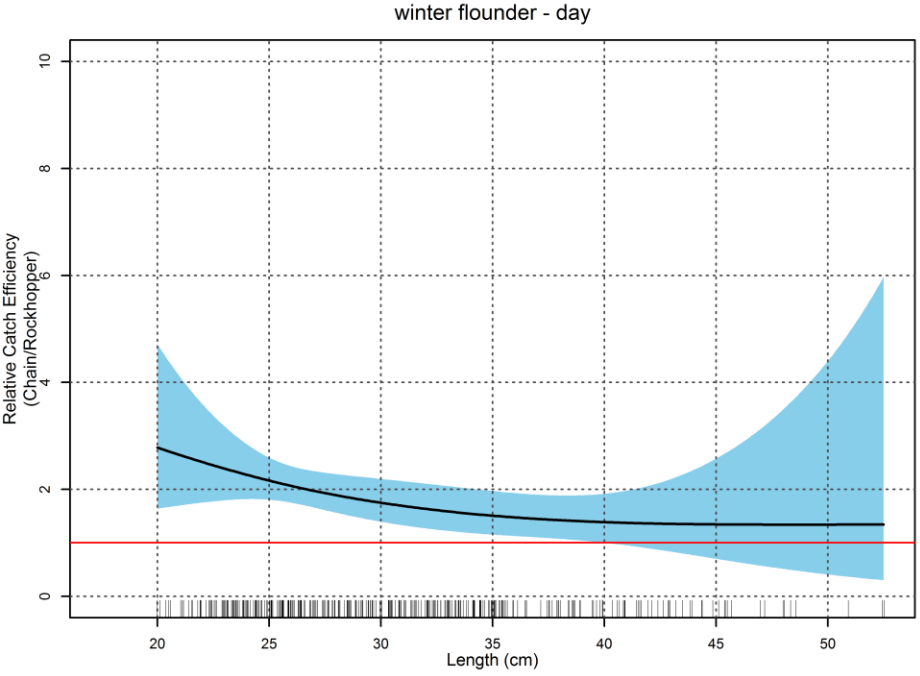

windowpane - night
Relative Catch Efficiency
(Chain/Rockhopper)
Length (cm)

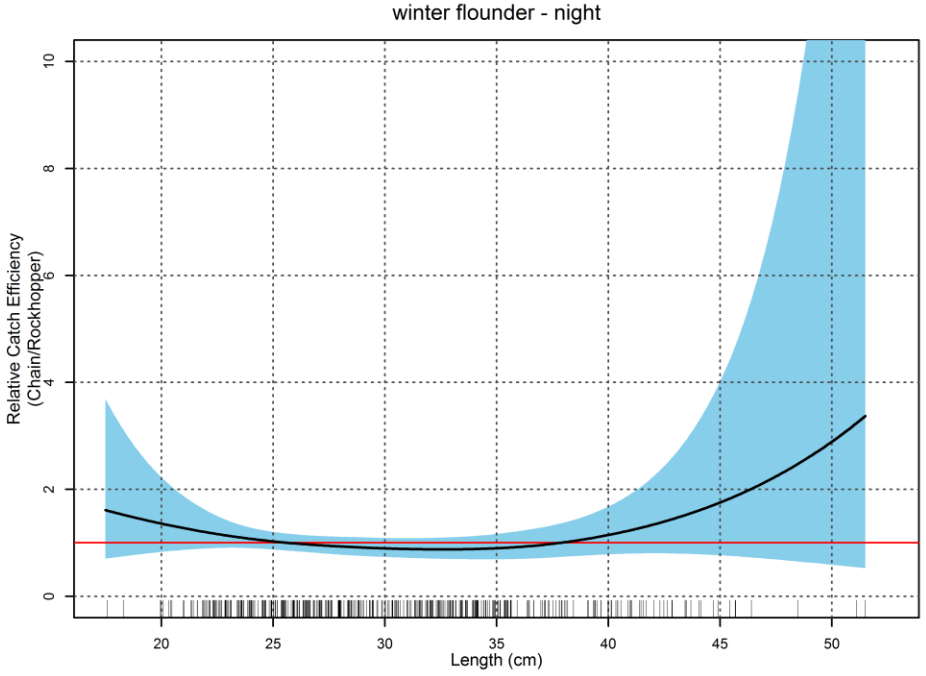

winter flounder
n = 1,809
Number per km2
20
10
0
10
20
20
25
30
35
40
45
50
Length (cm)
chain sweep
rockhopper sweep

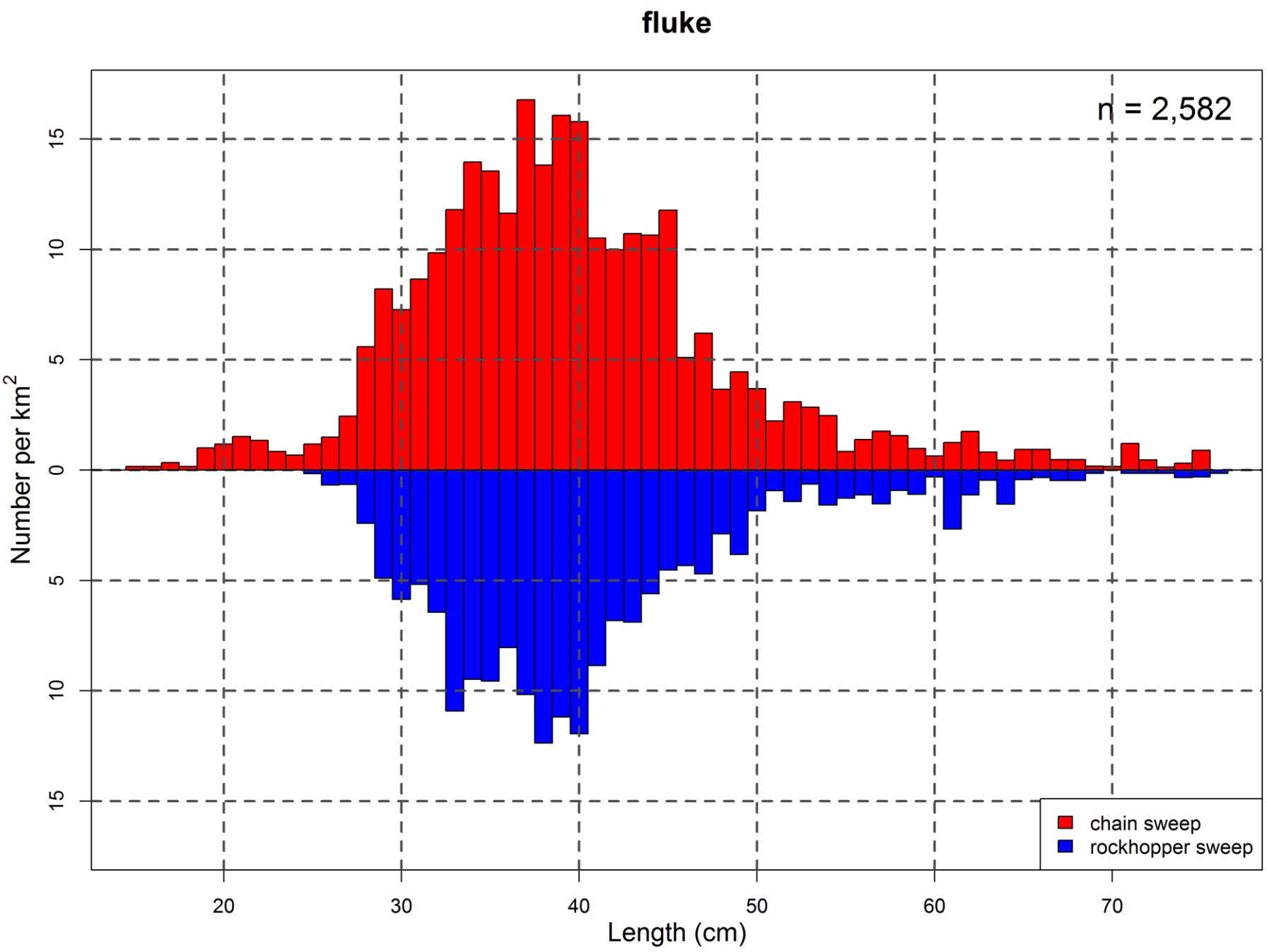

winter flounder
Relative Catch Efficiency
(Chain/Rockhopper)
0
2
4
6
8
10
20
25
30
35
40
45
50
Length (cm)

