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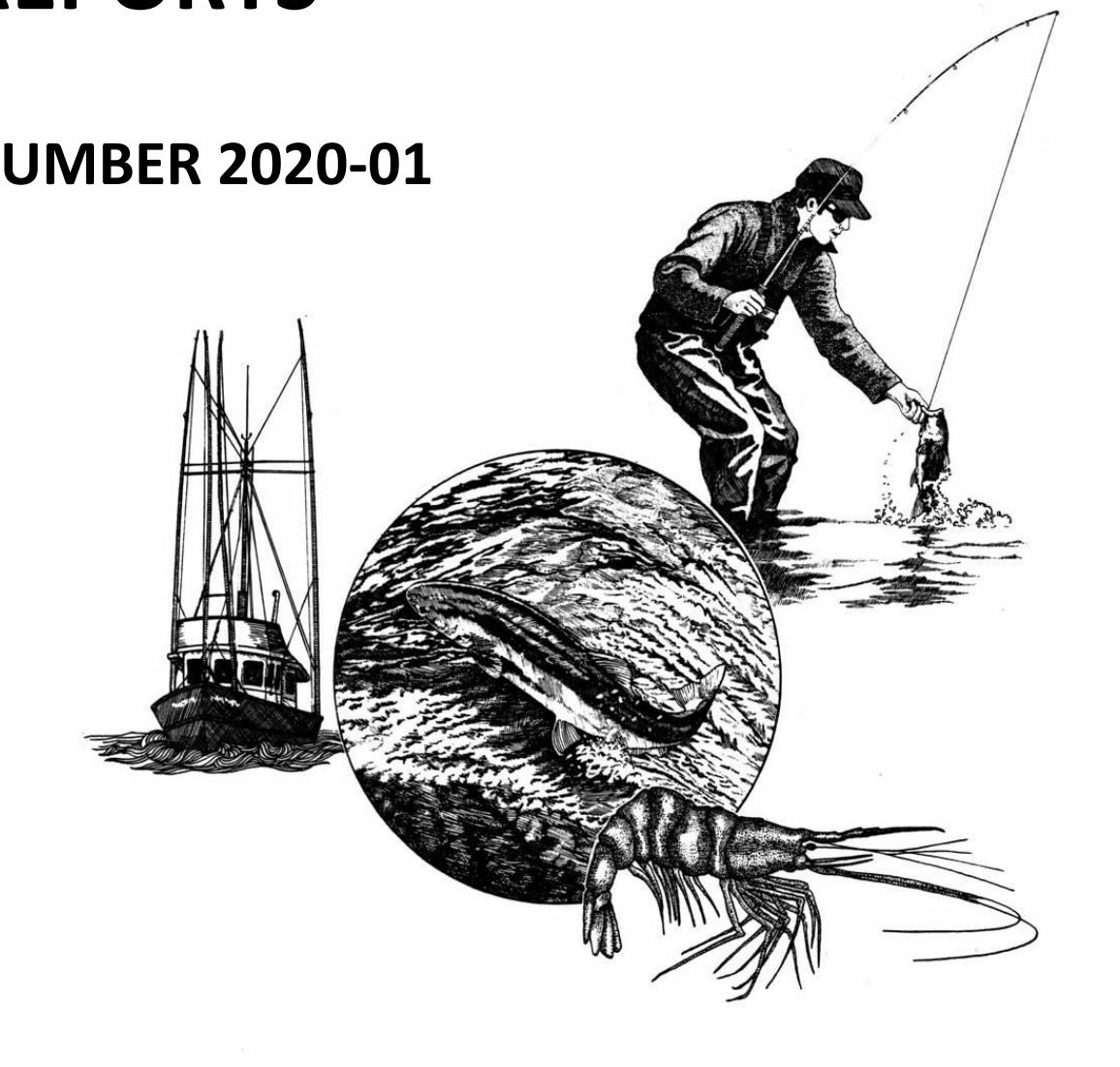

MARINE RESOURCES PROGRAM

Oregon Department of Fish and Wildlife

Nine years of video landers at the Oregon Department of Fish & Wildlife's Marine Resources Program.

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Executive Summary

The purpose of this report is to describe the large body of fishery independent video lander data that has been collected by Oregon Department of Fish and Wildlife (ODFW) staff and partners. The underwater video lander data presented in this report includes data collected from three different research groups (Fisheries, Reserves, and Nearshore), carrying out over 10 independent studies from 2009 – 2017 as part of ODFW's Marine Resources Program. This document summarizes the similarities and differences of video lander configurations and field methods used by ODFW over this nine-year period, describes the spatial and temporal extent of the data collected, and provides results for some of the species observed by utilizing a common set of abundance metrics. The design and configuration of the underwater video landers varied greatly over time, both across the three research groups, as well as within the Fisheries Group and Reserves Group. In the nine years video landers have been in use, ten configurations have been designed and tested in the field. Lander design was determined by the study site, species of interest, and considerations of cost and repeatability. All lander deployment sites summarized by this report were categorized into one of five general regions; north coast (sites north of Cascade Head, n=339), central coast (nearshore sites between Cascade Head and Cape Perpetua, n=864), Perpetua (sites on or adjacent to Perpetua Reef, n=61), south coast (sites south of Cape Blanco, n=259), and offshore (any site west of the 80 m line, n=1168). All three groups used the same deployment and retrieval methods while conducting video lander surveys. Over the years, video review protocols have varied between groups, as well as within both the Fisheries and Reserves Groups, mainly due to advances in technology and advancing applications of video as a management tool. For the purposes of this document, standardization of each video review protocol was applied. Different estimation techniques were used to estimate the parameters that describe the distribution of the count data. Preliminary examination of the MaxN count data (regardless of species or study area) showed that it was best described by a negative binomial distribution. Therefore, in this document, we have only provided parameters to describe a negative binomial fit for each species/study area combination. In general, there was a moderate amount of agreement between the parameter estimates generated using the two methods. This suggests that there is consistency in the data observed by different landers and in the different study areas. Ultimately, we consider this indicative of no major biases in what species or how many fish were observed by each research group in each study area. This information is meant to be useful to stock assessors, fishery scientists and managers, as well as the general public. In particular, the information presented here seeks to help inform discussions about the ongoing efforts to enhance fishery independent surveys in untrawlable rocky habitat using video landers, and the potential to use such data in stock assessments. Synthesizing all of this information in one document offers a picture of the full extent of work completed to date. Moving forward, we suggest that video landers are a useful tool for providing fishery independent data from Oregon's rocky reefs. Key benefits of this tool are cost effectiveness and the ability to work in untrawlable habitats. This document also includes an appendix where underwater video lander data, collected by the Fisheries Group, is used to parameterize a variety of simulations of an annual synoptic fishery independent survey for Yelloweye Rockfish, and we provide a table of estimated uncertainty and cost.

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1. Introduction

Sustainable fisheries management requires accurate and precise stock assessment which can be achieved by including information on species biology, fishery dependent catch and effort data, and fishery independent surveys of abundance. Fishery independent surveys are especially important sources of information for assessments because resulting data inform models independently of the potentially biased data collected directly from fisheries. A lack of fishery independent data exists for many species that live on or around rocky substrate along the U.S. west coast, especially for those that live in nearshore waters. This is because currently, the primary source of fishery independent groundfish data is from trawl surveys. These surveys are not conducted in waters less than 55 m deep, or in areas deemed untrawlable, such as rocky reefs (Bradburn et al. 2011). While trawl surveys are useful for many of the species included in the federal Pacific Coast Groundfish Fishery Management Plan, these data are not useful for the large number of species that are either not observed at frequencies high enough to generate an index of abundance, or are absent from the survey entirely. Many of these reef-associated species represent important fisheries in Oregon and are managed by the Oregon Department of Fish and Wildlife (ODFW) in partnership with the federal government. The lack of fishery independent abundance data from untrawlable, and nearshore rocky habitat, makes sustainable fisheries management at both the federal and state levels challenging. The need to conduct fishery independent surveys for species that inhabit rocky habitats, both in Oregon and along the west coast has been recognized in the Oregon Nearshore Strategy (ODFW 2016), and the Pacific Fishery Management Council's Research and Data Needs document (PFMC 2013, 2018). This is especially true for rockfish species such as Quillback, Tiger, Brown, and Copper that have only been assessed with data-poor or data-moderate methods (Dick and MacCall 2010; Cope et al. 2015). However, even for nearshore rocky reef species with full assessments, many have little or no fishery independent survey data.

Stock assessment authors have articulated a clear need for fishery independent survey information targeted at reef groundfish species. In the recent assessments for Black Rockfish (Cope et al. 2016), Blue/Deacon Rockfish (Dick et al. 2017), Cabezon (Cope et al. 2019), Canary Rockfish (Thorson and Wetzel 2016), China Rockfish (Dick et al. 2016), Kelp Greenling (Berger et al. 2015), Lingcod (Haltuch et al. 2017), and Yelloweye Rockfish (Gertseva and Cope 2017), authors specifically mention the need for fishery independent survey data to help improve future assessments of these species. Assessment authors Dick et al. (2017), succinctly stated the issues related to scaling biomass estimates and the need for a fishery independent survey:

> "A fisheries-independent nearshore survey should be supported to improve estimates of abundance trends (not having to rely on fisheries data for such trends) and, if possible, absolute abundance. Population scale has proven difficult to estimate for many nearshore species without informative data."

It is therefore both useful and timely to explore any available source of fishery independent data for its potential relevance to informing stock assessment and the management process.

Various visual techniques have been used to conduct fishery independent surveys throughout the world and each has its associated benefits and limitations. Benthic video landers, stationary camera systems on the seafloor, have proven to be useful tools for visually sampling the benthic fish community and habitat. Video landers have a long history of use in the marine environment,

and have been used in a wide variety of habitats. Decades of research has resulted in numerous fish abundance metrics developed from video data (Ellis and DeMartini 1995, Priede and Merrett 1996, Babcock et al. 1999; Priede et al. 2000, Willis and Babcock 2000, Watson et al. 2005, Farnsworth et al. 2007, Harvey et al. 2007, Watson et al. 2007; Watson et al. 2010; Merritt et al. 2011, Burge et al. 2012, Hannah and Blume 2012, Bacheler et al. 2013, Hannah and Blume 2014, Mallet and Pelletier 2014, Mallet et al. 2014, Pita et al. 2014, Schobernd et al. 2014, Campbell et al. 2015, Dunlap et al. 2015, Easton et al. 2015, Starr et al. 2016, Hannah and Blume 2016, Watson and Huntington 2016). Fishery independent survey data from stationary bottom camera systems have been used in stock assessment models in the U.S. as an index of abundance for both data-limited species (SEDAR 2016) and species with full assessments such as Gag Grouper (*Mycteroperca microlepis*), Red Grouper (*Mycteroperca microlepis*), and Red Snapper (*Lutjanus campechanus*) in the Gulf of Mexico (see the Southeast Data Assessment and Review website for stock assessment reports http://sedarweb.org/). These data came from surveys with large spatiotemporal coverage. Such extensive spatial and temporal targeted video lander survey work has yet to be done off Oregon for any species, but ODFW has a growing inventory of video lander data that has targeted rocky reef fish communities.

The Oregon Department of Fish and Wildlife conducts work relevant to stock assessments for many rocky reef species. Some of the tools that have been utilized in such work include SCUBA, hook and line, Passive Integrated Transponder tagging, acoustic telemetry, remotely operated vehicle, video lander, and a novel technique that combines hydroacoustics with a drop camera. Some of this work has informed stock assessments. For example, results from a Black Rockfish mark-recapture study, using Passive Integrated Transponder tags recovered from recreational fishery port samplers, were directly applied in two stock assessments (Sampson et al. 2007; Cope et al. 2016). Although not directly incorporated into the stock assessment model, data from visual fishery independent surveys conducted by ODFW, including SCUBA, remotely operated vehicle, and stereo video lander, informed density to help scale the biomass estimate in the stock assessment for Kelp Greenling (Berger et al. 2015). Similarly, the recent Blue/Deacon Rockfish assessment (Dick et al. 2017) incorporated length-at-age data from fishery independent hook and line surveys, remotely operated vehicle surveys, and a pilot study combining hydroacoustic and drop camera data. These data, presented by ODFW staff to the Stock Assessment Review Panels and assessors, proved important in model parameterization that resulted in realistic biomass scale estimates (P. Mirick, ODFW, personal communication).

The purpose of this report is to describe the large body of fishery independent video lander data that has been collected by ODFW staff and partners from 2009 through 2017. The video lander systems utilized over the years vary in configuration, but the basic concept is the same: a camera system is dropped to rest on the seafloor where it captures video of the fish community and associated bottom substrate. Three individual groups within ODFW conducted video lander work for differing purposes, and as such the study designs and field methods varied. However, taken together, these efforts provide data for an extensive spatial area off the Oregon coast that includes both shallow and deep water, over a time period approaching a decade. This document summarizes the similarities and differences of video lander configurations and field methods used by ODFW, describes the spatial and temporal extent of the data collected, and provides results for some of the species observed by utilizing a common set of abundance metrics. The hope is this information will be useful to stock assessors, fishery scientists and managers, and the

general public. In particular, the information presented here should help inform discussions about the ongoing efforts to enhance fishery independent surveys in untrawlable rocky habitat using video landers, and the potential to use such data in stock assessments. Synthesizing all of this information in one document offers a picture of the full extent of work completed to date.

2. Methods

Underwater video lander data collected by the Oregon Department of Fish & Wildlife's Marine Resources Program has come from three different research groups carrying out over 10 independent studies from 2009 – 2017 (Fig. 1, Table 1). The Marine Fisheries Research group (hereafter Fisheries Group), which is focused on supporting fishery management and stock assessments, was the first to adopt this visual survey method. Initial field tests were conducted in the nearshore reefs adjacent to Newport in 2009 and 2010. Subsequent research by this group was primarily conducted within an offshore rocky reef complex comprised of Stonewall Bank, Enterprise Reef, and Heceta Bank, with additional nearshore surveys conducted in rocky reefs known as Three Arch Rocks on the northern Oregon coast, and Siletz, Seal Rocks, and Perpetua reefs on the central coast.

The Marine Reserves, Ecological Monitoring Program (hereafter Reserves Group) is responsible for overseeing the ecological monitoring of Oregon's five marine reserves, and adapted the video lander from the Fisheries Group as one of several long-term monitoring tools. Using video landers, the Reserves Group conducts underwater visual surveys to characterize habitats and fish populations, and to observe fish behaviors inside Oregon's system of marine reserves and in the associated comparison areas (Fig. 1, Table 1). The Reserves Group has conducted video lander surveys in all five marine reserve sites (Redfish Rocks, Otter Rock, Cascade Head, Cape Perpetua, and Cape Falcon) and the eight adjacent comparison areas. The Reserves Group will continue to conduct video lander surveys at four of the five sites at regular intervals. Because hard bottom habitats are limited at Cape Perpetua Marine Reserve, video lander monitoring at this site, and its comparison area, was discontinued after initial surveys. Video lander surveys began at four of the five Oregon marine reserves and their associated comparison areas before harvest restrictions were implemented at these reserves. The earliest surveys available are for the first two reserves (Redfish Rocks and Otter Rock) and the associated comparison areas in 2010, two years before harvest restrictions began in the reserves. The Cape Falcon Marine Reserve lacks video lander surveys prior to implementation of harvest restrictions in 2016 because of limited weather windows and poor visibility in 2014 – 2015.

The third research group to adopt the video lander as a research tool was the Nearshore Research group (hereafter Nearshore Group). The Nearshore Group focuses on research and conservation efforts that implement the Oregon Nearshore Strategy recommendations (ODFW 2006,

Table 1. Specifications of individual studies conducted by each individual project (FG = Fisheries Group, RG = Reserves Group, NG = Nearshore Group). Data for the 2011 Heceta Bank survey and all 2019 work are not included in this report.

Project	Dates operated	Location(s)	Publication	Study goal	Bottom time
FG	2009-2011	Central Coast, Offshore & Perpetua Region	Hannah & Blume (2012)	Develop and test a video lander as a visual survey tool for rocky reef habitat and evaluate the Yelloweye Rockfish Conservation Area	4-5 min
FG	2011	Perpetua Region & Offshore	Unpublished	Perpetua work in response to request from science community to monitor hypoxic event. Offshore work in Heceta Bank to test utility of video lander at deeper depths	
FG	2011	North Coast	Easton et al. (2015)	Test ability of lander to comprehensively quantify habitat and fish community composition in nearshore temperate reefs	5 min
FG	2013	Offshore	Hannah & Blume (2014)	Evaluate influence of bait on species size and composition	12 min
FG	2014	Offshore	Unpublished	Determine if the color of light used on a video lander impacts fish behavior	12 min
FG	2014-2015	Offshore & Central Coast	Hannah & Blume (2016)	Impact of water clarity, light, and fish size on maximum detection range of fish	6-15 min
FG	2016	Offshore	Unpublished	Test upgraded equipment (HD cameras and better lights) in deeper depths of Heceta Bank	12 min
FG	2019-Present	Offshore & Central Coast	In progress	Examine how operating video landers during daylight and nighttime hours affects the utility of the tool to survey rocky reefs at nearshore, middle shelf, and off shelf depths	15 min
FG	2019-Present	Offshore	In progress	Compare the utility of the Fisheries Group's landers to the Alaska Fisheries Science Center's cameras and eDNA to provide corrections for portions of the federal trawl survey that are untrawlable	15 min
RG	2010-2011	Central Coast & South Coast	Oregon Marine Reserves Ecological Monitoring Report 2010-2011 (2014)	Ongoing Monitoring	3-6 min
RG	2012-2013	Central Coast & South Coast	Oregon Marine Reserves Ecological Monitoring Report 2012-2013 (2015)	Ongoing Monitoring	3-6 min
RG	2010-2015	Central Coast	Lawrence et al. 2016	Developing a method for quantifying biogenic habitat from a stationary underwater video camera	8 min
RG	2014	Central Coast, Perpetua Region & South Coast	Unpublished	Ongoing Monitoring	8 min
RG	2015-Present	North Coast, Central Coast & South Coast	Unpublished	Ongoing Monitoring	8 min
RG	2014-2015	Central Coast & South Coast	Watson & Huntington (2016)	Measure influence of bait, drop duration, and behavioral responses on estimating relative abundance, and diversity of nearshore fish using a small, cost-effective video lander	8 min
RG	2014	Central Coast & South Coast	Watson & Huntington (In review)	Hook and line, underwater visual census, and unbaited underwater video surveys performed to compare (1) detection, (2) community composition, and (3) size structure of temperate reef fishes among methods	8 min
NG	2014-2015	Central Coast	Krutzikowsky 2019	Characterize finfish abundance on a nearshore rocky reef system with fishery independent survey. Examine effects of different sampling times on data	15 min

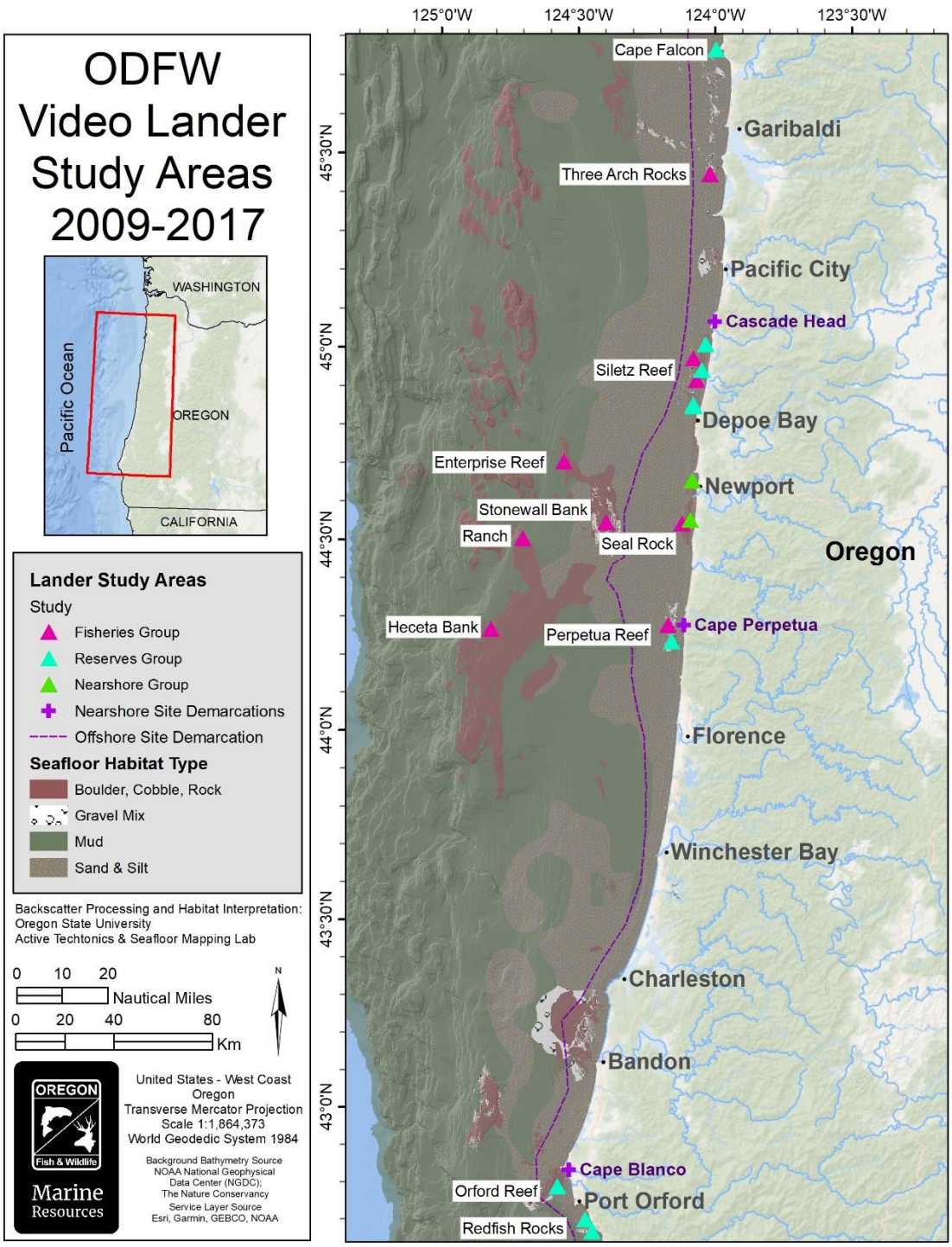

Figure 1. Map of study areas where the Oregon Department of Fish and Wildlife conducted video lander deployments from 2009-2017. Sites west of the offshore site demarcation line (80 m isobath) were grouped in the Offshore region, while sites east of the line were broken into four regions: north coast (sites north of Cascade Head), central coast (sites between Cascade Head and Cape Perpetua), south coast (sites south of Cape Blanco) and the Perpetua region (sites on or adjacent to Perpetua Reef). Higher resolution maps showing locations of individual drops by area are available in Appendix A.

2016). In support of this mission, a one-time video lander survey was conducted by the Nearshore Group in 2014 – 2015 within the nearshore rocky reefs bounded by Cape Foulweather to the north, and Alsea Bay to the south (Fig. 1, Table 1; Krutzikowsky 2019).

It is important to note that the video lander data included in this report are only those that passed a rigorous data standardization process. In other words, the findings reported here only represent successful lander designs and field methods where lander deployments resulted in usable videos and video review was deemed possible.

2.1. Lander design

The design and configuration of the underwater video landers varied greatly over time, both across the three research groups, as well as within the Fisheries Group and Reserves Group. In the nine years that video landers have been in use, ten configurations have been designed and tested in the field (Fig. 2, Table 2).

Design was determined by the study site, species of interest, and considerations of cost and repeatability. The Reserves Group and Nearshore Group sampled in depths ranging from 3-54 m, while the Fisheries Group sampled in depths ranging from 20-150 m. Differences in sampling environments such as these resulted in large differences in video lander design, including the use and power of lighting, the type of camera(s) selected, and the overall shape and size of the frame (Fig. 2, Table 2).

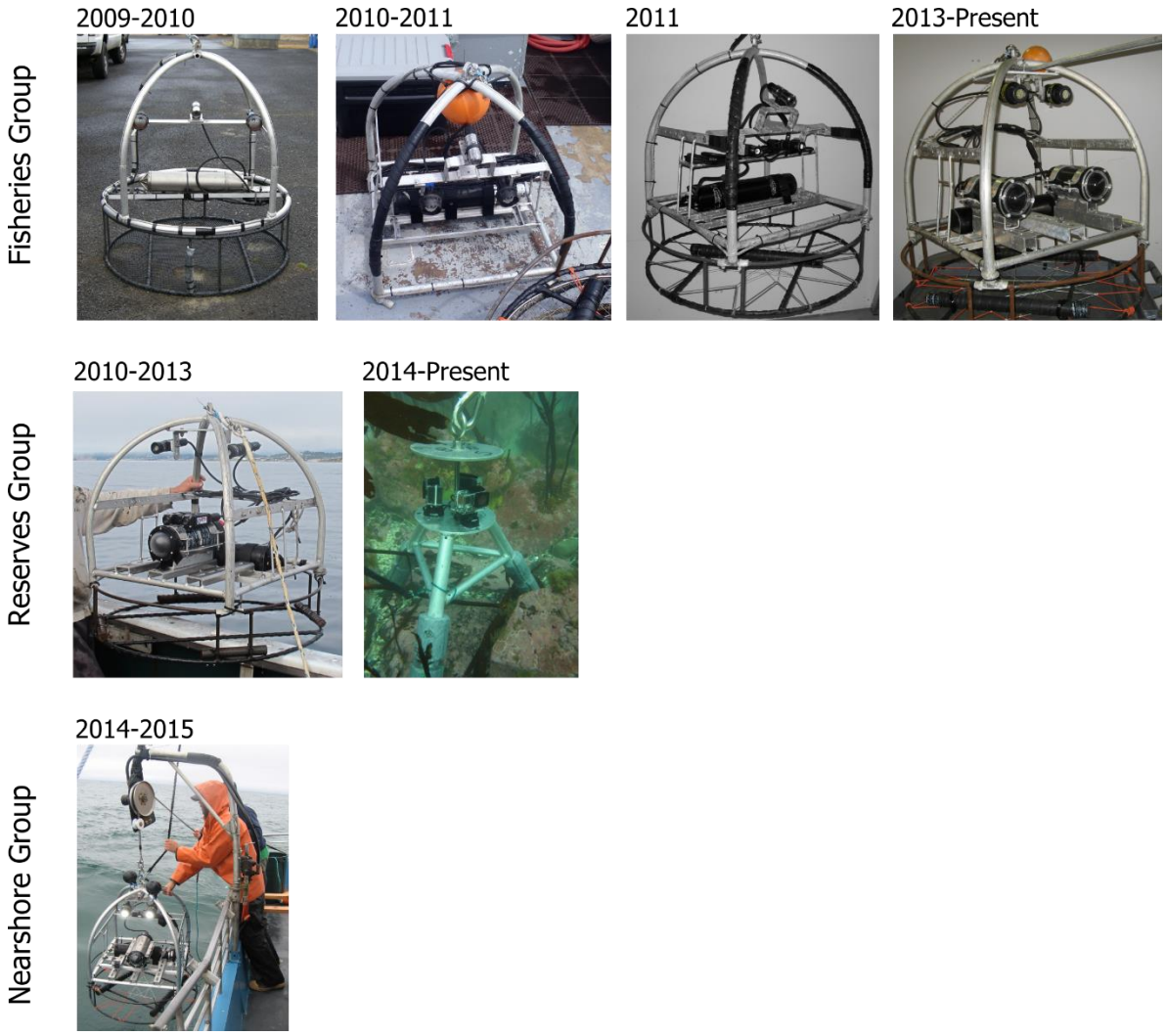

Figure 2. Photographs of video landers employed by each research group. Retrieval method with pot hauler shown in the lower-left photograph.

Table 2. Description of lander design and components of each lander platform used by ODFW since 2009 for each research group (FG = Fisheries Group, RG = Reserves Group, NG = Nearshore Group), and the number of successful deployments for each system that were included in this report.

Project	Dates Operated	n	Bait	FOV	Area	Stereo	Camera(s)	Light(s)	Other
FG	2009-2010	191	N	75°	7.7 m^2	N	SD DSPL Multi-SeaCam 2060 color	Two DSPL Ritelites with Halogen bulbs (25W-200W depending on power source)	
FG	2010-2011	650	N	75°	7.7 m^2	N	SD DSPL Multi-SeaCam 2060 color	Two DSPL Ritelites with LED bulbs (850 lm, 3000 K)	
FG	2011-2011	596	N	75°	7.7 m^2	N	SD DSPL Multi-SeaCam 2060 color	Two DSPL LED Mini-SeaLites (850 lm, 6500 K)	10cm paired scaling lasers for 12/2011 survey only
FG	2013- present	212	Y/N	78.7°	8.0 m^2	Y	Two HD Canon Vixia HF S21 with Impact DVP-WA50-58 Digital 0.5x wide-angle adaptors	Two DSPL LED SeaLite Spheres (3200 lm, 6500 K)	
FG	2018-present	0	N	96.7	9.9 m^2	Y	Two HD Canon Vixia HF G20 with Impact DVP-WA50-58 Digital 0.5x wide-angle adaptors	Two DSPL LED SeaLite Spheres (3200 lm, 6500 K)	
RG	2010-2012	333	N	75°	7.7 m^2	N	SD DSPL Multi-SeaCam 2060 color	Two DSPL Ritelite with LED bulbs (850 lm, 3000 K)	paired lasers
RG	2013	65	N	80°	8.2 m^2	N	HD Canon Vixia HF G10 with Impact DVP-WA50-58 Digital 0.5x wide-angle adaptor	Two DSPL SeaLite Six (1200 lm, 6000 K)	paired lasers
RG	2016	28	N	118.2°	12.1 m^2	N	GoPro HERO3 Black Edition	Bigblu Dive Lights (1800 lm)	magenta filters
RG	2014-present	454	Y/N	118.2°	12.1 m^2	N	Three GoPro HERO3 Black Edition	N	magenta filters
NG	2014-2015	145	N	96.7°	9.9 m^2	N	HD Canon HF G20 with Impact DVP-WA50-58 Digital 0.5x wide-angle adaptors	Two DSPL LED SeaLite Spheres (3000 lm, 6000 K)	

FOV: Horizontal Field of View ($AreaViewed$=(θ/360)πx^2), Area: The maximum distance of 3.42 m was used to calculate area, as reported by Hannah and Blume (2016) for stereo video lander work on Oregon nearshore rocky reefs. SD: Standard Definition, HD: High Definition, DSPL: DeepSea Power and Light.

Fisheries Group

The original video lander systems were developed in 2009 – 2010 and were based on camera technology used by the Alaska Fisheries Science Center for observing the inside of commercial trawl nets. The original video lander used by the Fisheries Group was built to be deployed autonomously and retrieved using a hydraulic crab block. The frame was constructed in a rounded cage-like structure to both protect the video and lighting systems but to also avoid hang-ups in the rocky habitat when possible (Fig. 2). To increase the prospect of recovering the equipment, the frame sat on top of a sacrificial base designed to break away from the main frame of the video lander, attached to the buoy line, allowing the video equipment to be recovered (Hannah and Blume 2012). While this frame and base design is still in use today, the video equipment within the lander frame has changed multiple times since the original video lander (Table 2).

The first video lander used a single standard-definition color video camera (DeepSea Power & Light; Multi-SeaCam 2060), paired with two halogen lights (DeepSea Power & Light; Ritelites). This design was field tested (n=191 deployments) within the nearshore rocky reefs of Oregon's central coast, at Cape Perpetua, and at Stonewall Bank Yelloweye Rockfish Conservation Area. The lighting system was upgraded in 2010 by replacing the halogen bulbs with 5-watt LED bulbs (DeepSea Power & Light; Ritelite) which significantly reduced the power drain on the batteries. This system was used through 2011 to conduct research (n=650) at the three areas previously mentioned, as well as at Three Arch Rocks on Oregon's north coast. This design was described in Hannah & Blume (2012) and Easton et al. (2015). The next lighting upgrade greatly increased the light output from the two lights (DeepSea Power & Light; LED Mini-SeaLites), and was used to conduct research at Stonewall Bank (n=596). In 2013, a second camera was added create a stereo video lander in order to generate precise fish length data as well as obtain range estimates of fish to potentially quantify the area being sampled. This system used twin high-definition cameras (Canon; Vixia HF S21) equipped with 0.5x wide-angle digital adapters, and two LED lights (DeepSea Power & Light; SeaLite Spheres). This system was used in continued research at Stonewall Bank that was reported in Hannah & Blume (2014, 2016), as well as for research within the nearshore reefs of the central coast (n=212). This design and video equipment are still in use today and an additional video lander has been created in its likeness to increase sampling efficiency in future studies (Table 2).

A majority of the research with video landers conducted by the Fisheries Group has been related to the Yelloweye Rockfish. This species continues to be severely constraining to fisheries due to low bycatch quotas undergoing a long-term population rebuilding process. Because of this, the majority of the Fisheries Group's video lander surveys were conducted in offshore environments, requiring substantially more lighting and battery systems than nearshore surveys, ultimately requiring a larger platform in order to support all of the equipment (Fig. 2).

Reserves Group

The ODFW Marine Reserves Program's ecological monitoring is the first ecosystem-focused, long-term monitoring program to be conducted in Oregon's nearshore marine environment (ODFW, 2017). This program has built upon advances in sampling technology and gear to design robust and contemporary survey tools that can function in Oregon's challenging nearshore environment. During the development of this long-term monitoring program, adaptations have

been made to the video lander based on tool and methods testing, lessons learned in the field, data analyses, and advice from other scientific experts.

The first video lander used was modeled after the original Fisheries Group video lander. This design consisted of an aluminum frame, with breakaway mild steel sections in case of snagging developed by Hannah and Blume (2012). The video system consisted of a low-light color camera (DeepSea Power & Light; Multi-SeaCam 2060), paired with two LED lights (DeepSea Power & Light; Ritelite). Lights were mounted high in the video lander frame, well separated from the camera to minimize backscatter from debris in the water column. A DeepSea Power & Light parallel laser with 10 cm spacing was used to estimate scale in the image. This design was used from 2010 to 2012 to collect videos (n=333) from three marine reserves (Otter Rock, Cascade Head, Cape Perpetua, and Redfish Rocks) and their associated comparison areas (Table 2).

In 2013 the video lander was modified by upgrading the camera to a high-definition camera system (Canon; Vixia HF G10), fitted with a 0.5x wide-angle digital adaptor to enhance the field of view. Additionally, the lights were upgraded to two brighter LED lights (DeepSea Power & Light; SeaLite Six). This design was only used for one year (n=65), and only at the comparison areas associated with the Cascade Head Marine Reserve.

After trials by ODFW staff proved GoPro cameras a viable alternative to larger camcorders, the Reserves Group redesigned the video lander in 2014 by switching to a more cost-effective camera and housing (GoPro HERO) and a smaller, lightweight tripod-shaped frame (Fig. 2). This configuration was built to be streamlined to reduce the chance of the frame becoming stuck in rocky habitat but strong enough to withstand contact with rocky substrates with limited damage. Three high-definition cameras (GoPro HERO 3+ Black Edition) with magenta filters were mounted 42 cm from the base of the video lander (comparable to larger lander) on an aluminum plate with 120 degree separation. Using three cameras maximized the chance that a given deployment obtained useful video footage from at least one camera. Fully assembled, this video lander weighed 16 kg, and is currently still in use.

LED lights (Bigblu) were initially tested (n=28) but the majority of deployments (n=454) used no added lights because surveys occurred in very shallow water (average 19.5 m) where ambient light was sufficient to view fish and habitat. Two video lander units were built to increase sampling efficiency by using both units simultaneously. This set of low-cost, lightweight video lander systems was designed to be deployed and retrieved by small vessels, eliminating the need for contracting large vessels (Watson and Huntington 2016).

Nearshore Group

A video lander following the designs of Hannah and Blume (2012, 2014) was utilized to sample the finfish community found in the nearshore waters off Newport. The video lander was equipped with two lights (DeepSea Power & Light; SeaLite Spheres) and a single high-definition color video camera (Canon; Vixia HF G20) fitted with a 0.5x wide-angle digital adaptor lens to increase field of view (Fig. 2, Table 2). Both the camera, and batteries to power the lights, were housed in aluminum pressure housings and the camera housing was equipped with a dome port. The video lander frame was made of aluminum tubing enclosing the lights, camera, and battery housings for protection and attached to a sacrificial weighted base by weak links that allow the frame with equipment to break free for recovery if the base becomes stuck in rocky habitat (Fig. 2), developed by Hannah and Blume (2012).

2.2. Study areas

All lander deployment sites summarized by this report were categorized into one of five general regions (Fig. 1 and Fig. 3); north coast (sites north of Cascade Head, n=339), central coast (nearshore sites between Cascade Head and Cape Perpetua, n=864), Perpetua (sites on or adjacent to Perpetua Reef, n=61), south coast (sites south of Cape Blanco, n=259), and offshore (any site west of the 80 m line, n=1168).

Figure 3. Timeline of video drops by research group and study area.

North Coast

In total there were 339 successful deployments in the northernmost region, encompassing the area north of Cascade Head. Completed deployments in this region include, twenty-five deployments by the Reserves Group in the Cape Falcon Marine Reserve and neighboring comparison area, and 314 deployments by the Fisheries Group at Three Arch Rocks rocky-reef (Fig. A1). The Cape Falcon Marine Reserve is Oregon's northernmost marine reserve and is located just north of Nehalem Bay, near the town of Manzanita. The Cape Falcon Marine Reserve encompasses 32 km^2 with a depth range of 0 – 55 m. The seafloor at Cape Falcon is dominated by sandy soft-bottom habitats. In shallower waters, the reserve has small isolated patches of rock. The associated comparison area for Cape Falcon Marine Reserve is a reef off the coast of Cape Meares, which is of similar size, habitat, and depth range. Of the 25 deployments completed in the Cape Falcon Region from 2016 – 2017, 15 were completed in Cape Falcon Marine Reserve, and the remaining ten deployments were conducted in the Cape Meares Comparison Area (Fig. A1). The depths of these deployments ranged from 8.7 – 23.5 m.

The remaining 314 north coast deployments were conducted as part of a collaborative study between the Fisheries Group and Oregon State University in 2011 that was conducted at Three Arch Rocks rocky reef complex (Easton et al. 2015). This reef is located approximately 4 km offshore and 11 km south of the mouth of Tillamook Bay (Fig. A1). This study area was chosen due to the high depth gradient within the reef, and for the high diversity of species that inhabit the reef. The substrate of this reef is composed of a mixture of rock, gravel and sand. The study area covered approximately 15 km^2 with deployment sites (n=314) ranging in depth from 10.8 – 73.3 m. The perimeter of the sampling grid created for this study coincided with the available seafloor habitat data created by the Active Tectonics and Seafloor Mapping Lab at Oregon State University (Goldfinger et al. 2014). Sample locations included all habitat types identified across the entire reef structure and depth range (Easton et al. 2015).

Central Coast

A total of 863 deployments in the central coast area from the three ODFW research groups are included in this report. The central coast area is comprised of a long, narrow rocky reef extending from the headland of Cascade Head south to the mouth of Alsea Bay, near the town of Waldport (Fig. A2). The northern and southern end of this study area straddle the major commercial and recreational fishing port of Newport. Within the central coast area, there are two marine reserves and three neighboring comparison areas in which video lander monitoring is conducted by the Reserves Group. The Cascade Head Marine Reserve is located off the central Oregon coast, stretching between the Cascade Head headland and Lincoln City. Harvest restrictions began there in

2014. This site includes the Cascade Head Marine Reserve surrounded by three Marine Protected Areas. The reserve encompasses 25 km^2 with a depth range 0 – 50 m. The reserve includes the complex rocky reef habitats of the north segment of Siletz Reef. The rocky reef protected within the reserve also extends southward into the South Marine Protected Area and the comparison areas of Schooner Creek and Cavalier.

The second marine reserve in the central study area is Otter Rock Marine Reserve. This reserve encompasses 3 km^2, and is located south of Depoe Bay and north of Newport in depths ranging from 0 – 18 m. Harvest restrictions began in this reserve in 2012. Three prominent islands comprise the western boundary of the site: Gull Rock on the northwest corner, and Otter Rock and Whale Back Rock on the southwest corner. The reserve includes a shallow rocky reef, kelp beds, soft bottom habitats, and sand dollar beds. Cape Foulweather, located just north of the reserve, is the comparison area for this marine reserve site.

A total of 232 deployments were completed by the Reserves Group in the Otter Rock area from 2010 – 2017. The depths of these deployments ranged from 2.8 – 18.7 m. Of the 232 deployments, 104 were completed at the Otter Rock Marine Reserve. The remaining 128 deployments were conducted in the Cape Foulweather Comparison Area (Fig. A2).

The Fisheries Group conducted initial field tests of video landers in the nearshore reefs of Siletz and Seal Rocks in 2009 – 2010 (Hannah and Blume 2012) and returned to Seal Rocks to test stereo-video lander capabilities in 2014 – 2015 (Fig. A2 [in present paper]; Hannah and Blume 2016). A total of 127 deployments in these areas were retained for the purposes of this document. Siletz Reef, approximately 3 km off the coast of Lincoln City, is comprised of rock, gravel, sand, and small amounts of mud. Video lander deployments conducted by the Fisheries Group at Siletz Reef (n=85) ranged in depth from 29.1 – 73.2 m. All of the deployments completed by the Fisheries Group in the northern region of the central coast area fall within the boundaries of the marine protected area and the comparison area south of Cascade Head Marine Reserve.

The Fisheries Group completed 42 successful video lander deployments at Seal Rocks Reef. This is a long (~13 km) reef located directly south of the Yaquina River mouth, spanning south to the town of Seal Rock. The roughly 20 km^2 rocky reef is surrounded by sand with small patches of mud, and ranges in depth from 12.8 – 67.7 m. This area was chosen in part because of its proximity to Newport, where the Marine Resources Program office is located, and because it is relatively diverse in terms of depth, rugosity, and species assemblages.

A total of 294 deployments were completed by the Reserves Group in the Cascade Head region from 2012 – 2017. Of those, 73 were completed in the Cascade Head Marine Reserve, and the remaining 221 deployments were conducted in Cascade Head comparison areas: 73 at Cavalier Comparison Area and 148 at Schooner Creek Comparison Area. The depths in which these deployments were conducted ranged from 6.4 – 47.5 m.

The Nearshore Group conducted 177 lander deployments in 2014 and 2015. The study area, totaling approximately 30 km^2 of rocky reef, was bounded by Cape Foulweather in the north and Alsea Bay in the south, which includes Seal Rocks Reef south of Newport. Of the 177 deployments, 145 deployments resulted in successful video samples included in this report. The area was chosen because it encompassed a wide variety of substrates, rugosity, and depths. Rocky substrates include bedrock, boulders, and cobble, some of which were surrounded by sand or mud. Substrates sampled included 29 different combinations of primary and secondary

substrate types. The study area was also chosen because it comprised the entire tagging area of the Black Rockfish passive integrated transponder tag study (Krutzikowsky et al. 2019) plus a relatively small additional rocky area to the north. This allowed for comparison of estimates of Black Rockfish abundance derived from two different methods. Finally, the study area was conveniently located close to the Marine Resources Program office in Newport which simplified logistics in taking advantage of weather windows conducive to sampling. Deployments occurred in depths ranging from 5.4 - 41 m (Fig. A2).

Cape Perpetua

Perpetua Reef is located approximately 30 km south of Newport and 5 km southwest of Cape Perpetua, with rock patches scattered throughout a roughly 14 km long area (north to south). The reef is comprised mainly of gravel and cobble with small (<0.1 km^2), low relief rock patches (Fig. A3). Due to distinctive substrate and hydrographic conditions, paired with the fact that the reef is relatively isolated from other rocky reef structure, we elected to separate Cape Perpetua from the rest of the Central Coast study area (Wheeler et al. 2003; Grantham et al. 2004; Goldfinger et al. 2014). Further, studies of fish behavior at Cape Perpetua have demonstrated that frequent hypoxic events results in unique fish behavior, ultimately affecting how video landers count species (Rankin et al. 2013). The reef falls entirely within the boundaries of a marine reserve and two marine protected areas. The Cape Perpetua Marine Reserve is Oregon's largest marine reserve, and harvest restrictions began in 2014. The site is located off the central Oregon coast stretching between the towns of Yachats and Florence. The marine reserve encompasses 37 km^2 with a depth range of 0 – 55 m.

Prior to marine reserve implementation, the Fisheries Group conducted a brief survey in this area in 2010, (Hannah and Blume 2012). The 57 completed video lander deployments were focused on the small rocky patches on the western, deeper edge of the reef, ranging in depth from 45.2 – 53.8 m.

Five deployments were completed by the Reserves Group in the Cape Perpetua Region in 2012. The depths of these deployments ranged from 10.9 – 51.3 m. Of the 5 useable deployments, 4 were within the Cape Perpetua Marine Reserve (depths ranging from 20.2 – 51.3 m) and the remaining was conducted in the Postage Stamp Comparison Area, a small rocky reef to the north of the mouth of Alsea Bay. Given the small size and deep depth of the rocky reef in the Cape Perpetua Marine Reserve, the video lander was determined to not be the most efficient or appropriate tool for monitoring this location; therefore, long-term video lander monitoring at this site was discontinued by the Reserves Group (Fig. 3).

South of Cape Blanco

Video lander research conducted south of Cape Blanco has exclusively been by the Reserves Group. The Redfish Rocks Marine Reserve is located off the southern Oregon coast between Rocky Point and Coal Point, just south of Port Orford (Fig. A4). The site includes the marine reserve, and a marine protected area to the west that stretches offshore nearly to the state's Territorial Sea boundary. The marine reserve includes emergent rocks and islands surrounded by high-relief rocky reef and bedrock, intermixed with cobble and boulder fields. Kelp beds are prevalent between the islands and the shore. The Redfish Rocks Marine Reserve encompasses 7 km^2 with a depth range of 0 – 54 m, and harvest restrictions began in 2012. The associated comparison areas for the Redfish Rocks Marine Reserve include Humbug to the south of the reserve, and Orford Reef located north of the reserve.

A total of 228 successful deployments were completed in the Redfish Rocks region from 2010 – 2017. Deployments were conducted at depths ranging from 7.1 – 53.4 m. Of the 228 deployments completed in the Redfish Rocks Region, 113 were in the Redfish Rocks Marine Reserve. The remaining 115 deployments were conducted in the associated comparison areas: 82 at the Humbug Comparison Area and 33 at the Orford Reef Comparison Area.

Offshore

The offshore reef complex that has been the focus of Fisheries Group video lander studies (1168 of 1666 total lander deployments) is comprised of Stonewall Bank, Enterprise Reef, and Heceta Bank (Fig. A5 [in present paper]; Hannah and Blume 2012, 2014, 2016). This rocky reef complex is located off the central Oregon coast approximately 25 – 60 km offshore. The most frequented reef within this complex, Stonewall Bank, is located approximately 25 km west of Newport. Stonewall Bank was selected as an ideal location for initial field tests and ongoing large-scale surveys due to the abundant rocky substrate and frequent favorable underwater visibility. Additionally, the center of the Stonewall Bank reef structure is incorporated into a Yelloweye Rockfish Conservation Area (approximately 5 km east-west and 42 km north-south) and was shown to contain a diverse population of demersal fishes (target species for video landers). Of the 1168 offshore video lander deployments completed by the Fisheries Group, 1128 were on Stonewall Bank reef, 599 of which were inside the boundary of the Yelloweye Rockfish Conservation Area. The remaining 40 offshore deployments were split over the adjacent reefs; Enterprise Reef (approximately 13 km northwest of Stonewall Bank, n=10), the Ranch (approximately 20 km west of Stonewall Bank, n=7), Heceta Bank (approximately 40 km southwest of Stonewall Bank, n=16), and 4 deployments on

high relief pinnacles adjacent to Heceta Bank. See Hannah & Blume (2012, 2014, 2016) for more information on site selection and specific research questions addressed.

2.3. Field methods

All three groups used the same deployment and retrieval methods while conducting video lander surveys. Stationary underwater video landers were freely deployed off the side of the research vessel, and retrieved using a pot hauler (Fig. 2). For each video lander deployment, GPS location data were recorded. Bottom time was recorded and defined as the time the video lander was sitting on the benthos (i.e., excluding deploy and retrieval time). Bottom times varied by study. The Fisheries, Reserves and Nearshore Groups ranged in bottom time from 4-17 minutes, 3-8 minutes, and 15 minutes respectively. The majority of video lander deployments were carried out at least 1 hour after sunrise and 1 hour prior to sunset to avoid the crepuscular period. Survey design varied by project, with the majority of deployments following a stratified sampling grid design; however, the Reserves Group's ongoing monitoring is based on stratified random design with a minimum of 100-250 m distance (depending on use of bait) to assure independence. All three research groups targeted areas containing hard substrate such as bedrock and boulders, or, in the absence of consolidated substrate, cobble and gravel. Habitat selection was based on bathymetry and seafloor substrate maps available at the time of the respective studies. Maps were primarily provided by the Oregon State University, Active Tectonics & Seafloor Mapping Lab (Goldfinger et al. 2014).

Fisheries Group

Video lander surveys were conducted either on nearshore or offshore rocky reef complexes typical of the Oregon coast. In general, deployments targeted hard or rocky substrate such as bedrock, but in some cases high-relief substrates, such as large boulders or vertical walls, were targeted due to a higher likelihood of encountering the species of concern (i.e., Yelloweye Rockfish). Aside from occasional experimental deployments that targeted a specific feature (i.e., substrate type, known demersal fish habitat, or large pelagic schools viewed on echo sounder), surveys were carried out on rectangular sampling grids with pre-determined distances between deployment locations (Hannah and Blume 2016). Within sampling grids, minimum distance between deployment locations was used to avoid counting the same fish at two different locations. A minimum distance of 100 m was used for most studies but was increased to 400 m in the baited video lander study (Hannah and Blume 2012, 2014). Surveys were conducted from a variety of platforms including commercial passenger fishing vessels, commercial fishing vessels, and research vessels out of Newport. Initial development and research of sampling locations was based, in part, on the local knowledge and expertise of the skippers taking part in these studies.

Bottom time was variable across studies performed by the Fisheries Group (Table 2). Initial field tests showed that a bottom time in the 4-5 minute range was sufficient for allowing any disturbed sediment to clear from the field of view, as well as for the number of fish in the frame to stabilize (additional time did not result in higher counts or more species observed). Furthermore, shorter deployment times allowed for the completion of additional deployments, maximizing the area surveyed each day (Easton et al. 2015; Hannah and Blume 2012). Bottom time was increased to 12 minutes for the baited stereo video lander survey, Hannah & Blume (2014), to increase the ability of fish to respond to the bait while still maintaining an adequate daily sampling rate.

Bottom time ranged from 6-15 minutes for the stereo video lander range study (Hannah and Blume 2016), because rather than simply deploying on rocky substrate, this study was targeting large fish schools using the vessel's echo sounder. The goal was to sample in a variety of light and water clarity conditions and to maximize the number and variety of fish seen at various distances from the camera (Hannah and Blume 2016).

Hannah and Blume (2014) was the only study conducted by the Fisheries Group in which the video lander was outfitted with bait, and accounts for 166 of the 1666 successful deployments. Bait was suspended in front of the stereo cameras by hanging a mesh bait bag to one end of a 152 cm pole, and attaching the other end to the top of the frame. Bait consisted of either Pacific Sardine *Sardimops sagax*, Pacific Herring *Clupea harengus*, or a mixture of both species. The remaining deployments (n=1500) conducted by the Fisheries Group were unbaited deployments.

Stereo video was introduced to the Fisheries Group video lander in 2013 and accounts for 212 of the 1666 successful deployments conducted by the Fisheries Group (209 of which occurred at offshore study areas). In order to use paired video for measuring fish length, the video cameras must be synchronized in the field before each deployment. A number of methods were used to achieve synchronization of the cameras, including showing a running stopwatch to the cameras so video could be paired to the nearest hundredth of a second, as well as using a clapper board to identify the same frame in both the right and left videos (Hannah and Blume 2014, 2016; Knight et al. 2018).

In time, additional environmental sensors were either added to the video lander frame or deployed simultaneously from another platform. The 2016 study by Hannah and Blume tested the detection range of various sizes and species of rockfish in varied light and water clarity conditions. In order to achieve this, the video lander was outfitted with additional optical sensors including a Wildlife Computers TDR-MK9 tag that measured ambient light, as well as a Wetlabs ECO-BBB scattering meter that measured water clarity. The 2016 study found that the ability to detect and identify fish may be impacted by the water clarity, and that measuring clarity has the potential to control for these differences across varying conditions (Hannah and Blume 2016). Therefore, subsequent to this study, the video lander was deployed with the scatter meter to allow for analysis when necessary.

Reserves Group

Leading up to the 2012 implementation of harvest restrictions in Oregon's first two marine reserves, the video lander was used for systematic rapid assessments of habitat from 2010 to 2011. Deployments were made on a regular grid system at each site. For the Otter Rock site, a 200 x 200 m grid was used; for the Redfish Rock site a 350 x 350 m grid was used. These experimental units were chosen to balance sampling effort based on differences in reserve size, and to assure independence between units (ODFW 2014).

The video lander was also deployed in 2010 – 2011 to target rocky substrate types using a stratified random design (rocky substrates stratified by depth). Locations for video lander deployments were randomly assigned on rocky substrate within depth bins stratified as 0 – 7 m, 7.1 – 14 m, 14.1 – 21 m, and 21+ m. Deployments were separated by a minimum distance of 100 m to assure independence. Based on previous video lander studies off the Oregon coast (as recommended by Hannah and Blume 2012), a bottom time of four minutes was targeted (ODFW 2014).

In 2012 – 2013, sampling days were chosen based on reports of good underwater visibility, and multi-day trips were preferred to minimize temporal variation in the data. Deployment locations were determined using a stratified random design (rock substrates stratified by depth). Beginning in 2012, depth stratification was altered to reflect 10 m depth bins (i.e., 0 – 10 m, 10.1 – 20 m, etc.) and a bottom time of four minutes was targeted (ODFW 2015).

Beginning in 2014, a new lightweight video lander configuration was designed for improved cost-effective sampling in Oregon's nearshore waters and marine reserves. This video lander used a three-camera array, with each camera covering one third of a 360° field of view, and only one camera is chosen for analysis (Fig. 2). To determine the ideal bottom time for this newly configured video lander within the nearshore, the four minute bottom time suggested by Hannah and Blume (2012) was extended to 12 minutes. Extending the bottom time allowed evaluation of the potential impact of removing lights, and therefore attraction potential for certain species, as well as evaluation of whether additional bottom time yielded greater observed diversity or MaxN estimates following the initial 'disturbance' of the lander settling on the seafloor. Methods for these analyses can be found in Watson and Huntington (2016). Video lander deployment locations were selected using a stratified random design, first constraining the study area to rocky reef habitats between 3 – 33 m in depth, and then randomly selecting points using a minimum buffer distance of 200 m.

In 2015, pilot tests of the lightweight nearshore video lander were continued in order to evaluate whether to bait the video lander in the nearshore. Testing of bait was conducted at two sites, Otter Rock and Seal Rocks, within 10 nautical miles of Newport. A stratified random design was used to generate 40 sampling points on rocky substrates between 5 – 25 m depths. Sampling points were spaced a minimum of 250 m apart to minimize the influence of bait on adjacent deployments. Methods for these analyses can be found in Watson and Huntington (2016).

Based on the findings in Watson and Huntington (2016), subsequent deployments (conducted from 2016 – 17) were unbaited with a bottom time of 8 minutes, and videos collected from 2014-2016 with bottom time durations greater than 8 min were clipped and re-scored to standardize videos to 8 min in length.

Nearshore Group

For the study conducted in 2014-15 by the Nearshore Group, sampling focused on rocky reefs near Newport within 3 nautical miles of shore. Target deployment locations were determined by selecting a random starting point within the mapped rocky habitat, and spacing at 400 m intervals on a hexagonal grid. Rocky areas were mapped using the substrate layer produced during the Oregon state waters mapping program (Goldfinger et al. 2014), and supplemented by adding a number of small rocky reef areas near the mouth of Alsea Bay commonly referred to as the "postage stamp". The postage stamp area is known to local fishers as a productive area, and was included as part of the 12-year Black Rockfish passive integrated transponder tag study conducted by ODFW (Krutzikowsky et al. 2019).

All field sampling was conducted aboard a commercial passenger fishing vessel. In general, if rocky substrate was not detected on the vessel's sounder at the target location, the video lander was deployed at the nearest location that rocky habitat was detected within a 200 m radius, otherwise the target location was not sampled. Several target locations were not sampled because it appeared to be soft bottom habitat throughout the surrounding area, but despite this effort,

some video lander deployments were made in soft bottom habitat. Only target locations that could have been accessed safely were sampled.

The video lander was deployed at sampling stations and left on the benthos for approximately 15 minutes, considerably longer than the 4 to 5 minute bottom times utilized by Hannah and Blume (2012) and Easton et al. (2015). The increased bottom time was used to evaluate whether longer bottom times resulted in higher species diversity, or a greater number of individuals for any given species. Actual bottom times varied from 13 to 18 minutes. No bait was used for video lander deployments by the Nearshore Group (Krutzikowsky 2019).

2.4. Video review

Over the years, video review protocols have varied between groups, as well as within both the Fisheries and Research Groups, mainly due to advances in technology and advancing applications of video as a management tool. For the purposes of this document, standardization of each video review protocol was applied, which resulted in certain videos, species and studies being excluded from this document (see section 2.5). Protocol standardization for this document did not apply to bottom time (the amount of time the lander spent on the seafloor). While fine scale review methods varied between studies (see Hannah & Blume 2012, 2014, 2016; Easton et al. 2015; Watson and Huntington 2016; Knight et al. 2018; and Krutzikowsky 2019), the data developed and reported in this document met the following standardized criteria:

- All video was reviewed in Adobe Premiere Software.
- For each deployment, the video was required to meet the minimum view and visibility standards (Table 3, Fig. 4).
- If the view was greatly obstructed, skewed up or downward when the lander settled to the seafloor, or the visibility was so poor that the surrounding substrate was completely obstructed (fish identification impossible) then the video was excluded from further analysis.
- Alternatively, if the view and visibility received a moderate to good score, the review proceeded to the next step which was to define the primary and secondary habitat types from six predetermined categories: bedrock, large boulder, small boulder, cobble, gravel/pebble, or soft (Table 4). These categories were adapted from collaborative habitat research between the Oregon Department of Fish and Wildlife and Oregon State University (Stein et al. 1992).
- The final habitat-related step was to classify topographic relief of the substrate into one of three relief categories: low, moderate, or high. Of note, this step was not completed by the Fisheries Group.
- For deployments conducted by the Reserves Group, using the lander with three cameras, the camera with the best view, visibility, and habitat was selected for analysis. When all three cameras were equal, one video was randomly chosen.

Table 3. Criteria used to classify the visibility and view for each lander drop (adapted from Hannah and Blume 2012).

Category	Class	Description
Visibility	Poor (0)	View of surrounding substrate completely obscured by turbidity or marine snow. Video excluded from further analysis/this report
	Moderate (1)	View of surrounding substrate is not obscured but viewing distance is limited by variable turbidity and/or marine snow
	Good (2)	View of surrounding substrate is clear to the limit of the lighted area
View Quality	Poor (0)	Camera is facing a rock in close proximity, looking straight down at the substrate or up in open water. Video excluded from further analysis/this report
	Moderate (1)	View is at acceptable angle, substrate can be seen, however a portion of the view is blocked by nearby habitat
	Good (2)	View is at an acceptable angle and view is unobstructed

Application of the view, visibility, and habitat criteria resulted in a total of 2691 deployments for the purposes of this document (Reserves Group=880, Nearshore Group=145, and Fisheries Group=1666). The video from these deployments was reviewed using a standard MaxN approach for quantifying relative abundance for each fish species (Ellis and DeMartini 1995, Harvey et al. 2007), which results in a conservative abundance estimate. The MaxN approach determines all individuals that can be identified to species throughout the whole video and the frame containing the largest number of each species is defined as the MaxN frame.

For the purposes of this report, supplemental data (such as observed invertebrate, habitat or oceanographic data) assigned to each deployment were excluded; however, these data may support further analysis or modeling, and are available on request.

It should be noted that the Reserves Group had an additional step in their video review protocol in which any video containing soft substrate for both primary and secondary habitat was removed from further analysis. This step resulted in a slightly different number of videos kept/reviewed for further analysis than was true for the Fisheries and Nearshore groups.

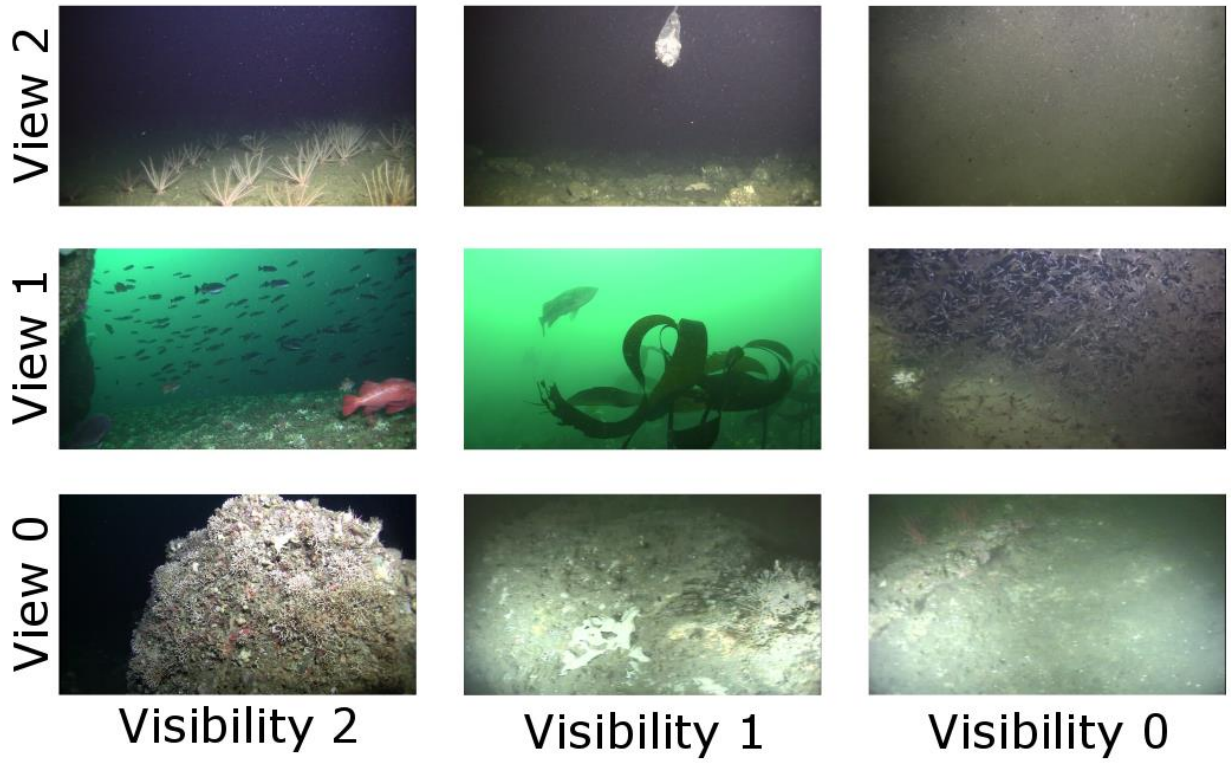

Figure 4. Examples of all possible combinations of view and visibility. See Table 3 for definition of each view and visibility category.

Table 4. Criteria used to classify primary and secondary habitat types. Adapted from Stein et al. (1992), and standardized for this report.

Habitat type	Description
Bedrock	Rock that is "fixed" to the bottom.
Large boulder	Boulders approximately 1-3 m in diameter (includes angular blocks of broken bedrock)
Small boulder	Boulders approximately 0.25-1 m diameter
Cobble	Cobble approximately 6-25 cm diameter
Gravel/Pebble	Gravel or pebble approximately 2-60 mm diameter
Soft	Unconsolidated, sand (grain sizes 0.06-2 mm diameter), mud or hash (small broken bits of shell)

2.5. Data Standardization

As previously stated, the manner in which videos were collected and reviewed has varied over the years, both between projects and within each project. Variations in protocols have mainly been in response to changes in technology such as; the lights and cameras used to collect video (e.g. advancing from halogen to LED bulbs, and moving from standard definition video to high definition), as well as the software used in lander video review (e.g. upgrading from video editing software to highly specialized photogrammetry software). Protocols have also evolved over the years to accommodate changing management objectives (e.g. the use of larger systems equipped with maximum lighting to capture presence/absence of a target species in deeper, darker reefs, versus the use of a smaller, unlit systems for the purpose of capturing relative abundance and density of species found within nearshore reefs). Despite differences in gear, review methodology, and original intent for each survey, lander video collected across these systems has sufficient underlying similarities to allow for standardization, and therefore analysis. The following steps were carried out to combine the video review databases from each of the three groups included in this report;

A. Created a standardized list of species (see Table 5.) that met the following criteria;
    i. Identified to the species level (genus or unknown species were excluded)
    ii. Identified as present or absent by all three groups (eliminated false negatives by not assuming that if a species was not seen it was not there)
    iii. Combined species according to their stock assessment status (i.e. Blue and Deacon Rockfish are assessed as one species complex)
B. Standardized visibility scores between groups
    i. Reduced the level of detail from 4 scores to 3 (0, 1 or 2)
    ii. Excluded videos with scores of 0
C. Standardized view scores between groups
    i. Reduced the level of detail from 4 scores to 3 (0, 1 or 2)
    ii. Removed videos with scores of 0
D. Standardized habitat scores
    i. Vertical wall and crevice were reclassified as bedrock
    ii. Mud, sand and shell hash were reclassified into one category: soft
E. Removed relief scores from the Reserve and Nearshore group's databases because this habitat observation was not scored by the Fisheries Group.
F. Removed biogenic habitat scores from the Reserve and Nearshore group's databases because this habitat observation was not scored by the Fisheries Group.

Standardization steps were limited to post-processed video only, in other words, no video was re-reviewed for the purposes of inclusion in this document. However, each dataset was subjected to the quality assurance procedure composed by the group collecting the data. Details about those procedures may be found in the publications cited in Table 1.

2.6. Statistical analysis

One of the best utilities of landers to the stock assessment process is to provide estimates of species abundances, which requires estimates of average density. Therefore, we estimated the parameters describing the distribution of the count data using different estimation techniques. Preliminary examination of the MaxN count data (regardless of species or study area) showed

that it was best described by a negative binomial distribution. Therefore, we only provide parameters to describe a negative binomial fit for each species/study area combination (Table 6, Appendix B). However, it should be noted that some species (e.g. Kelp Greenling) were better explained with a Poisson distribution (Appendix C). Parameter estimates were generated using both maximum likelihood and Bayesian methods in R version 3.5.1 Feather Spray (Appendix B, R Core Team 2018).

Maximum likelihood parameter estimates were generated using the fitdistrplus package (Delignette-Muller and Dutang 2015). To assess the effect of outliers on the quality of the parameter estimate, 90% of the data were subsampled with replacement, 4,000 times, and parameter estimates generated.

Bayesian parameter estimates were generated using the rstanarm package by fitting a generalized linear model to the count data with an intercept of 1 (Goodrich et al. 2018). For simplicity, the same priors were used for each species area combination. The prior for the mean was a normal distribution with a mean of 0 and standard deviation of 10. The prior for size was an exponential distribution with a rate of 1. Four thousand samples were collected for each species/study area combination.

For the maximum likelihood and Bayesian estimates, variance was calculated as

$$Variance = \mu + \frac{\mu^2}{k}$$

where μ is the estimated mean and *k* is the over-dispersion or size parameter (Bolker 2008).

Only a subset of species was included in the video analysis (Table 5). Since Yelloweye Rockfish are currently the only overfished stock sampled in this work, count data from this report were utilized to develop simulations of a video lander survey of untrawlable habitat. Methods and results are presented in Appendix D.

Table 5. Species observed in the lander video, whether they were analyzed or not, and their common depth range and PMFC Rockfish Category (Thom 2018) * Blue and Deacon were grouped as a species complex, ** Bocaccio and Silvergray were grouped as a species complex

Scientific name	Common name	Primary Depth Range	PFMC Rockfish Complex	Analyzed
Sebastes melanops	Black Rockfish	< 73 m	Black/Blue/Deacon	Included
Sebastes auriculatus	Brown Rockfish	< 70 m	Nearshore	Included
Scorpaenicthys marmoratus	Cabezon	< 73 m	NA	Included
Sebastes pinniger	Canary Rockfish	80 – 200 m	Major	Included
Sebastes nebulosus	China Rockfish	10 – 128 m	Nearshore	Included
Sebastes caurinus	Copper Rockfish	0 – 70 m	Nearshore	Included
Sebastes elongatus	Greenstriped Rockfish	100 – 300 m	Shelf	Included
Hexigrammos decagrammus	Kelp Greenling	0 – 130 m	NA	Included
Ophiodon elongatus	Lingcod	0 – 200 m	NA	Included
Sebastes maliger	Quillback Rockfish	10 – 130 m	Nearshore	Included
Sebastes helvomaculatus	Rosethorn Rockfish	80 – 350 m	Shelf	Included
Sebastes nigrocinctus	Tiger Rockfish	30 – 298 m	Shelf	Included
Sebastes miniatus	Vermilion Rockfish	6 – 478 m	Shelf	Included
Sebastes entomelas	Widow Rockfish	< 200 m	Major	Included
Sebastes ruberrimus	Yelloweye Rockfish	91 – 180 m	Shelf	Included
Sebastes flavidus	Yellowtail Rockfish	90 – 180 m	Major	Included
Sebastes mystinus	Blue Rockfish*	< 549 m	Black/Blue/Deacon	Included
Sebastes diaconus	Deacon Rockfish*	<549 m	Black/Blue/Deacon	Included
Sebastes paucispinis	Bocaccio**	95 – 225 m	Major	Included
Sebastes brevispinis	Silvergray**	100 – 300 m	Shelf	Included
Embiotocidae family	Surfperch species	NA	NA	Excluded
Hippoglossus stenolepis	Pacific Halibut	27 – 274 m	NA	Excluded
Ronquilus jordani	Northern Ronquil	< 150 m	NA	Excluded
Eptatetus spp.	Hagfish	91 – 366 m	NA	Excluded
Hydrolagus colliei	Spotted Ratfish	50 – 400 m	NA	Excluded
Sebastes zaventrus	Sharpchin Rockfish	200 – 300 m	Slope	Excluded
Sebastes proriger	Redstripe Rockfish	55 – 300 m	Shelf	Excluded
Zaprora silenus	Prowfish	100 – 250 m	NA	Excluded
Cottidae Family	Sculpin species	NA	NA	Excluded
Anarrhichthys ocellatus	Wolf Eel	0 – 309 m	NA	Excluded
Family Arhynchobatidae or Rajidae	Skates	NA	NA	Excluded
Unidentified species		NA	NA	Excluded

Table 6. Summary statistics and negative binomial parameter estimates for each project and study area combination for 18 species of groundfish. Parameter estimates were generated using both a maximum likelihood and a Bayesian methods. Plots displaying goodness of fit for each estimate method are presented in Appendix B. Plots comparing Poisson and negative binomial distributions are presented in Appendix C. In both appendices figures are not provided for all species, research group and study area combinations. These figures were omitted in situations where very few sightings occurred. Ultimately, these low number of sightings resulted in a model that was unable to coalesce around parameter estimates. FG = Fisheries Group, RG = Reserves Group, NG = Nearshore Group, SD- Standard Deviation, NaN- Not a Number

					Maximum Likelihood Estimates			Bayesian Estimates		
Species	**Location**	**Project**	**Sample Size**	**# Positive Stations (Percentage)**	**Mean ± SD**	**Size ± SD**	**Variance**	**Mu ± SD**	**Size ± SD**	**Variance**
Black	Entire State	FG, NG & RG	2691	526 (19.55 %)	0.978 ± 0.067	0.086 ± 0.005	12.154	0.983 ± 0.096	0.086 ± 0.005	12.242
Rockfish	Nearshore	FG, NG & RG	1523	526 (34.54 %)	1.729 ± 0.112	0.173 ± 0.01	19.041	1.731 ± 0.159	0.173 ± 0.010	19.071
	Offshore	FG	1168	0	NaN	NaN	NaN	NaN	NaN	NaN
	South Coast	RG	259	128 (49.42 %)	1.83 ± 0.209	0.351 ± 0.046	11.364	0.983 ± 0.095	0.086 ± 0.005	12.228
	Cape Perpetua	FG & RG	62	20 (32.26 %)	2.418 ± 0.869	0.132 ± 0.037	46.886	2.787 ± 1.671	0.138 ± 0.039	59.007
	Central Coast	FG, NG & RG	863	340 (39.4 %)	1.97 ± 0.155	0.207 ± 0.015	20.723	1.98 ± 0.216	0.208 ± 0.015	20.827
		FG	127	43 (33.86 %)	1.559 ± 0.341	0.184 ± 0.038	14.754	1.628 ± 0.53	0.19 ± 0.039	15.602
		NG	145	70 (48.28 %)	4.628 ± 0.852	0.213 ± 0.032	105.141	4.78 ± 1.304	0.215 ± 0.034	111.034
		RG	591	227 (38.41 %)	1.406 ± 0.126	0.248 ± 0.024	9.369	1.417 ± 0.18	0.25 ± 0.024	9.462
	North Coast	FG & RG	339	38 (11.21 %)	0.908 ± 0.263	0.037 ± 0.007	23.418	0.991 ± 0.427	0.038 ± 0.007	27.039
		FG	314	35 (11.15 %)	0.92 ± 0.278	0.036 ± 0.007	24.323	1.02 ± 0.479	0.037 ± 0.007	28.92
		RG	25	3 (12 %)	0.76 ± 0.744	0.044 ± 0.032	13.839	11.427 ± 158.573	0.063 ± 0.045	2095.166
Blue/	Entire State	FG, NG & RG	2691	323 (12 %)	0.786 ± 0.075	0.043 ± 0.003	15.141	0.795 ± 0.11	0.043 ± 0.003	15.414
Deacon	Nearshore	FG, NG & RG	1523	278 (18.25 %)	0.91 ± 0.086	0.080 ± 0.006	11.282	0.921 ± 0.123	0.080 ± 0.006	11.507
Rockfish	Offshore	FG	1168	45 (3.85 %)	0.624 ± 0.19	0.009 ± 0.002	42.436	0.698 ± 0.33	0.009 ± 0.002	52.056
	South Coast	RG	259	80 (30.89 %)	1.139 ± 0.177	0.186 ± 0.029	8.099	0.815 ± 0.109	0.045 ± 0.003	15.604
	Cape Perpetua	FG & RG	62	4 (6.45 %)	0.081 ± 0.043	0.187 ± 0.257	0.115	0.088 ± 0.108	0.81 ± 0.895	0.097
	Central Coast	FG, NG & RG	863	169 (19.58 %)	1.106 ± 0.14	0.081 ± 0.008	16.12	1.120 ± 0.195	0.082 ± 0.008	16.399
		FG	127	31 (24.41 %)	2.354 ± 0.729	0.085 ± 0.019	67.468	2.612 ± 1.317	0.088 ± 0.02	80.136
		NG	145	47 (32.41 %)	1.697 ± 0.375	0.154 ± 0.029	20.391	1.753 ± 0.563	0.158 ± 0.030	21.228
		RG	591	91 (15.4 %)	0.692 ± 0.112	0.071 ± 0.01	7.473	0.712 ± 0.164	0.072 ± 0.01	7.804
	North Coast	FG & RG	339	25 (7.37 %)	0.389 ± 0.13	0.028 ± 0.007	5.738	0.432 ± 0.227	0.03 ± 0.007	6.687
		FG	314	25 (7.96 %)	0.42 ± 0.14	0.031 ± 0.008	6.169	0.468 ± 0.247	0.032 ± 0.008	7.292
		RG	25	0	NaN	NaN	NaN	NaN	NaN	NaN

Brown Rockfish	Entire State	FG, NG & RG	2218	3 (0.14 %)	NaN	NaN	NaN	0.002 ± 0.003	0.331 ± 0.632	0.002
	Nearshore	FG, NG & RG	1209	3 (0.25 %)	0.003 ± 0.002	0.005 ± 0.005	0.006	NaN	NaN	NaN
	Offshore	FG	1009	0	NaN	NaN	NaN	NaN	NaN	NaN
	South Coast	RG	259	0	NaN	NaN	NaN	NaN	NaN	NaN
	Cape Perpetua	FG & RG	62	3 (4.84 %)	0.065 ± 0.041	0.101 ± 0.134	0.106	0.08 ± 0.266	0.688 ± 0.801	0.089
	Central Coast	FG, NG & RG	863	0	NaN	NaN	NaN	NaN	NaN	NaN
		FG	127	0	NaN	NaN	NaN	NaN	NaN	NaN
		NG	145	0	NaN	NaN	NaN	NaN	NaN	NaN
		RG	591	0	NaN	NaN	NaN	NaN	NaN	NaN
	North Coast	FG & RG	25	0	NaN	NaN	NaN	NaN	NaN	NaN
		FG	0	0	NaN	NaN	NaN	NaN	NaN	NaN
		RG	25	0	NaN	NaN	NaN	NaN	NaN	NaN
Cabezon	Entire State	FG, NG & RG	2532	27 (1.07 %)	0.011 ± 0.002	0.174 ± 0.21	0.012	0.011 ± 0.003	0.864 ± 0.904	0.011
	Nearshore	FG, NG & RG	1523	26 (1.71 %)	0.018 ± 0.003	0.299 ± 0.397	0.019	0.018 ± 0.005	0.952 ± 0.889	0.018
	Offshore	FG	1009	1 (0.1 %)	0.018 ± 0.003	0.299 ± 0.397	0.019	0.001 ± 0.001	0.987 ± 0.997	0.001
	South Coast	RG	259	2 (0.77 %)	0.008 ± 0.005	NaN	0.008	0.011 ± 0.003	0.817 ± 0.866	0.011
	Cape Perpetua	FG & RG	62	4 (6.45 %)	0.081 ± 0.043	0.187 ± 0.257	0.115	0.088 ± 0.075	0.81 ± 0.879	0.098
	Central Coast	FG, NG & RG	863	17 (1.97 %)	0.02 ± 0.005	39133.48 ± 329.345	0.02	0.02 ± 0.007	1.281 ± 1.076	0.02
		FG	127	2 (1.57 %)	0.016 ± 0.011	NaN	0.016	0.016 ± 0.017	0.978 ± 0.965	0.017
		NG	145	6 (4.14 %)	0.041 ± 0.017	147767.8 ± 33554.43	0.041	0.042 ± 0.026	1.232 ± 1.094	0.044
		RG	591	9 (1.52 %)	0.015 ± 0.005	NaN	0.015	0.015 ± 0.007	1.133 ± 1.027	0.016
	North Coast	FG & RG	339	3 (0.88 %)	0.009 ± 0.005	NaN	0.009	0.009 ± 0.008	1.04 ± 1.048	0.009
		FG	314	3 (0.96 %)	0.01 ± 0.005	2822.839 ± 3290.283	0.01	0.01 ± 0.008	1.007 ± 1.042	0.01
		RG	25	0	NaN	NaN	NaN	NaN	NaN	NaN
Canary Rockfish	Entire State	FG, NG & RG	2691	445 (16.54 %)	0.778 ± 0.058	0.074 ± 0.005	8.948	0.781 ± 0.082	0.074 ± 0.005	8.971
	Nearshore	FG, NG & RG	1523	229 (15.04 %)	0.717 ± 0.075	0.066 ± 0.006	8.513	0.723 ± 0.108	0.066 ± 0.006	8.580
	Offshore	FG	1168	216 (18.49 %)	0.717 ± 0.075	0.066 ± 0.006	8.513	0.865 ± 0.128	0.085 ± 0.008	9.611
	South Coast	RG	259	26 (10.04 %)	0.378 ± 0.113	0.048 ± 0.013	3.334	0.778 ± 0.082	0.074 ± 0.005	8.926
	Cape Perpetua	FG & RG	62	40 (64.52 %)	5.566 ± 1.116	0.433 ± 0.096	77.112	5.797 ± 1.731	0.442 ± 0.1	81.794
	Central Coast	FG, NG & RG	863	109 (12.63 %)	0.457 ± 0.065	0.065 ± 0.008	3.676	0.466 ± 0.096	0.065 ± 0.008	3.787
		FG	127	44 (34.65 %)	1.386 ± 0.293	0.202 ± 0.043	10.883	1.451 ± 0.445	0.209 ± 0.046	11.536
		NG	145	25 (17.24 %)	0.586 ± 0.168	0.097 ± 0.027	4.112	0.637 ± 0.281	0.104 ± 0.029	4.526
		RG	591	40 (6.77 %)	0.225 ± 0.053	0.035 ± 0.007	1.673	0.236 ± 0.082	0.036 ± 0.008	1.761
	North Coast	FG & RG	339	54 (15.93 %)	0.755 ± 0.161	0.071 ± 0.013	8.744	0.795 ± 0.26	0.073 ± 0.013	9.448
		FG	314	54 (17.2 %)	0.815 ± 0.172	0.078 ± 0.014	9.339	0.849 ± 0.254	0.08 ± 0.014	9.855
		RG	25	0	NaN	NaN	NaN	NaN	NaN	NaN

China Rockfish	Entire State	FG, NG & RG	2691	10 (0.37 %)	0.004 ± 0.001	NaN	0.004	0.004 ± 0.002	1.06 ± 1.058	0.004
	Nearshore	FG, NG & RG	1523	10 (0.66 %)	0.007 ± 0.002	NaN	0.007	NaN	NaN	NaN
	Offshore	FG	1168	0	NaN	NaN	NaN	NaN	NaN	NaN
	South Coast	RG	259	2 (0.77 %)	0.008 ± 0.005	NaN	0.008	0.004 ± 0.002	1.049 ± 1.029	0.004
	Cape Perpetua	FG & RG	62	0	NaN	NaN	NaN	NaN	NaN	NaN
	Central Coast	FG, NG & RG	863	7 (0.81 %)	0.008 ± 0.003	NaN	0.008	0.008 ± 0.004	1.076 ± 1.018	0.008
		FG	127	3 (2.36 %)	0.024 ± 0.014	89132.362 ± 519.211	0.024	0.025 ± 0.023	1.052 ± 0.988	0.026
		NG	145	2 (1.38 %)	0.014 ± 0.01	13744.2 ± 1640.22	0.014	0.015 ± 0.02	1 ± 0.977	0.015
		RG	591	2 (0.34 %)	0.003 ± 0.002	NaN	0.003	0.003 ± 0.003	1.029 ± 0.976	0.004
	North Coast	FG & RG	339	1 (0.29 %)	0.003 ± 0.003	8885.571 ± 3007.22	0.003	0.003 ± 0.005	1.012 ± 1.013	0.003
		FG	314	1 (0.32 %)	0.003 ± 0.003	NaN	0.003	0.003 ± 0.005	1.013 ± 1.024	0.003
		RG	25	0	NaN	NaN	NaN	NaN	NaN	NaN
Copper Rockfish	Entire State	FG, NG & RG	2691	38 (1.41 %)	0.017 ± 0.003	0.036 ± 0.014	0.026	0.017 ± 0.004	0.047 ± 0.023	0.024
	Nearshore	FG, NG & RG	1523	35 (2.3 %)	0.028 ± 0.005	0.062 ± 0.026	0.041	0.028 ± 0.007	0.091 ± 0.069	0.037
	Offshore	FG	1168	3 (0.26 %)	0.028 ± 0.005	0.062 ± 0.026	0.041	0.018 ± 0.608	0.371 ± 0.66	0.019
	South Coast	RG	259	2 (0.77 %)	0.015 ± 0.014	0.006 ± 0.006	0.054	0.018 ± 0.004	0.047 ± 0.022	0.024
	Cape Perpetua	FG & RG	62	7 (11.29 %)	0.145 ± 0.059	0.307 ± 0.312	0.214	0.152 ± 0.086	0.768 ± 0.746	0.182
	Central Coast	FG, NG & RG	863	20 (2.32 %)	0.028 ± 0.007	0.071 ± 0.043	0.039	0.028 ± 0.009	0.179 ± 0.249	0.032
		FG	127	7 (5.51 %)	0.063 ± 0.025	0.282 ± 0.395	0.077	0.065 ± 0.036	0.886 ± 0.877	0.069
		NG	145	7 (4.83 %)	0.048 ± 0.018	NaN	0.048	0.05 ± 0.028	1.229 ± 1.052	0.052
		RG	591	6 (1.02 %)	0.015 ± 0.007	0.014 ± 0.01	0.032	0.017 ± 0.012	0.054 ± 0.148	0.022
	North Coast	FG & RG	339	6 (1.77 %)	0.018 ± 0.007	NaN	0.018	0.018 ± 0.01	1.109 ± 0.971	0.018
		FG	314	6 (1.91 %)	NaN	NaN	NaN	0.019 ± 0.011	1.108 ± 1.011	0.02
		RG	25	0	NaN	NaN	NaN	NaN	NaN	NaN
Greenstripe Rockfish	Entire State	FG, NG & RG	2377	9 (0.38 %)	0.004 ± 0.001	0.019 ± 0.02	0.005	0.004 ± 0.002	0.489 ± 0.713	0.004
	Nearshore	FG, NG & RG	1209	0	NaN	NaN	NaN	NaN	NaN	NaN
	Offshore	FG	1168	9 (0.77 %)	0.004 ± 0.001	0.019 ± 0.02	0.005	0.009 ± 0.004	0.581 ± 0.755	0.009
	South Coast	RG	259	0	NaN	NaN	NaN	NaN	NaN	NaN
	Cape Perpetua	FG & RG	62	0	NaN	NaN	NaN	NaN	NaN	NaN
	Central Coast	FG, NG & RG	863	0	NaN	NaN	NaN	NaN	NaN	NaN
		FG	127	0	NaN	NaN	NaN	NaN	NaN	NaN
		NG	145	0	NaN	NaN	NaN	NaN	NaN	NaN
		RG	591	0	NaN	NaN	NaN	NaN	NaN	NaN
	North Coast	FG & RG	25	0	NaN	NaN	NaN	NaN	NaN	NaN
		FG	0	NaN	NaN	NaN	NaN	NaN	NaN	NaN
		RG	25	0	NaN	NaN	NaN	NaN	NaN	NaN

