Gear Selectivity of Red Snapper (*Lutjanus campechanus*) Obtained by Southeast Reef Fish Survey Sampling in Atlantic Waters from North Carolina to Florida

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SEDAR90-DW-06

April 2025

Please cite this document as:

Bubley, Walter, Homer Hiers and Julie Vecchio. 2025. Gear Selectivity of Red Snapper (*Lutjanus campechanus*) Obtained by Southeast Reef Fish Survey Sampling in Atlantic Waters from North Carolina to Florida. SEDAR90-DW-06. SEDAR, North Charleston, SC. 13 pp.

Gear Selectivity of Red Snapper (*Lutjanus campechanus*) Obtained by Southeast Reef Fish Survey Sampling in Atlantic Waters from North Carolina to Florida

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MARMAP/SEAMAP-SA Reef Fish Survey Technical Report #2025-10

Background

The South Carolina Department of Natural Resources (SCDNR) Marine Resources Monitoring, Assessment, and Prediction program (MARMAP) has been performing a standardized, multi-species, fishery-independent survey using chevron traps since 1990. In 2009, MARMAP was augmented by the Southeast Area Monitoring and Assessment Program-South Atlantic (SEAMAP-SA) and in 2010 with the initiation of the National Marine Fishery Service (NMFS) Southeast Fishery-Independent Survey (SEFIS). These three programs are collectively referred to as the Southeast Reef Fish Survey (SERFS). As part of the collaborative effort with SEFIS, video cameras were attached to all chevron traps to create the standardized trap-video survey. Measuring fish length using the standard video cameras used by SERFS (single video cameras) was not possible, so length/age compositions were borrowed from the trap catch data for the video data when developing indices of abundance.

All fishing gears are inherently selective due to physical limitations of the gear and decisions made by researchers, such as when to measure fish in videos. Selectivity curves are used in stock assessment models to quantify the probability that a given length or age class of a given fish species will be captured, assuming it is available to the gear. Because of potential differential gear selectivity, there were concerns regarding whether a selectivity curve from one gear (chevron trap) can be applied to a completely different gear (video camera). A study by Christiansen et al. (2022) began to examine this issue by utilizing stereo-cameras, which can obtain length measurements using the parallax between concurrently collected images, paired with trap gear in Atlantic waters off Florida in 2016. Because the SERFS chevron trap-video survey occurs throughout the Atlantic waters off the southeastern US covering 4 states, SCDNR followed similar methodology, but over a larger spatial and temporal window, to characterize selectivity of several gears, including chevron traps and stereo-video cameras. This allowed a direct comparison of Red Snapper lengths caught in traps deployed during the survey to those seen on stereo-camera collected videos affixed to those same traps, which can be used to characterize selectivity between gears for use in the SEDAR90-Red Snapper assessment.

Methods

<u>Equipment Description</u>

- Chevron Traps are "A" shaped traps with dimensions described by (Collins, 1990). The trap mouth opening was approximately 18 cm wide and 45 cm tall and shaped like an upside-down teardrop. The traps are baited with a total of 24 whole *Brevoortia sp*. strung from top to bottom of the trap or tossed in loose. Chevron traps were deployed for approximately 90 minutes (Smart et al., 2015).
- Stereo-video units used in this study consist of two SeaGIS "Aluminum Base Bar System: Narrow Separation" stereo-video units. Each stereo-video unit included a SeaGIS housing containing two GoPro Hero 9 action cameras, and two external battery packs, one attached to each GoPro camera. The GoPro Hero 9 has a wide-angle lens with an approximate underwater field of view of 3.5 m width at 2 m distance. Each camera was set to record in *1080p* and 30 frames per second with the field of view set to "*wide"*. The distance between the centers of the two GoPro lenses is 355 mm in the assembled housing.

Field Methods

- Stereo-video units were deployed on 1/3 of traps deployed by SCDNR during the 2022 and 2023 SERFS fishery-independent sampling season.
    - All chevron traps were standard for SERFS and deployed in accordance with field protocols, including 90-minute deployments on pre-selected randomly assigned stations (Smart et al., 2015).
- All physically collected specimens were brought aboard the vessel and measured in mm for maximum total length (TL), fork length (FL), and standard length.
- All stereo-video recordings were downloaded from the memory cards and saved to external hard drives for later observation.