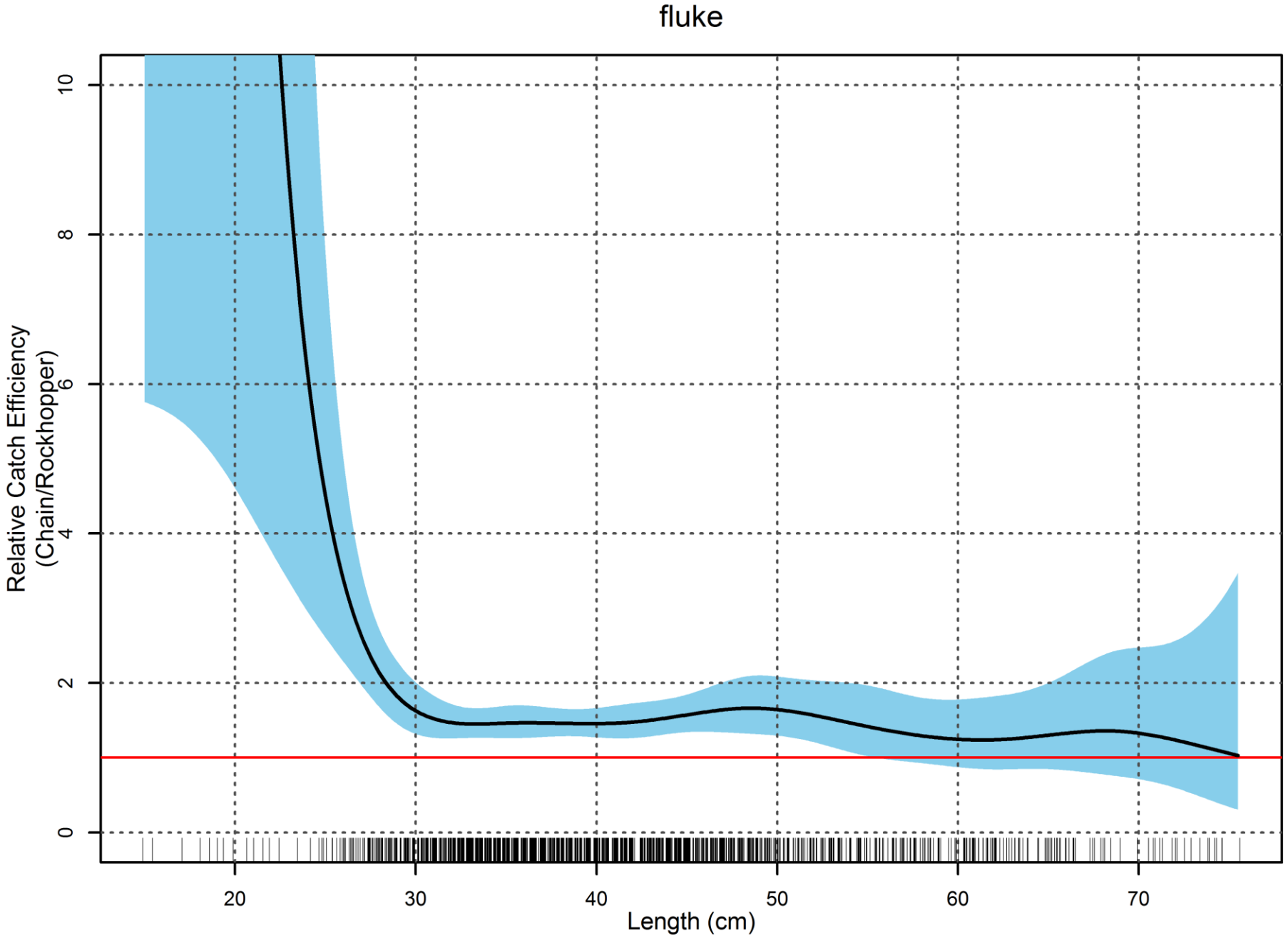

winter flounder - night
n = 950
Number per km2
Length (cm)
chain sweep
rockhopper sweep

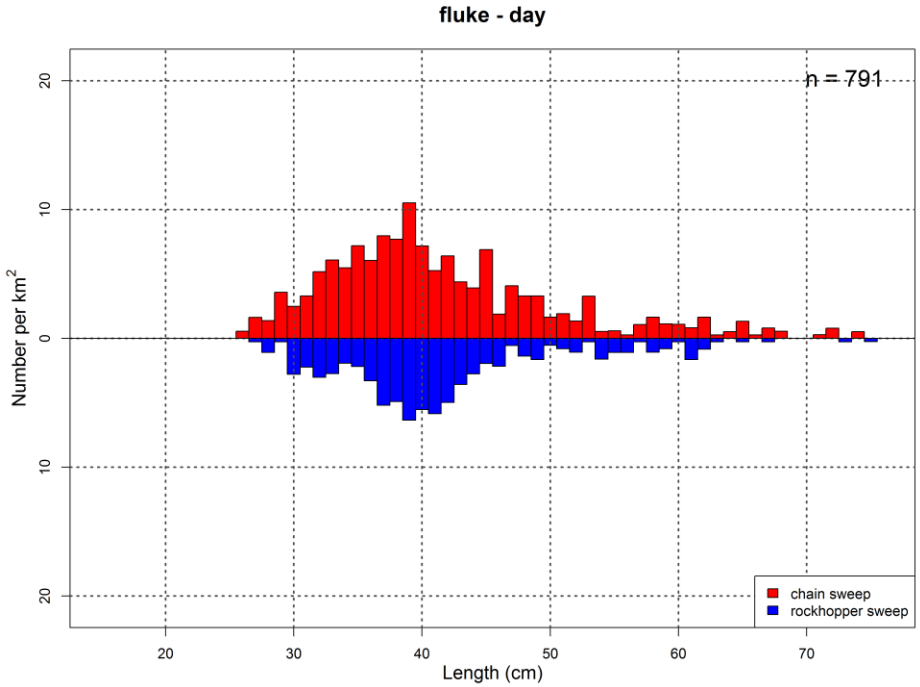

winter flounder - night
n = 950
Number per km2
Length (cm)
chain sweep
rockhopper sweep

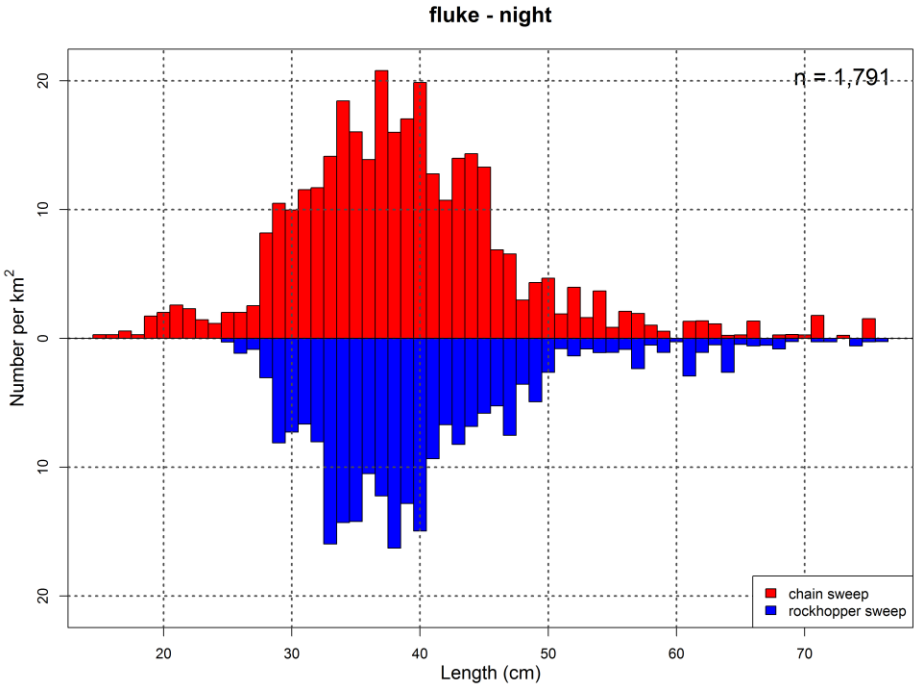

winter flounder - day
Relative Catch Efficiency
(Chain/Rockhopper)
Length (cm)

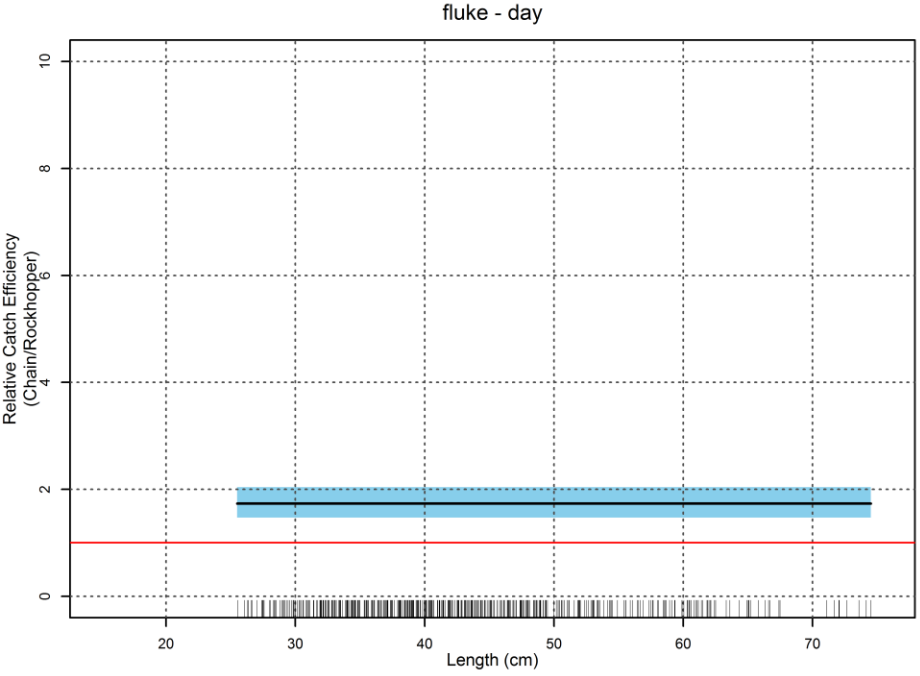

winter flounder - night
Relative Catch Efficiency
(Chain/Rockhopper)
Length (cm)

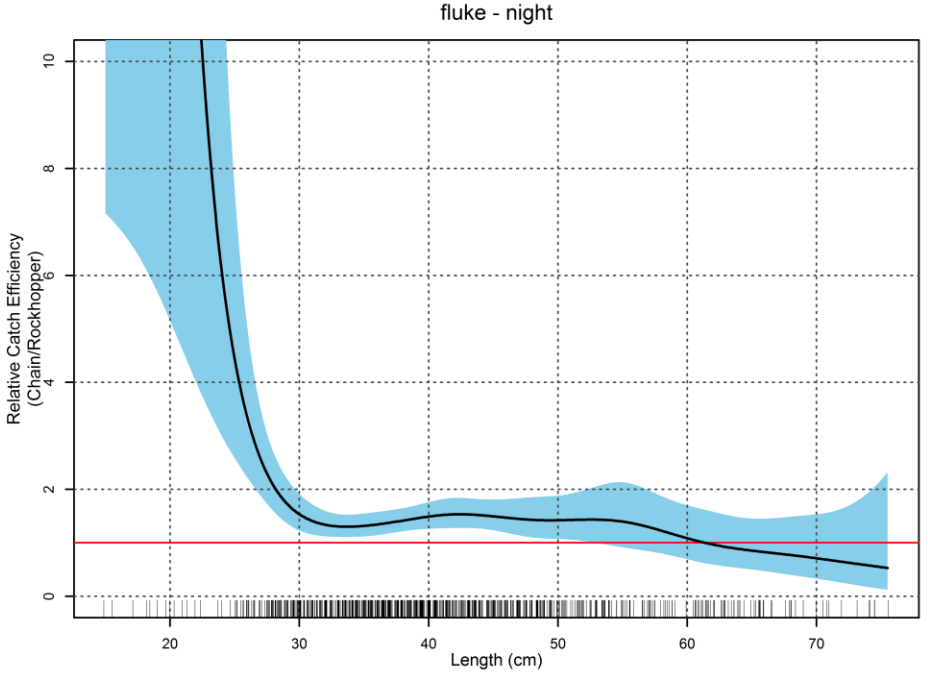

fluke
n = 2,582
Number per km2
15
10
5
0
5
10
15
20
30
40
50
60
70
Length (cm)
chain sweep
rockhopper sweep