Kelp	Entire State	FG, NG & RG	2691	663 (24.64 %)	0.299 ± 0.011	1.587 ± 0.302	0.355	0.299 ± 0.017	1.616 ± 0.313	0.355
Greenling	NG	FG, NG & RG	1523	541 (35.52 %)	0.445 ± 0.018	2.856 ± 0.729	0.515	0.445 ± 0.026	2.771 ± 0.690	0.517
	Offshore	FG	1168	122 (10.45 %)	0.109 ± 0.01	404337 ± 266.607	0.109	0.109 ± 0.014	2.594 ± 1.276	0.113
	South Coast	RG	259	116 (44.79 %)	0.51 ± 0.044	NaN	0.51	0.3 ± 0.016	1.62 ± 0.318	0.355
	Cape Perpetua	FG & RG	62	23 (37.1 %)	0.532 ± 0.103	2.182 ± 2.474	0.662	0.538 ± 0.159	1.657 ± 0.999	0.712
	Central Coast	FG, NG & RG	863	332 (38.47 %)	0.489 ± 0.026	2.476 ± 0.674	0.586	0.489 ± 0.037	2.408 ± 0.623	0.588
		FG	127	43 (33.86 %)	0.441 ± 0.067	1.576 ± 0.972	0.564	0.442 ± 0.099	1.599 ± 0.782	0.564
		NG	145	77 (53.1 %)	0.848 ± 0.098	1.298 ± 0.396	1.403	0.855 ± 0.139	1.339 ± 0.41	1.401
		RG	591	212 (35.87 %)	0.411 ± 0.026	509944.8 ± 110.867	0.411	0.411 ± 0.039	5.182 ± 1.726	0.443
	North Coast	FG & RG	339	70 (20.65 %)	0.268 ± 0.033	0.799 ± 0.344	0.359	0.268 ± 0.045	0.971 ± 0.485	0.342
		FG	314	70 (22.29 %)	0.29 ± 0.035	0.93 ± 0.424	0.38	0.291 ± 0.05	1.124 ± 0.578	0.367
		RG	25	0	NaN	NaN	NaN	NaN	NaN	NaN
Lingcod	Entire State	FG, NG & RG	2691	455 (16.91 %)	0.211 ± 0.01	0.731 ± 0.129	0.272	0.212 ± 0.014	0.76 ± 0.143	0.27
	Nearshore	FG, NG & RG	1523	336 (22.06 %)	0.272 ± 0.015	1.436 ± 0.41	0.323	0.272 ± 0.021	1.517 ± 0.450	0.321
	Offshore	FG	1168	119 (10.19 %)	0.272 ± 0.015	1.436 ± 0.41	0.323	0.133 ± 0.019	0.306 ± 0.085	0.19
	South Coast	RG	259	36 (13.9 %)	0.143 ± 0.023	990407.9 ± 45.922	0.143	0.211 ± 0.014	0.767 ± 0.144	0.27
	Cape Perpetua	FG & RG	62	14 (22.58 %)	0.323 ± 0.092	0.505 ± 0.339	0.529	0.332 ± 0.141	0.769 ± 0.59	0.475
	Central Coast	FG, NG & RG	863	234 (27.11 %)	0.337 ± 0.021	2.656 ± 1.321	0.38	0.337 ± 0.029	2.467 ± 0.952	0.384
		FG	127	37 (29.13 %)	0.362 ± 0.056	4.414 ± 8.347	0.392	0.365 ± 0.083	2.006 ± 1.118	0.431
		NG	145	58 (40 %)	0.538 ± 0.064	5.167 ± 6.991	0.594	0.539 ± 0.096	2.442 ± 1.144	0.658
		RG	591	139 (23.52 %)	0.283 ± 0.023	2.756 ± 2.004	0.311	0.283 ± 0.032	2.269 ± 1.046	0.318
	North Coast	FG & RG	339	52 (15.34 %)	0.195 ± 0.028	0.555 ± 0.257	0.263	0.195 ± 0.039	0.761 ± 0.451	0.245
		FG	314	51 (16.24 %)	0.207 ± 0.03	0.596 ± 0.283	0.279	0.208 ± 0.043	0.798 ± 0.461	0.262
		RG	25	1 (4 %)	0.04 ± 0.04	NaN	0.04	47.213 ± 2923.784	1.025 ± 1.003	2221.476
Quillback	Entire State	FG, NG & RG	2691	91 (3.38 %)	0.041 ± 0.005	0.097 ± 0.027	0.059	0.041 ± 0.007	0.111 ± 0.033	0.057
Rockfish	Nearshore	FG, NG & RG	1523	64 (4.2 %)	0.054 ± 0.007	0.098 ± 0.029	0.083	0.054 ± 0.010	0.113 ± 0.037	0.080
	Offshore	FG	1168	27 (2.31 %)	0.054 ± 0.007	0.098 ± 0.029	0.083	0.025 ± 0.007	0.694 ± 0.719	0.026
	South Coast	RG	259	6 (2.32 %)	0.039 ± 0.019	0.025 ± 0.018	0.098	0.041 ± 0.007	0.113 ± 0.036	0.057
	Cape Perpetua	FG & RG	62	11 (17.74 %)	0.307 ± 0.105	0.252 ± 0.153	0.68	0.325 ± 0.162	0.439 ± 0.384	0.565
	Central Coast	FG, NG & RG	863	25 (2.9 %)	0.031 ± 0.006	0.242 ± 0.224	0.035	0.032 ± 0.009	0.773 ± 0.772	0.033
		FG	127	11 (8.66 %)	0.094 ± 0.028	1.167 ± 2.687	0.102	0.096 ± 0.043	1.163 ± 0.965	0.104
		NG	145	5 (3.45 %)	0.034 ± 0.015	NaN	0.034	0.036 ± 0.023	1.13 ± 1.023	0.037
		RG	591	9 (1.52 %)	0.017 ± 0.006	0.08 ± 0.093	0.02	0.017 ± 0.008	0.691 ± 0.855	0.018
	North Coast	FG & RG	339	22 (6.49 %)	0.077 ± 0.017	0.254 ± 0.173	0.1	0.078 ± 0.024	0.561 ± 0.539	0.088
		FG	314	22 (7.01 %)	0.083 ± 0.018	0.28 ± 0.194	0.107	0.082 ± 0.026	0.625 ± 0.57	0.093
		RG	25	0	NaN	NaN	NaN	NaN	NaN	NaN

Rosethorn Rockfish	Entire State	FG, NG & RG	2377	192 (8.08 %)	0.12 ± 0.01	0.127 ± 0.019	0.232	0.12 ± 0.014	0.131 ± 0.02	0.229
	Nearshore	FG, NG & RG	1209	0	NaN	NaN	NaN	NaN	NaN	NaN
	Offshore	FG	1168	192 (16.44 %)	0.12 ± 0.01	0.127 ± 0.019	0.232	0.244 ± 0.027	0.32 ± 0.056	0.43
	South Coast	RG	259	0	NaN	NaN	NaN	NaN	NaN	NaN
	Cape Perpetua	FG & RG	62	0	NaN	NaN	NaN	NaN	NaN	NaN
	Central Coast	FG, NG & RG	863	0	NaN	NaN	NaN	NaN	NaN	NaN
		FG	127	0	NaN	NaN	NaN	NaN	NaN	NaN
		NG	145	0	NaN	NaN	NaN	NaN	NaN	NaN
		RG	591	0	NaN	NaN	NaN	NaN	NaN	NaN
	North Coast	FG & RG	25	0	NaN	NaN	NaN	NaN	NaN	NaN
		FG	0	0	NaN	NaN	NaN	NaN	NaN	NaN
		RG	25	0	NaN	NaN	NaN	NaN	NaN	NaN
Silvergray/ Bocaccio Rockfish	Entire State	FG, NG & RG	2377	21 (0.88 %)	0.014 ± 0.004	0.011 ± 0.004	0.032	0.014 ± 0.005	0.013 ± 0.007	0.029
	Nearshore	FG, NG & RG	1209	0	NaN	NaN	NaN	NaN	NaN	NaN
	Offshore	FG	1168	21 (1.8 %)	0.014 ± 0.004	0.011 ± 0.004	0.032	0.03 ± 0.011	0.027 ± 0.011	0.062
	South Coast	RG	259	0	NaN	NaN	NaN	NaN	NaN	NaN
	Cape Perpetua	FG & RG	62	0	NaN	NaN	NaN	NaN	NaN	NaN
	Central Coast	FG, NG & RG	863	0	NaN	NaN	NaN	NaN	NaN	NaN
		FG	127	0	NaN	NaN	NaN	NaN	NaN	NaN
		NG	145	0	NaN	NaN	NaN	NaN	NaN	NaN
		RG	591	0	NaN	NaN	NaN	NaN	NaN	NaN
	North Coast	FG & RG	25	0	NaN	NaN	NaN	NaN	NaN	NaN
		FG	0	#DIV/0!	NaN	NaN	NaN	NaN	NaN	NaN
		RG	25	0	NaN	NaN	NaN	NaN	NaN	NaN
Tiger Rockfish	Entire State	FG, NG & RG	2691	8 (0.3 %)	0.003 ± 0.001	0.01 ± 0.011	0.004	0.003 ± 0.002	0.44 ± 0.69	0.003
	Nearshore	FG, NG & RG	1523	4 (0.26 %)	0.003 ± 0.001	0.01 ± 0.011	0.004	NaN	NaN	NaN
	Offshore	FG	1168	4 (0.34 %)	0.003 ± 0.001	0.01 ± 0.011	0.004	0.005 ± 0.003	0.401 ± 0.634	0.005
	South Coast	RG	259	0	NaN	NaN	NaN	NaN	NaN	NaN
	Cape Perpetua	FG & RG	62	0	NaN	NaN	NaN	NaN	NaN	NaN
	Central Coast	FG, NG & RG	863	3 (0.35 %)	0.002 ± 0.001	7367.612 ± 2447.208	0.002	0.002 ± 0.002	0.963 ± 0.993	0.002
		FG	127	2 (1.57 %)	0.016 ± 0.011	NaN	0.016	0.016 ± 0.019	1.017 ± 1.009	0.017
		NG	145	1 (0.69 %)	0.007 ± 0.007	18077.4 ± NaN	0.007	0.166 ± 8.076	1.006 ± 1.022	0.193
		RG	591	0	NaN	NaN	NaN	NaN	NaN	NaN
	North Coast	FG & RG	339	1 (0.29 %)	0.003 ± 0.003	8885.571 ± 3007.22	0.003	0.004 ± 0.012	0.988 ± 1.002	0.004
		FG	314	1 (0.32 %)	0.003 ± 0.003	NaN	0.003	0.004 ± 0.006	0.992 ± 0.994	0.004
		RG	25	0	NaN	NaN	NaN	NaN	NaN	NaN

Vermilion Rockfish	Entire State	FG, NG & RG	2377	8 (0.34 %)	0.003 ± 0.001	NaN	0.003	0.003 ± 0.002	1.037 ± 1.002	0.003
	Nearshore	FG, NG & RG	1209	3 (0.25 %)	0.002 ± 0.001	NaN	0.002	NaN	NaN	NaN
	Offshore	FG	1168	5 (0.43 %)	0.002 ± 0.001	NaN	0.002	0.004 ± 0.003	1.031 ± 1.026	0.004
	South Coast	RG	259	1 (0.39 %)	0.004 ± 0.004	NaN	0.004	0.003 ± 0.002	1.056 ± 1.03	0.003
	Cape Perpetua	FG & RG	62	1 (1.61 %)	0.016 ± 0.016	NaN	0.016	0.197 ± 9.977	0.991 ± 1.01	0.236
	Central Coast	FG, NG & RG	863	1 (0.12 %)	0.016 ± 0.016	NaN	0.016	0.001 ± 0.002	0.996 ± 0.987	0.001
		FG	127	1 (0.79 %)	0.008 ± 0.008	NaN	0.008	0.009 ± 0.017	1.03 ± 0.991	0.009
		NG	145	0	NaN	NaN	NaN	NaN	NaN	NaN
		RG	591	0	NaN	NaN	NaN	NaN	NaN	NaN
	North Coast	FG & RG	25	0	NaN	NaN	NaN	NaN	NaN	NaN
		FG	0	0	NaN	NaN	NaN	NaN	NaN	NaN
		RG	25	0	NaN	NaN	NaN	NaN	NaN	NaN
Widow Rockfish	Entire State	FG, NG & RG	2187	30 (1.37 %)	0.927 ± 0.414	0.002 ± 0	3.74E+02	1.152 ± 0.925	0.002 ± 0	5.67E+02
	Nearshore	FG, NG & RG	1028	2 (0.19 %)	0.927 ± 0.414	0.002 ± 0	3.74E+02	NaN	NaN	NaN
	Offshore	FG	1159	28 (2.42 %)	0.927 ± 0.414	0.002 ± 0	3.74E+02	2.237 ± 1.995	0.004 ± 0.001	1.20E+03
	South Coast	RG	259	1 (0.39 %)	0.927 ± 0.414	0.002 ± 0	3.74E+02	1.172 ± 0.905	0.002 ± 0	5.85E+02
	Cape Perpetua	FG & RG	5	0	NaN	NaN	NaN	NaN	NaN	NaN
	Central Coast	FG, NG & RG	739	1 (0.14 %)	0.927 ± 0.414	0.002 ± 0	3.74E+02	0.001 ± 0.002	0.987 ± 0.954	1.00E-03
		FG	3	0	NaN	NaN	NaN	NaN	NaN	NaN
		NG	145	1 (0.69 %)	0.007 ± 0.007	NaN	7.00E-03	0.008 ± 0.019	1.023 ± 0.957	8.00E-03
		RG	591	0	NaN	NaN	NaN	NaN	NaN	NaN
	North Coast	FG & RG	25	0	NaN	NaN	NaN	NaN	NaN	NaN
		FG	0	0	NaN	NaN	NaN	NaN	NaN	NaN
		RG	25	0	NaN	NaN	NaN	NaN	NaN	NaN
Yelloweye Rockfish	Entire State	FG, NG & RG	2691	215 (7.99 %)	0.12 ± 0.009	0.122 ± 0.017	0.237	0.12 ± 0.013	0.125 ± 0.017	0.236
	Nearshore	FG, NG & RG	1523	54 (3.55 %)	0.047 ± 0.007	0.073 ± 0.022	0.076	0.047 ± 0.010	0.090 ± 0.029	0.073
	Offshore	FG	1168	161 (13.78 %)	0.215 ± 0.019	0.213 ± 0.035	0.432	0.216 ± 0.027	0.221 ± 0.037	0.428
	South Coast	RG	259	6 (2.32 %)	0.027 ± 0.012	0.085 ± 0.102	0.036	0.12 ± 0.013	0.125 ± 0.018	0.235
	Cape Perpetua	FG & RG	62	3 (4.84 %)	0.065 ± 0.041	0.101 ± 0.134	0.106	0.17 ± 3.442	0.693 ± 0.852	0.211
	Central Coast	FG, NG & RG	863	14 (1.62 %)	0.022 ± 0.007	0.029 ± 0.016	0.039	0.023 ± 0.01	0.049 ± 0.04	0.033
		FG	127	7 (5.51 %)	0.095 ± 0.044	0.06 ± 0.039	0.244	0.108 ± 0.082	0.115 ± 0.114	0.211
		NG	145	1 (0.69 %)	0.007 ± 0.007	NaN	0.007	0.02 ± 0.505	0.968 ± 0.989	0.02
		RG	591	6 (1.02 %)	0.01 ± 0.004	54538.25 ± 469.212	0.01	0.01 ± 0.006	1.051 ± 0.976	0.01
	North Coast	FG & RG	339	31 (9.14 %)	0.121 ± 0.024	0.217 ± 0.098	0.188	0.122 ± 0.033	0.313 ± 0.222	0.169
		FG	314	31 (9.87 %)	0.131 ± 0.025	0.24 ± 0.11	0.202	0.132 ± 0.036	0.358 ± 0.24	0.181
		RG	25	0	NaN	NaN	NaN	NaN	NaN	NaN

Yellowtail	Entire State	FG, NG & RG	2691	200 (7.43 %)	0.399 ± 0.047	0.029 ± 0.003	5.97	0.403 ± 0.069	0.029 ± 0.003	6.064
Rockfish	Nearshore	FG, NG & RG	1523	86 (5.65 %)	0.192 ± 0.031	0.028 ± 0.004	1.495	0.197 ± 0.046	0.029 ± 0.004	1.551
	Offshore	FG	1168	114 (9.76 %)	0.192 ± 0.031	0.028 ± 0.004	1.495	0.688 ± 0.164	0.034 ± 0.004	14.435
	South Coast	RG	259	8 (3.09 %)	0.058 ± 0.026	0.028 ± 0.016	0.177	0.404 ± 0.069	0.029 ± 0.003	6.088
	Cape Perpetua	FG & RG	62	14 (22.58 %)	0.92 ± 0.36	0.119 ± 0.043	8.046	1.065 ± 0.733	0.132 ± 0.048	9.664
	Central Coast	FG, NG & RG	863	37 (4.29 %)	0.088 ± 0.019	0.034 ± 0.009	0.313	0.091 ± 0.028	0.037 ± 0.01	0.317
		FG	127	14 (11.02 %)	0.268 ± 0.097	0.078 ± 0.031	1.191	0.298 ± 0.169	0.092 ± 0.039	1.265
		NG	145	8 (5.52 %)	0.069 ± 0.026	0.155 ± 0.146	0.1	0.072 ± 0.039	0.608 ± 0.689	0.081
		RG	591	15 (2.54 %)	0.054 ± 0.019	0.019 ± 0.007	0.207	0.061 ± 0.035	0.023 ± 0.009	0.225
	North Coast	FG & RG	339	27 (7.96 %)	0.425 ± 0.136	0.031 ± 0.007	6.299	0.467 ± 0.23	0.032 ± 0.008	7.206
		FG	314	27 (8.6 %)	0.459 ± 0.147	0.033 ± 0.008	6.772	0.508 ± 0.253	0.035 ± 0.009	7.946
		RG	25	0	NaN	NaN	NaN	NaN	NaN	NaN

3. Results and Discussion

In general, there was a moderate amount of agreement between the parameter estimates generated using the maximum likelihood and Bayesian methods (Table 6). Further, these similarities were also observed between project (different landers) and study area. Ultimately, we hypothesize this coherence in the data is indicative that there were not major biases in which fish were observed by each research group in each study area. Further, for most of the datasets, there was relatively minimal effect of outliers (Appendix B). There were, however, some exceptions, such as Kelp Greenling on Oregon's south coast, and offshore Blue/Deacon. For Kelp Greenling, the difference is likely due to the fact that the distribution of the data was better explained using a Poisson distribution than a negative binomial (Appendix C). This is likely due to the ubiquitous spatial distribution of this species on nearshore rocky reefs. Variability and high variance in the data for offshore Blue/Deacons resulted from a single observation of 204 individuals. In this case, and for other species with extreme outliers, the algorithms had difficulties converging around a single estimate, and often bimodal or skewed distributions of the estimates were observed (Appendix B). For research or stock assessment purposes, it is worth considering whether it would be beneficial to exclude these outliers.

For species with relatively few observations (e.g. Cabezon, China Rockfish and Tiger Rockfish), one or more of the parameters were estimated poorly (e.g. north coast China Rockfish) or, in some cases, no estimates were generated at all (e.g. nearshore Tiger Rockfish). This can be attributed to the difficulty of the algorithms to coalesce around a single value due to zero-inflation in the data (Appendix B). Thus, for species with relatively few observations, the quality of the parameter estimates should be considered before being used. In these situations, there may be more utility to modeling these data by 1) presence/absence or 2) using a zero-inflated modeling approach.

In addition to differences in parameter estimates due to low counts, there are noticeable influences of species ecology on the parameter estimates. For example, for species such as Rosethorn and Greenstriped Rockfish, which are defined as shelf rockfish by PFMC, many of the estimates are reported as NaN (Not a Number) because all observations for in the nearshore were zero. This is due to the fact that many of these surveys were conducted in the nearshore, outside of the depth range these shelf species occupy. Consequently, although a parameter estimate was generated for the entire state, for these shelf species, the offshore parameter estimates better explain these species, as they are not inflated by zeros collected in inappropriate habitat. Ultimately it is important to remember that for these shelf species, the zero counts from nearshore sites are not indicative of low populations but rather sampling occurring outside of the species range.

The parameter estimates for some schooling and semi-pelagic species (e.g. Black, Blue/Deacon, and Canary Rockfish) are likely also influenced by their life history characteristics. In instances where very large schools are observed, the probability of incorrect fish counts is higher than when only one or a few individuals are observed. These errors in counts can occur due to inaccurately defining the MaxN frame, fish obstructing other fish from view, and other factors. Video landers, as a benthic sampling tool, may not be an optimal means of obtaining counts for semi-pelagic species. Designed to look forward while collecting observations on the bottom, video landers are likely only observing the very bottom of semi-pelagic fish schools.

Consequently, resulting population estimates may not be as accurate as those generated by other tools that collect abundance estimates throughout the water column.

4. Conclusions

In this document we provide an overview of the nine years of video lander data that the Oregon Department of Fish and Wildlife's Marine Resources Program has collected. We recognize five main limitations to our data due to the variability between and within projects in: 1) the type of video lander, 2) deployment procedures, 3) sample spacing, 4) length of bottom time, and 5) video review methods. Each of these differences can influence the number of fish counted at a given station or deployment. The relative effect of these differences has been the focus of multiple studies throughout the world (Watson et al. 2005), with the finding that noticeable effects exist, but ultimately can be addressed. For our data specifically, the type of video lander likely had the largest influence on count data. First, it influenced the number of fish observed, as some video landers had larger fields of view and therefore saw more of the seafloor (Table 2 [in present paper], Harvey et al. 2010). Second, each video lander differed in the amount of light used, which has been shown to strongly influence the response of different fishes (Rooper et al. 2015; Campbell et al. 2018) as well as how wide and long the field of view is (Harvey et al. 2010; Campbell et al. 2018). In addition to video lander type, variability in bottom time may have affected our data. Given the temporal variance in fish responses to or from a video lander (Hannah and Blume 2012, Krutzikowsky 2019, and Watson and Huntington 2016), bottom time of each deployment is likely to influence the total number of fish observed. Finally, if video lander deployments were not conducted at adequate distances apart, there is a strong potential for spatial autocorrelation. Although a problem, autocorrelation can be remedied using model-based approaches with mixed-effects models; potential spatial and temporal autocorrelations can be examined using variogram or autocorrelation functions. Autocorrelation can also be addressed in the models using variance structures or through the development of more complex models using techniques such as integrated nested Laplace approximations or Hamilton Monte-Carlo methods, both of which have well-developed packages available in the R Statistical Computing environment (Bacheler et al. 2014, 2017). Addressing these concerns should be considered when developing species distribution models (Thorson 2019; Munoz et al. 2013).

Moving forward, Oregon Department of Fish and Wildlife's projects utilizing video landers should attempt to standardize some or all of the data collection methods, starting with recording data in the standardized format developed for this report (see section 2.5). Another important component to consider in the future would be to conduct occupancy modeling studies to address the effects of species attraction and repulsion (Coggins et al. 2014). To examine the effects of attraction and repulsion of each lander type, three main options exist: 1) acoustic tagging (Bacheler et al. 2018), 2) occupancy modeling (Coggins et al. 2017) and the use of 3) acoustic survey tools (Boldt et al. 2018). Most of the tools needed to conduct these studies are available to ODFW scientists and work is ongoing to address these concerns.

There are multiple ways a large dataset of underwater video observations can be used to support sustainable management of Oregon's fisheries. Large datasets such as this can easily be developed into species distribution models, which can inform area-based management, survey development, and stock delineation. Further development of these models could incorporate abiotic variables recorded at sea or external datasets such as multibeam or hydrodynamic model data. Using the generalized field of view data, densities of individual species can be generated in

order to ground-truth density estimates generated by stock assessments. ODFW's video lander data were already utilized in this way in the most recent Kelp Greenling assessment (Berger et al. 2015), and other visual tools, such as ROV and suspended cameras, were an important input to the Blue/Deacon assessment (Dick et al. 2017). Future development of indices of abundance for use in stock assessments would be possible from this dataset, given that we account for differences between project and survey area. Video landers are already used as a stock assessment index for multiple species throughout the Gulf of Mexico (Campbell et al. 2017), and other forms of visual tools have been used in the California Current Large Marine Ecosystem to develop indices of abundance (Yoklavich et al. 2007).

In addition to informing future stock assessments, these data can be used to develop survey simulations. The Yelloweye Rockfish stock on the U.S. West Coast, including Oregon, was declared overfished in 2002 (Wallace 2001), resulting in significant restrictions in recreational and commercial fisheries. A shelf-wide survey is needed to provide a critical abundance input for future assessments of this stock. The ODFW Fisheries Group used the extensive data collected from their video landers to develop a simulation of a shelf-based stereo video lander survey (see Appendix D). The results of this simulation can be used to evaluate tradeoffs between cost and variance minimization in survey design. Conducting simulations like this for other species and areas will allow future studies to be developed using an optimized design.

While there are several ways to generate counts from underwater videos, we felt that MaxN was the most appropriate for Oregon waters. The MaxN approach defines the count of each species for a given video as the maximum number of that species observed for the period of video reviewed (Cappo et al. 2006). An alternative metric is mean MaxN, where frames spaced evenly from a randomized point are selected and the average of these counts is used (Schobernd et al. 2014). This method provides a variance metric associated with the video and reduces the impact of rare shoaling and other anomalous events. Although there are benefits to the mean MaxN approach, given Oregon's conditions and the relatively small numbers of fish observed in the videos, it results in an even greater proportion of zero-count data than does a MaxN approach. Both the mean MaxN and the MaxN approaches have implications for how the data should be considered and modeled (Campbell et al. 2015; Bacheler and Shertzer 2015), primarily in how secondary explanatory variables are incorporated into the model (Misa et al. 2016).

Moving forward, we suggest that video landers are a useful tool for providing fishery independent data from Oregon's rocky reefs. Key benefits of this tool are cost effectiveness and the ability to work in untrawlable habitats. The cost effectiveness results from the fact that video landers do not require specialized large-vessel charters and are built from easily sourced parts. Given the importance of untrawlable habitat surveys to multiple management agencies (Jagielo et al. 2003; PFMC 2019), the Oregon Department of Fish and Wildlife is continuing to develop landers as survey tools, with ongoing effort to address the concerns raised above. At the time of publication, the Fisheries Group is conducting studies to assess the ability and usefulness of sampling with landers at night, the Reserves Group is continuing long-term video monitoring at four marine reserves and six comparison area sites with landers, and the Nearshore Group has donated their video lander to the Fisheries Group to allow for multi-lander deployments.

Although not discussed in depth here, stereo video camera systems (Hannah and Blume 2014) were used to collect many of the videos described in this document, and are expected to be used for most or all video collected in the future. By viewing the same image with two different

cameras at a slightly different angles, we are able to generate fish lengths (Watson et al. 2005) and to determine viewable area (Campbell et al. 2018; Williams et al. 2018). Consequently, stereo video systems can offer the potential to provide fish densities and fish size distributions. Ultimately, stereo video data will make video landers an even better tool for age-structured stock assessments (Methot & Wetzel 2013).

The data from ODFW's video landers, offers some of the best data on abundances of nearshore fish in Oregon. This information can be used in a number of ways to guide future research and management. For example, densities calculated from fish counts and estimates of viewed area can be used in stock assessments. The data could be used to develop species distribution models, which may be useful in the identification of Essential Fish Habitat (Huff et al. 2013; Valvanis et al. 2004) as well as abundance and diversity hotspots; potentially highlighting areas to avoid in order to minimize fishery interactions with non-target species (Hobday & Hartman 2006; Howell et al. 2008), and to assist managers with marine spatial planning (Maxwell et al. 2009; McGowan et al. 2013). Finally, video landers with a stereo configuration are an efficient and cost-effective tool with potential for use in statewide fish surveys in untrawlable habitats.

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Appendix A. Study area maps

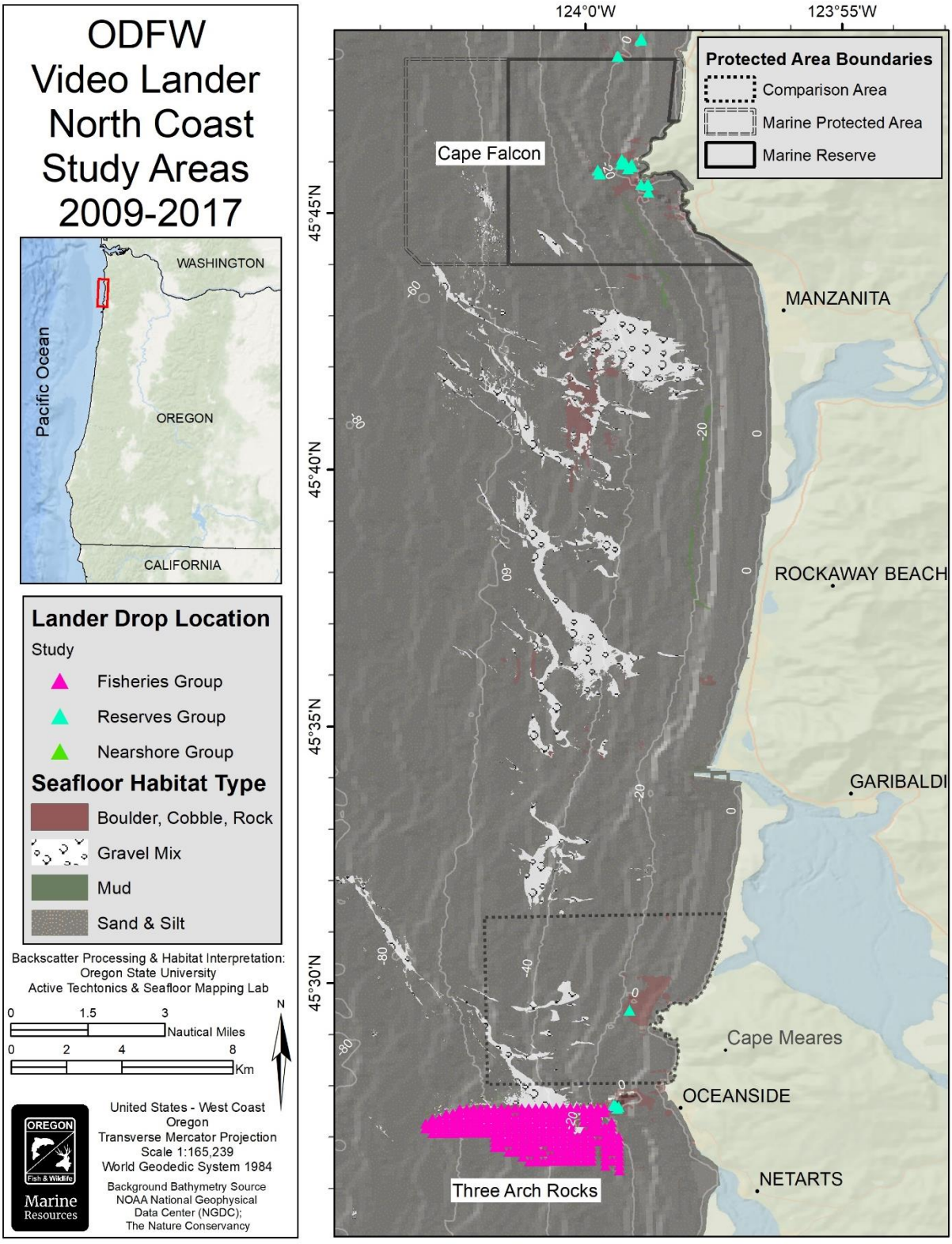


Figure A1. Map of deployment locations for the North Coast study areas.

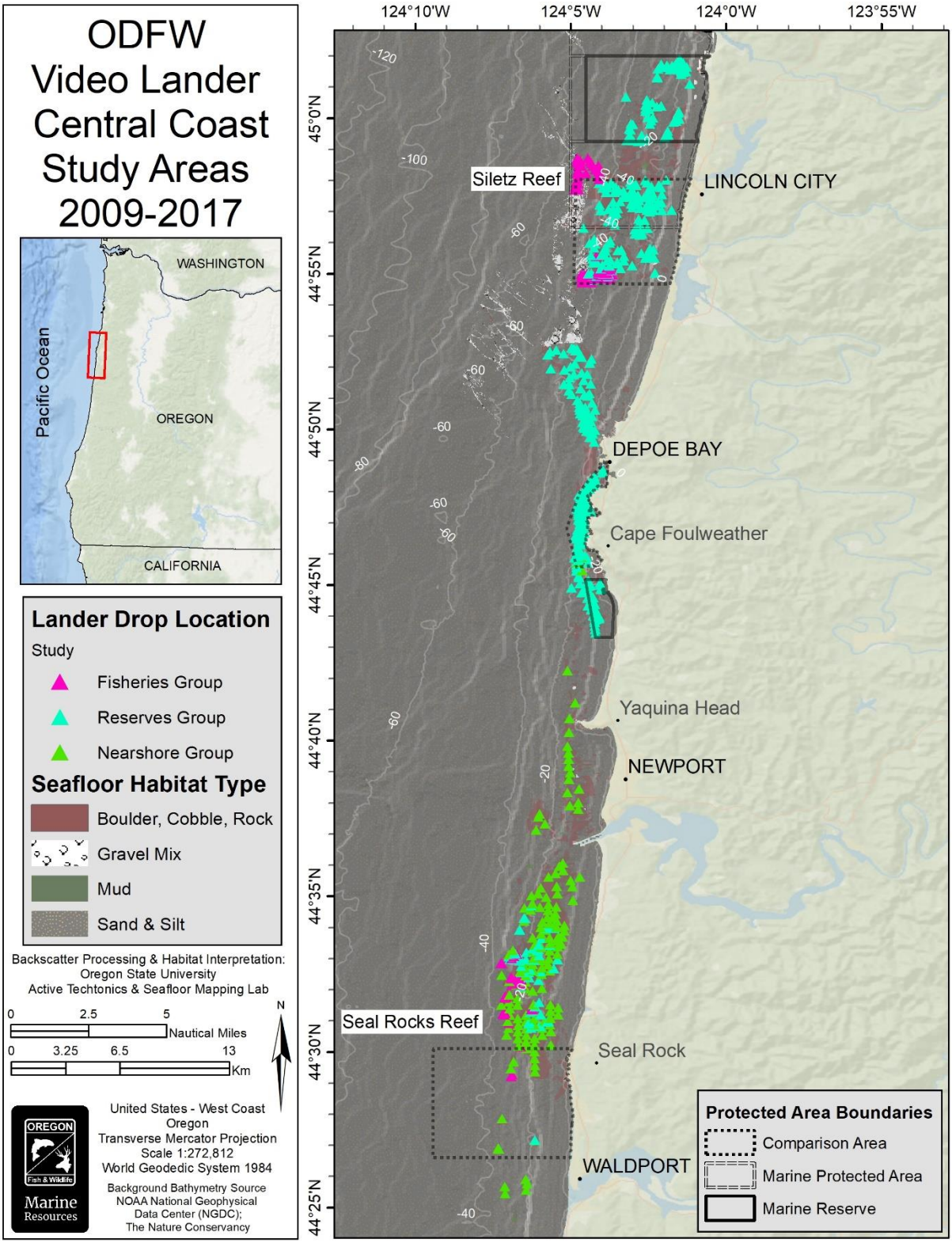


Figure A2. Map of deployment locations for the Central Coast study areas.

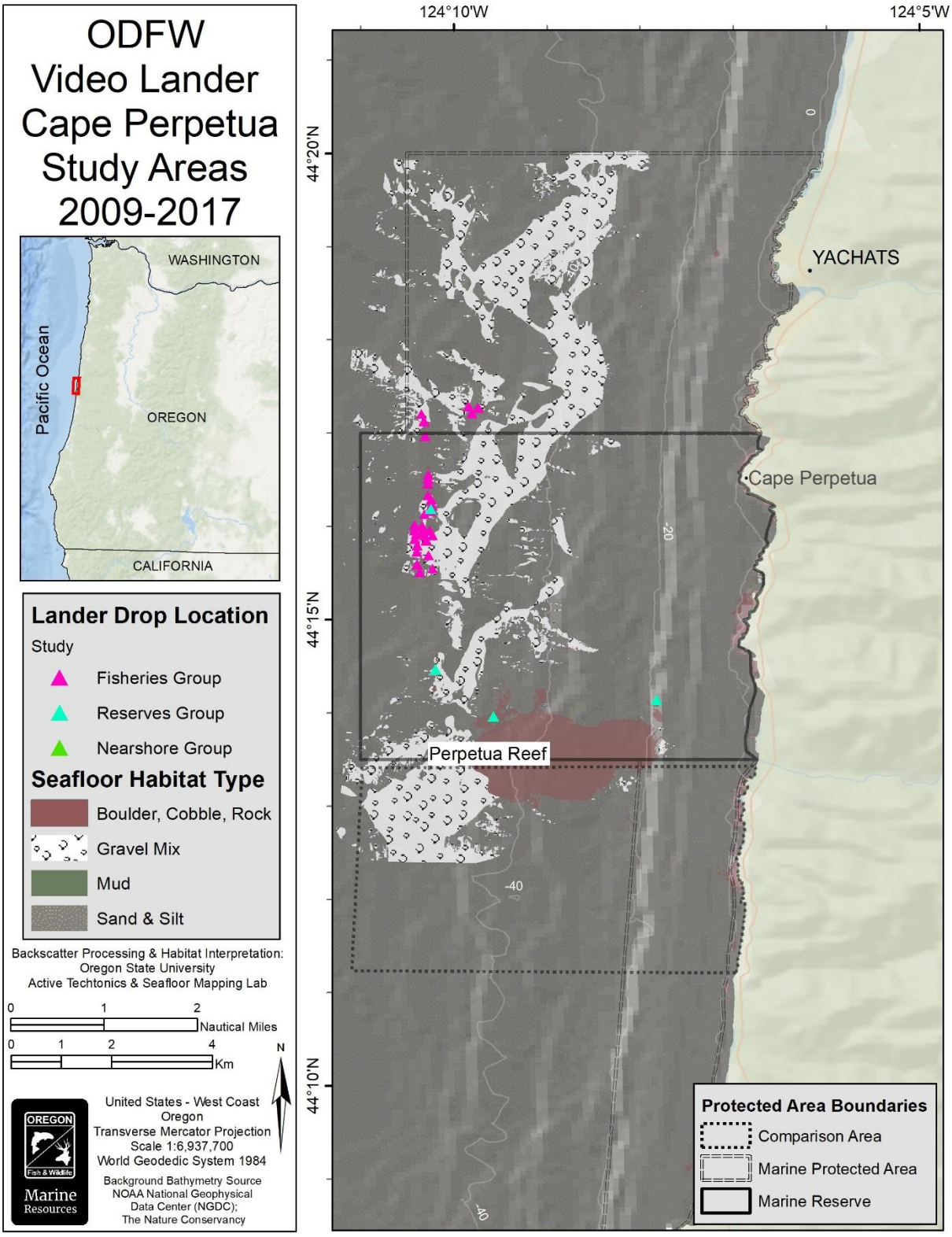


Figure A3. Map of deployment locations for the Cape Perpetua study area.

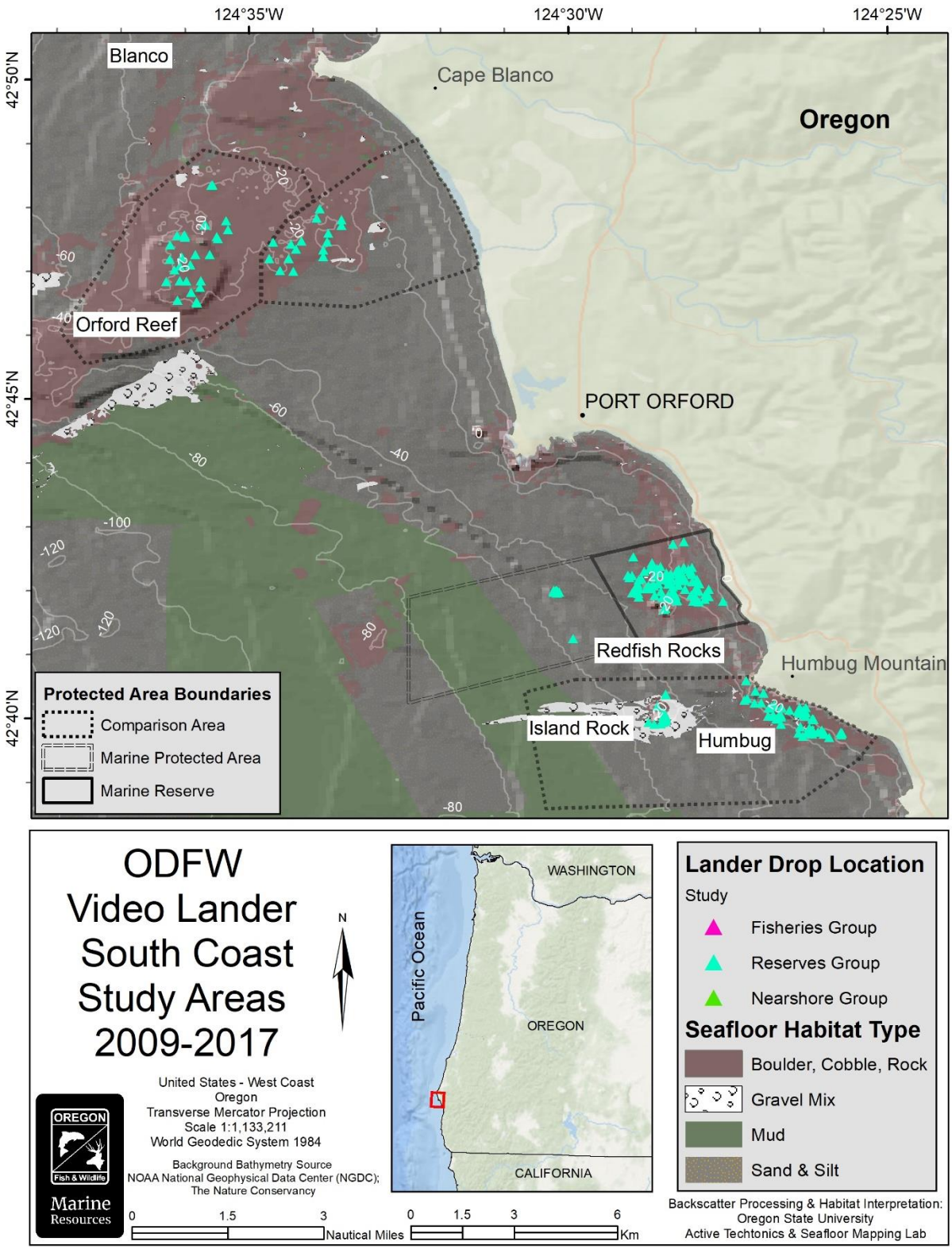


Figure A4. Map of deployment locations for the South Coast study areas.

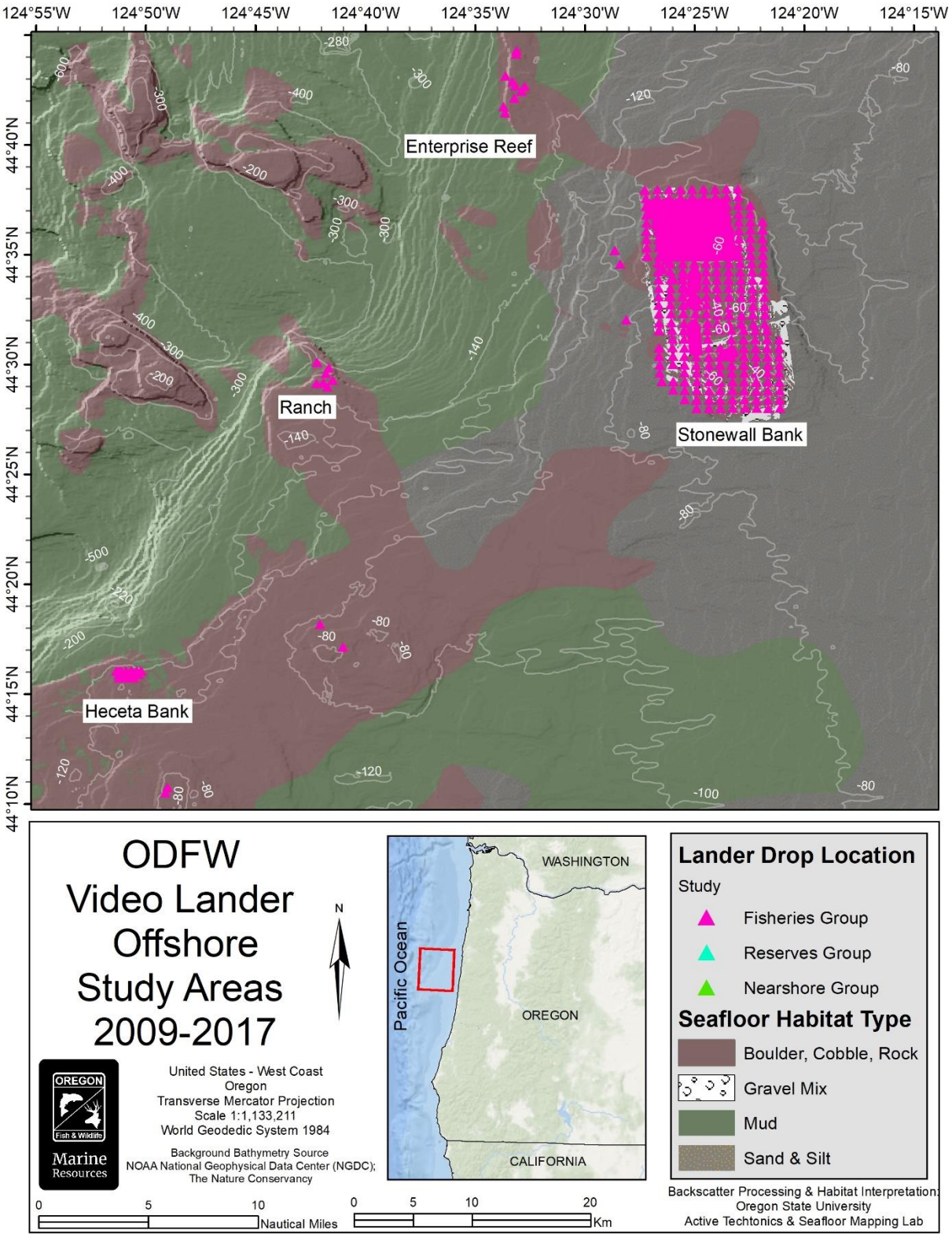
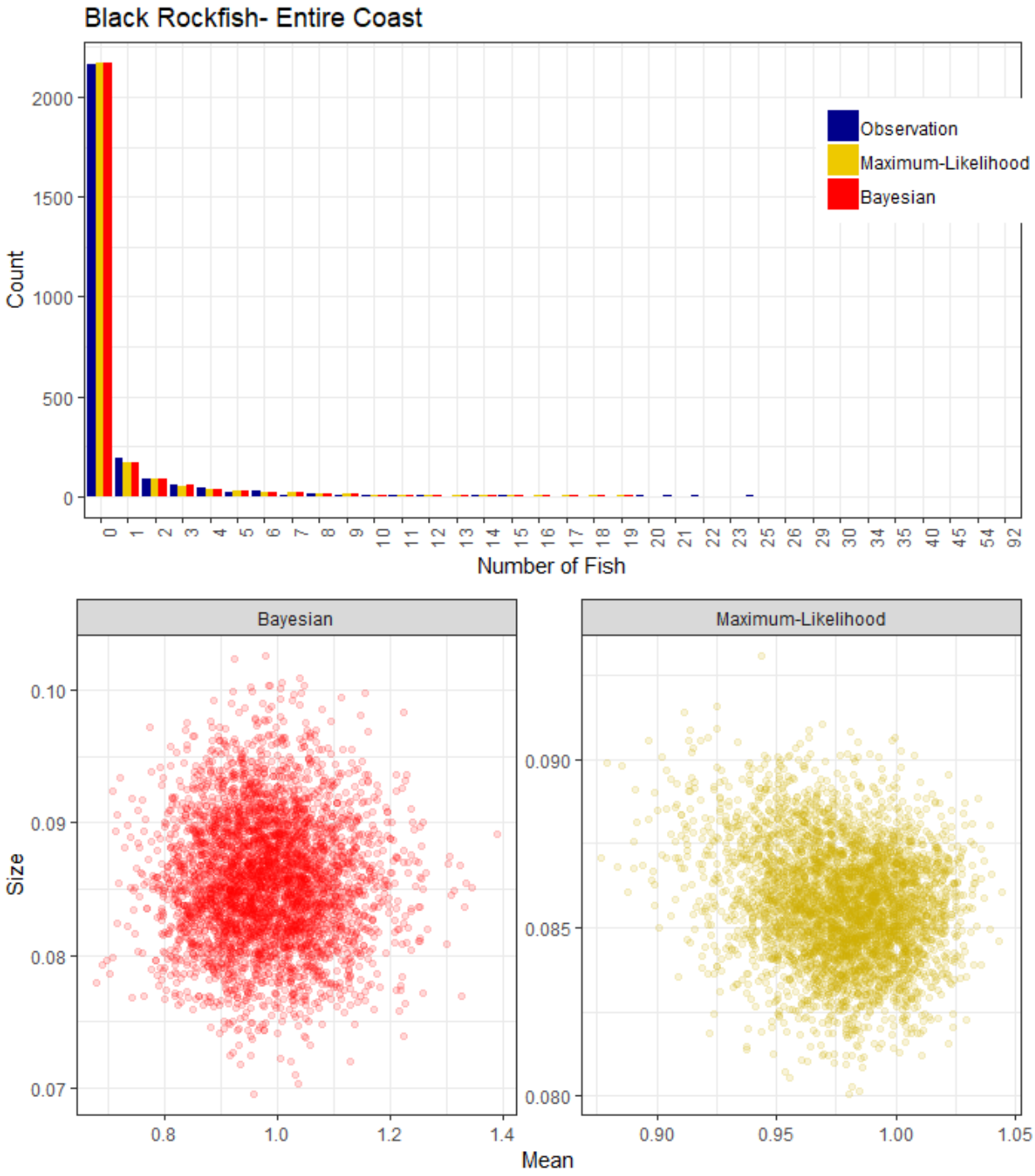
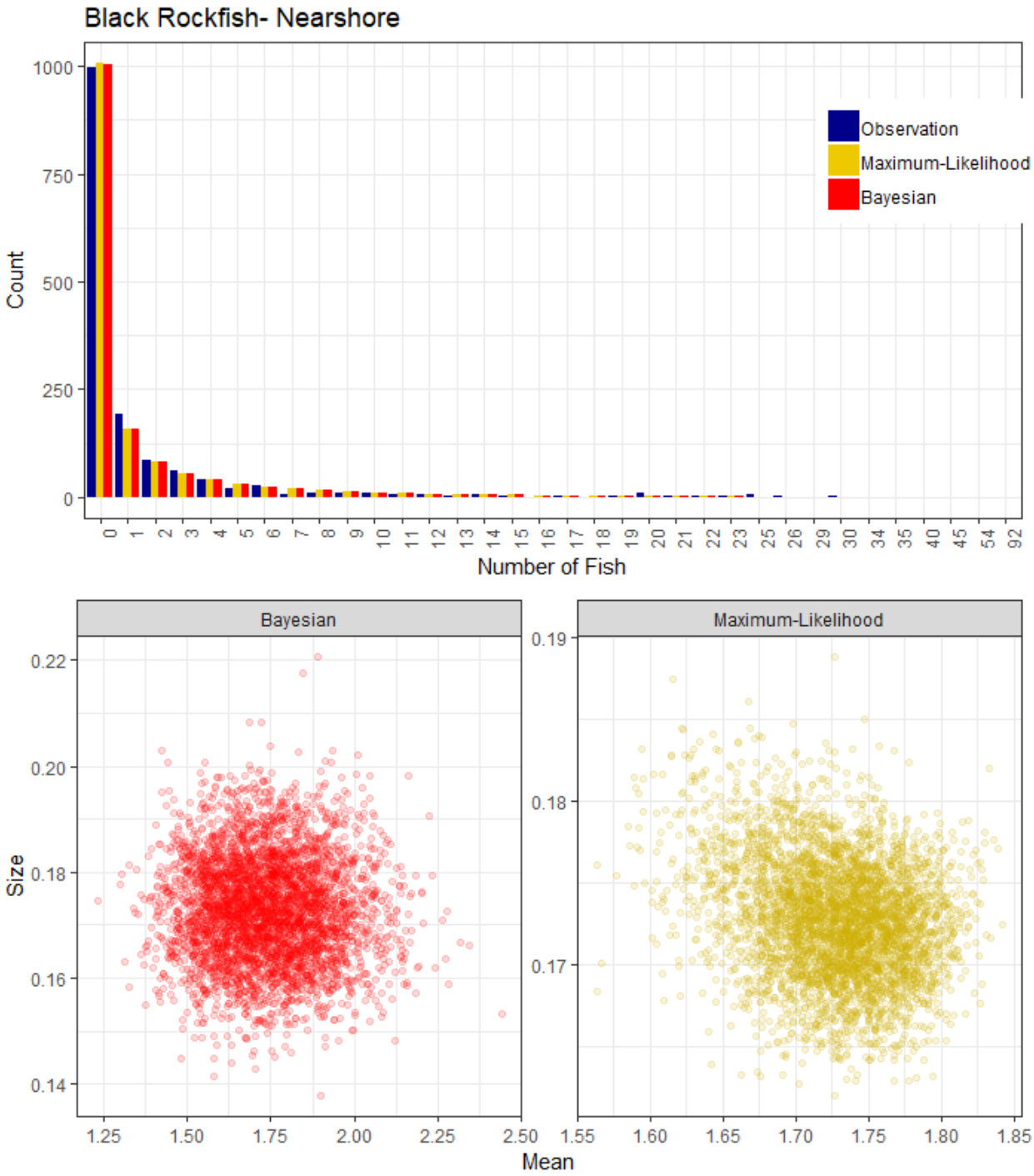


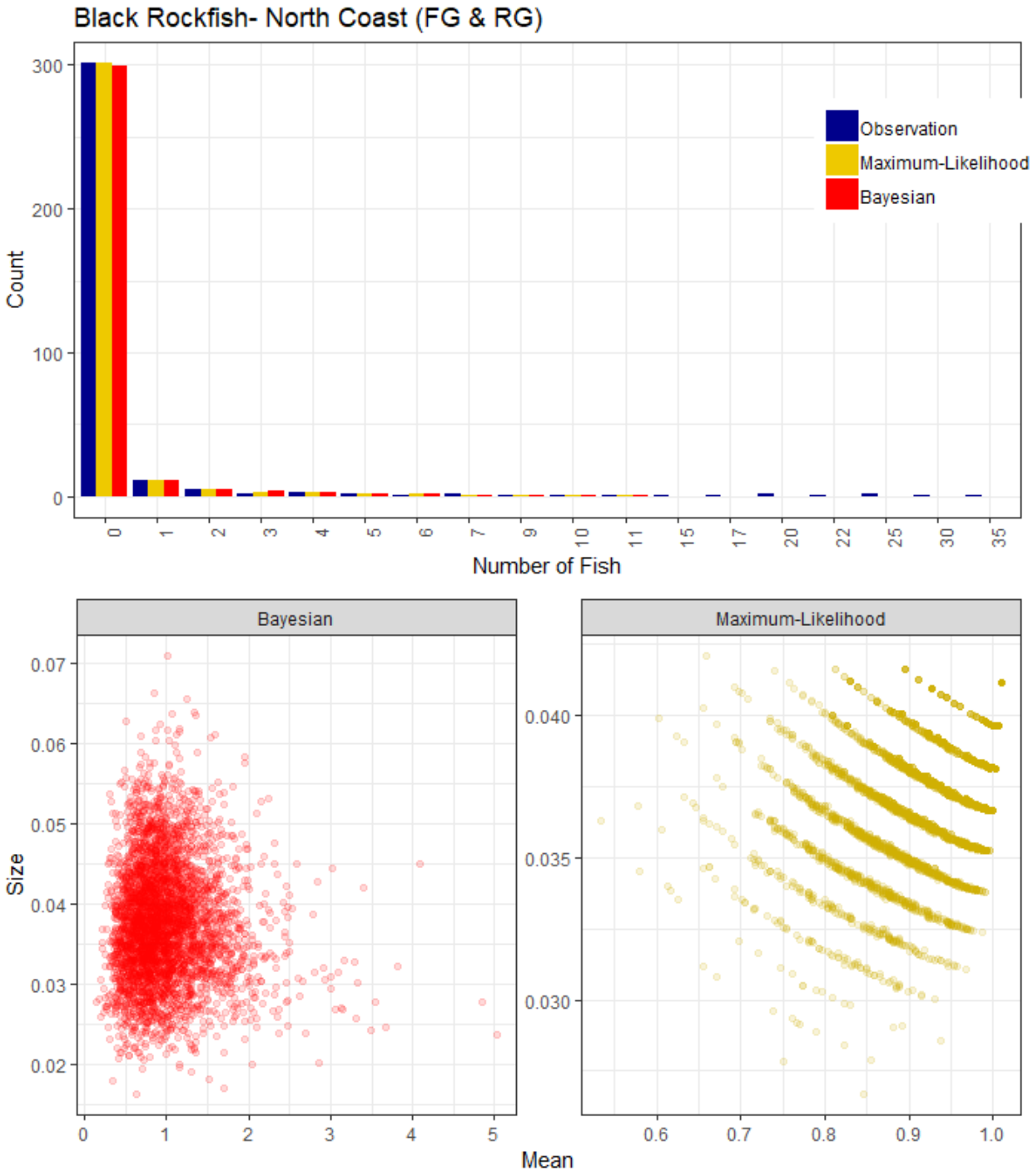
Figure A5. Map of deployment locations for the Offshore study areas.

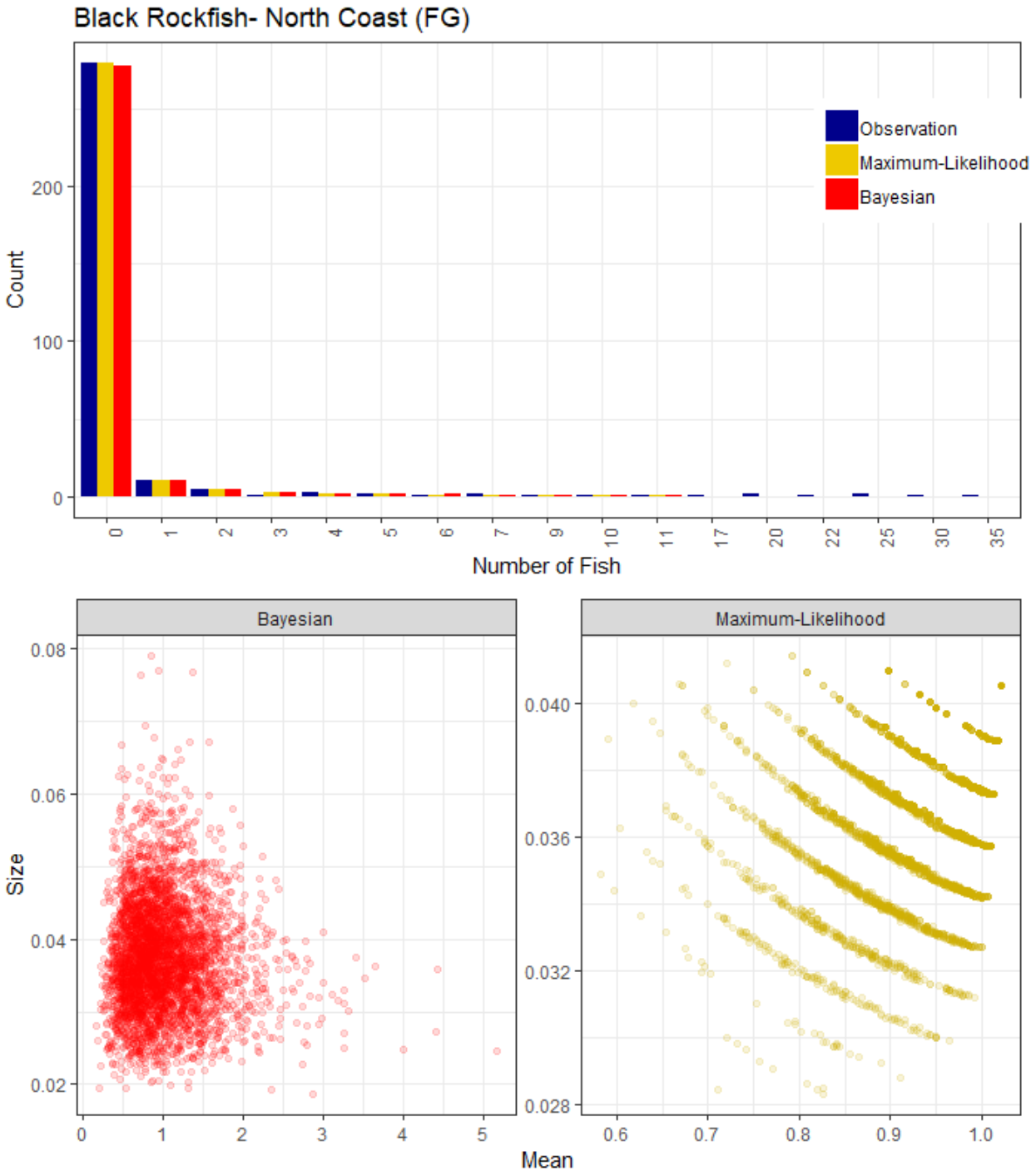
Appendix B. Species by study area count distributions and negative binomial parameter estimates

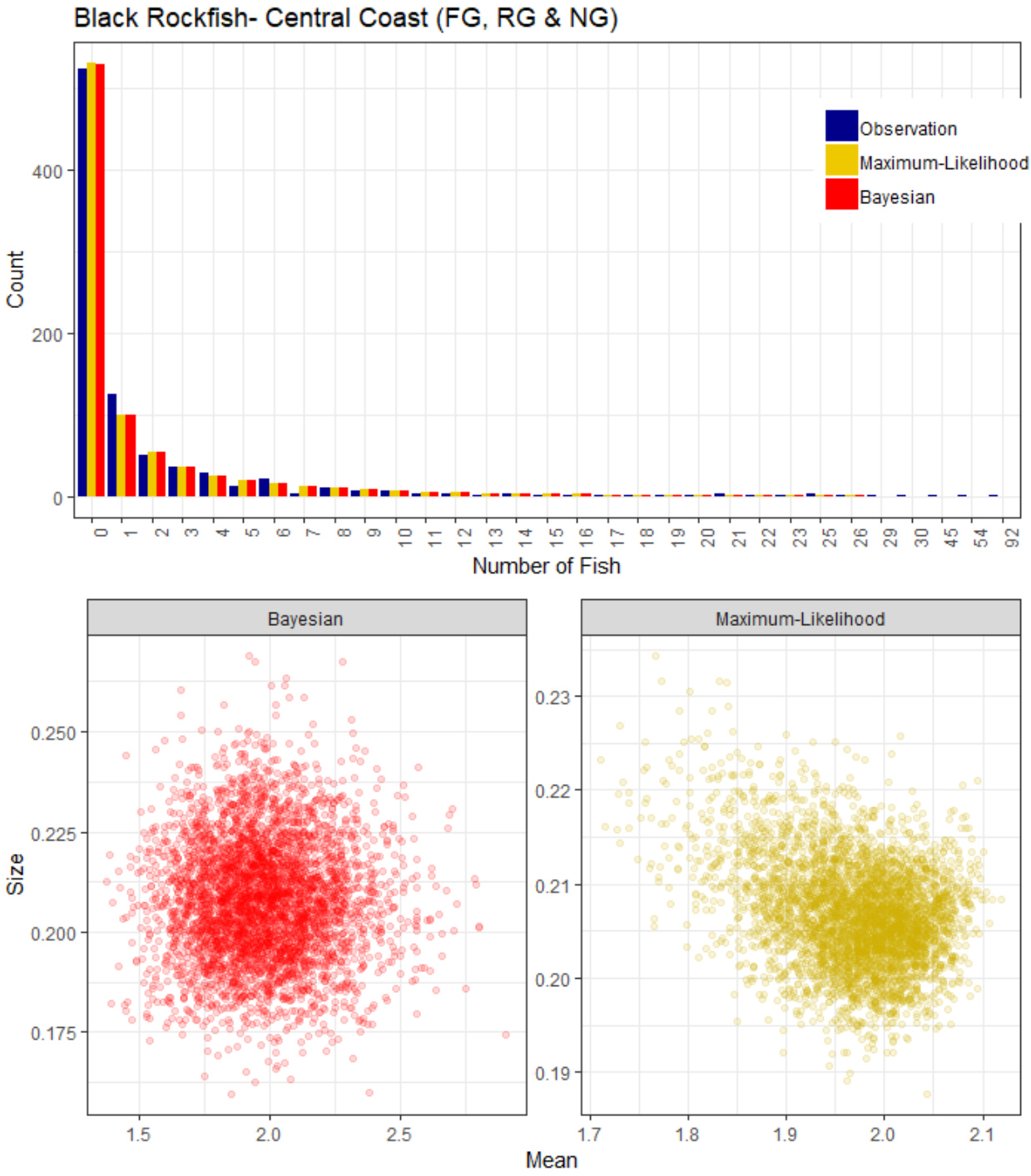
These figures provide graphic representations of how well the two different parameter estimation methods describe the fit of each species, study area and research group combination. The upper figure provides a histogram of the actual (blue) and estimated (gold-maximum likelihood and red- Bayesian) fish counts. The x-axis is not continuous due to rare occurrences of extremely high counts. The lower figures depict the variability in the mean and size parameter estimates using the Bayesian (left red plot) and maximum likelihood (right gold plot) methods. Not all species, study area and research group combinations are presented. The reasons for figures being left out is due to the inability of the parameter estimate algorithms to plot the data, usually due to a low presence to absence ratio. Entire coast denotes all samples collected in this document. Some species do not reside in the nearshore and others do not reside in the offshore, as such, some estimates may have a large number of zero observations that were collected outside of the depth range the species is most commonly found at.

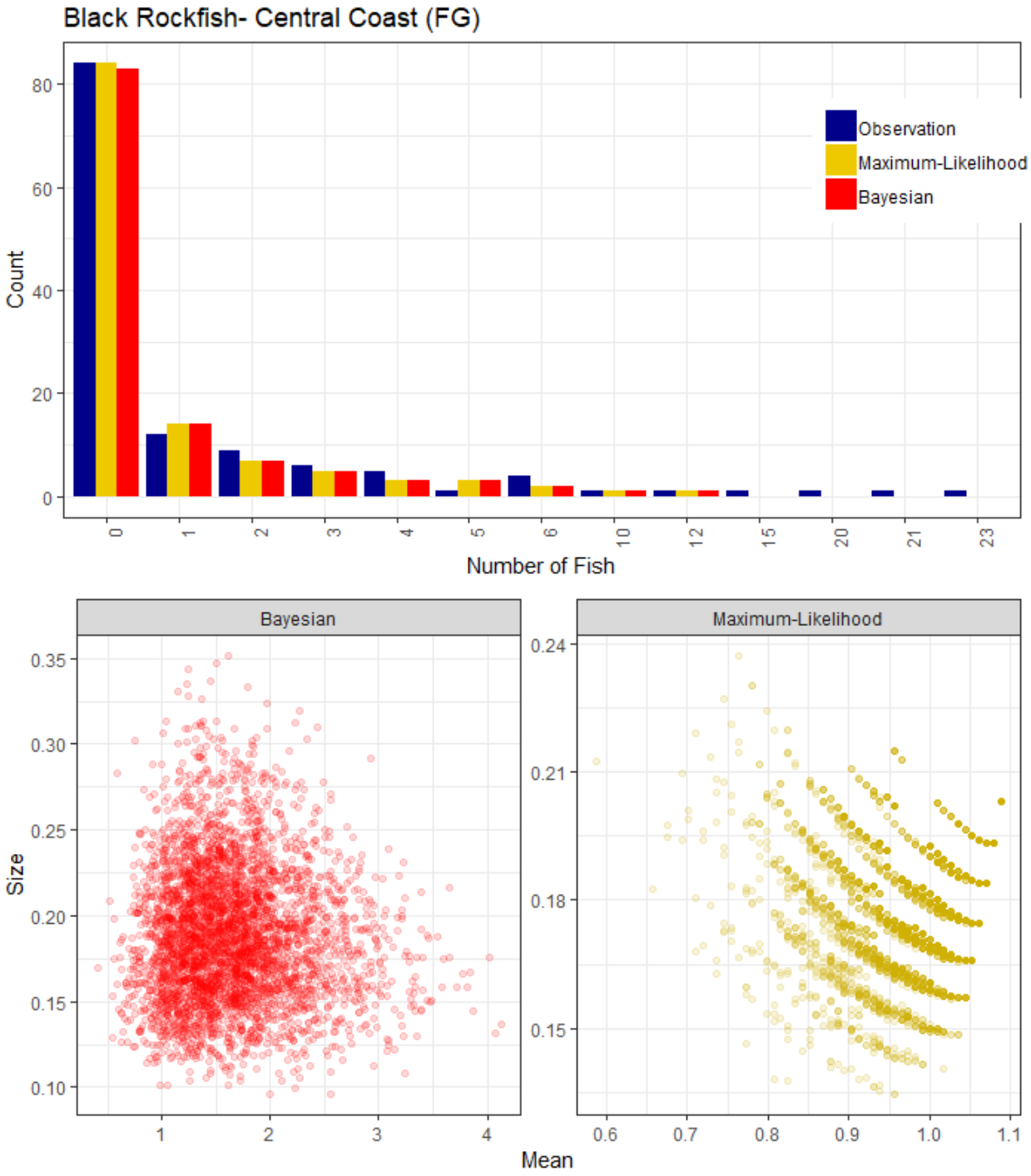

Black Rockfish- Entire Coast
Observation
Maximum-Likelihood
Bayesian
Count
Number of Fish
Bayesian
Maximum-Likelihood
Size
Mean

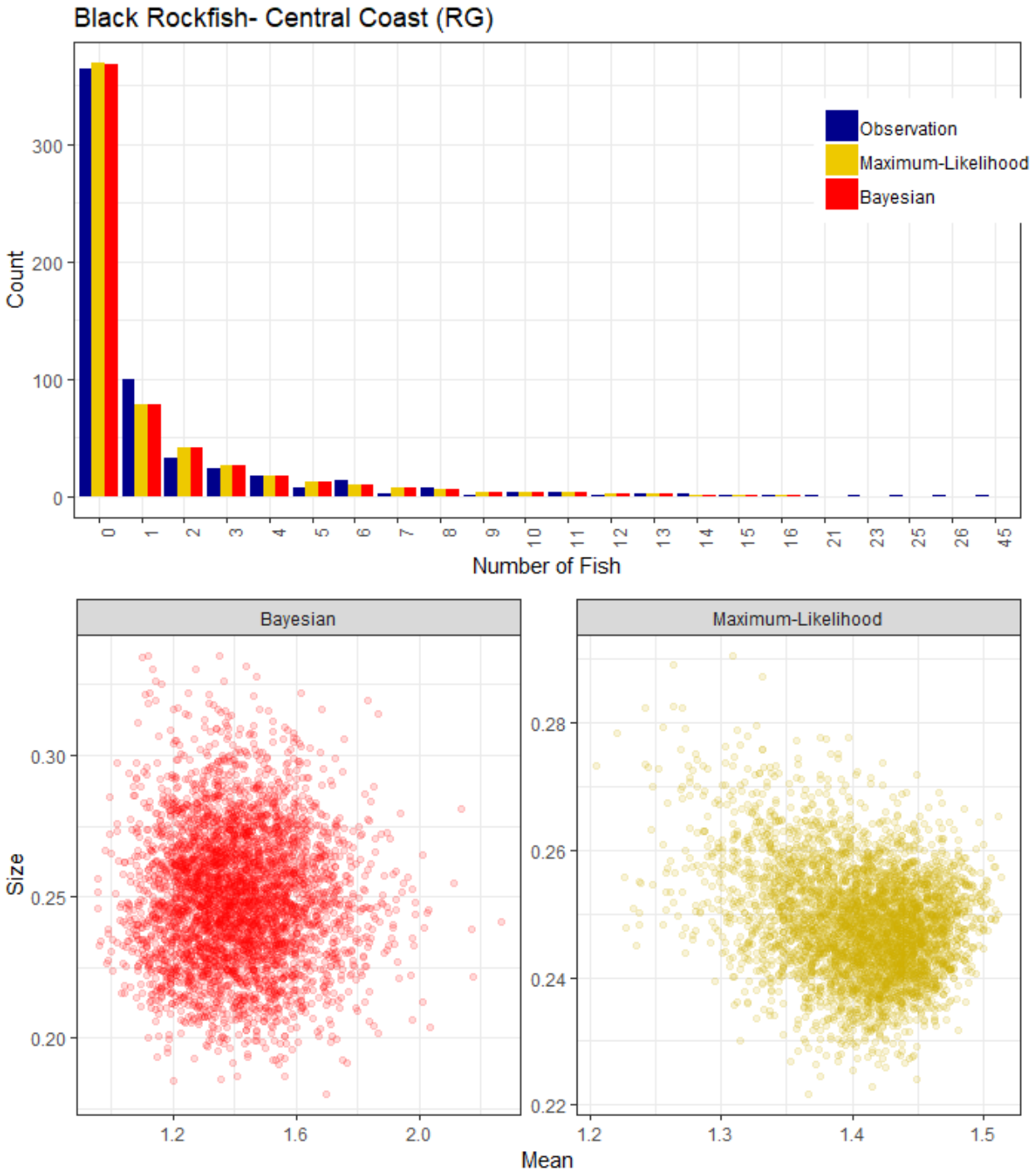

Black Rockfish- Nearshore
Observation
Maximum-Likelihood
Bayesian
Count
Number of Fish
Bayesian
Maximum-Likelihood
Size
Mean

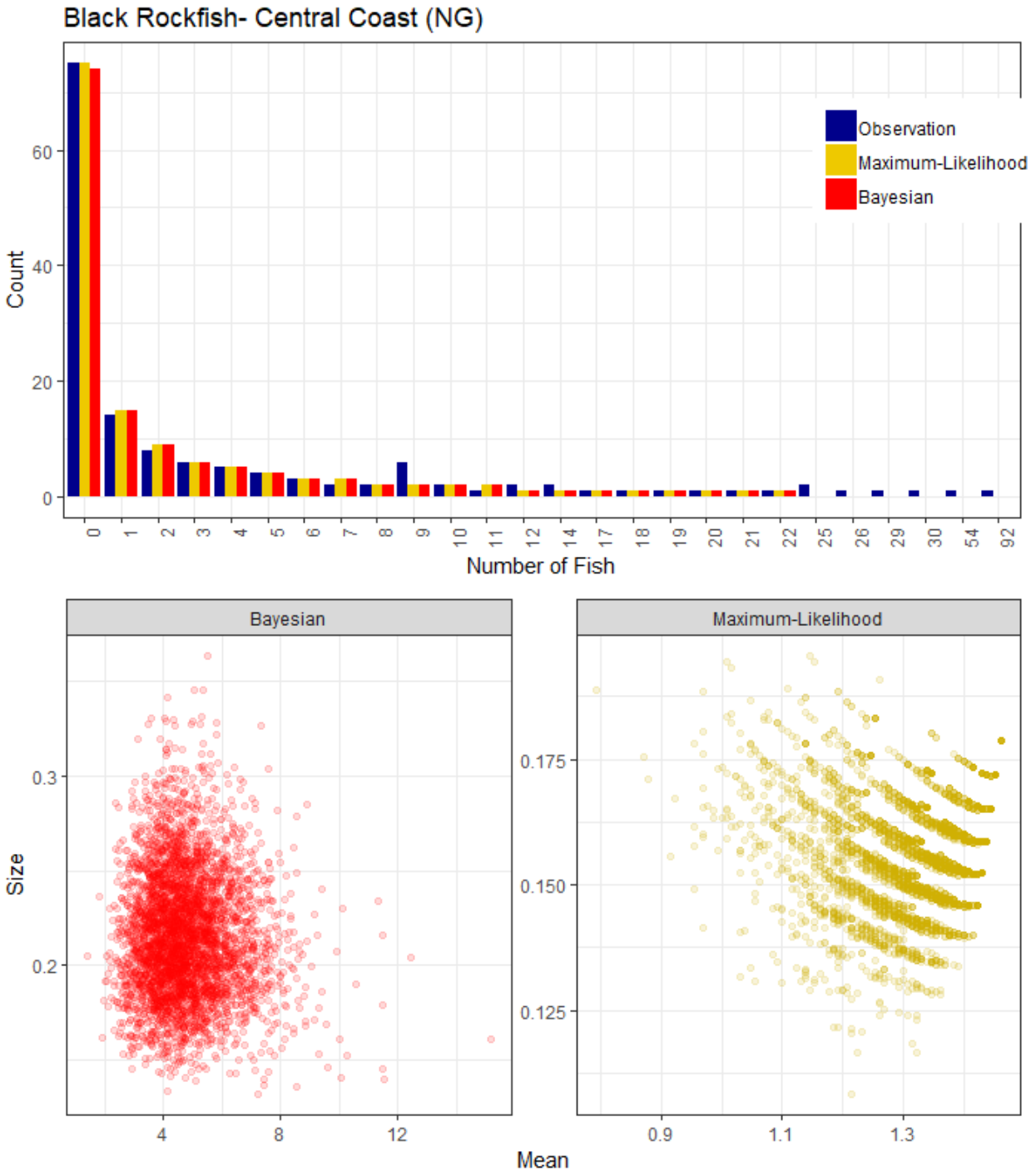

Black Rockfish- North Coast (FG & RG)
Observation
Maximum-Likelihood
Bayesian
Count
Number of Fish
Bayesian
Maximum-Likelihood
Size
Mean

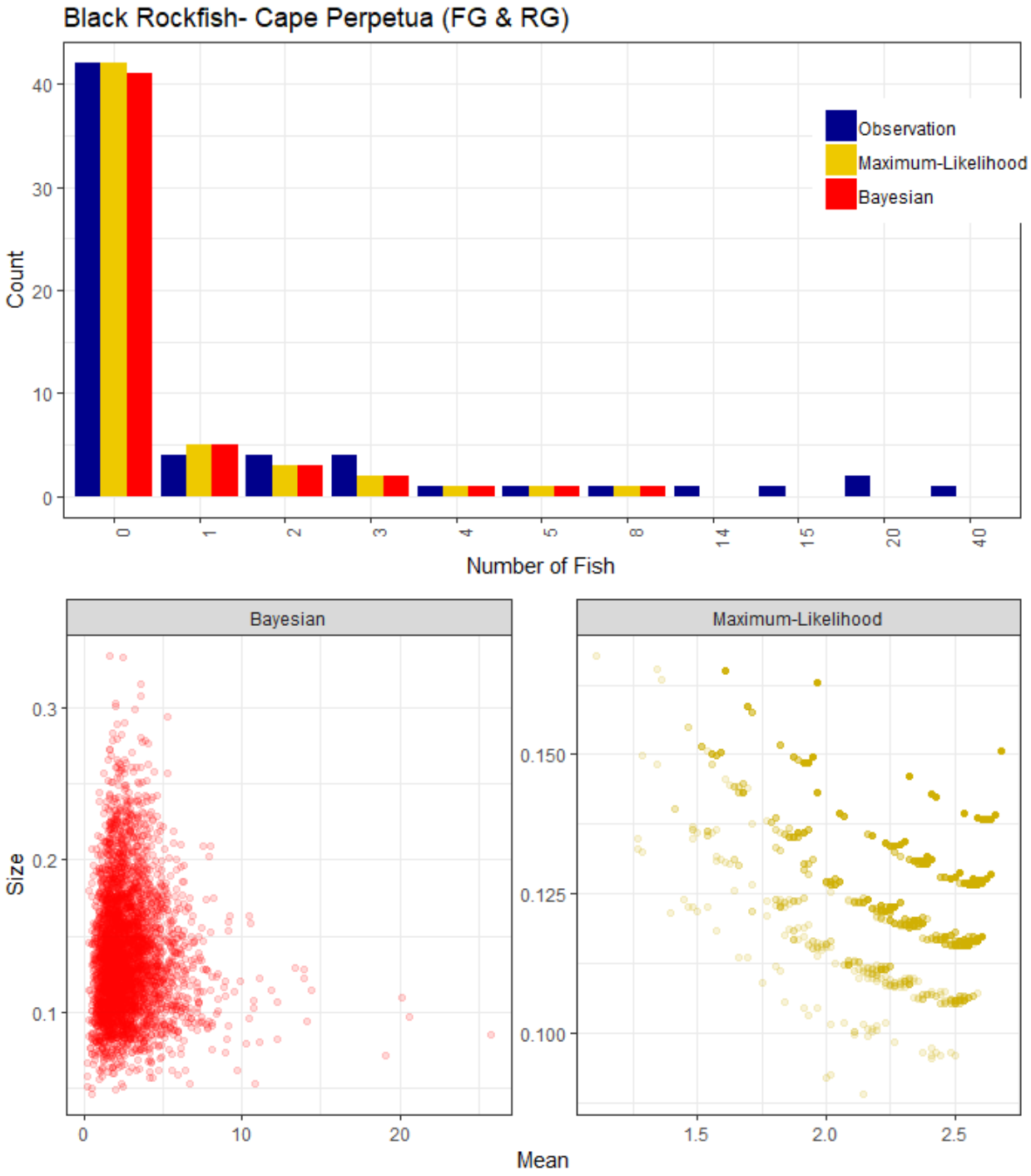

Black Rockfish- North Coast (FG)
Observation
Maximum-Likelihood
Bayesian
Count
200
100
0
0
1
2
3
4
5
6
7
9
10
11
17
20
22
25
30
35
Number of Fish
Bayesian
Maximum-Likelihood
Size
0.08
0.06
0.04
0.02
0.040
0.036
0.032
0.028
0
1
2
3
4
5
0.6
0.7
0.8
0.9
1.0
Mean