Video Analysis

- The videos were analyzed for Red Snapper abundance using the MinCount/MaxN method (Campbell et al. 2015).
    - Video reads began 10 minutes after the trap/stereo-video unit landed on the bottom.
        - From this point, the video was watched for 20 minutes and the maximum number of individuals observed on-screen during one frame, was considered the number of Red Snapper (MaxN) for the deployment.
            - This ensures that no fish are measured or counted more than once.

Stereo-video Measurement Calibration

- Five confined water calibration sessions were completed for each stereo-video camera unit over the course of the project (pre-2022, post-2022, pre-2023, mid-2023, and post-2023).
    - During each calibration session, video of an anodized aluminum rectangular prism (calibration cube) was recorded.
        - The dimensions of the calibration cube were 1000 x 1000 x 500 mm, and it was positioned 1.5 meters from the cameras and centered in the field of view of both GoPro cameras within the same stereo-video unit.
    - The stereo-video unit and calibration cube were submerged in a saltwater pool at a depth of 1.2 meters for the duration of the calibration filming.
        - Repeatable stereo-video unit and calibration cube positioning was achieved using a PVC positioning template (Fig. 1).
        - Calibration by means of photogrammetric bundle adjustment were completed in SeaGIS CAL software following the standard calibration protocol for CAL 4.0 (SeaGIS 2021).

Stereo-video Measuring

- For each individual video during which fish were measured, the calibration file from the calibration closest in time to the field collection (always within the same sampling season) was utilized.
- A midline length (equivalent to FL) measurement was made using EventMeasure software (SeaGIS 2021) for recorded observations.
    - Specific criteria must be met in order for measuring of individuals to take place.
        - The end of the snout and the fork of the tail of each individual must be visible in concurrent left and right frames.
        - Preference was given to times when fish that were centered in the screen, within three meters of the camera, and turned perpendicular to the lenses.
- Numbers of measured fish never exceeded MaxN but may have been lower than MaxN due to the difficulty of measuring every fish in the frame.
- The decision of what time within the video to measure individual Red Snapper was made using the following hierarchy:
    - If any number of fish were measurable at the time when MaxN was observed, those fish were measured.
    - If no fish were measurable at the time of MaxN, an alternate time was found during the read to measure individuals in view.
        - Recorded instances of Red Snapper were evaluated in order from those with the highest number of individuals to those with the least number of individuals observable until an instance occurred during which at least one individual could be measured. Once at least one individual was measured, the procedure was stopped for that video.

Data Analysis

- Lengths
    - FL measurements from stereo-video camera length measurements were converted to maximum TL to comply with the unit decisions for SEDAR90 using the meristic conversion equation developed for SEDAR41 and utilized in SEDAR73 and SEDAR90 as well (SEDAR 2017; SEDAR 2021)
        - Equation: $TL = 2.22 + (1.07*FL)$
- Comparisons
    - Data were compared between simultaneously deployed gear (i.e. only traps with associated stereo-cameras were included in the dataset)
    - Data were pooled across all sampling locations for each gear type
- Statistical Methods (from Langlois et al.,2012 and Christiansen et al., 2022) – All statistical analysis was conducted using R statistical software (R Core Team, 2025)
    - Test for differences in shape and location of length frequency distributions
        - Kernal density estimates (KDE) compared the area between KDEs from gear types

        - KDE bandwidths were chosen utilizing the plug-in bandwidth selection process (Sheather and Jones, 1991)
        - Statistical differences were tested by comparing the area between KDEs between gear type to random pairs using 10,000 permutations of the data (Langlois et al., 2012; Christiansen et al. 2022).
        - Gears were considered significantly different if the KDE function of each was outside of the standard error from the null model.
- Test for differences in shape of length frequency distributions
    - TL data were standardized by the median and variance of the length frequency distributions (Bowman and Azzalini, 1997)
        - Y = X - median/stdev
    - Kernal density estimates (KDE) compared the area between KDEs from gear types
        - KDE bandwidths were chosen utilizing the plug-in bandwidth selection process (Sheather and Jones, 1991)
        - Statistical differences were tested by comparing the area between KDEs between gear type to random pairs using 10,000 permutations of the data (Langlois et al., 2012; Christiansen et al. 2022).
        - Gears were considered significantly different if the KDE function of each was outside of the standard error from the null model.
- Examine indirect relative selectivity
    - For indirect selectivity analysis, length frequency data were rounded to nearest 30 mm TL size bin to comply with the length binning decisions for SEDAR90.
    - Proportion of total measurements within each size bin were calculated by gear.
    - Catch ratio was calculated within each size bin
        - Catch Ratio = $\text{Proportion}_{\text{Trap.}} / (\text{Proportion}_{\text{Trap.}} + \text{Proportion}_{\text{Stereo}})$
            - Where:
                - $\text{Proportion}_{\text{Trap}}$ = Proportion of measurements from trap catch at that size bin
                - $\text{Proportion}_{\text{Stereo}}$ = Proportion of measurements from stereo-video at that size bin
    - To provide an indirect estimate of the shape of the selectivity between gears, the catch ratio of chevron traps relative to stereo-videos was plotted
        - 95% binomial confidence intervals at each size bin were calculated using the Wilson score interval method in the R package "binom" (Wilson, 1927; Dorai-Raj, 2015)