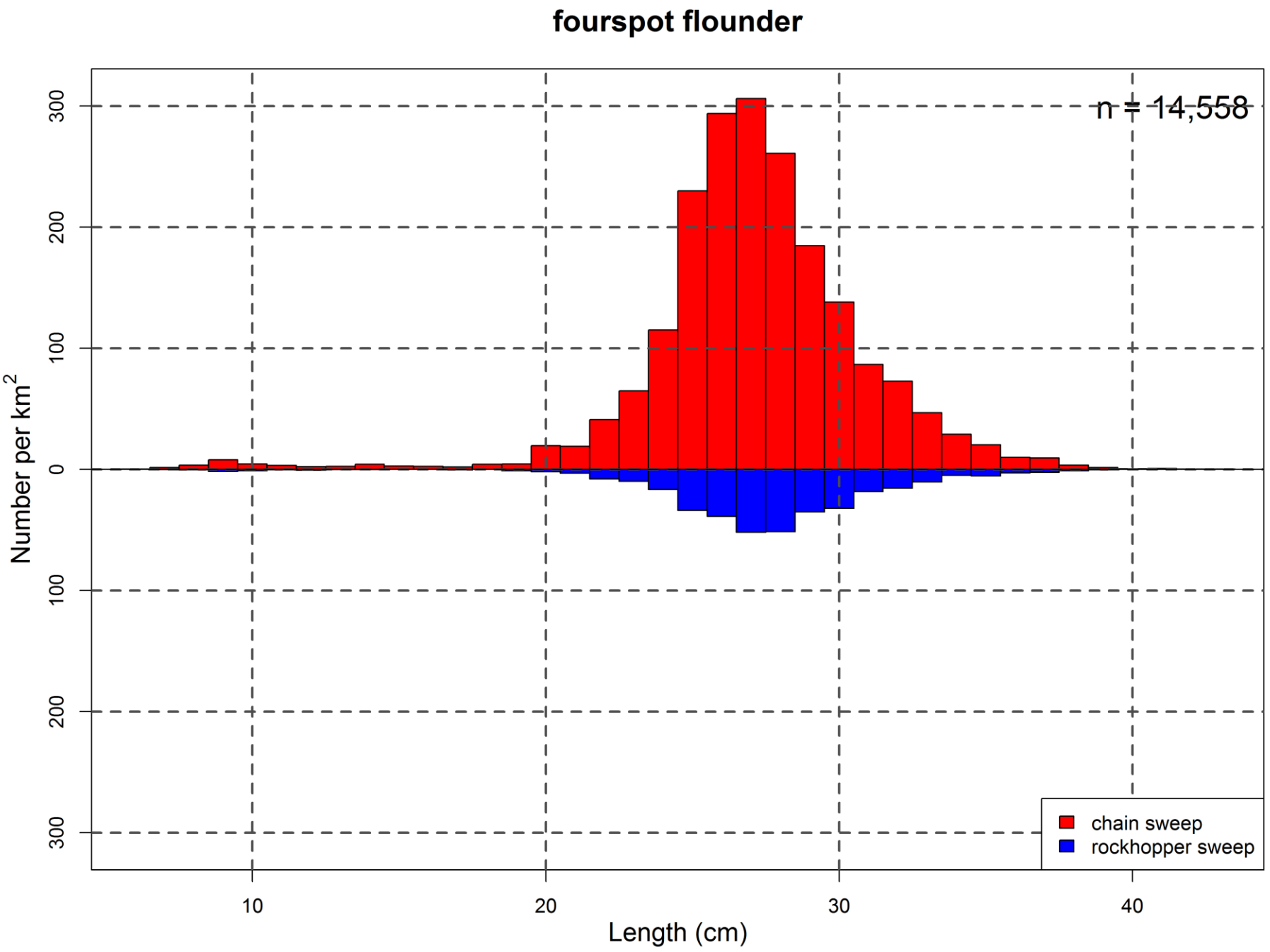

fluke
Relative Catch Efficiency
(Chain/Rockhopper)
0
2
4
6
8
10
20
30
40
50
60
70
Length (cm)