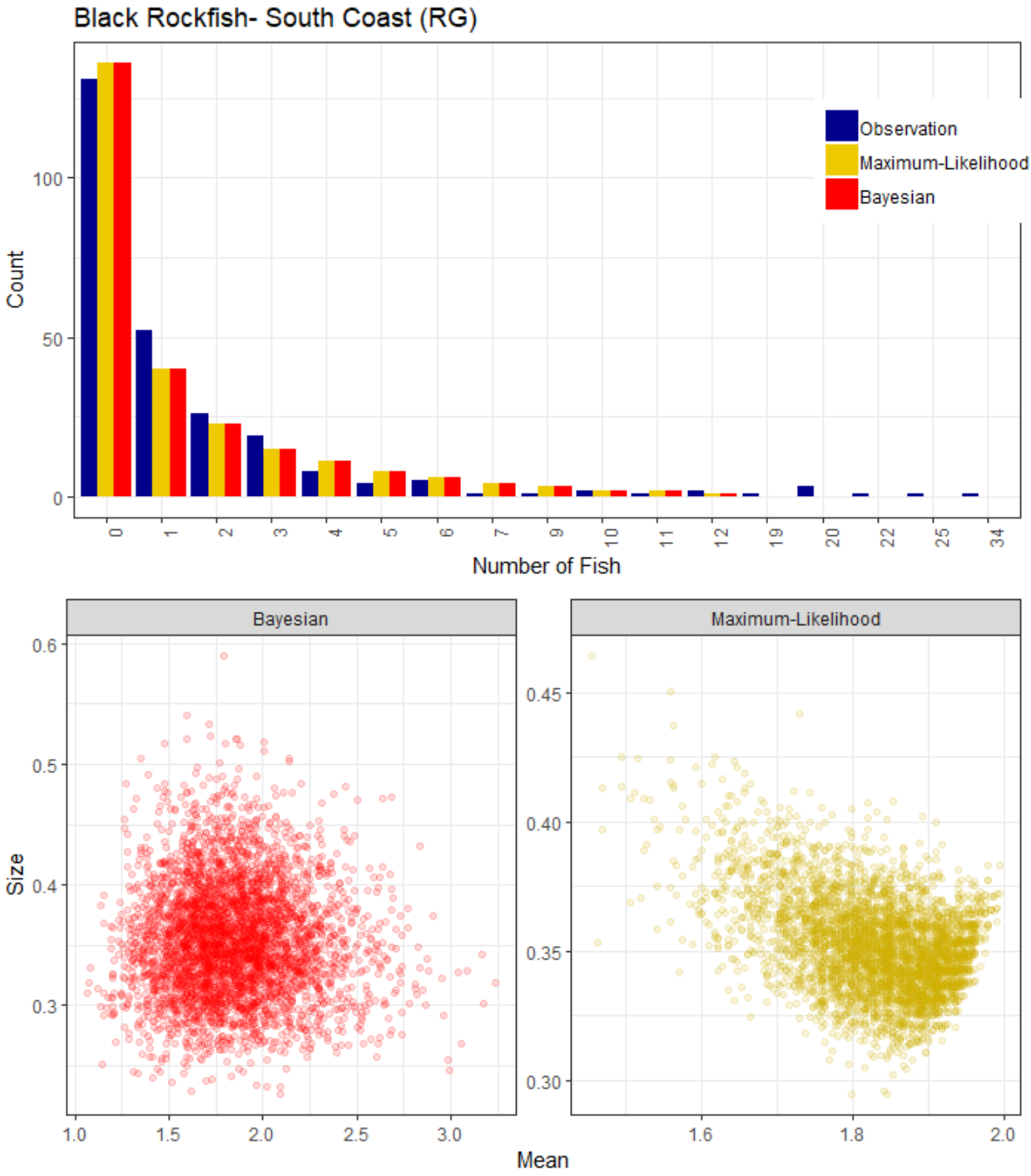

Black Rockfish- Central Coast (FG, RG & NG)
Observation
Maximum-Likelihood
Bayesian
Count
Number of Fish
Bayesian
Maximum-Likelihood
Size
Mean

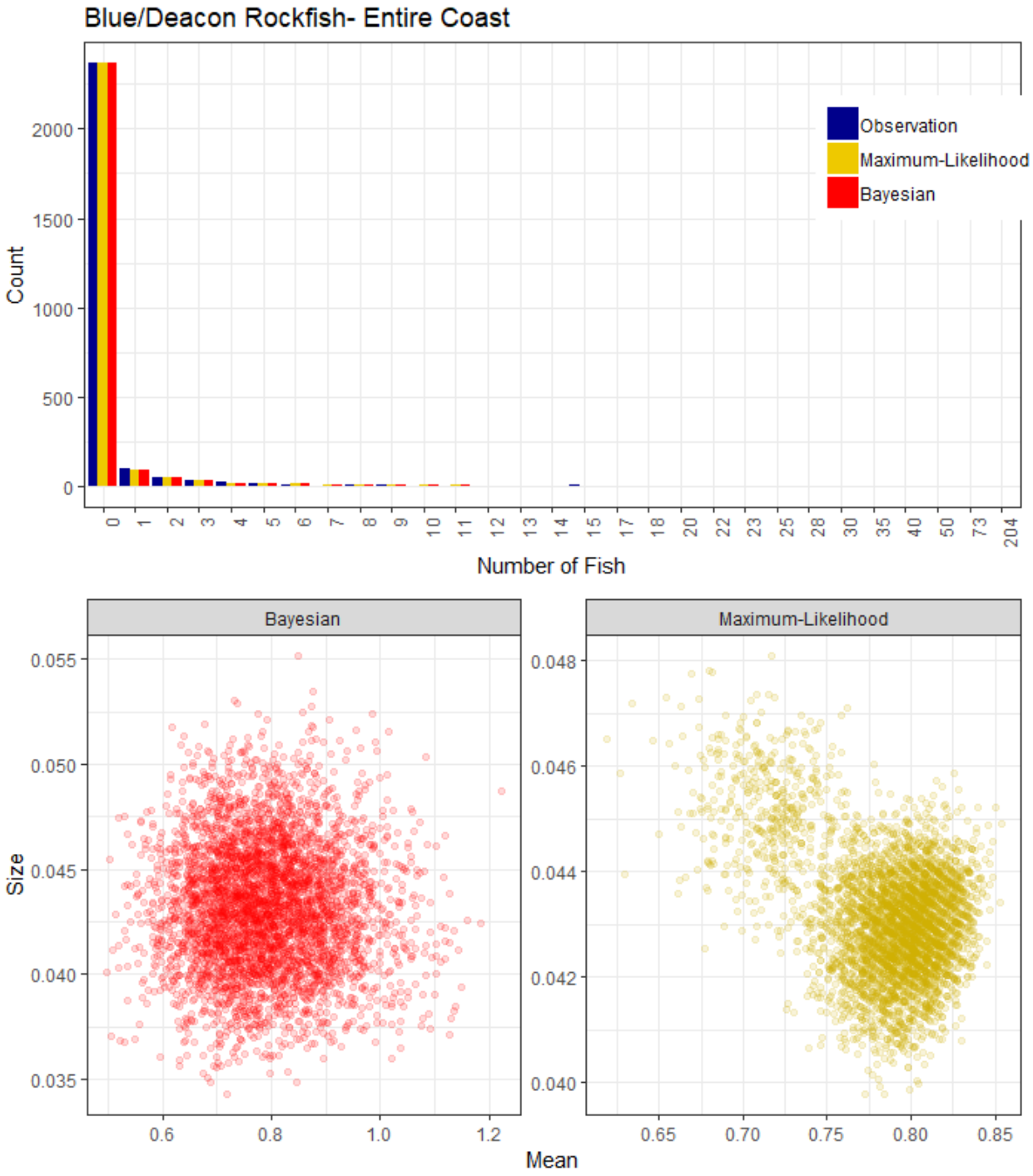

Black Rockfish- Central Coast (FG)
Observation
Maximum-Likelihood
Bayesian
Count
Number of Fish
Bayesian
Maximum-Likelihood
Size
Mean

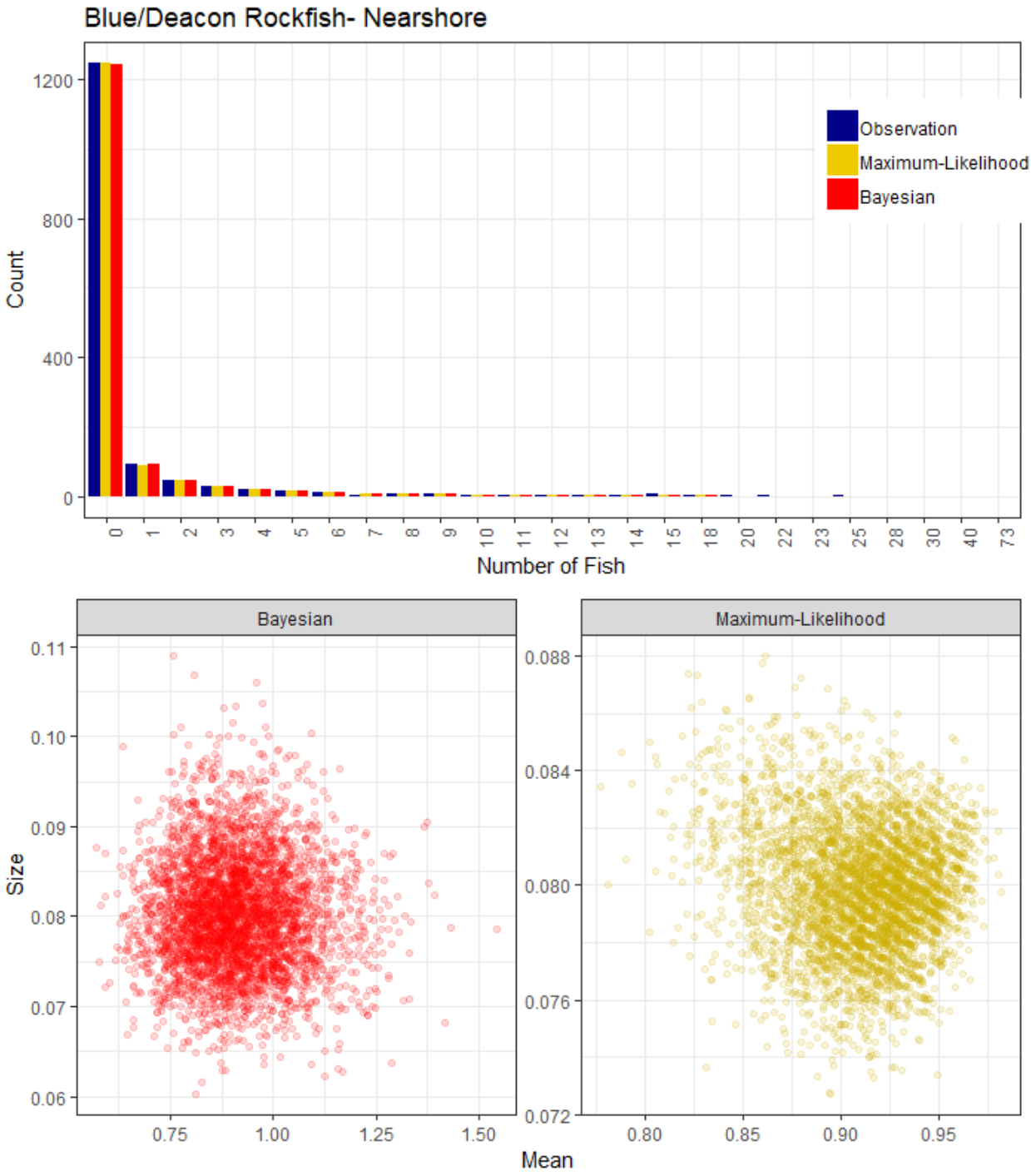

Black Rockfish- Central Coast (RG)
Observation
Maximum-Likelihood
Bayesian
Count
Number of Fish
Bayesian
Maximum-Likelihood
Size
Mean

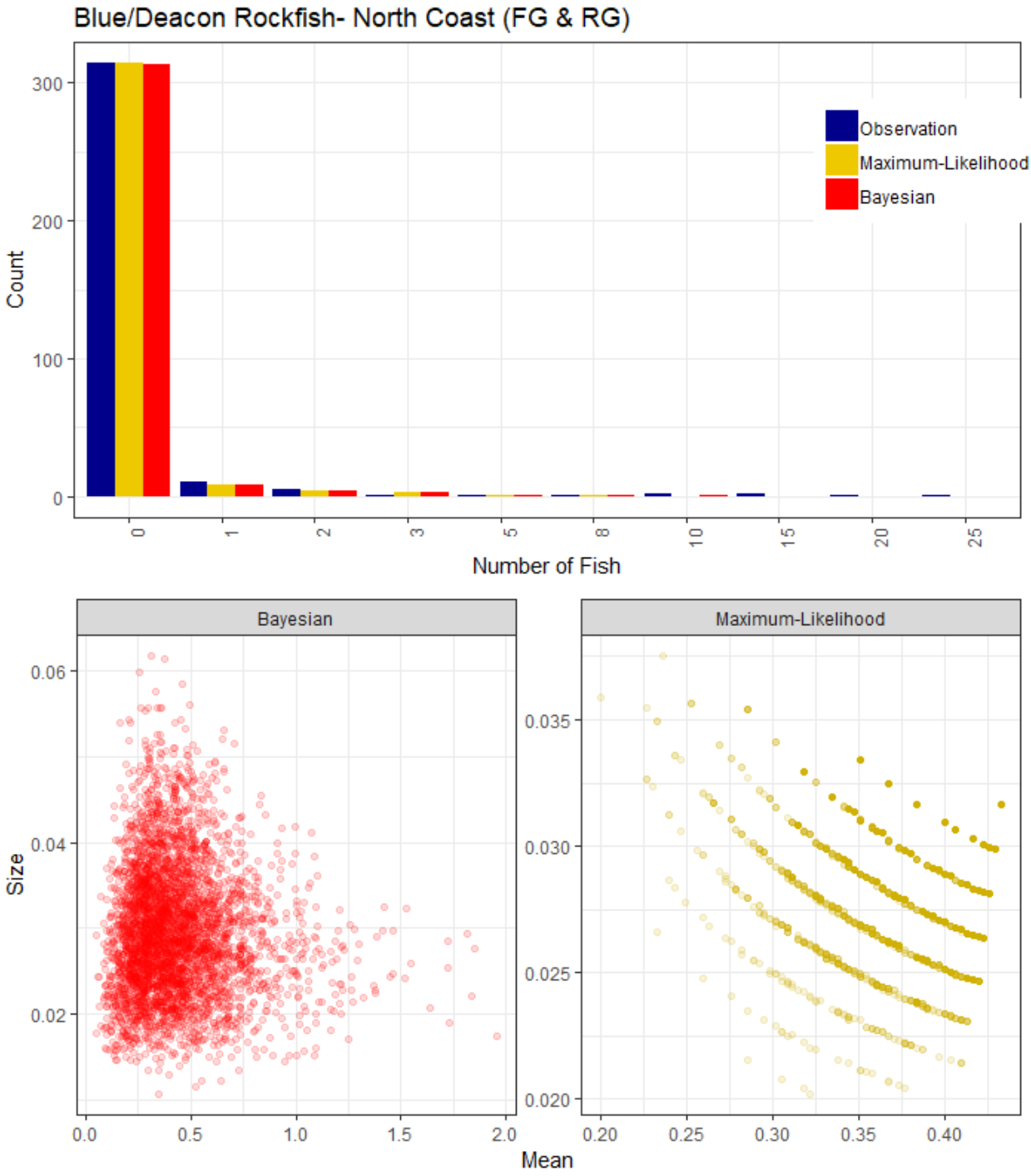

Black Rockfish- Central Coast (NG)
Observation
Maximum-Likelihood
Bayesian
Count
Number of Fish
0
1
2
3
4
5
6
7
8
9
10
11
12
14
17
18
19
20
21
22
25
26
29
30
54
92
Bayesian
Maximum-Likelihood
Size
Mean
0.3
0.2
0.175
0.150
0.125
4
8
12
0.9
1.1
1.3

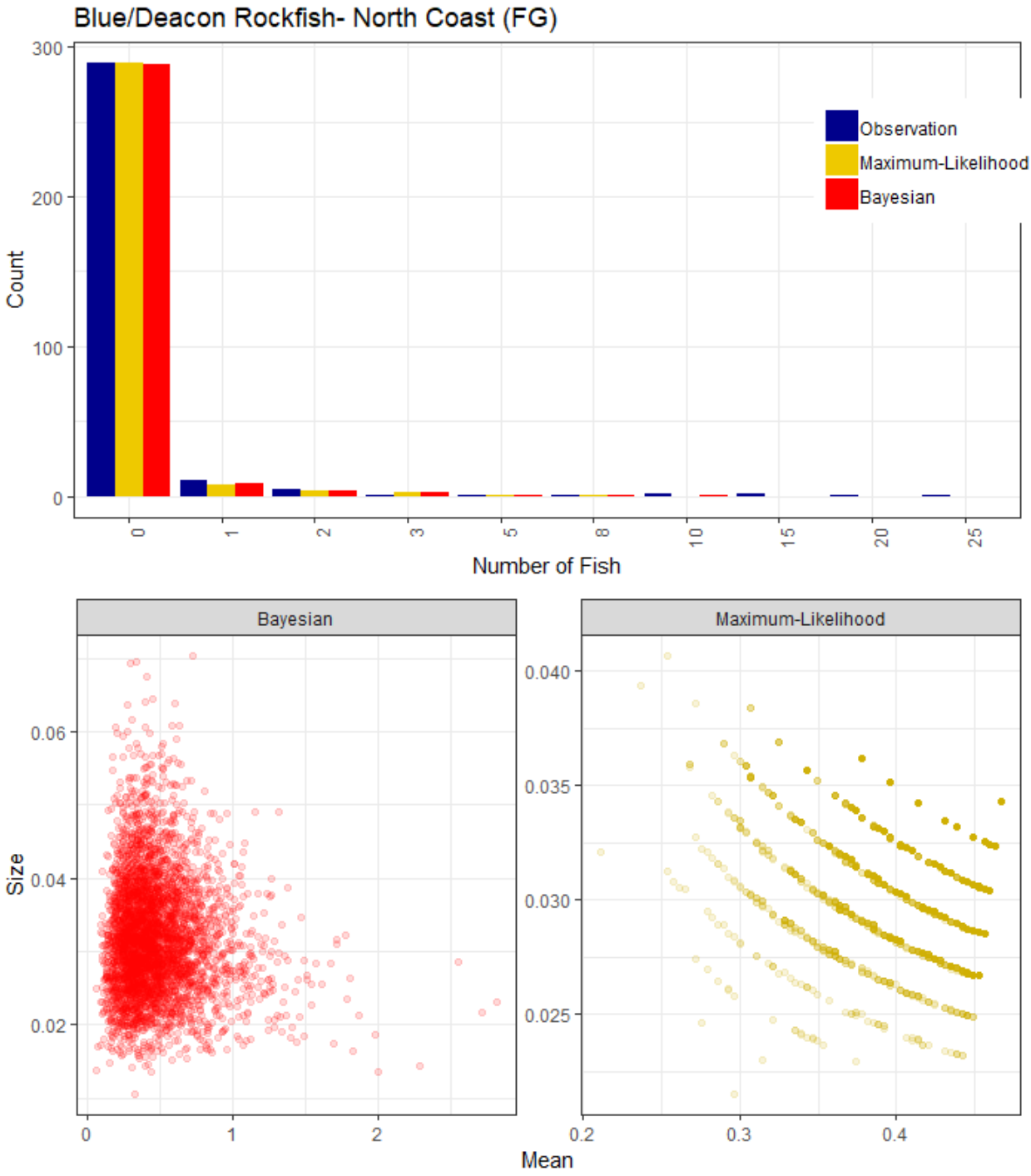

Black Rockfish- Cape Perpetua (FG & RG)
Observation
Maximum-Likelihood
Bayesian
Count
Number of Fish
0
1
2
3
4
5
8
14
15
20
40
10
30
Bayesian
Maximum-Likelihood
Size
Mean
0.3
0.2
0.1
0.150
0.125
0.100
1.5
2.0
2.5


Black Rockfish- South Coast (RG)
Observation
Maximum-Likelihood
Bayesian
Count
100
50
0
0
1
2
3
4
5
6
7
9
10
11
12
19
20
22
25
34
Number of Fish
Bayesian
Maximum-Likelihood
Size
0.6
0.5
0.4
0.3
0.45
0.40
0.35
0.30
1.0
1.5
2.0
2.5
3.0
1.6
1.8
2.0
Mean


Blue/Deacon Rockfish- Entire Coast
Observation
Maximum-Likelihood
Bayesian
Count
2000
1500
1000
500
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 17 18 20 22 23 25 28 30 35 40 50 73 204
Number of Fish
Bayesian
Maximum-Likelihood
Size
0.055
0.050
0.045
0.040
0.035
0.048
0.046
0.044
0.042
0.040
0.6 0.8 1.0 1.2
0.65 0.70 0.75 0.80 0.85
Mean


Blue/Deacon Rockfish- Nearshore
Observation
Maximum-Likelihood
Bayesian
Count
Number of Fish
Bayesian
Maximum-Likelihood
Size
Mean


Blue/Deacon Rockfish- North Coast (FG & RG)
Observation
Maximum-Likelihood
Bayesian
Count
Number of Fish
Bayesian
Maximum-Likelihood
Size
Mean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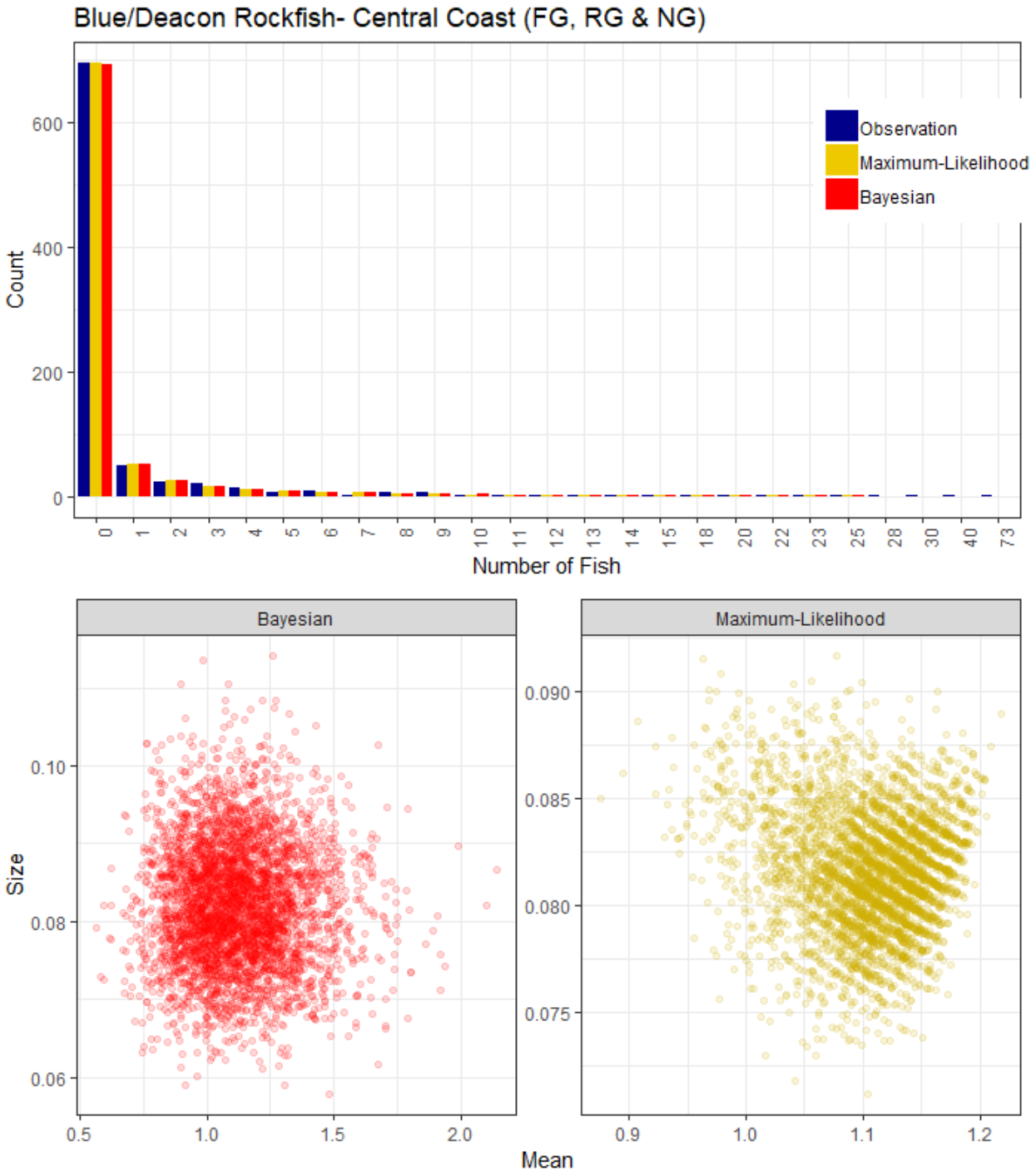
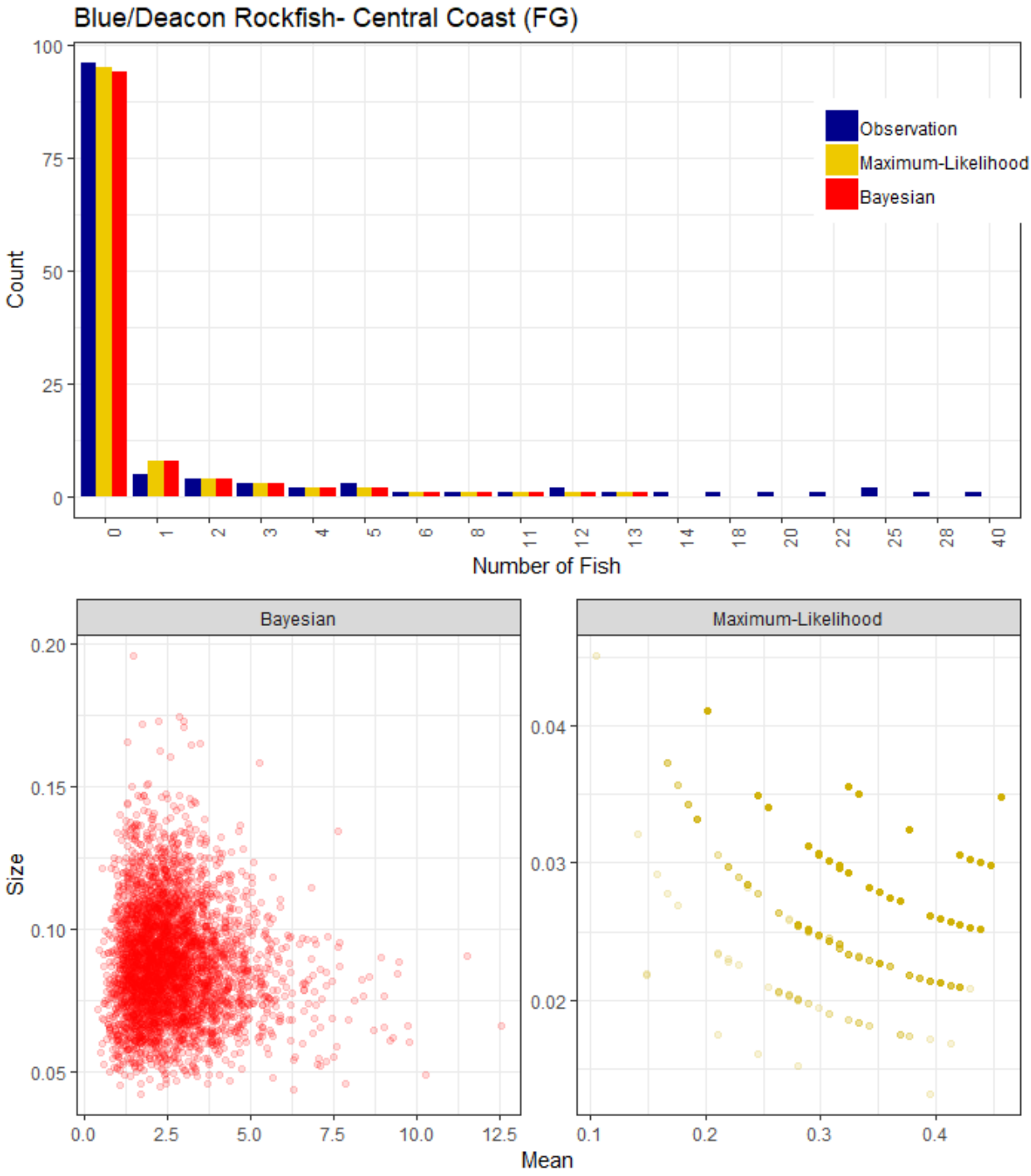
Observation
Maximum-Likelihood
Bayesian
Count
Number of Fish
Bayesian
Maximum-Likelihood
Size
Mean


Blue/Deacon Rockfish- Central Coast (FG, RG & NG)
Observation
Maximum-Likelihood
Bayesian
Count
Number of Fish
Bayesian
Maximum-Likelihood
Size
Mean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Observation
Maximum-Likelihood
Bayesian
Count
Number of Fish
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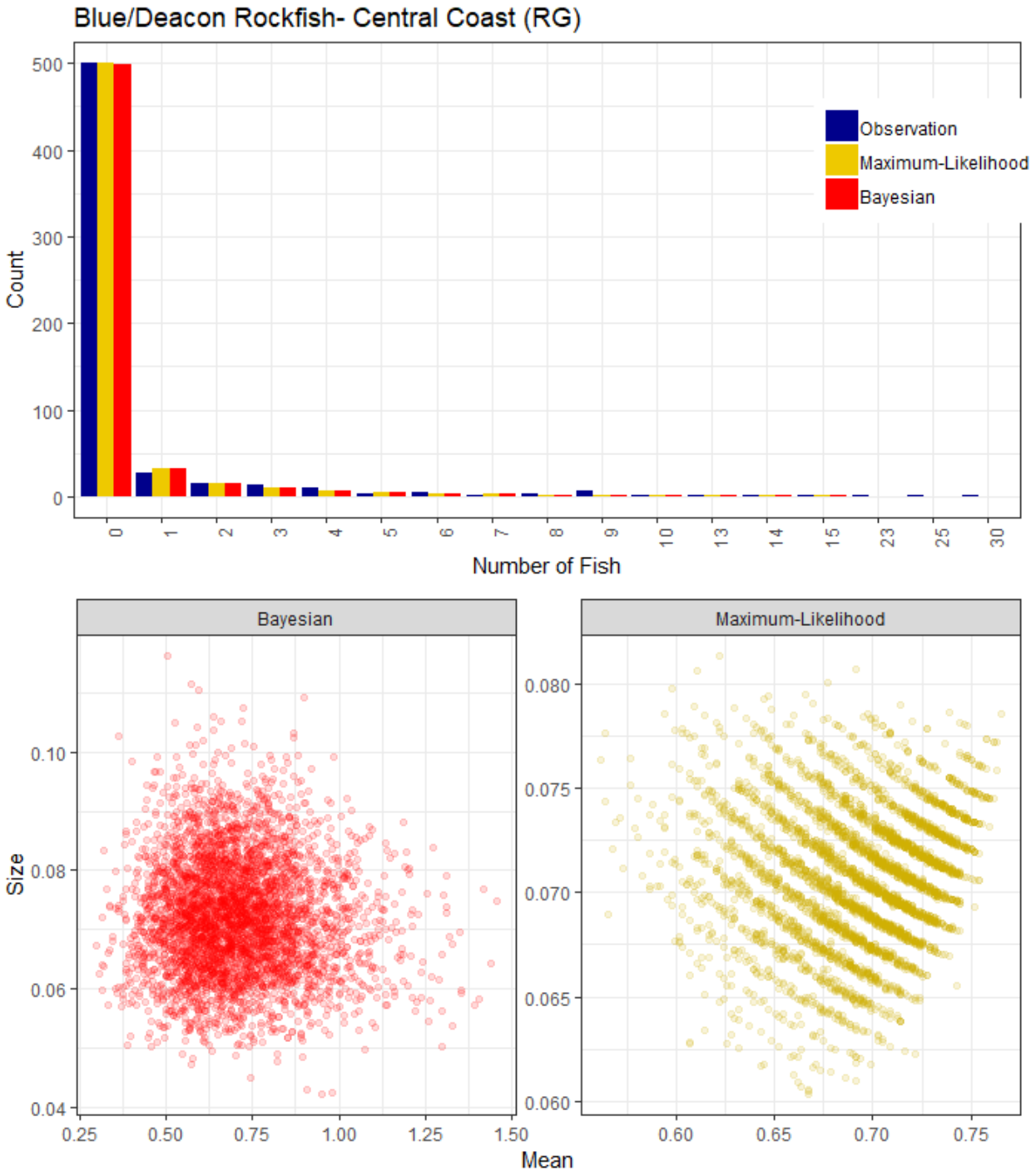
Maximum-Likelihood
Size
Mean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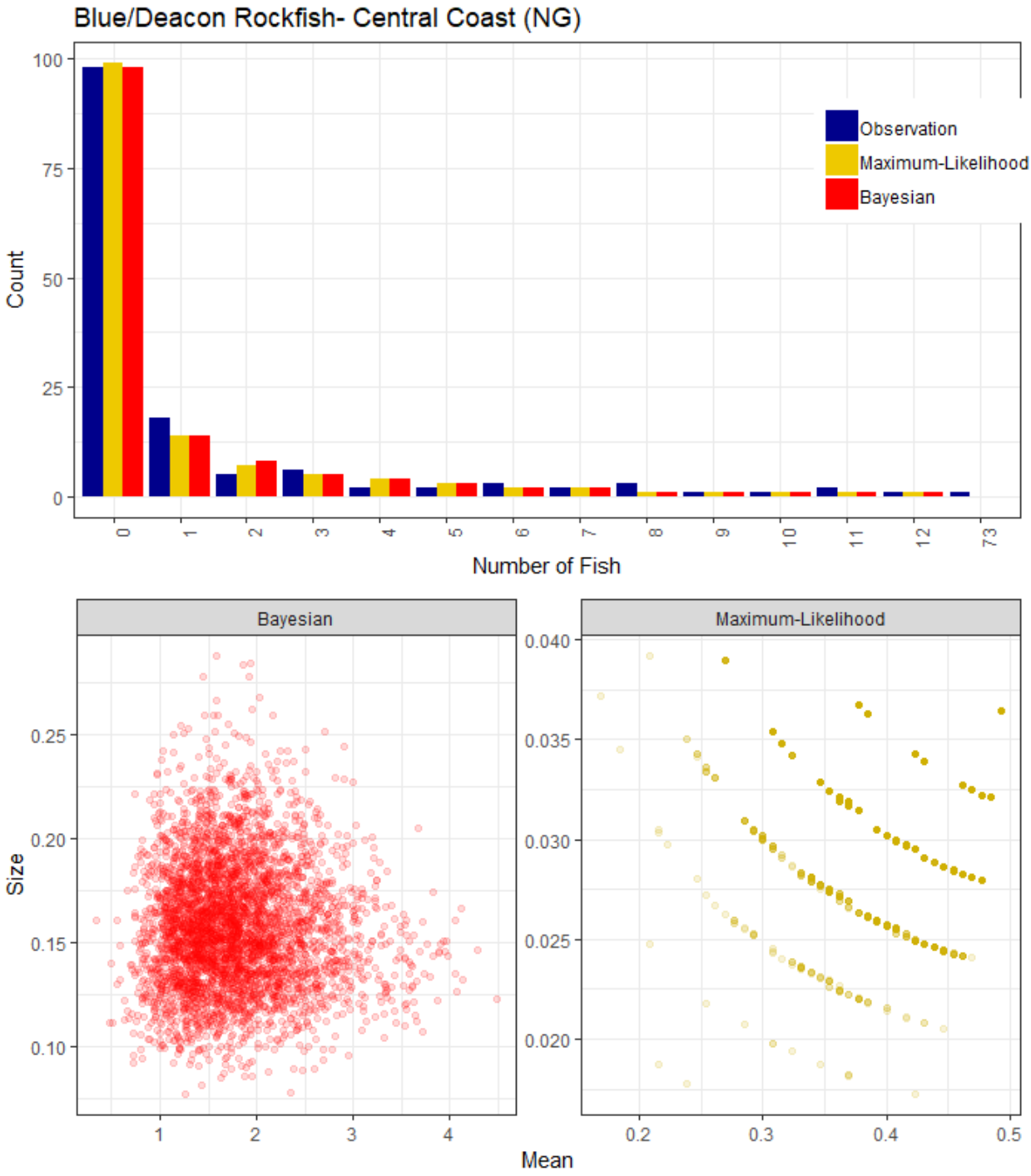
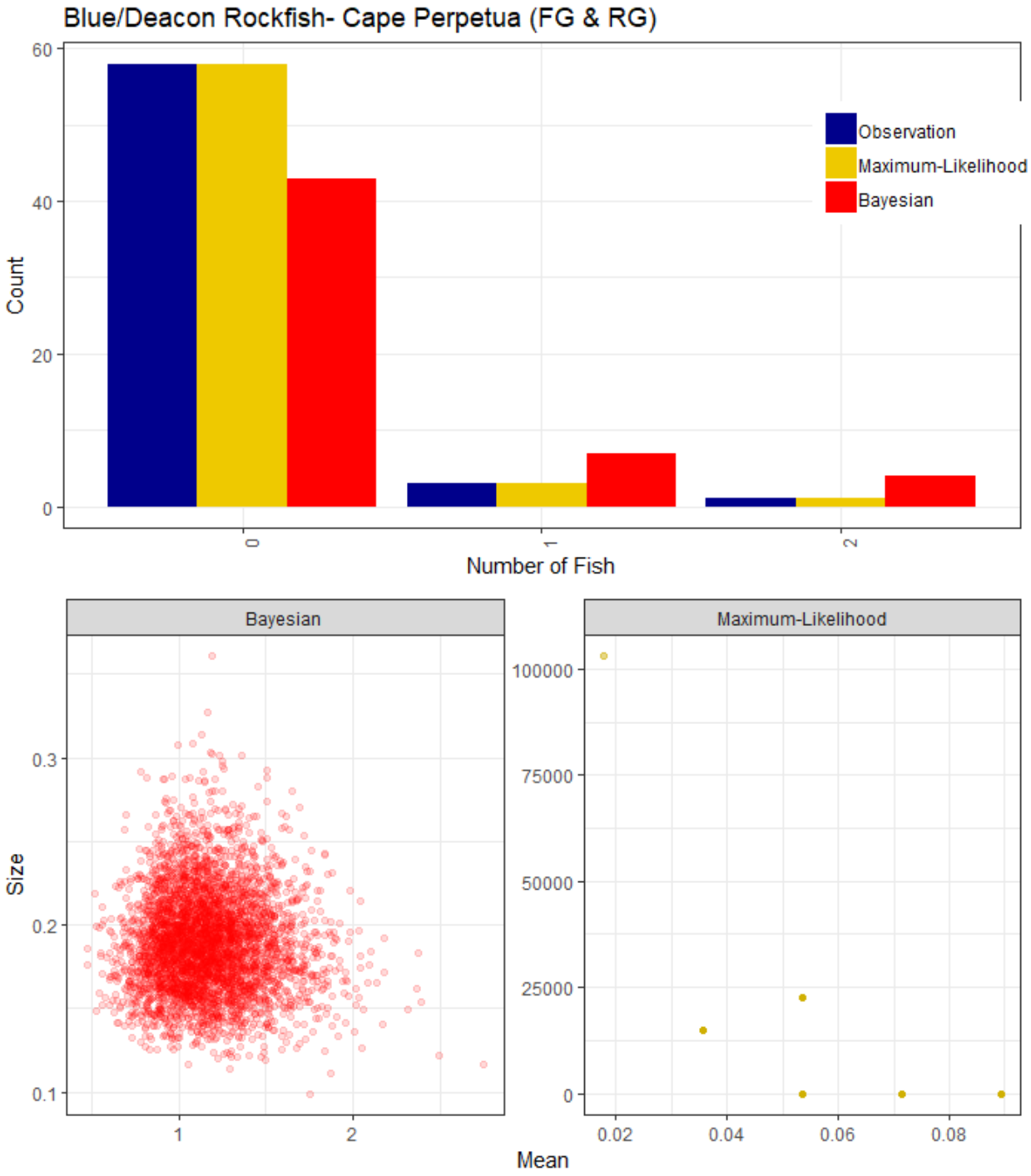
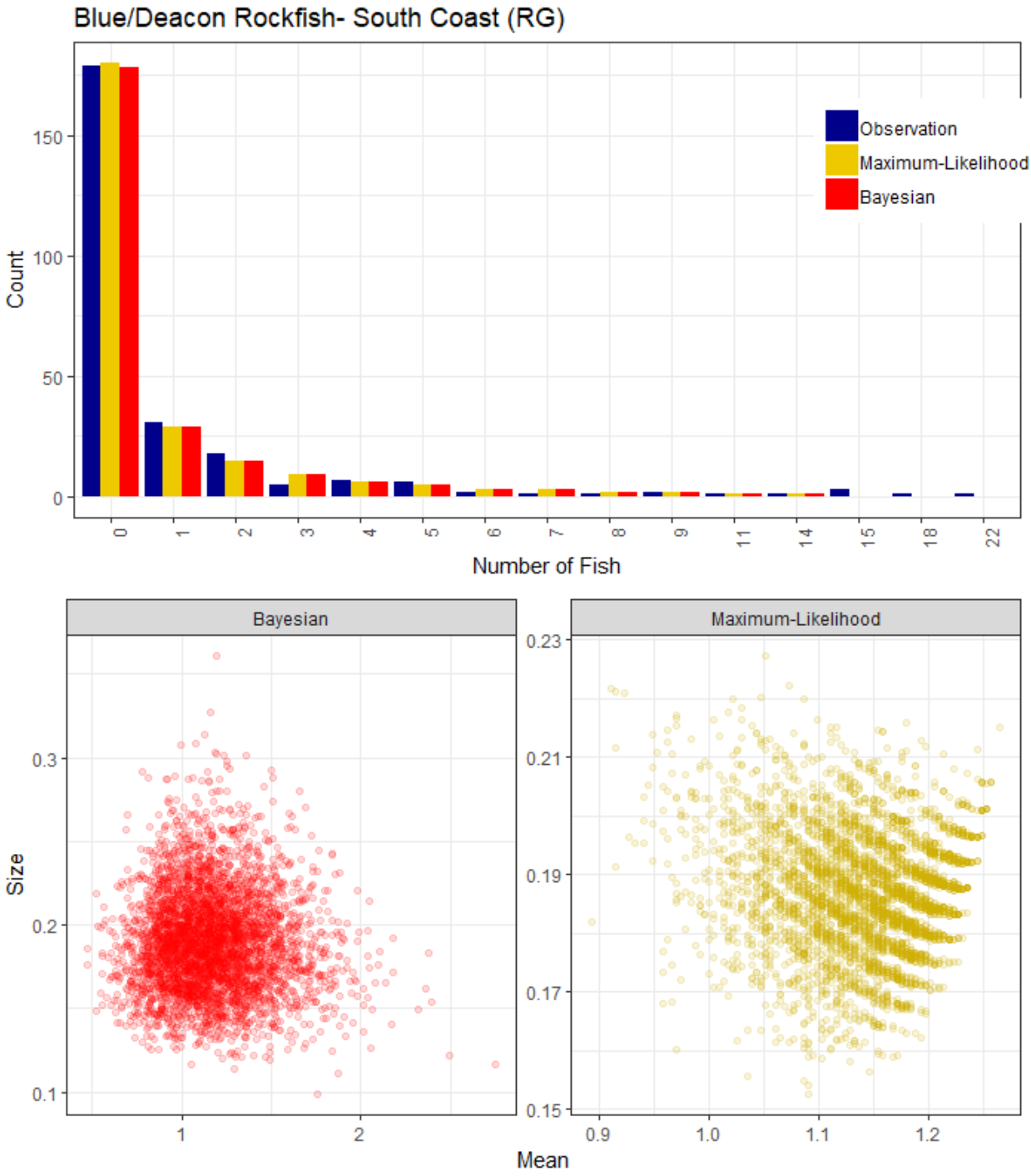
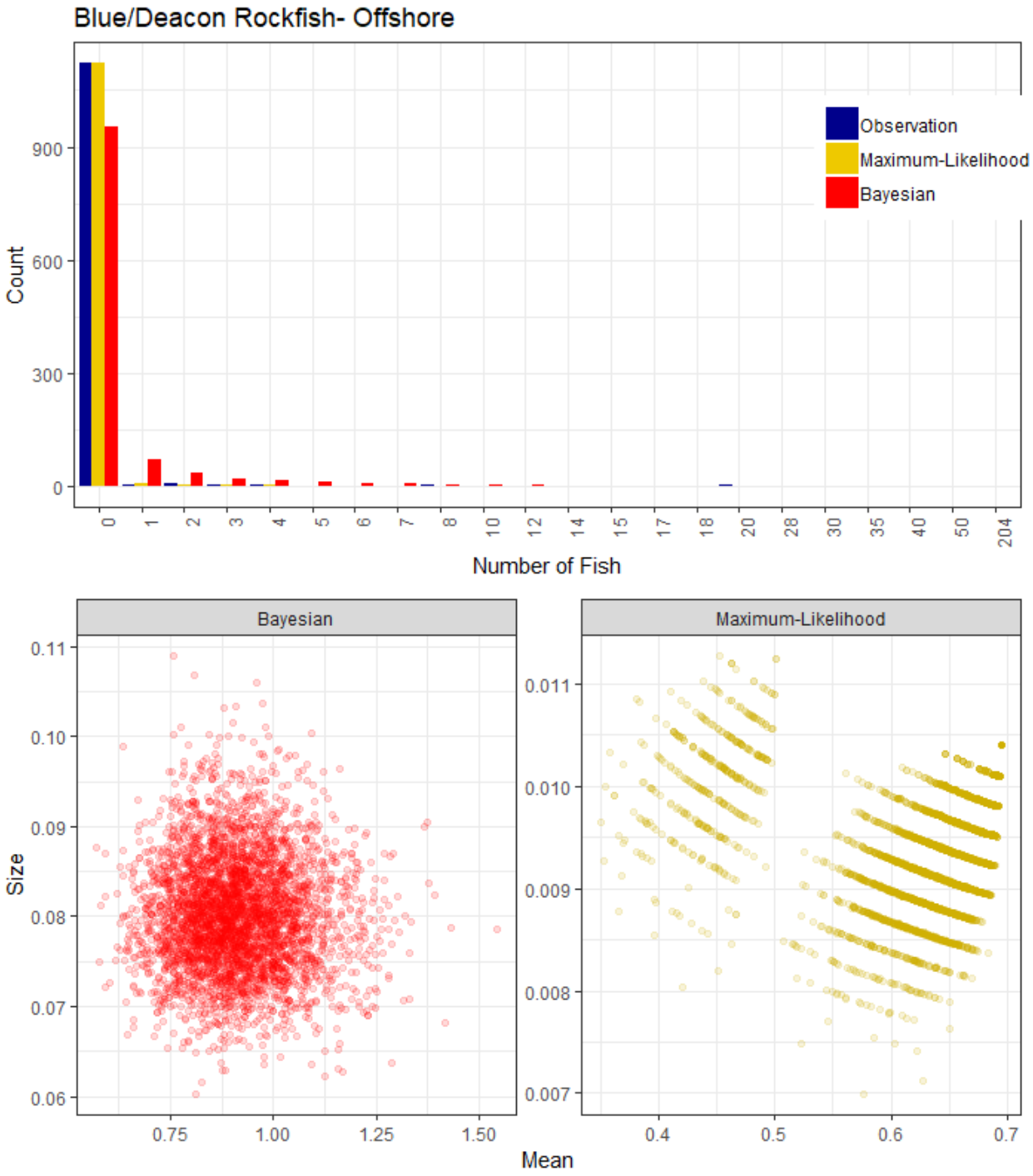
Observation
Maximum-Likelihood
Bayesian
Count
Number of Fish
Bayesian
Maximum-Likelihood
Size
Mean


Blue/Deacon Rockfish- Central Coast (NG)
Observation
Maximum-Likelihood
Bayesian
Count
Number of Fish
Bayesian
Maximum-Likelihood
Size
Mean


Blue/Deacon Rockfish- Cape Perpetua (FG & RG)
Count
Number of Fish
Observation
Maximum-Likelihood
Bayesian
Bayesian
Maximum-Likelihood
Size
Mean


Blue/Deacon Rockfish- South Coast (RG)
Observation
Maximum-Likelihood
Bayesian
Count
Number of Fish
Bayesian
Maximum-Likelihood
Size
Mean


Blue/Deacon Rockfish- Offshore
Observation
Maximum-Likelihood
Bayesian
Count
900
600
300
0
0
1
2
3
4
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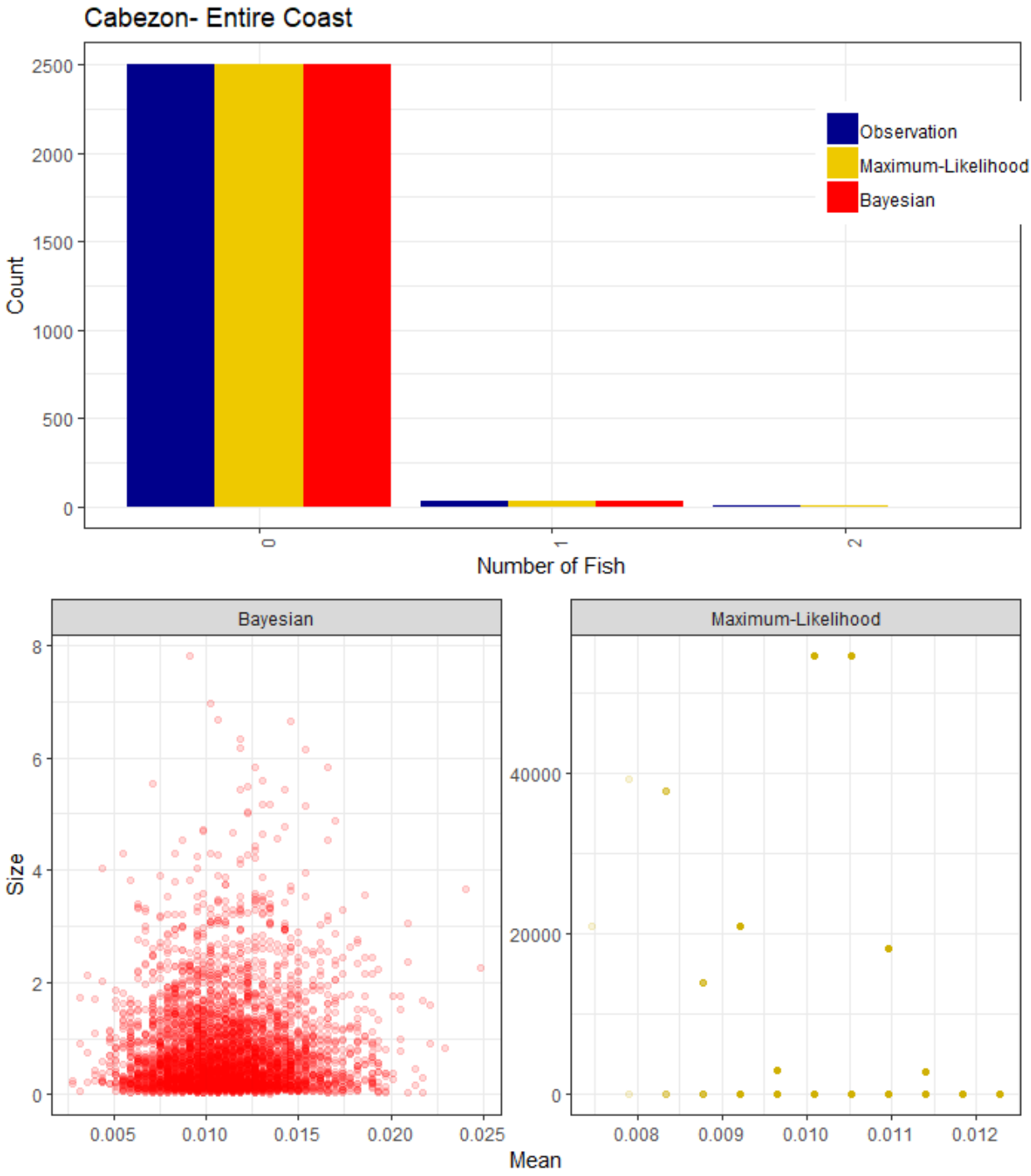
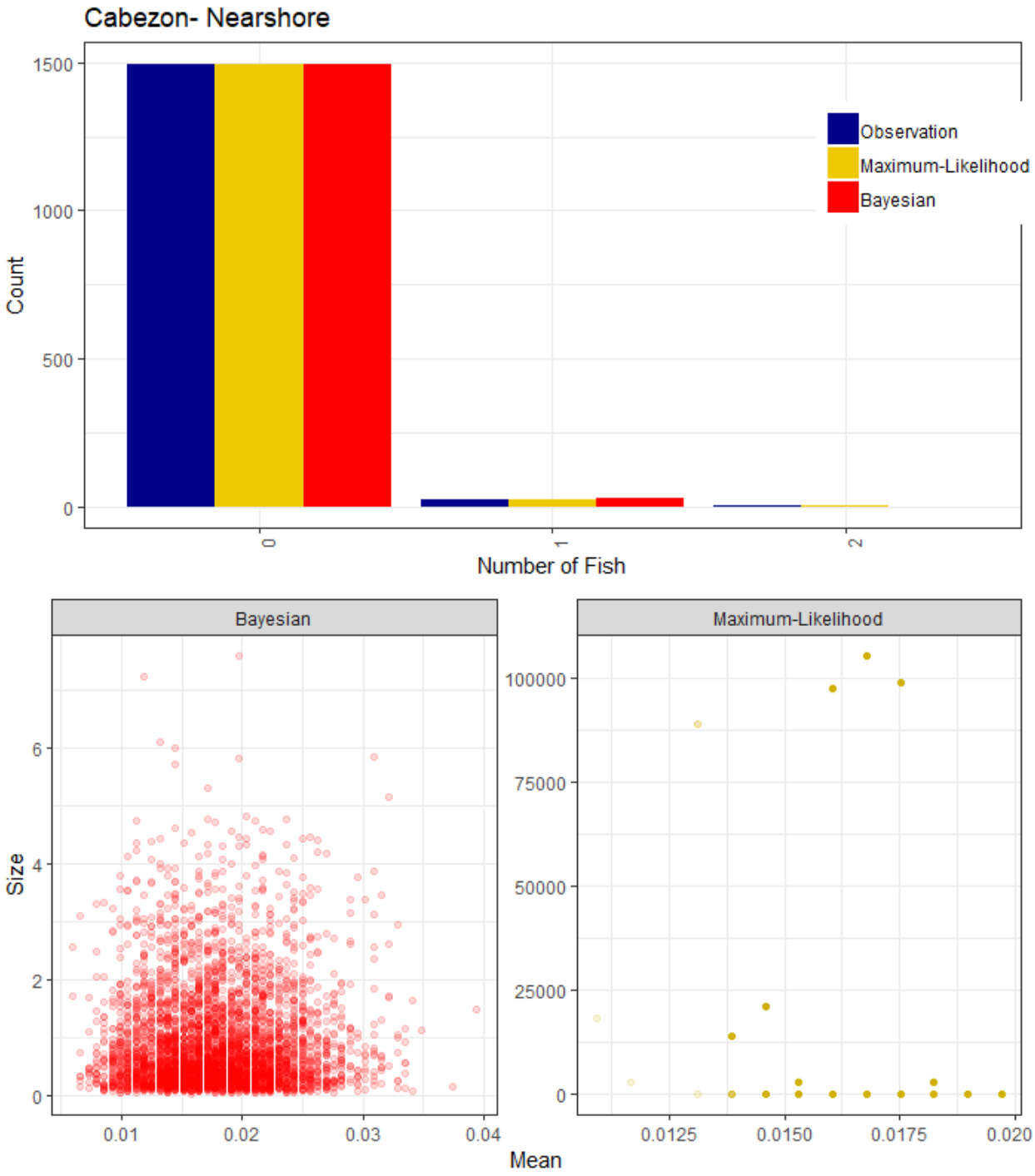
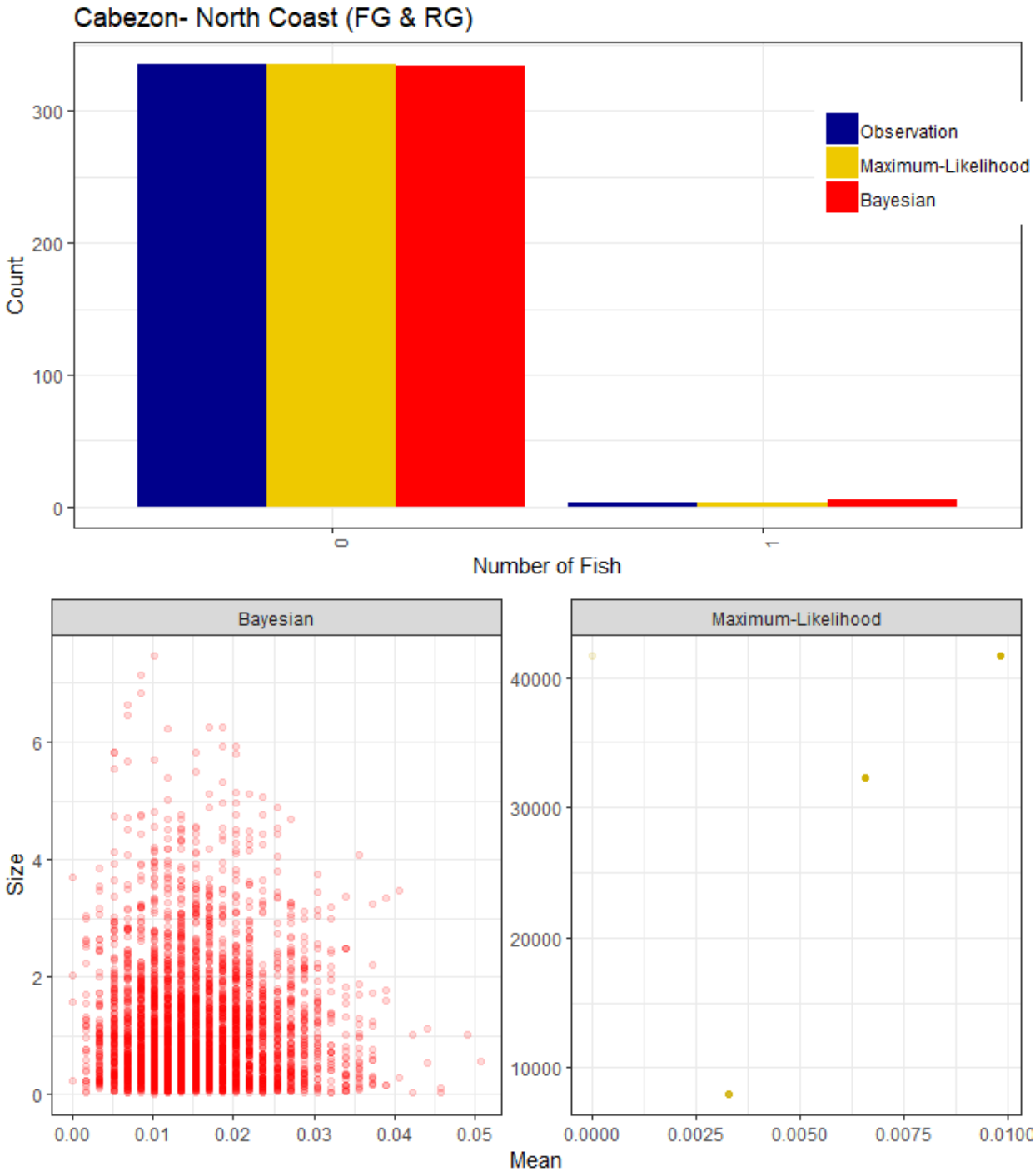
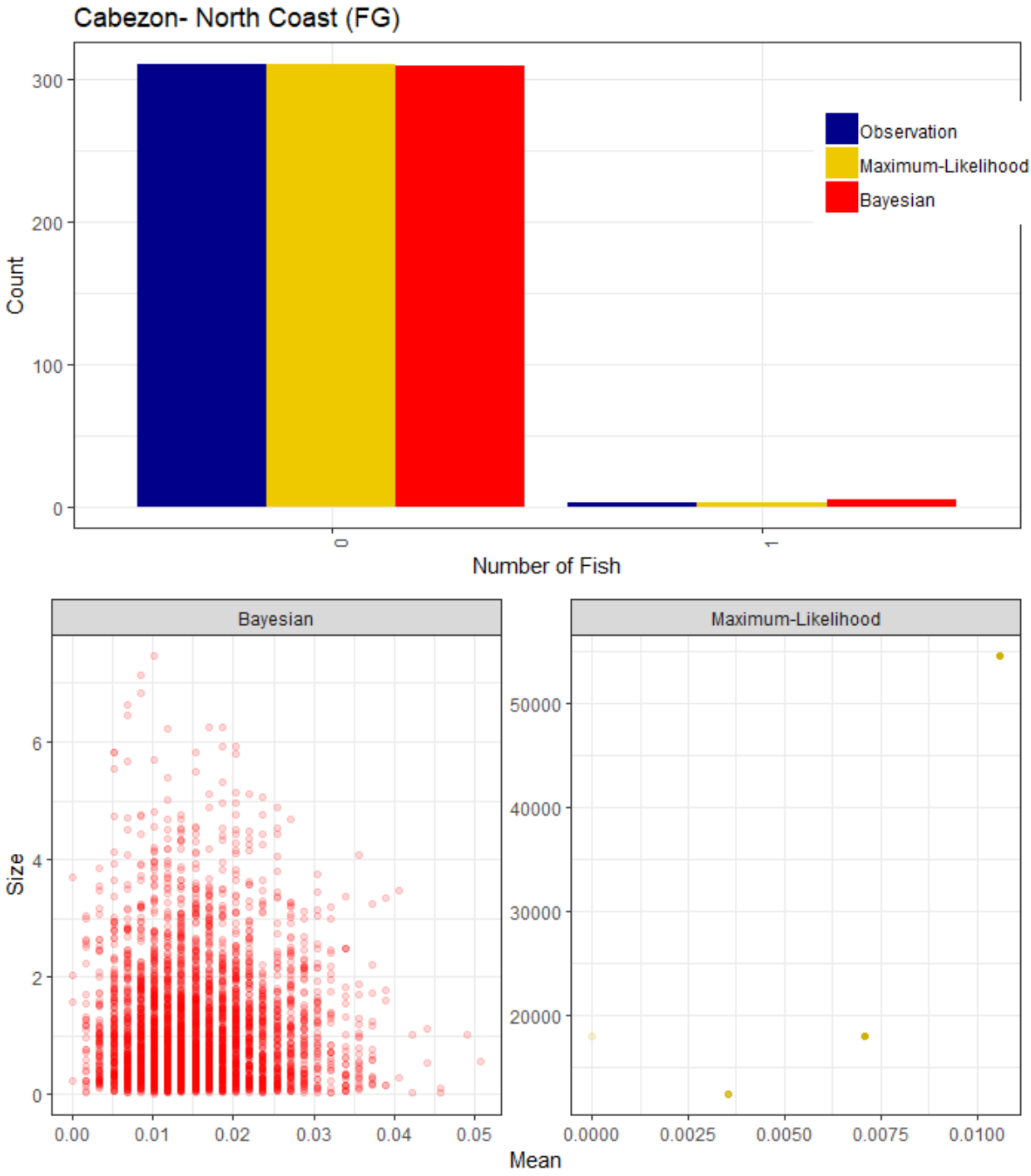
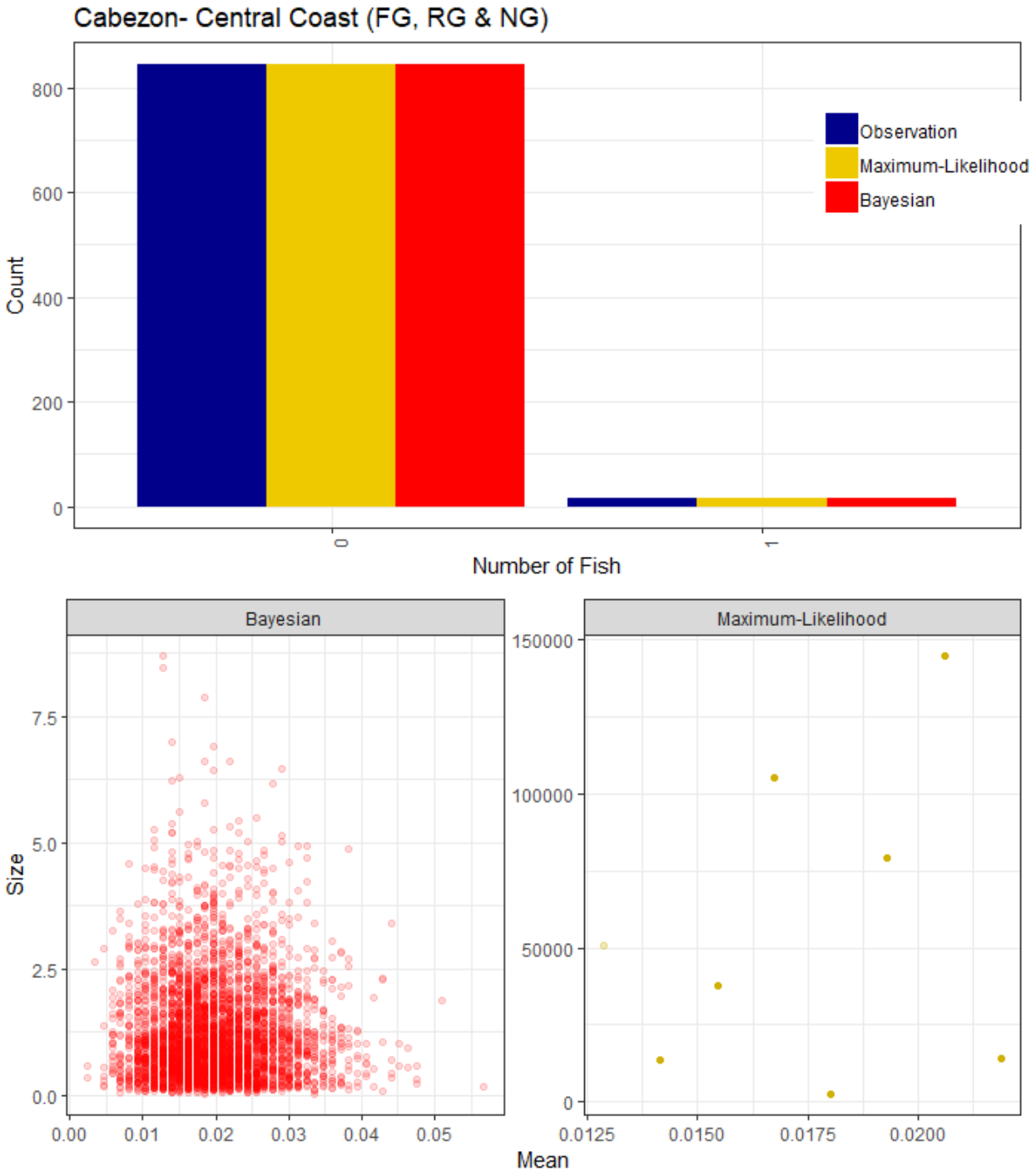
6
7
8
10
12
14
15
17
18
20
28
30
35
40
50
204
Number of Fish
Bayesian
Maximum-Likelihood
Size
0.11
0.10
0.09
0.08
0.07
0.06
0.011
0.010
0.009
0.008
0.007
0.75
1.00
1.25
1.50
0.4
0.5
0.6
0.7
Mean

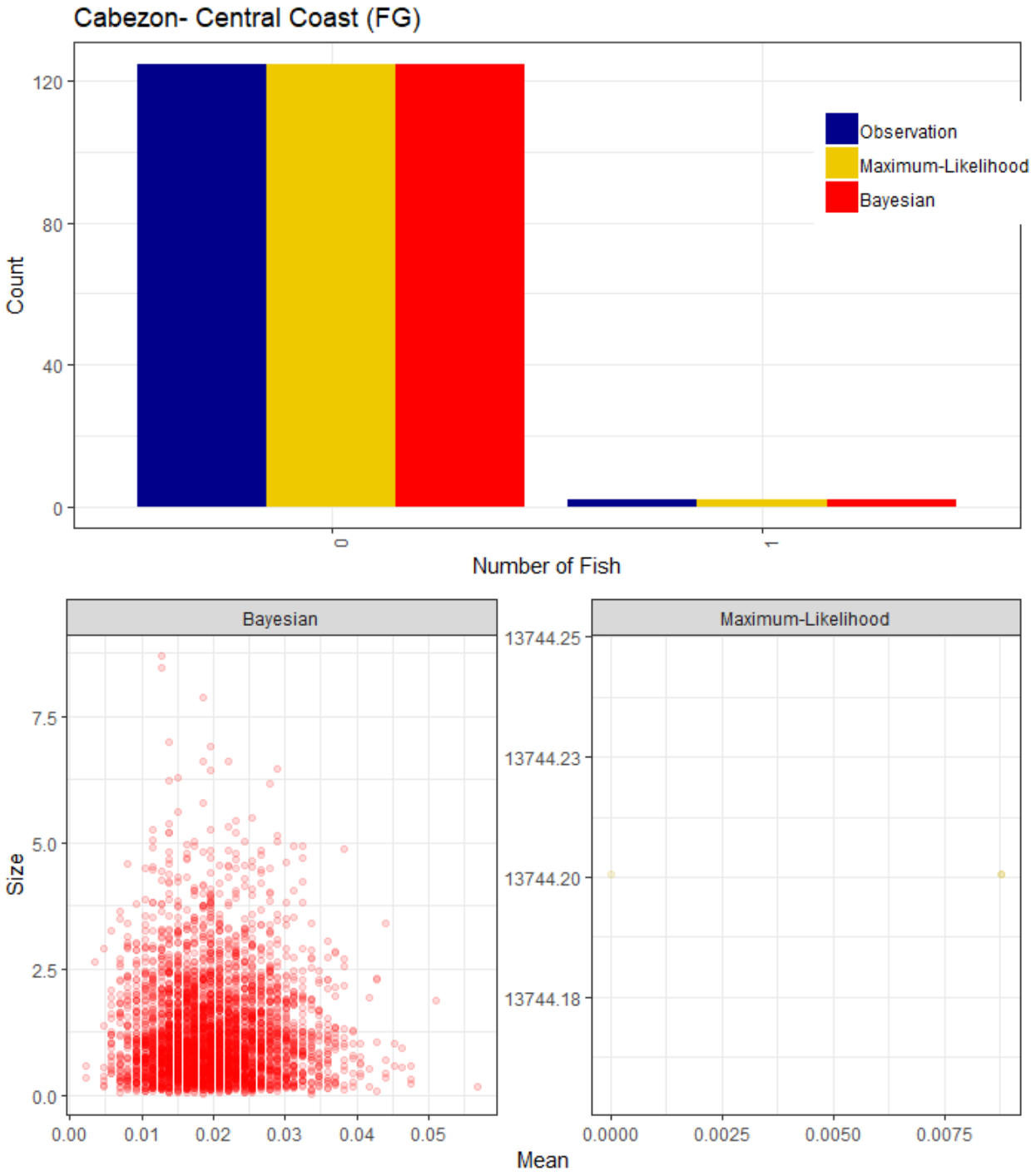

Cabezon- Entire Coast
2500
2000
1500
1000
500
0
Count
Observation
Maximum-Likelihood
Bayesian
0
1
2
Number of Fish
Bayesian
Maximum-Likelihood
8
6
4
2
0
Size
40000
20000
0
0.005
0.010
0.015
0.020
0.025
0.008
0.009
0.010
0.011
0.012
Mean

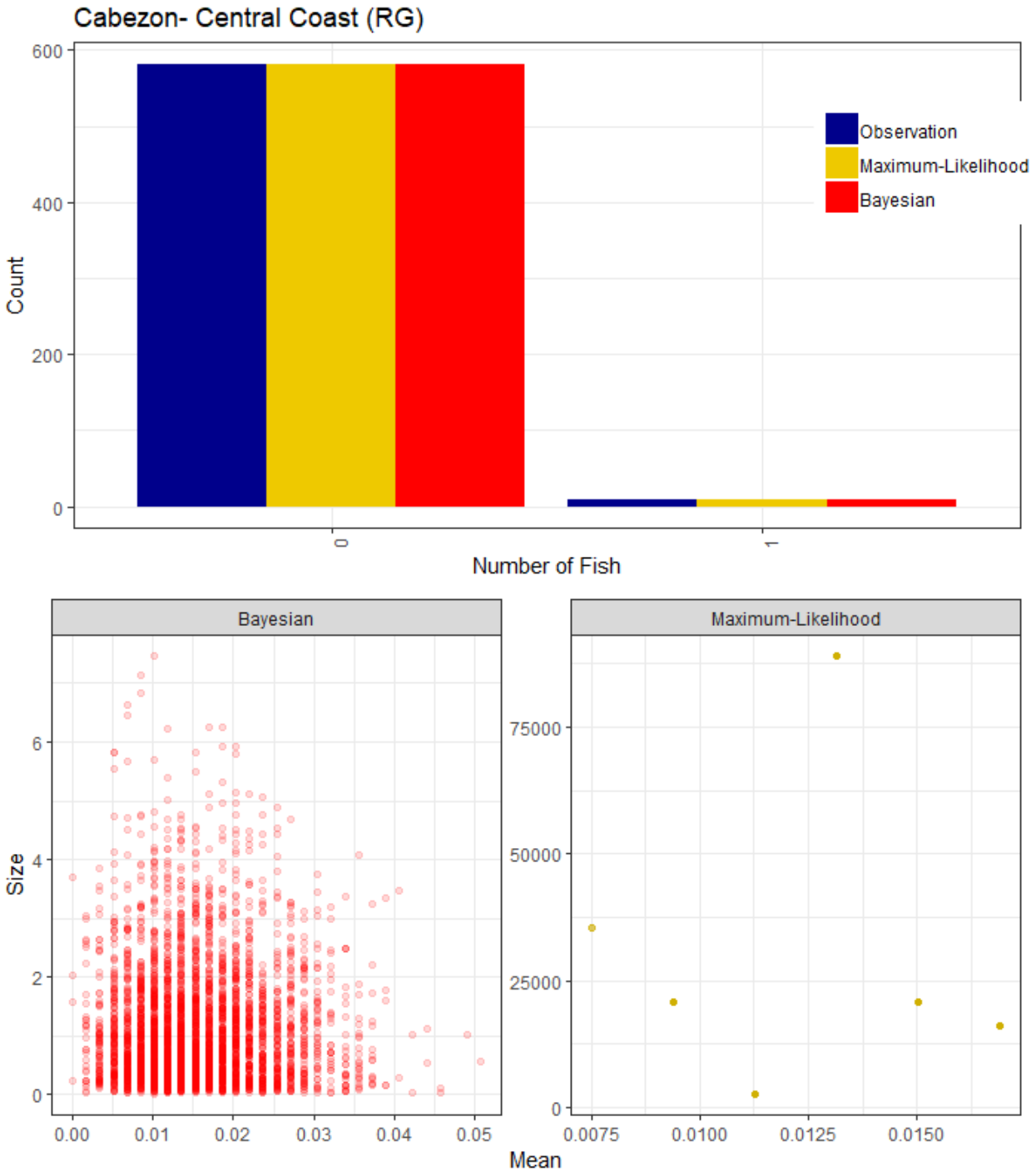

Cabezon- Nearshore
1500
1000
500
0
Count
Observation
Maximum-Likelihood
Bayesian
0
1
2
Number of Fish
Bayesian
Maximum-Likelihood
6
4
2
0
Size
100000
75000
50000
25000
0
0.01
0.02
0.03
0.04
0.0125
0.0150
0.0175
0.020
Mean

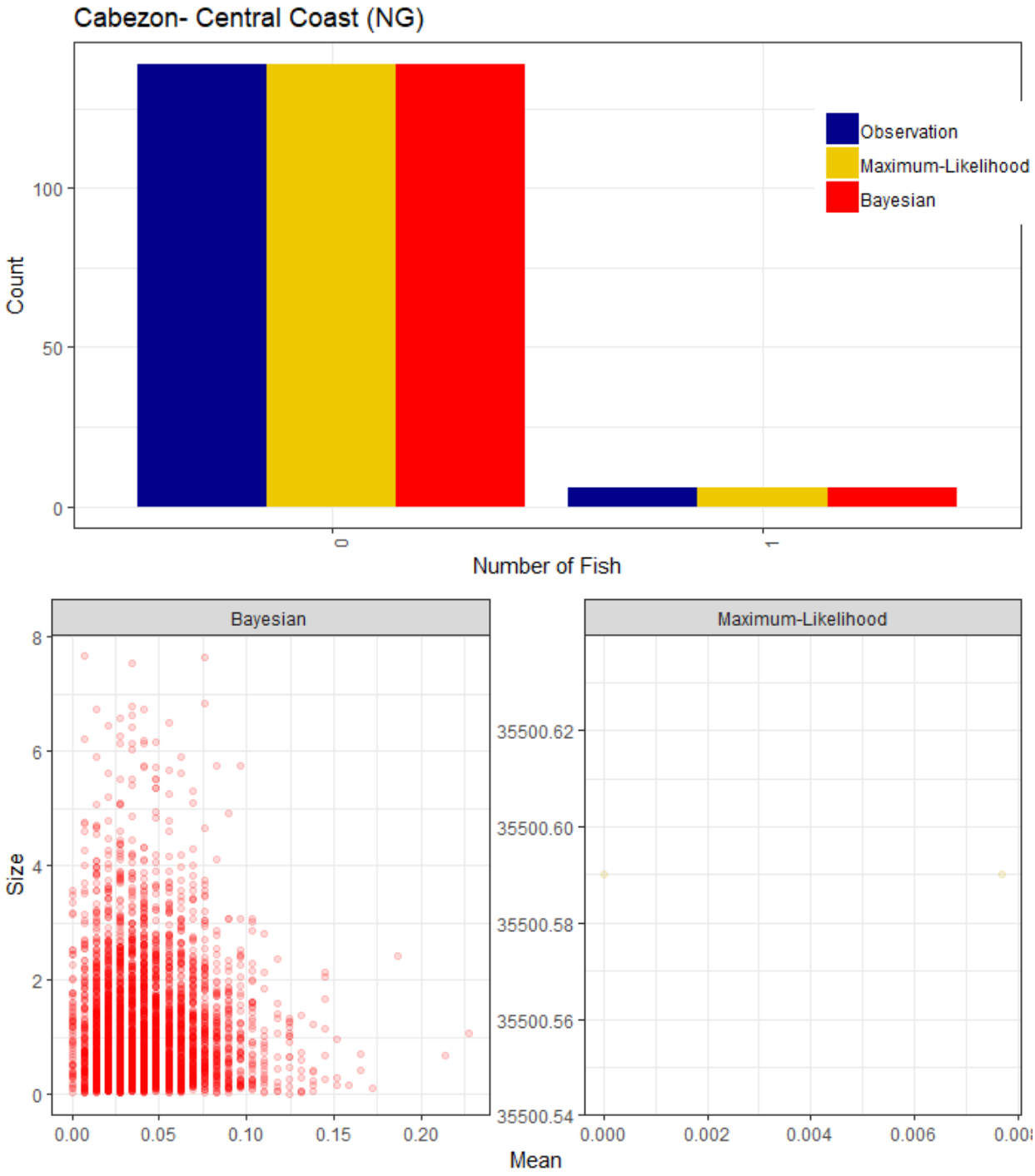

Cabezon- North Coast (FG & RG)
Count
300
200
100
0
Observation
Maximum-Likelihood
Bayesian
0
1
Number of Fish
Bayesian
Maximum-Likelihood
Size
6
4
2
0
0.00
0.01
0.02
0.03
0.04
0.05
40000
30000
20000
10000
0.0000
0.0025
0.0050
0.0075
0.0100
Mean

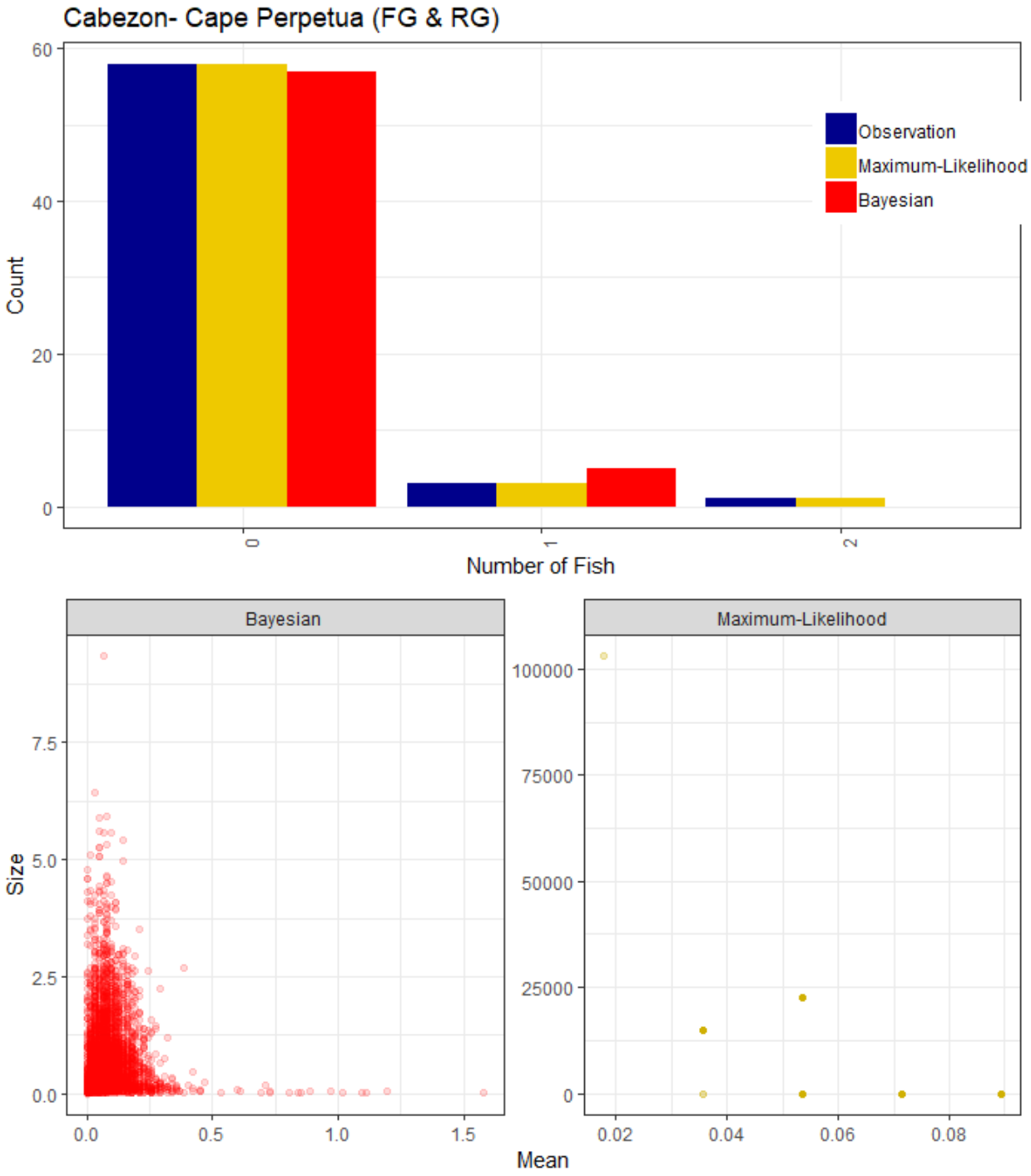

Cabezon- North Coast (FG)
Count
300
200
100
0
Observation
Maximum-Likelihood
Bayesian
0
1
Number of Fish
Bayesian
Maximum-Likelihood
Size
6
4
2
0
50000
40000
30000
20000
0.00
0.01
0.02
0.03
0.04
0.05
0.0000
0.0025
0.0050
0.0075
0.0100
Mean