Results

- A total of 470 stereo-video unit deployments were made over the two-year period atop actively sampling standard SERFS chevron traps (Fig. 2).
- Of these, there were 82 stereo-video unit deployments and 55 chevron trap deployments that captured red snapper
- Abundance estimates ranged from 1 to 34 in trap catches and a MaxN from 1 to 16 in stereo-video reads.
- In total, 187 individual Red Snapper measurements were obtained from trap catch and 189 individual Red Snapper measurements from stereo-video.
    - Length measurements for trap catches ranged from 290 mm to 917 mm and stereo-videos ranged from 231 mm to 922 mm (Fig. 3).
- KDE probability density functions for traps and stereo-videos identified significant differences between the median and shape of the two gear types (Fig. 4)
- KDE probability density functions for traps and stereo-videos identified significant differences between just the shape of the two gears (Fig. 5).
- The general indirect selectivity trend relative to stereo-videos shows larger proportions in trap catch at smaller sizes and lower proportions in trap catches at larger sizes, though very few size bins (5 of 18) had confidence intervals which did not cross the equal catch ratio line at 0.5 (Fig. 6).

Discussion/Conclusions

- Total length range for the two gears were almost identical, with individuals both small and larger entering traps and being observed on stereo-video cameras. This is different from the FWC study in which larger fish did not enter the traps (Christiansen et al., 2022).
- A key assumption of this study is that cameras have no selectivity, but caution should be used as factors such as field of view, timing of reads within the video, and video counting methodologies have potential to skew the measurements attributed to the videos, which invalidates the assumption of the videos being the "true" measurements.
- There is an indication that there is some selectivity difference between the gears as shown by KDE values that were significantly different relative to the gears and the pattern, but conversely there were few length bins (5 of 18) that were significantly different when examining indirect relative selectivity.
    - Sample sizes within the length bins could have played a role in those findings, both ways.
    - The largest difference between the gears is driven by the abundance of catch in the chevron trap at the 390 mm length bin, but nearly half of those fish were collected from one trap.

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Table 1. Number and proportion of fish measured in chevron trap catches or on stereo-videos in 30 mm bins. Catch ratios were calculated at each bin. Catch Ratio = $\text{Proportion}_{\text{Trap.}}$/ ($\text{Proportion}_{\text{Trap}}$ + $\text{Proportion}_{\text{Stereo}}$)

Chevron Trap			**Stereo-Video**			**Catch Ratio Between Gears**	
TL (mm)	N	Prop.	TL (mm)	N	Prop.	TL (mm)	Catch Ratio
240	0	0.000	240	1	0.005	240	0.000
270	0	0.000	270	0	0.000	270	--
300	2	0.011	300	2	0.011	300	0.503
330	11	0.059	330	2	0.011	330	0.848
360	20	0.107	360	14	0.074	360	0.591
390	43	0.230	390	14	0.074	390	0.756
420	16	0.086	420	13	0.069	420	0.554
450	12	0.064	450	11	0.058	450	0.524
480	16	0.086	480	11	0.058	480	0.595
510	12	0.064	510	11	0.058	510	0.524
540	12	0.064	540	9	0.048	540	0.574
570	8	0.043	570	12	0.063	570	0.403
600	3	0.016	600	11	0.058	600	0.216
630	9	0.048	630	16	0.085	630	0.362
660	4	0.021	660	10	0.053	660	0.288
690	3	0.016	690	15	0.079	690	0.168
720	3	0.016	720	11	0.058	720	0.216
750	4	0.021	750	7	0.037	750	0.366
780	4	0.021	780	8	0.042	780	0.336
810	0	0.000	810	6	0.032	810	0.000
840	4	0.021	840	2	0.011	840	0.669
870	0	0.000	870	2	0.011	870	0.000
900	0	0.000	900	0	0.000	900	--
930	1	0.005	930	1	0.005	930	0.503