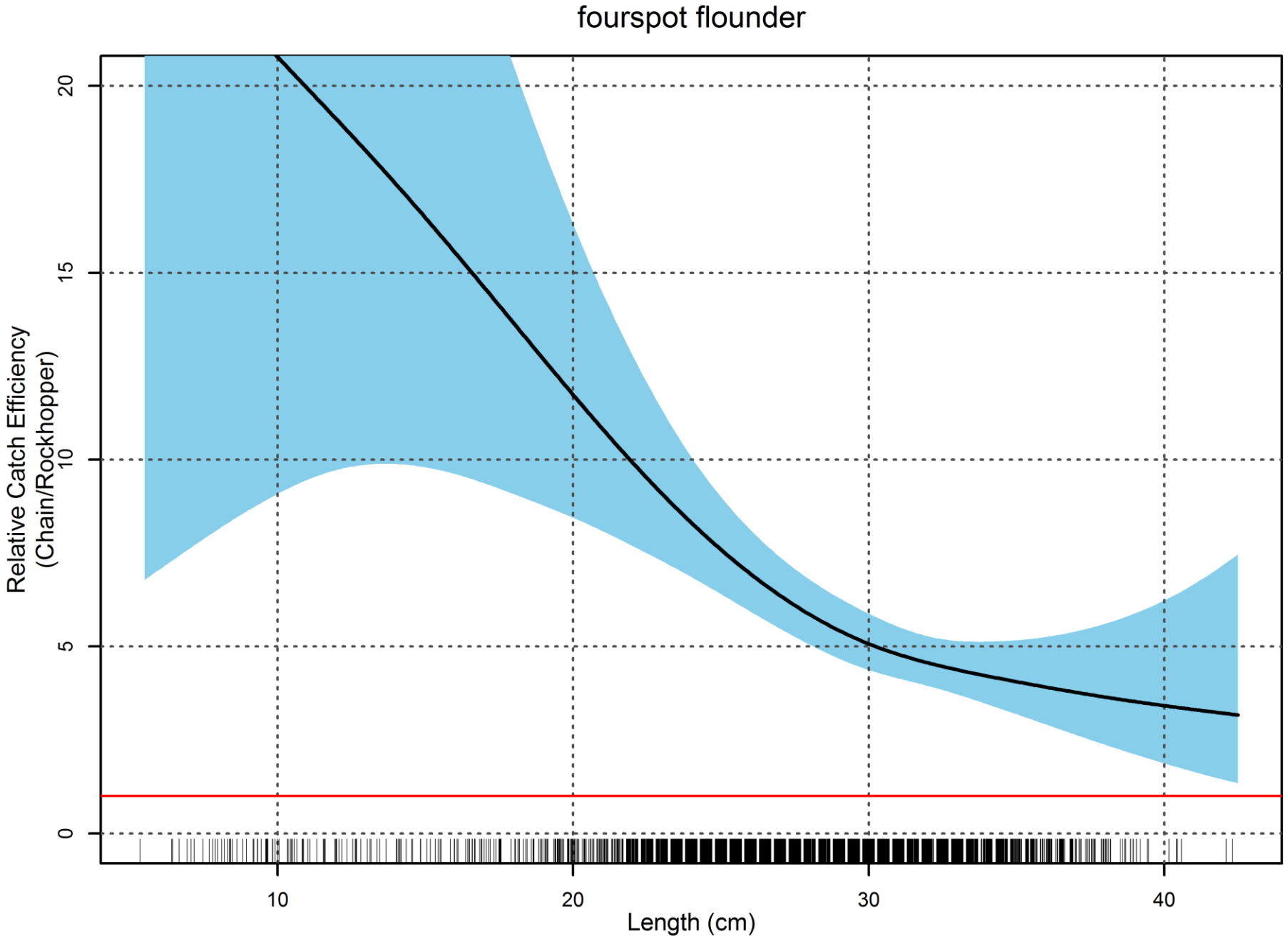

fluke - day
n = 791
Number per km2
Length (cm)
chain sweep
rockhopper sweep

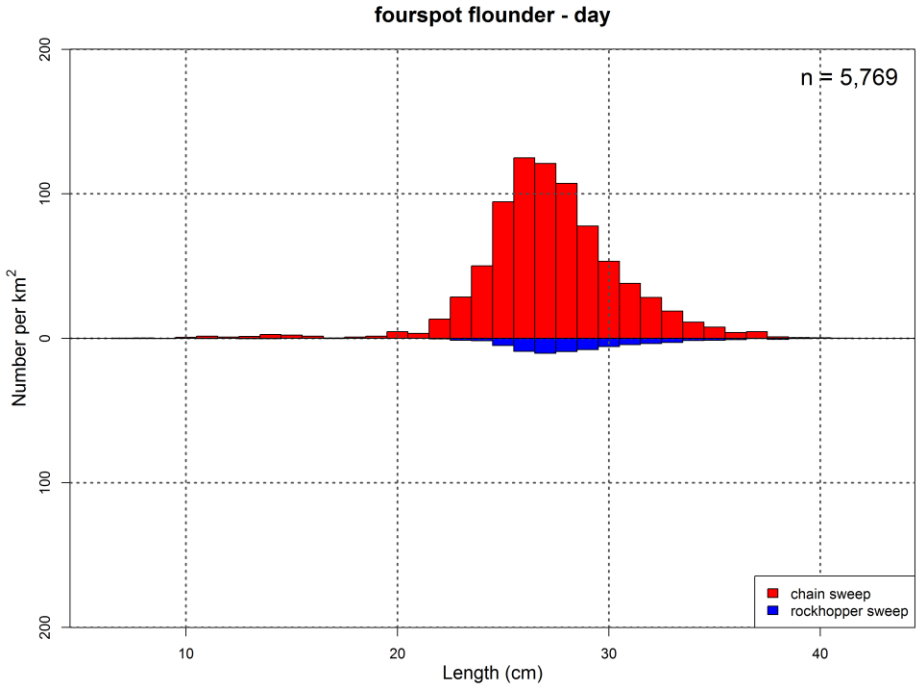

fluke - night
n = 1,791
Number per km2
Length (cm)
chain sweep
rockhopper sweep

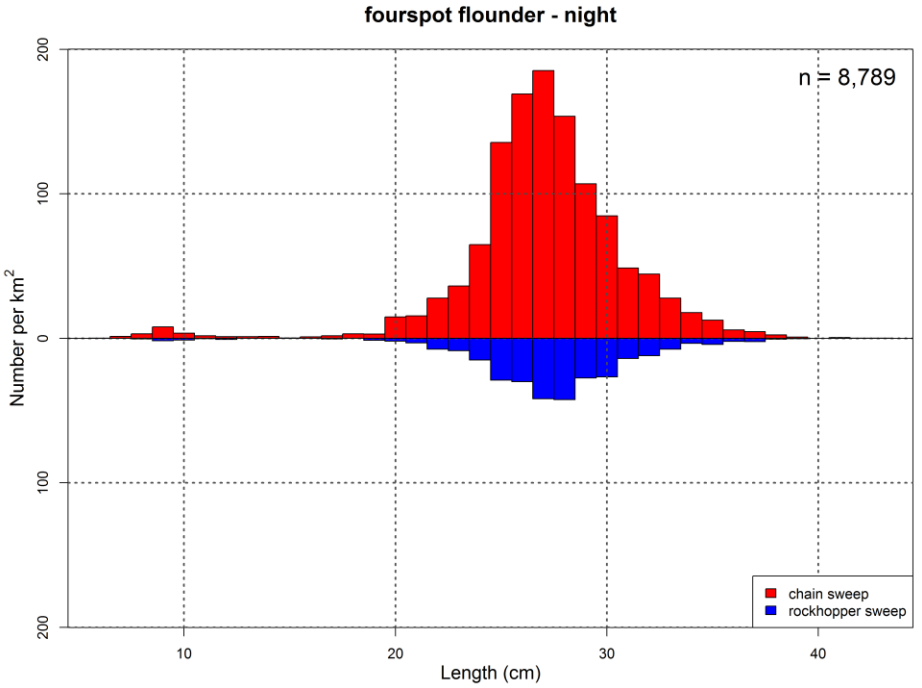

fluke - day
Relative Catch Efficiency
(Chain/Rockhopper)
Length (cm)

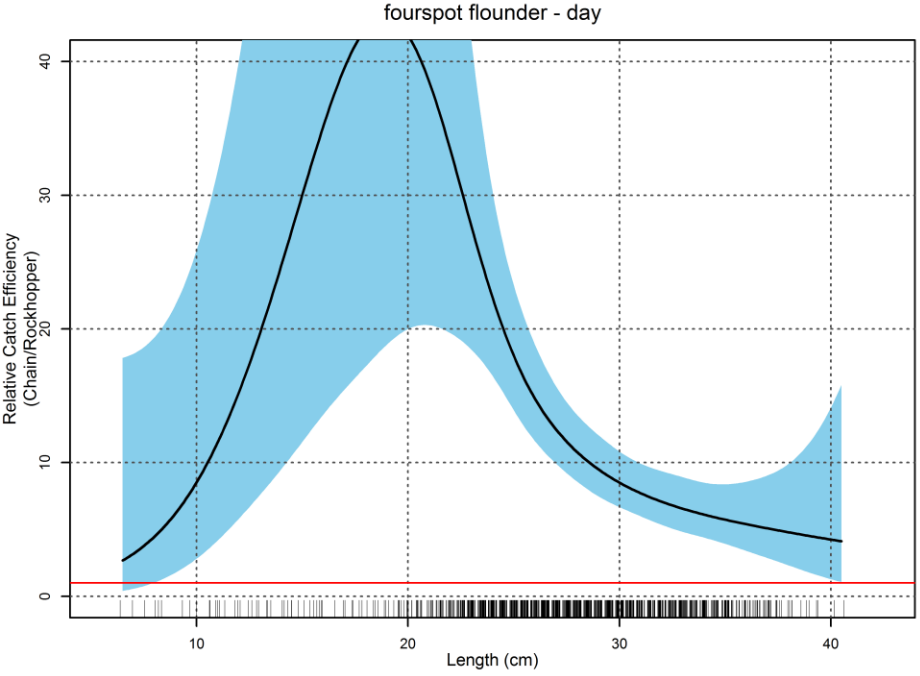

fluke - night
Relative Catch Efficiency
(Chain/Rockhopper)
Length (cm)

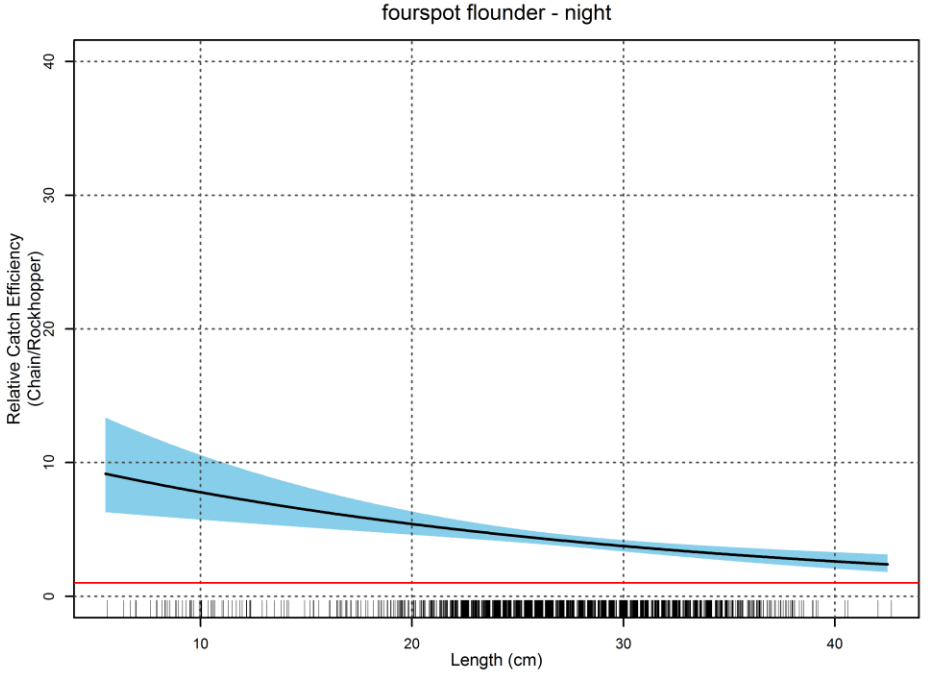

fourspot flounder
n = 14,558
Number per km2
300
200
100
0
100
200
300
10
20
30
40
Length (cm)
chain sweep
rockhopper sweep