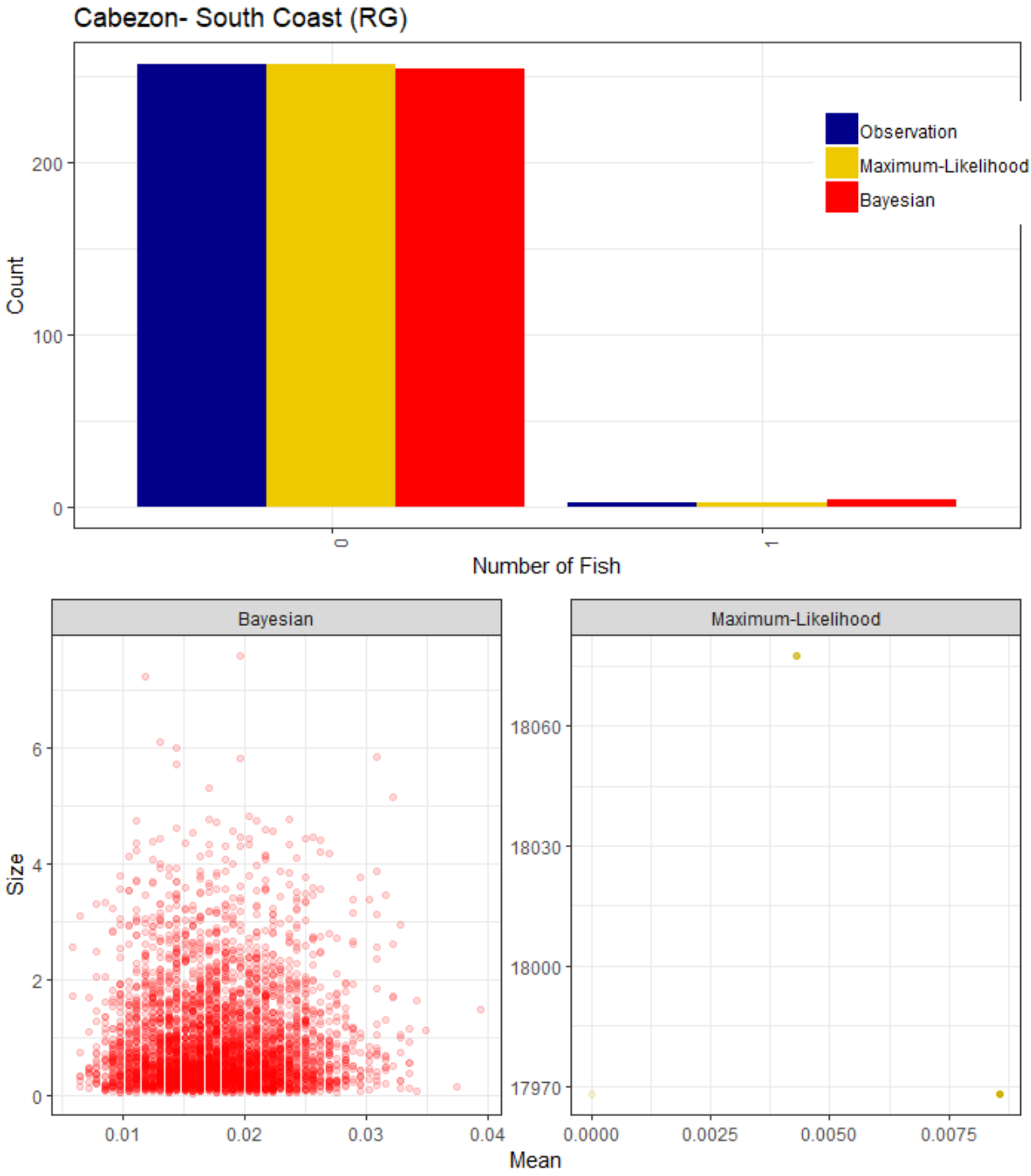

Cabezon- Central Coast (FG, RG & NG)
Observation
Maximum-Likelihood
Bayesian
Count
Number of Fish
Bayesian
Maximum-Likelihood
Size
Mean

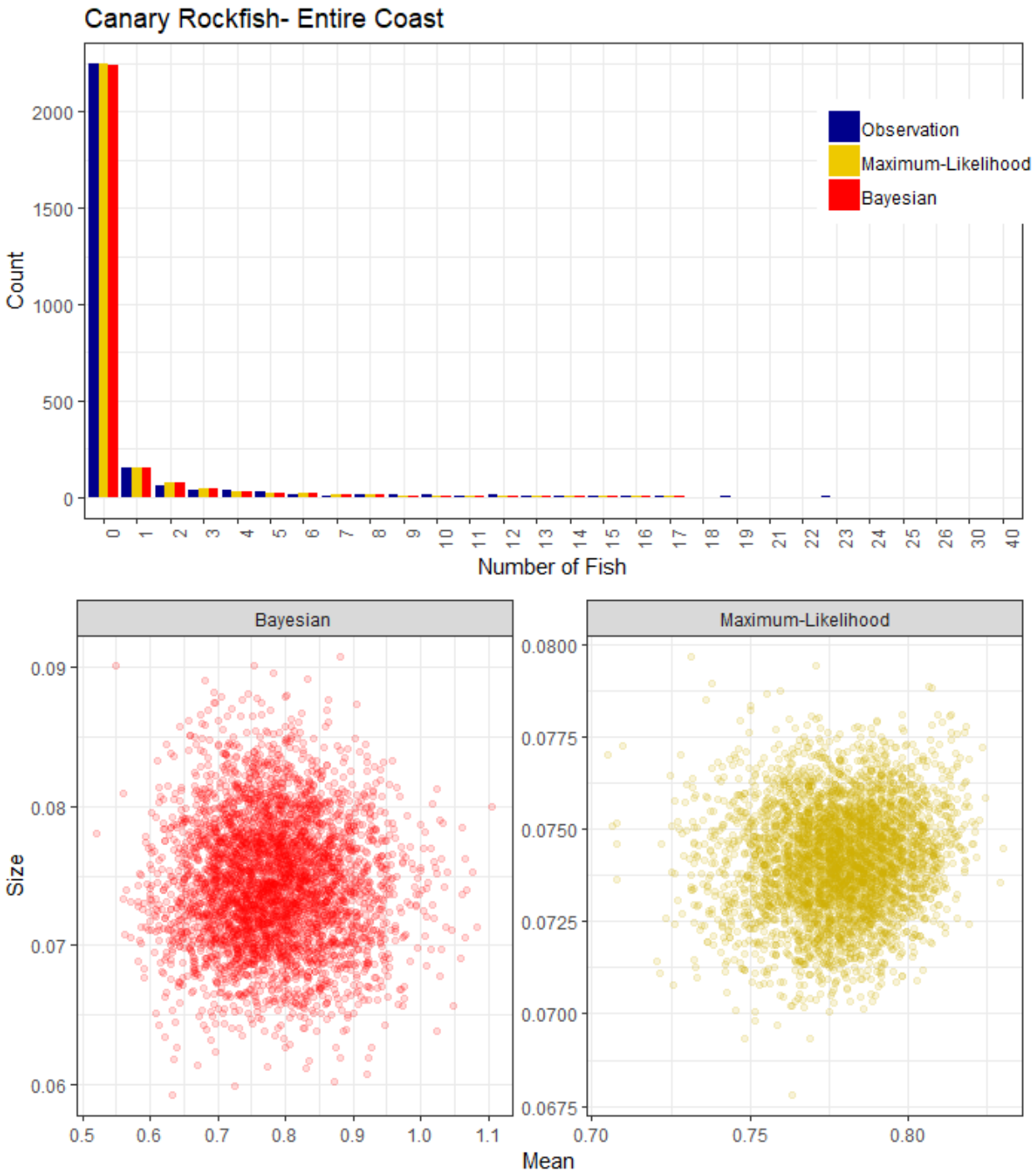

Cabezon- Central Coast (FG)
120
80
40
0
Count
Observation
Maximum-Likelihood
Bayesian
0
1
Number of Fish
Bayesian
Maximum-Likelihood
7.5
5.0
2.5
0.0
Size
13744.25
13744.23
13744.20
13744.18
0.00
0.01
0.02
0.03
0.04
0.05
0.0000
0.0025
0.0050
0.0075
Mean

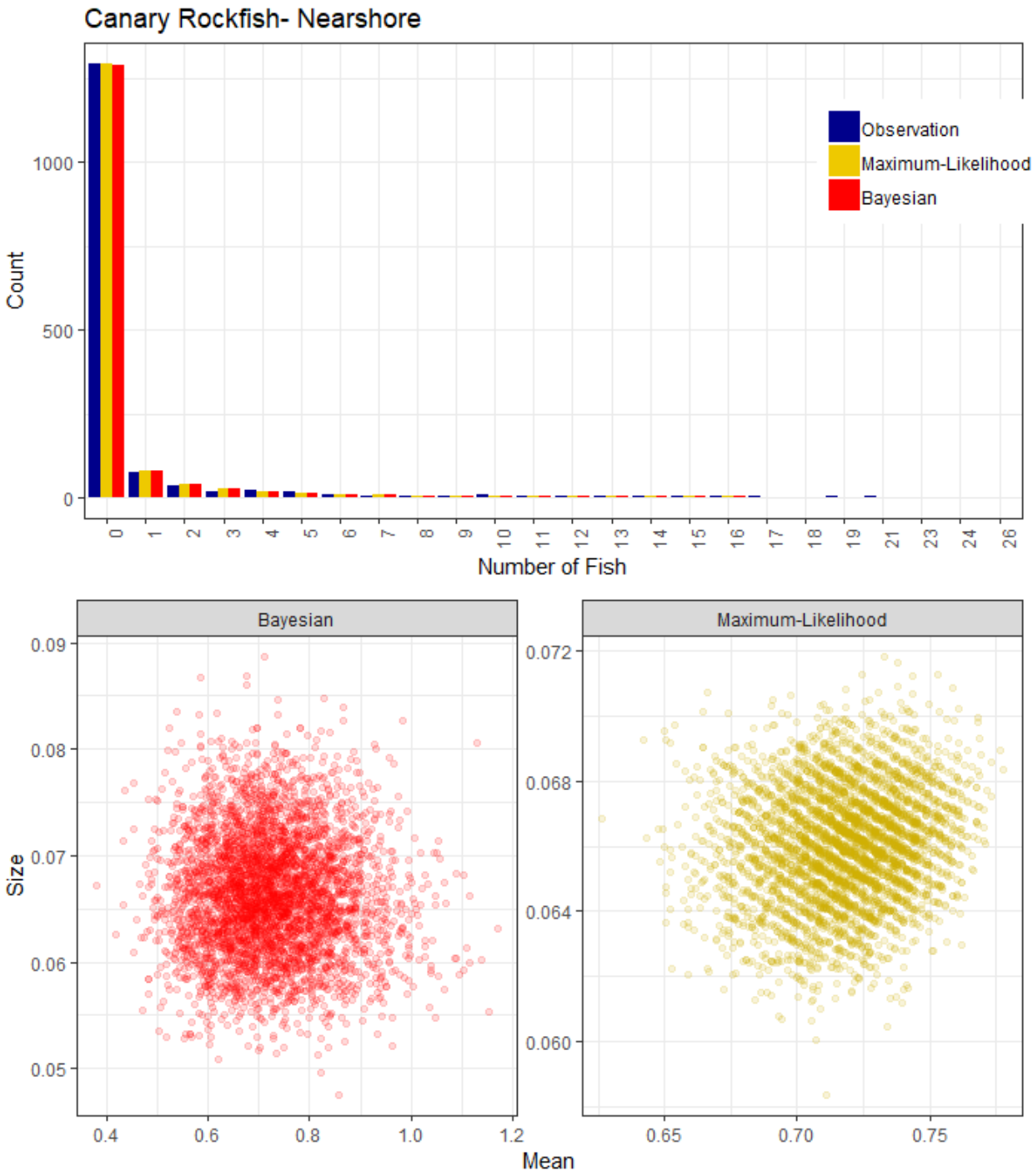

Cabezon- Central Coast (RG)
600
400
200
0
Count
Observation
Maximum-Likelihood
Bayesian
0
1
Number of Fish
Bayesian
Maximum-Likelihood
6
4
2
0
Size
75000
50000
25000
0
0.00
0.01
0.02
0.03
0.04
0.05
0.0075
0.0100
0.0125
0.0150
Mean

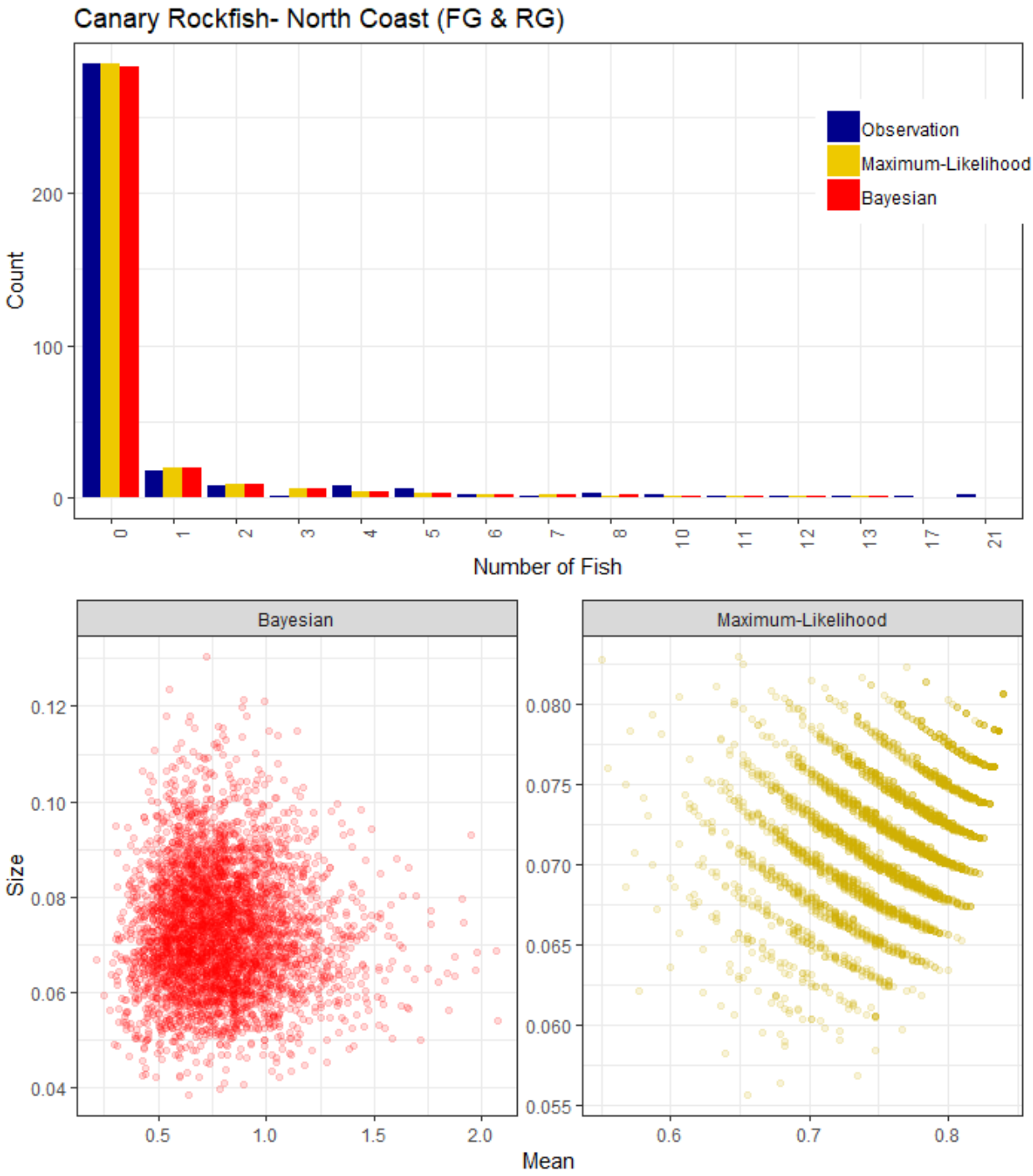

Cabezon- Central Coast (NG)
Observation
Maximum-Likelihood
Bayesian
Count
100
50
0
0
1
Number of Fish
Bayesian
Maximum-Likelihood
Size
8
6
4
2
0
0.00
0.05
0.10
0.15
0.20
35500.62
35500.60
35500.58
35500.56
35500.54
0.000
0.002
0.004
0.006
Mean

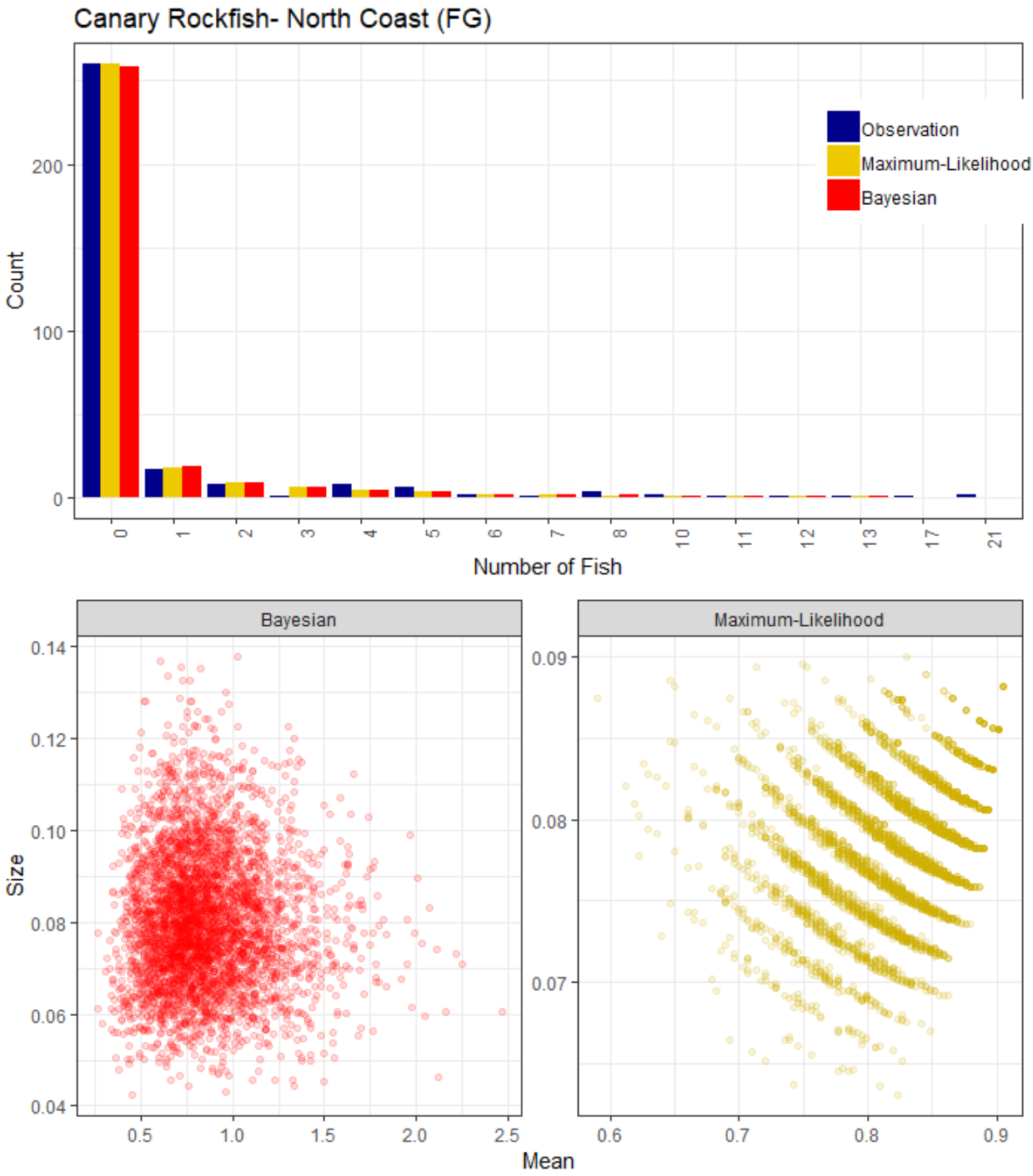

Cabezon- Cape Perpetua (FG & RG)
Count
Number of Fish
Observation
Maximum-Likelihood
Bayesian
Bayesian
Maximum-Likelihood
Size
Mean

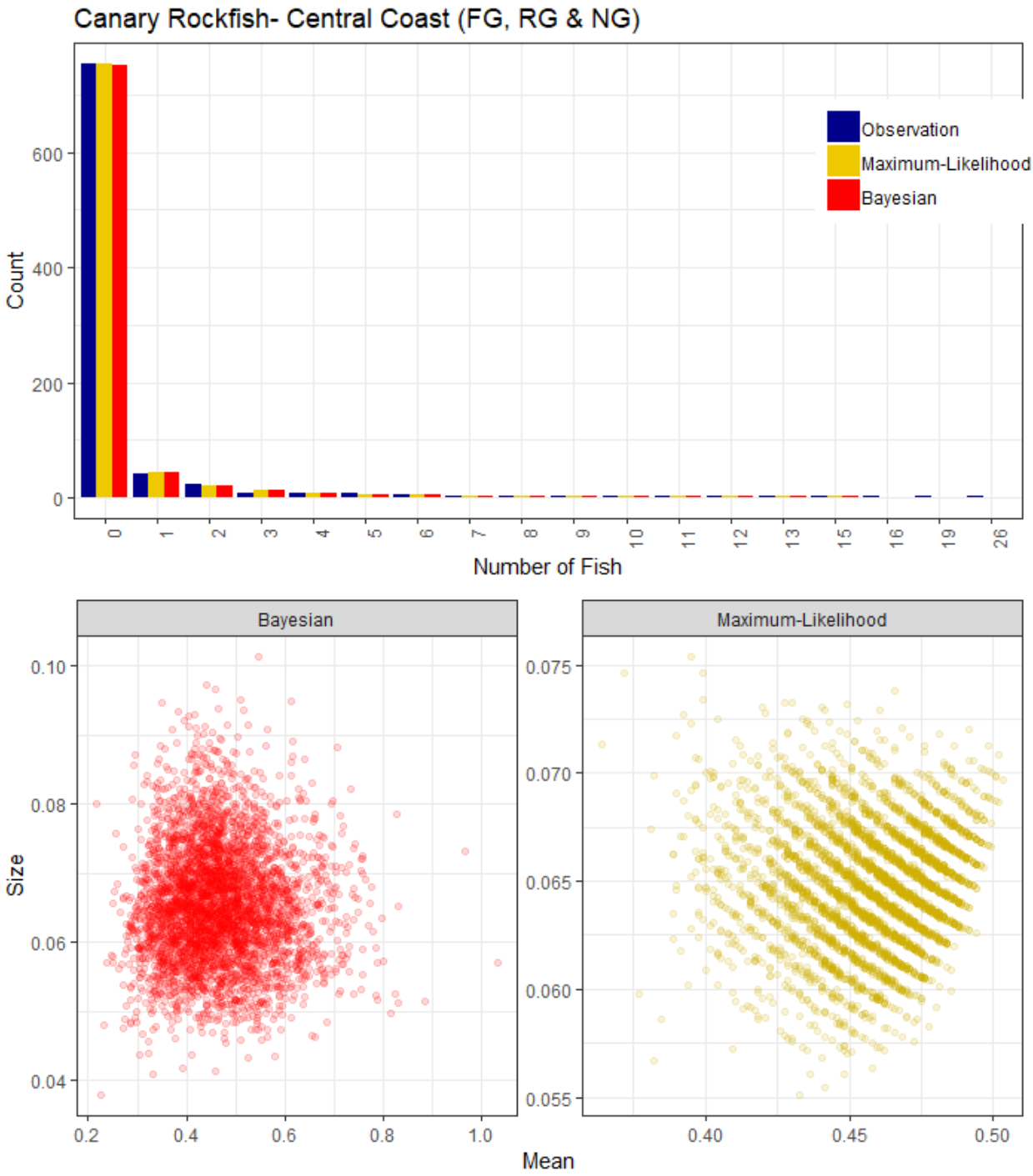

Cabezon- South Coast (RG)
Observation
Maximum-Likelihood
Bayesian
Count
200
100
0
0
1
Number of Fish
Bayesian
Maximum-Likelihood
Size
6
4
2
0
18060
18030
18000
17970
0.01
0.02
0.03
0.04
0.0000
0.0025
0.0050
0.0075
Mean

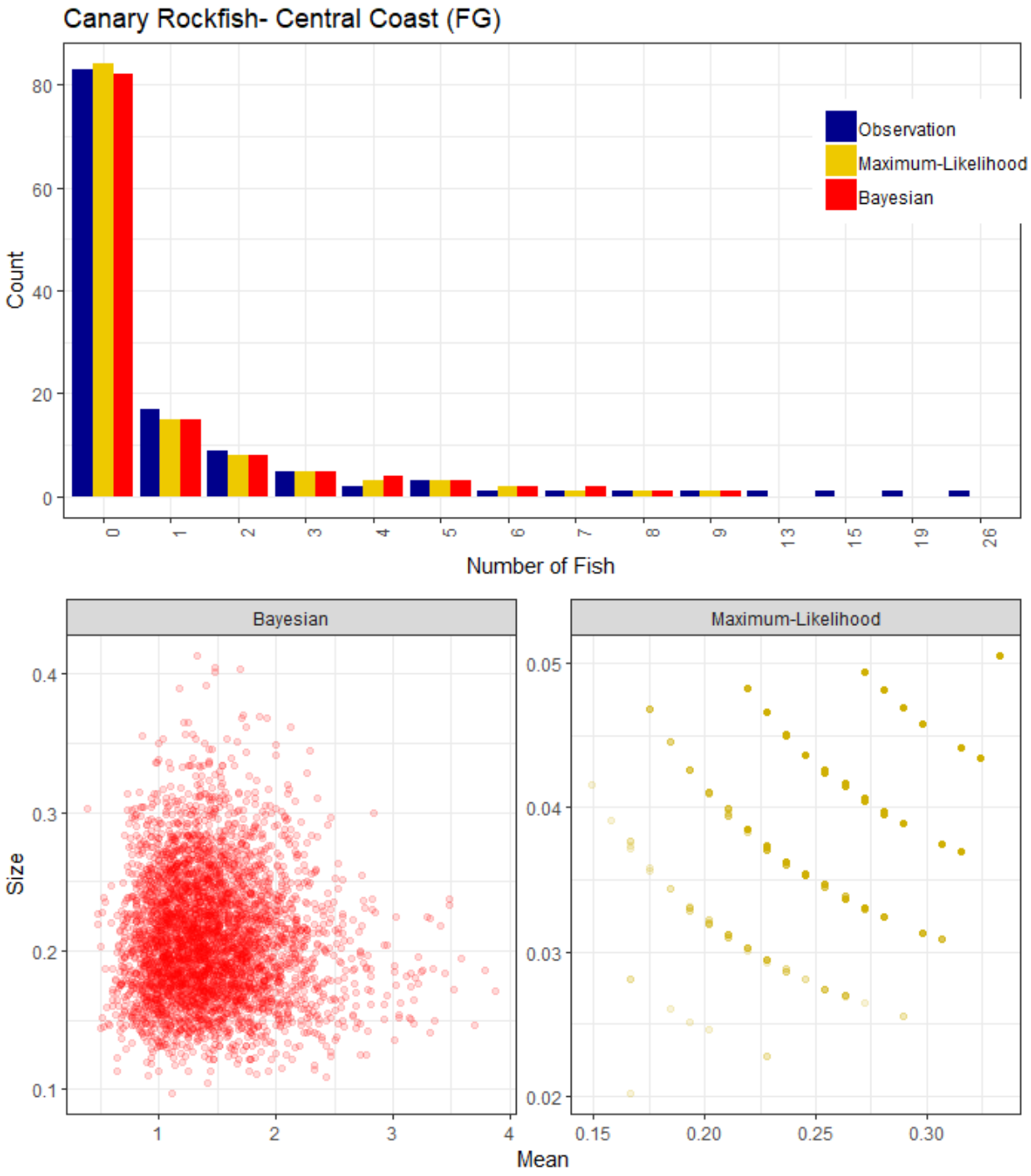

Canary Rockfish- Entire Coast
Observation
Maximum-Likelihood
Bayesian
Count
Number of Fish
Bayesian
Maximum-Likelihood
Size
Mean

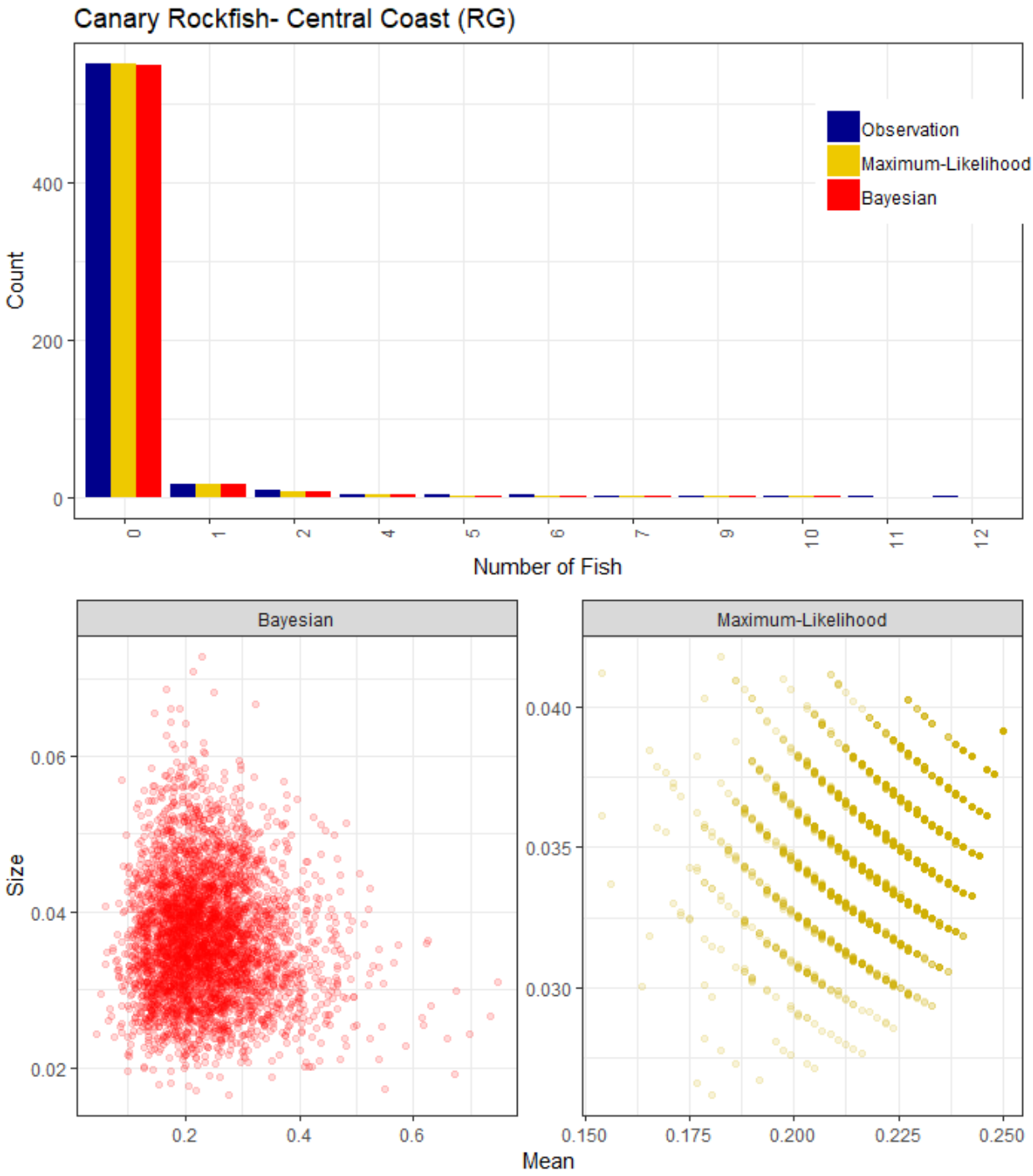

Canary Rockfish- Nearshore
Observation
Maximum-Likelihood
Bayesian
Count
1000
500
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 21 23 24 26
Number of Fish
Bayesian
Maximum-Likelihood
Size
0.09
0.08
0.07
0.06
0.05
0.072
0.068
0.064
0.060
0.4 0.6 0.8 1.0 1.2
0.65 0.70 0.75
Mean

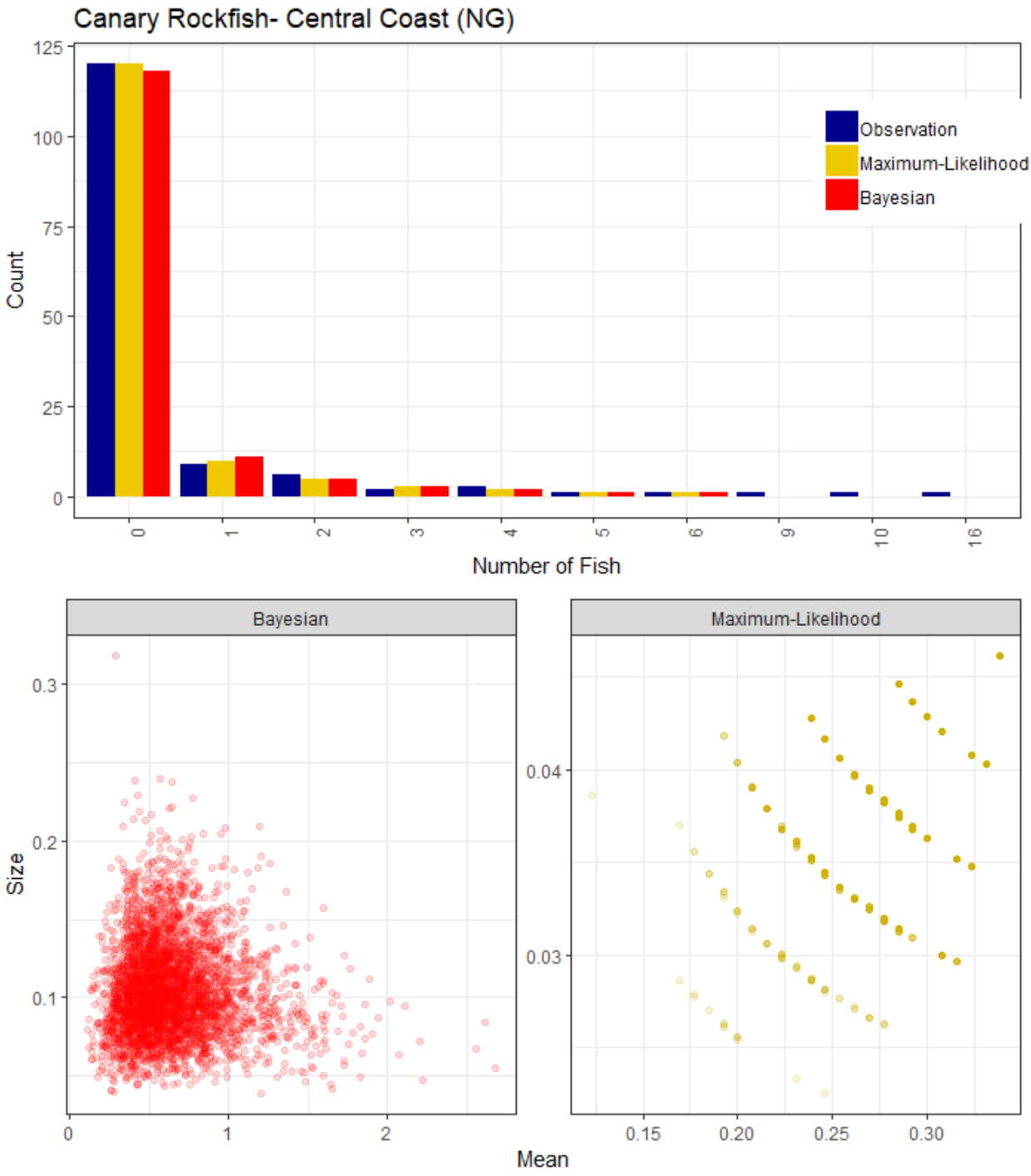

Canary Rockfish- North Coast (FG & RG)
Observation
Maximum-Likelihood
Bayesian
Count
200
100
0
0
1
2
3
4
5
6
7
8
10
11
12
13
17
21
Number of Fish
Bayesian
Maximum-Likelihood
Size
0.12
0.10
0.08
0.06
0.04
0.080
0.075
0.070
0.065
0.060
0.055
0.5
1.0
1.5
2.0
0.6
0.7
0.8
Mean

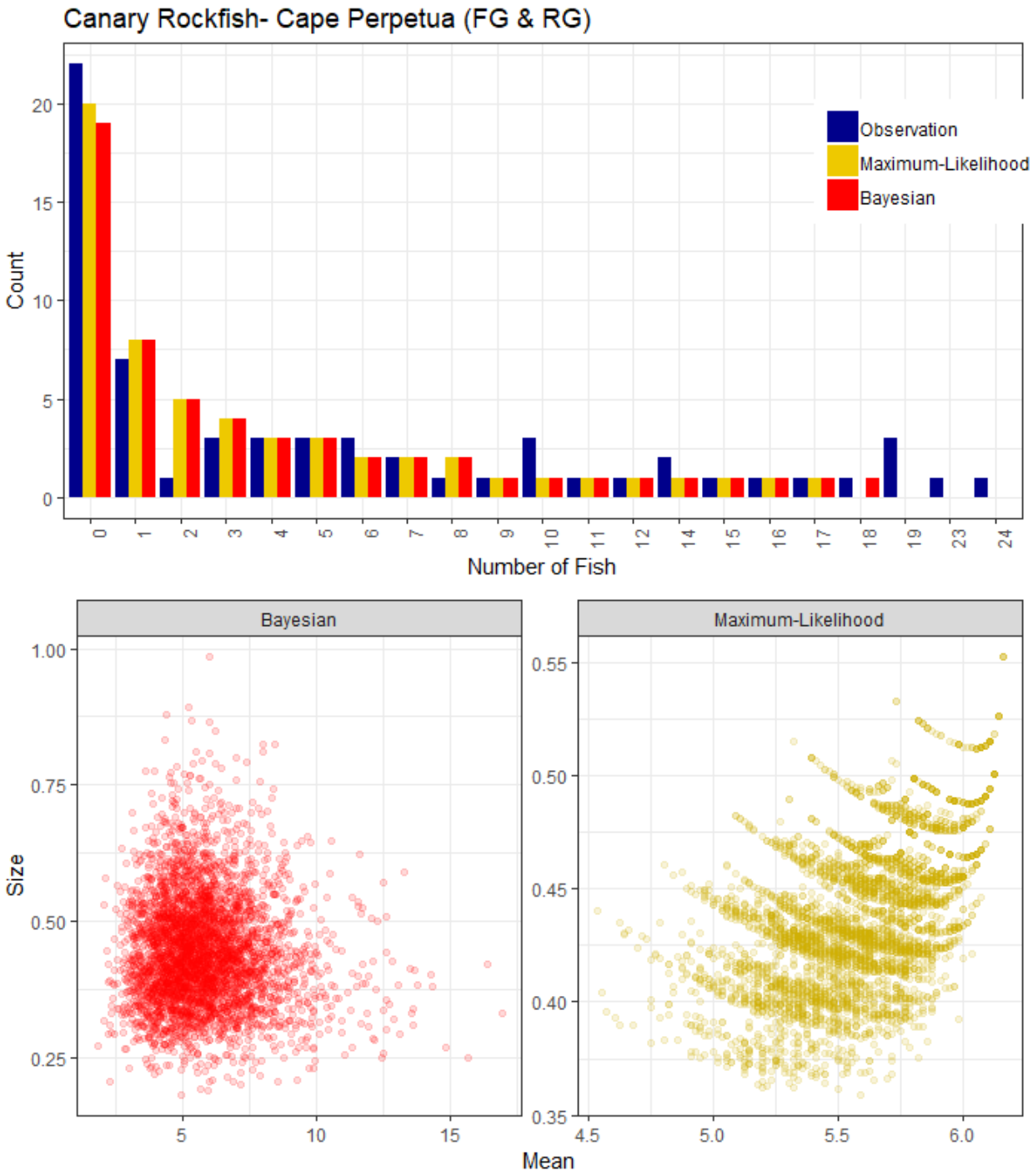

Canary Rockfish- North Coast (FG)
Observation
Maximum-Likelihood
Bayesian
Count
200
100
0
0
1
2
3
4
5
6
7
8
10
11
12
13
17
21
Number of Fish
Bayesian
Maximum-Likelihood
Size
0.14
0.12
0.10
0.08
0.06
0.04
0.09
0.08
0.07
0.5
1.0
1.5
2.0
2.5
0.6
0.7
0.8
0.9
Mean

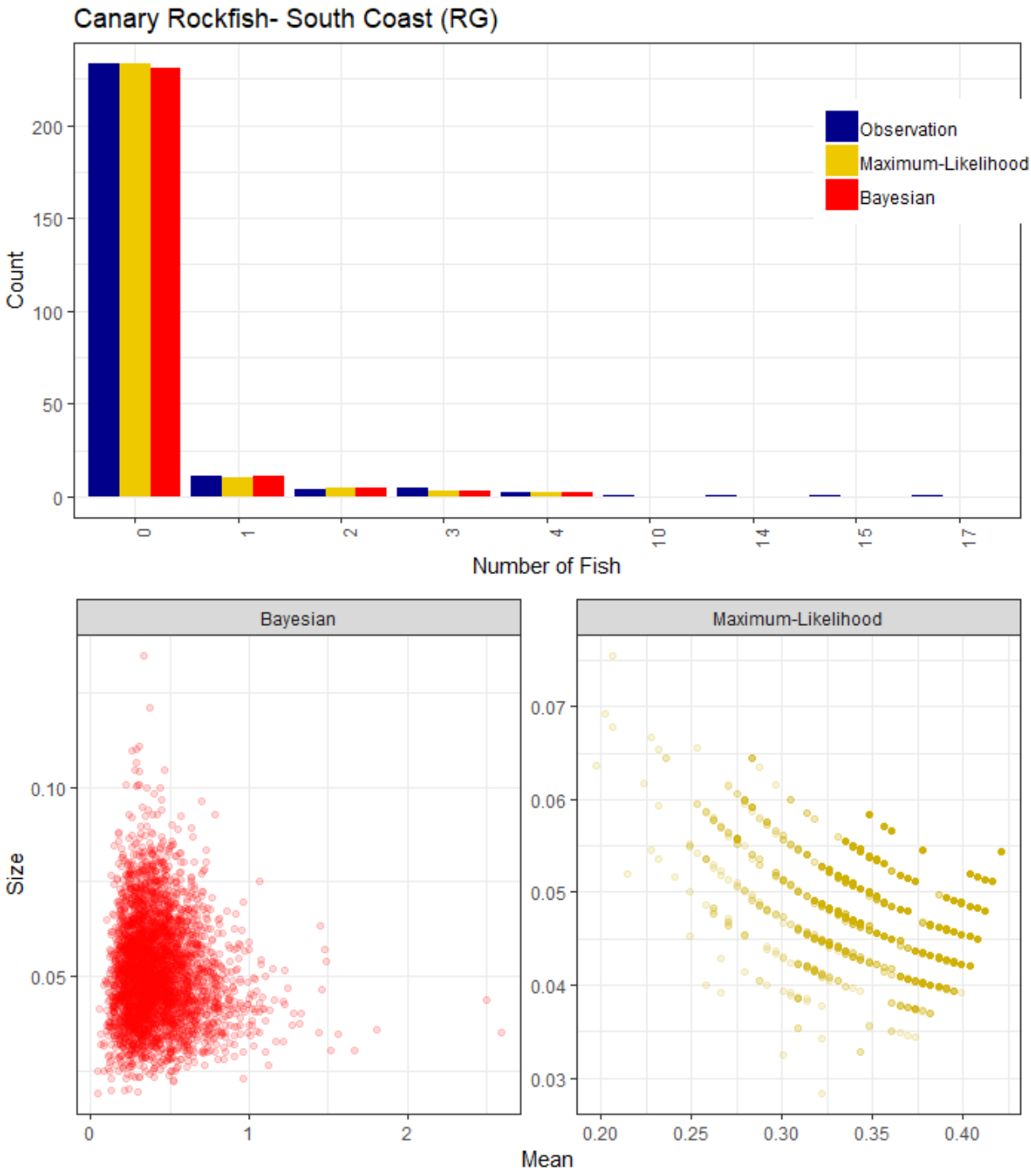

Canary Rockfish- Central Coast (FG, RG & NG)
Observation
Maximum-Likelihood
Bayesian
Count
Number of Fish
Bayesian
Maximum-Likelihood
Size
Mean

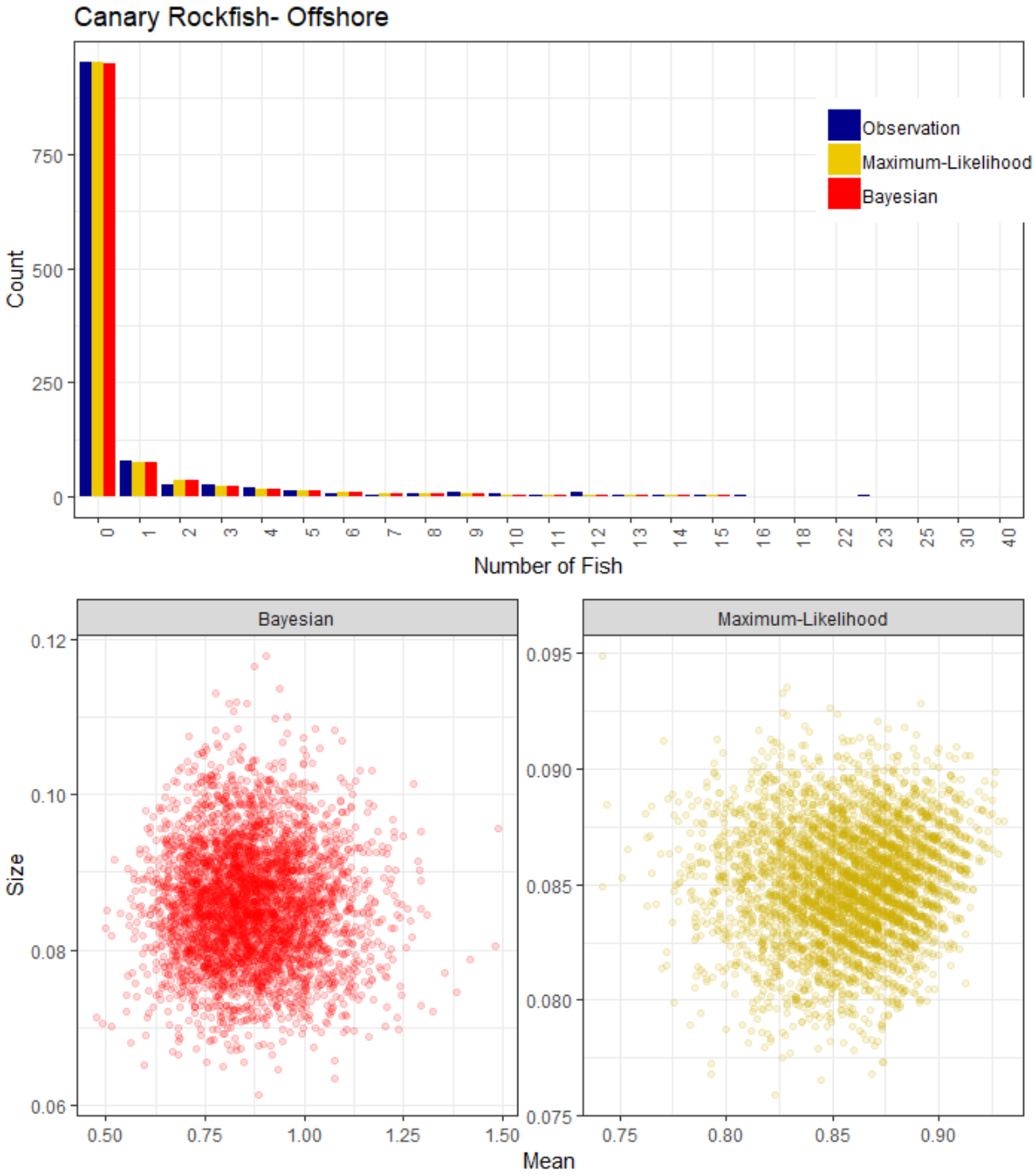

Canary Rockfish- Central Coast (FG)
Observation
Maximum-Likelihood
Bayesian
Count
Number of Fish
Bayesian
Maximum-Likelihood
Size
Mean

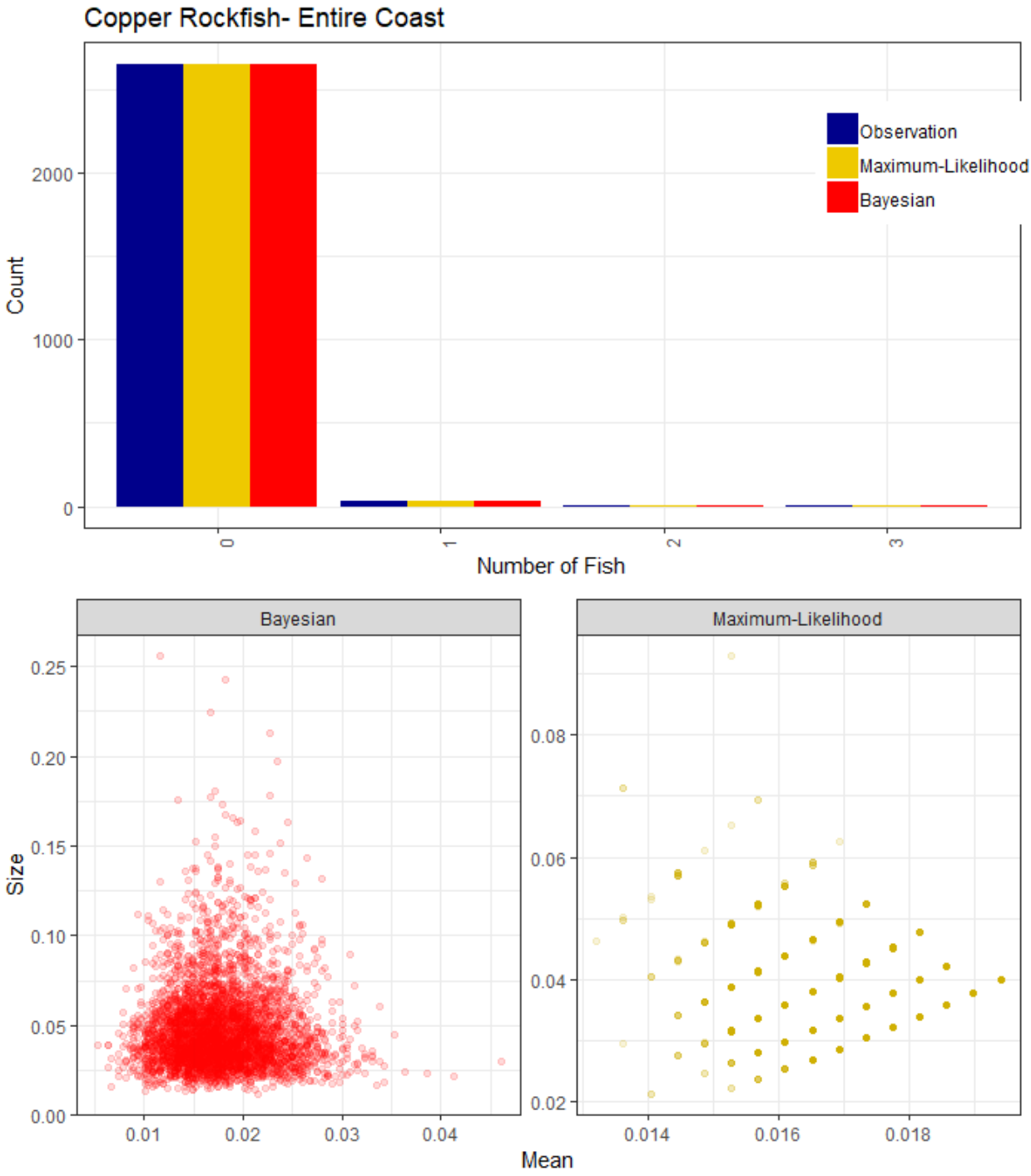

Canary Rockfish- Central Coast (RG)
Observation
Maximum-Likelihood
Bayesian
Count
400
200
0
0
1
2
4
5
6
7
9
10
11
12
Number of Fish
Bayesian
Maximum-Likelihood
Size
0.06
0.04
0.02
0.040
0.035
0.030
0.2
0.4
0.6
0.150
0.175
0.200
0.225
0.250
Mean

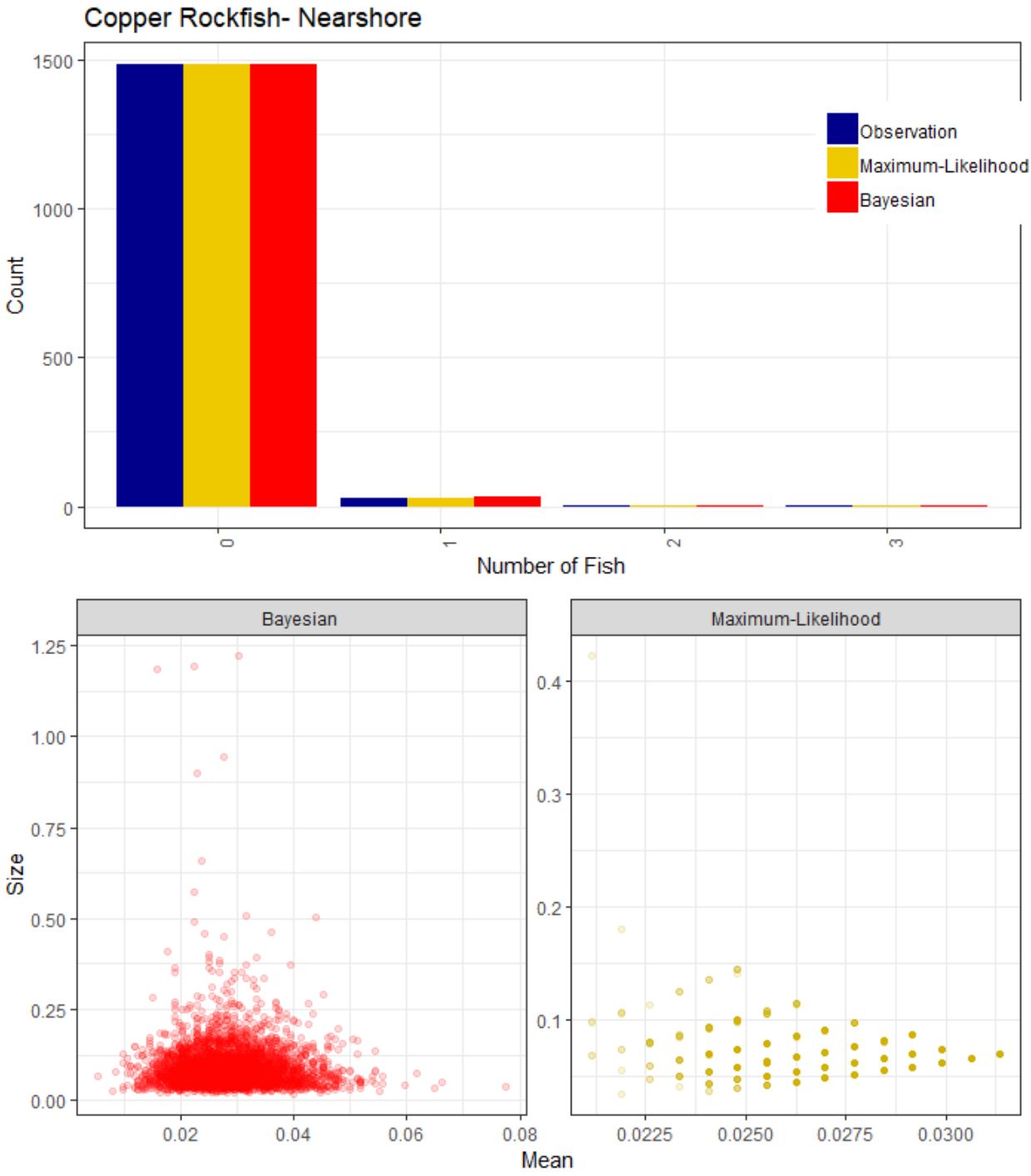

Canary Rockfish- Central Coast (NG)
Observation
Maximum-Likelihood
Bayesian
Count
Number of Fish
Bayesian
Maximum-Likelihood
Size
Mean

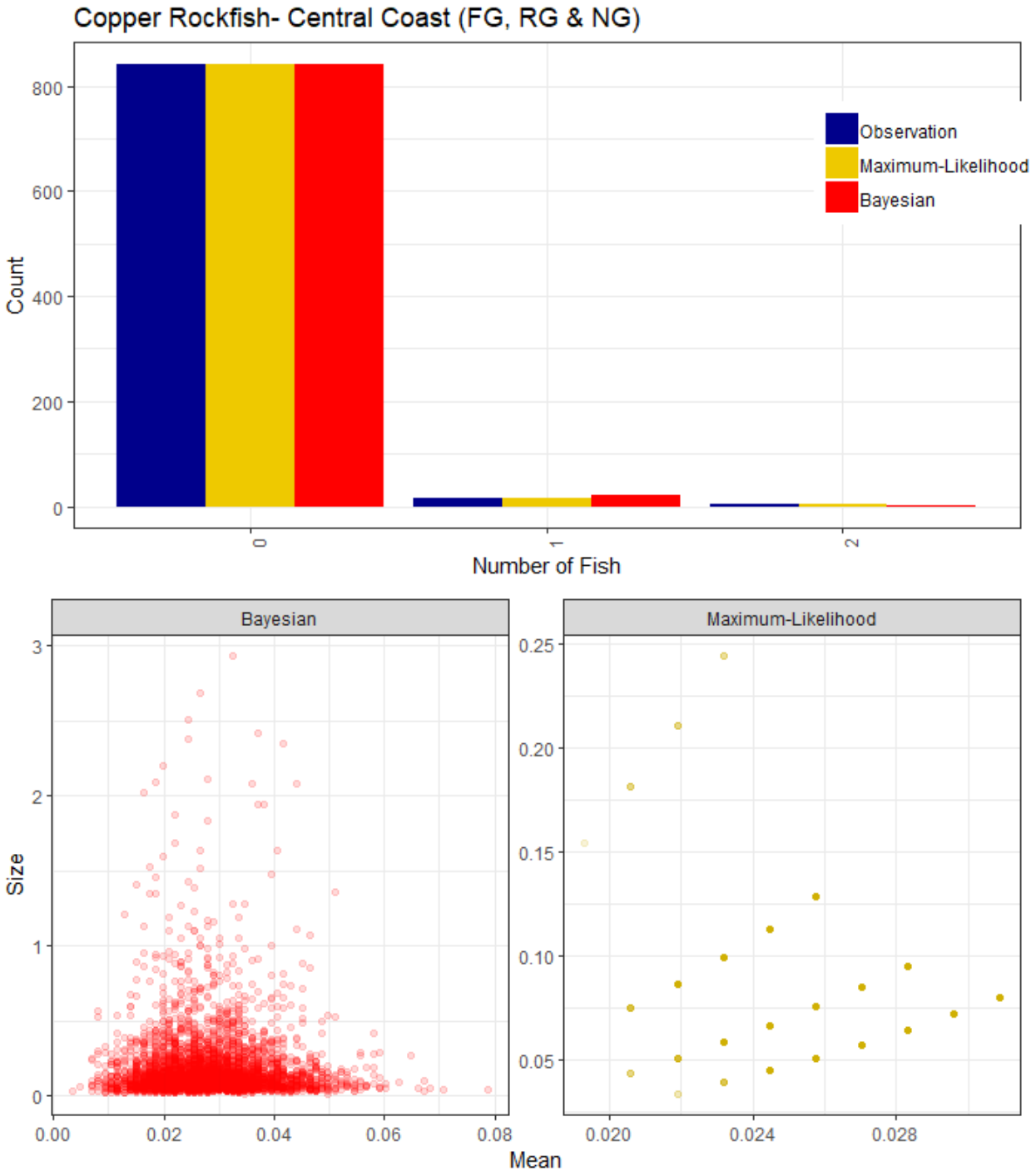

Canary Rockfish- Cape Perpetua (FG & RG)
Observation
Maximum-Likelihood
Bayesian
Count
Number of Fish
Bayesian
Maximum-Likelihood
Size
Mean

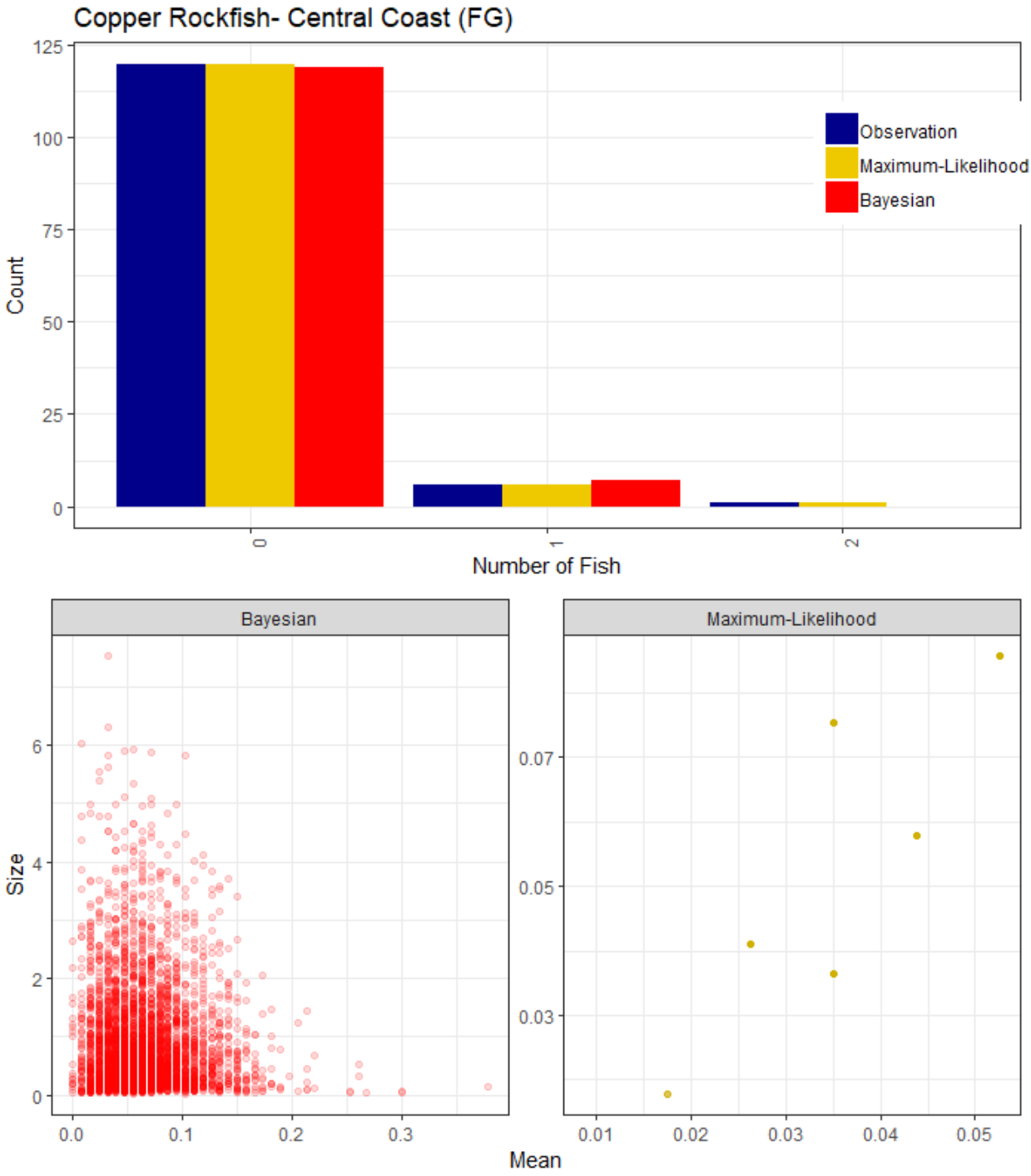

Canary Rockfish- South Coast (RG)
Observation
Maximum-Likelihood
Bayesian
Count
Number of Fish
Bayesian
Maximum-Likelihood
Size
Mean

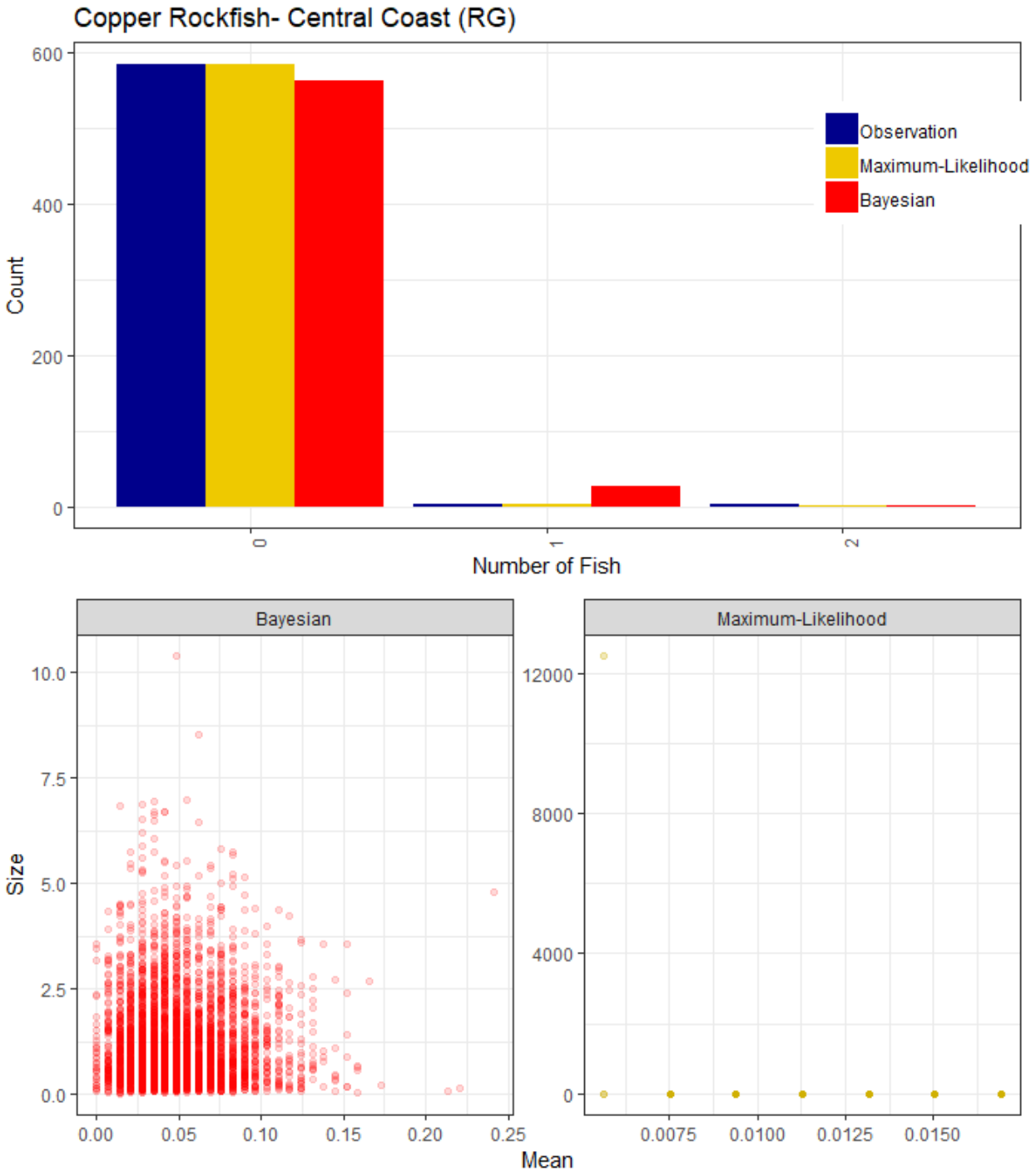

Canary Rockfish- Offshore
Observation
Maximum-Likelihood
Bayesian
Count
Number of Fish
Bayesian
Maximum-Likelihood
Size
Mean

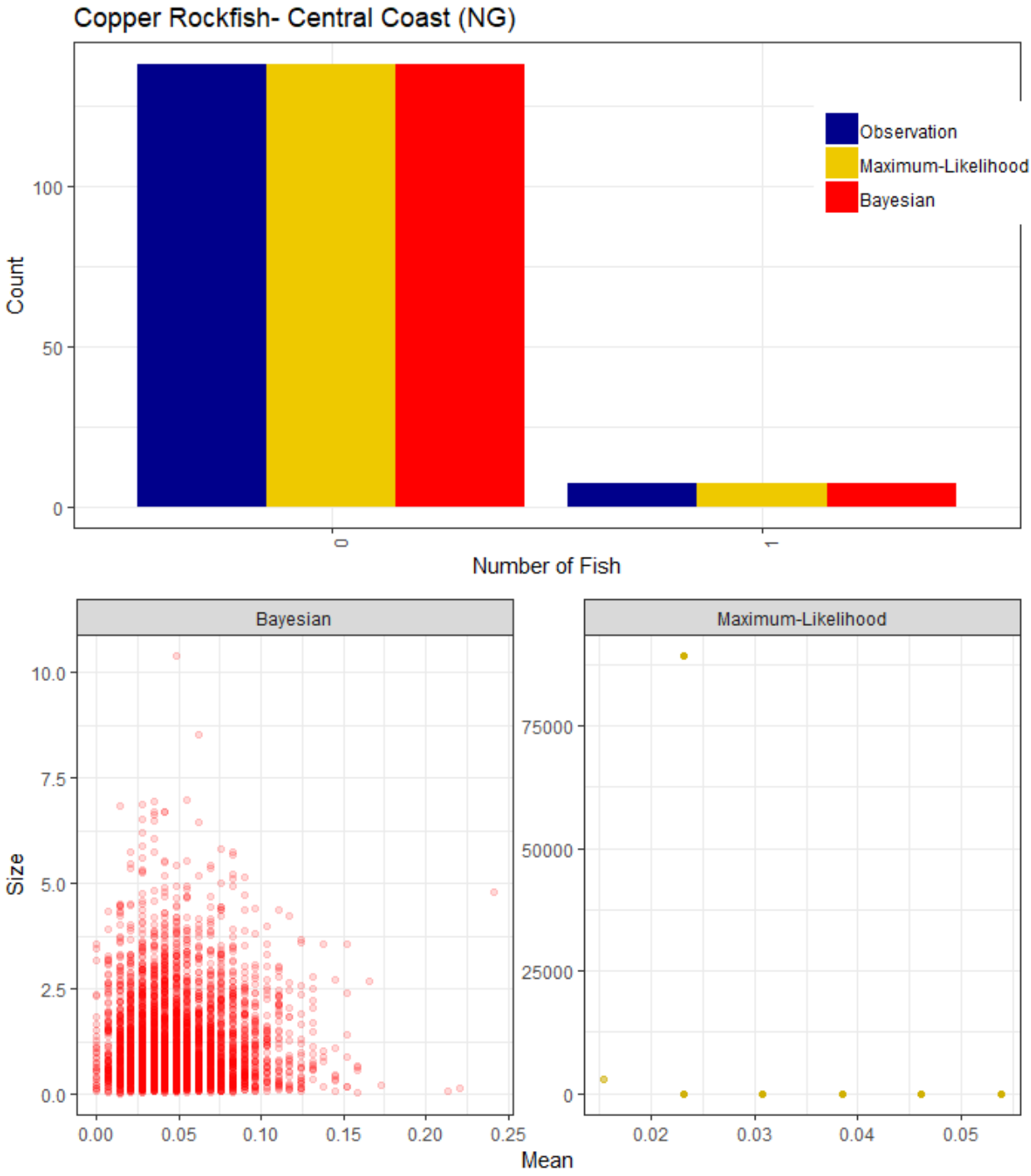

Copper Rockfish- Entire Coast
Observation
Maximum-Likelihood
Bayesian
Count
2000
1000
0
0
1
2
3
Number of Fish
Bayesian
Maximum-Likelihood
Size
0.25
0.20
0.15
0.10
0.05
0.00
0.08
0.06
0.04
0.02
0.01
0.02
0.03
0.04
0.014
0.016
0.018
Mean

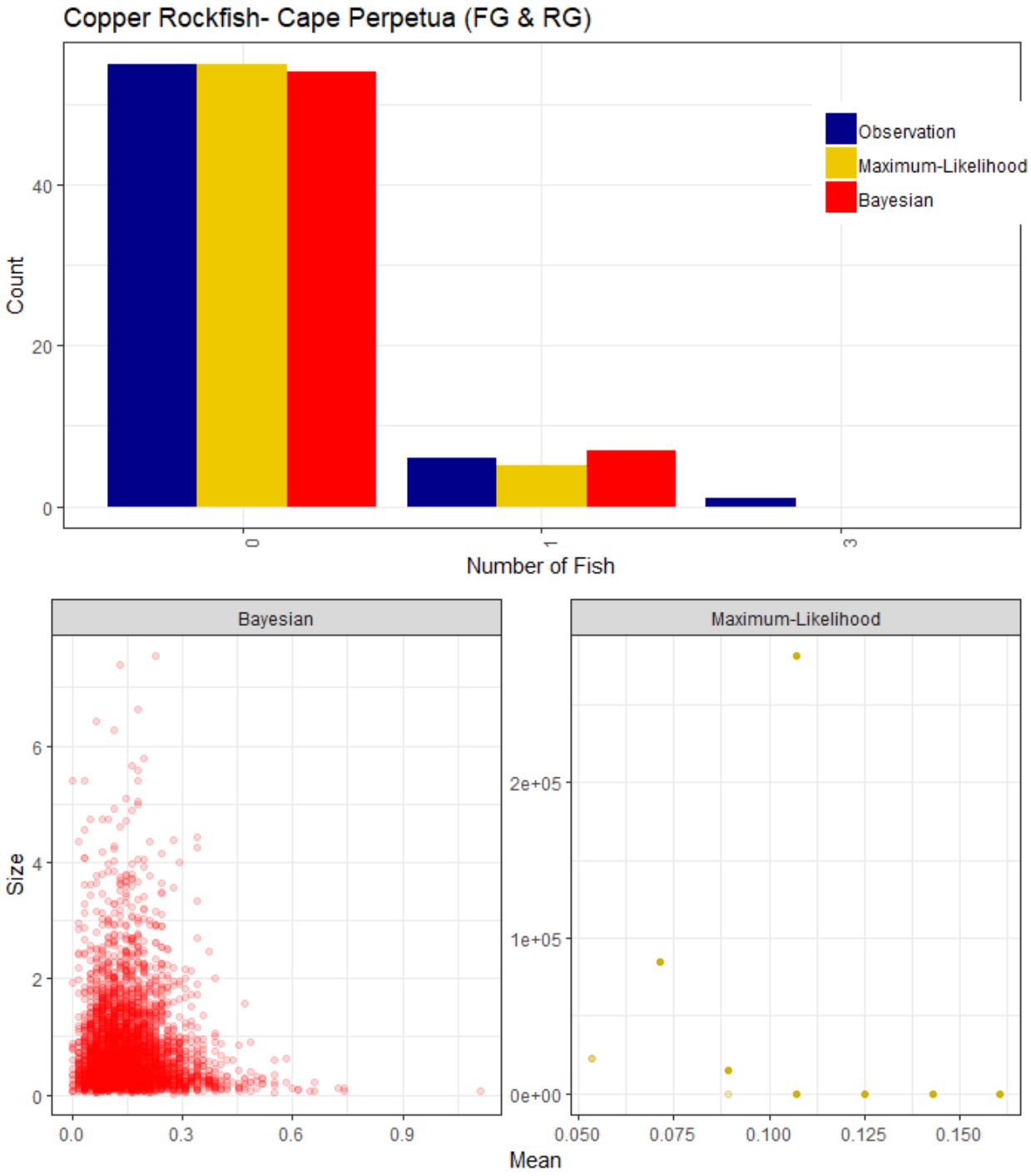

Copper Rockfish- Nearshore
1500
1000
500
0
Count
Observation
Maximum-Likelihood
Bayesian
0
1
2
3
Number of Fish
Bayesian
Maximum-Likelihood
1.25
1.00
0.75
0.50
0.25
0.00
Size
0.4
0.3
0.2
0.1
0.02
0.04
0.06
0.08
0.0225
0.0250
0.0275
0.0300
Mean

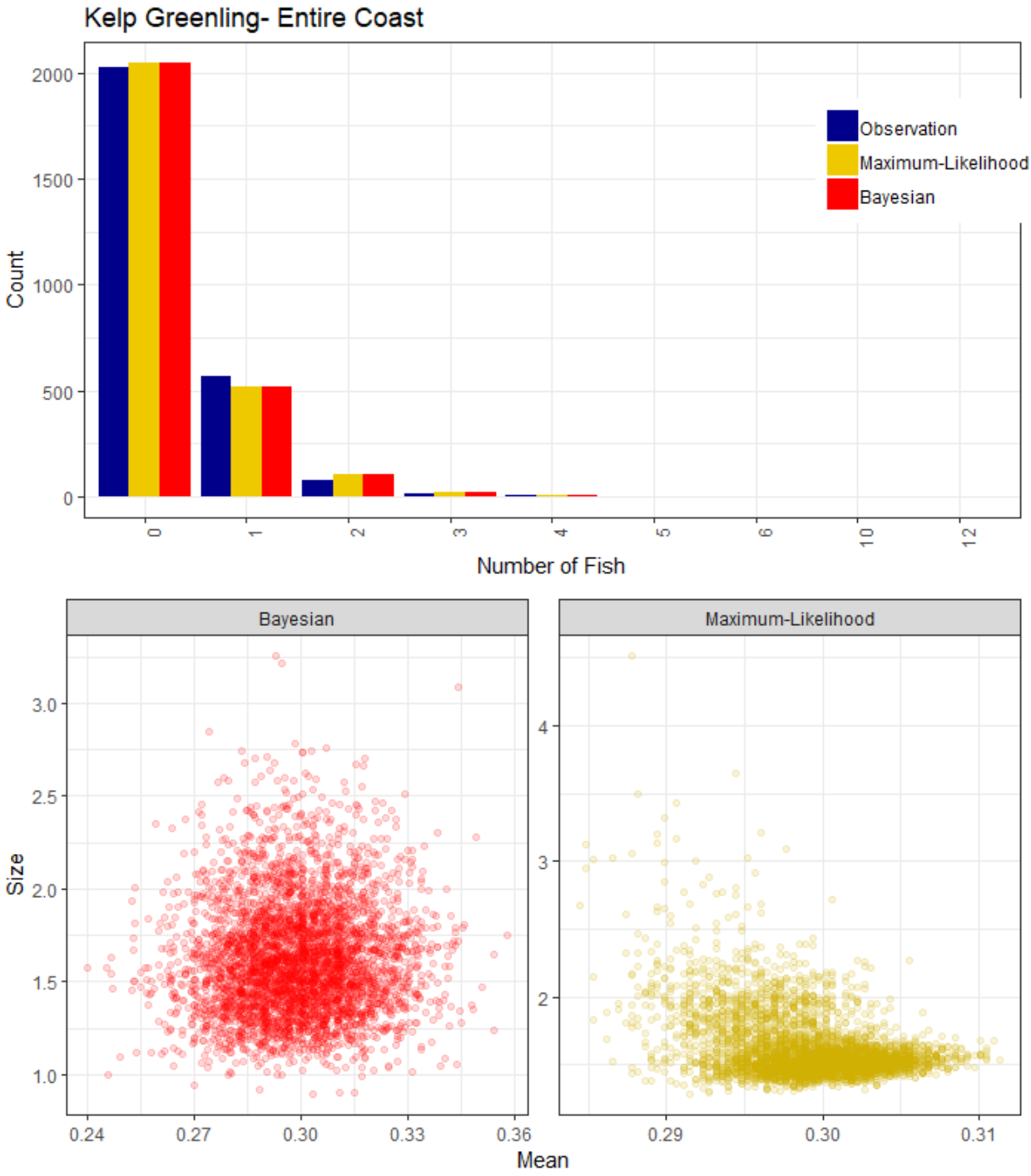

Copper Rockfish- Central Coast (FG, RG & NG)
Observation
Maximum-Likelihood
Bayesian
Count
Number of Fish
Bayesian
Maximum-Likelihood
Size
Mean

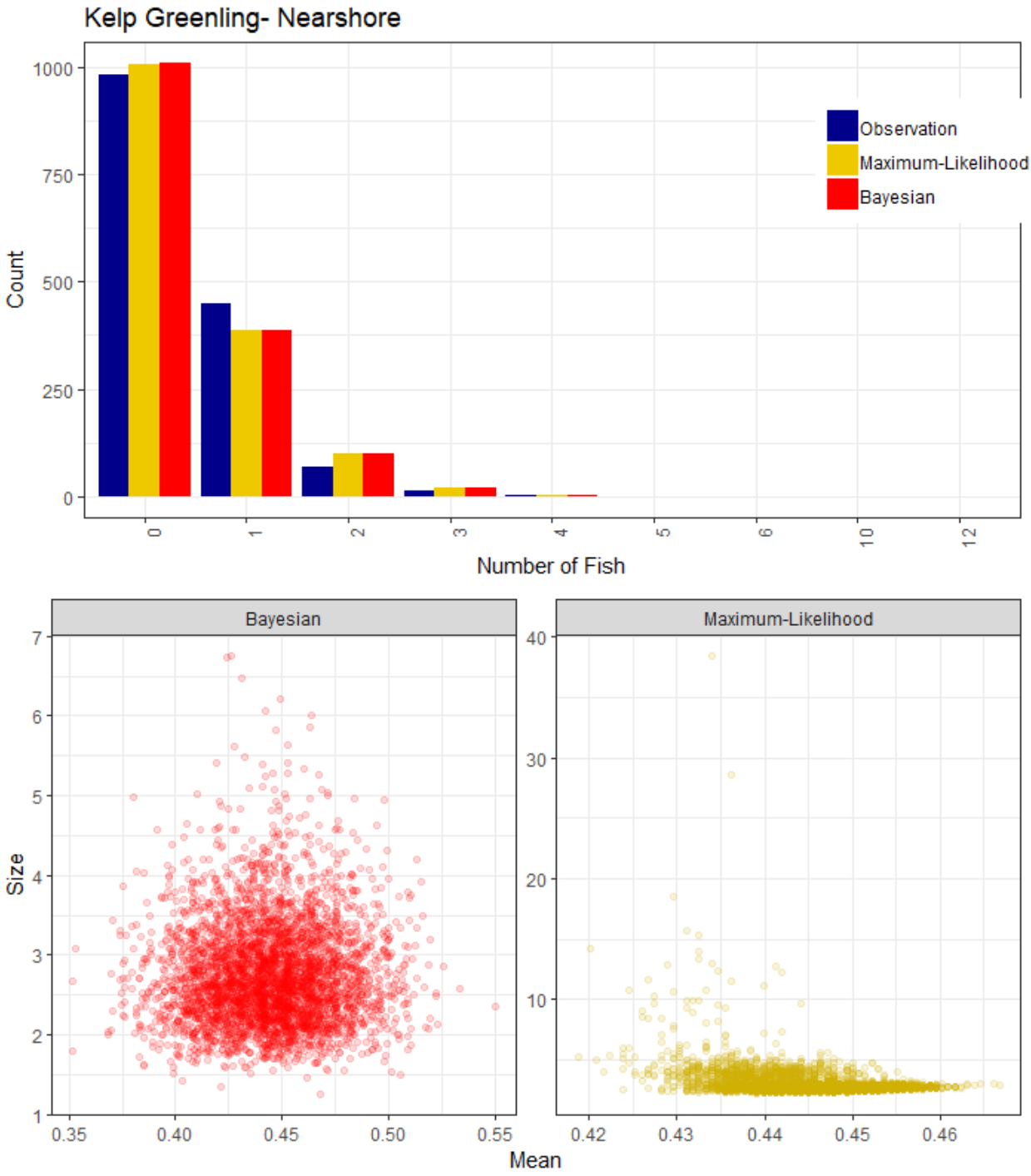

Copper Rockfish- Central Coast (FG)
Count
125
100
75
50
25
0
Observation
Maximum-Likelihood
Bayesian
0
1
2
Number of Fish
Bayesian
Maximum-Likelihood
Size
6
4
2
0
0.0
0.1
0.2
0.3
0.07
0.05
0.03
0.01
0.02
0.03
0.04
0.05
Mean