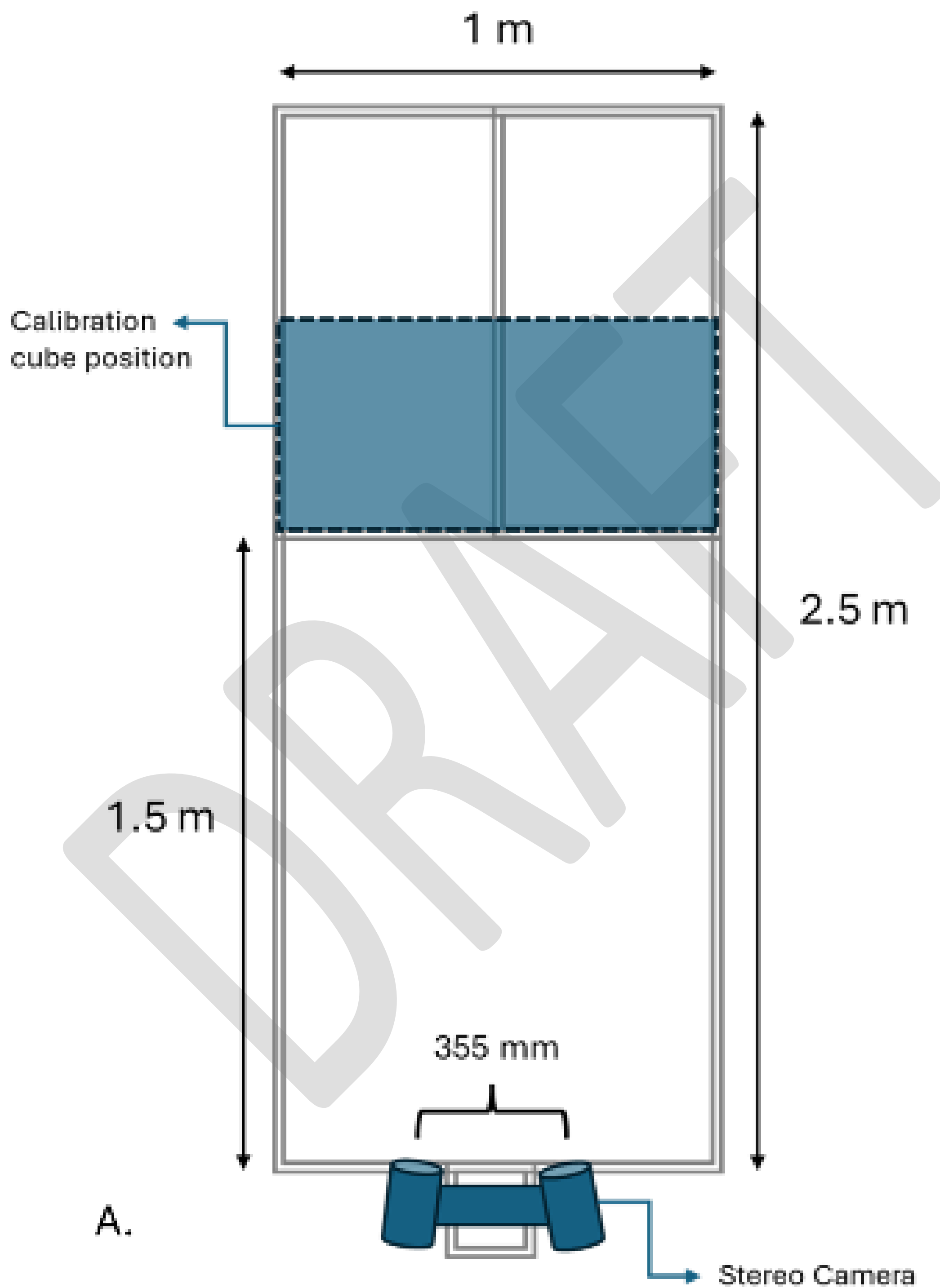

Figure 1. Position of calibration frame and camera in confined water.