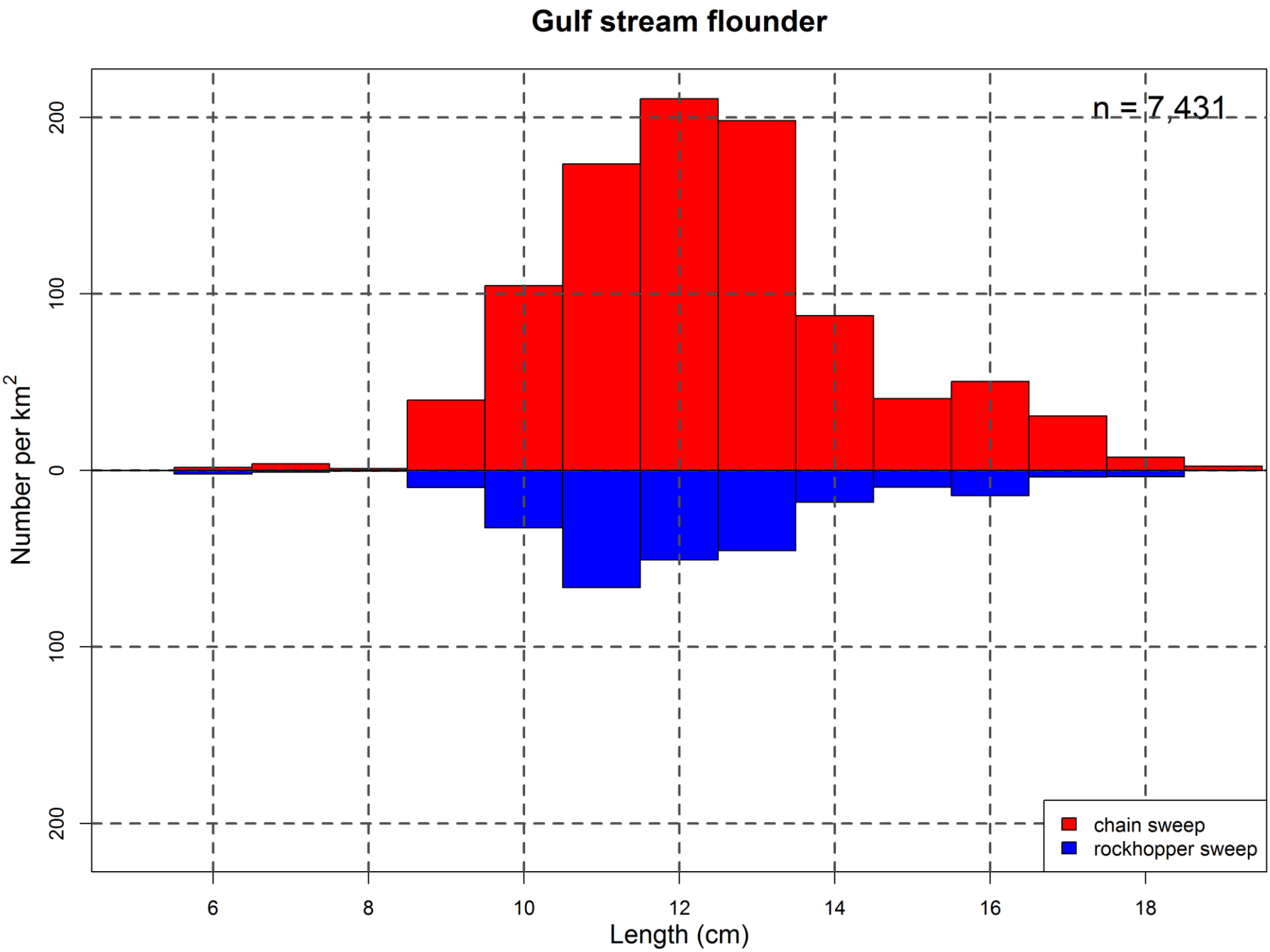

fourspot flounder
Relative Catch Efficiency
(Chain/Rockhopper)
0
5
10
15
20
10
20
30
40
Length (cm)

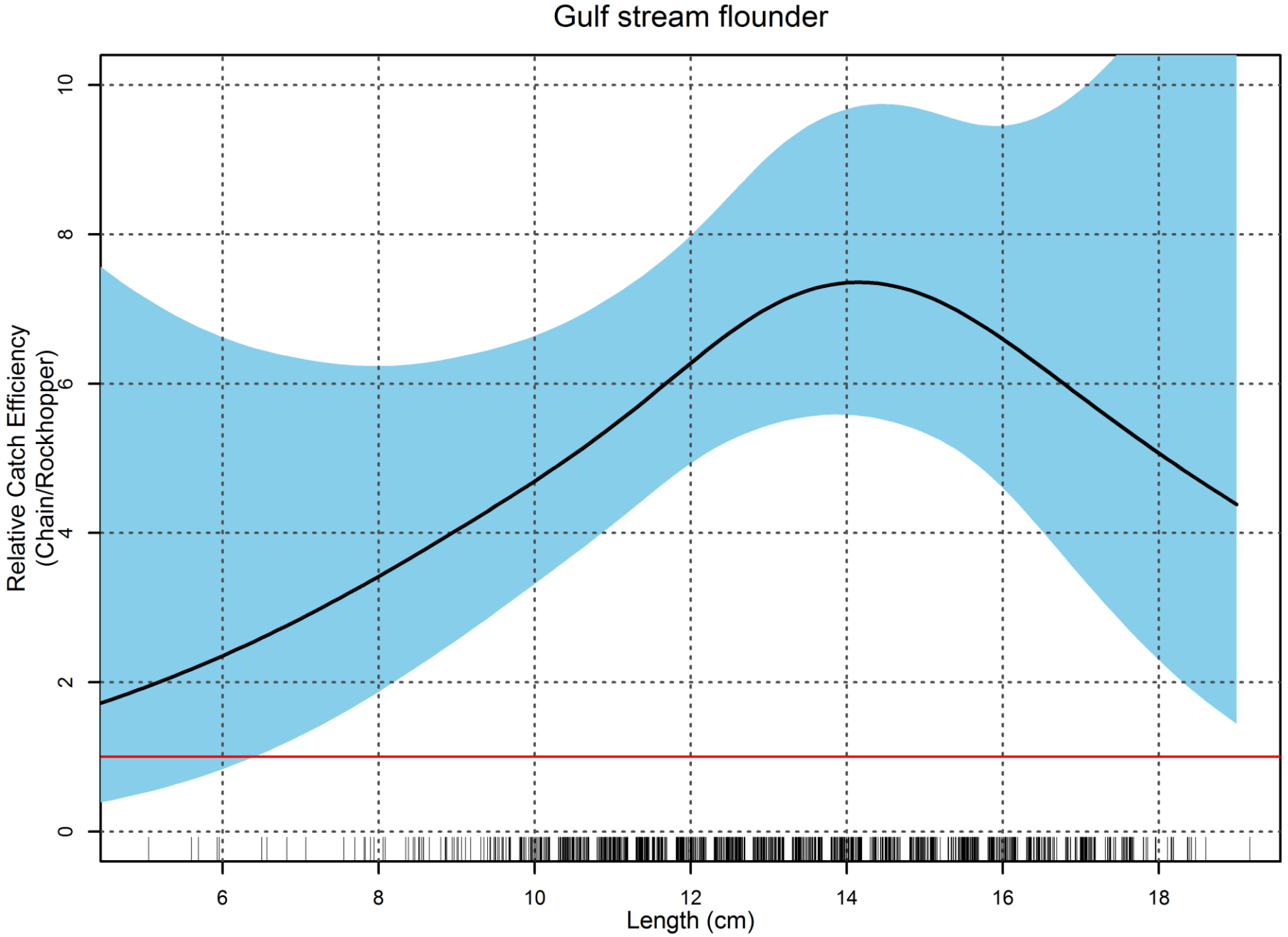

fourspot flounder - day
n = 5,769
Number per km2
Length (cm)
chain sweep
rockhopper sweep

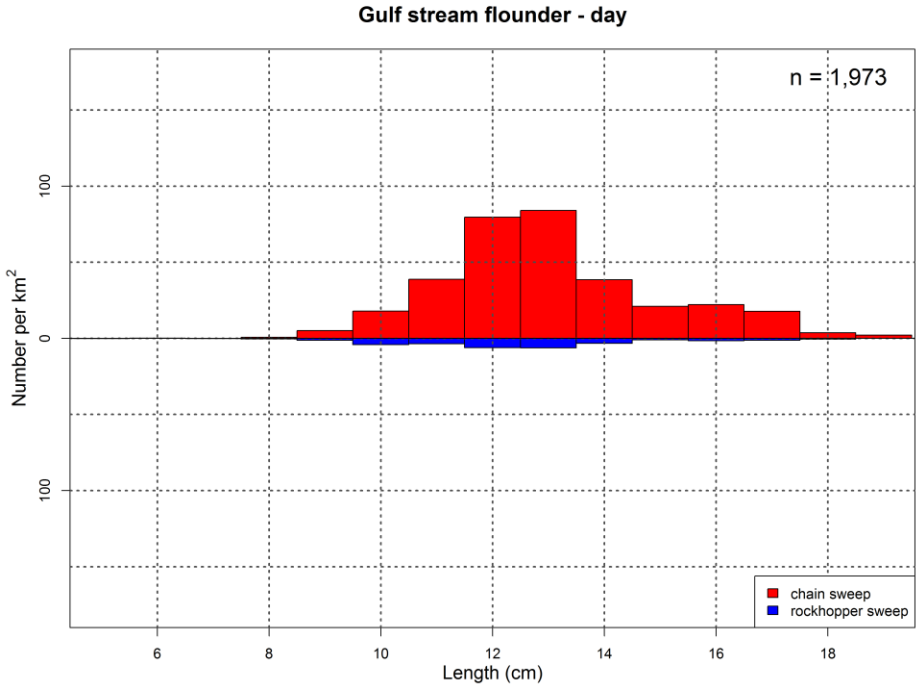

fourspot flounder - night
n = 8,789
Number per km2
Length (cm)
chain sweep
rockhopper sweep

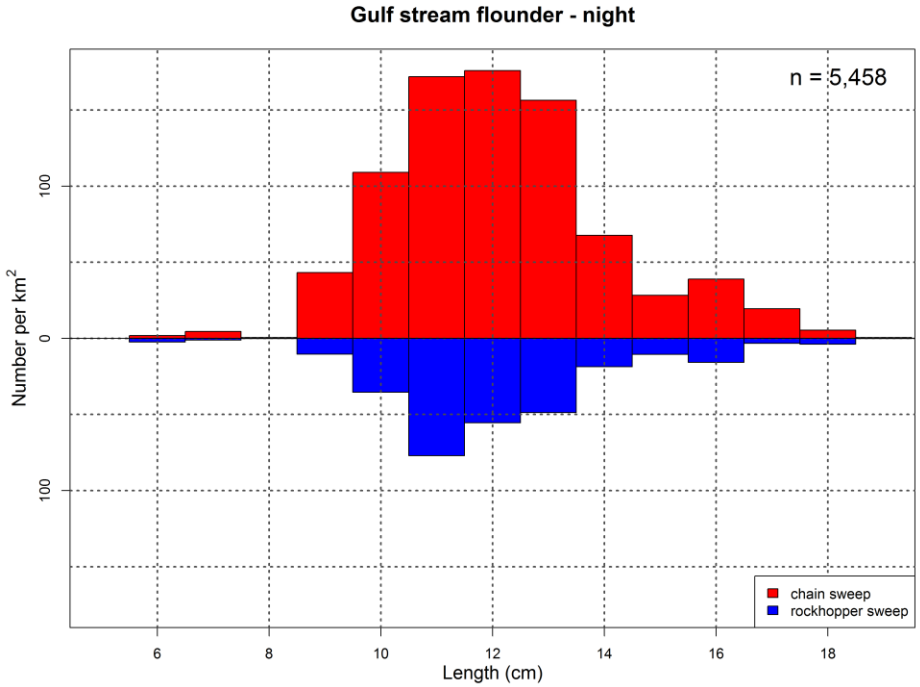

fourspot flounder - day
Relative Catch Efficiency
(Chain/Rockhopper)
Length (cm)