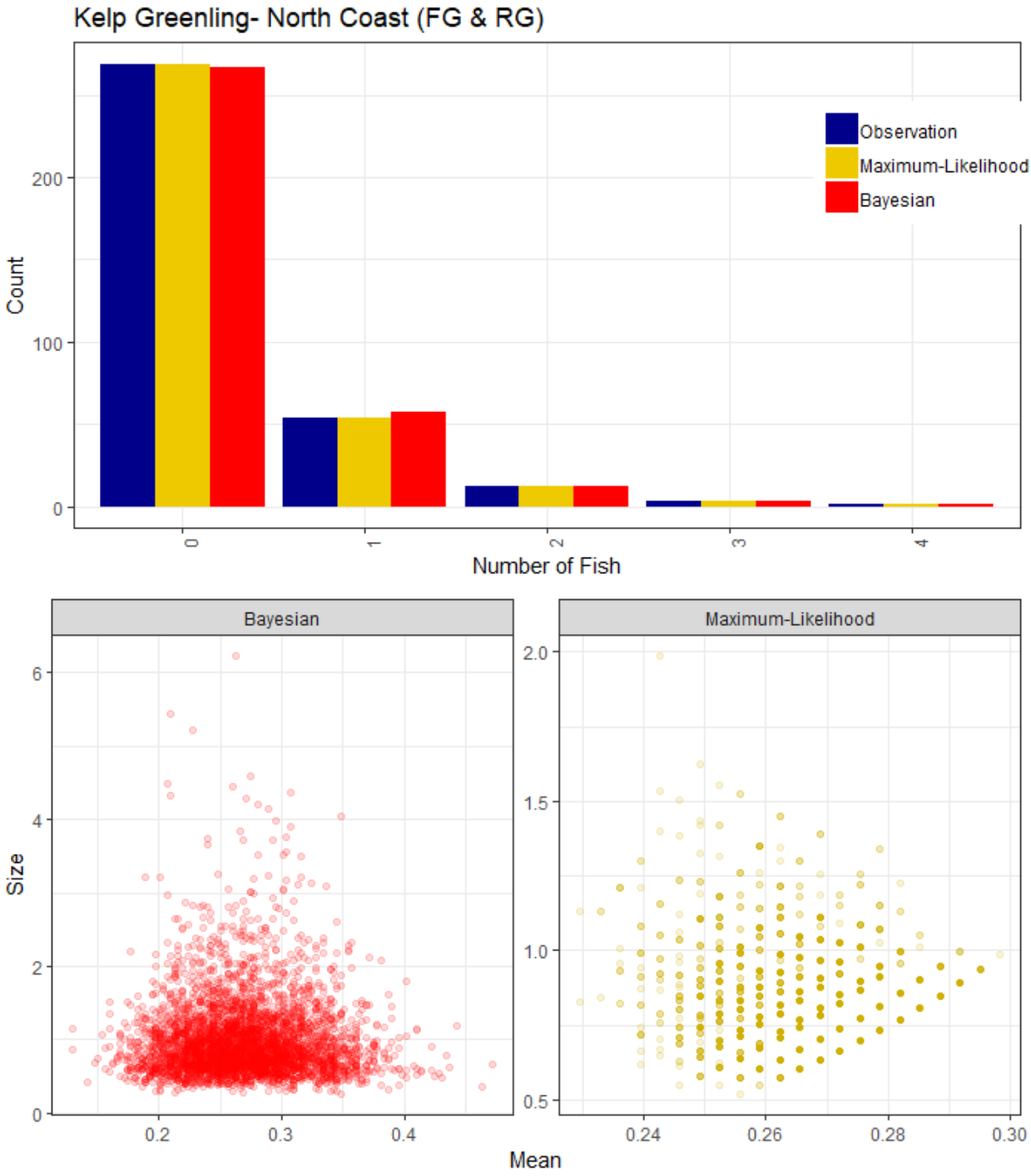

Copper Rockfish- Central Coast (RG)
Count
600
400
200
0
Observation
Maximum-Likelihood
Bayesian
0
1
2
Number of Fish
Bayesian
Maximum-Likelihood
Size
10.0
7.5
5.0
2.5
0.0
12000
8000
4000
0
0.00
0.05
0.10
0.15
0.20
0.25
0.0075
0.0100
0.0125
0.0150
Mean

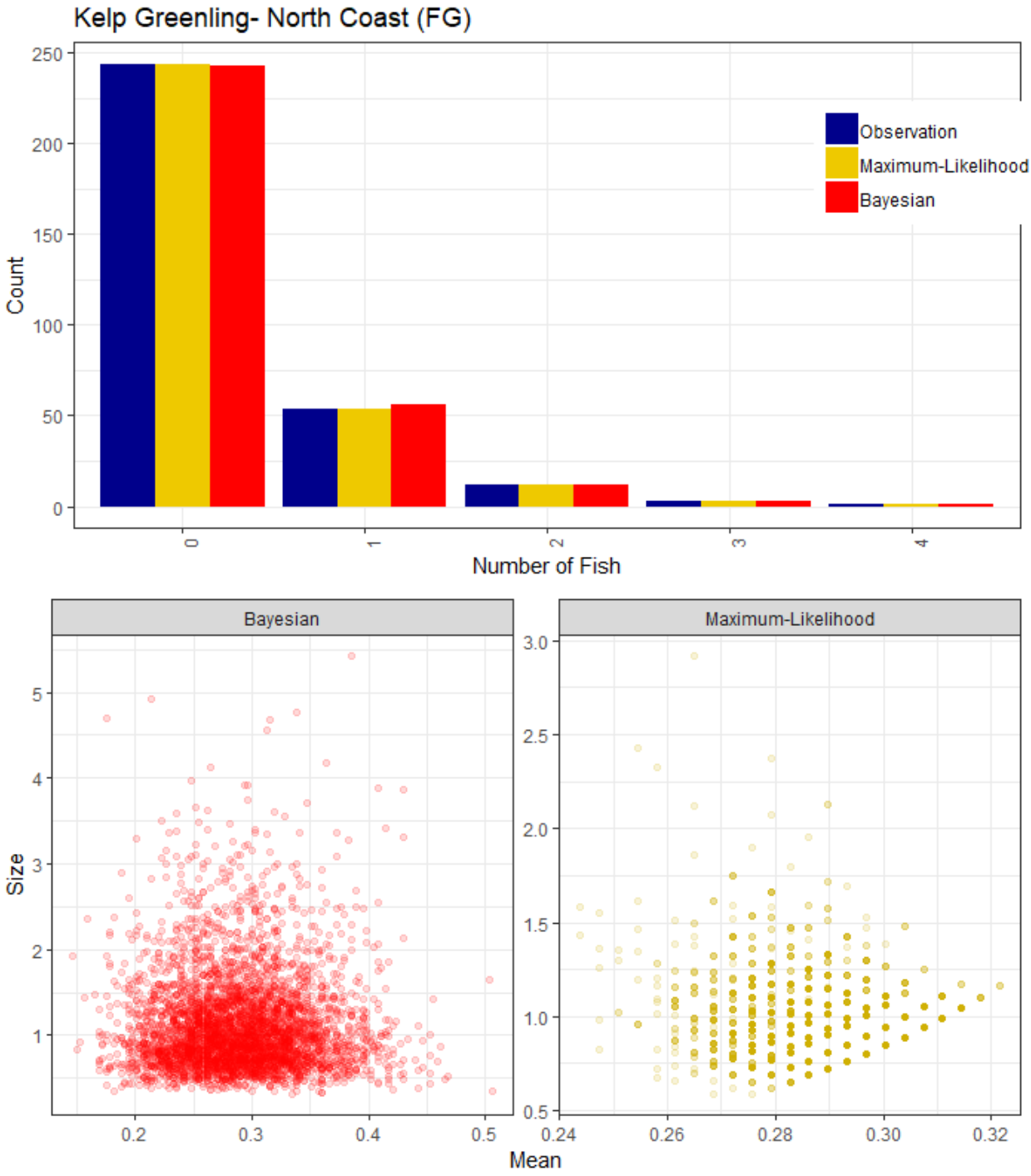

Copper Rockfish- Central Coast (NG)
Observation
Maximum-Likelihood
Bayesian
Count
100
50
0
0
1
Number of Fish
Bayesian
Maximum-Likelihood
Size
10.0
7.5
5.0
2.5
0.0
75000
50000
25000
0
0.00
0.05
0.10
0.15
0.20
0.25
0.02
0.03
0.04
0.05
Mean

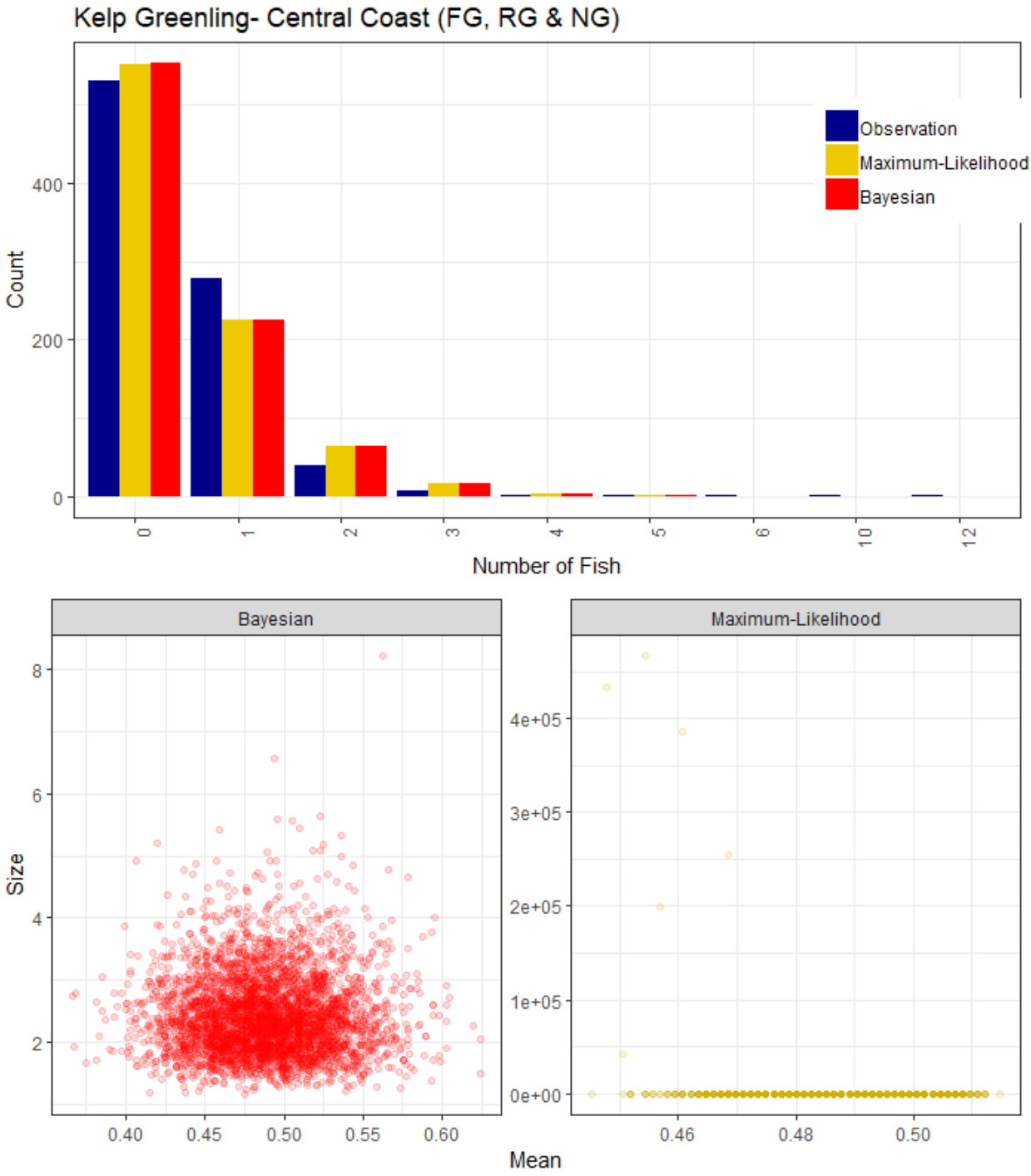

Copper Rockfish- Cape Perpetua (FG & RG)
Observation
Maximum-Likelihood
Bayesian
Count
40
20
0
0
1
3
Number of Fish
Bayesian
Maximum-Likelihood
Size
6
4
2
0
2e+05
1e+05
0e+00
0.0
0.3
0.6
0.9
0.050
0.075
0.100
0.125
0.150
Mean

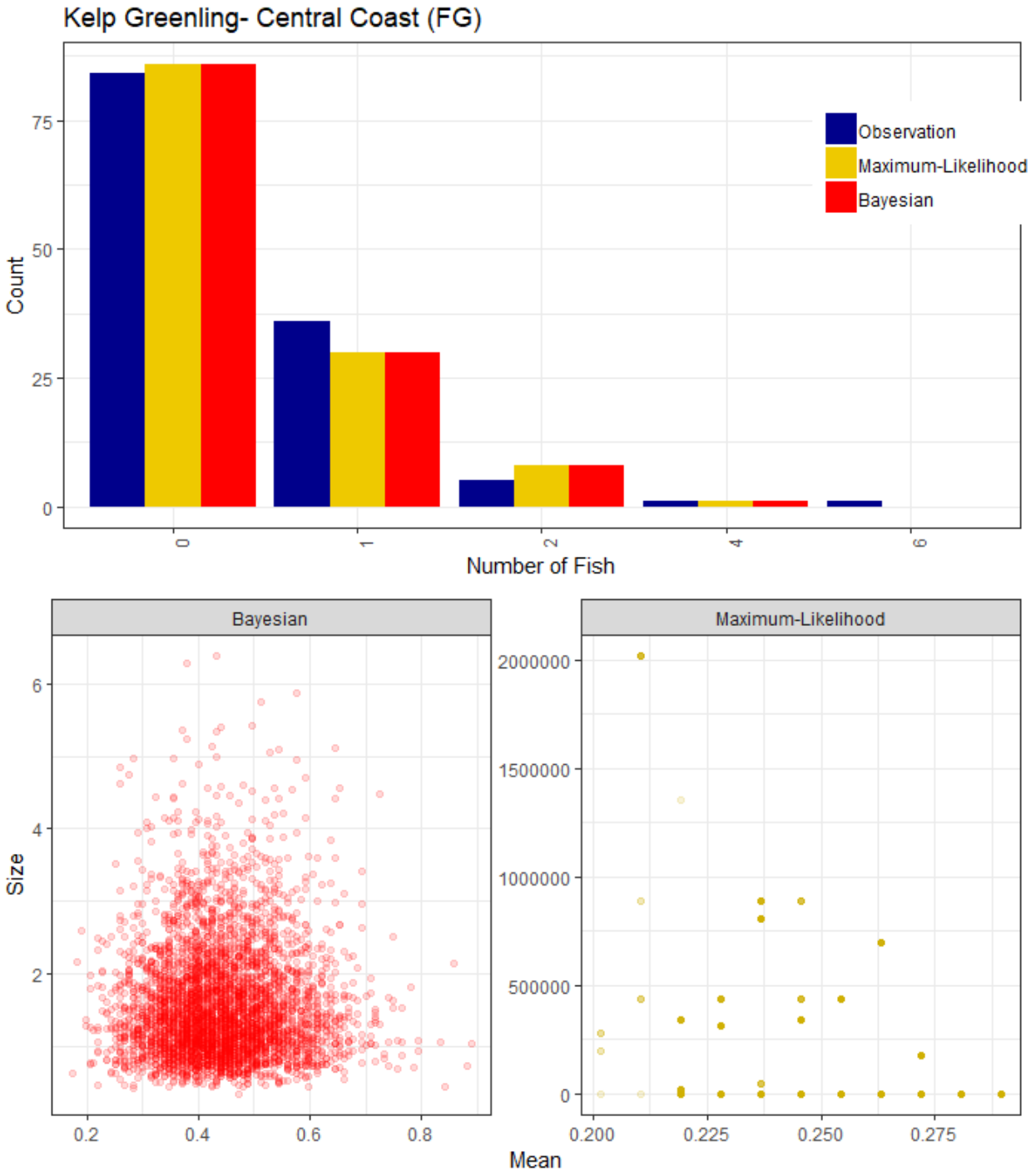

Kelp Greenling- Entire Coast
Observation
Maximum-Likelihood
Bayesian
Count
Number of Fish
Bayesian
Maximum-Likelihood
Size
Mean

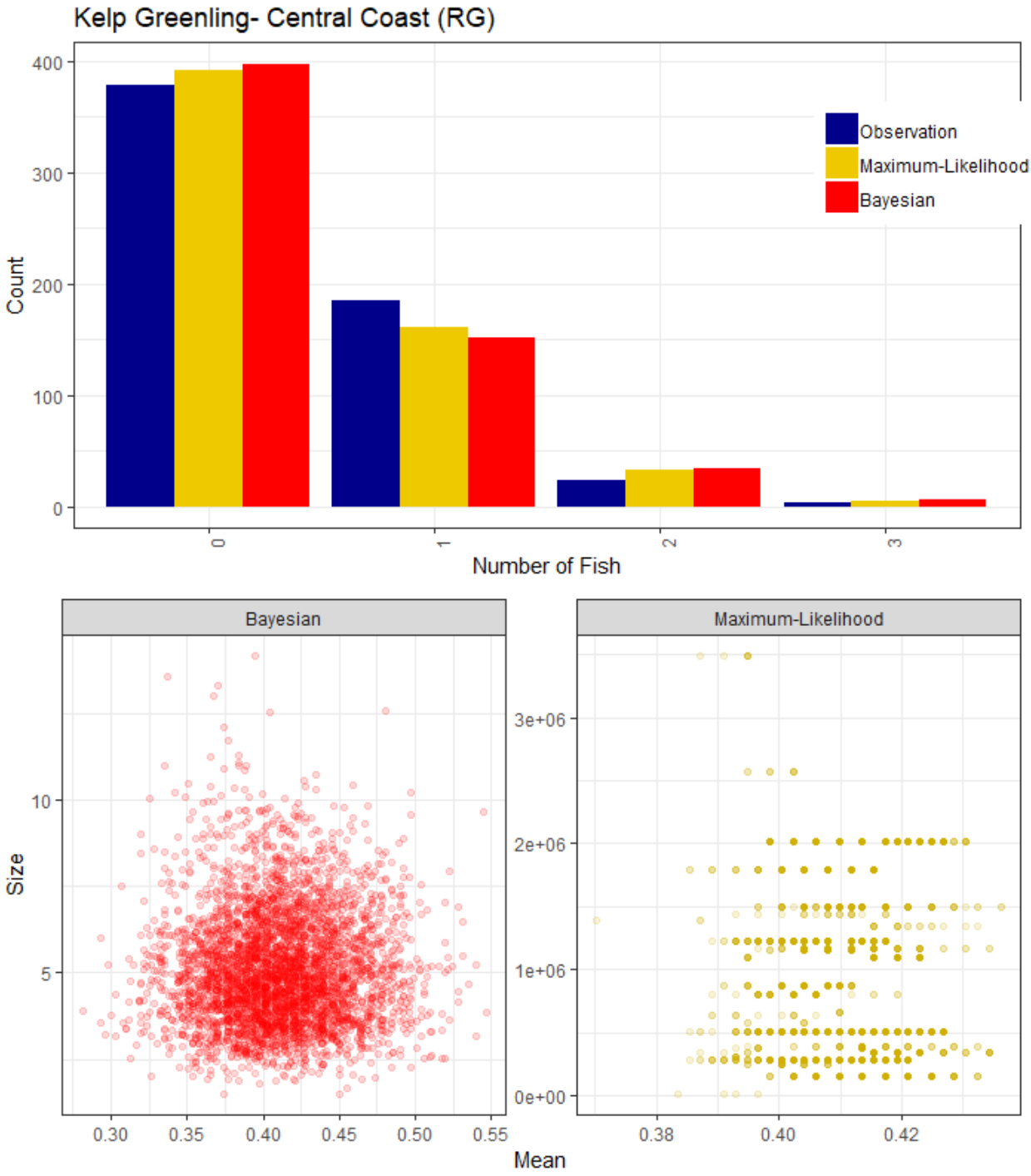

Kelp Greenling- Nearshore
Observation
Maximum-Likelihood
Bayesian
Count
Number of Fish
Bayesian
Maximum-Likelihood
Size
Mean

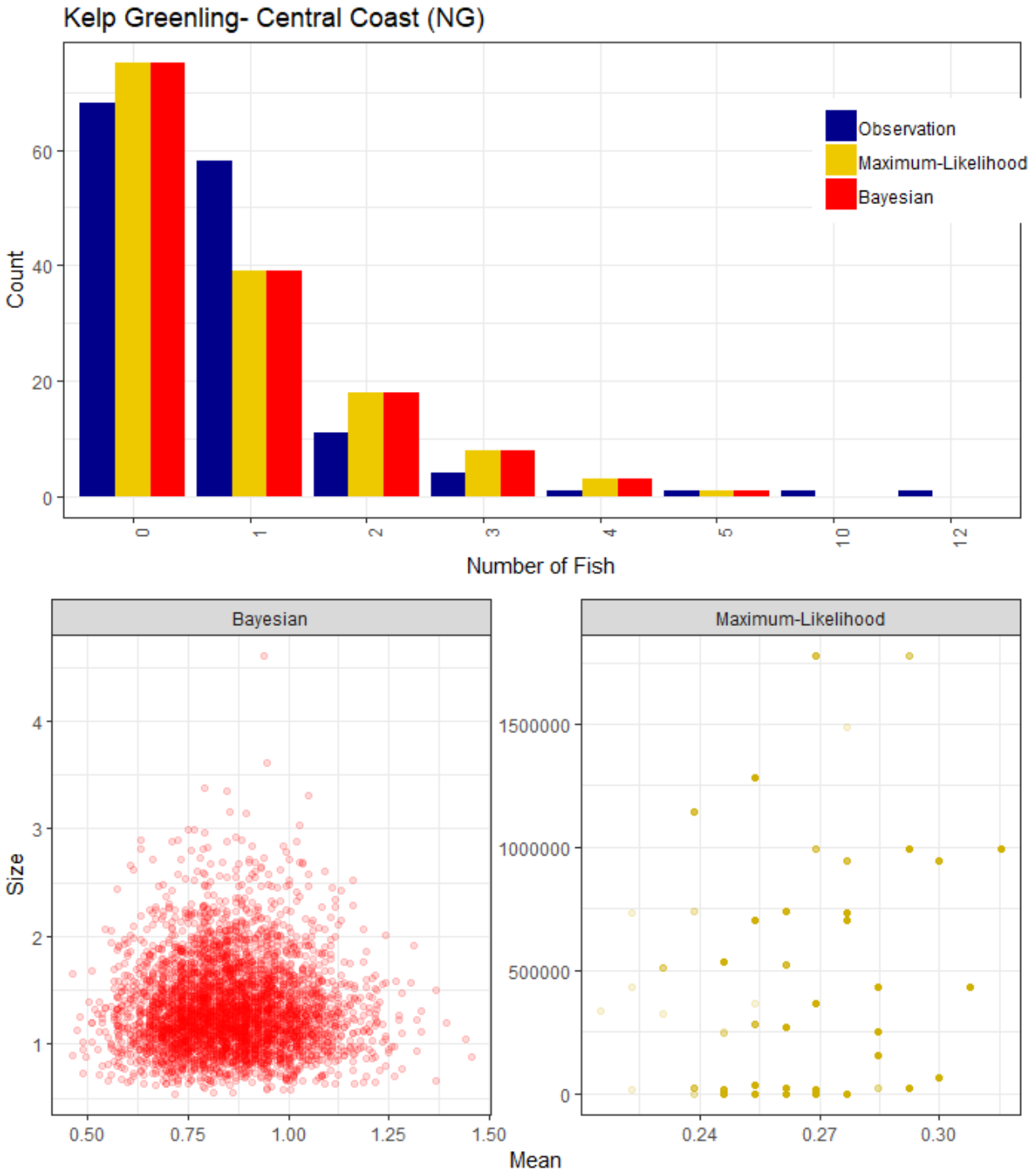

Kelp Greenling- North Coast (FG & RG)
Observation
Maximum-Likelihood
Bayesian
Count
200
100
0
0
1
2
3
4
Number of Fish
Bayesian
Maximum-Likelihood
Size
6
4
2
0
2.0
1.5
1.0
0.5
0.2
0.3
0.4
0.24
0.26
0.28
0.30
Mean

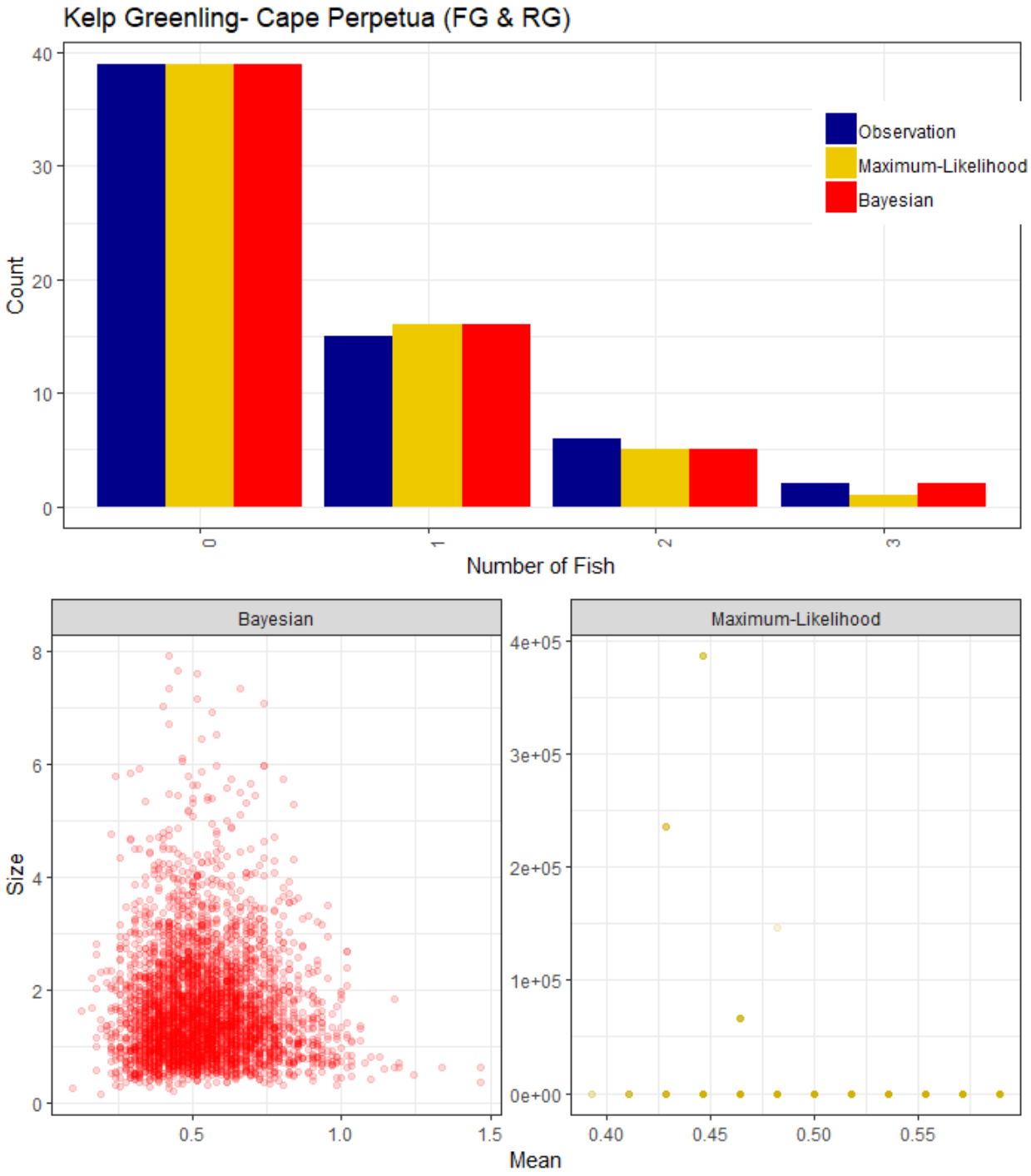

Kelp Greenling- North Coast (FG)
Count
Number of Fish
Observation
Maximum-Likelihood
Bayesian
Bayesian
Maximum-Likelihood
Size
Mean

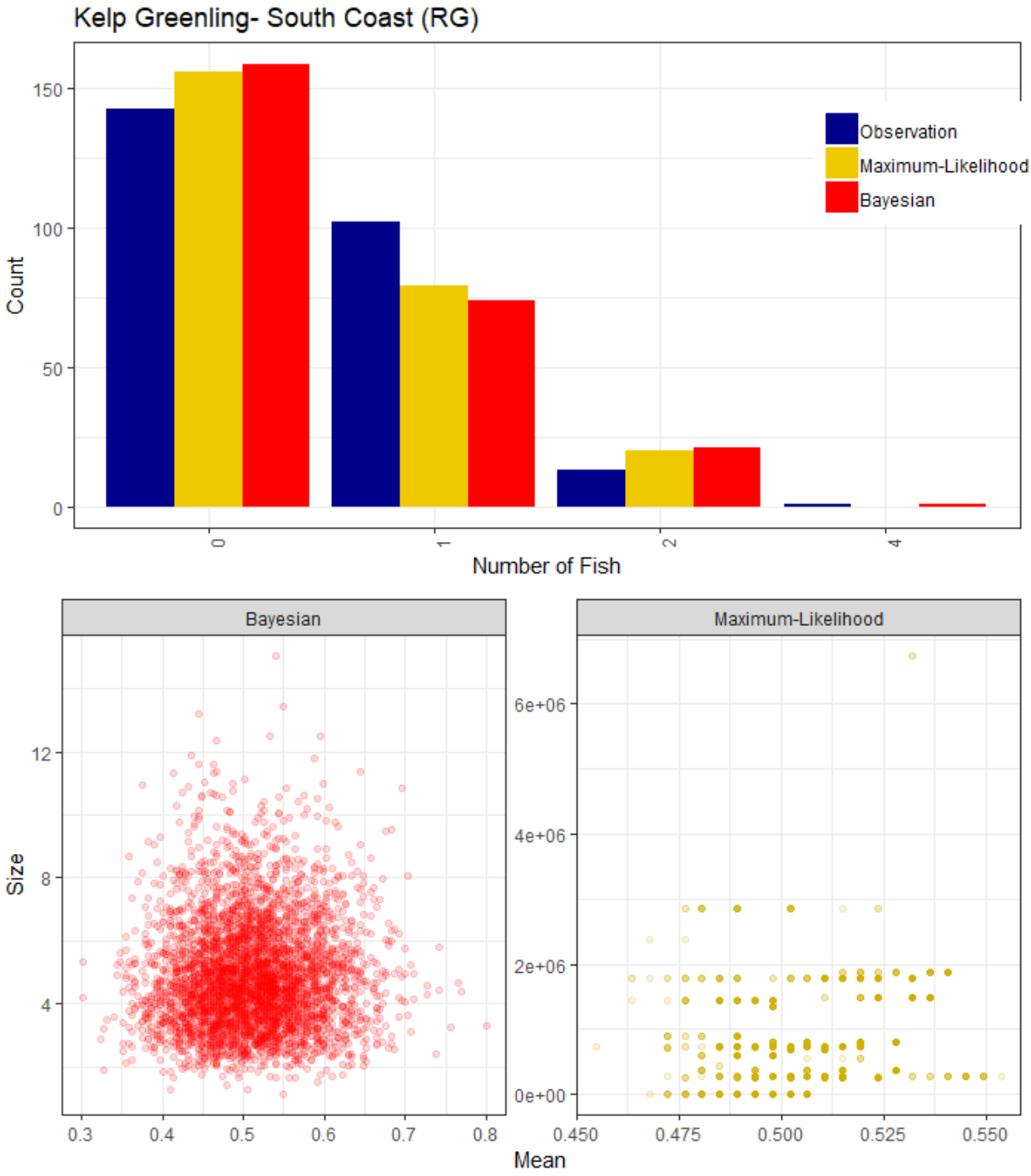

Kelp Greenling- Central Coast (FG, RG & NG)
Observation
Maximum-Likelihood
Bayesian
Count
400
200
0
0
1
2
3
4
5
6
10
12
Number of Fish
Bayesian
Maximum-Likelihood
Size
8
6
4
2
4e+05
3e+05
2e+05
1e+05
0e+00
0.40
0.45
0.50
0.55
0.60
0.46
0.48
0.50
Mean

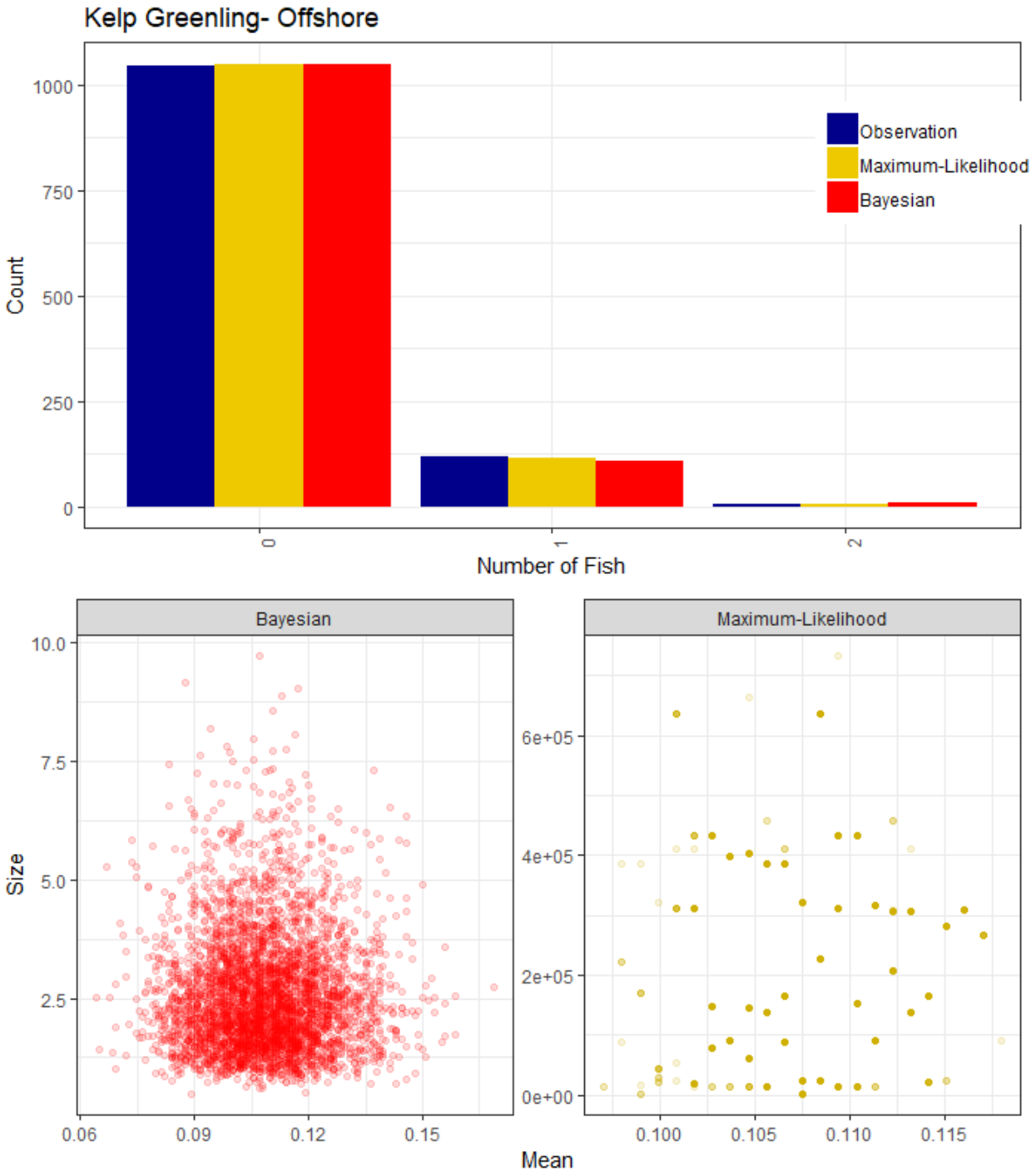

Kelp Greenling- Central Coast (FG)
Observation
Maximum-Likelihood
Bayesian
Count
Number of Fish
Bayesian
Maximum-Likelihood
Size
Mean

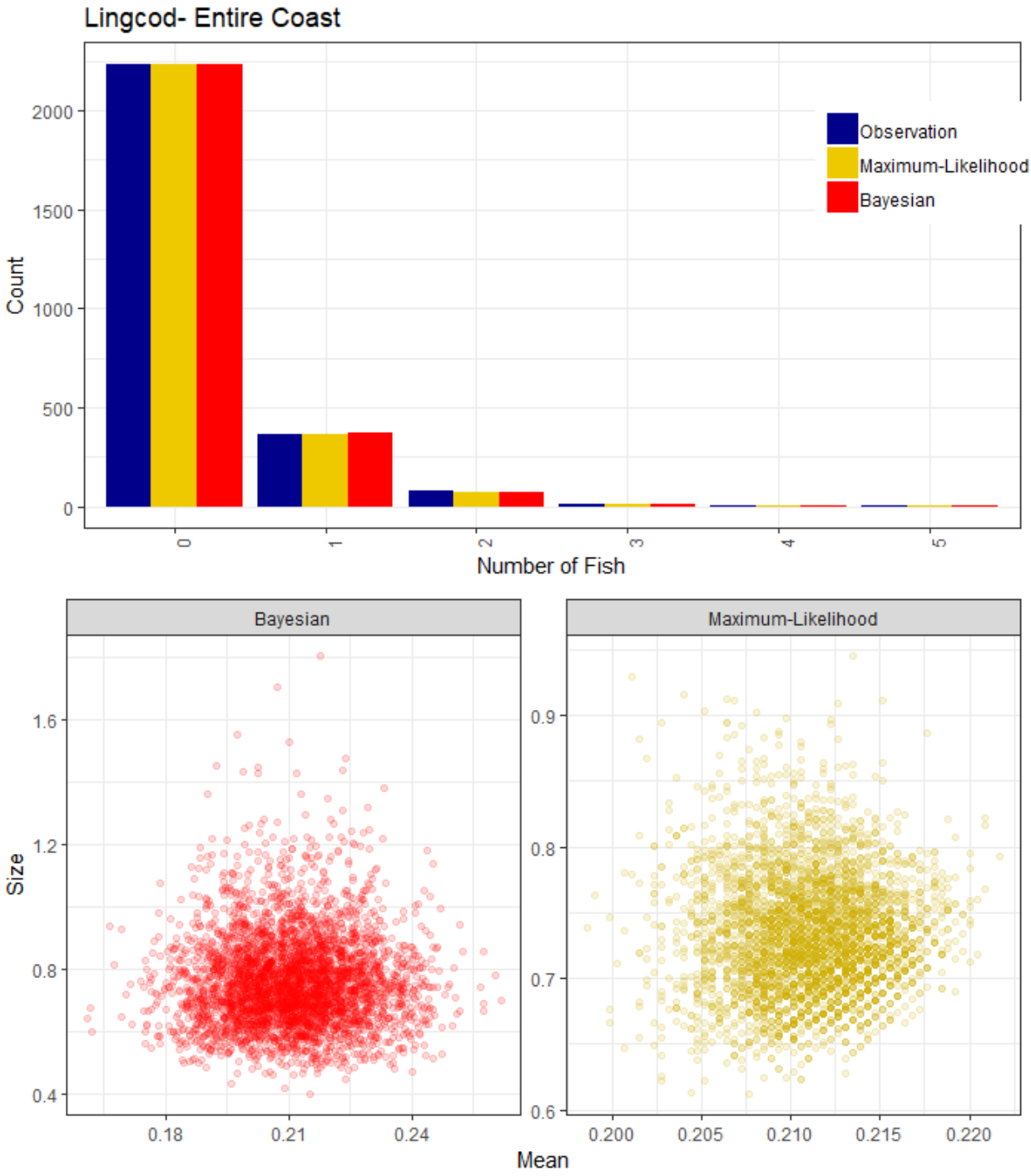

Kelp Greenling- Central Coast (RG)
Count
Number of Fish
Observation
Maximum-Likelihood
Bayesian
Bayesian
Maximum-Likelihood
Size
Mean

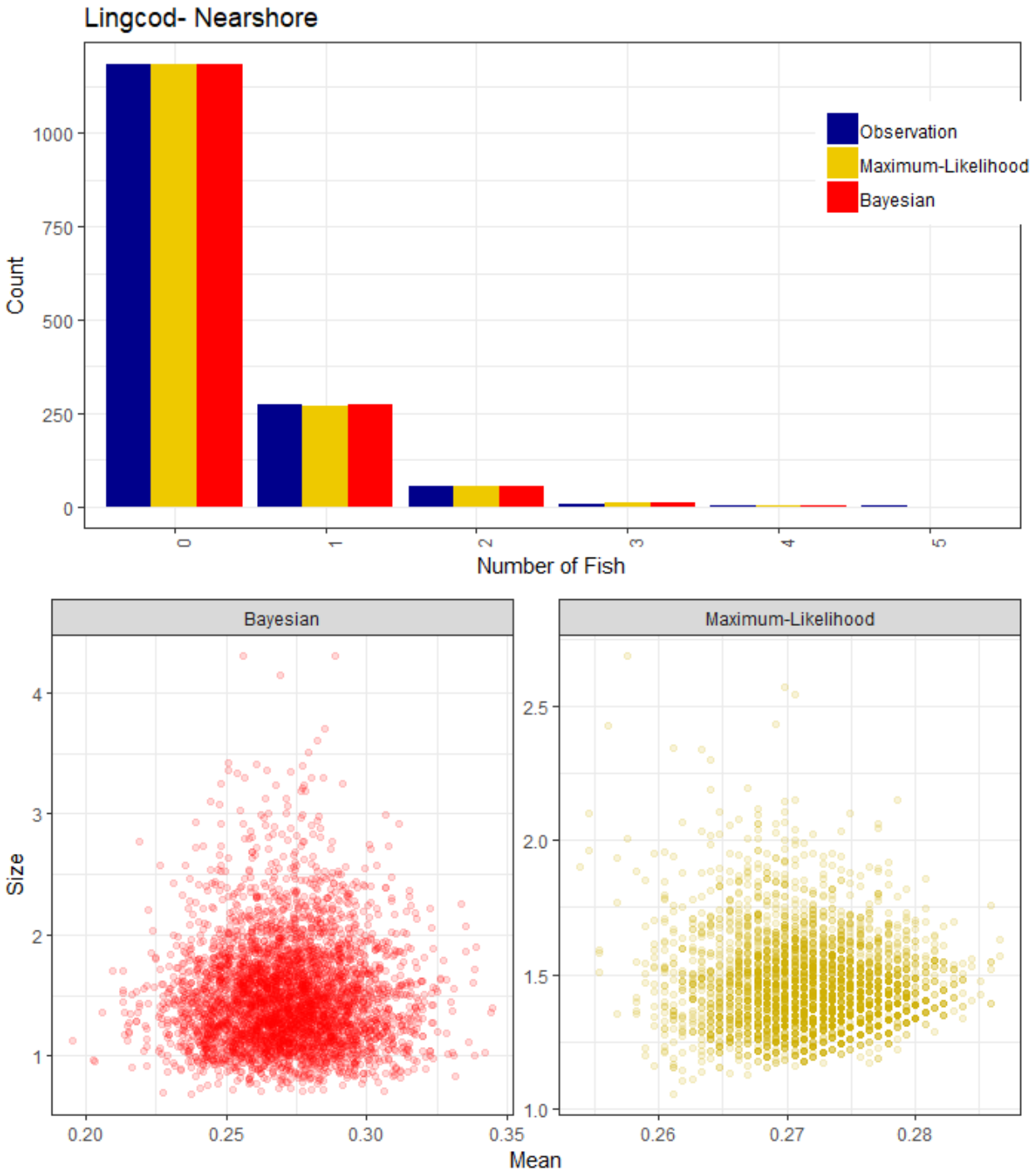

Kelp Greenling- Central Coast (NG)
Observation
Maximum-Likelihood
Bayesian
Count
Number of Fish
Bayesian
Maximum-Likelihood
Size
Mean

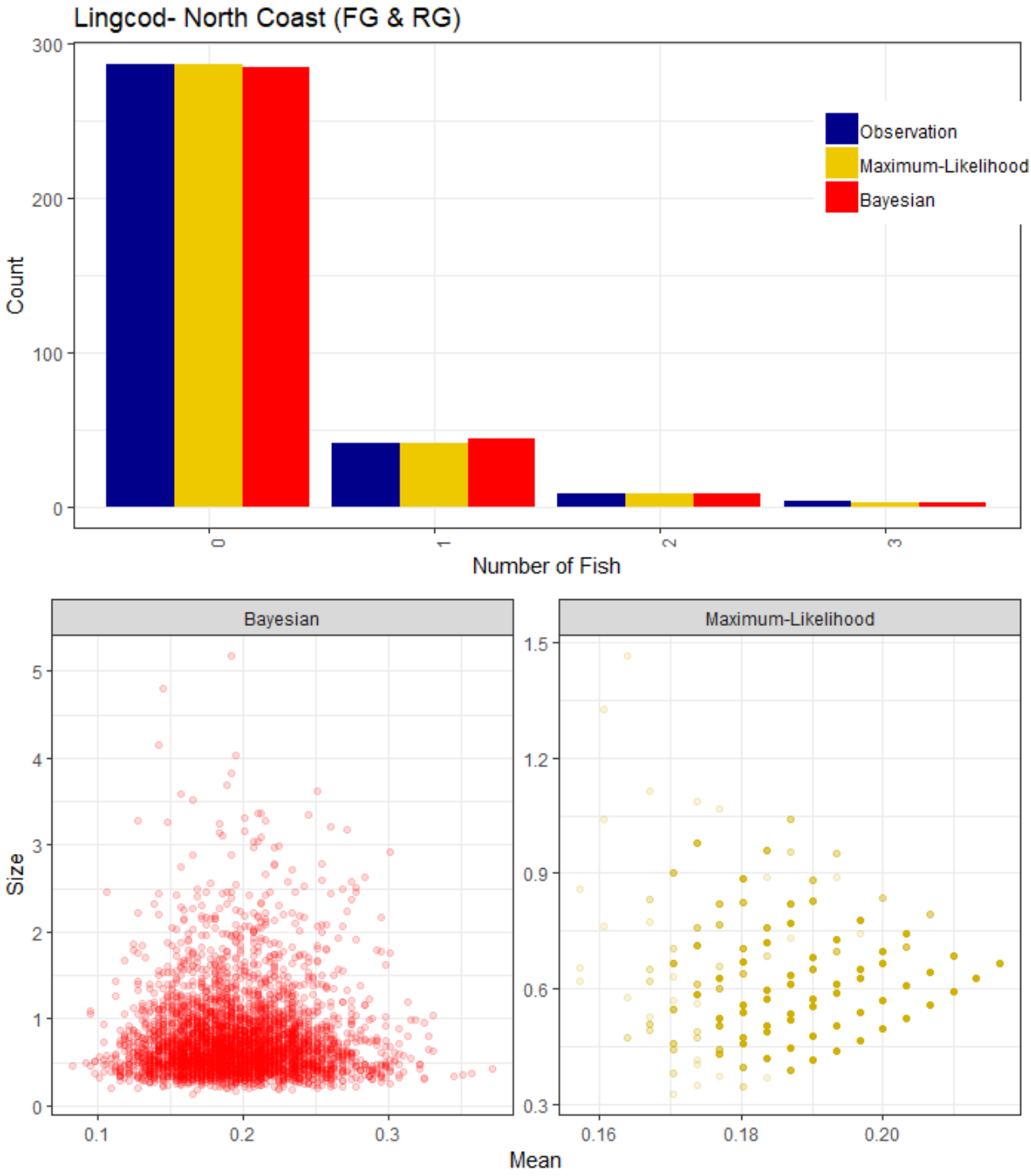

Kelp Greenling- Cape Perpetua (FG & RG)
Observation
Maximum-Likelihood
Bayesian
Count
Number of Fish
Bayesian
Maximum-Likelihood
Size
Mean

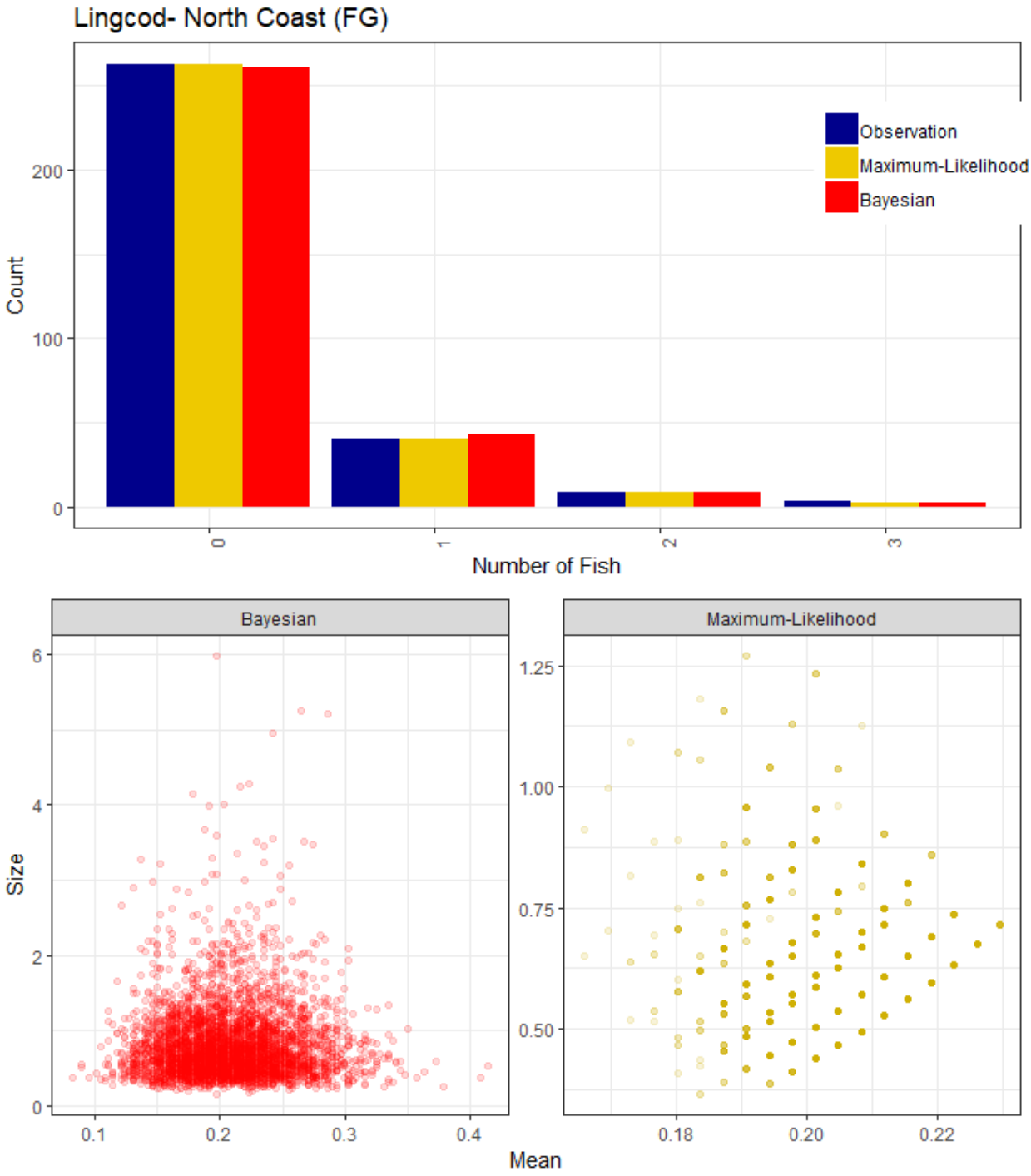

Kelp Greenling- South Coast (RG)
Count
Number of Fish
Observation
Maximum-Likelihood
Bayesian
Bayesian
Maximum-Likelihood
Size
Mean

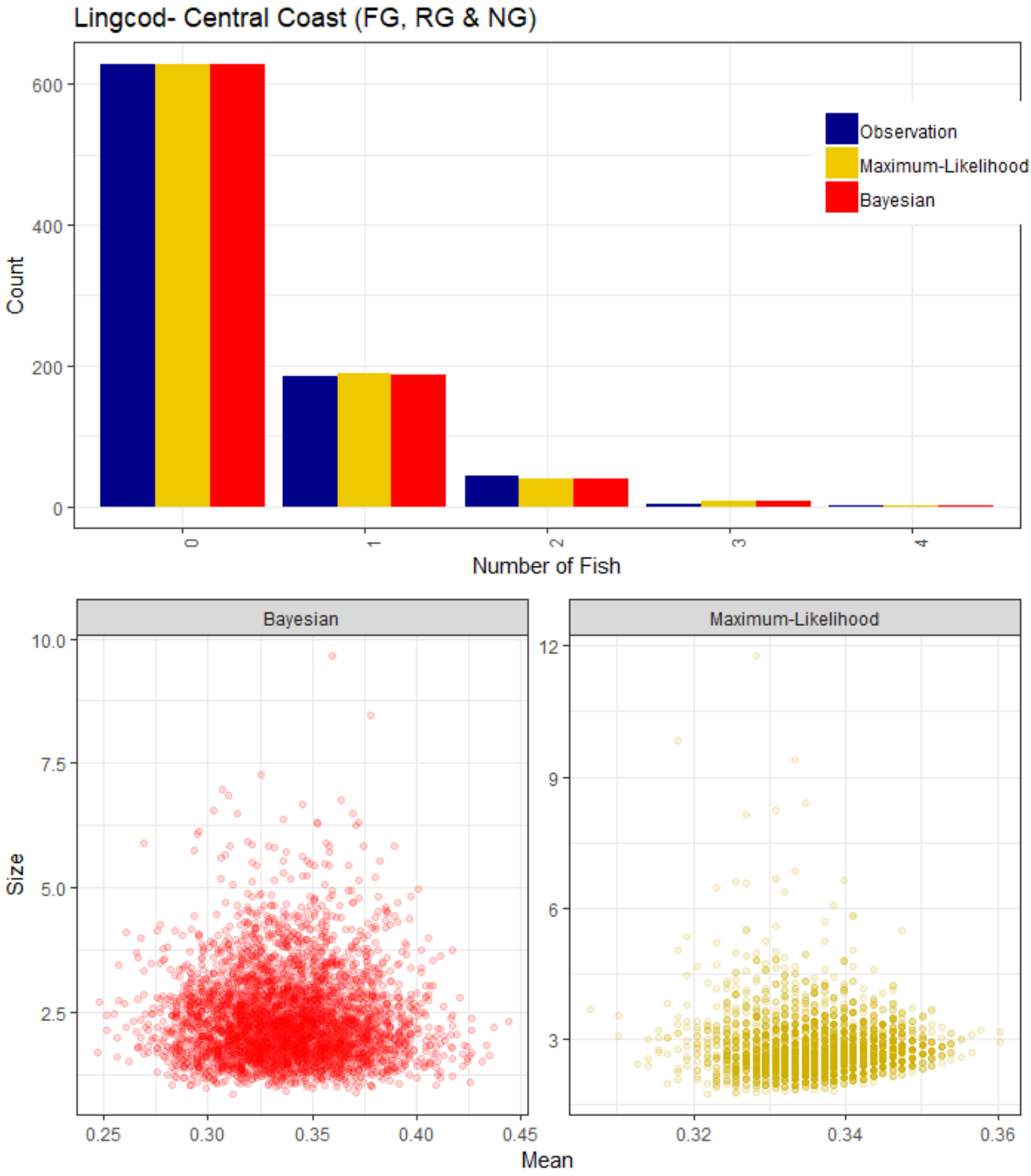

Kelp Greenling- Offshore
Count
1000
750
500
250
0
Observation
Maximum-Likelihood
Bayesian
0
1
2
Number of Fish
Bayesian
Maximum-Likelihood
Size
10.0
7.5
5.0
2.5
6e+05
4e+05
2e+05
0e+00
0.06
0.09
0.12
0.15
0.100
0.105
0.110
0.115
Mean

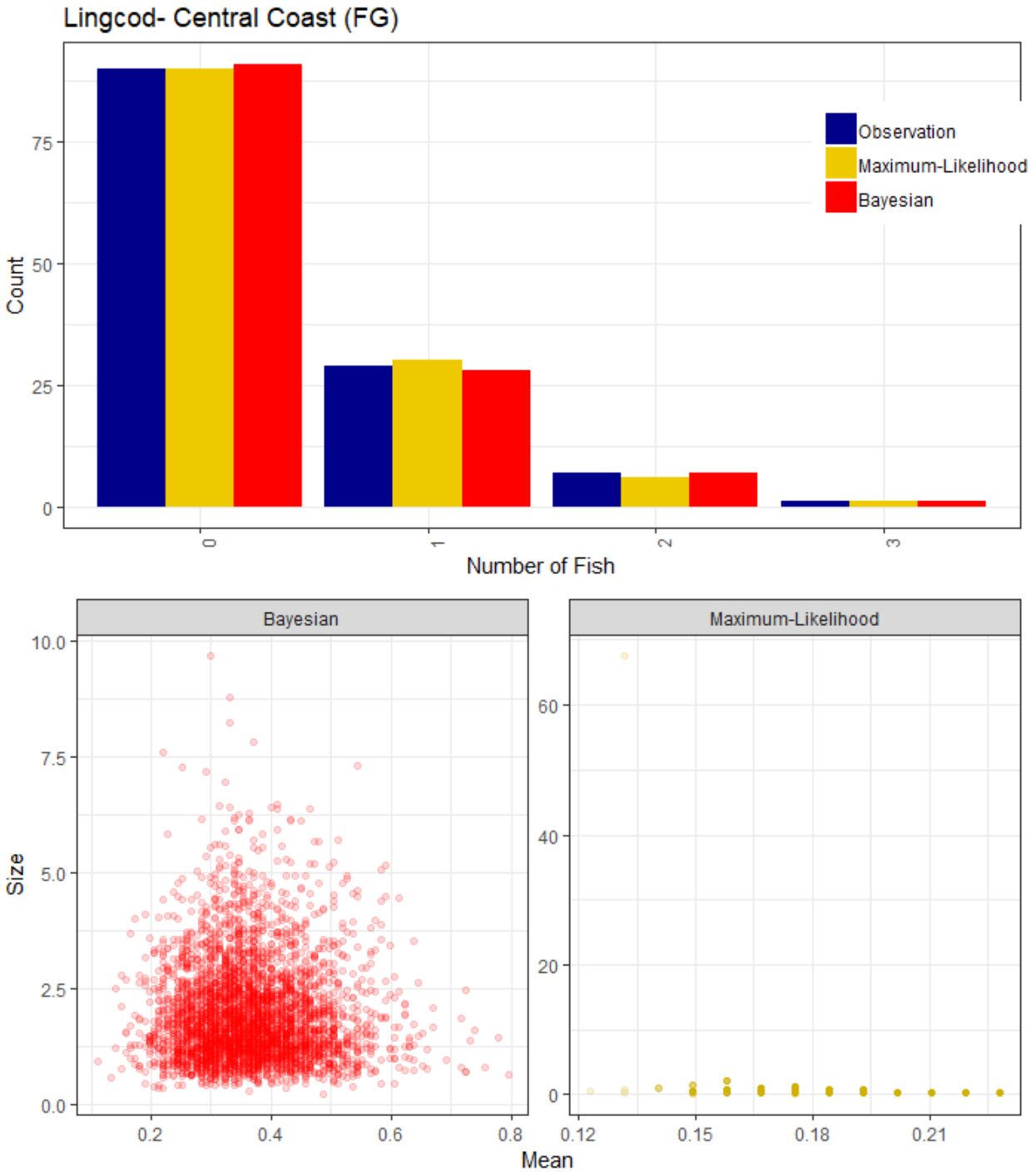

Lingcod- Entire Coast
Observation
Maximum-Likelihood
Bayesian
Count
Number of Fish
Bayesian
Maximum-Likelihood
Size
Mean

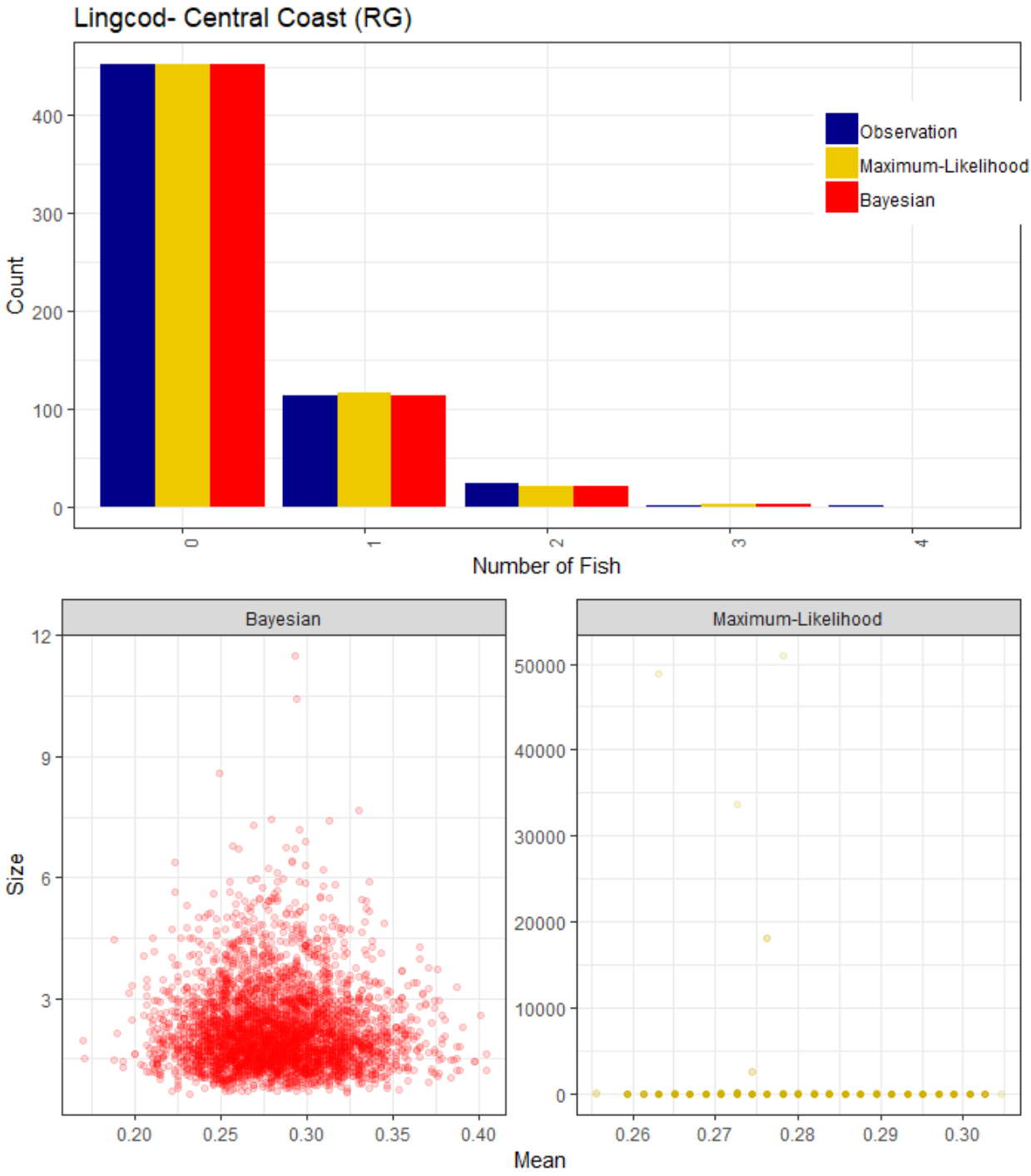

Lingcod- Nearshore
Observation
Maximum-Likelihood
Bayesian
Count
1000
750
500
250
0
0
1
2
3
4
5
Number of Fish
Bayesian
Maximum-Likelihood
Size
4
3
2
1
2.5
2.0
1.5
1.0
0.20
0.25
0.30
0.35
0.26
0.27
0.28
Mean

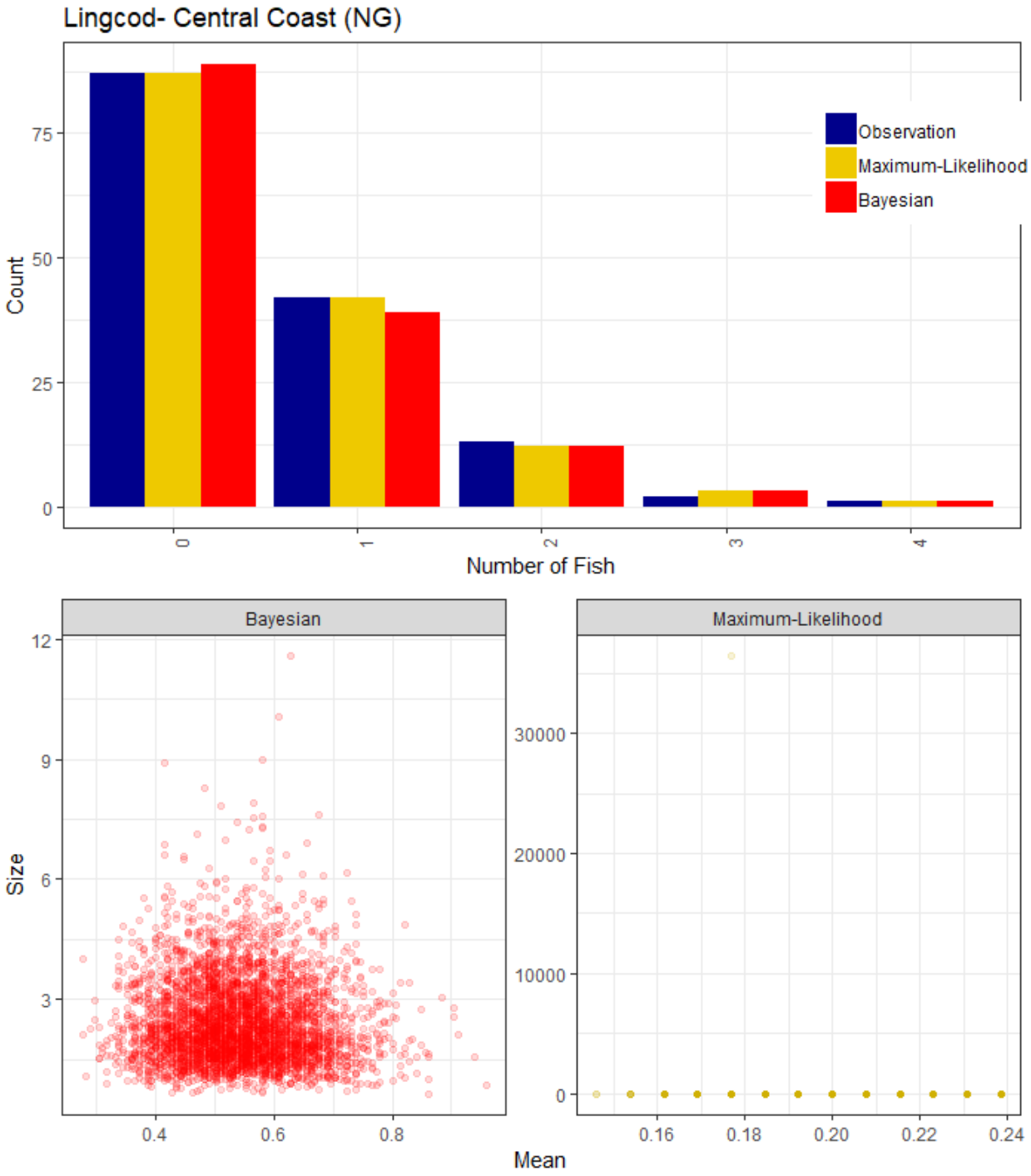

Lingcod- North Coast (FG & RG)
Count
Number of Fish
Observation
Maximum-Likelihood
Bayesian
Bayesian
Maximum-Likelihood
Size
Mean

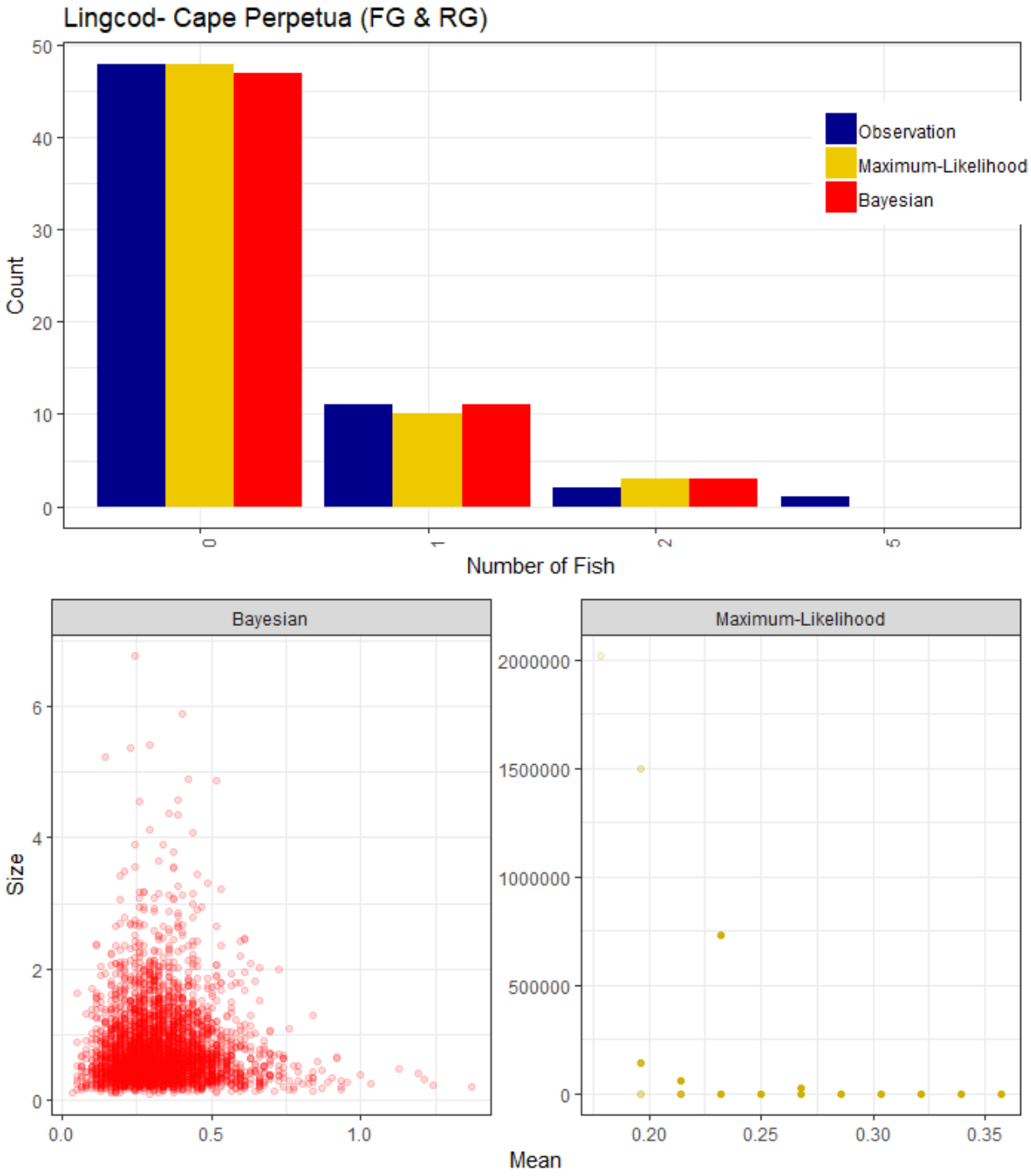

Lingcod- North Coast (FG)
Observation
Maximum-Likelihood
Bayesian
Count
200
100
0
0
1
2
3
Number of Fish
Bayesian
Maximum-Likelihood
Size
6
4
2
0
1.25
1.00
0.75
0.50
0.1
0.2
0.3
0.4
0.18
0.20
0.22
Mean

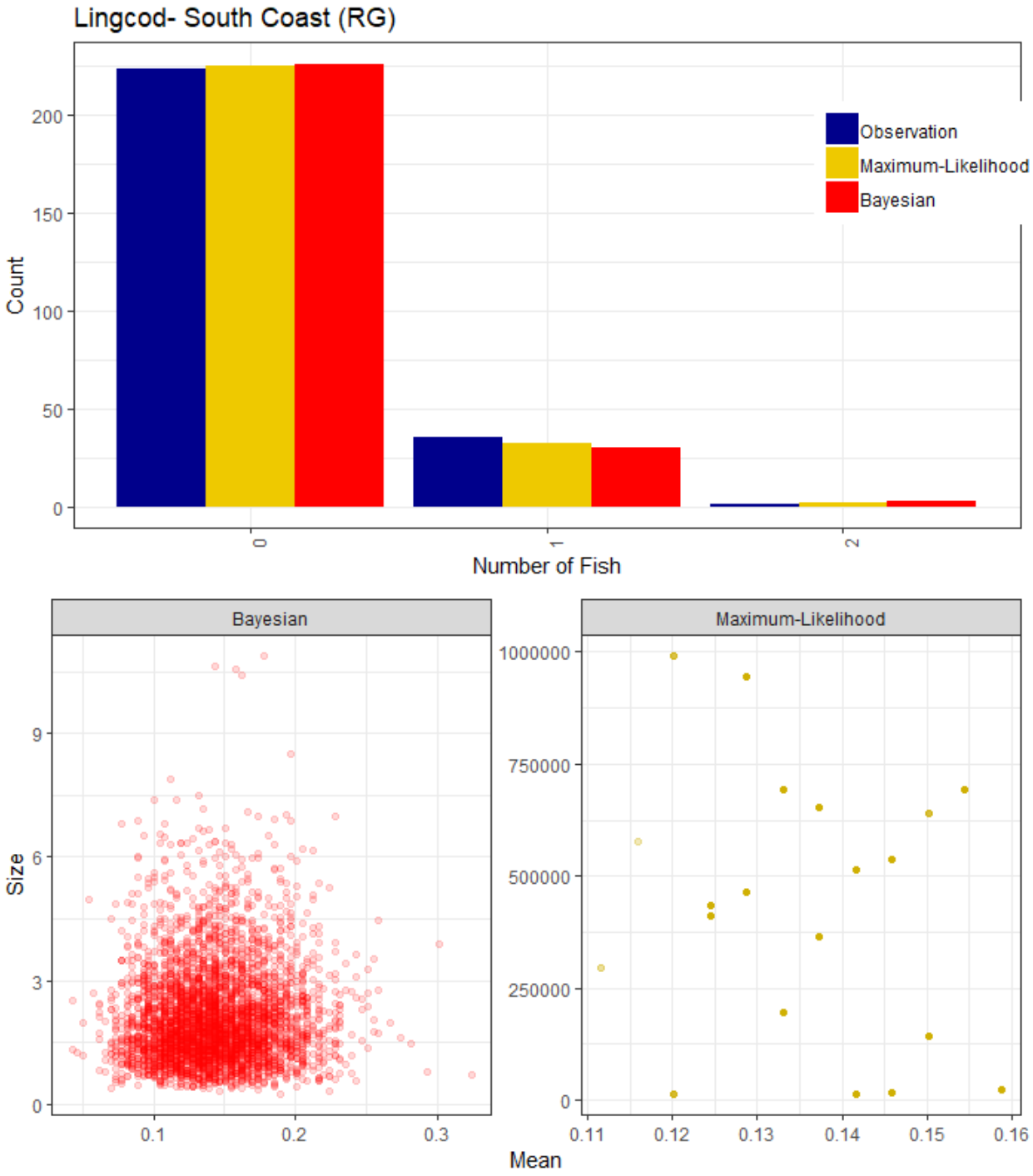

Lingcod- Central Coast (FG, RG & NG)
Observation
Maximum-Likelihood
Bayesian
Count
Number of Fish
Bayesian
Maximum-Likelihood
Size
Mean

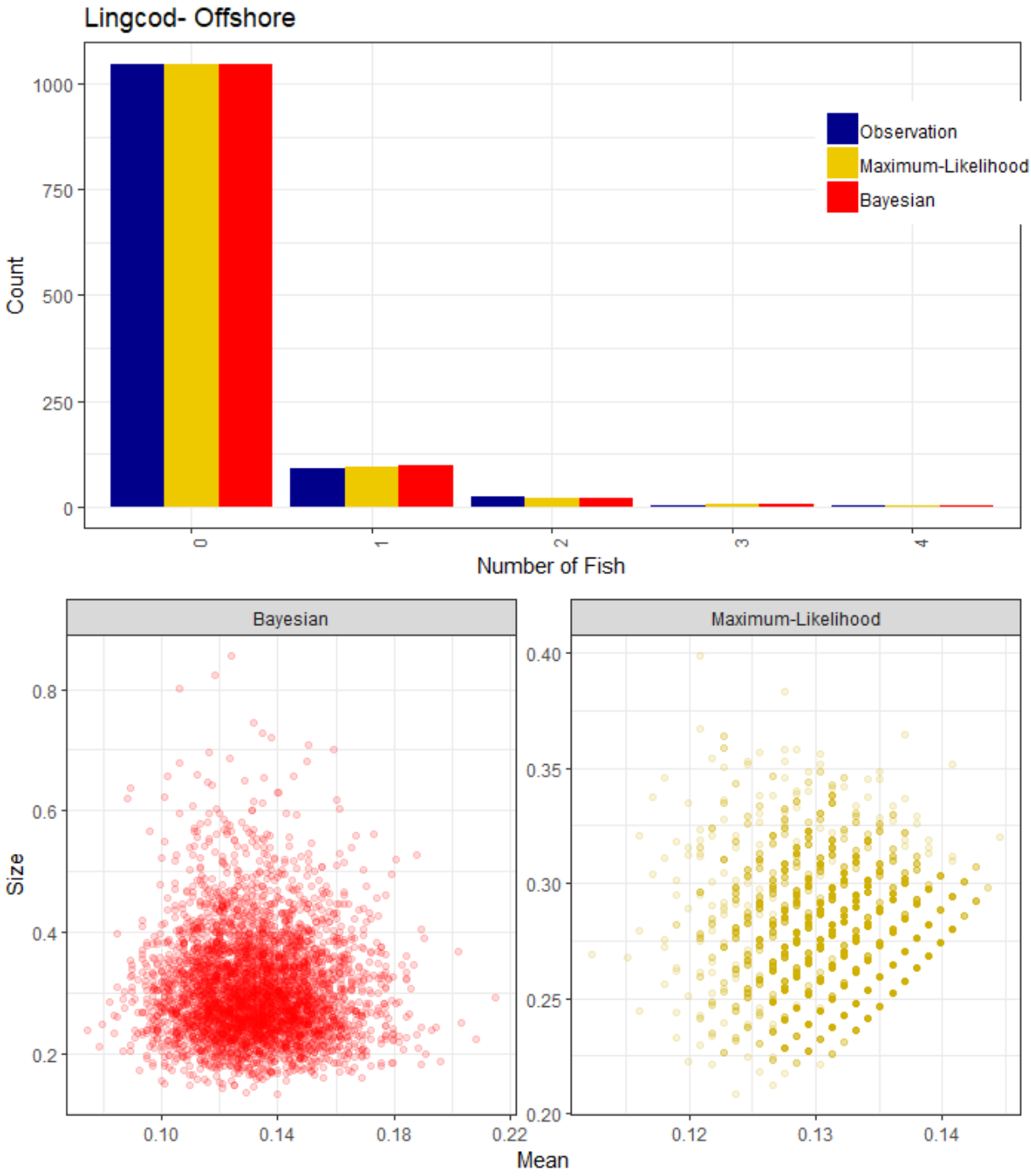

Lingcod- Central Coast (FG)
Observation
Maximum-Likelihood
Bayesian
Count
75
50
25
0
0
1
2
3
Number of Fish
Bayesian
Maximum-Likelihood
Size
10.0
7.5
5.0
2.5
0.0
60
40
20
0
0.2
0.4
0.6
0.8
0.12
0.15
0.18
0.21
Mean

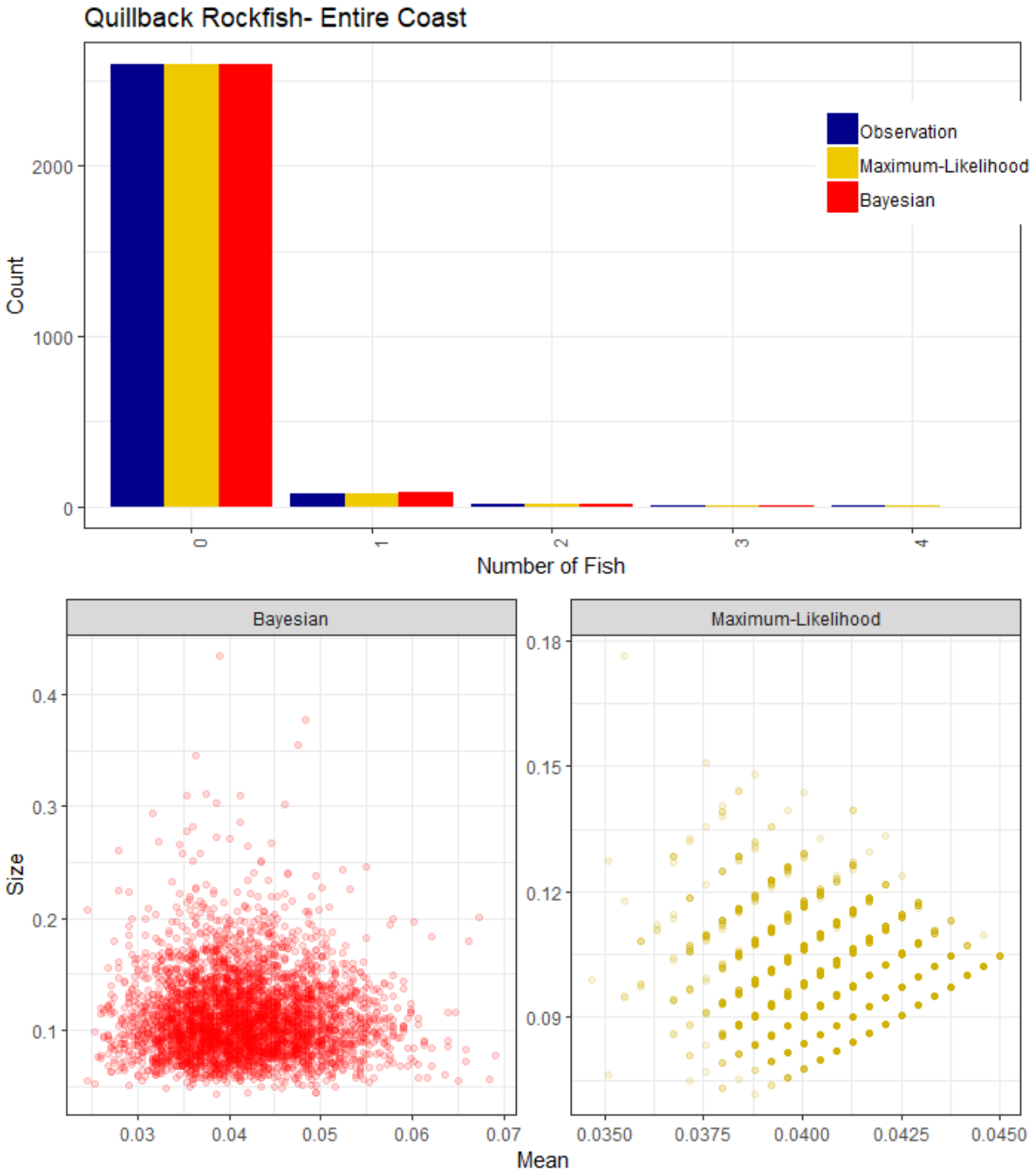

Lingcod- Central Coast (RG)
Observation
Maximum-Likelihood
Bayesian
Count
Number of Fish
Bayesian
Maximum-Likelihood
Size
Mean