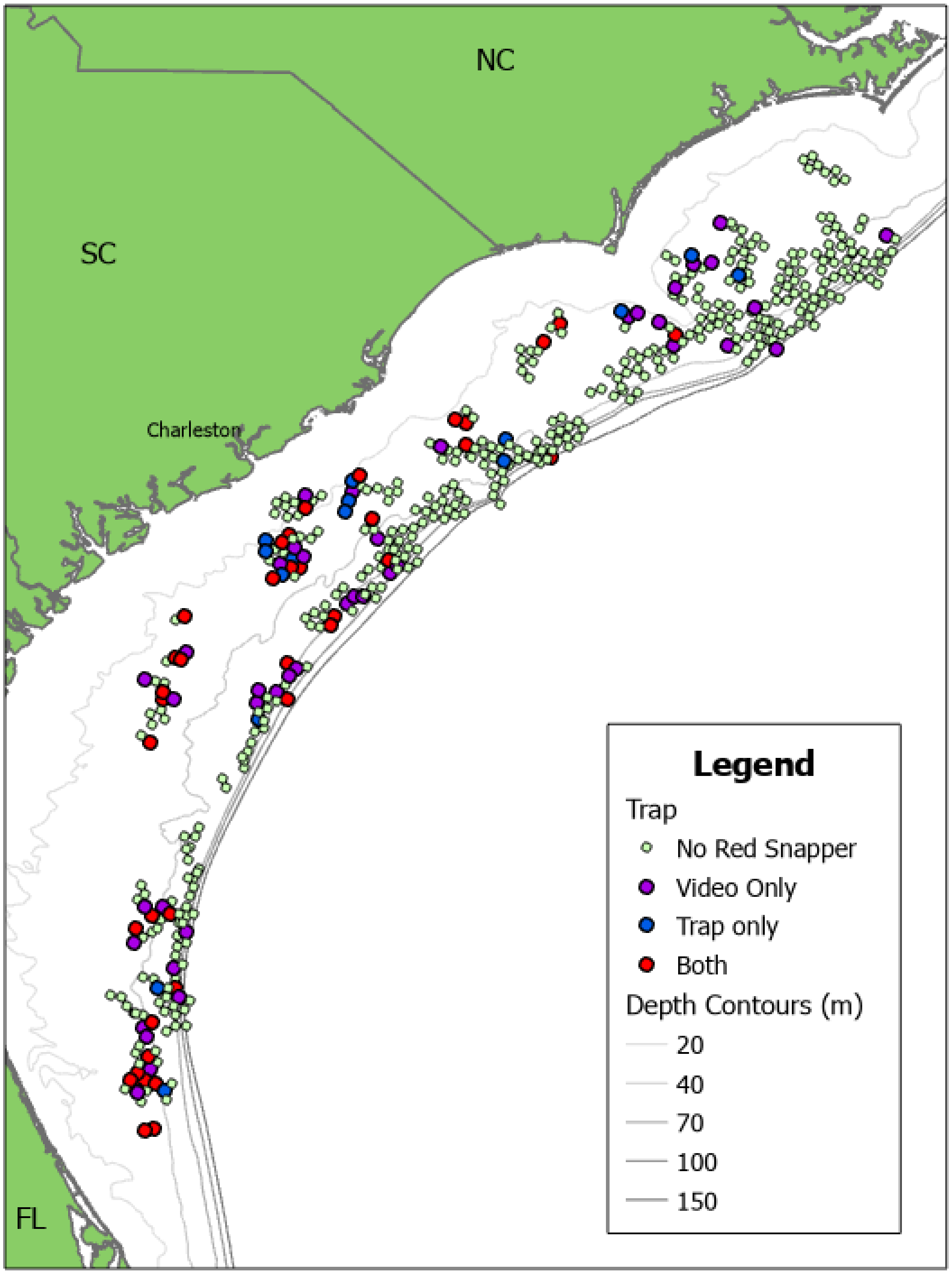

Figure 2. Sampled locations during 2022 and 2023 using chevron traps with affixed stereo-video cameras. Colors indicate whether a Red Snapper was encountered by none, one or the other, or both gears.