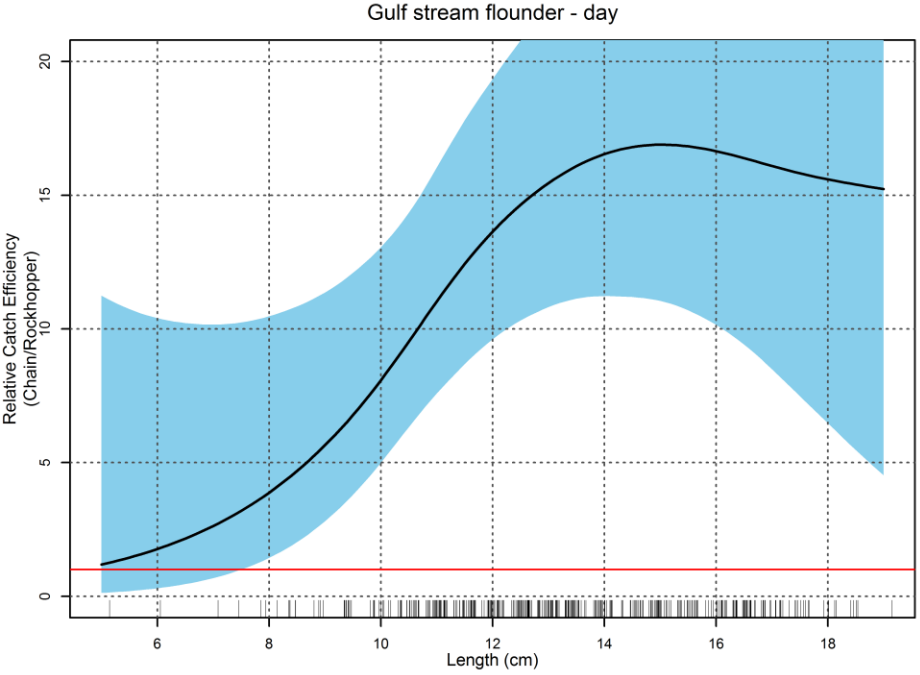

fourspot flounder - night
Relative Catch Efficiency
(Chain/Rockhopper)
Length (cm)

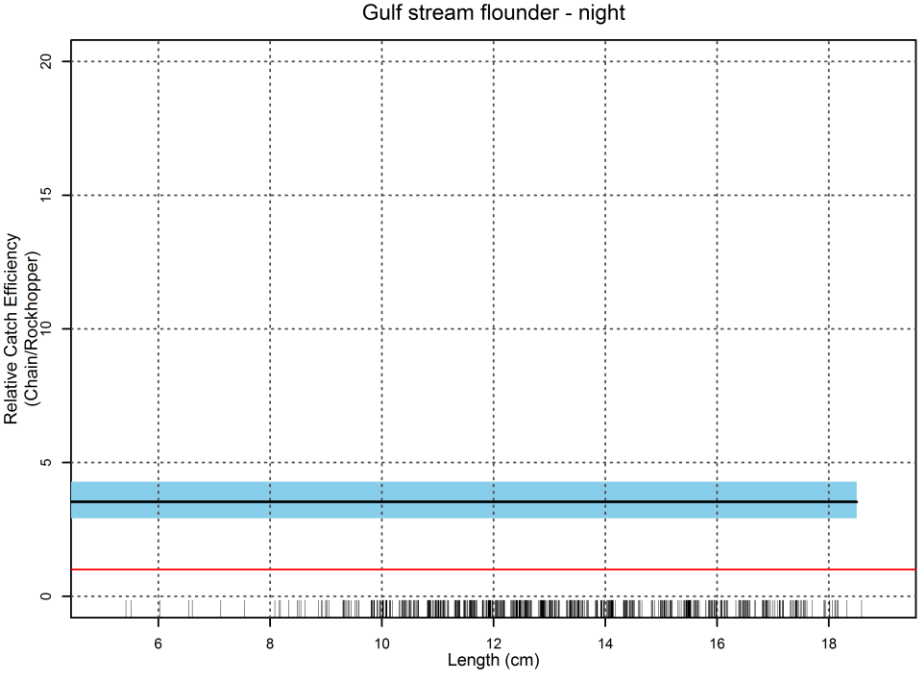

Gulf stream flounder
n = 7,431
Number per km2
200
100
0
100
200
6
8
10
12
14
16
18
Length (cm)
chain sweep
rockhopper sweep

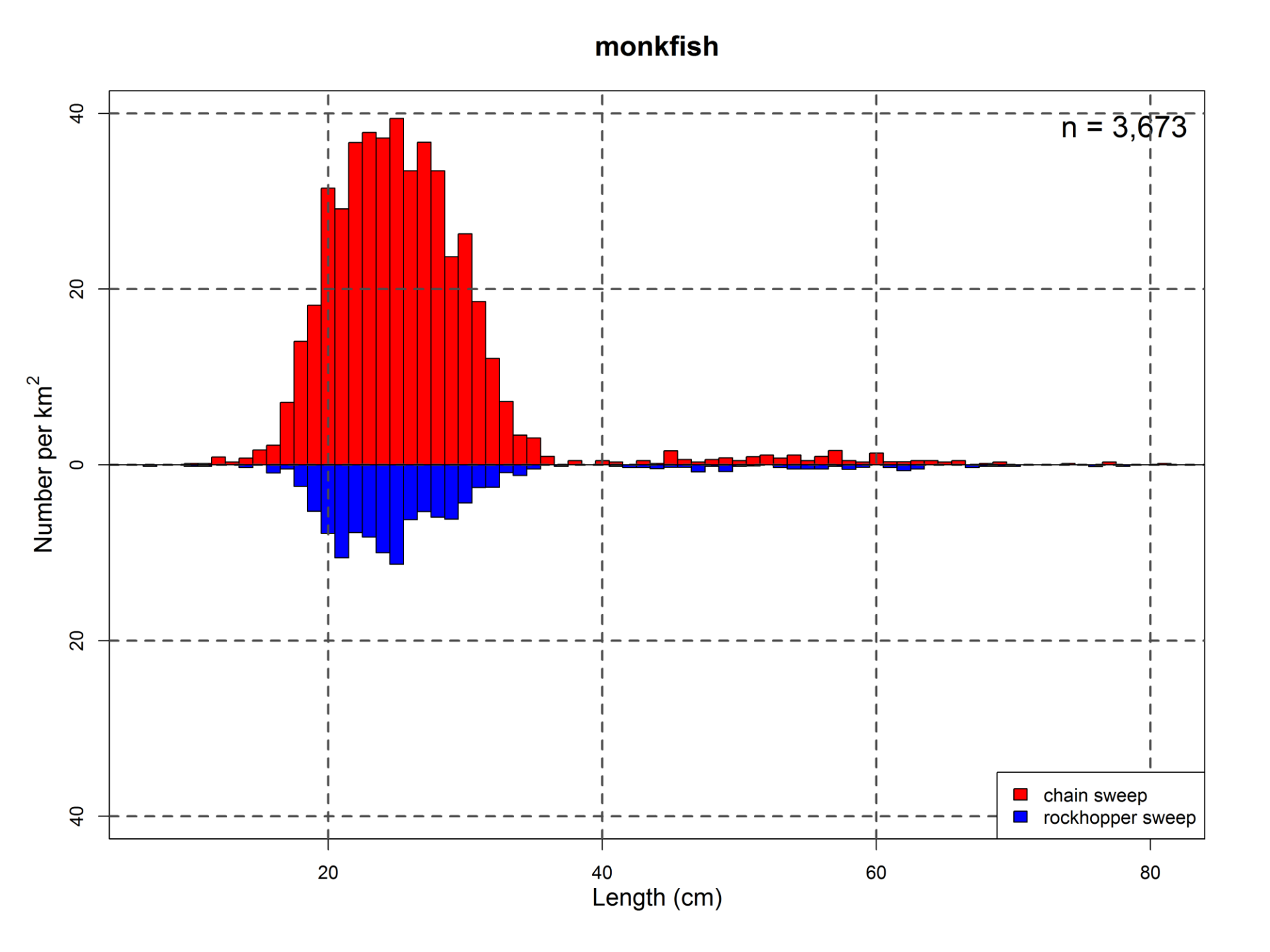

Gulf stream flounder
Relative Catch Efficiency
(Chain/Rockhopper)
0
2
4
6
8
10
6
8
10
12
14
16
18
Length (cm)