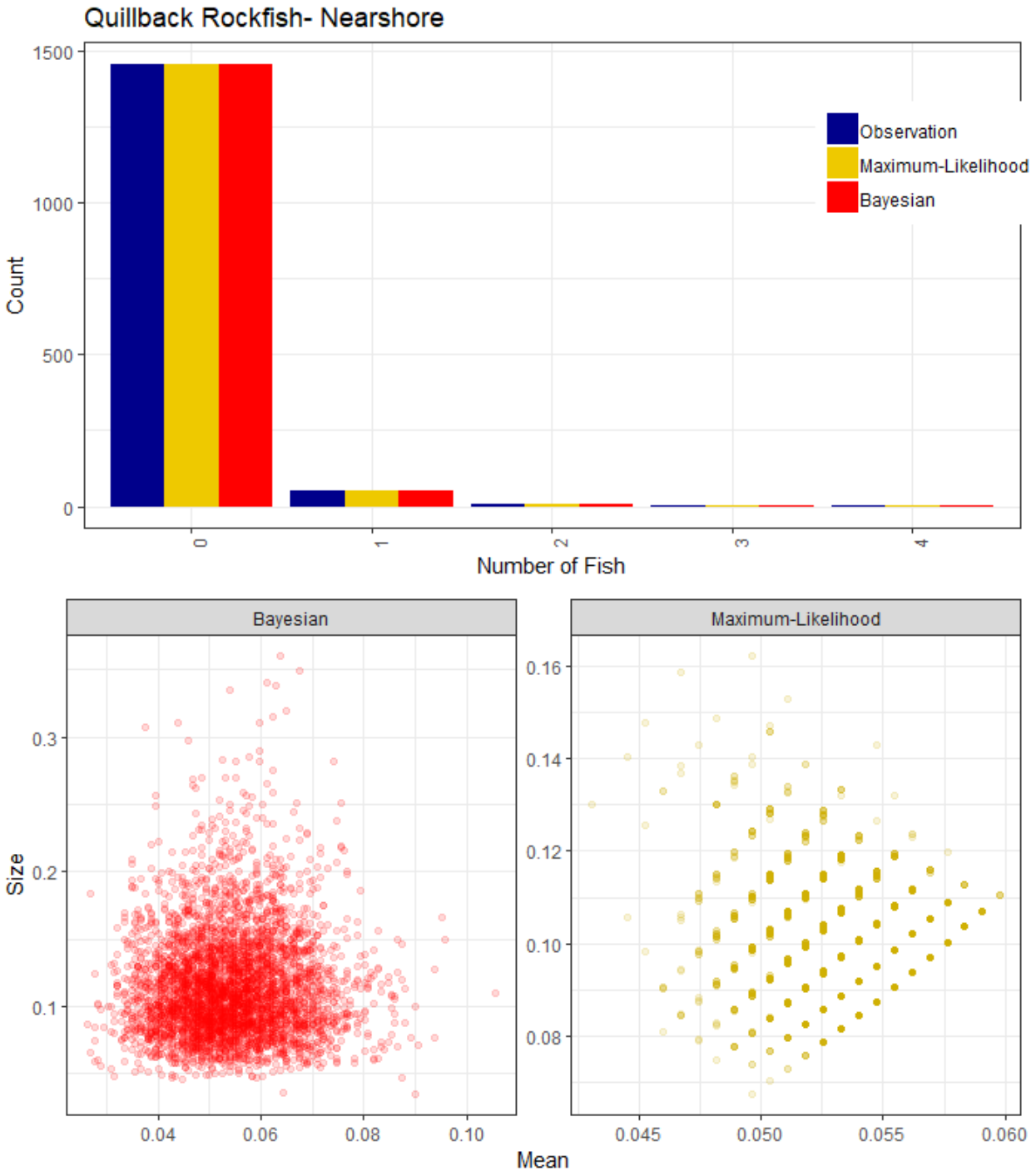

Lingcod- Central Coast (NG)
Observation
Maximum-Likelihood
Bayesian
Count
75
50
25
0
0
1
2
3
4
Number of Fish
Bayesian
Maximum-Likelihood
Size
12
9
6
3
30000
20000
10000
0
0.4
0.6
0.8
0.16
0.18
0.20
0.22
0.24
Mean

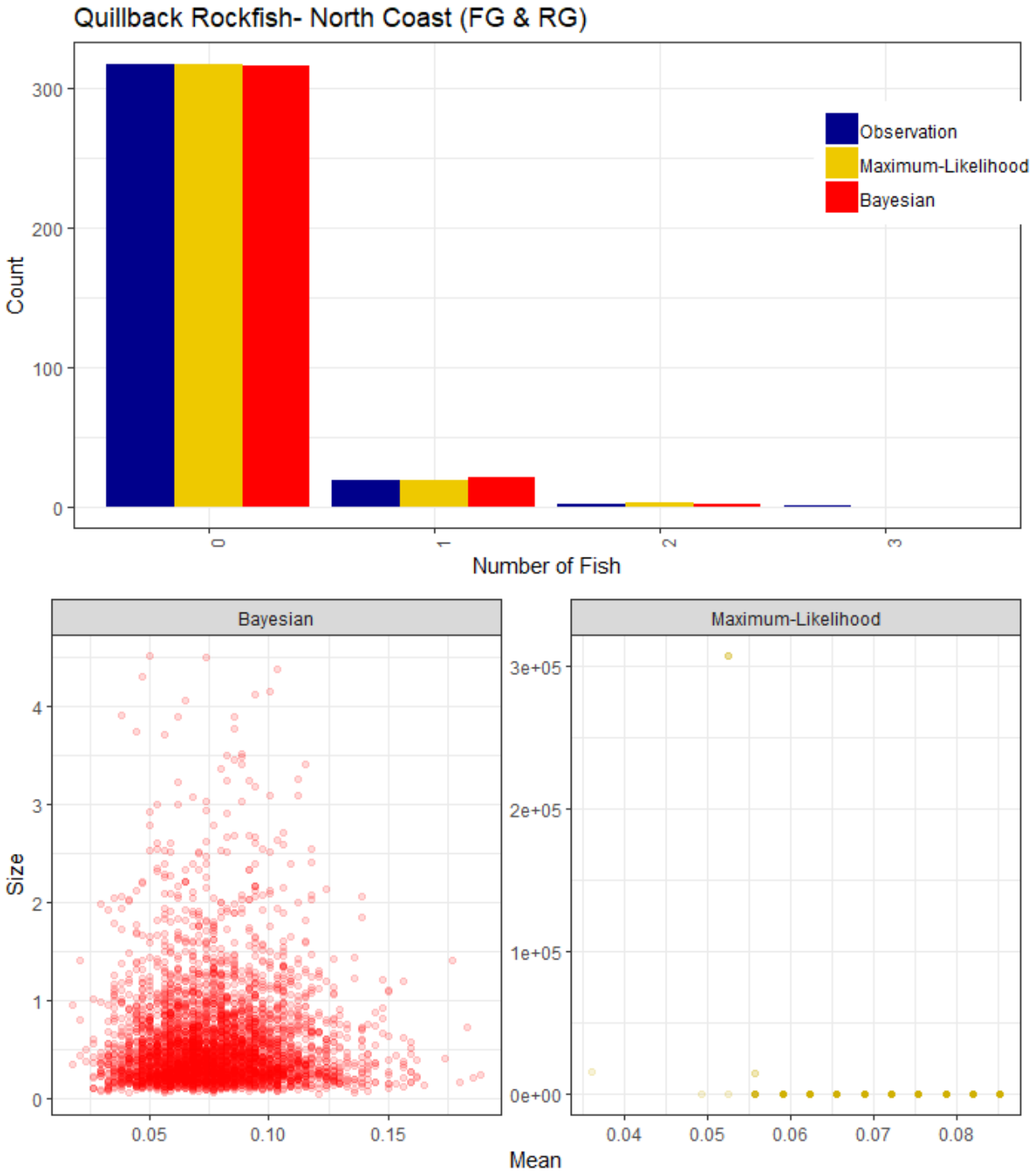

Lingcod- Cape Perpetua (FG & RG)
Count
Number of Fish
Observation
Maximum-Likelihood
Bayesian
Bayesian
Maximum-Likelihood
Size
Mean

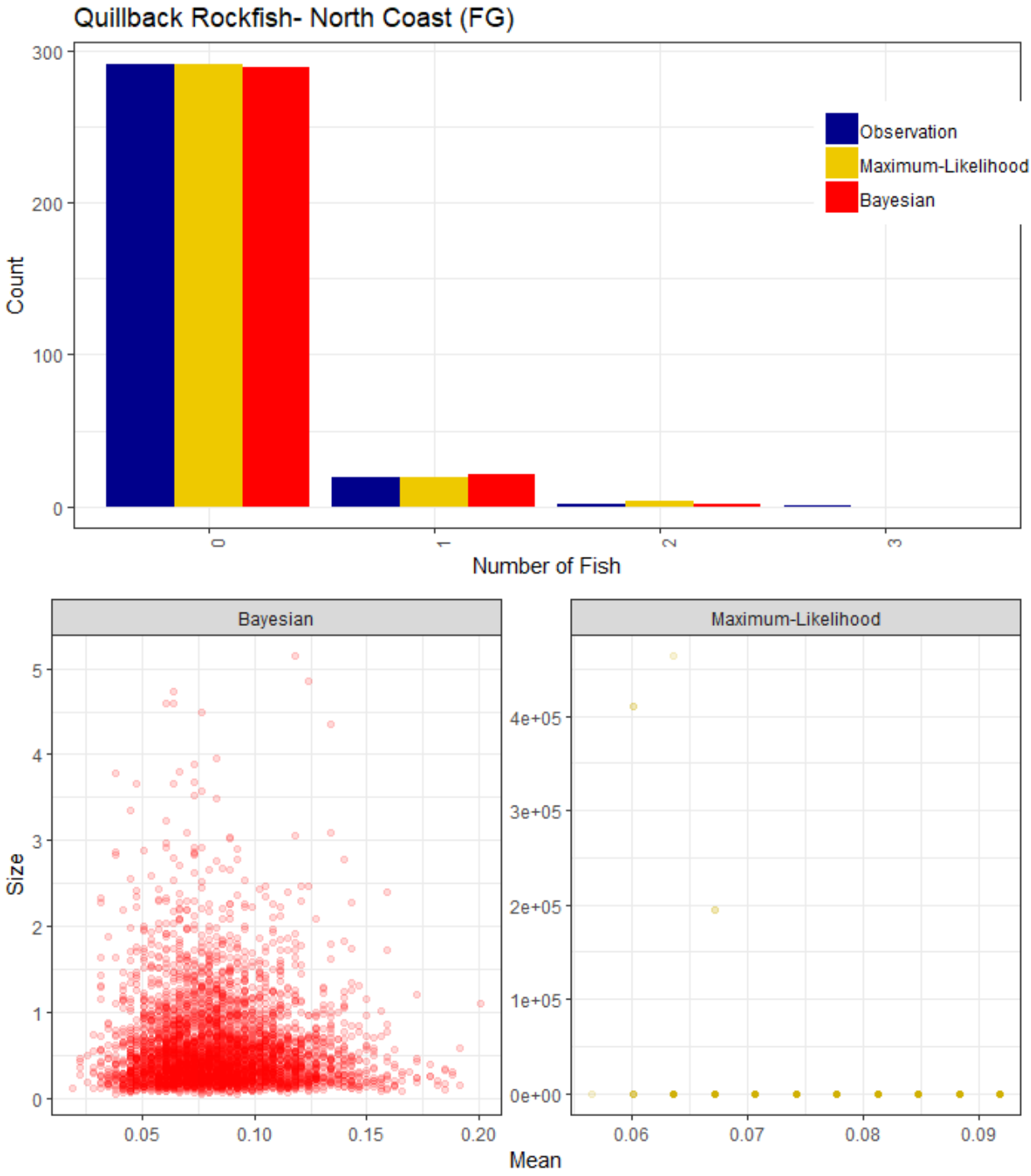

Lingcod- South Coast (RG)
Observation
Maximum-Likelihood
Bayesian
Count
Number of Fish
Bayesian
Maximum-Likelihood
Size
Mean

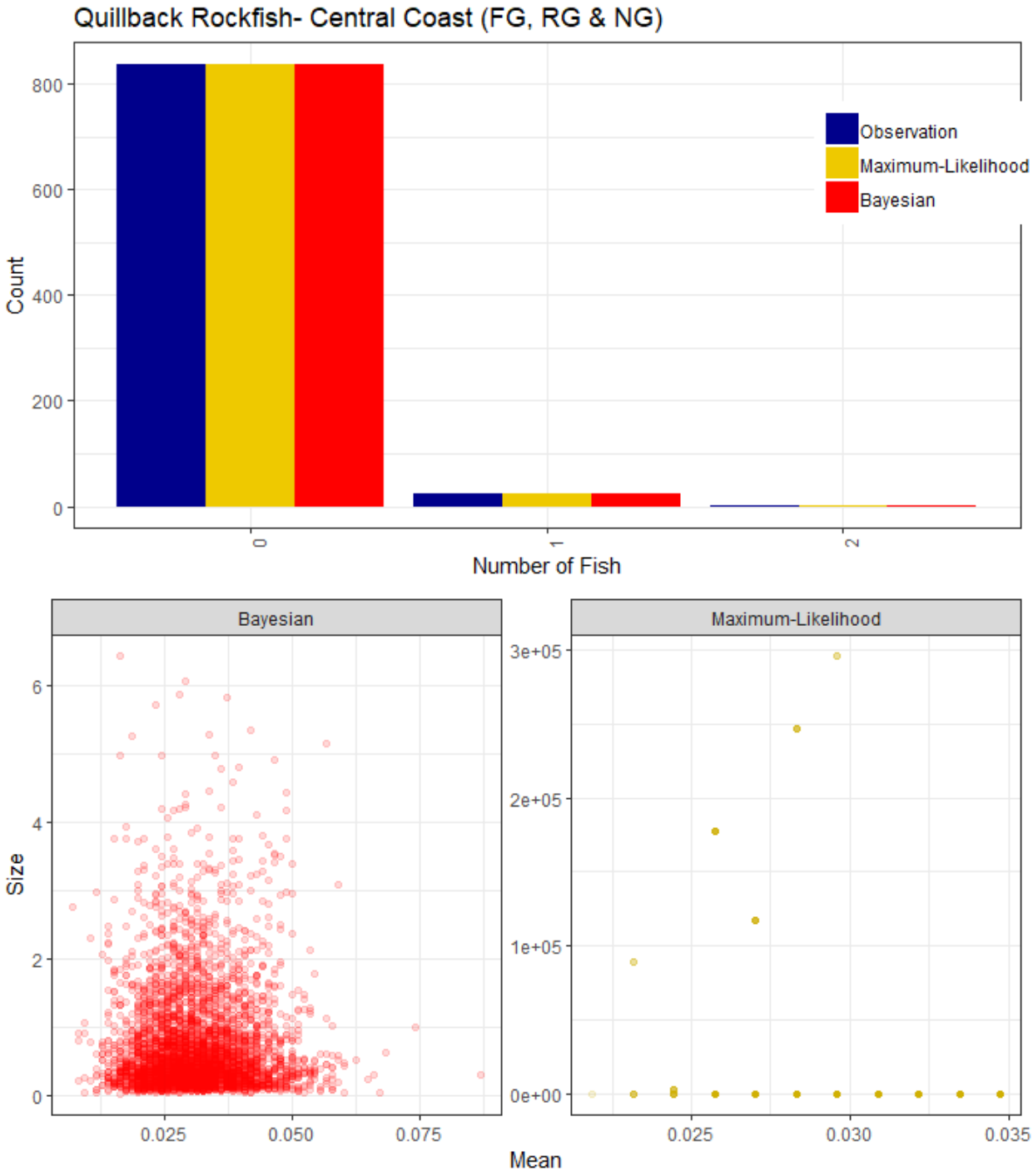

Lingcod- Offshore
Count
1000
750
500
250
0
Observation
Maximum-Likelihood
Bayesian
0
1
2
3
4
Number of Fish
Bayesian
Maximum-Likelihood
Size
0.8
0.6
0.4
0.2
0.40
0.35
0.30
0.25
0.20
0.10
0.14
0.18
0.22
0.12
0.13
0.14
Mean

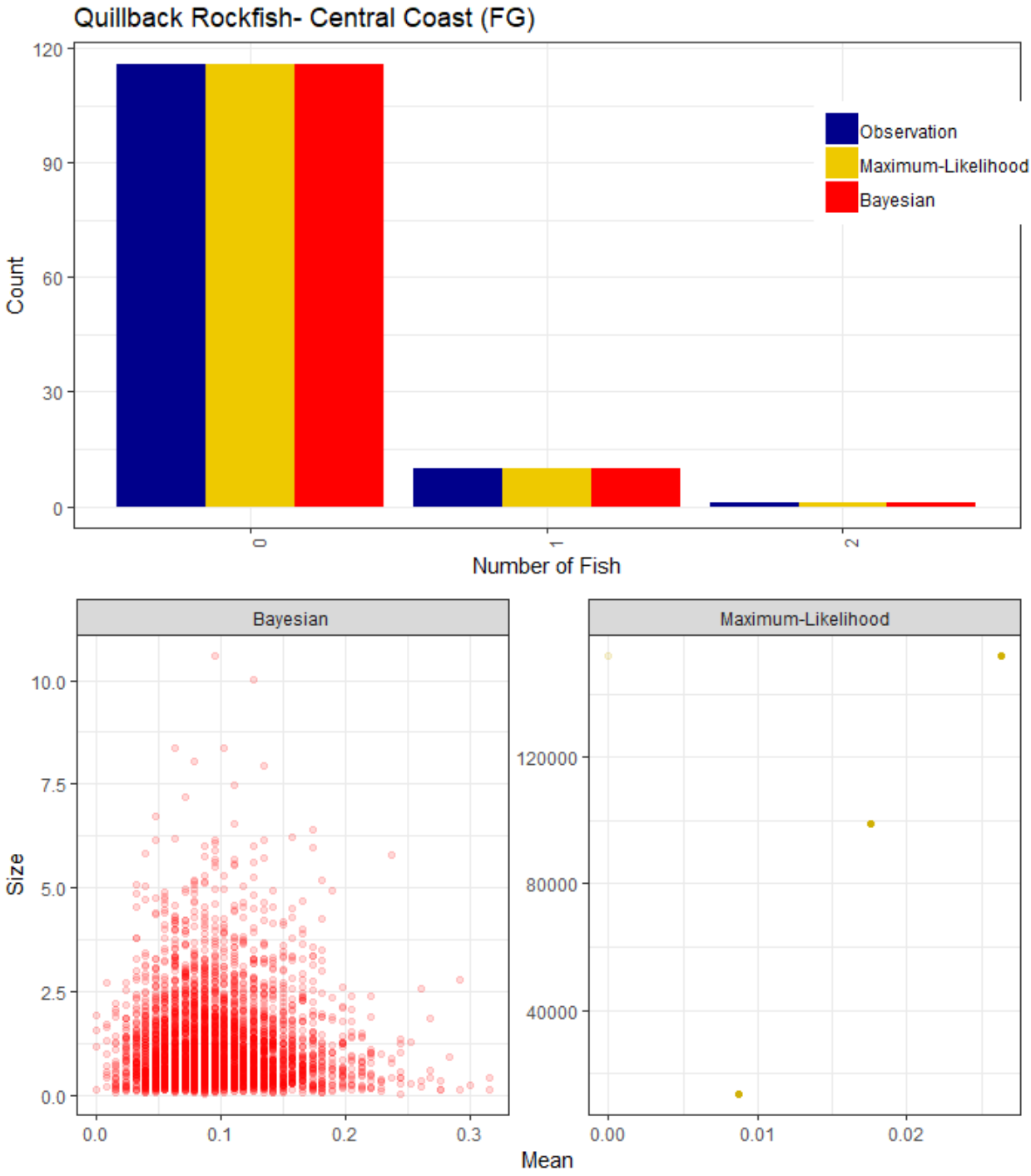

Quillback Rockfish- Entire Coast
Observation
Maximum-Likelihood
Bayesian
Count
2000
1000
0
0
1
2
3
4
Number of Fish
Bayesian
Maximum-Likelihood
Size
0.4
0.3
0.2
0.1
0.18
0.15
0.12
0.09
0.03
0.04
0.05
0.06
0.07
0.0350
0.0375
0.0400
0.0425
0.0450
Mean

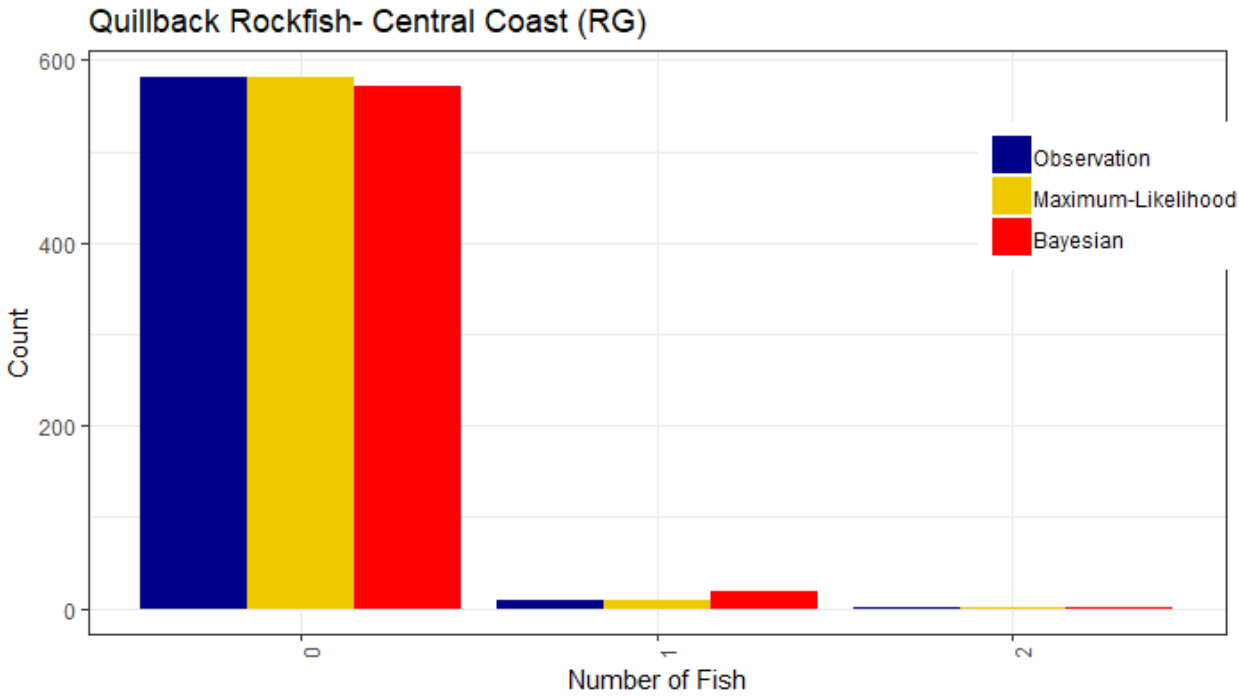

Quillback Rockfish- Nearshore
Count
1500
1000
500
0
Observation
Maximum-Likelihood
Bayesian
0
1
2
3
4
Number of Fish
Bayesian
Maximum-Likelihood
Size
0.3
0.2
0.1
0.16
0.14
0.12
0.10
0.08
0.04
0.06
0.08
0.10
0.045
0.050
0.055
0.060
Mean

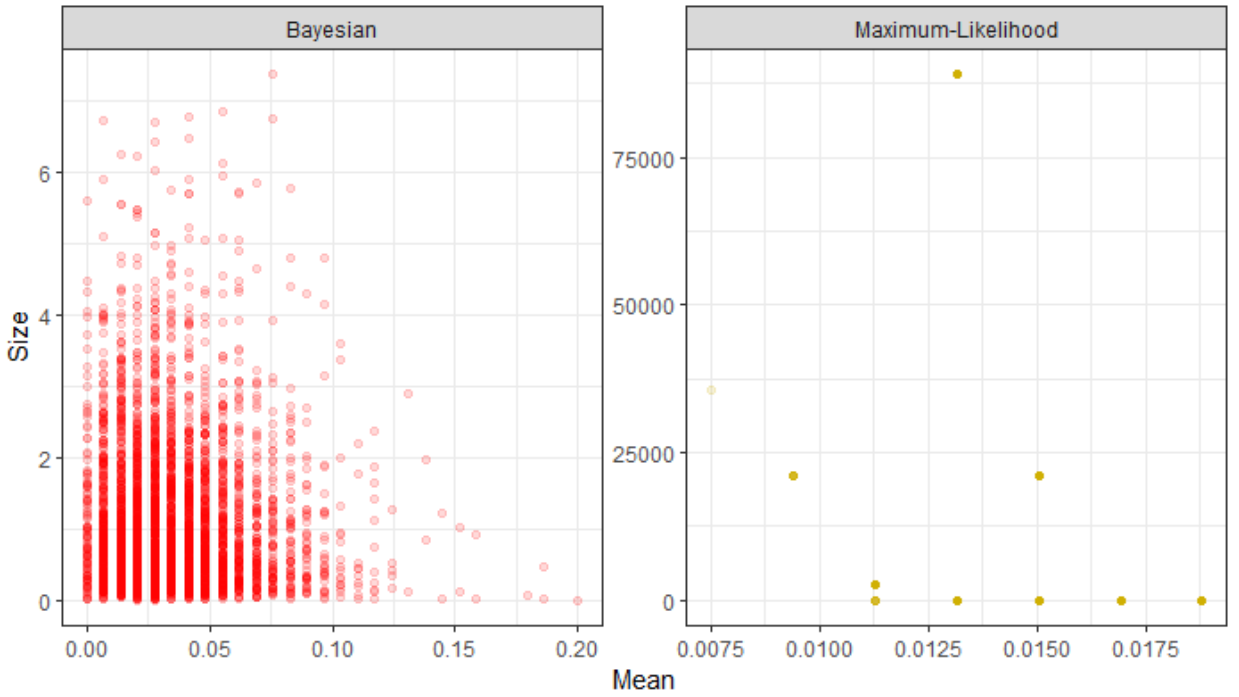

Quillback Rockfish- North Coast (FG & RG)
Observation
Maximum-Likelihood
Bayesian
Count
Number of Fish
Bayesian
Maximum-Likelihood
Size
Mean

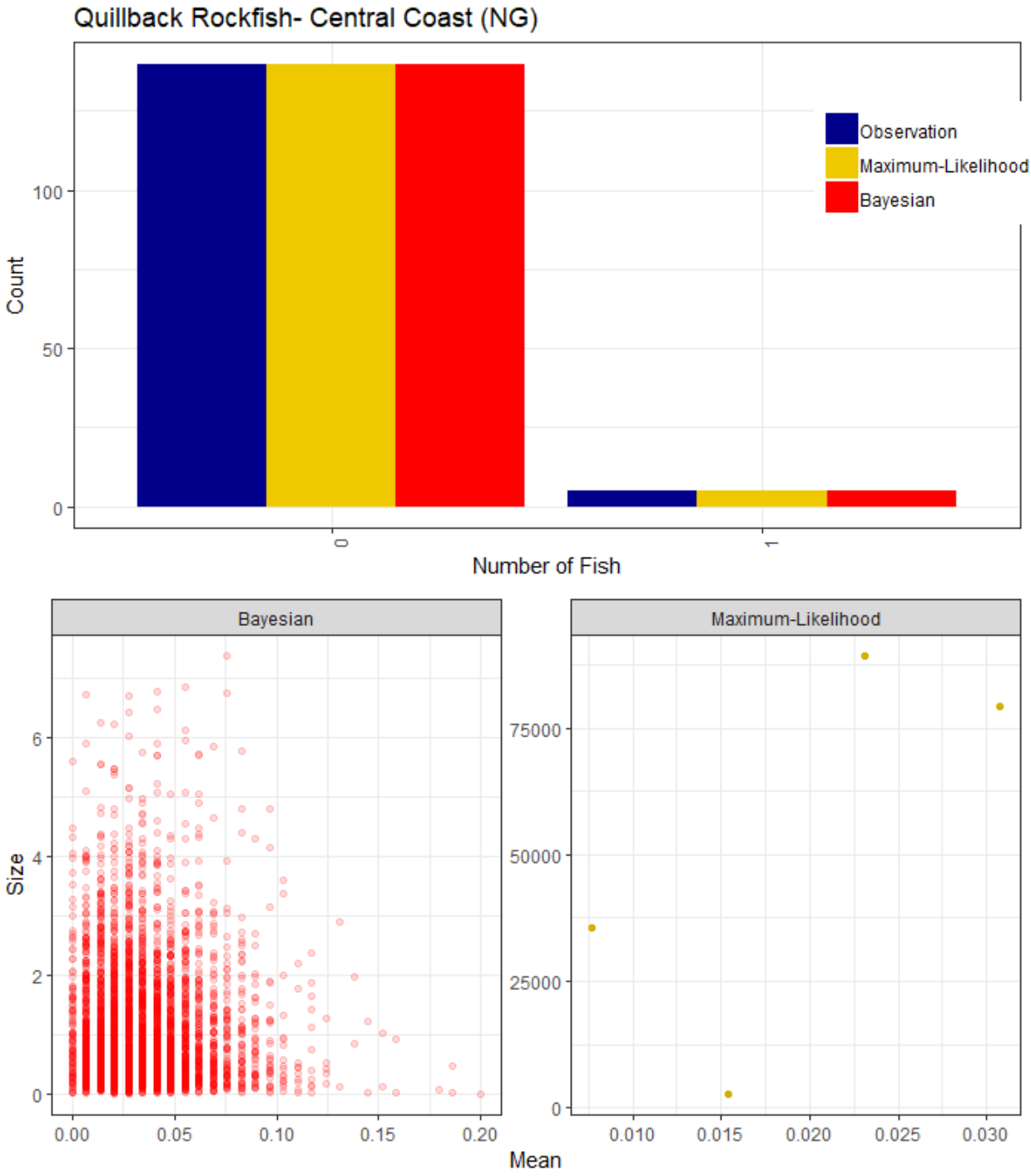

Quillback Rockfish- North Coast (FG)
Count
Number of Fish
Observation
Maximum-Likelihood
Bayesian
Bayesian
Maximum-Likelihood
Size
Mean

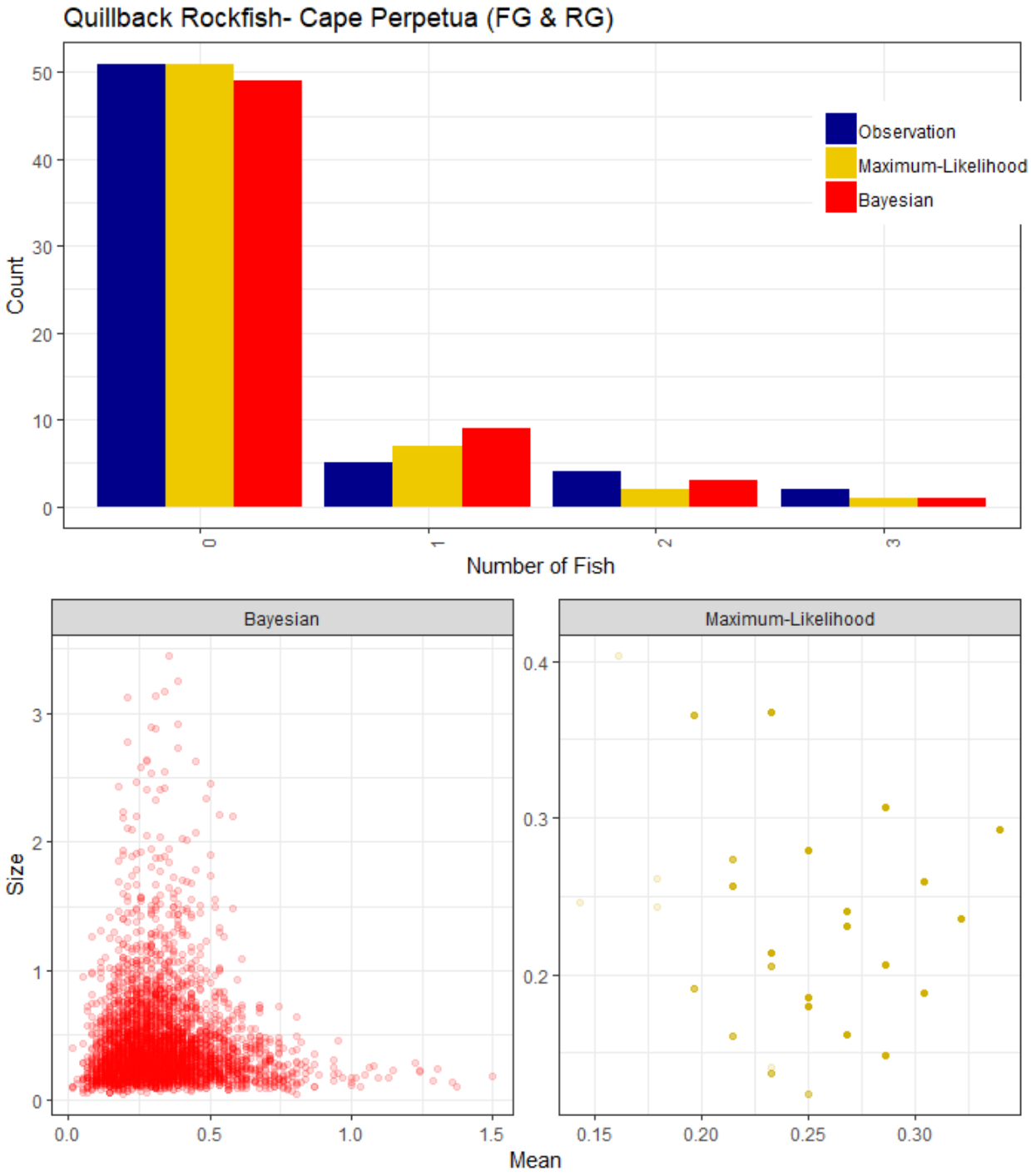

Quillback Rockfish- Central Coast (FG, RG & NG)
Count
800
600
400
200
0
Observation
Maximum-Likelihood
Bayesian
0
1
2
Number of Fish
Bayesian
Maximum-Likelihood
Size
6
4
2
0
3e+05
2e+05
1e+05
0e+00
0.025
0.050
0.075
0.025
0.030
0.035
Mean

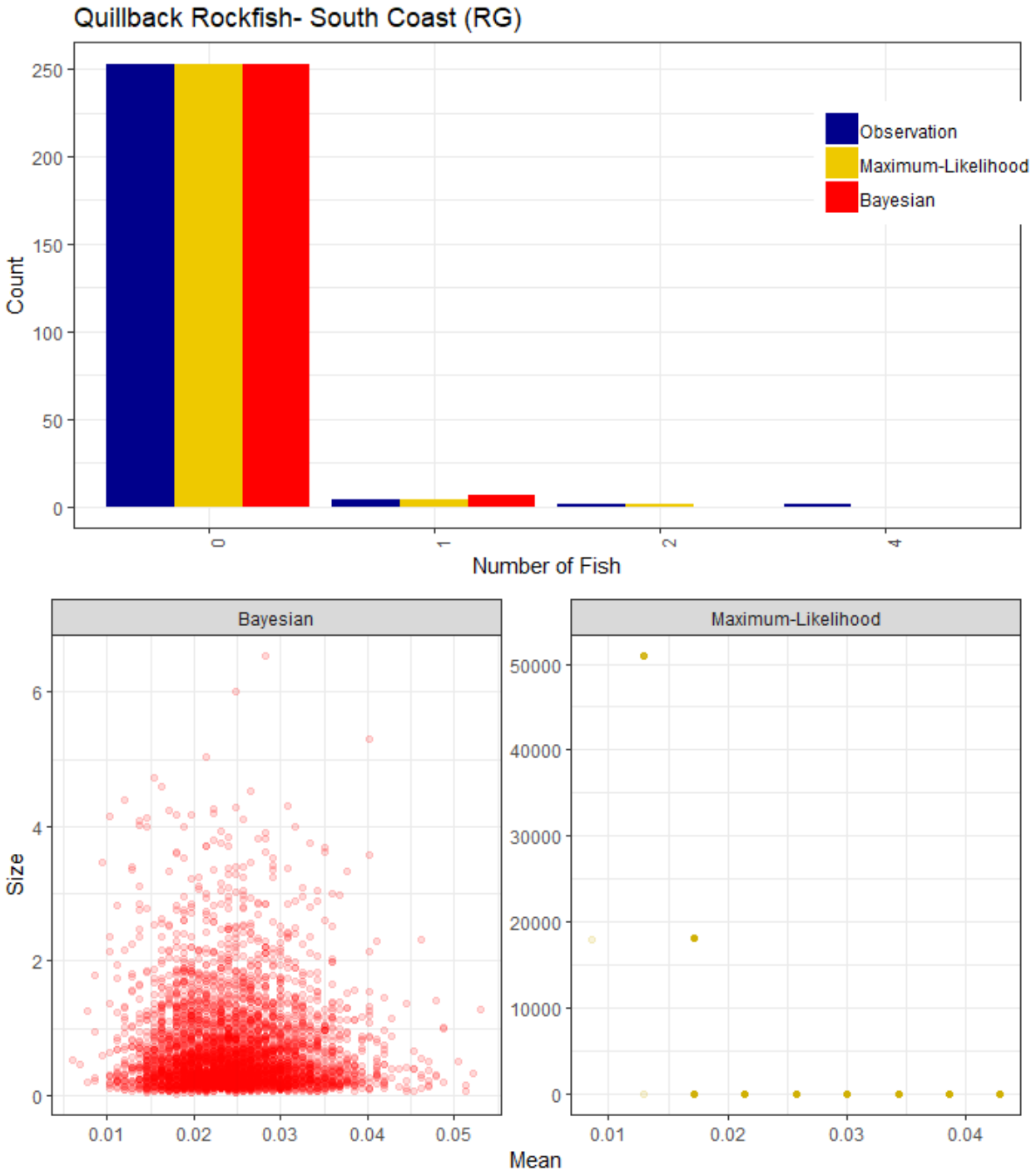

Quillback Rockfish- Central Coast (FG)
120
90
60
30
0
Count
Observation
Maximum-Likelihood
Bayesian
0
1
2
Number of Fish
Bayesian
Maximum-Likelihood
10.0
7.5
5.0
2.5
0.0
Size
120000
80000
40000
0.0
0.1
0.2
0.3
0.00
0.01
0.02
Mean

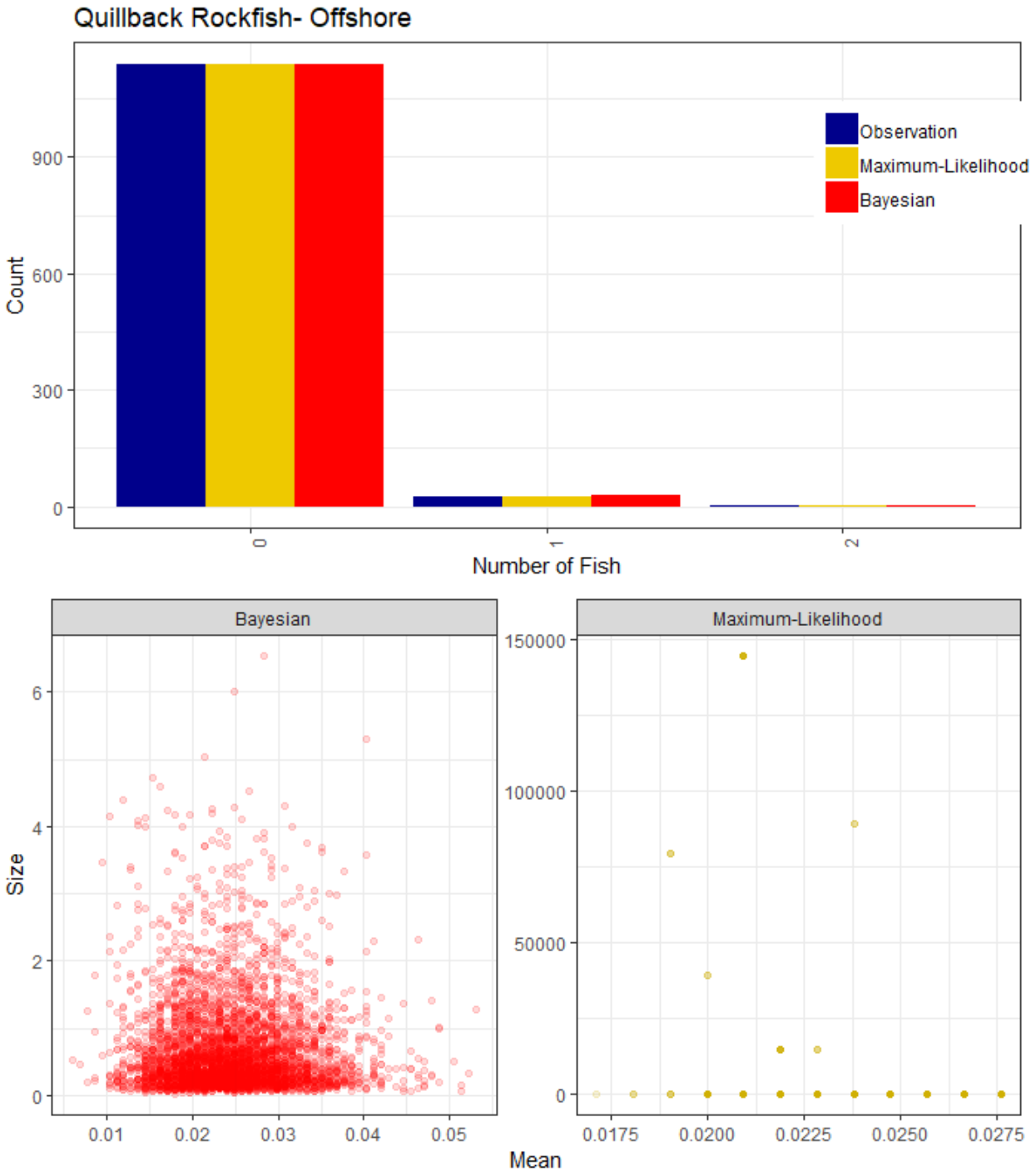

Quillback Rockfish- Central Coast (RG)
600
400
200
0
Count
Observation
Maximum-Likelihood
Bayesian
0
1
2
Number of Fish

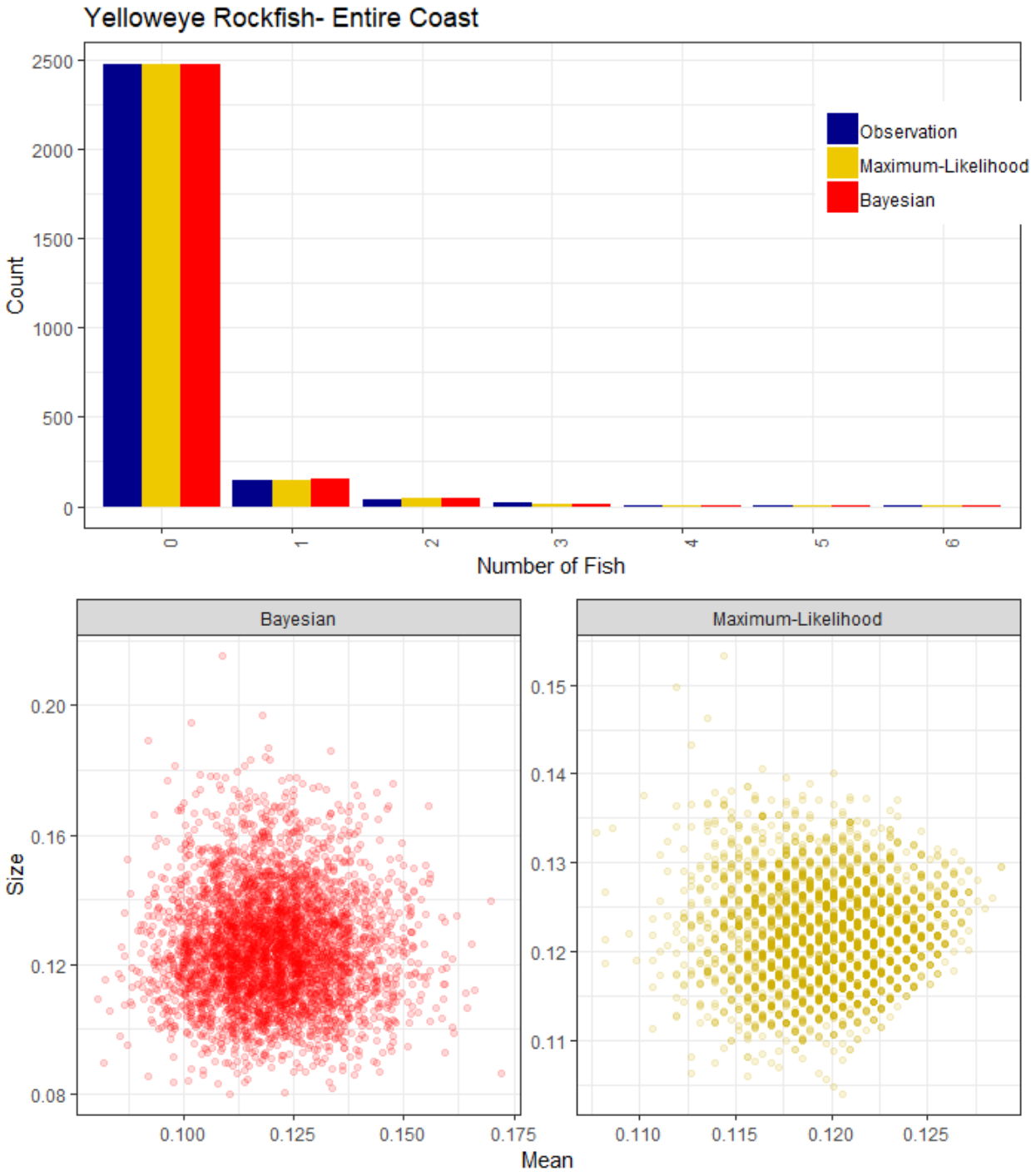

Bayesian
Maximum-Likelihood
Size
6
4
2
0
75000
50000
25000
0
0.00
0.05
0.10
0.15
0.20
0.0075
0.0100
0.0125
0.0150
0.0175
Mean

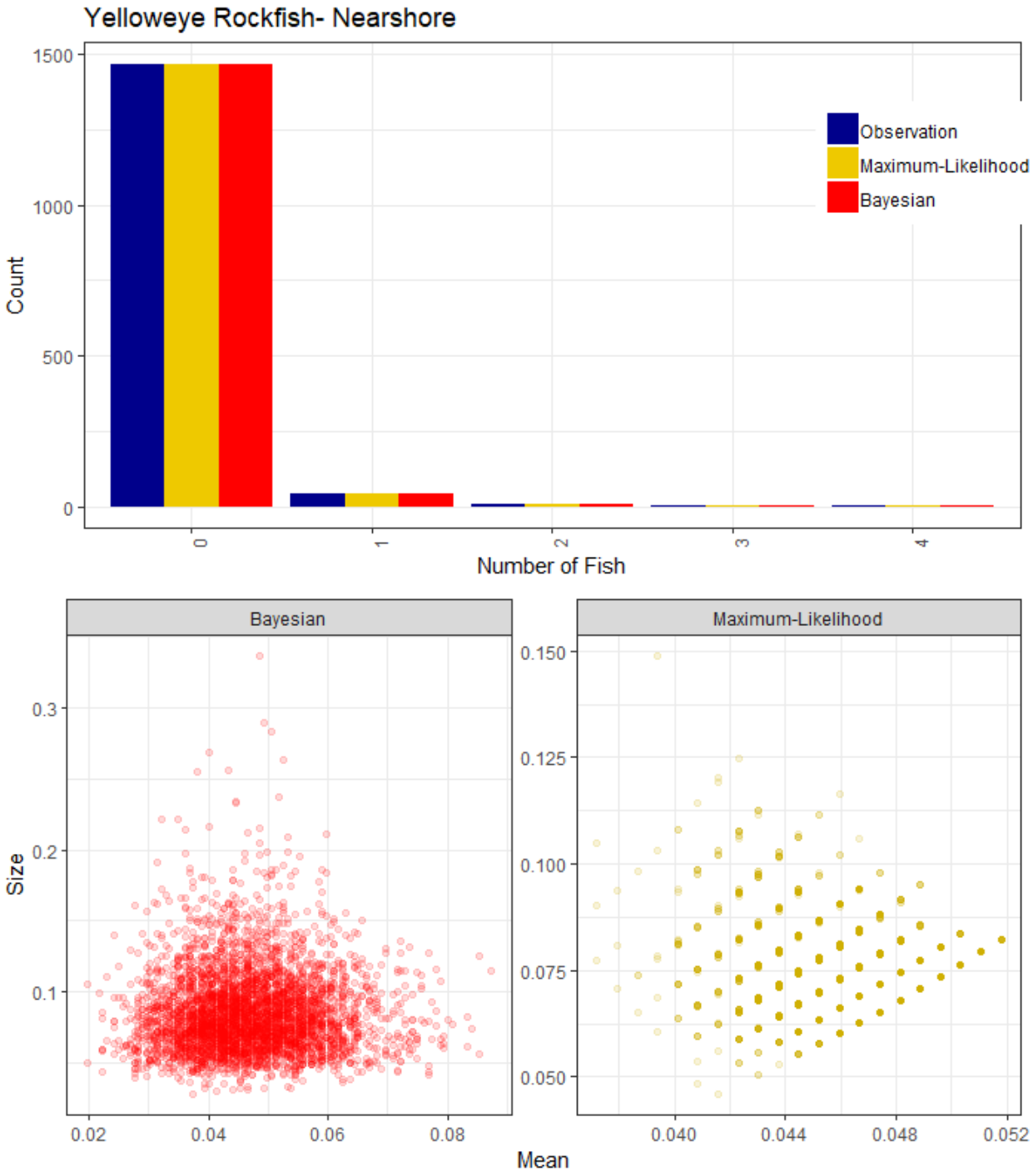

Quillback Rockfish- Central Coast (NG)
Observation
Maximum-Likelihood
Bayesian
Count
100
50
0
0
1
Number of Fish
Bayesian
Maximum-Likelihood
Size
6
4
2
0
0.00
0.05
0.10
0.15
0.20
75000
50000
25000
0
0.010
0.015
0.020
0.025
0.030
Mean

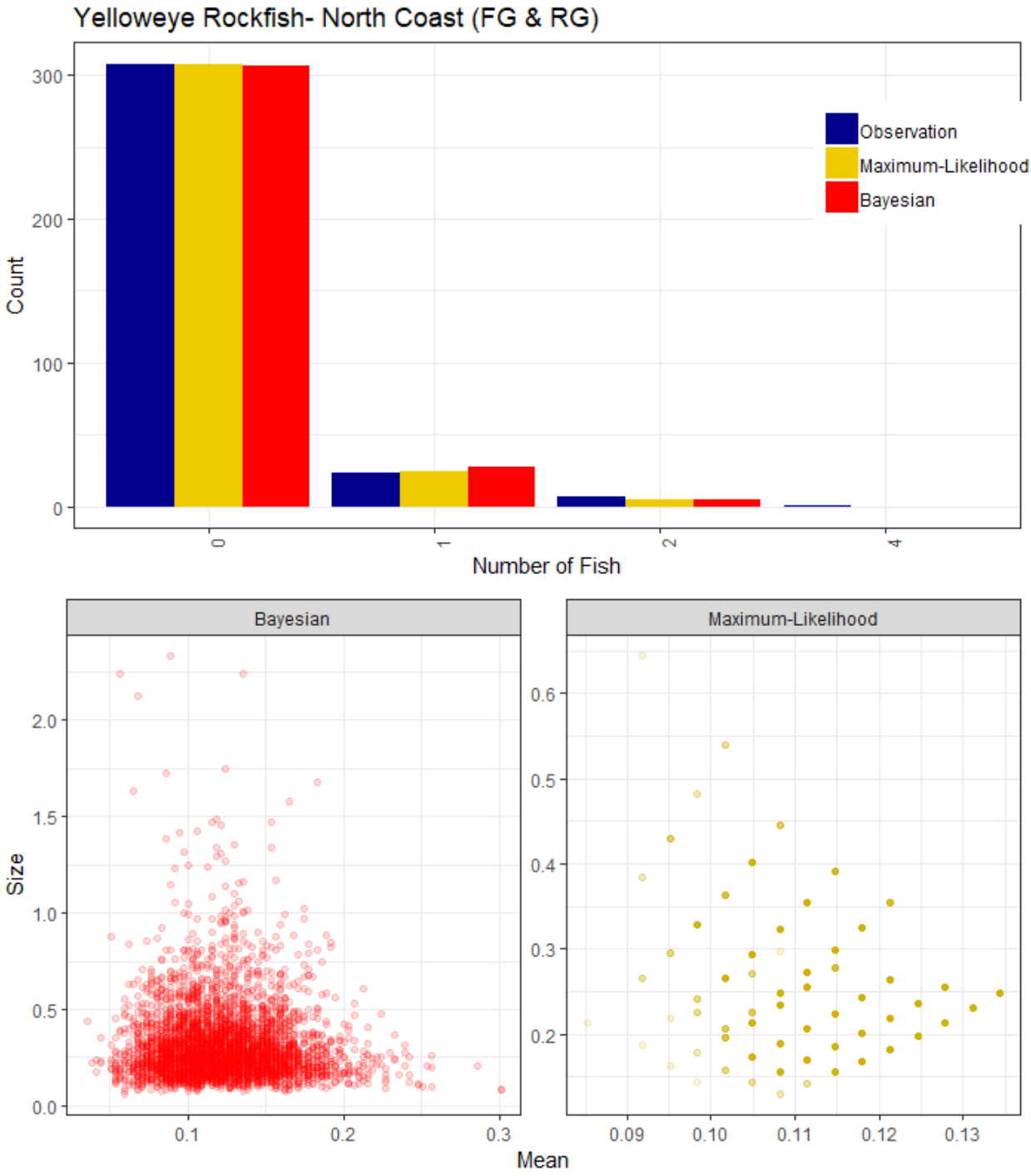

Quillback Rockfish- Cape Perpetua (FG & RG)
Count
Number of Fish
Observation
Maximum-Likelihood
Bayesian
Bayesian
Maximum-Likelihood
Size
Mean

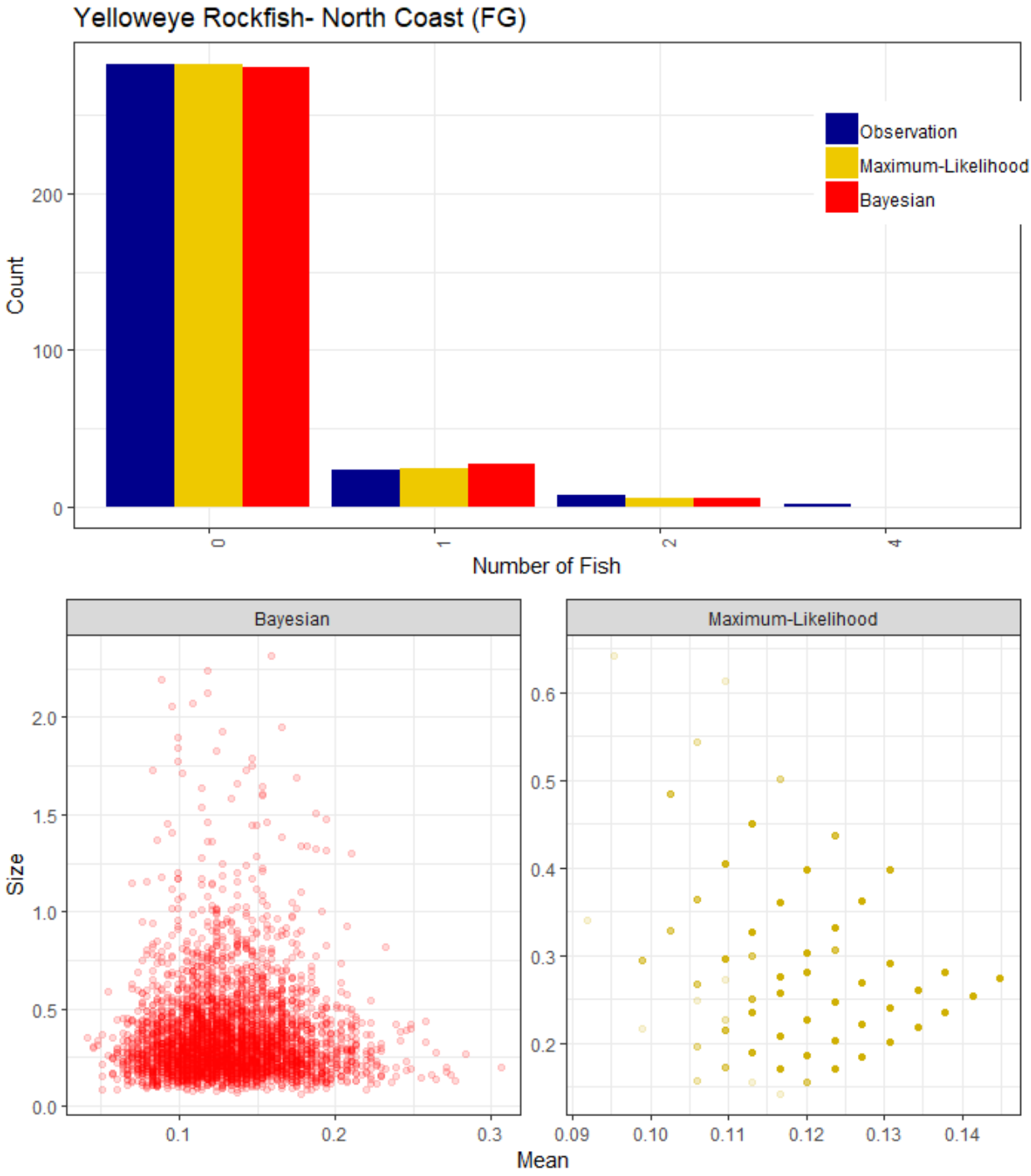

Quillback Rockfish- South Coast (RG)
Count
Number of Fish
Observation
Maximum-Likelihood
Bayesian
Bayesian
Maximum-Likelihood
Size
Mean

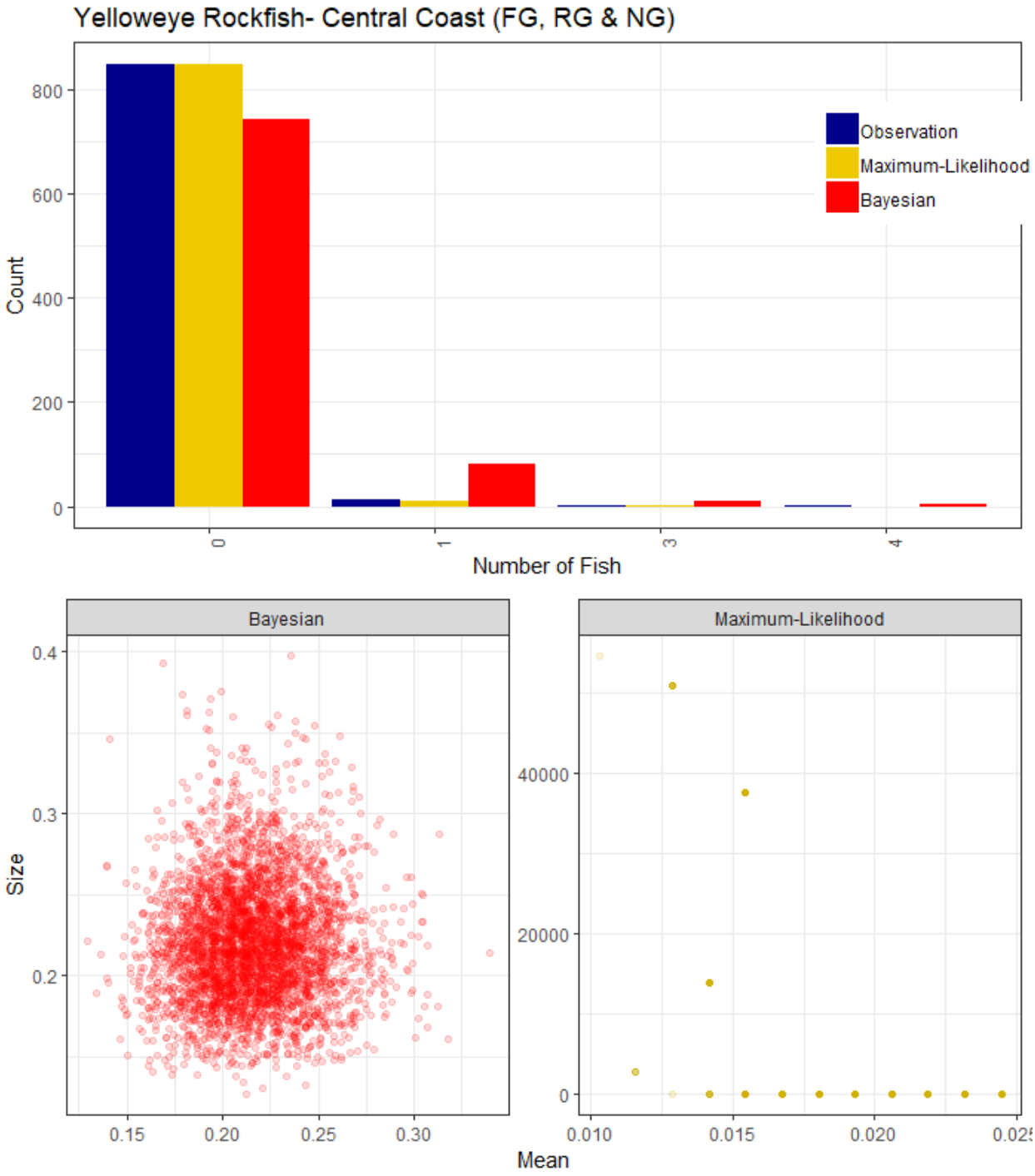

Quillback Rockfish- Offshore
Observation
Maximum-Likelihood
Bayesian
Count
900
600
300
0
0
1
2
Number of Fish
Bayesian
Maximum-Likelihood
Size
6
4
2
0
150000
100000
50000
0
0.01
0.02
0.03
0.04
0.05
0.0175
0.0200
0.0225
0.0250
0.0275
Mean

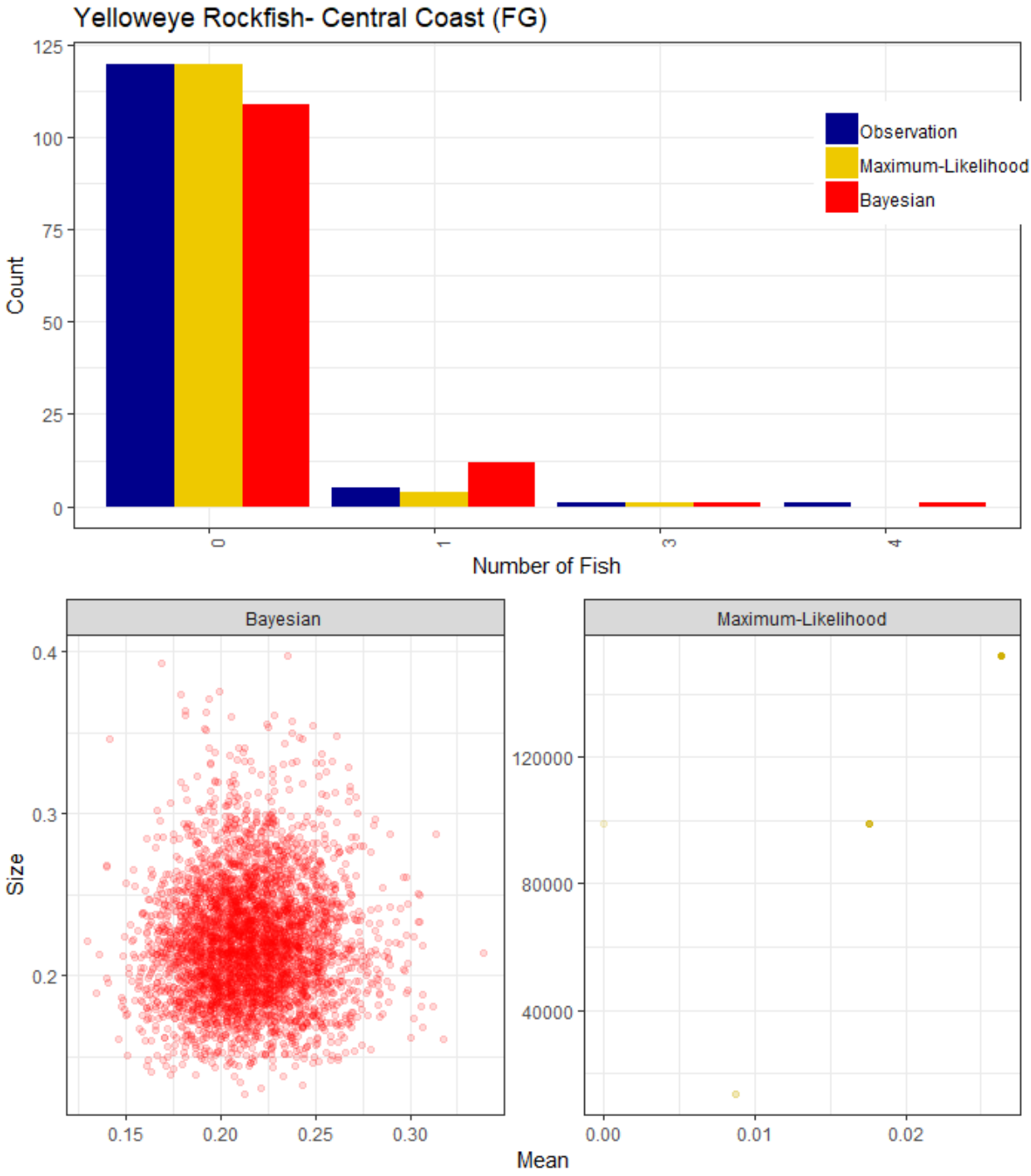

Yelloweye Rockfish- Entire Coast
Count
Number of Fish
Observation
Maximum-Likelihood
Bayesian
Bayesian
Maximum-Likelihood
Size
Mean

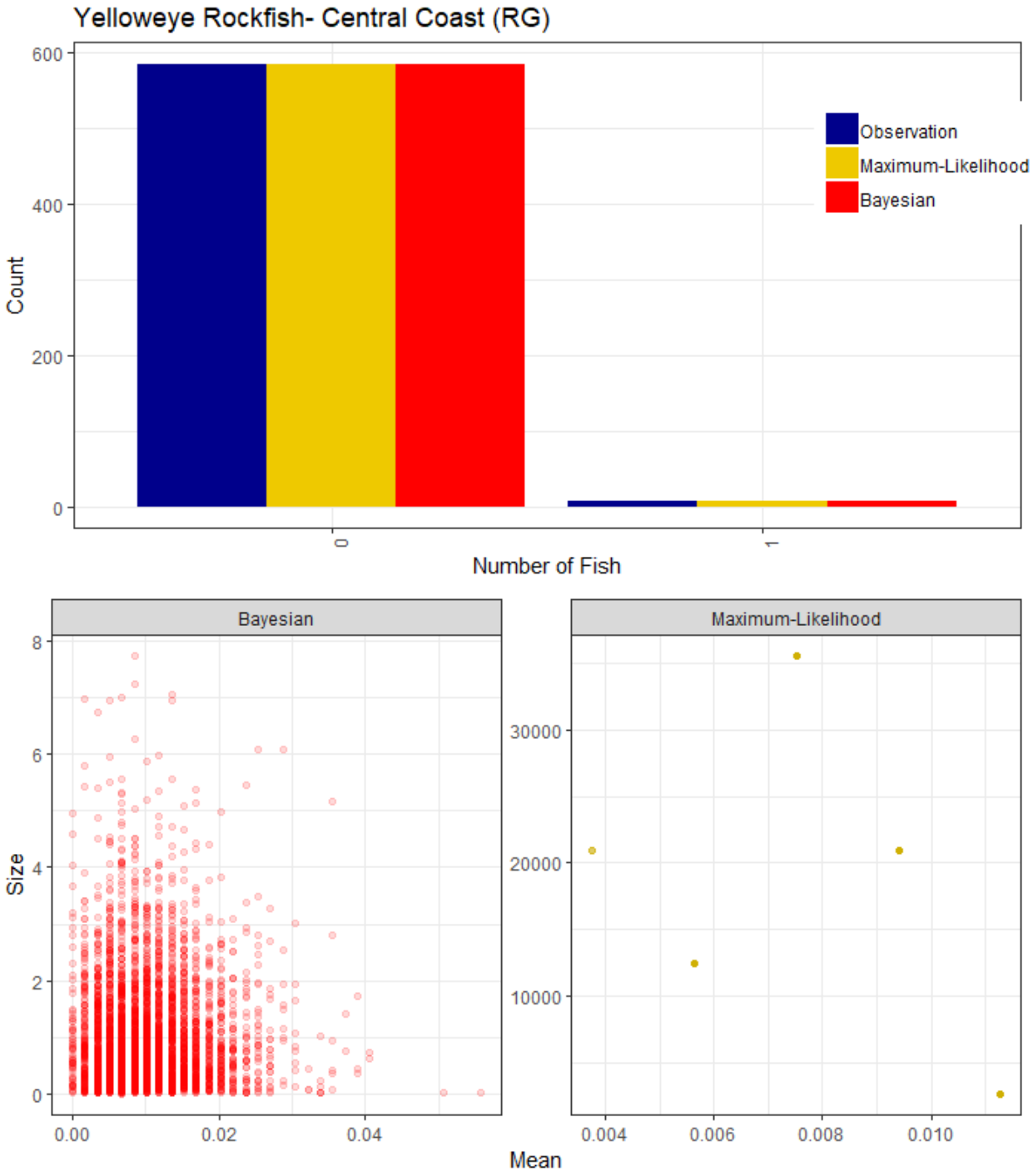

Yelloweye Rockfish- Nearshore
Count
1500
1000
500
0
Observation
Maximum-Likelihood
Bayesian
0
1
2
3
4
Number of Fish
Bayesian
Maximum-Likelihood
Size
0.3
0.2
0.1
0.150
0.125
0.100
0.075
0.050
0.02
0.04
0.06
0.08
0.040
0.044
0.048
0.052
Mean

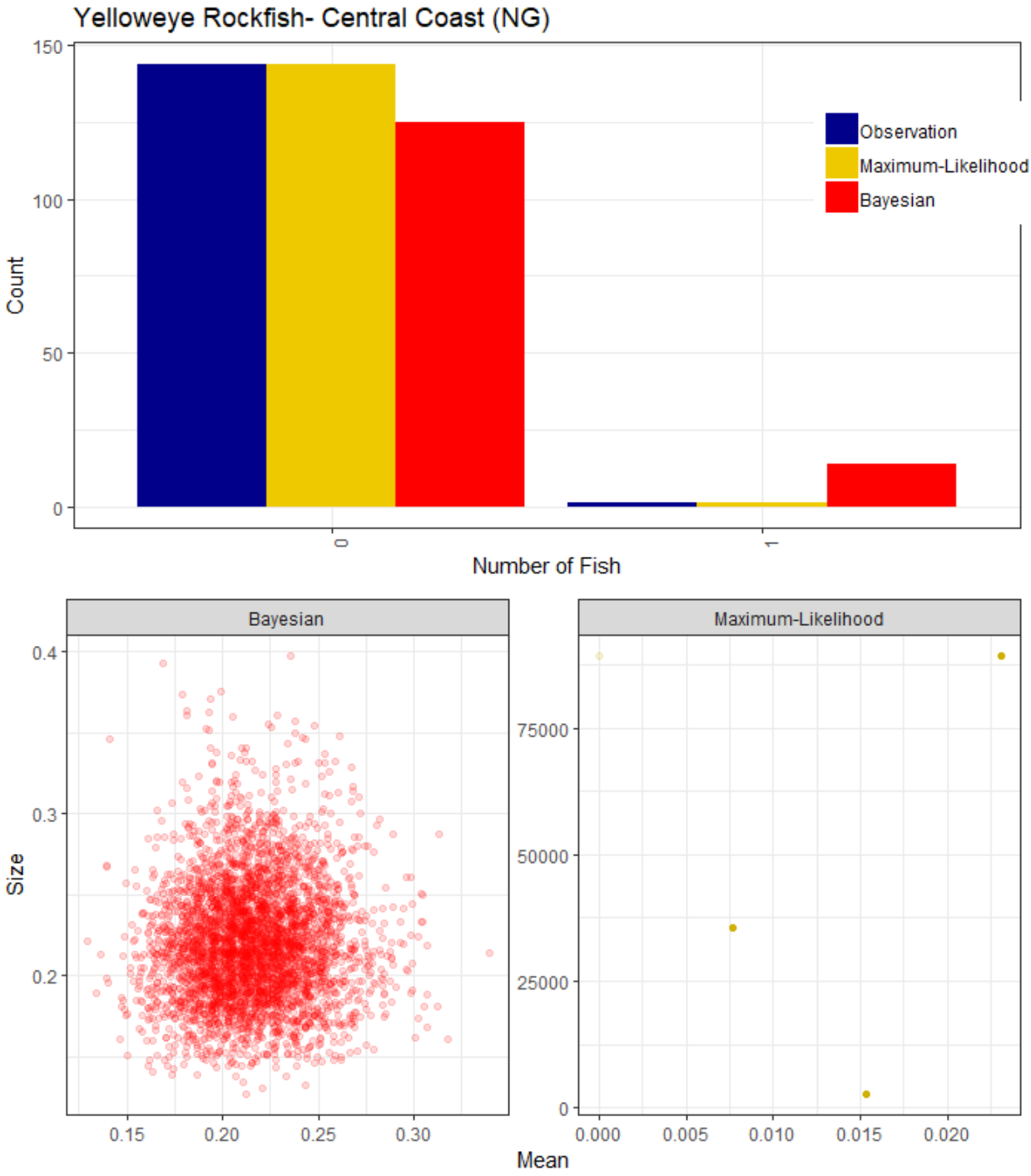

Yelloweye Rockfish- North Coast (FG & RG)
Count
Number of Fish
Observation
Maximum-Likelihood
Bayesian
Bayesian
Maximum-Likelihood
Size
Mean

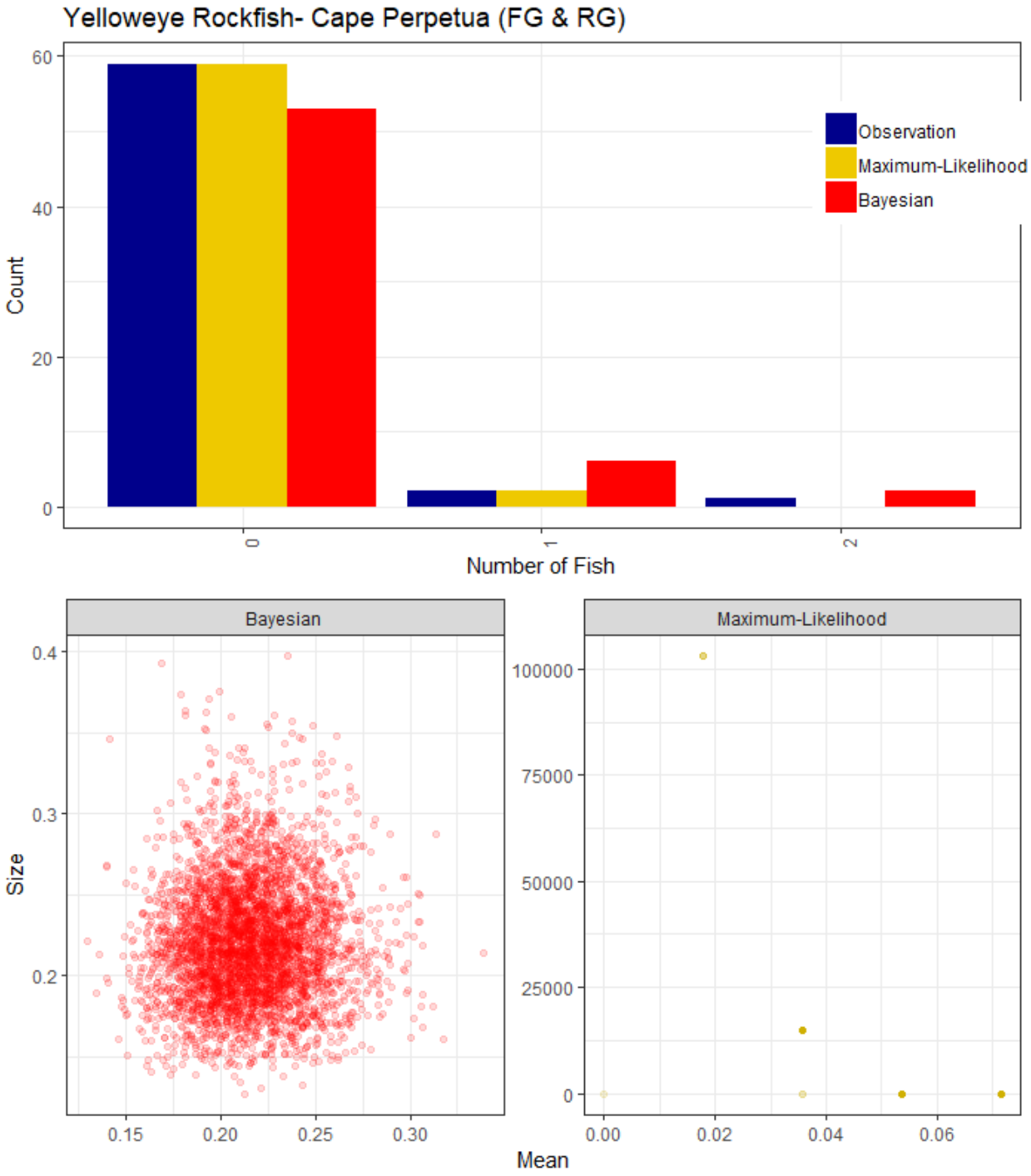

Yelloweye Rockfish- North Coast (FG)
Observation
Maximum-Likelihood
Bayesian
Count
200
100
0
0
1
2
4
Number of Fish
Bayesian
Maximum-Likelihood
Size
2.0
1.5
1.0
0.5
0.0
0.6
0.5
0.4
0.3
0.2
0.1
0.2
0.3
0.09
0.10
0.11
0.12
0.13
0.14
Mean

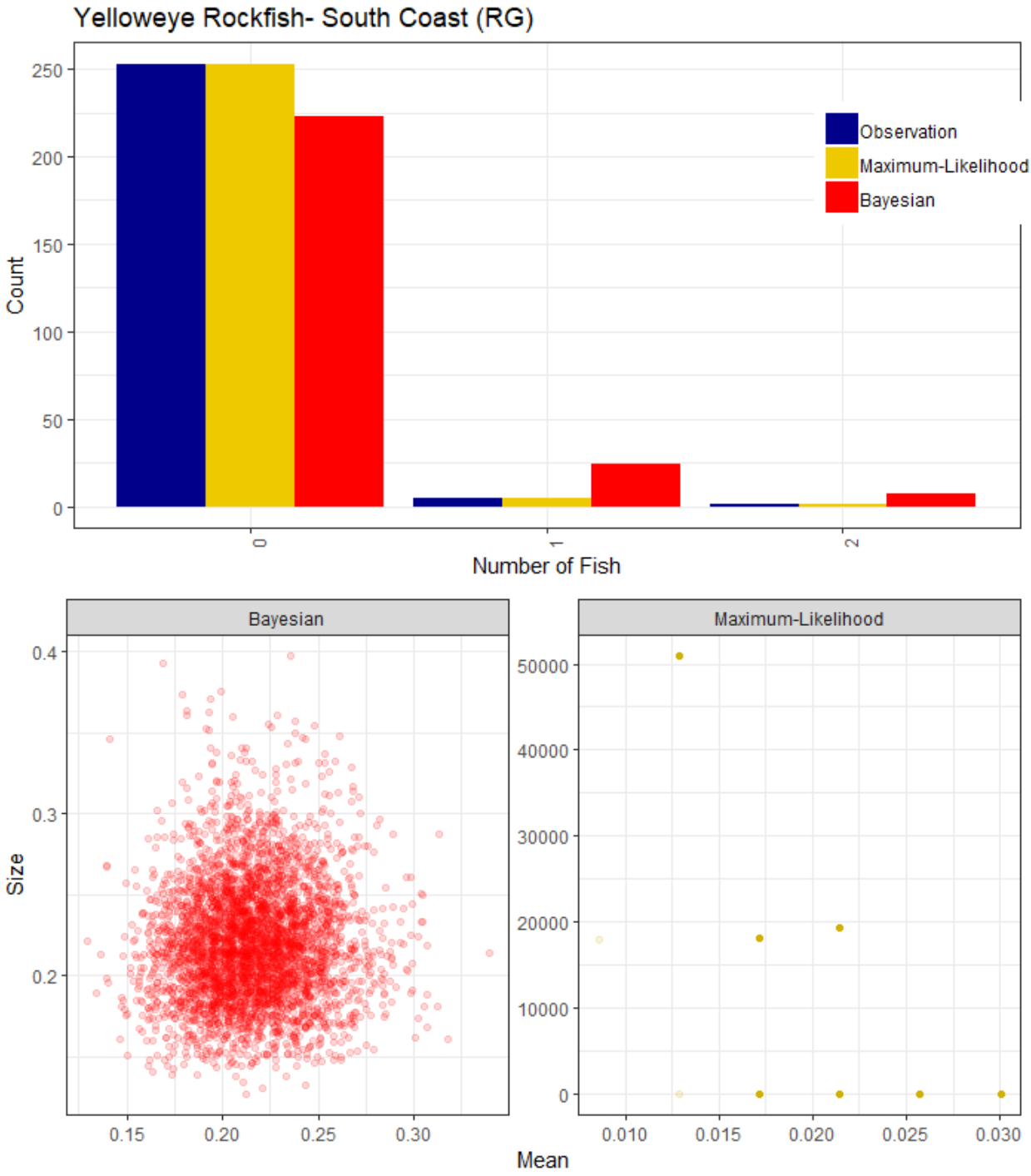

Yelloweye Rockfish- Central Coast (FG, RG & NG)
Observation
Maximum-Likelihood
Bayesian
Count
Number of Fish
Bayesian
Maximum-Likelihood
Size
Mean