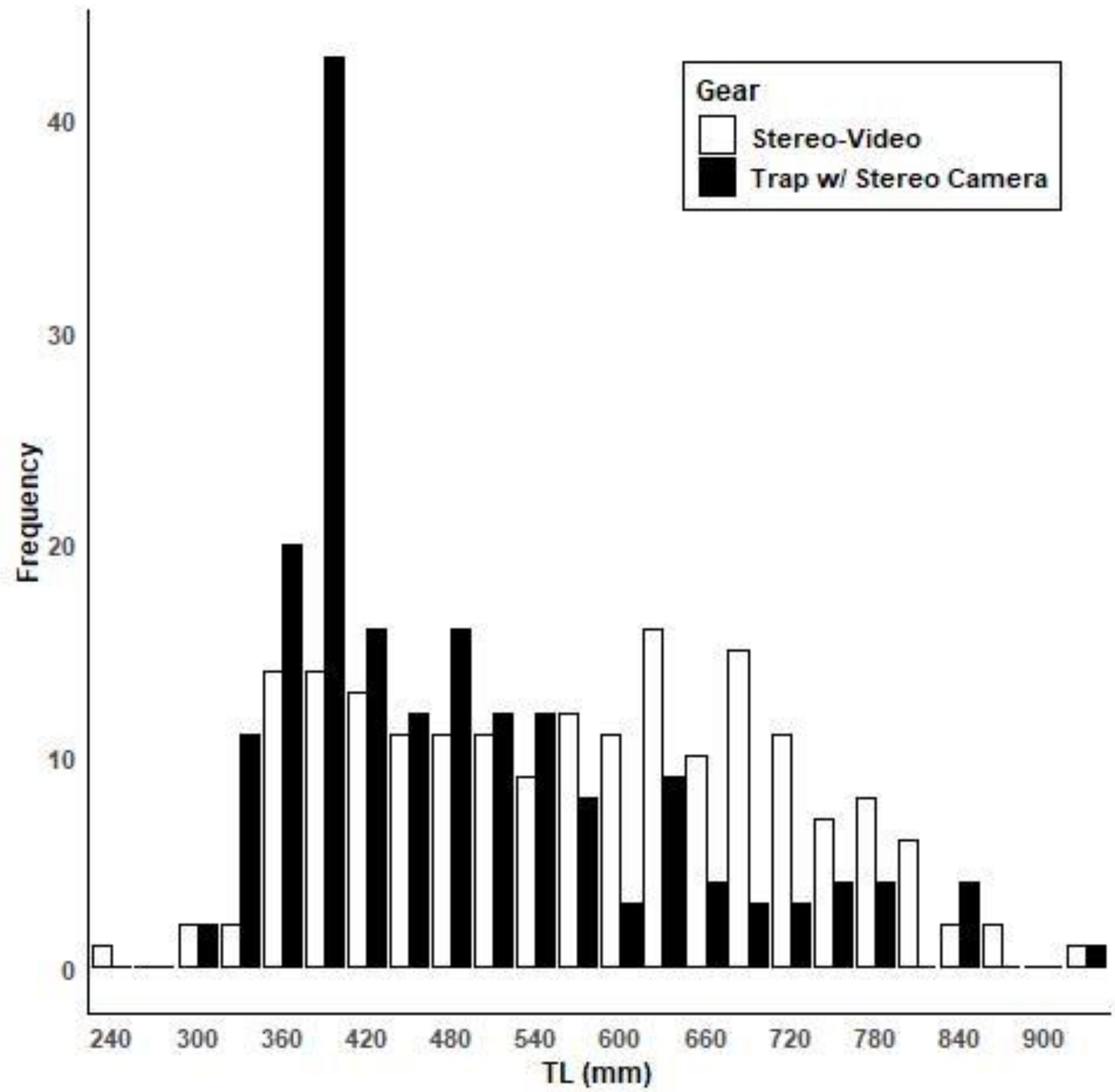

Figure 3. Length frequency of Red Snapper from stereo-video and trap measurements in 30 mm bins.