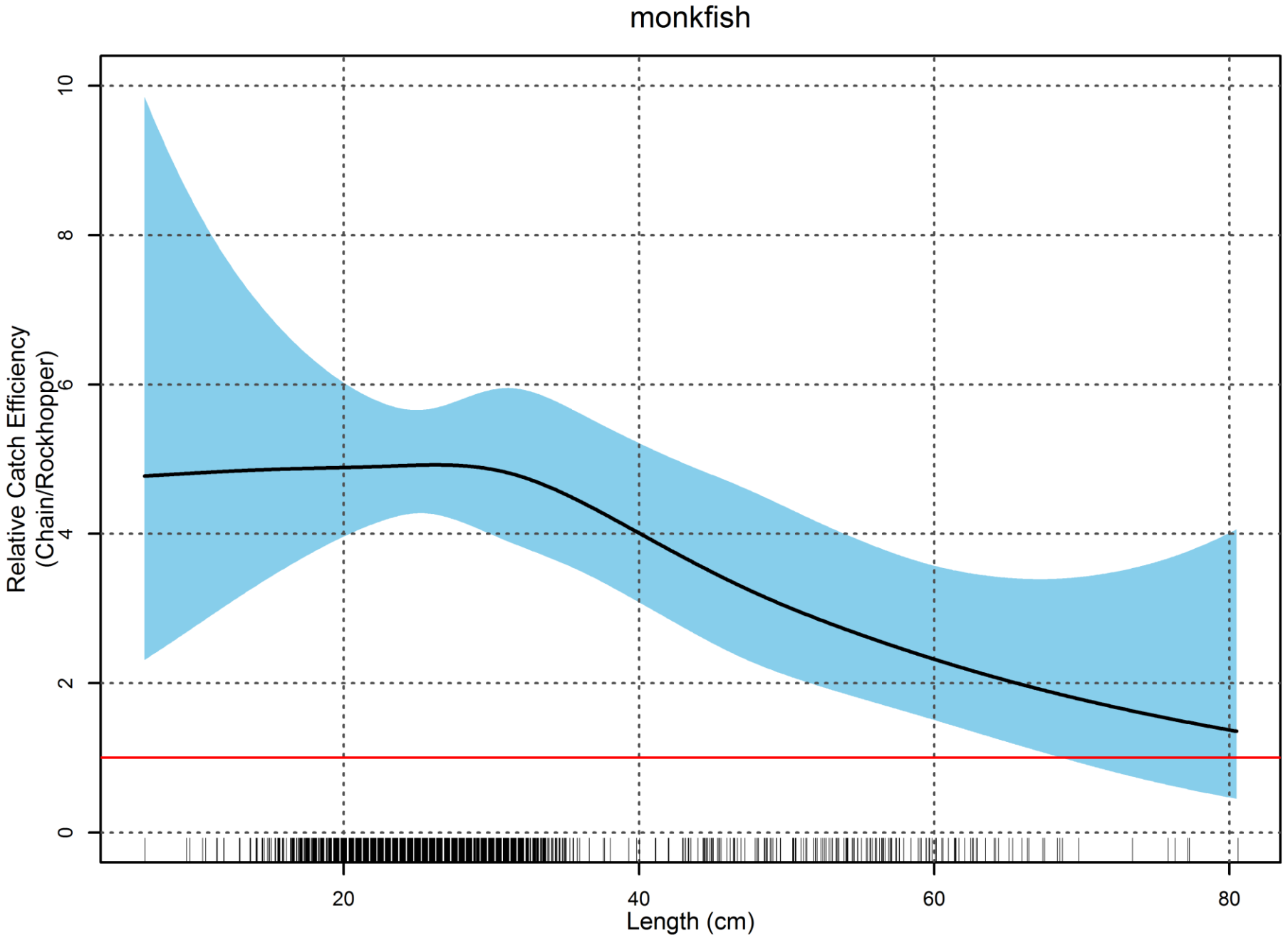

Gulf stream flounder - day
n = 1,973
Number per km2
100
0
100
chain sweep
rockhopper sweep
6
8
10
12
14
16
18
Length (cm)

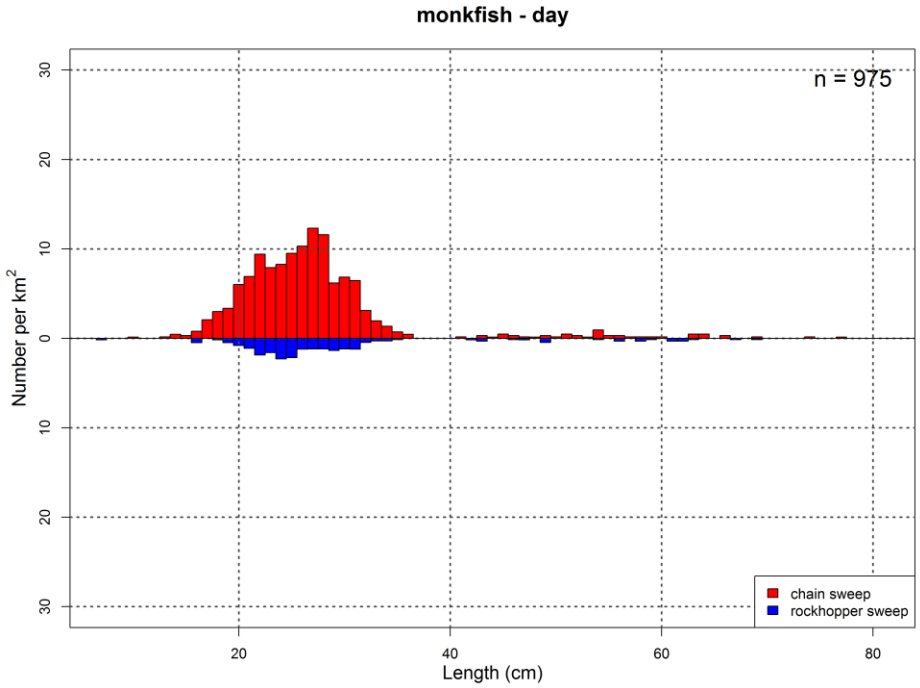

Gulf stream flounder - night
n = 5,458
Number per km2
100
0
100
chain sweep
rockhopper sweep
6
8
10
12
14
16
18
Length (cm)

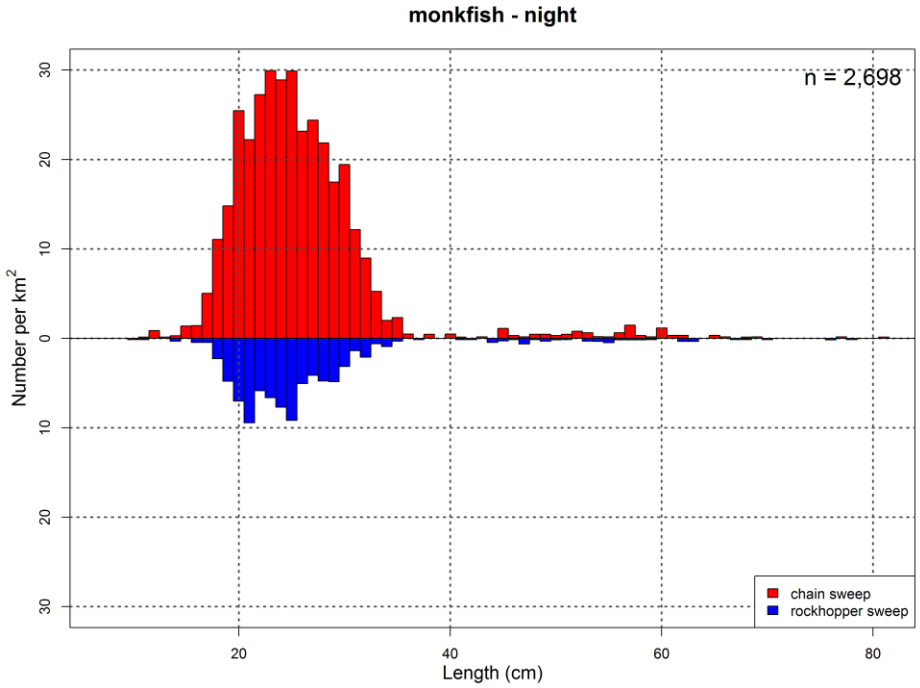

Gulf stream flounder - day
Relative Catch Efficiency
(Chain/Rockhopper)
0
5
10
15
20
6
8
10
12
14
16
18
Length (cm)

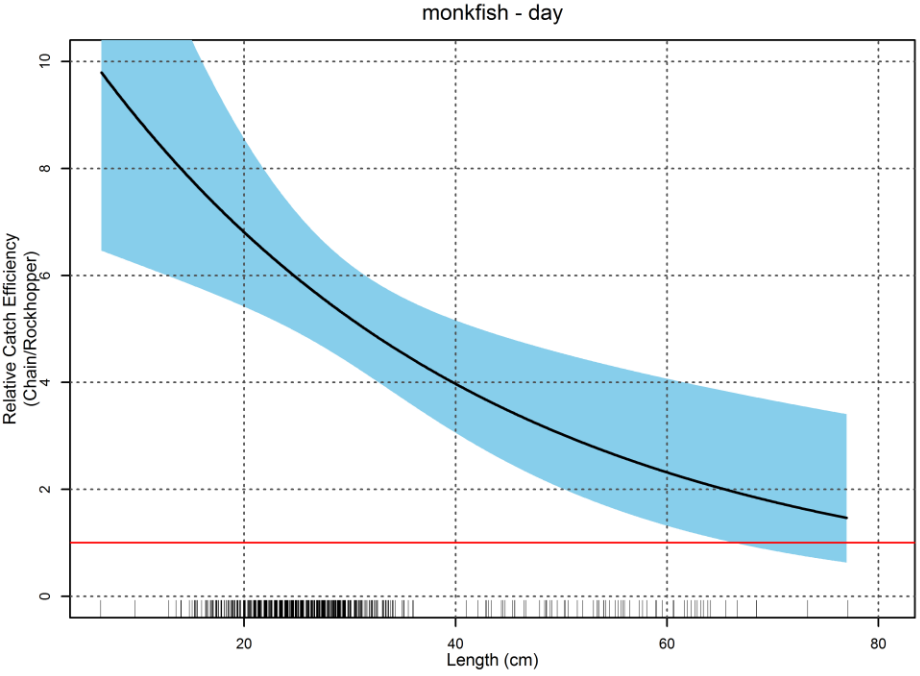

Gulf stream flounder - night
Relative Catch Efficiency
(Chain/Rockhopper)
0
5
10
15
20
6
8
10
12
14
16
18
Length (cm)

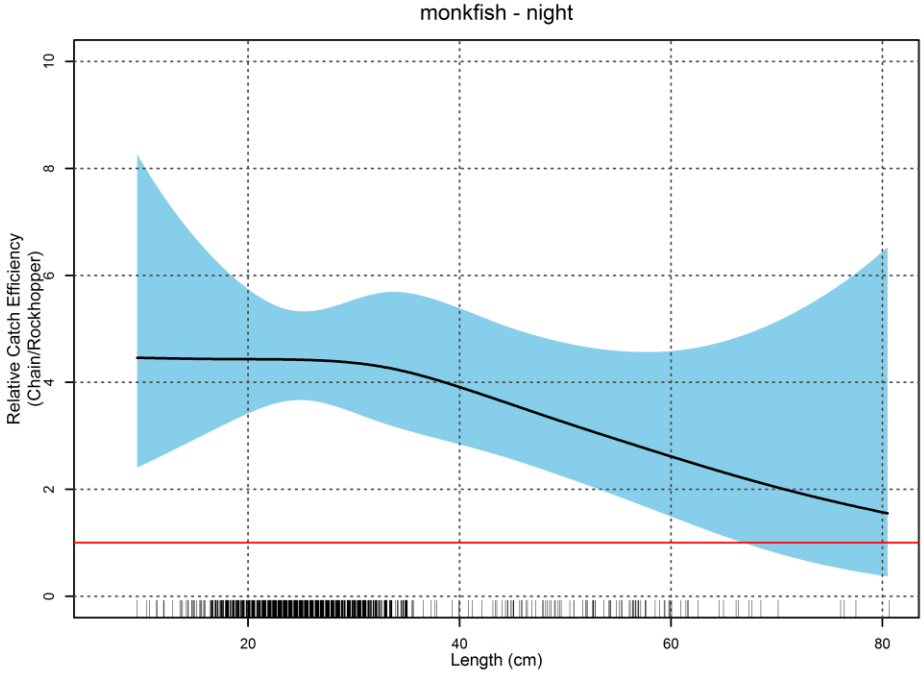

monkfish
n = 3,673
Number per km2
40
20
0
20
40
20
40
60
80
Length (cm)
chain sweep
rockhopper sweep