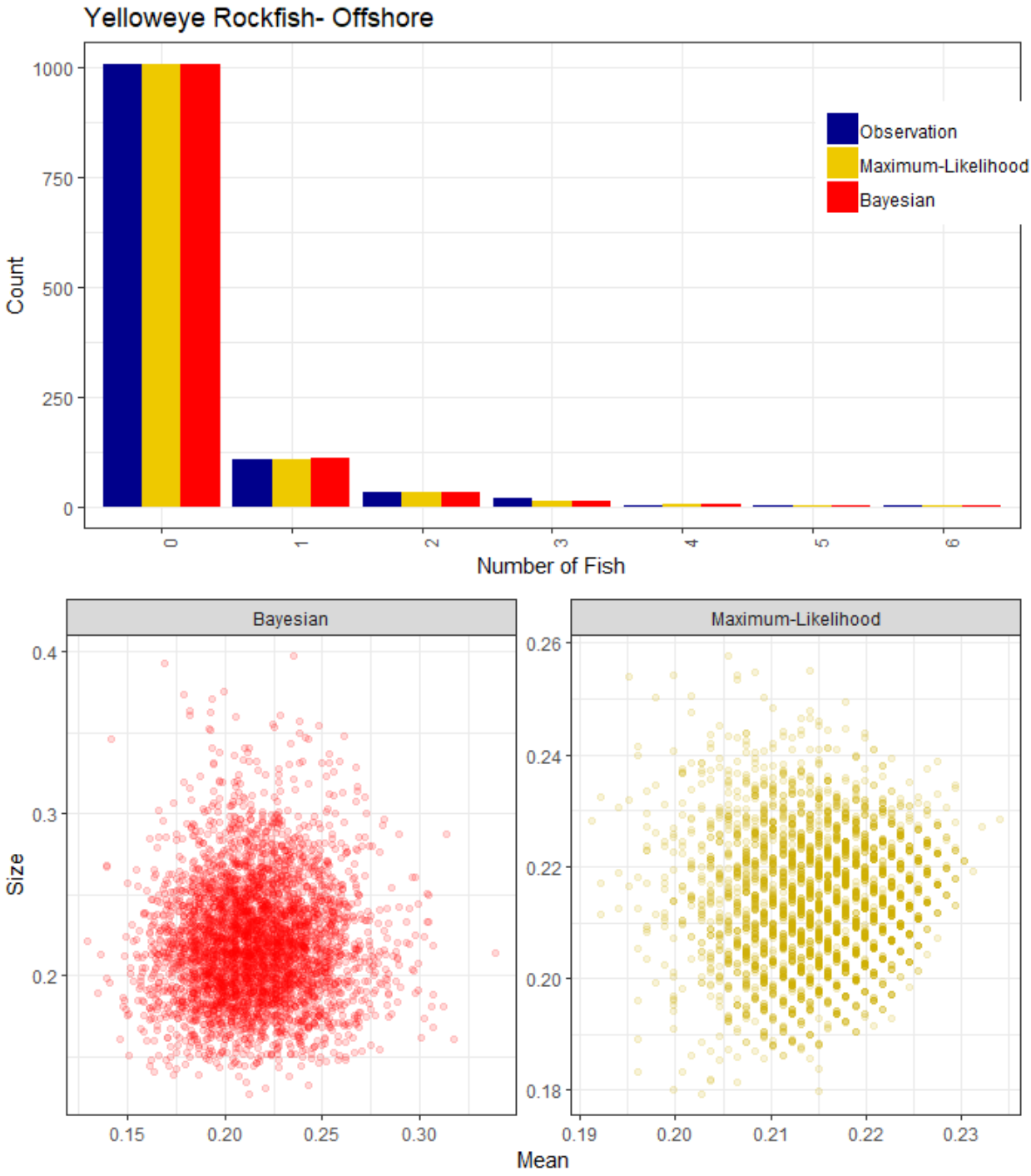

Yelloweye Rockfish- Central Coast (FG)
Count
Number of Fish
Observation
Maximum-Likelihood
Bayesian
Bayesian
Maximum-Likelihood
Size
Mean

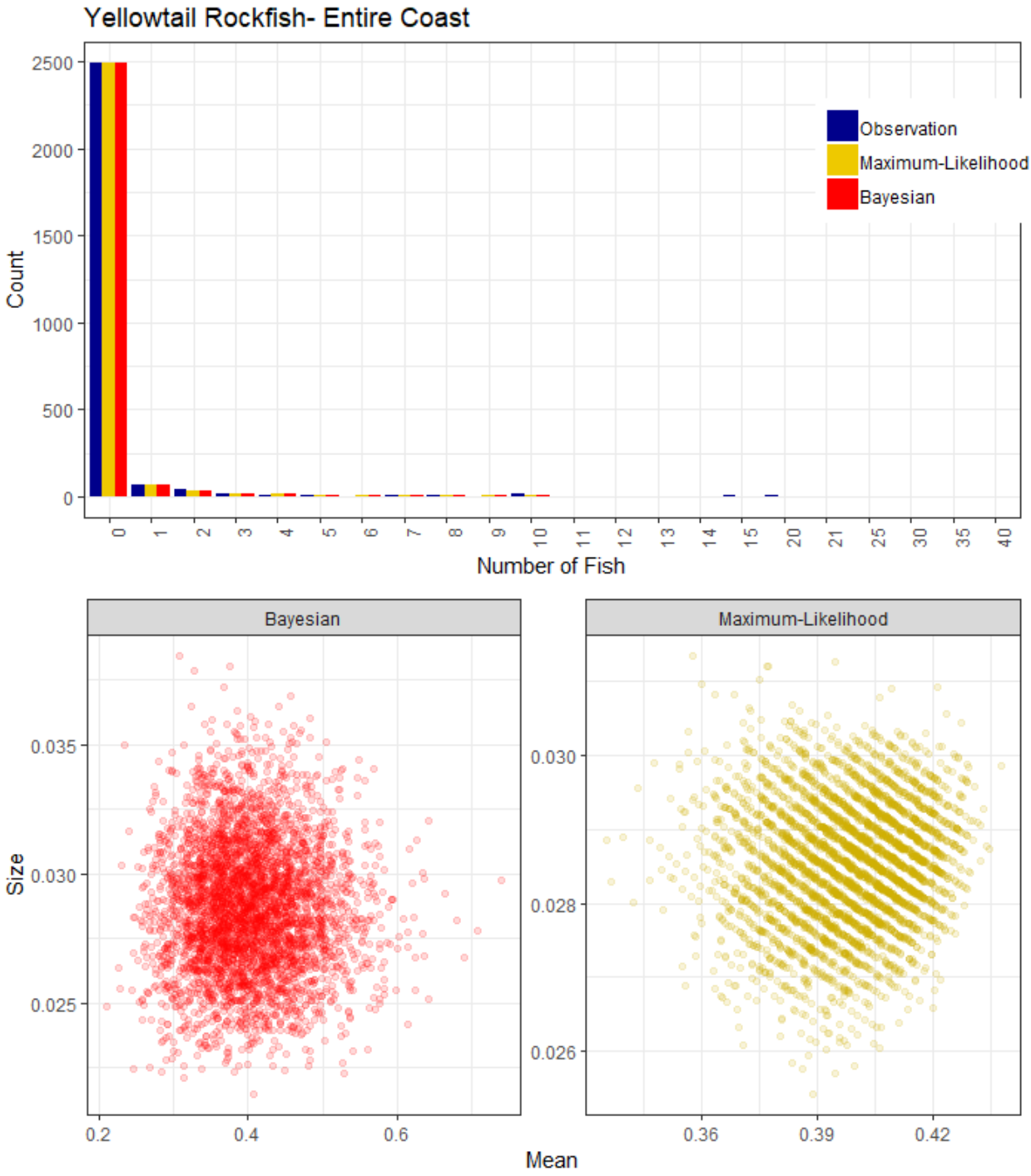

Yelloweye Rockfish- Central Coast (RG)
600
400
200
0
Count
Observation
Maximum-Likelihood
Bayesian
0
1
Number of Fish
Bayesian
Maximum-Likelihood
8
6
4
2
0
Size
30000
20000
10000
0.00
0.02
0.04
0.004
0.006
0.008
0.010
Mean

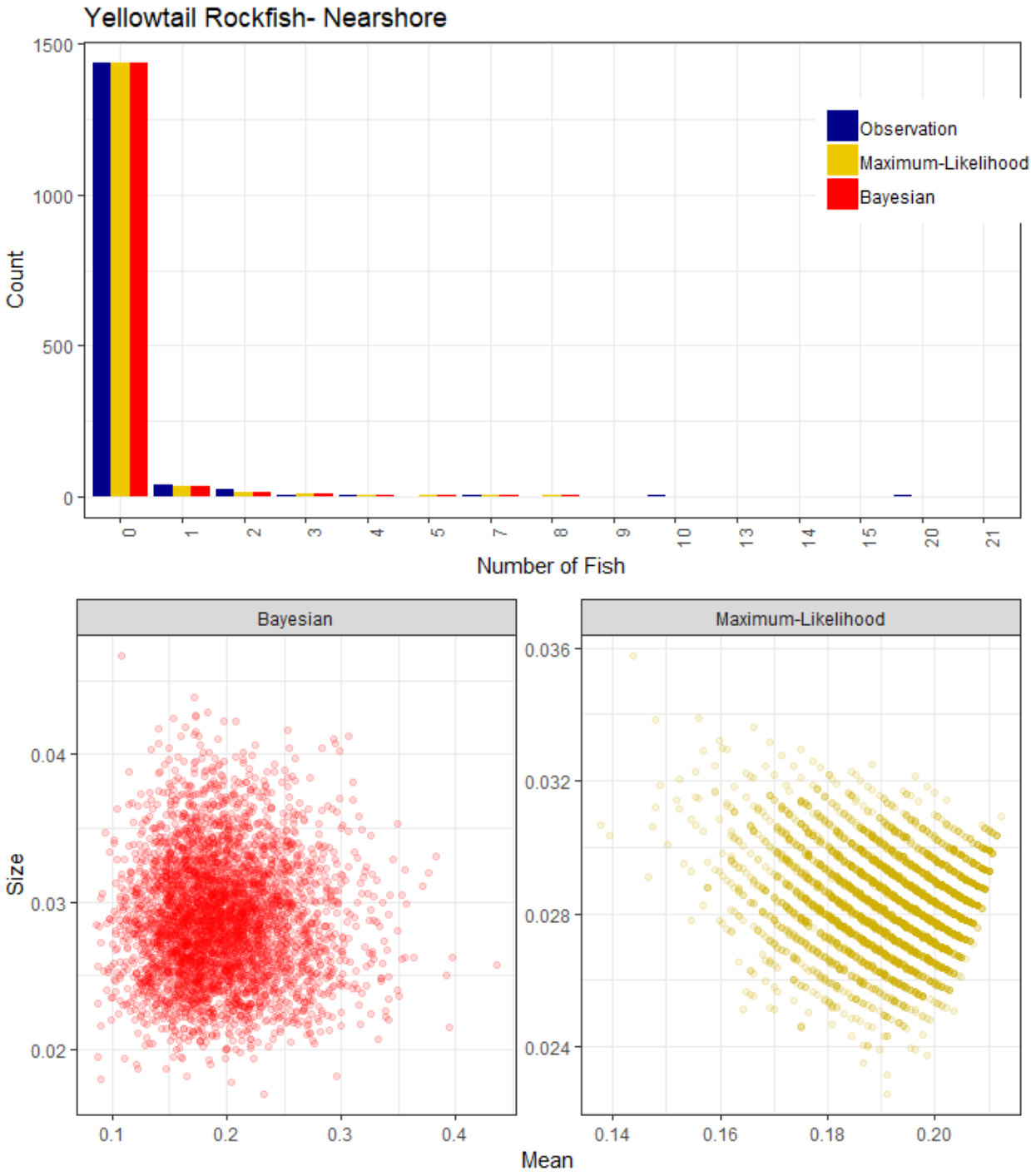

Yelloweye Rockfish- Central Coast (NG)
150
100
50
0
Count
Observation
Maximum-Likelihood
Bayesian
0
1
Number of Fish
Bayesian
Maximum-Likelihood
0.4
0.3
0.2
Size
75000
50000
25000
0
0.15
0.20
0.25
0.30
0.000
0.005
0.010
0.015
0.020
Mean

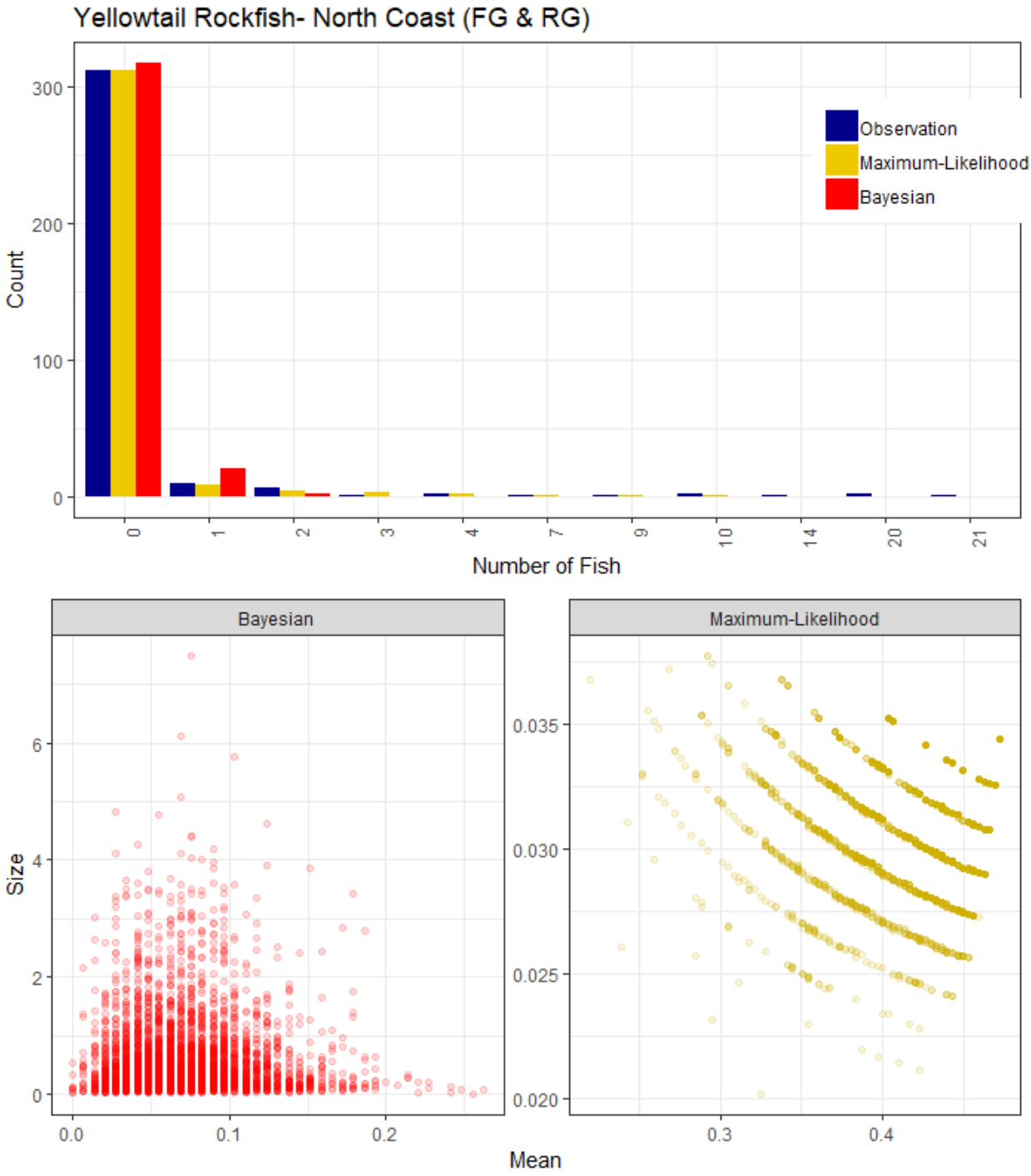

Yelloweye Rockfish- Cape Perpetua (FG & RG)
Count
Number of Fish
Observation
Maximum-Likelihood
Bayesian
Bayesian
Maximum-Likelihood
Size
Mean

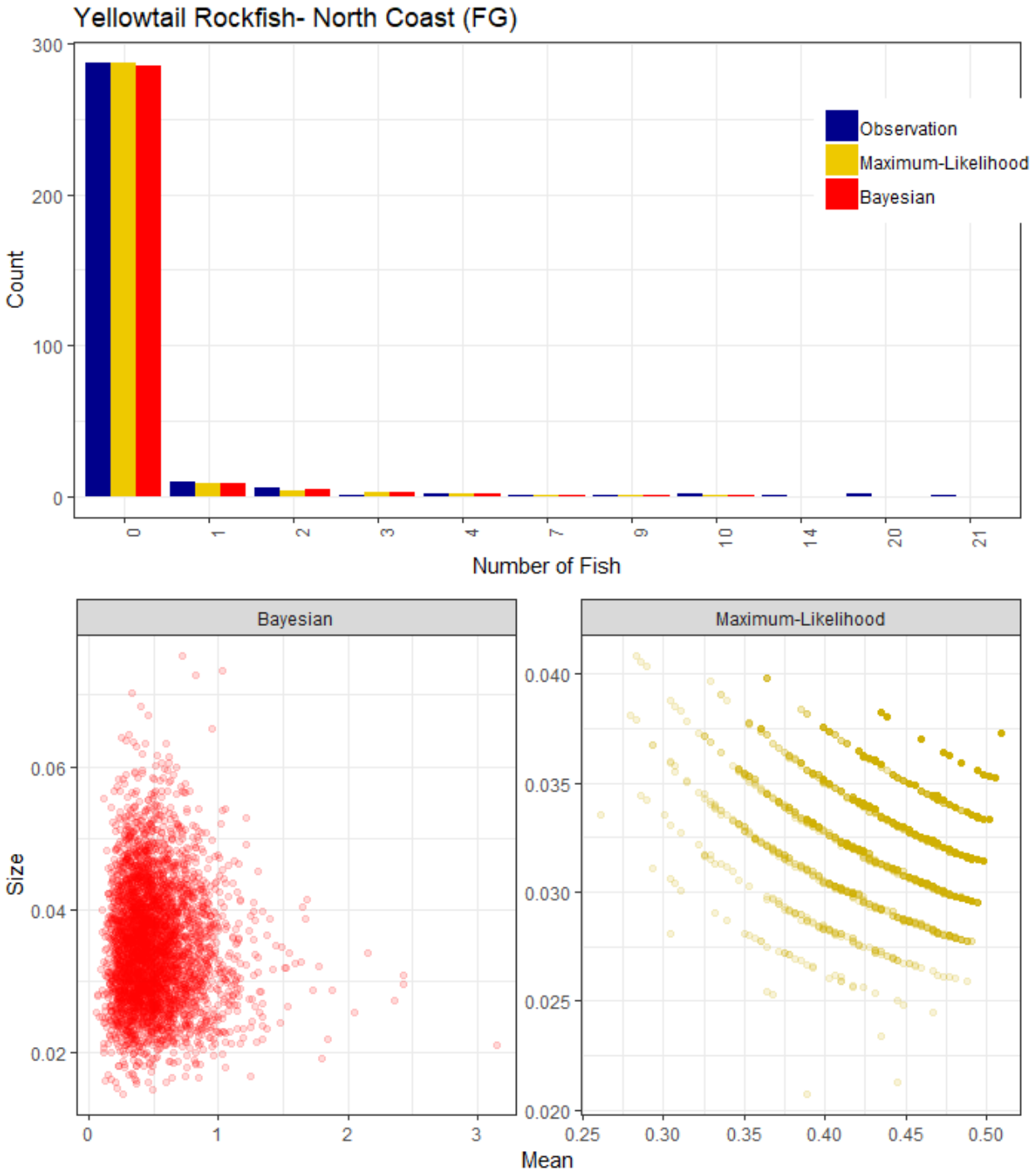

Yelloweye Rockfish- South Coast (RG)
Count
Number of Fish
Observation
Maximum-Likelihood
Bayesian
Bayesian
Maximum-Likelihood
Size
Mean

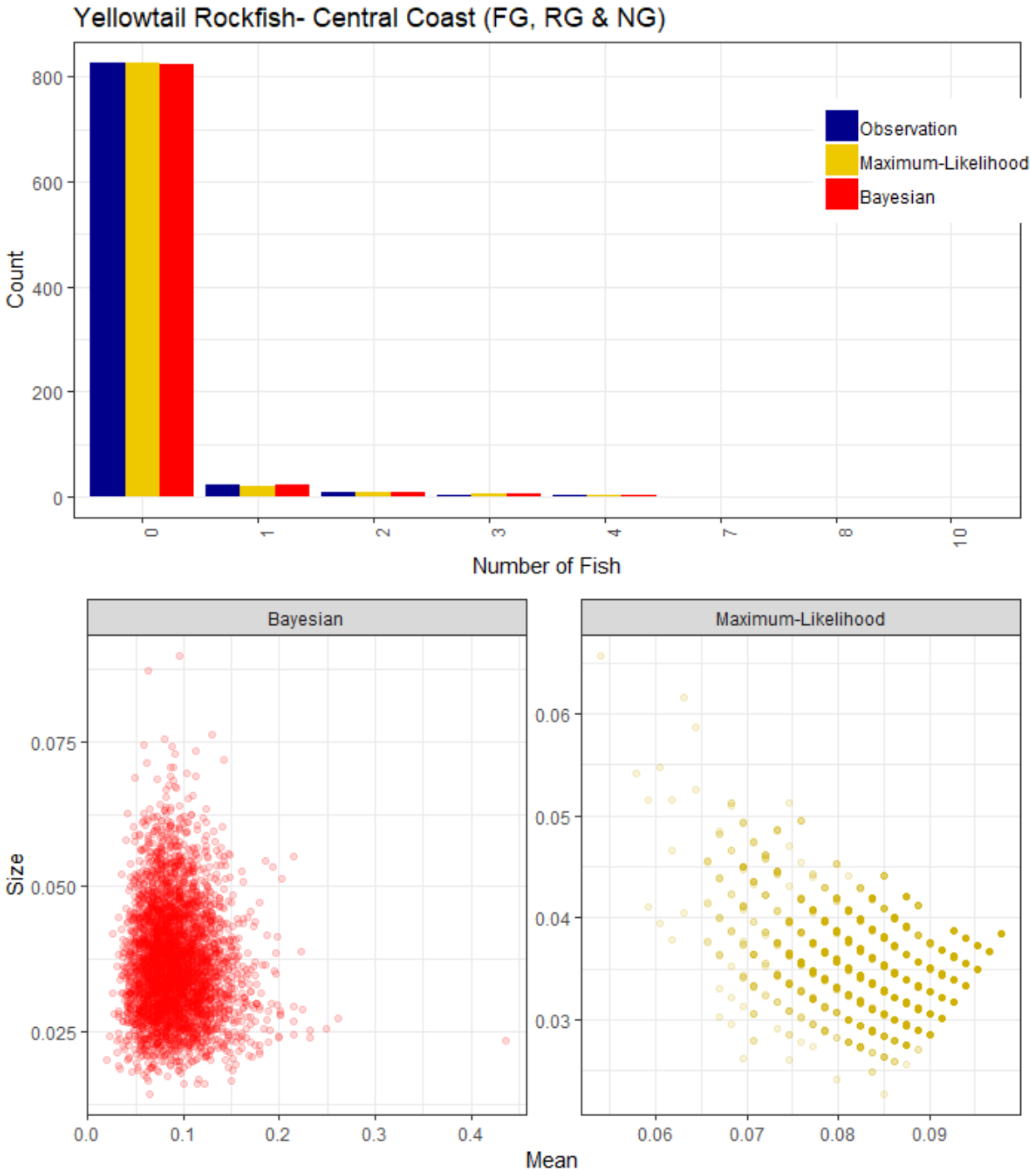

Yelloweye Rockfish- Offshore
Count
1000
750
500
250
0
0
1
2
3
4
5
6
Number of Fish
Observation
Maximum-Likelihood
Bayesian
Bayesian
Maximum-Likelihood
Size
0.4
0.3
0.2
0.26
0.24
0.22
0.20
0.18
0.15
0.20
0.25
0.30
0.19
0.20
0.21
0.22
0.23
Mean

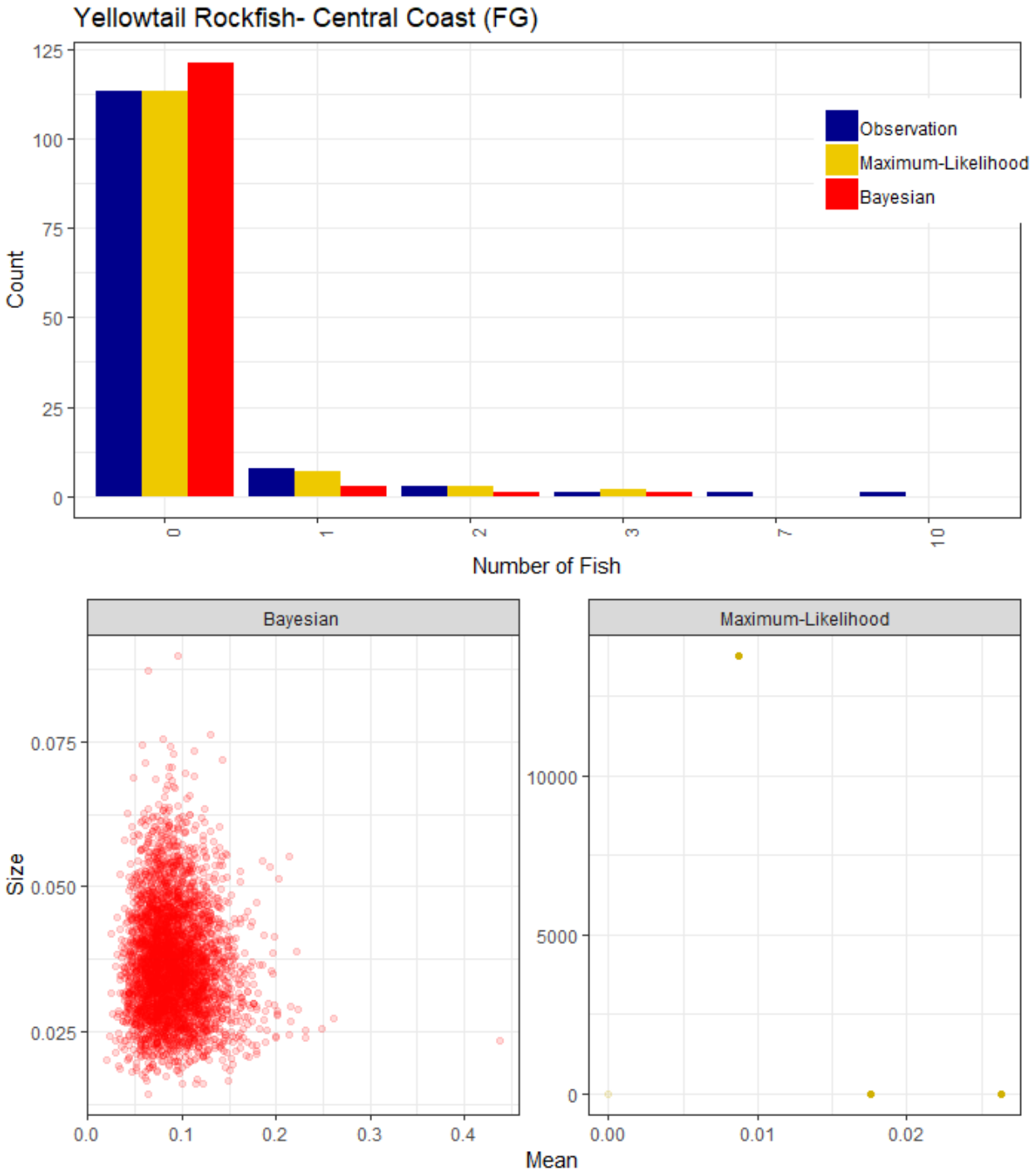

Yellowtail Rockfish- Entire Coast
Observation
Maximum-Likelihood
Bayesian
Count
Number of Fish
Bayesian
Maximum-Likelihood
Size
Mean

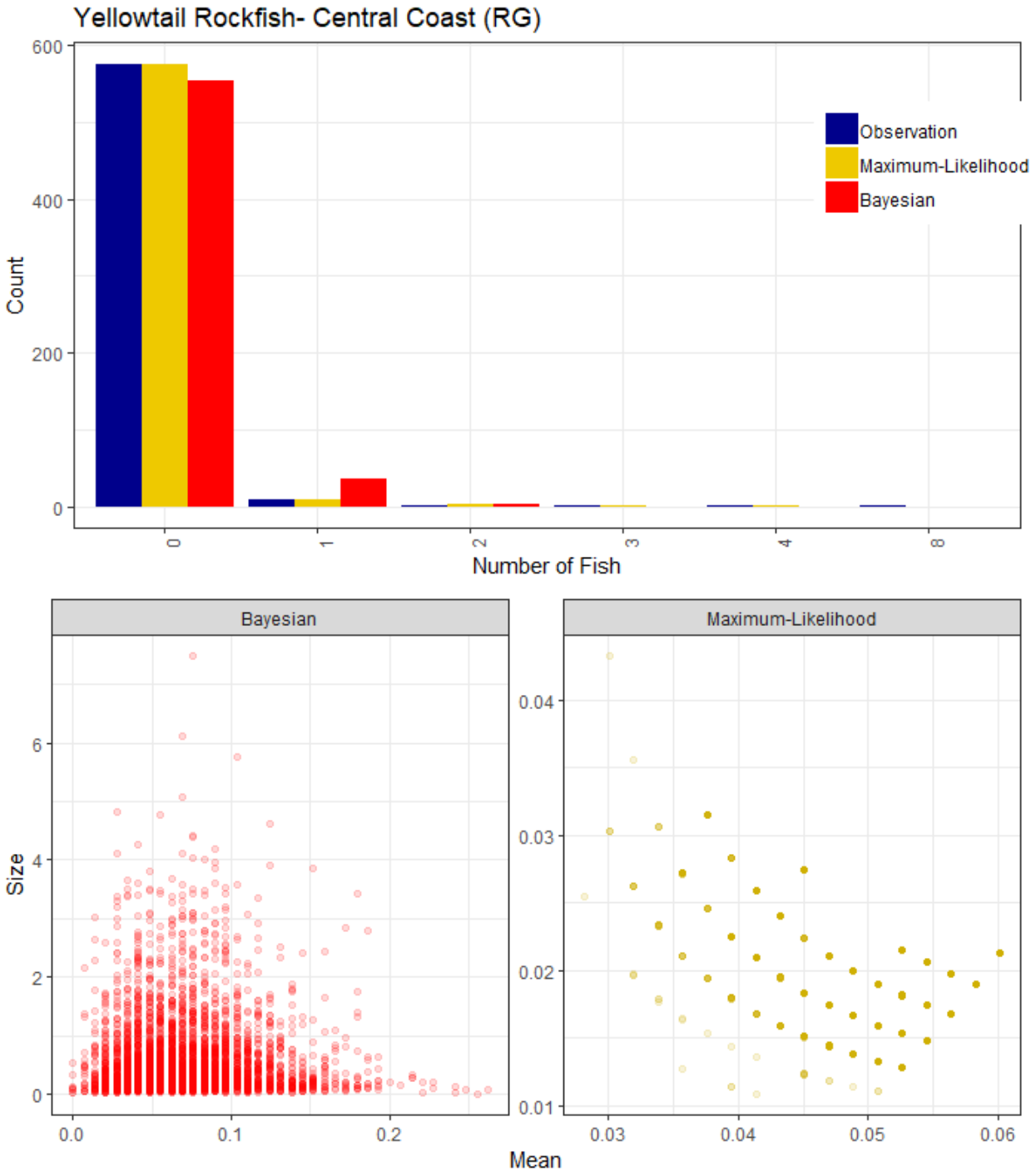

Yellowtail Rockfish- Nearshore
Observation
Maximum-Likelihood
Bayesian
Count
Number of Fish
Bayesian
Maximum-Likelihood
Size
Mean

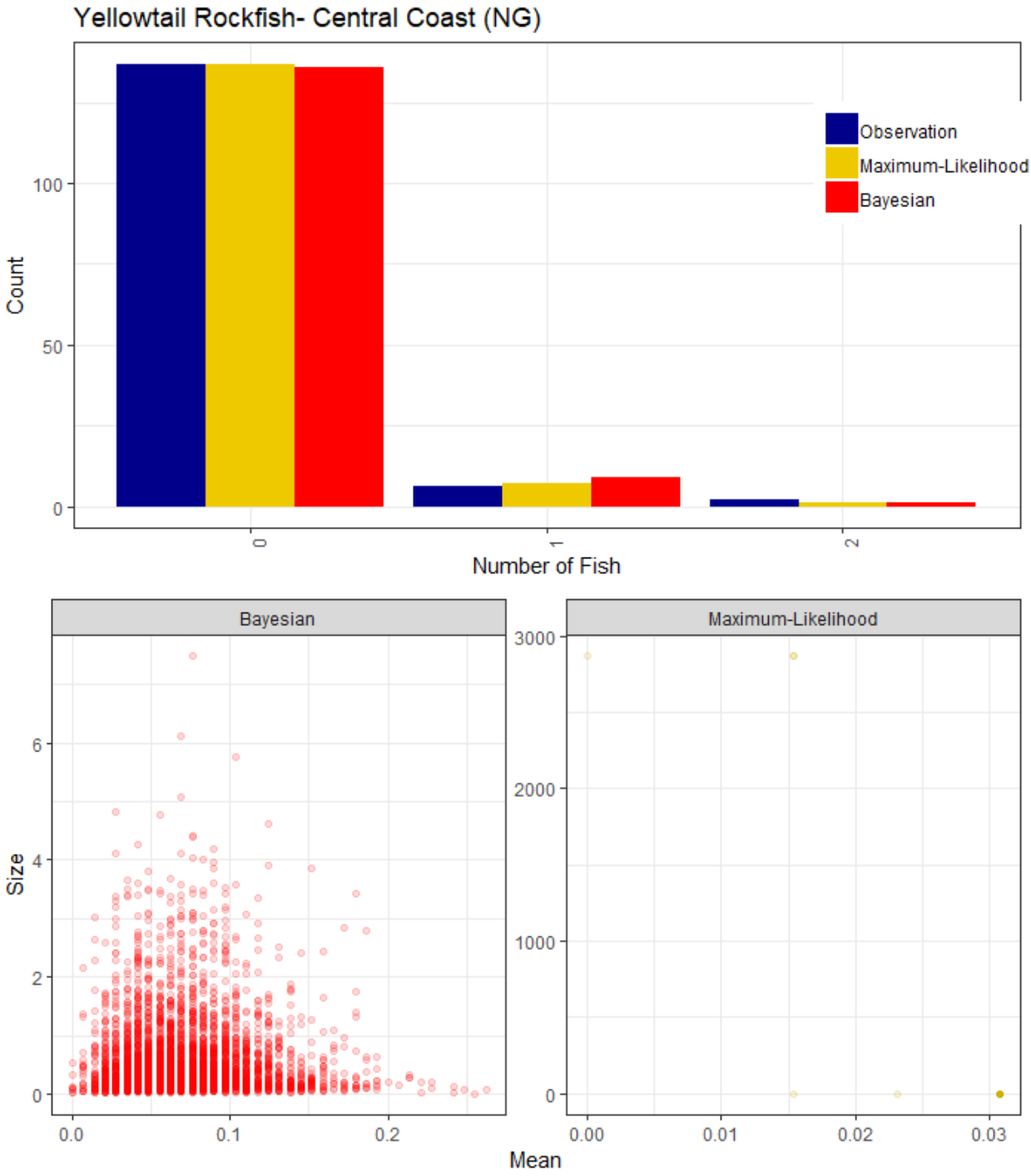

Yellowtail Rockfish- North Coast (FG & RG)
Observation
Maximum-Likelihood
Bayesian
Count
Number of Fish
Bayesian
Maximum-Likelihood
Size
Mean

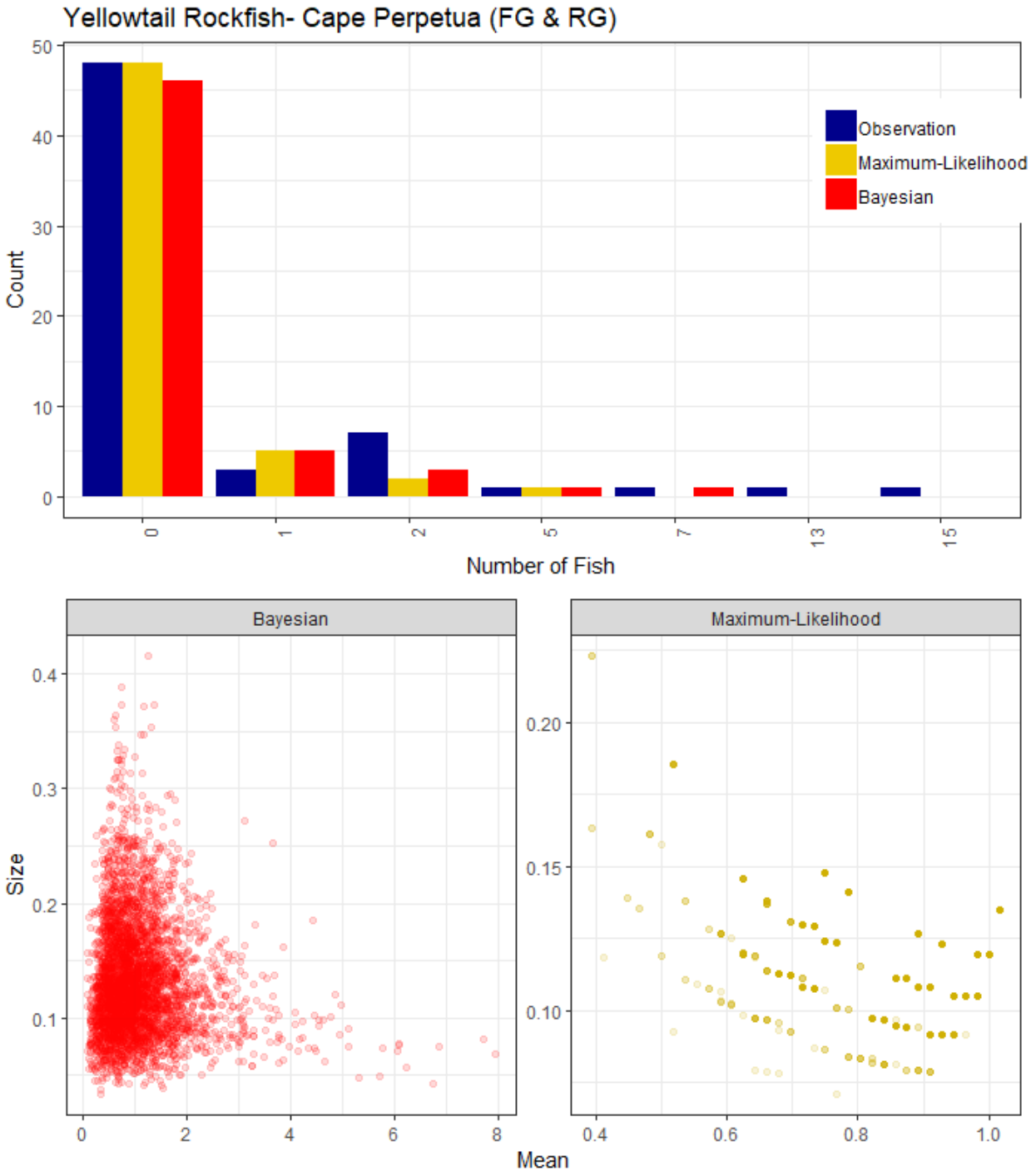

Yellowtail Rockfish- North Coast (FG)
Observation
Maximum-Likelihood
Bayesian
Count
Number of Fish
Bayesian
Maximum-Likelihood
Size
Mean

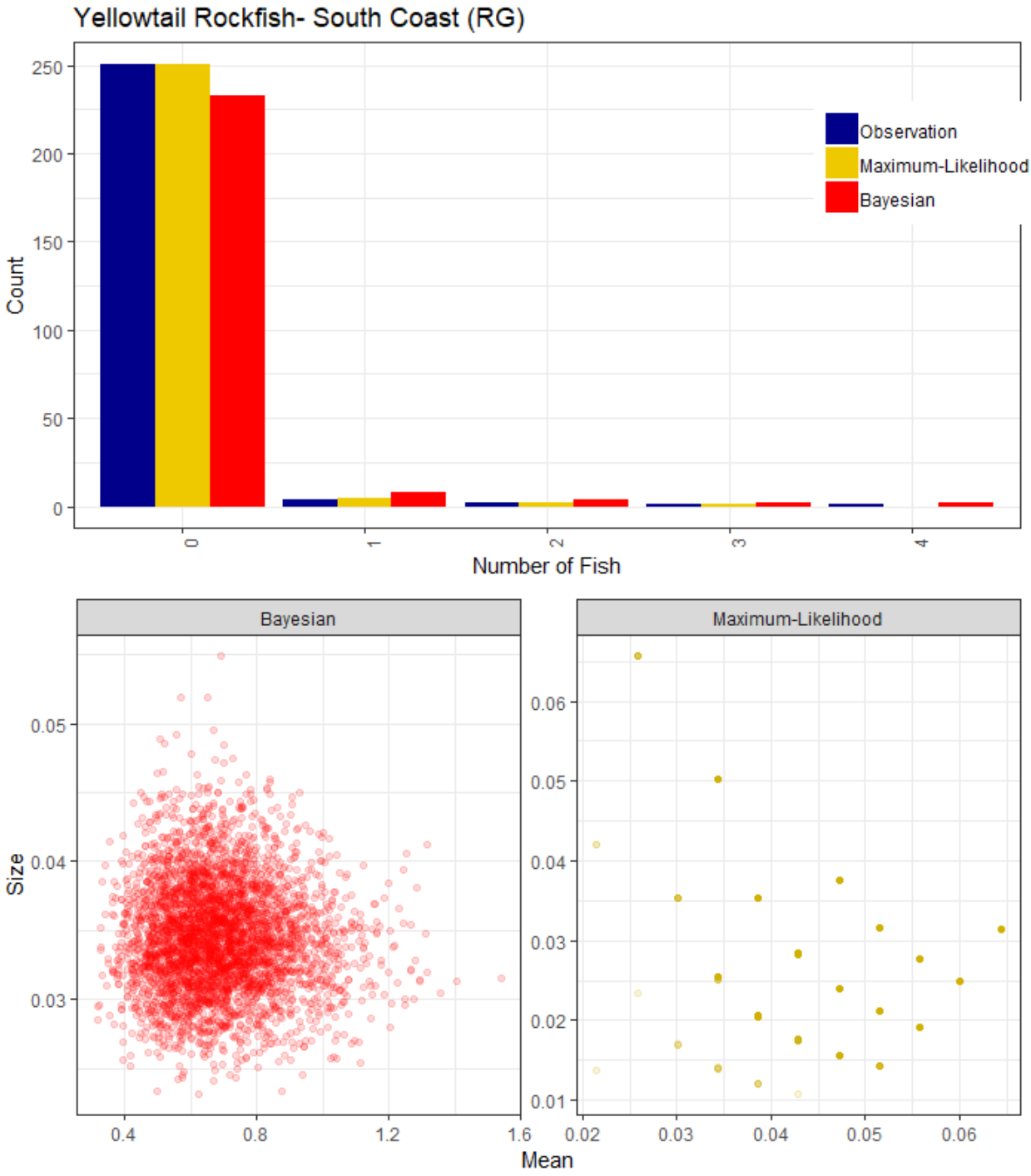

Yellowtail Rockfish- Central Coast (FG, RG & NG)
Observation
Maximum-Likelihood
Bayesian
Count
Number of Fish
Bayesian
Maximum-Likelihood
Size
Mean

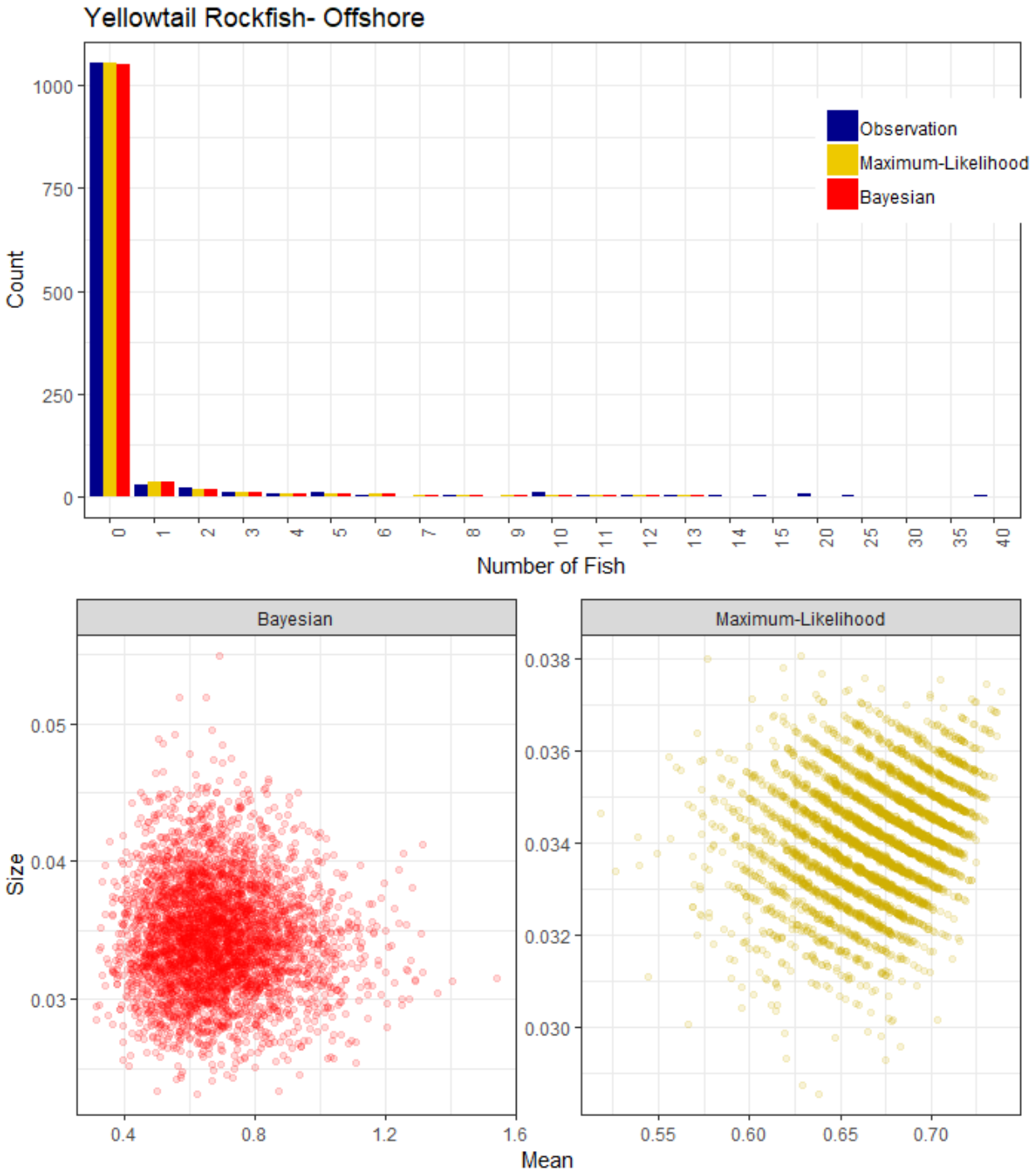

Yellowtail Rockfish- Central Coast (FG)
Count
125
100
75
50
25
0
Observation
Maximum-Likelihood
Bayesian
0
1
2
3
7
10
Number of Fish
Bayesian
Maximum-Likelihood
Size
0.075
0.050
0.025
10000
5000
0
0.0
0.1
0.2
0.3
0.4
0.00
0.01
0.02
Mean


Yellowtail Rockfish- Central Coast (RG)
Count
Number of Fish
Observation
Maximum-Likelihood
Bayesian
Bayesian
Maximum-Likelihood
Size
Mean


Yellowtail Rockfish- Central Coast (NG)
Observation
Maximum-Likelihood
Bayesian
Count
100
50
0
0
1
2
Number of Fish
Bayesian
Maximum-Likelihood
Size
6
4
2
0
3000
2000
1000
0
0.0
0.1
0.2
0.00
0.01
0.02
0.03
Mean


Yellowtail Rockfish- Cape Perpetua (FG & RG)
Count
Number of Fish
Observation
Maximum-Likelihood
Bayesian
Bayesian
Maximum-Likelihood
Size
Mean

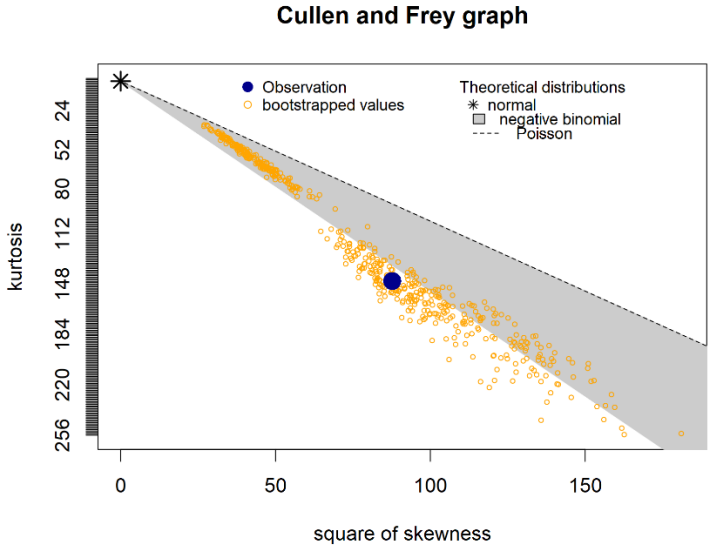

Yellowtail Rockfish- South Coast (RG)
Observation
Maximum-Likelihood
Bayesian
Count
Number of Fish
Bayesian
Maximum-Likelihood
Size
Mean

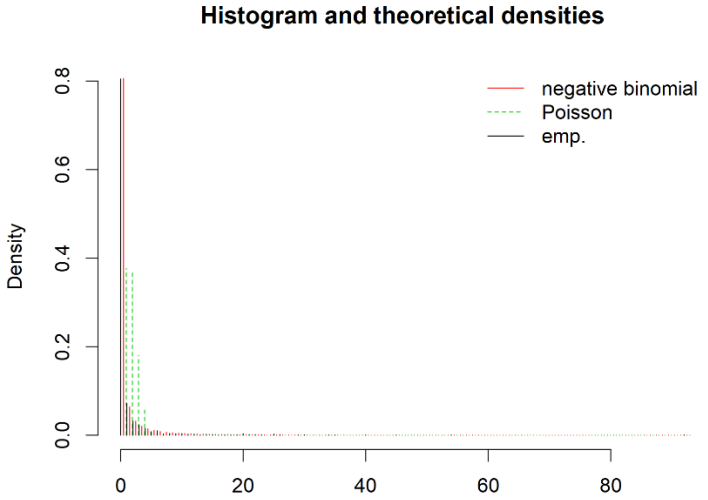

Yellowtail Rockfish- Offshore
Observation
Maximum-Likelihood
Bayesian
Count
Number of Fish
Bayesian
Maximum-Likelihood
Size
Mean

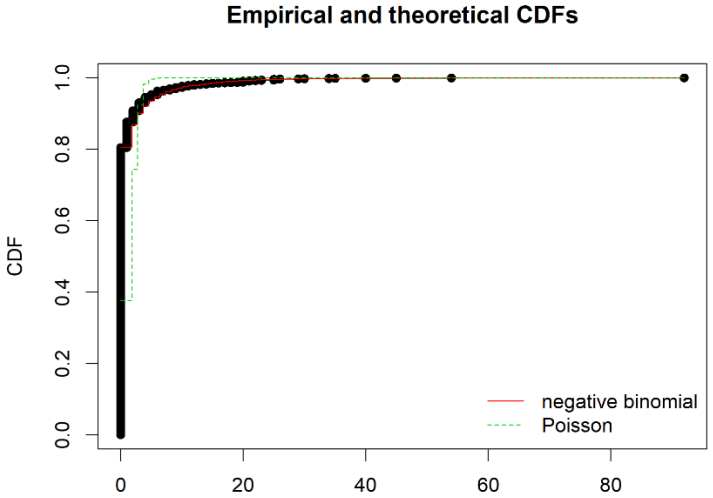
Appendix C. Distribution plots comparing negative binomial to Poisson distributions

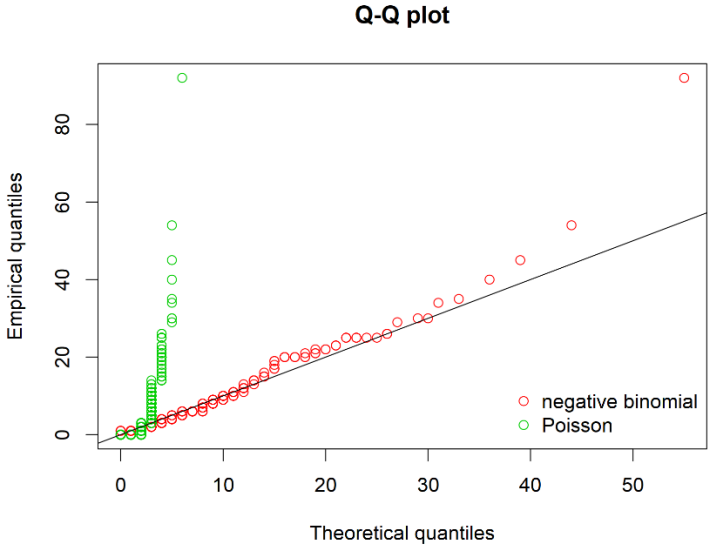
These figures provide graphical goodness of fit plots for how well each species, study area and research group combination is fit by both a negative binomial and Poisson distribution. Four different goodness of fit plots are presented to allow the reader multiple interpretations. In the upper left, the gold circles denote the goodness of fit estimate for one of 500 bootstrapping attempts. In some instances, bootstrapping was not possible due to the low presence to absence ratio of the count data. Not all species, study area and research group combinations are presented. The reasons for figures being left out is due to the inability of the parameter estimate algorithms to plot the data, usually due to a low presence to absence ratio.

Black Rockfish - Entire Coast

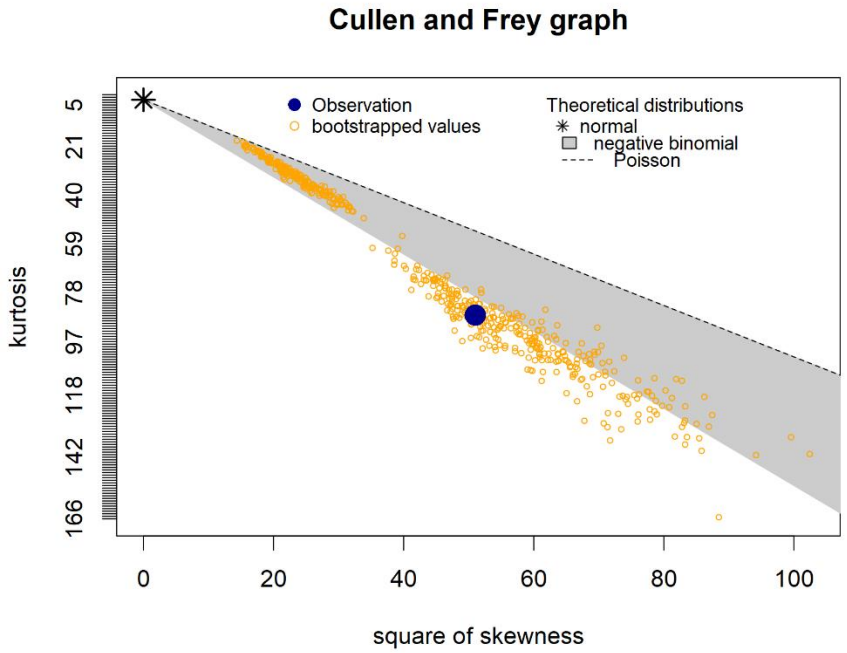


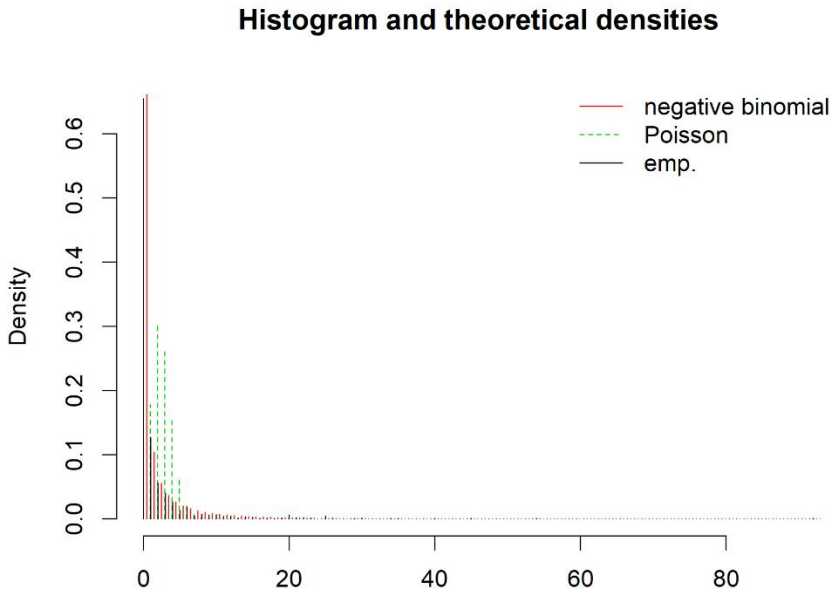


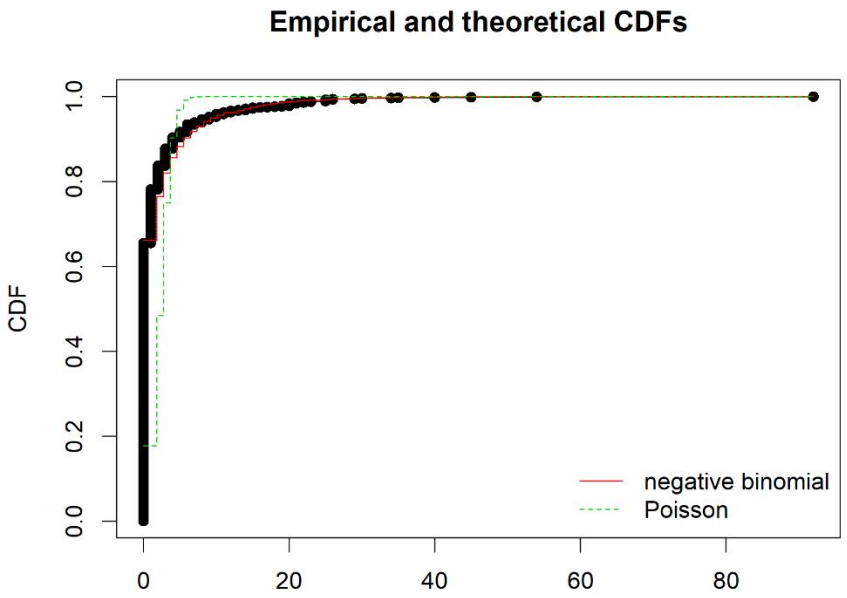


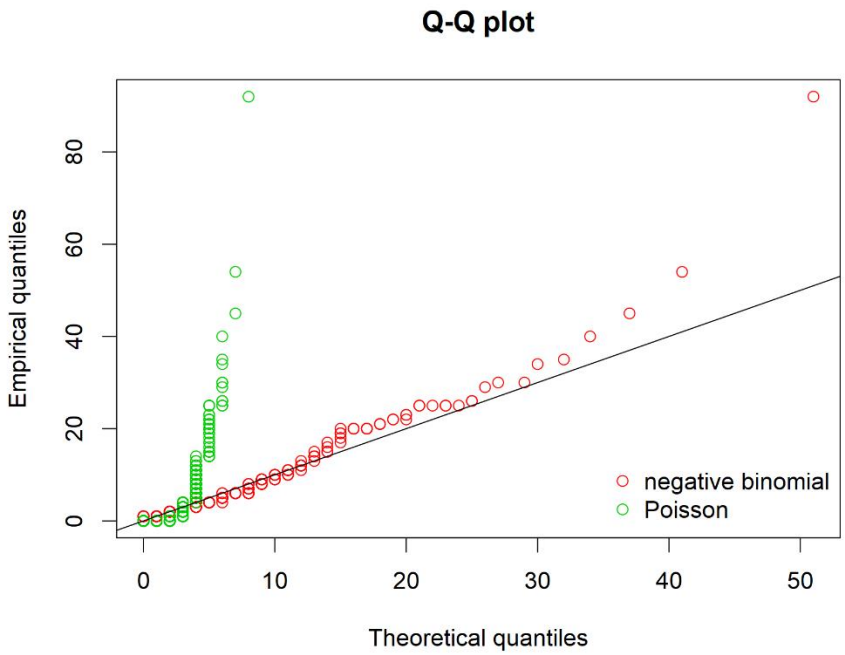


Black Rockfish - Nearshore

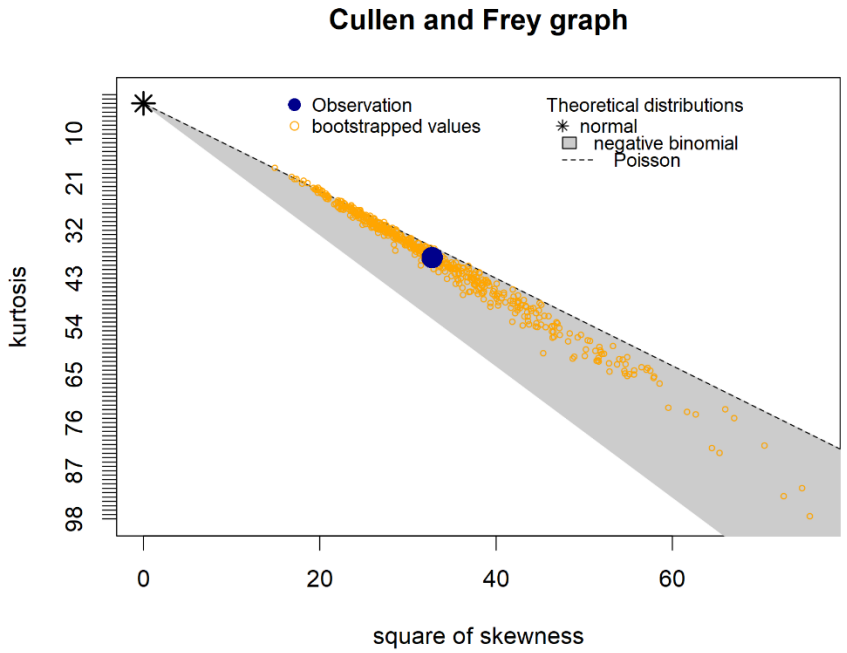


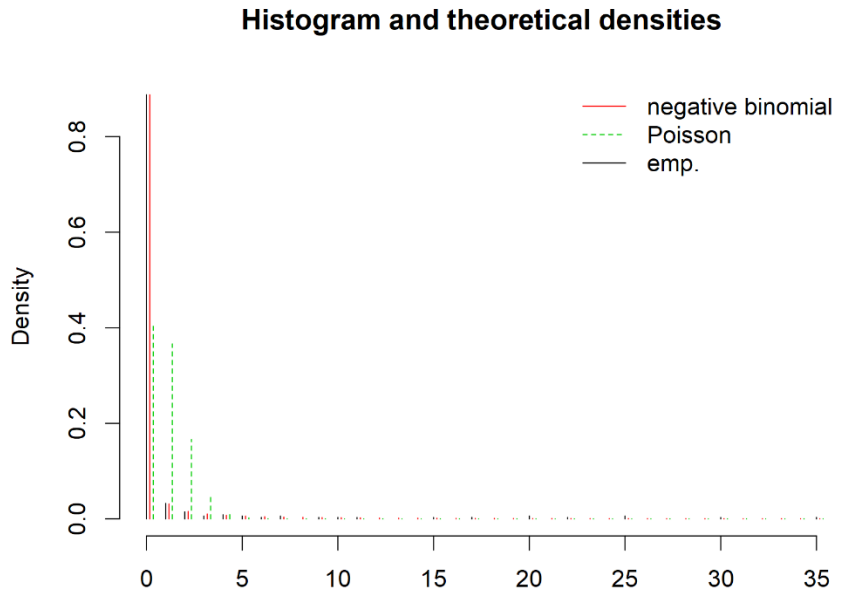


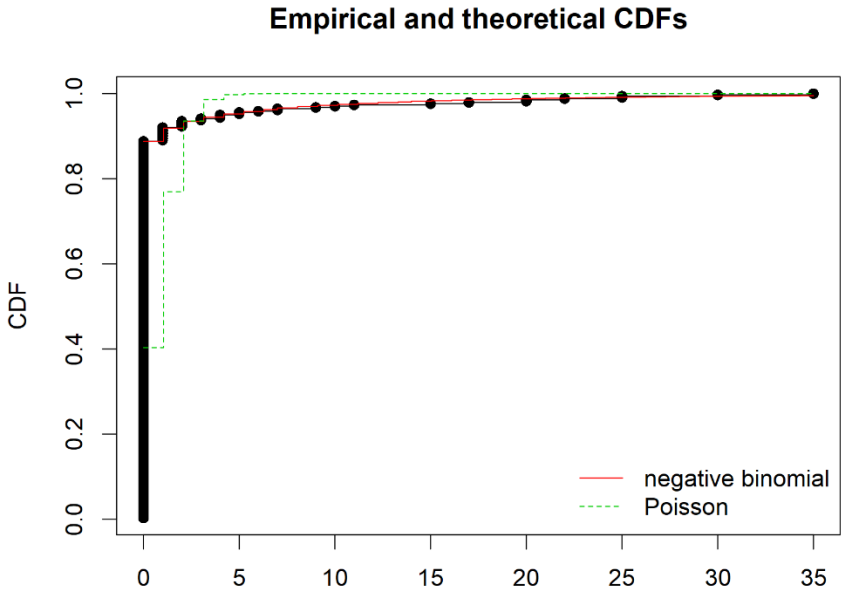


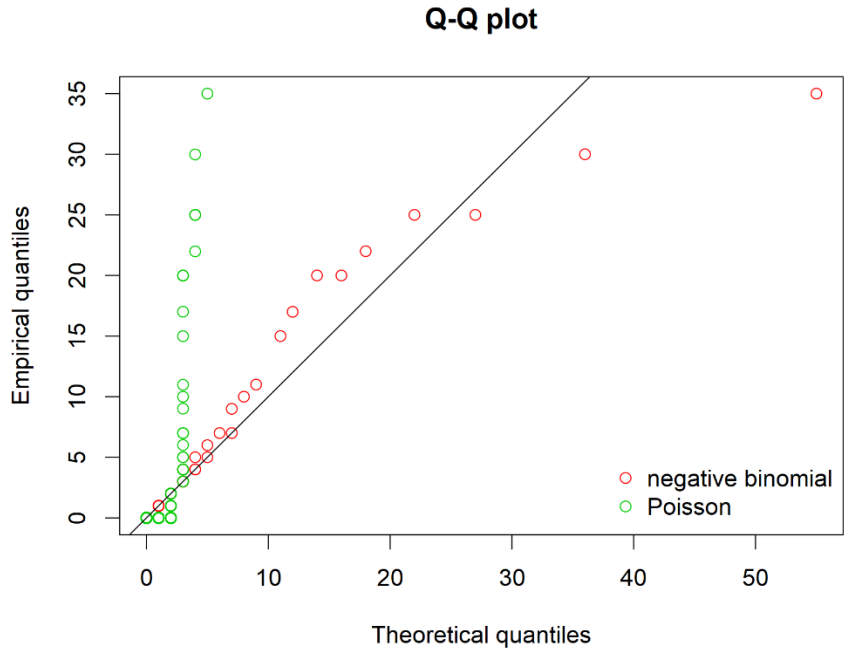


Black Rockfish - North Coast (FG & RG)

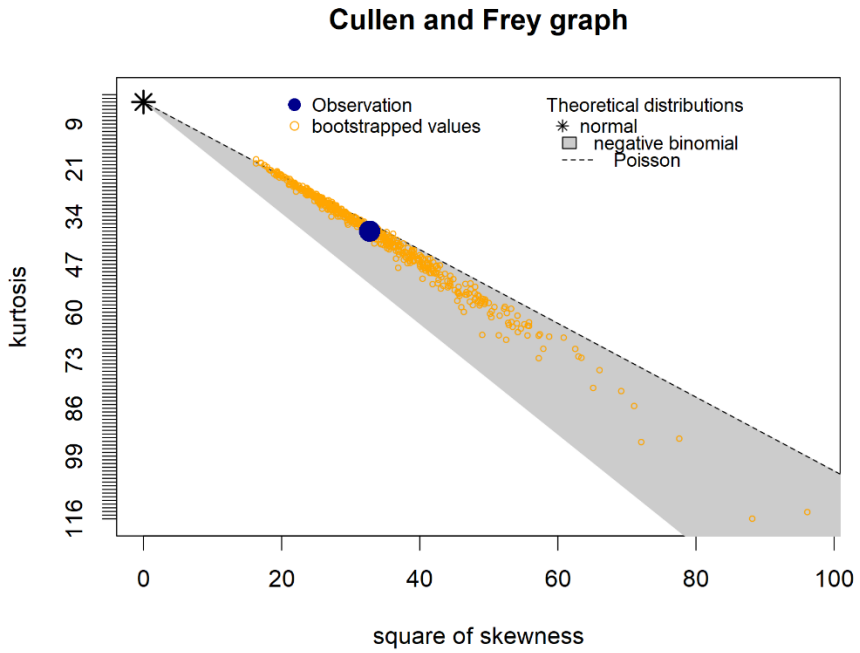


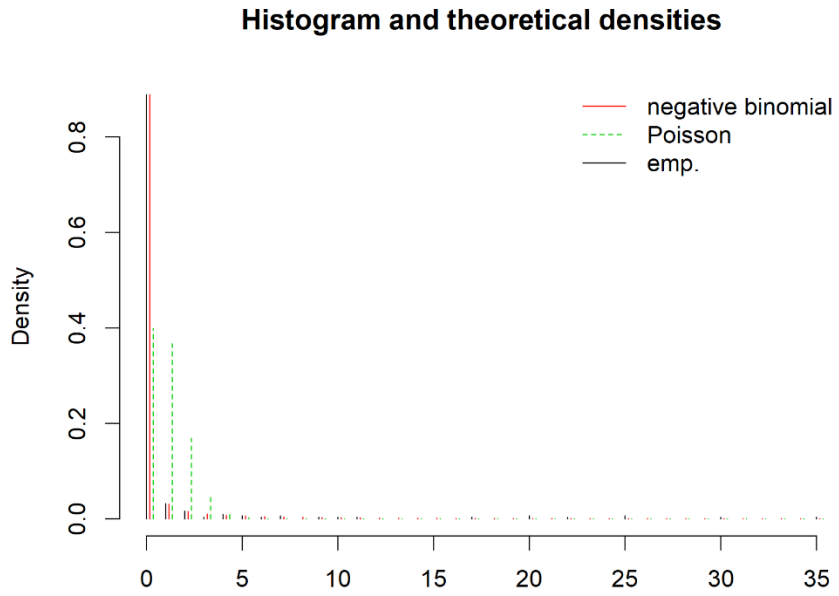


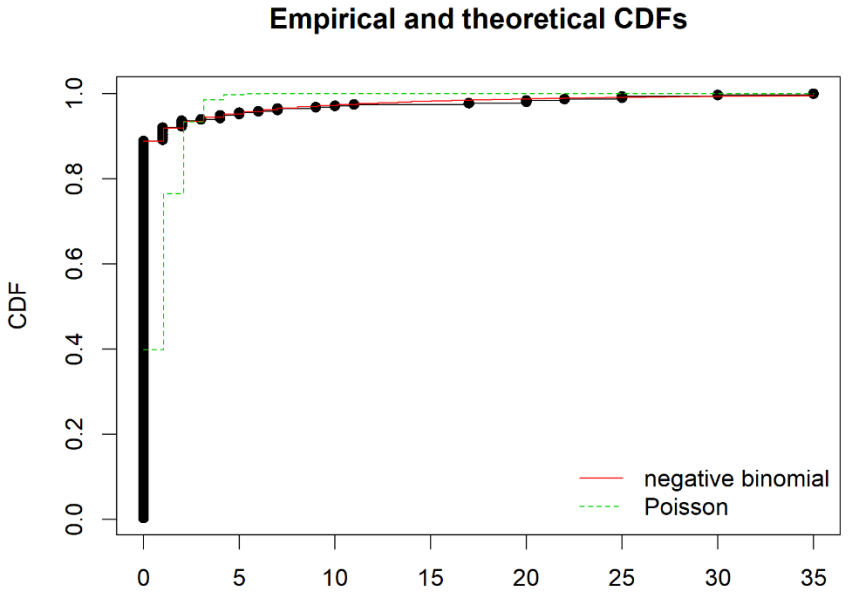


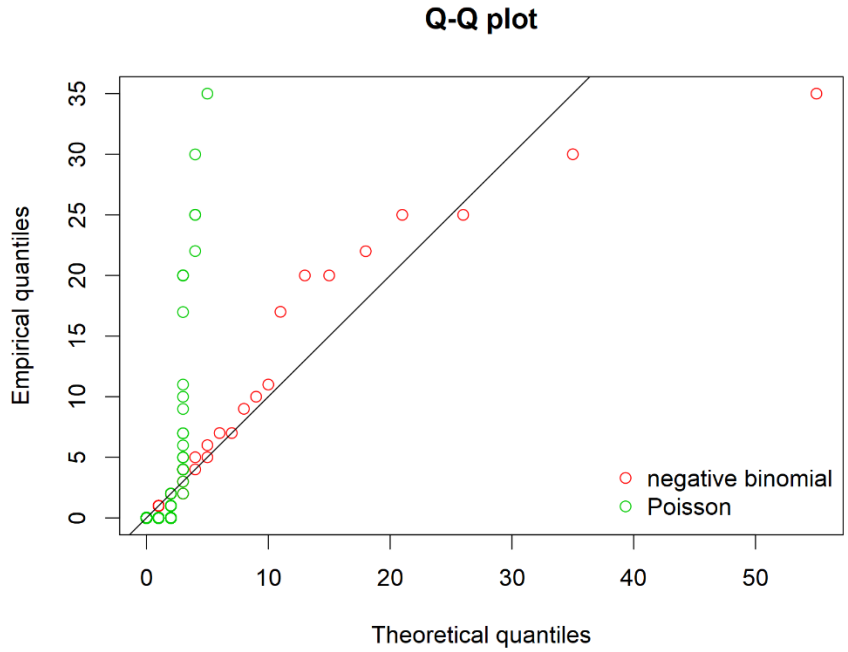


Black Rockfish - North Coast (FG)