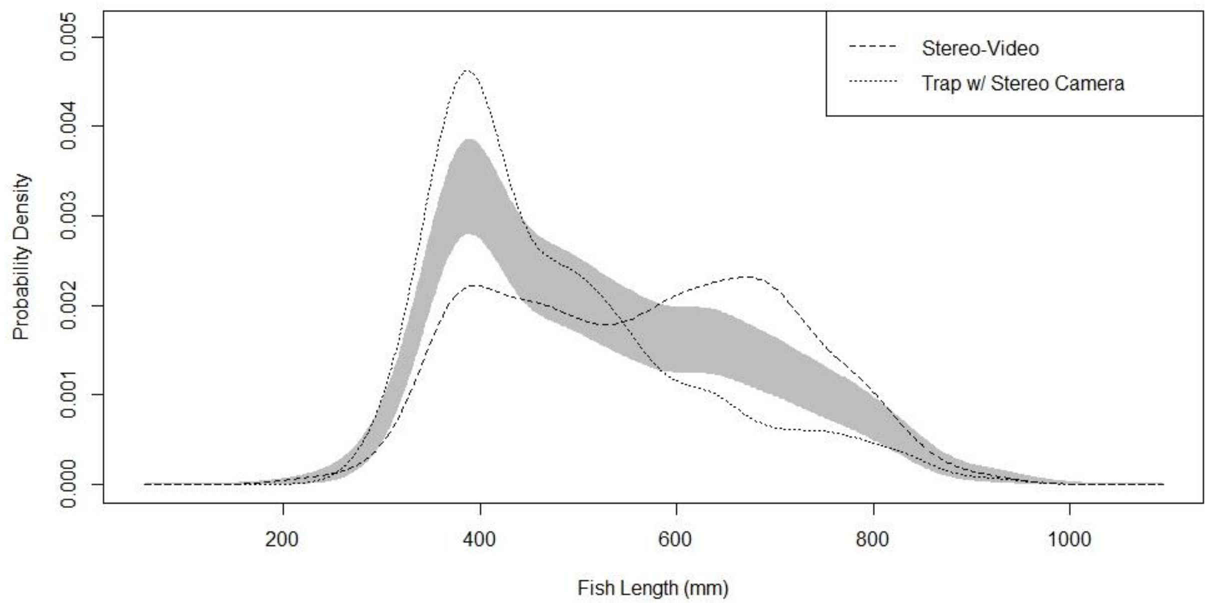

Figure 4. KDE Selectivity for trap and stereo-video measurements to compare curve shapes and locations.

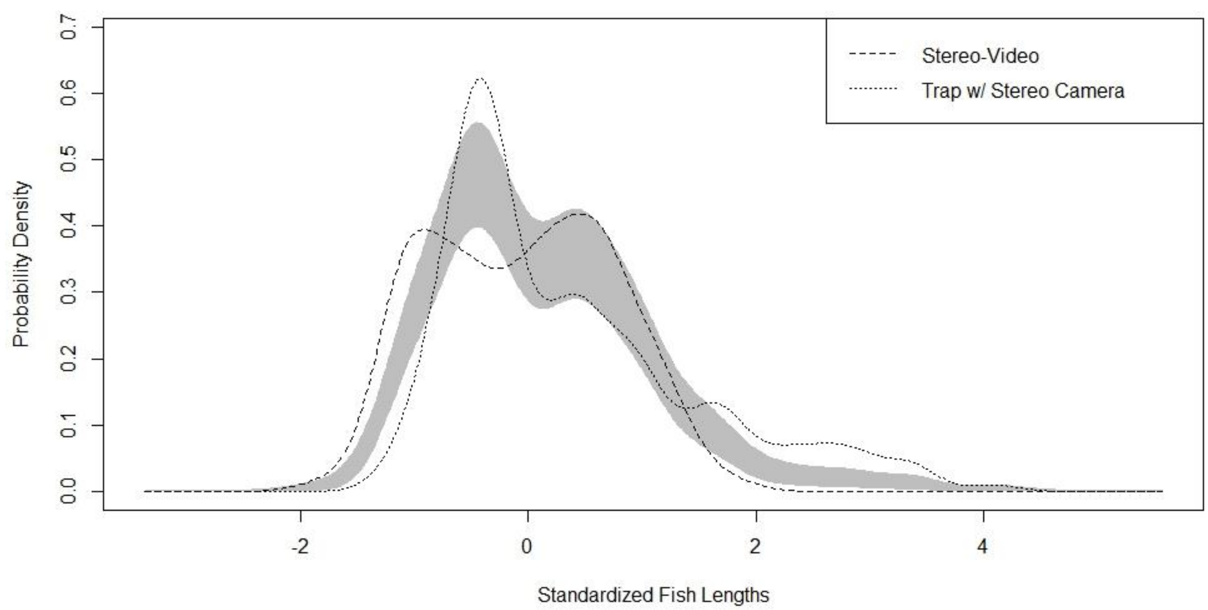

Figure 5. KDE Standardized selectivity between trap and stereo-video measurements to compare curve shapes.