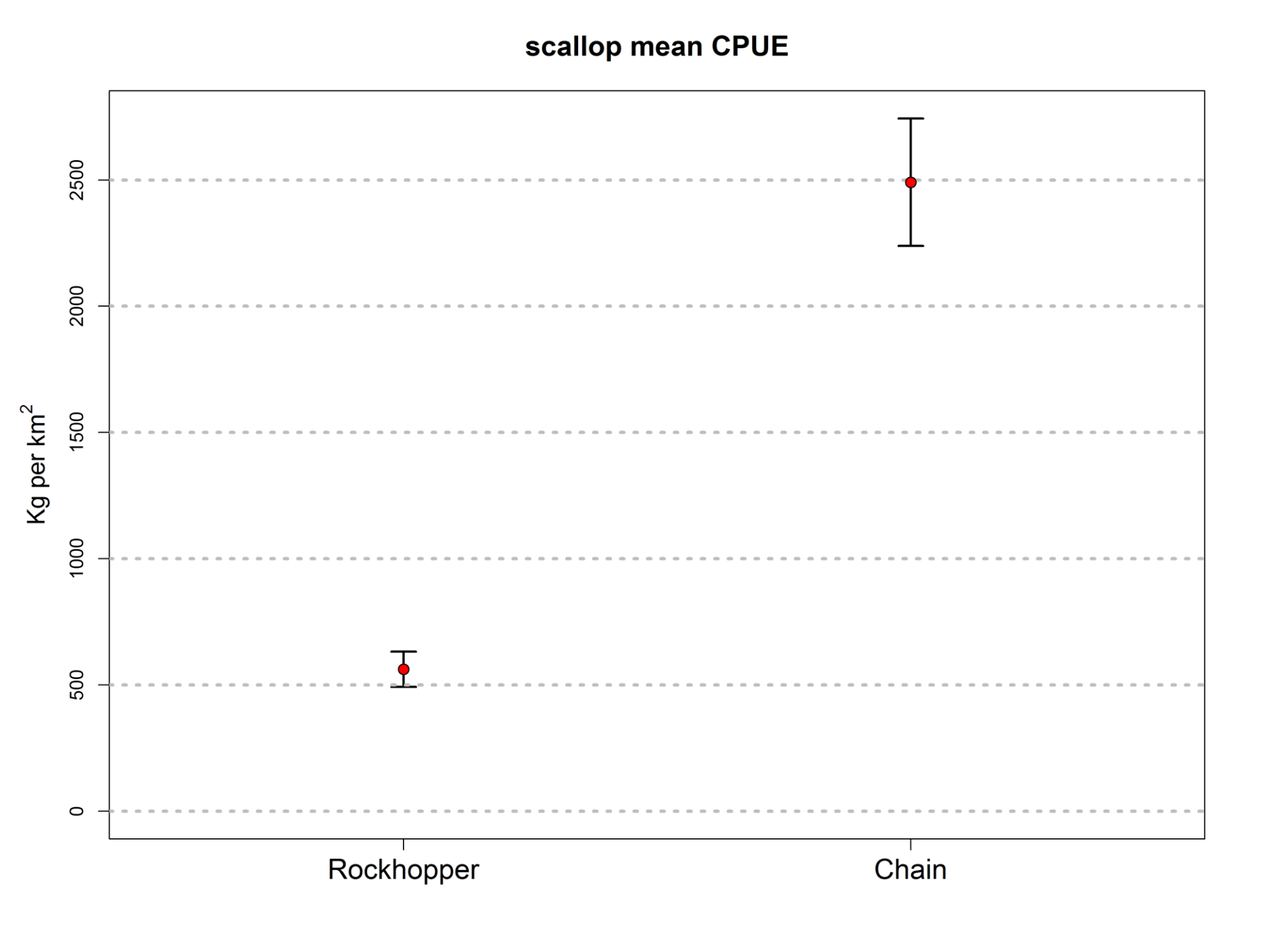

monkfish
Relative Catch Efficiency
(Chain/Rockhopper)
0
2
4
6
8
10
20
40
60
80
Length (cm)

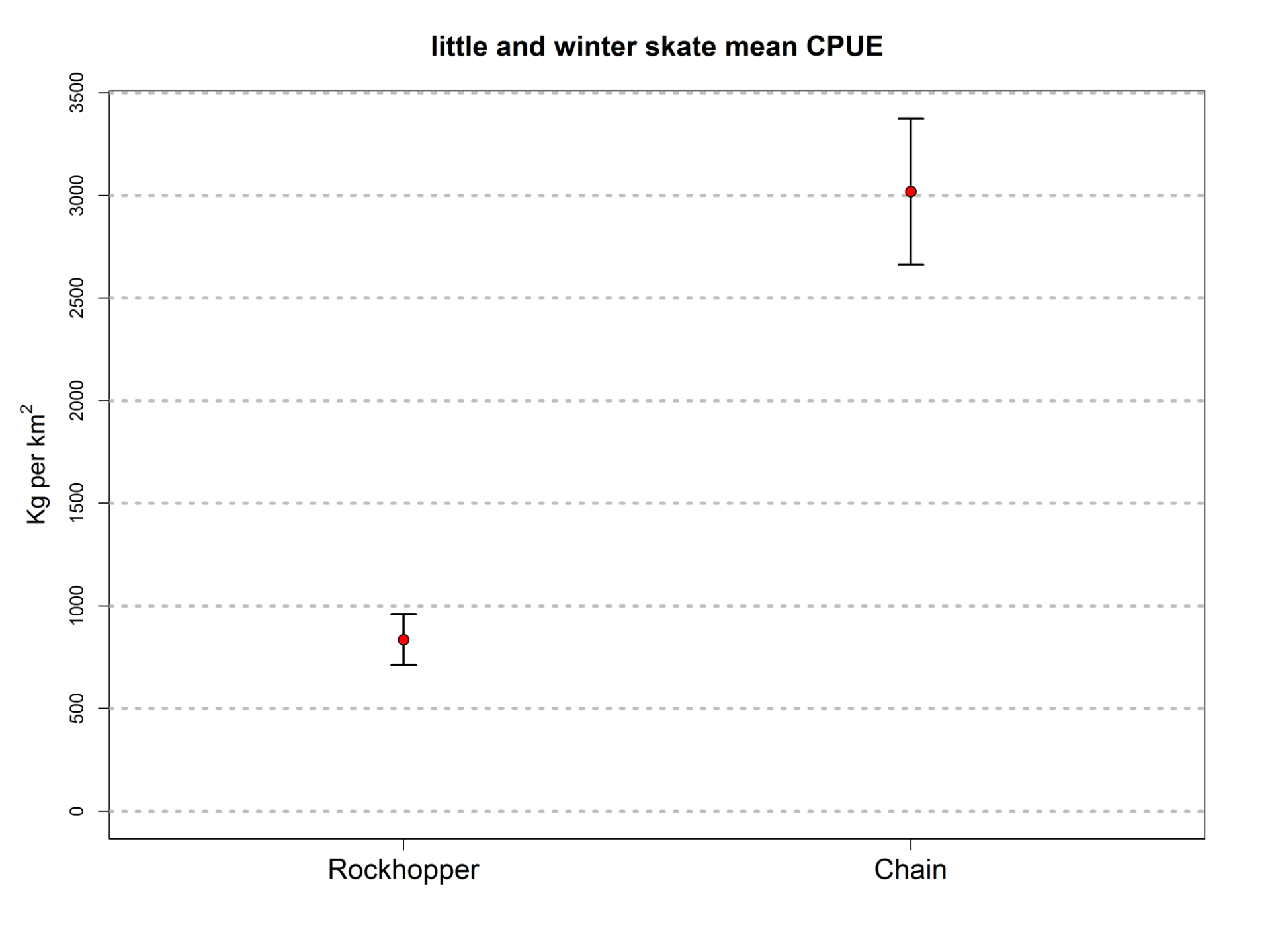

monkfish - day
n = 975
Number per km2
Length (cm)
chain sweep
rockhopper sweep


monkfish - night
n = 2,698
Number per km2
Length (cm)
chain sweep
rockhopper sweep


monkfish - day
Relative Catch Efficiency
(Chain/Rockhopper)
Length (cm)


monkfish - night
Relative Catch Efficiency
(Chain/Rockhopper)
Length (cm)


scallop mean CPUE
Kg per km2
0
500
1000
1500
2000
2500
Rockhopper
Chain


little and winter skate mean CPUE
Kg per km2
0
500
1000
1500
2000
2500
3000
3500
Rockhopper
Chain

Caveats

- Results may not be generally applicable
  - Study conducted on sand/mud bottoms only
  - Some portion of current survey area currently trawlable with rockhopper sweep would not be trawlable with chain sweep (fraction uncertain)
  - Environmental differences may affect fish behavior and relative efficiency
    - Ambient light
    - Temperature
    - Density-dependence

Future Work

- Analyze all previously collected gear efficiency data using same methods
  - Develop efficiency indices for rockhopper/cookie/chain where possible
  - Publish results to ensure wide dissemination and availability
  - Identify areas where further research may be needed
    - Other seafloor types
    - Different environmental conditions
    - Behavioral components (e.g., density dependence)

Questions?