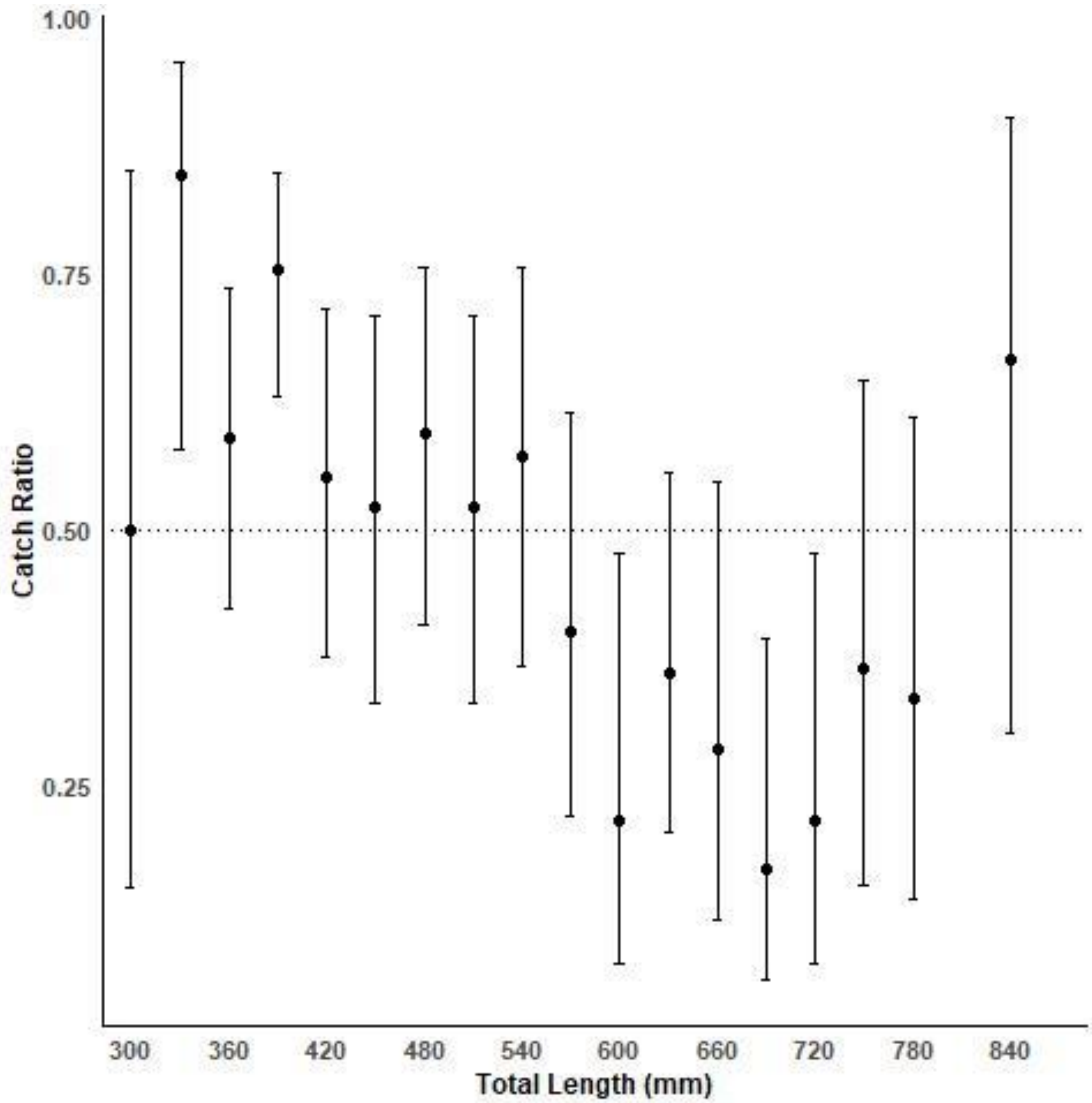

Figure 6. Indirect relative selectivity of Red Snapper for chevron traps relative to stereo-videos in 30 mm total length bins. The dotted line represents even catch ratios between the gears. Error bars encompass 95% confidence intervals.