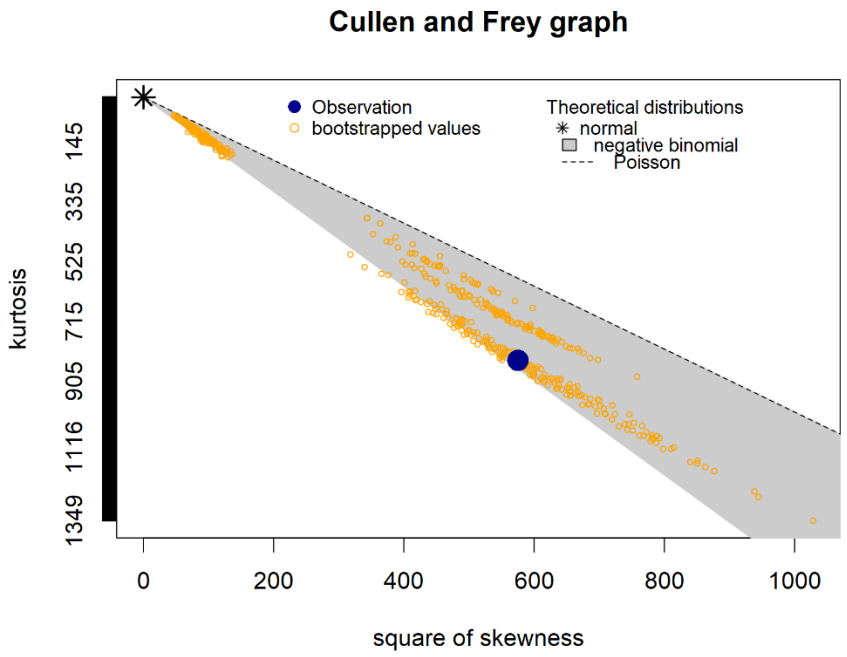


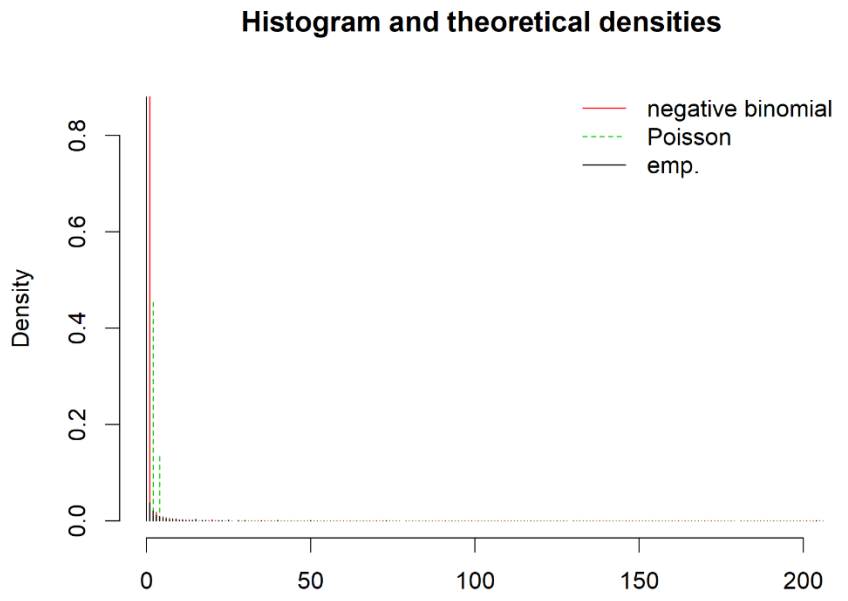


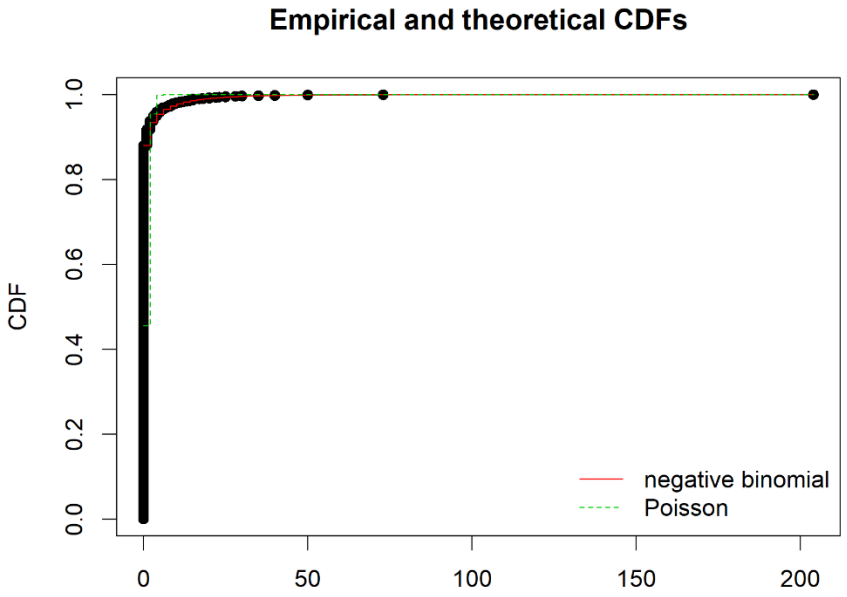


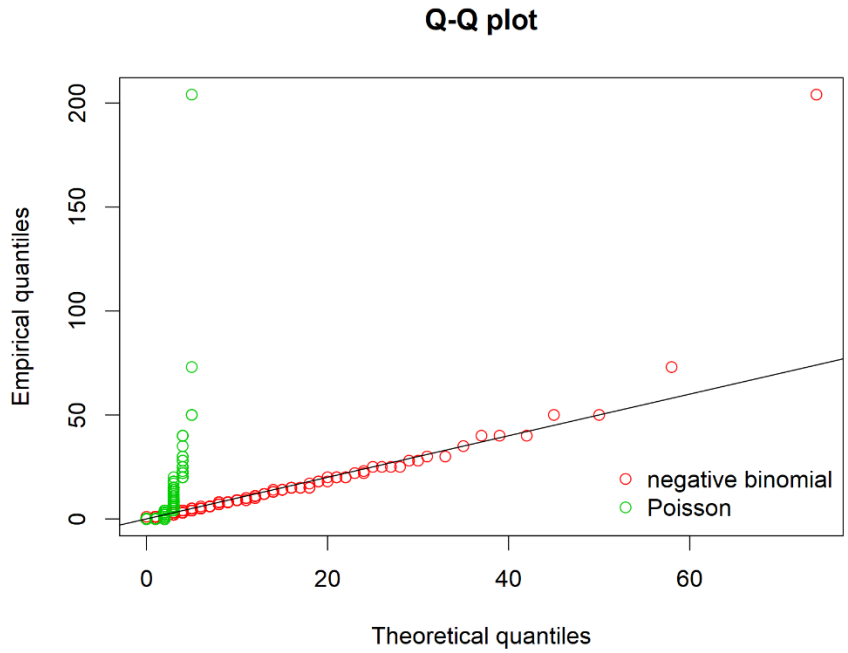


Blue_Deacon Rockfish - Entire Coast

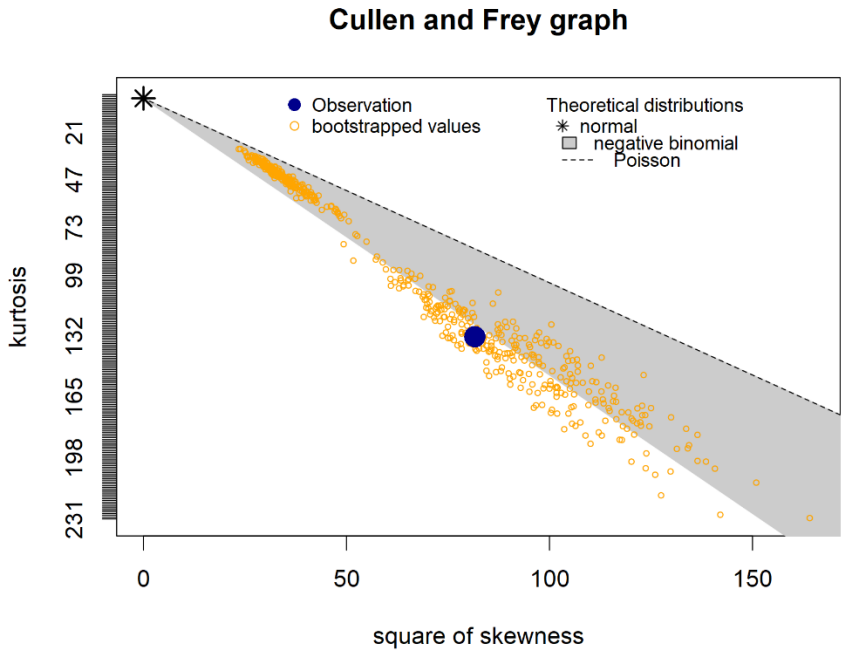


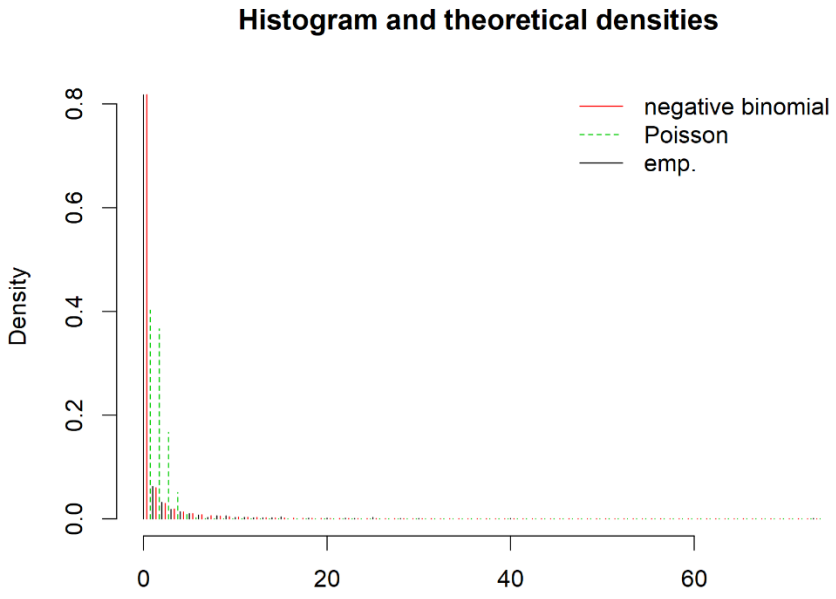


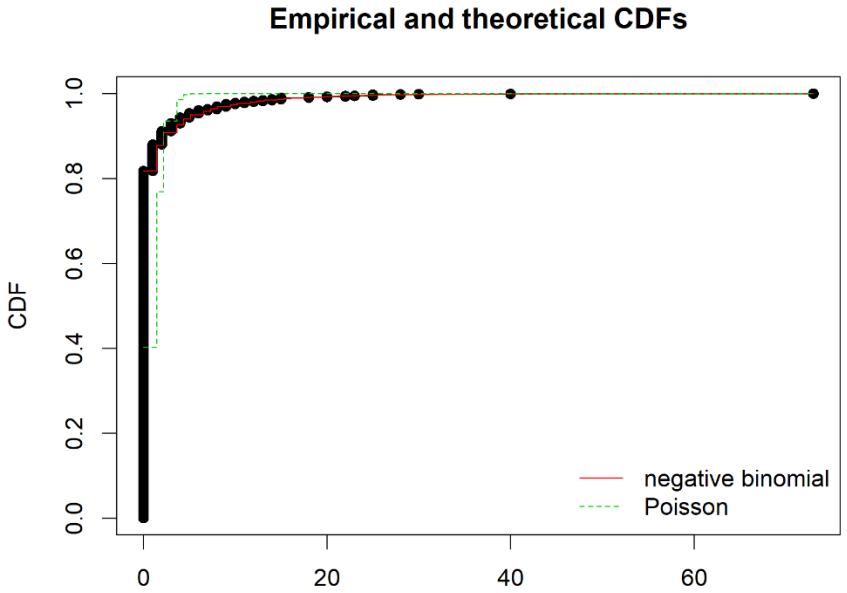


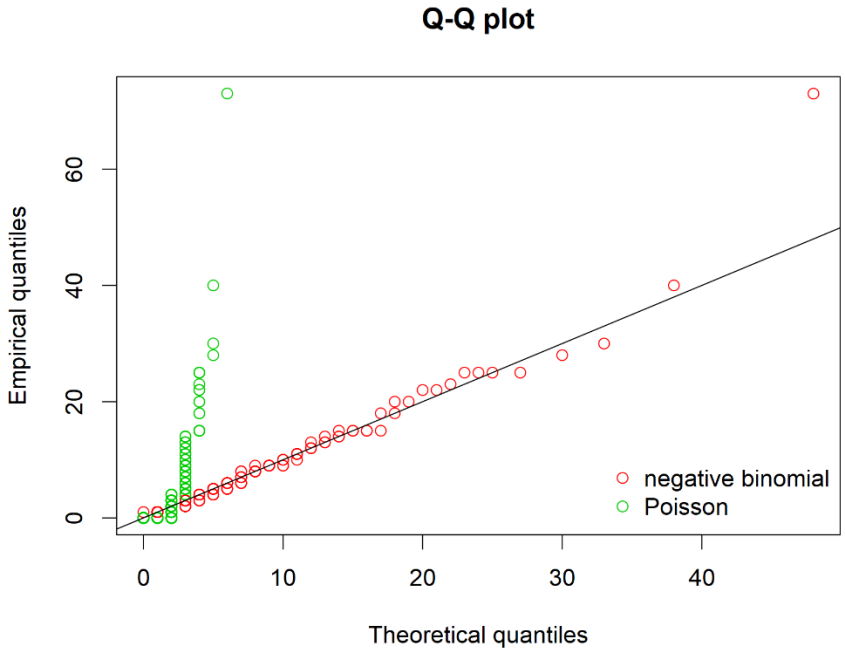


Blue_Deacon Rockfish - Nearshore

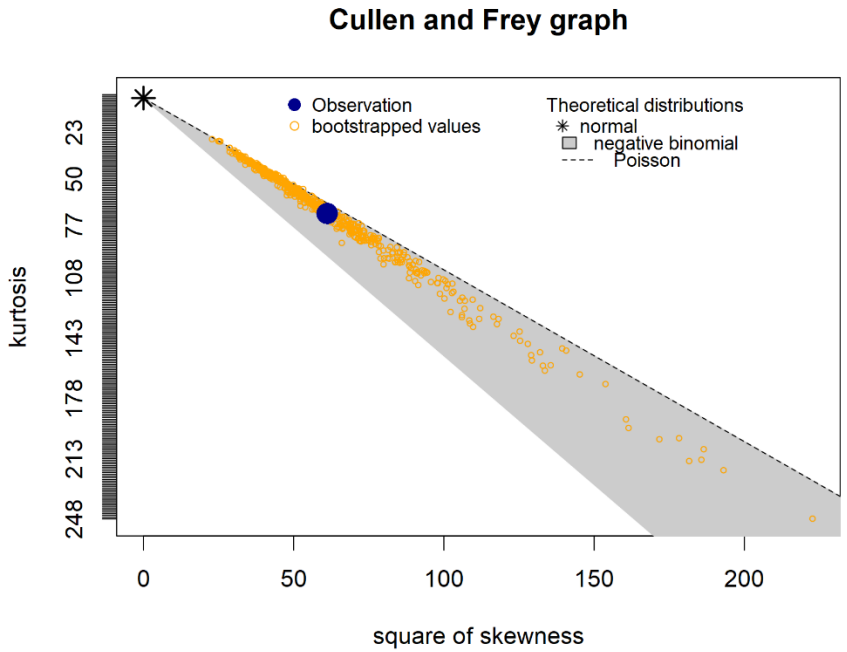


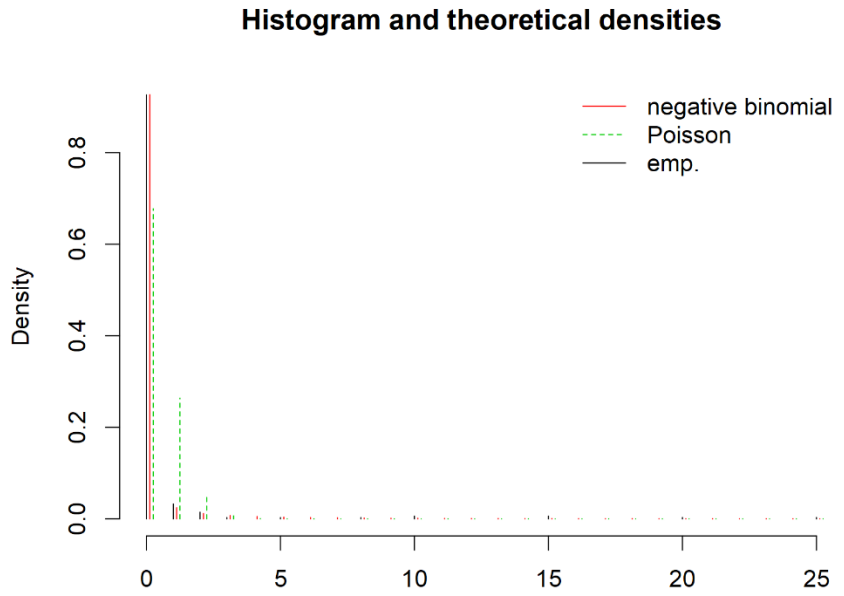


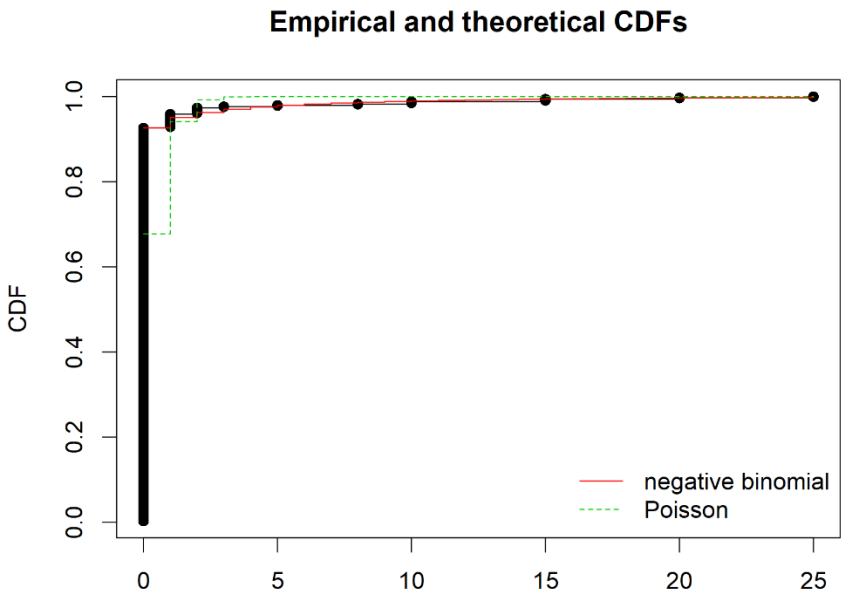


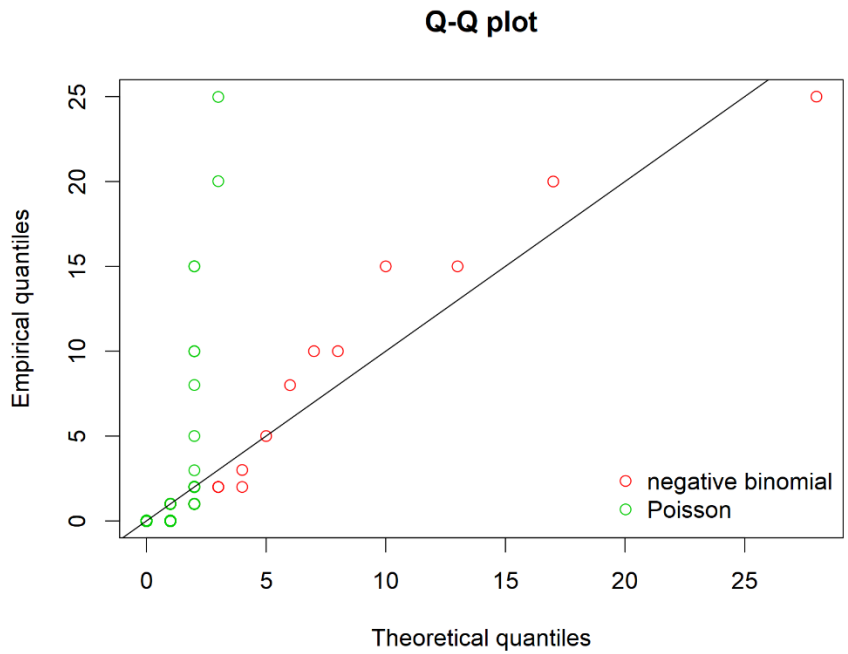


Blue_Deacon Rockfish - North Coast (FG & RG)

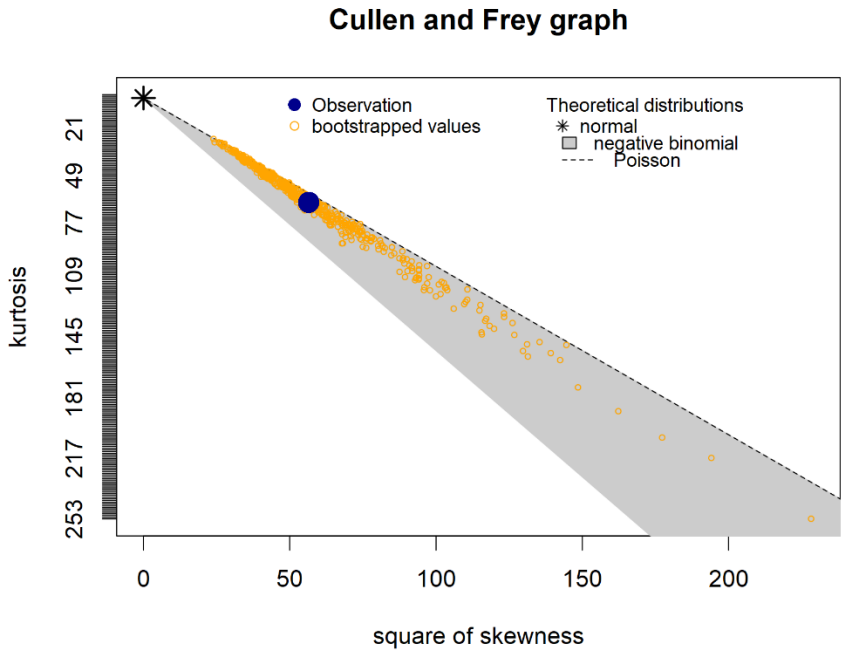


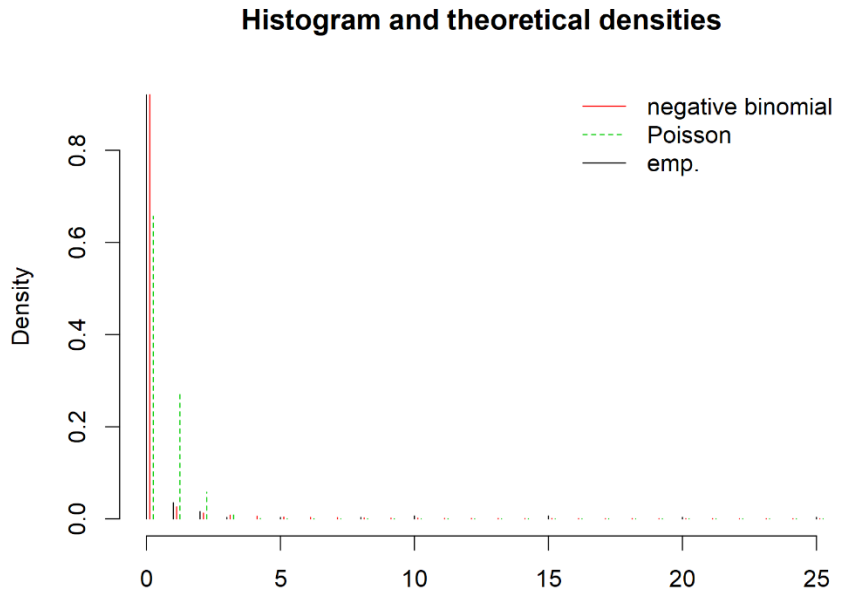


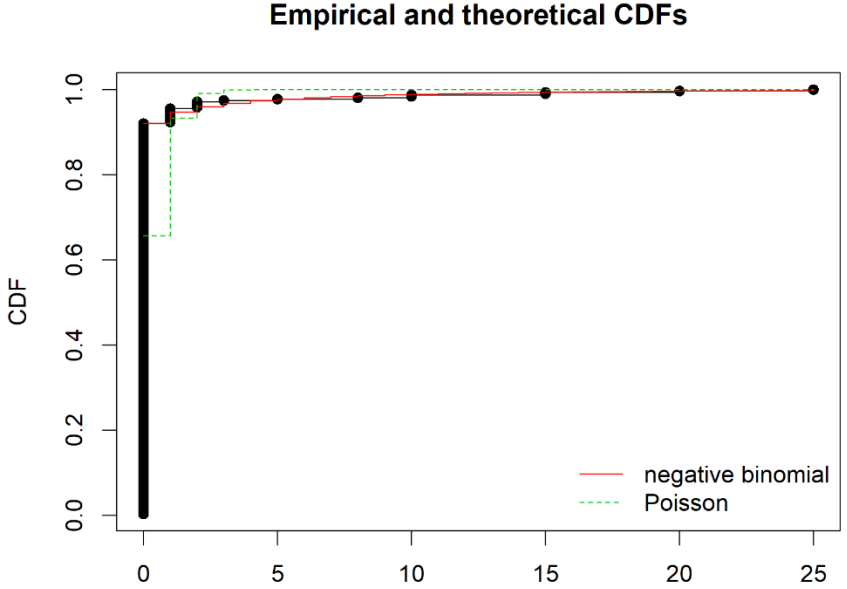


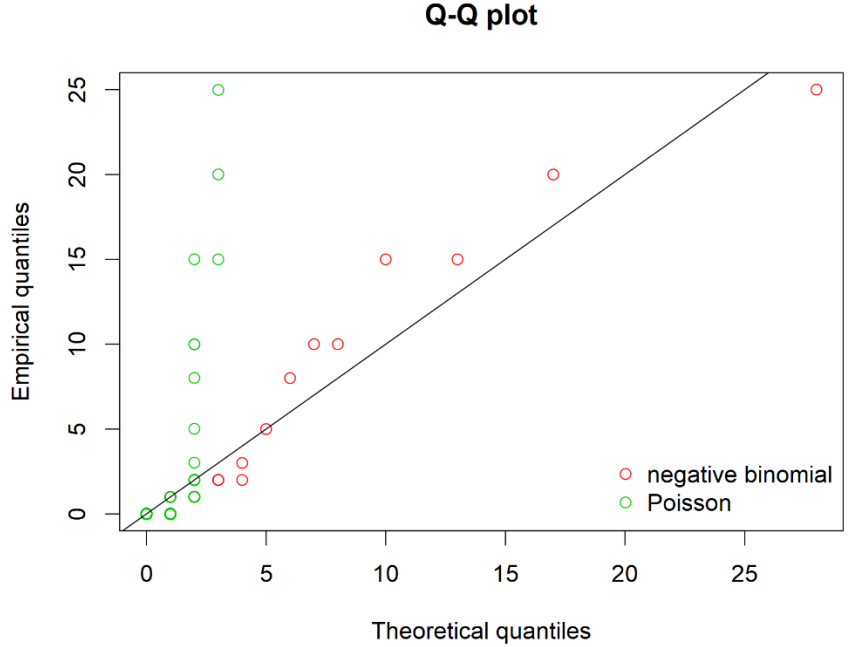


Blue_Deacon Rockfish - North Coast (FG)

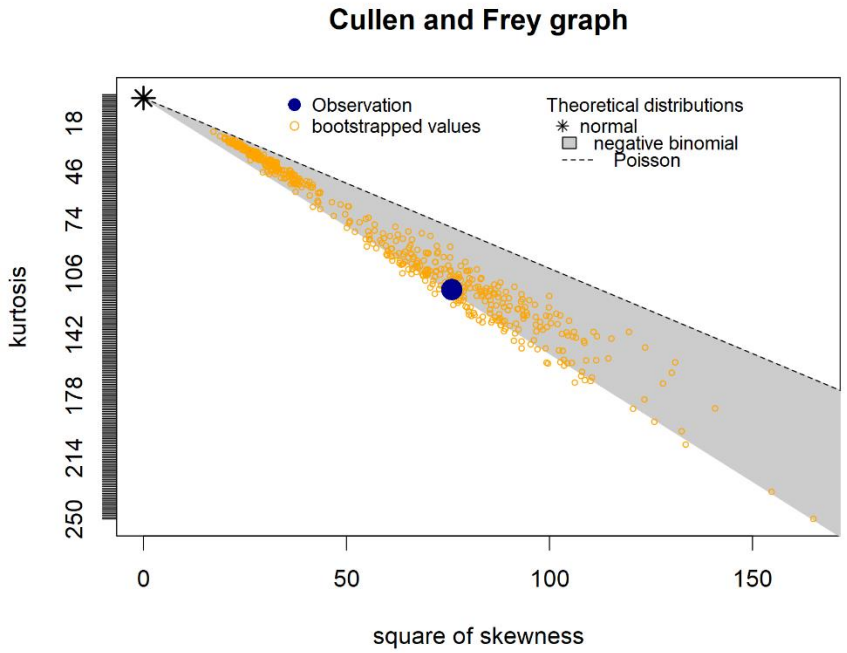


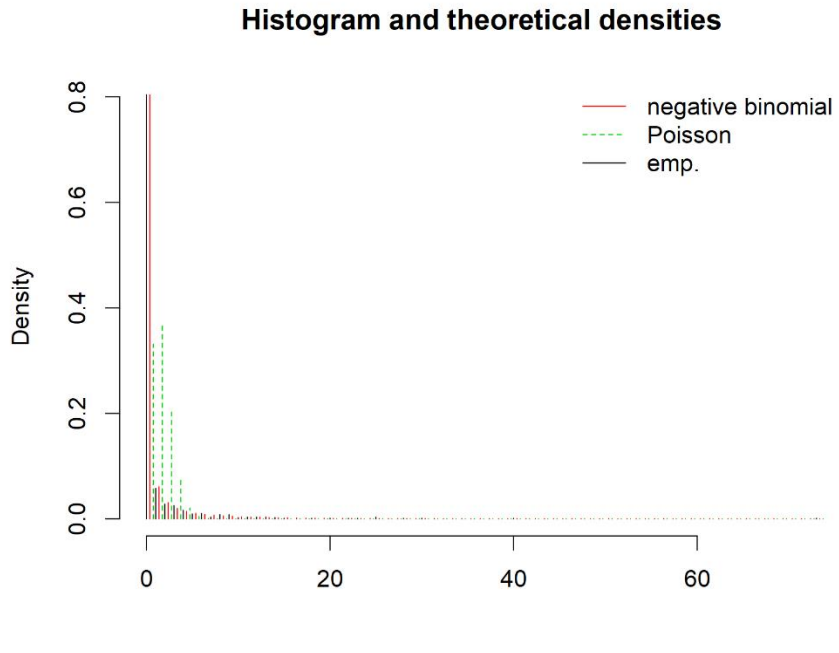


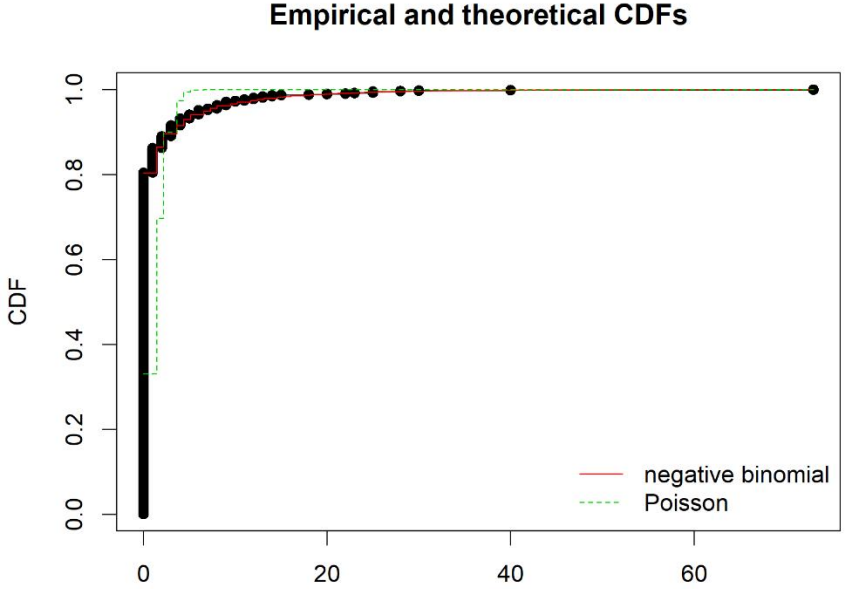


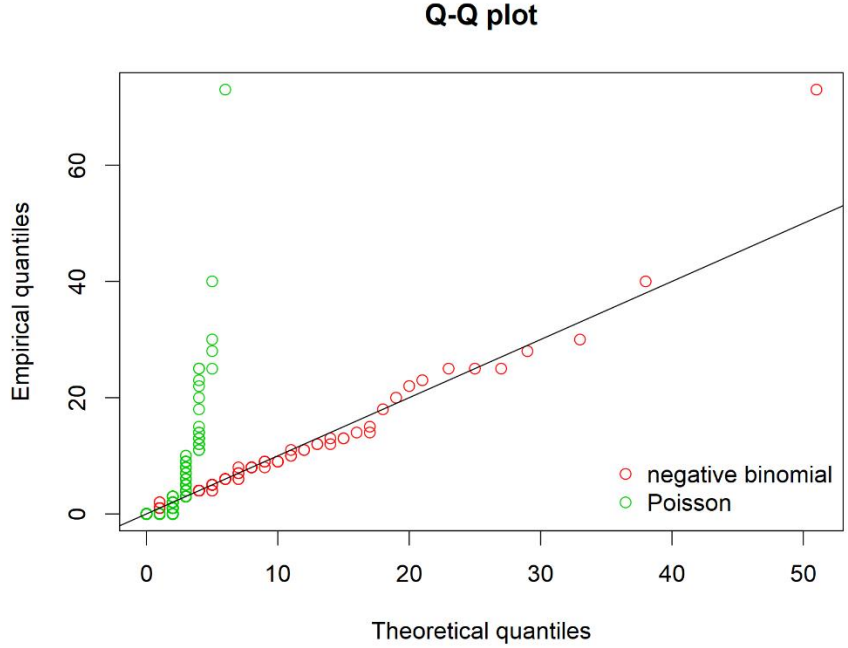


Blue_Deacon Rockfish - Central Coast (FG, RG, & NG)

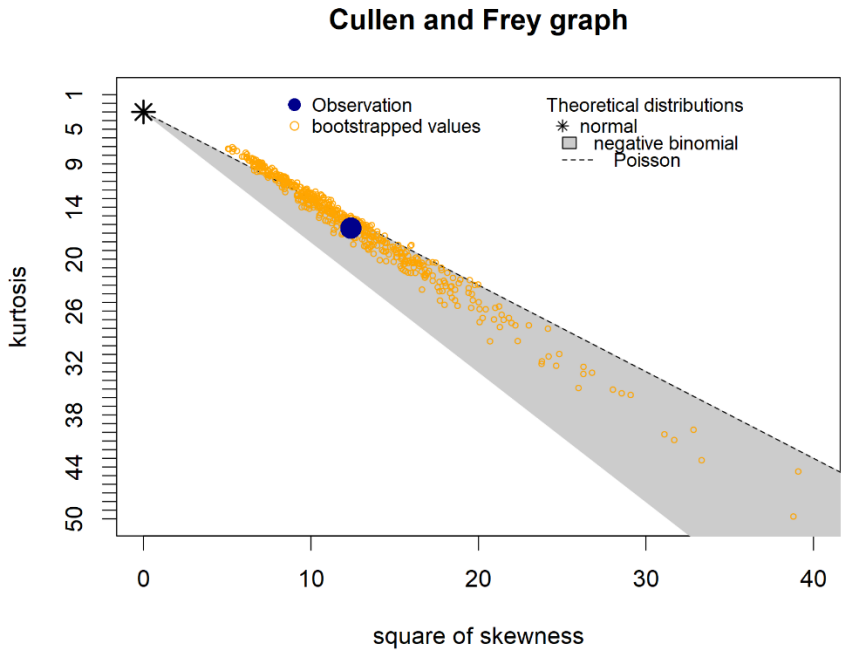


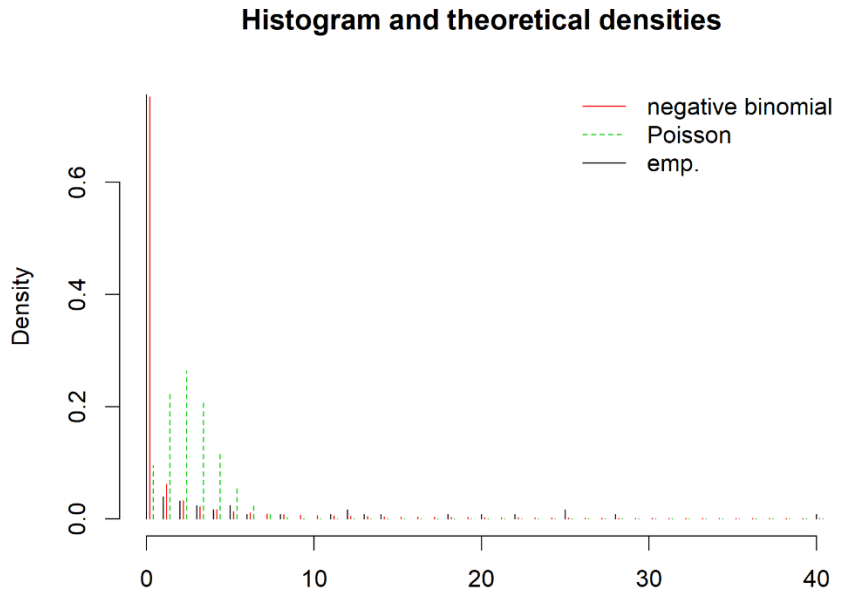


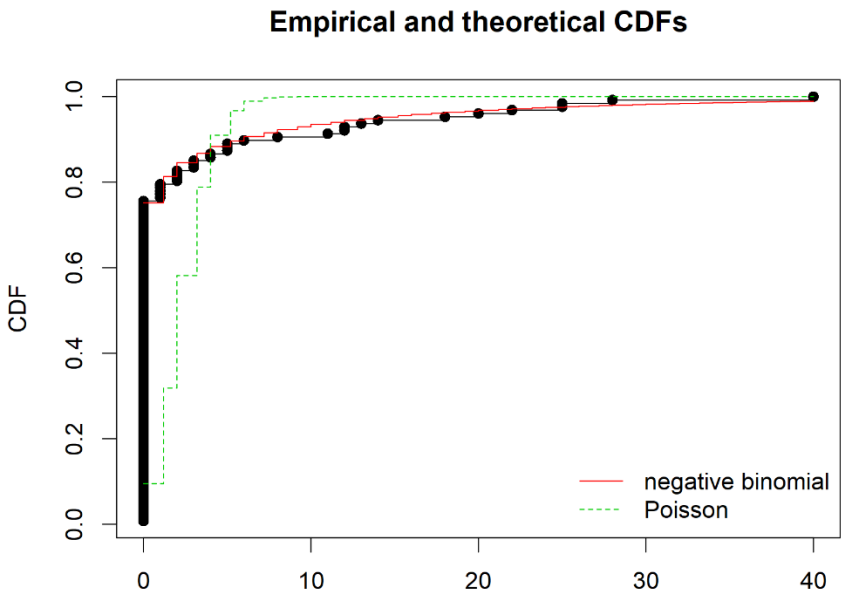


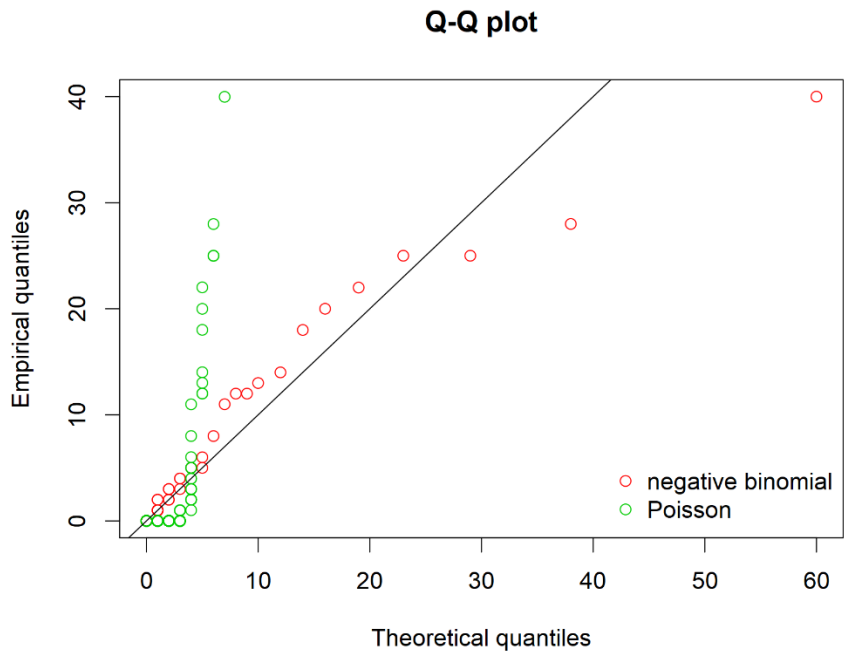


Blue_Deacon Rockfish - Central Coast (FG)

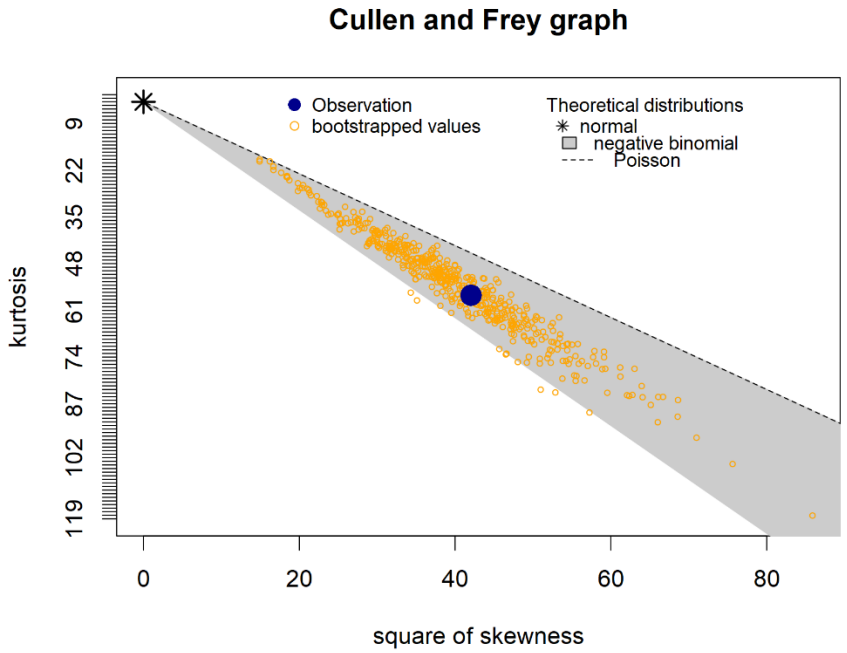


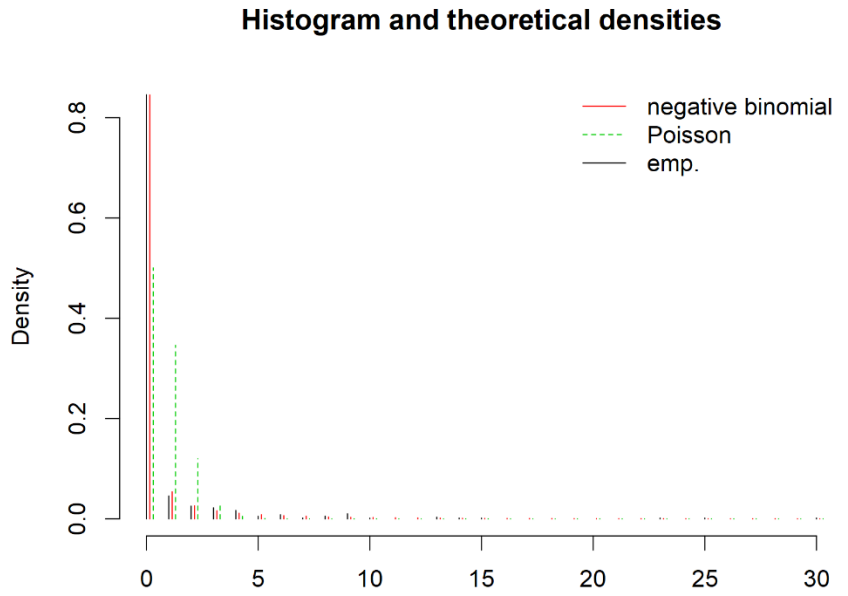


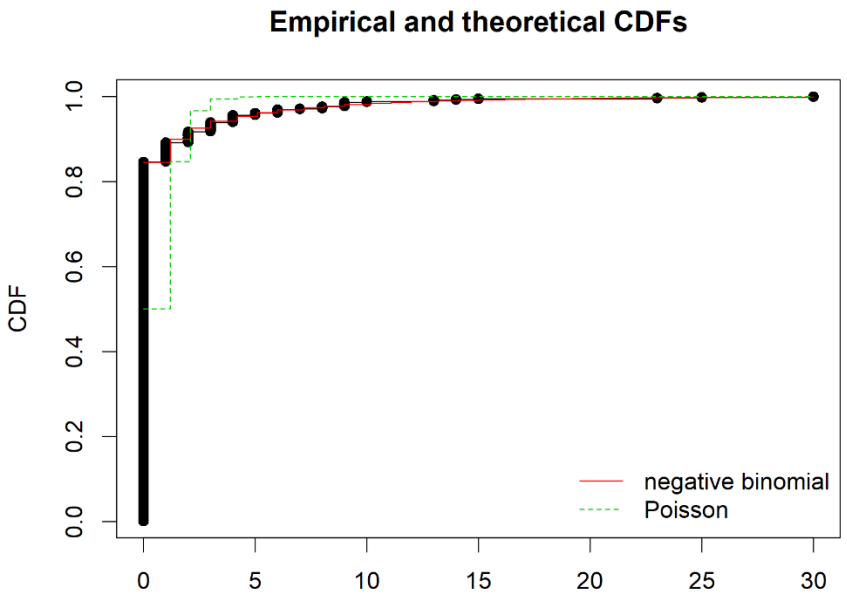


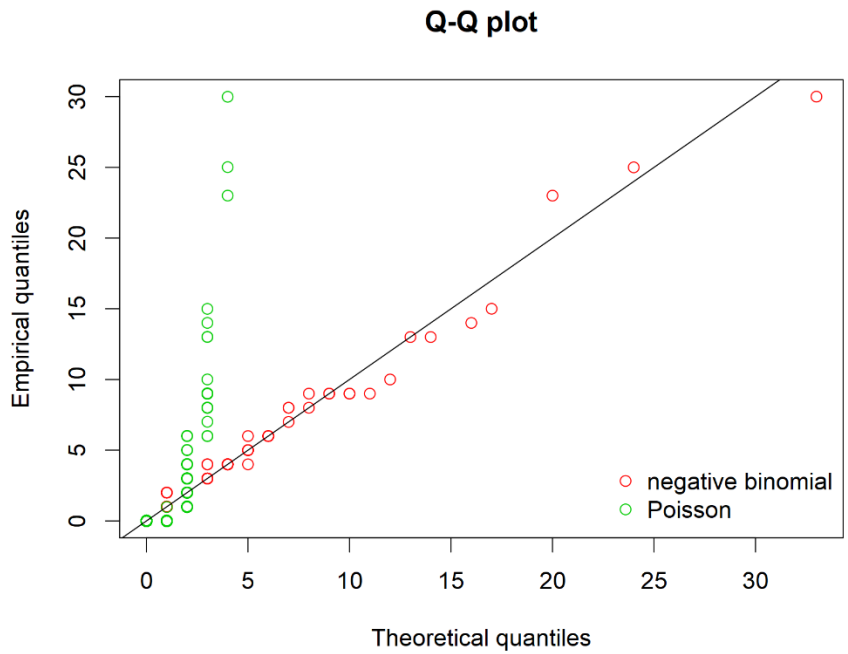


Blue_Deacon Rockfish - Central Coast (RG)

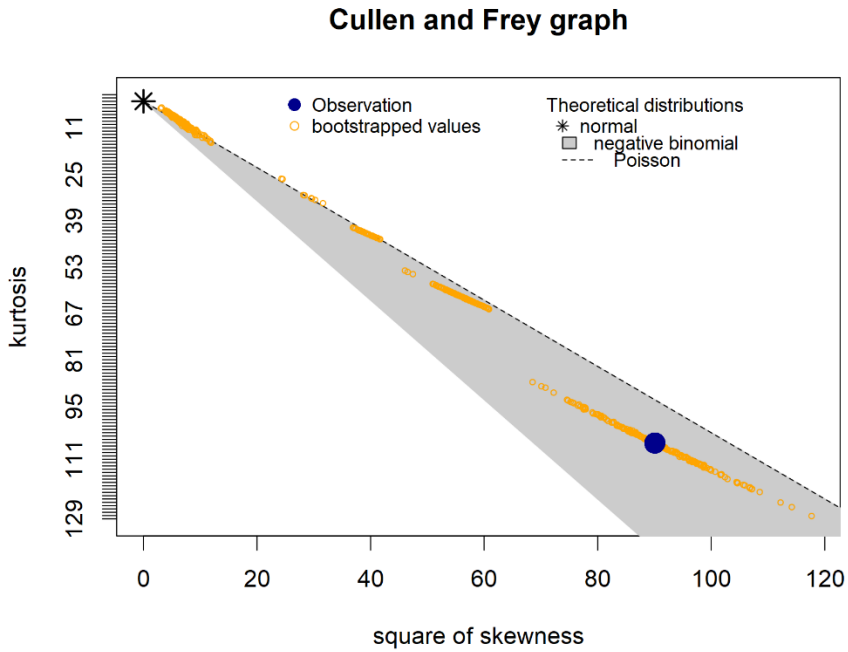


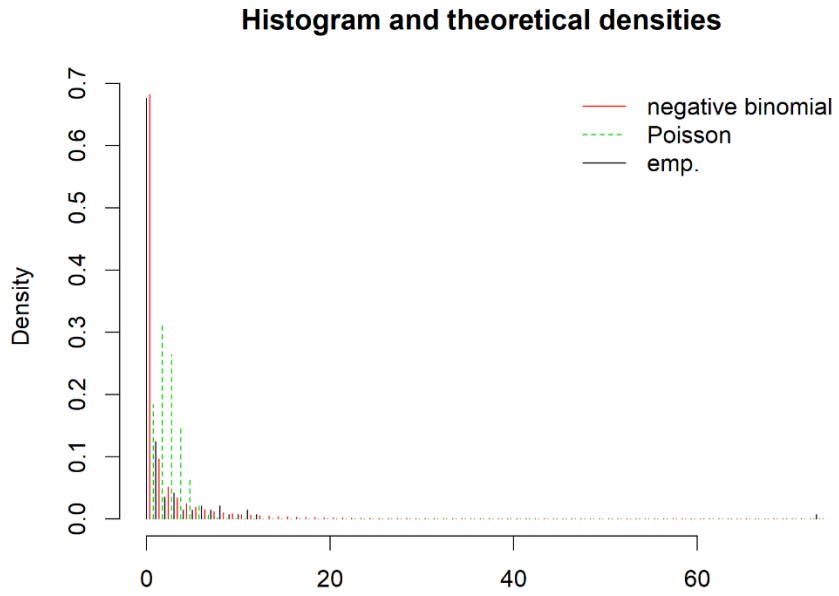


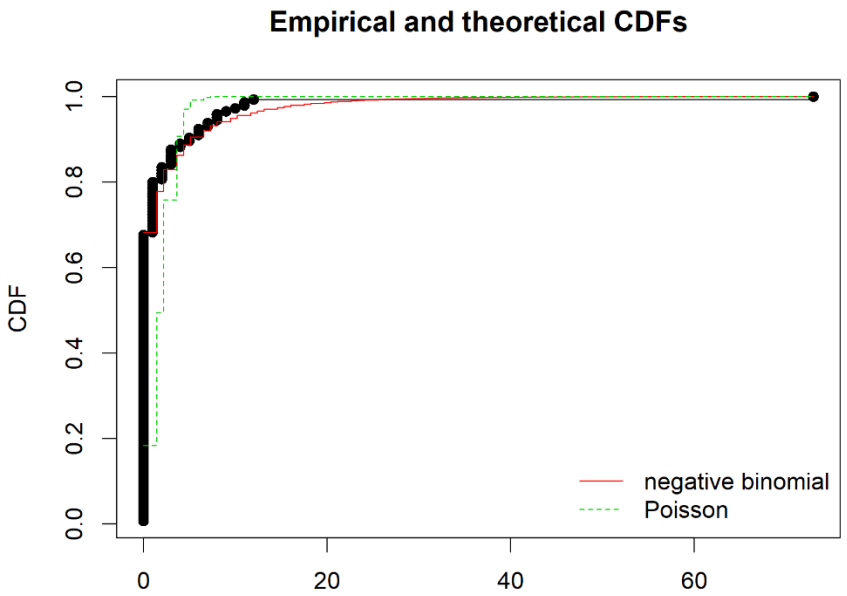


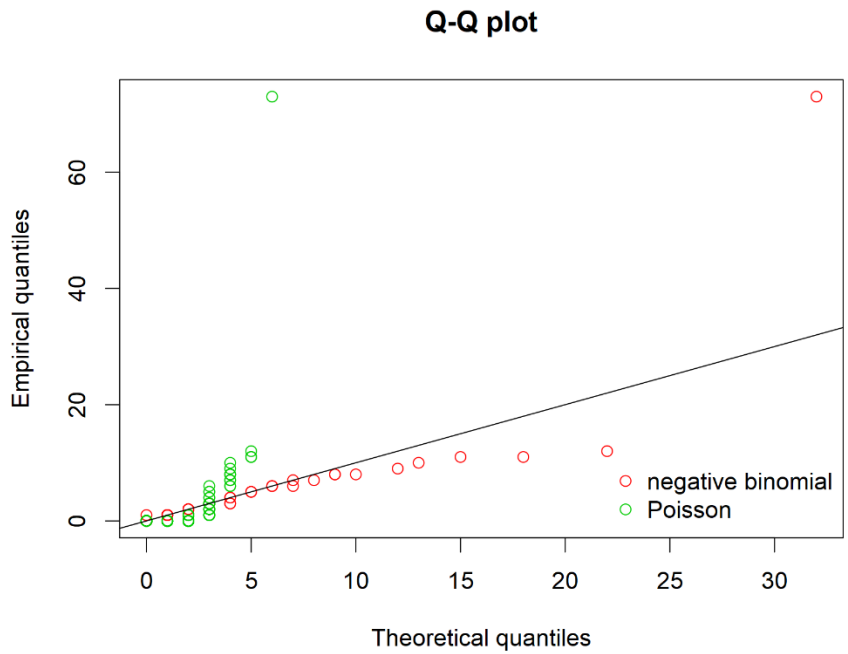


Blue_Deacon Rockfish - Central Coast (NG)

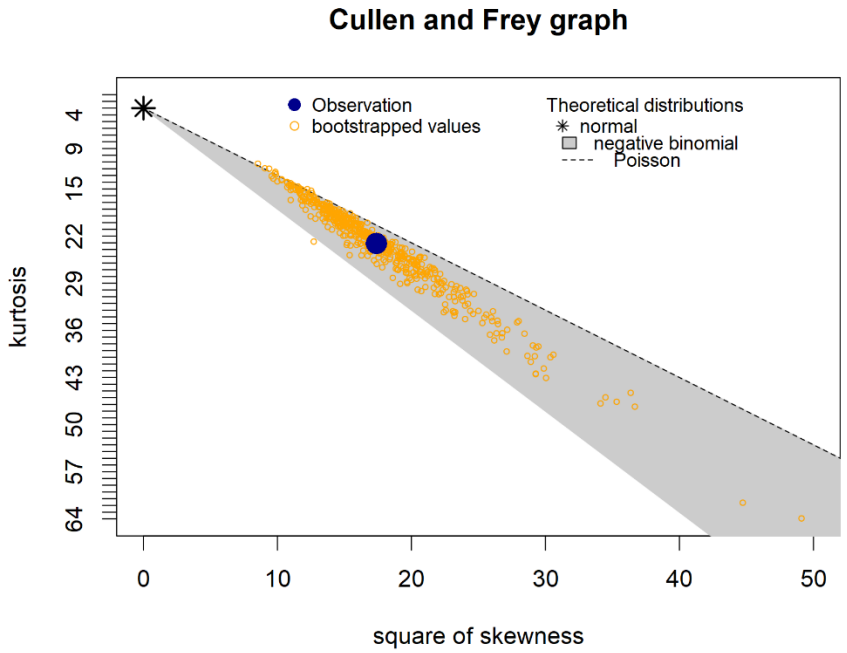


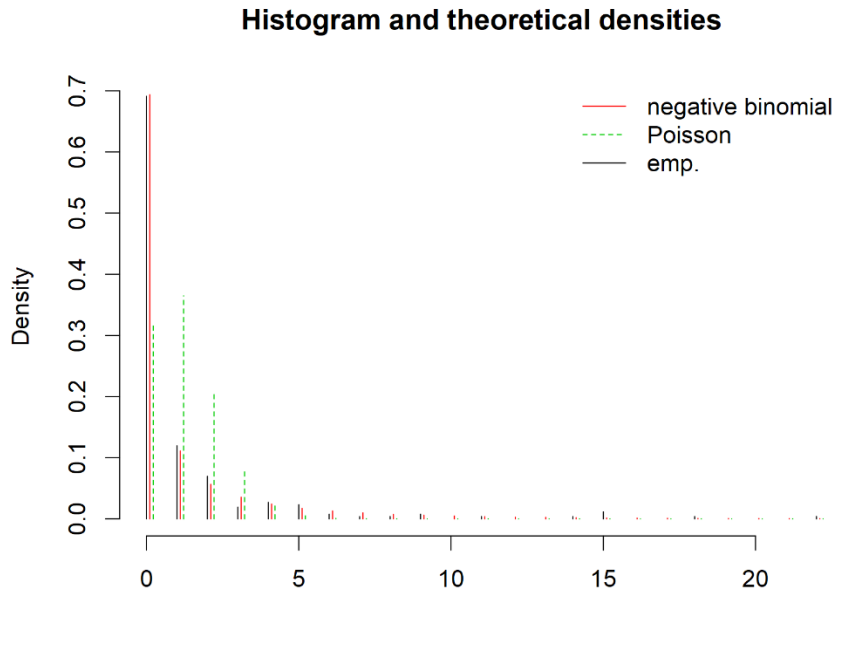


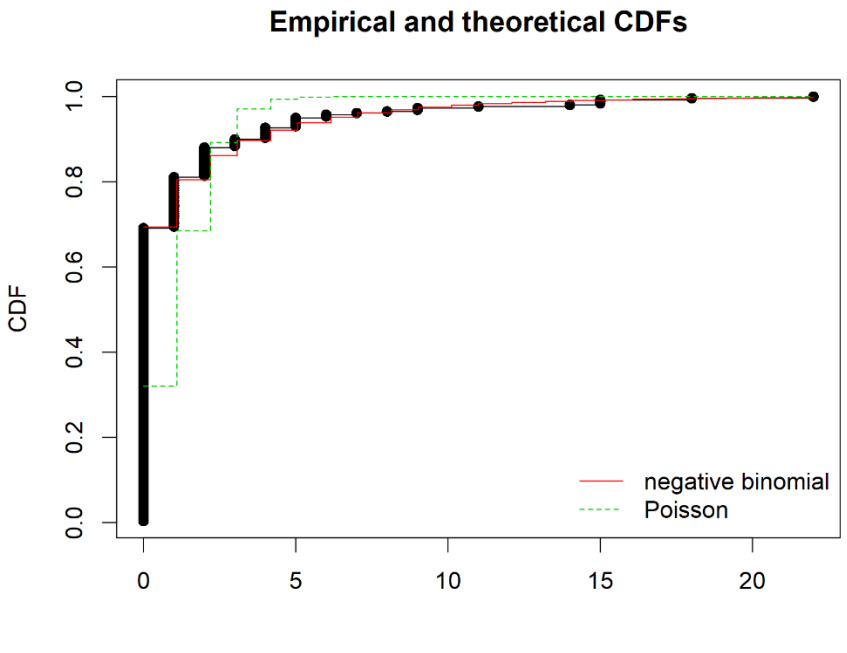


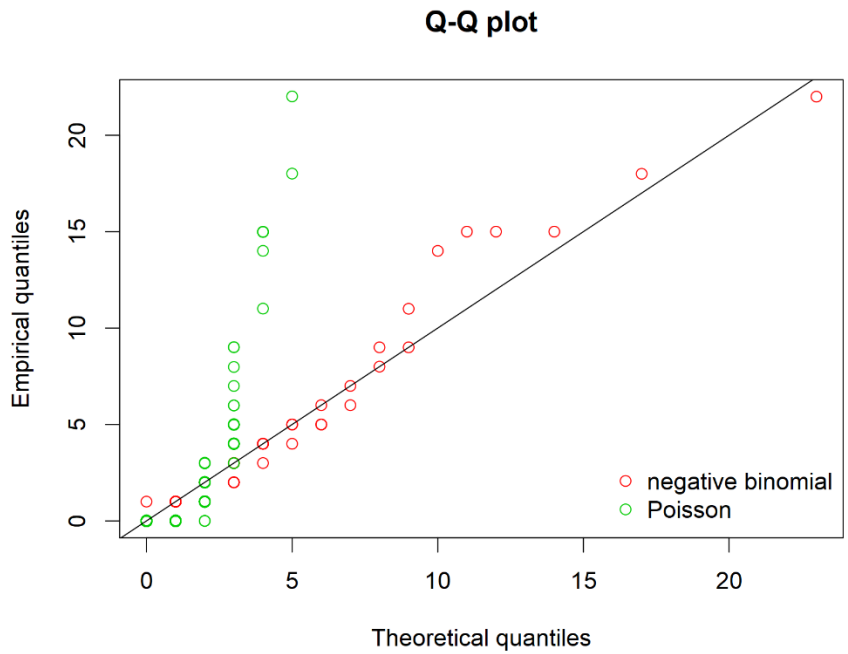


Blue_Deacon Rockfish - South Coast (RG)

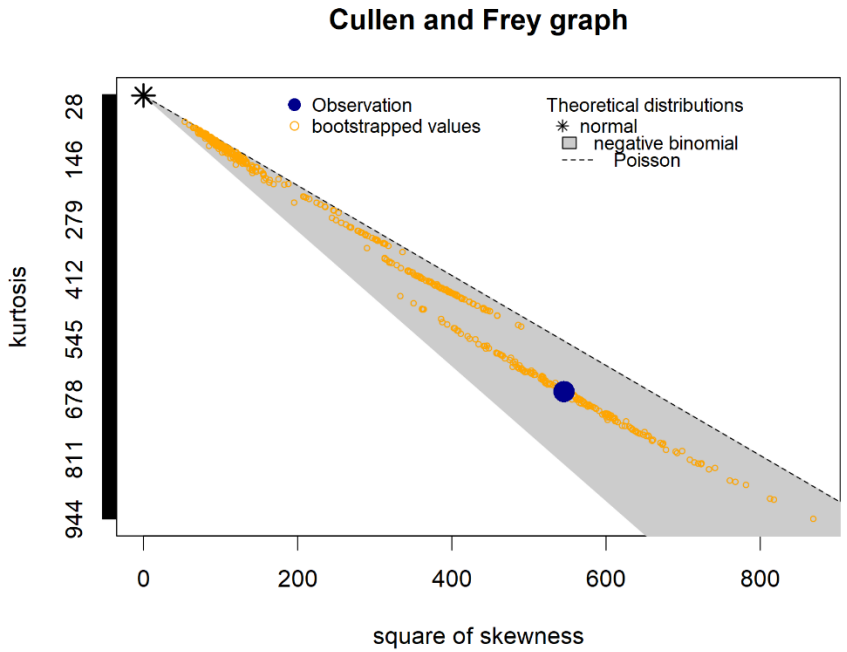


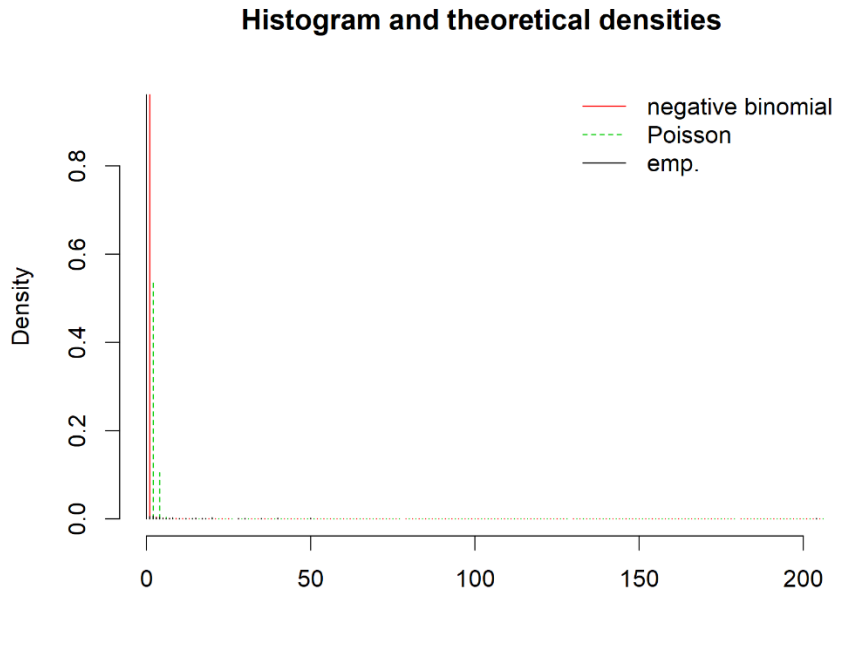


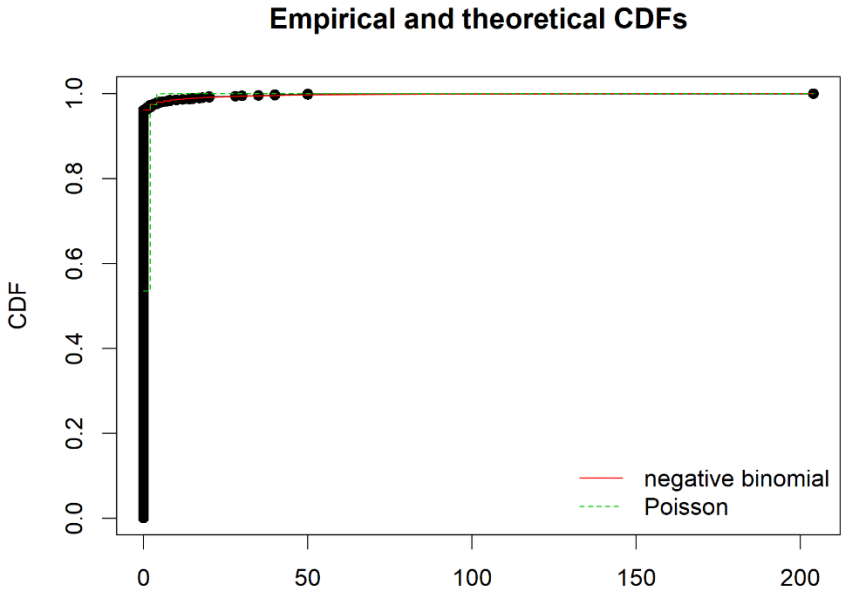


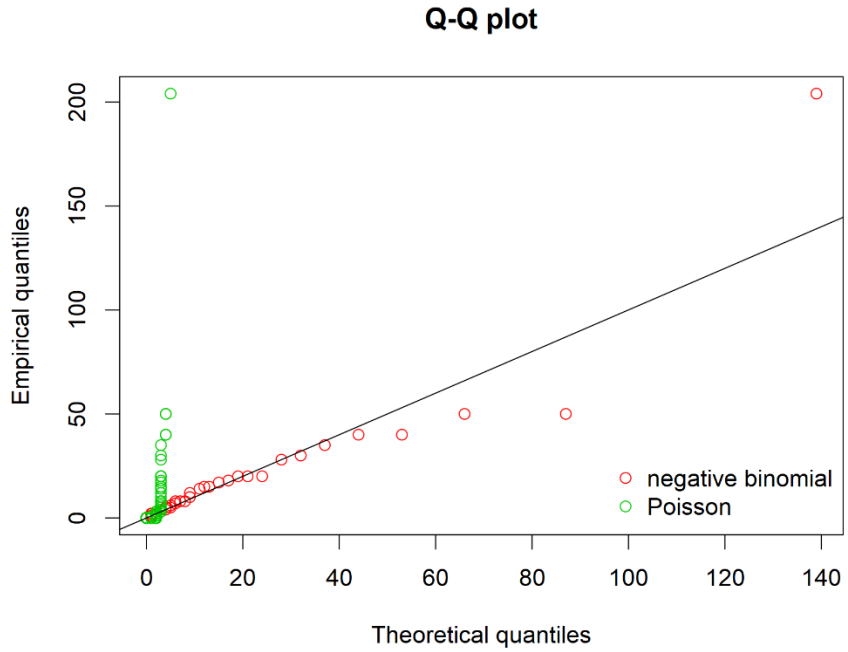


Blue_Deacon Rockfish - Offshore (FG)

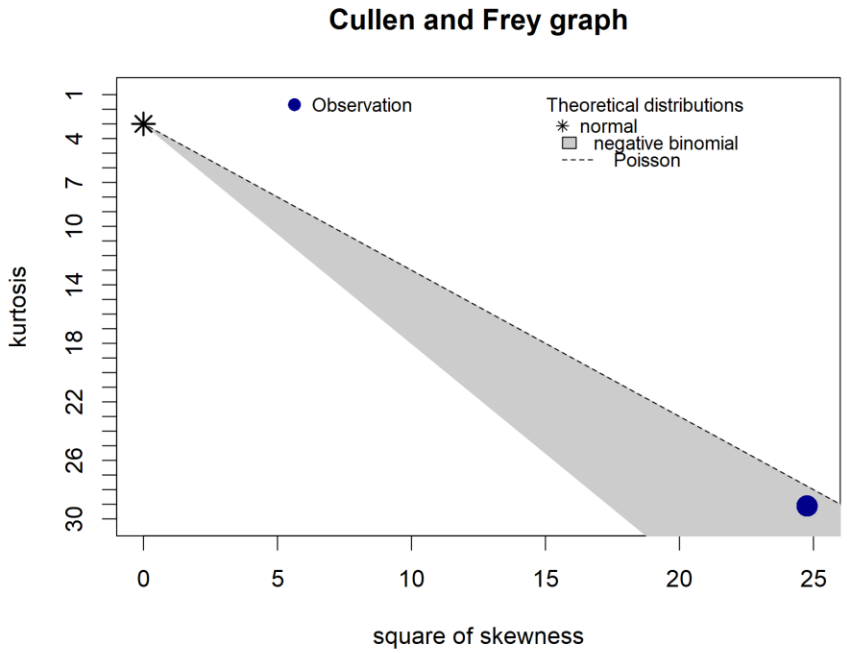


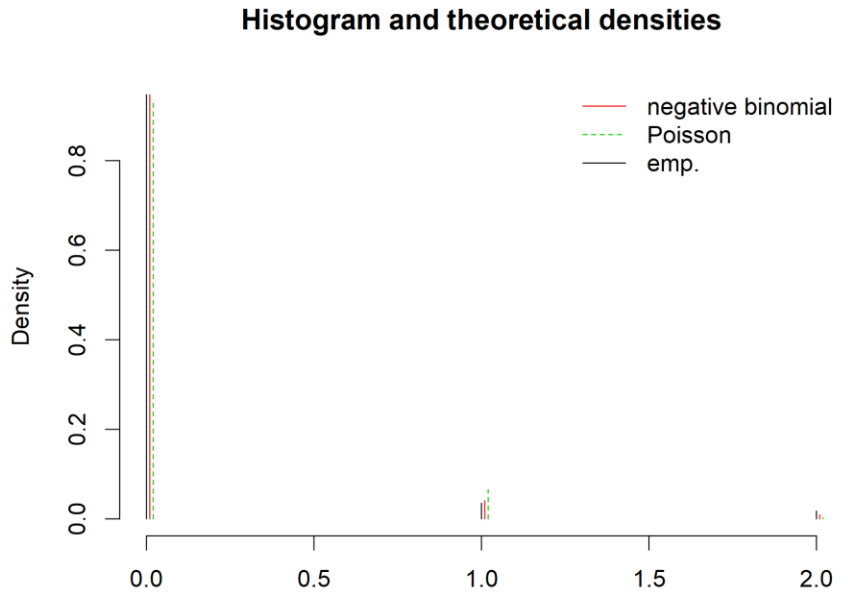


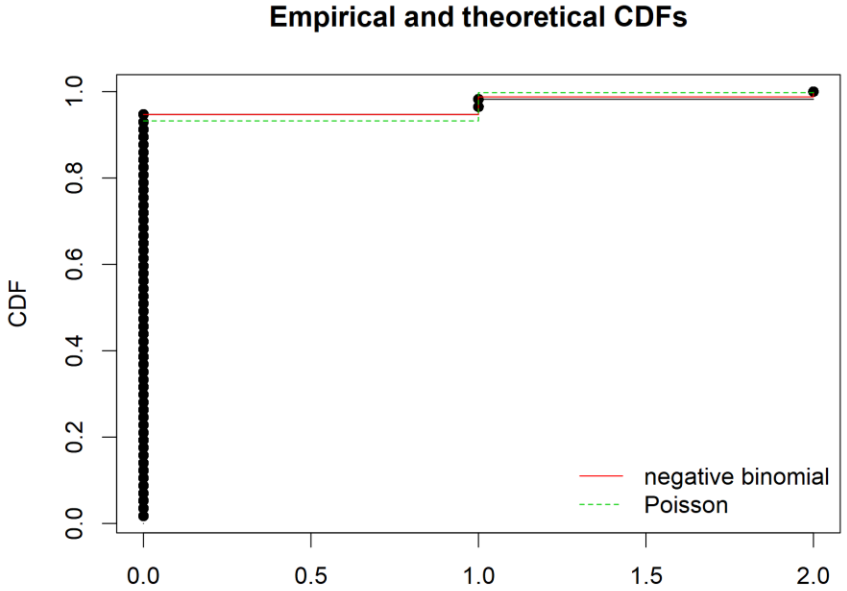


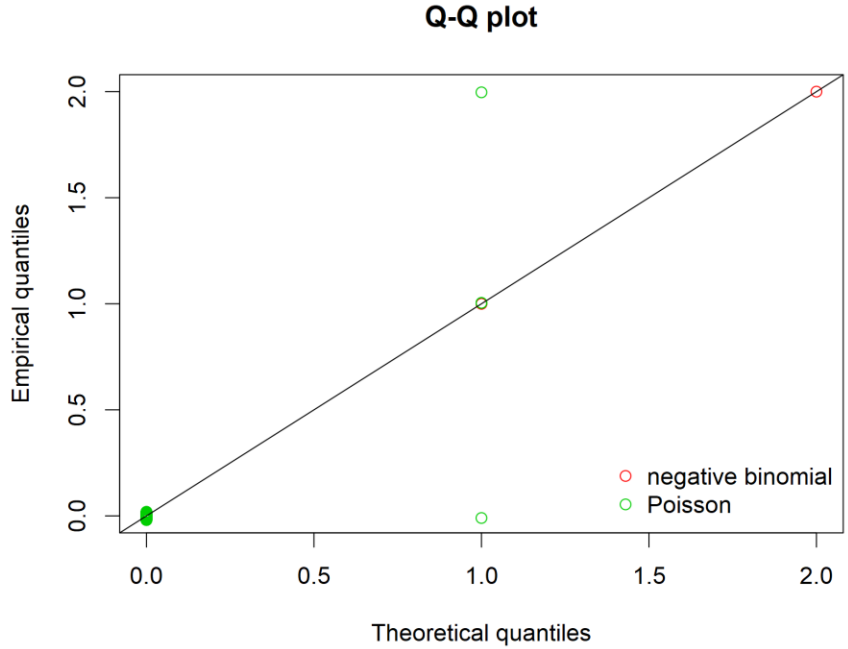


Brown Rockfish - Perpetua (FG)

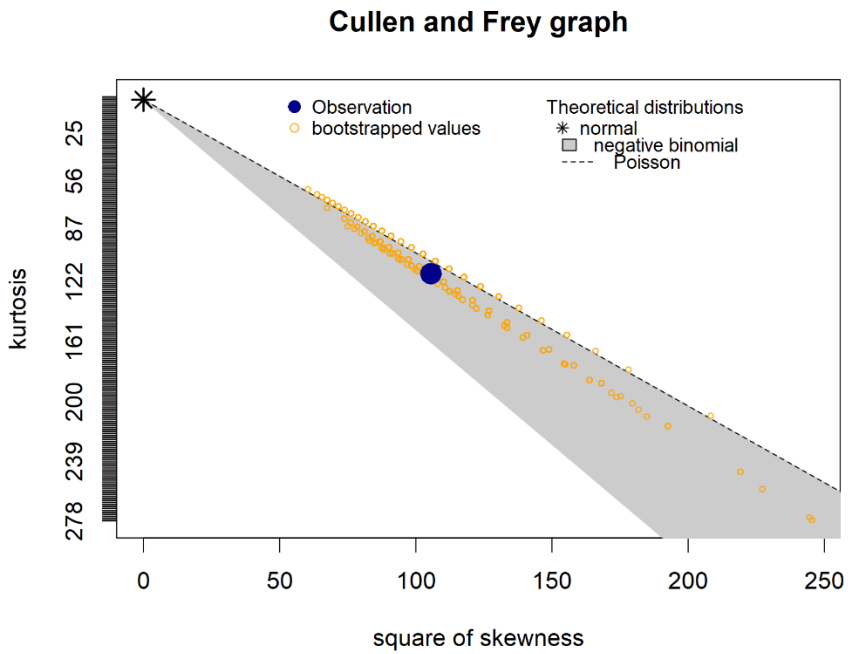


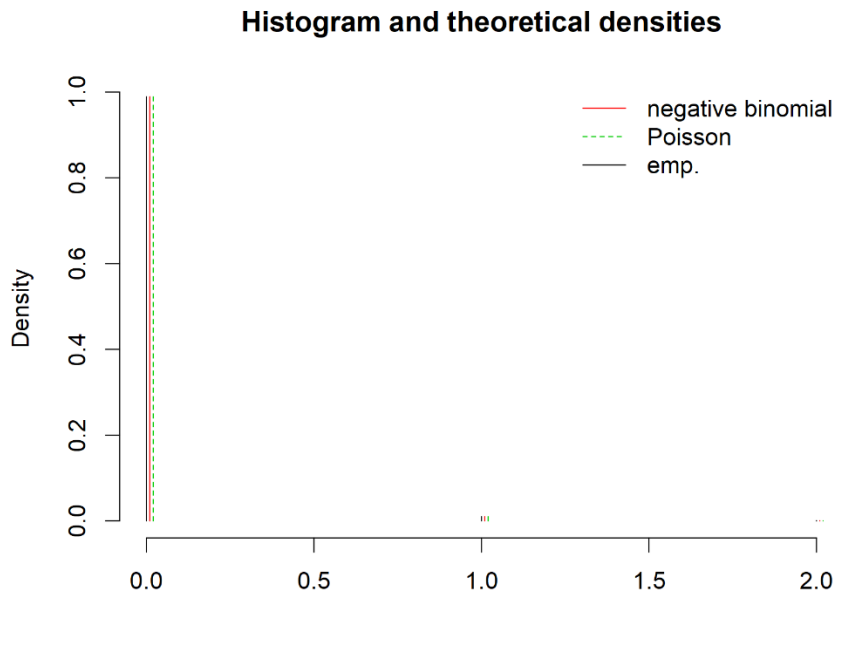


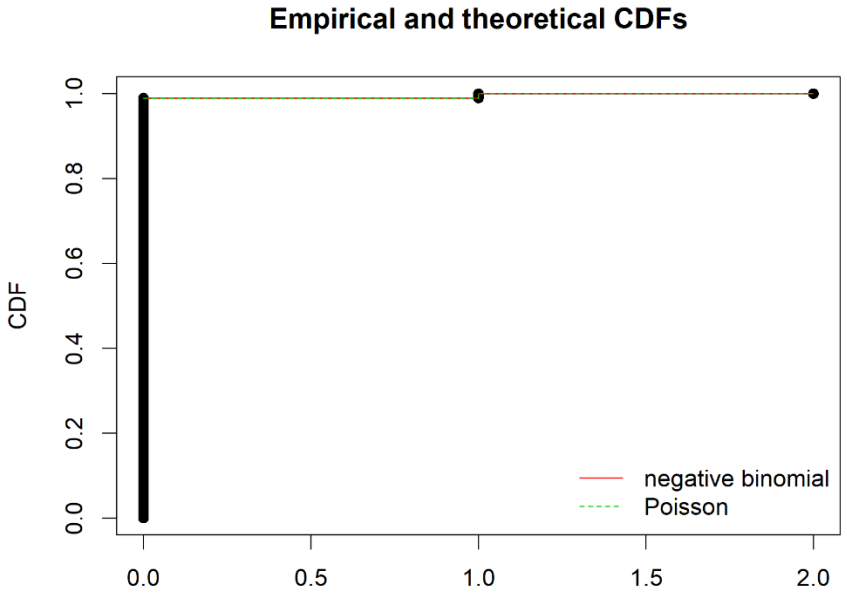


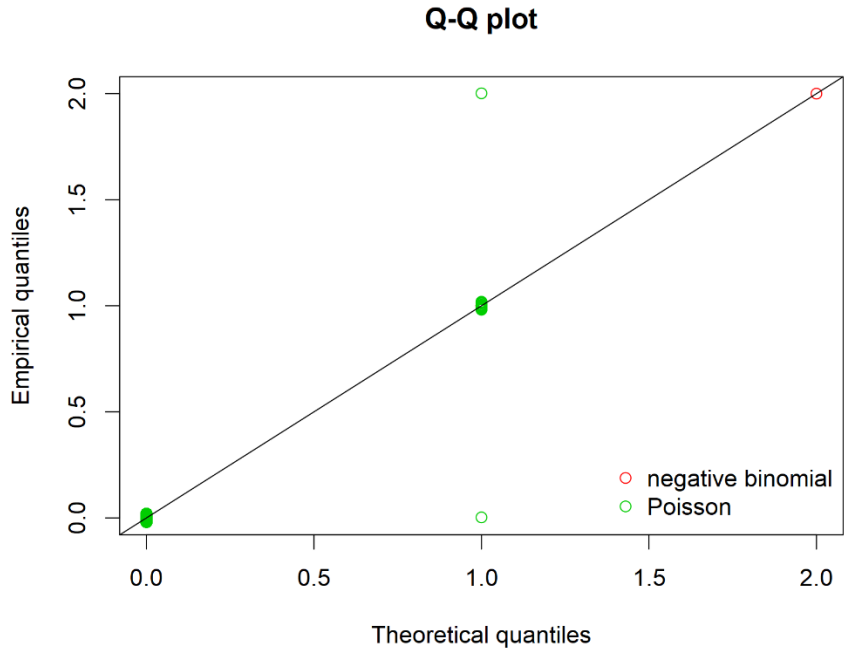


Cabezon - Entire Coast

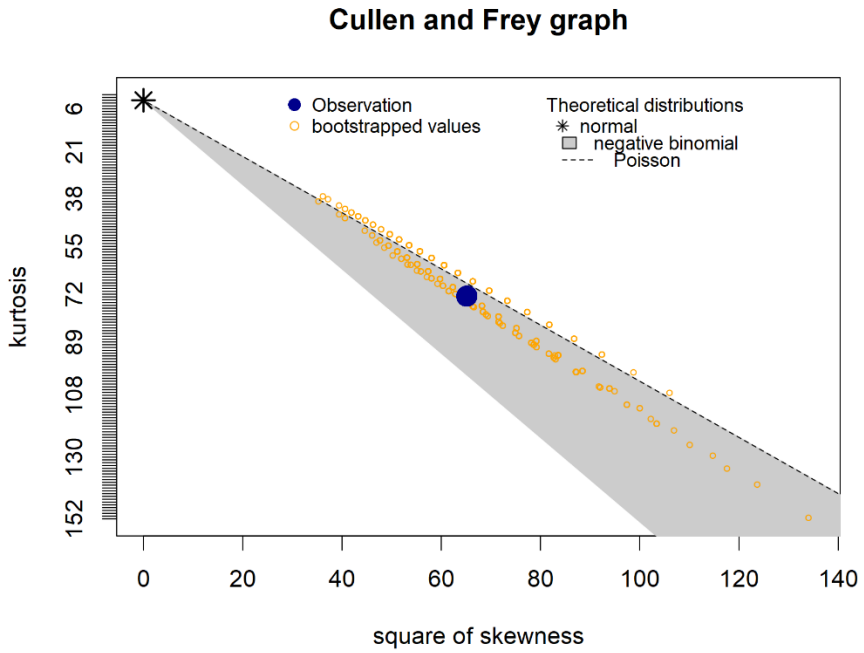


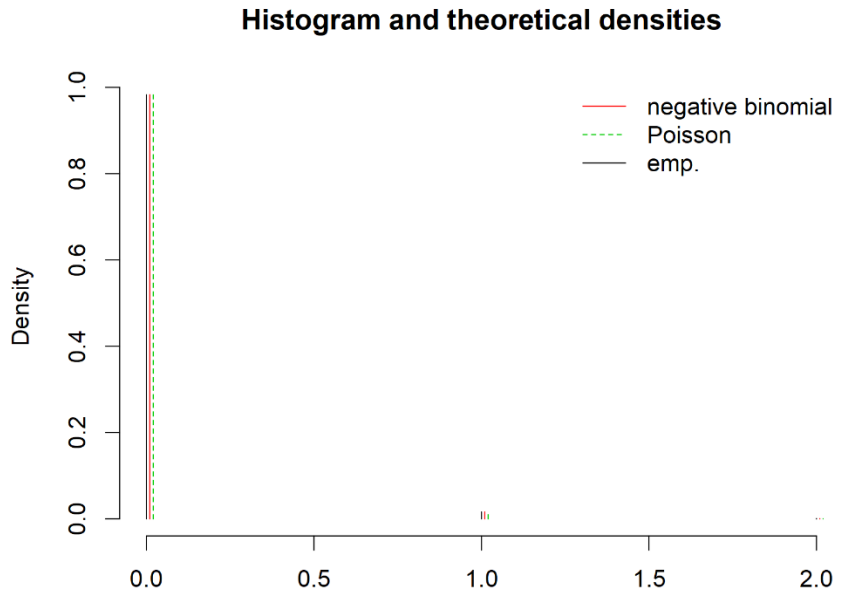


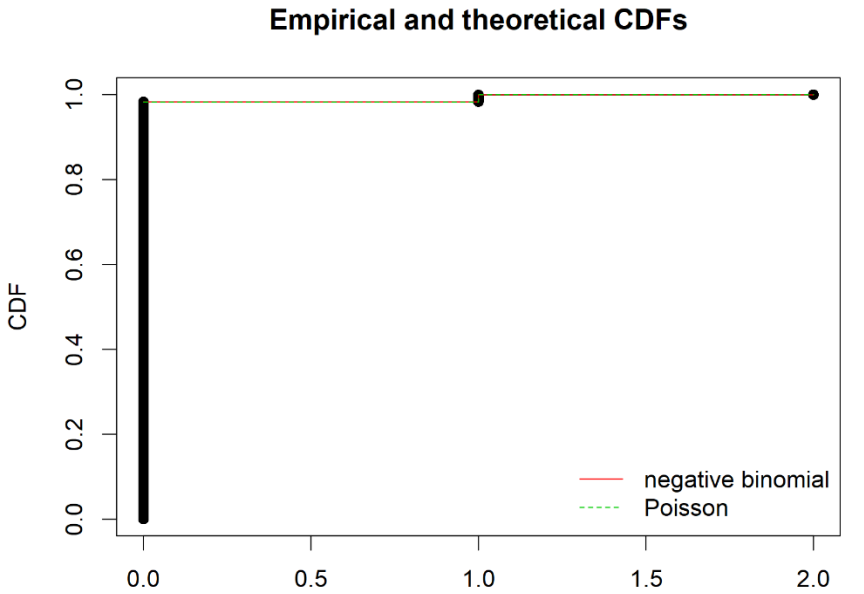


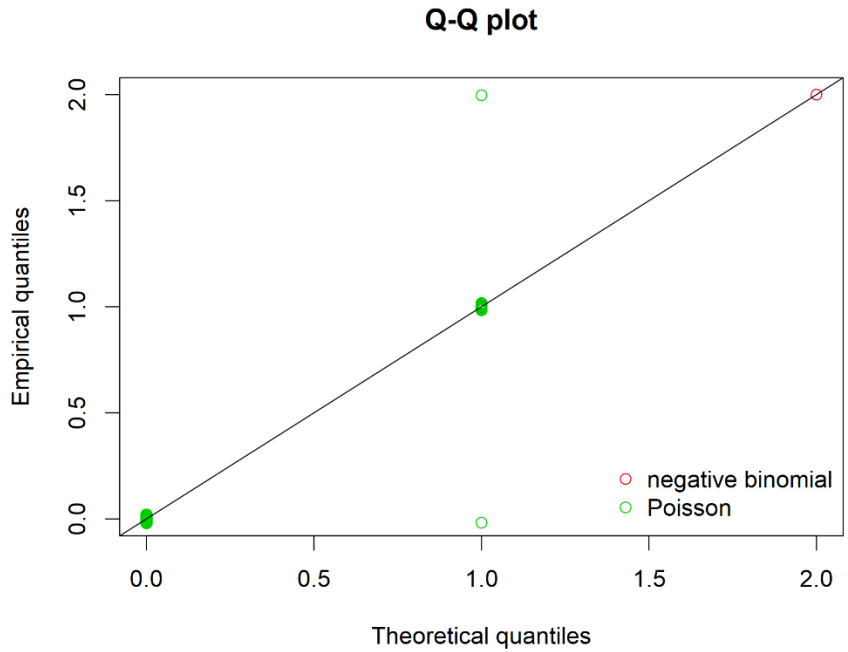


Cabezon - Nearshore

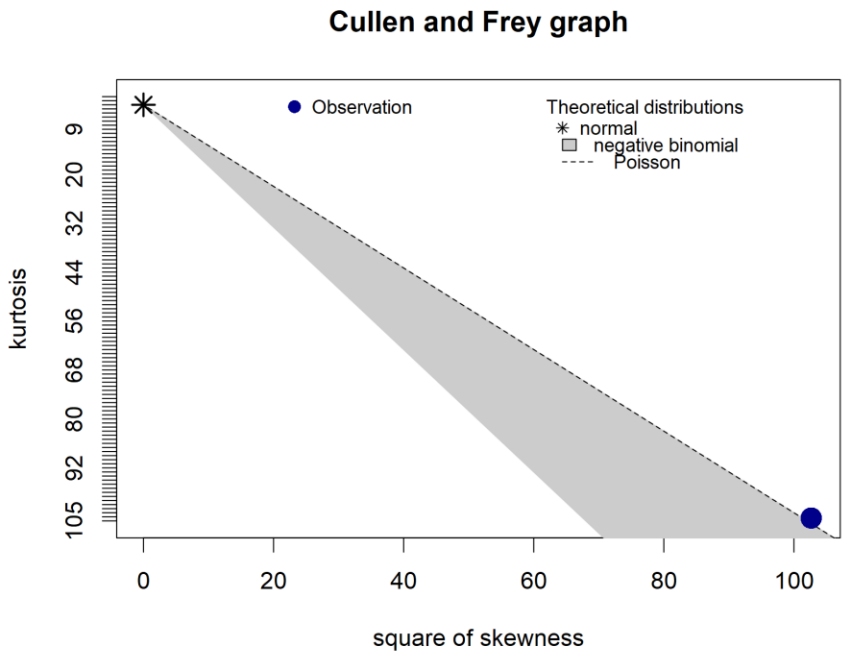


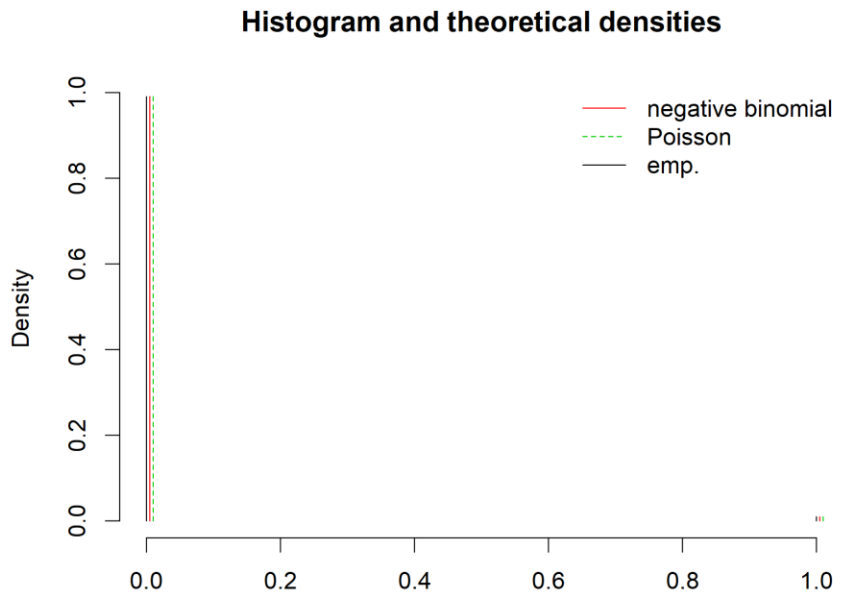


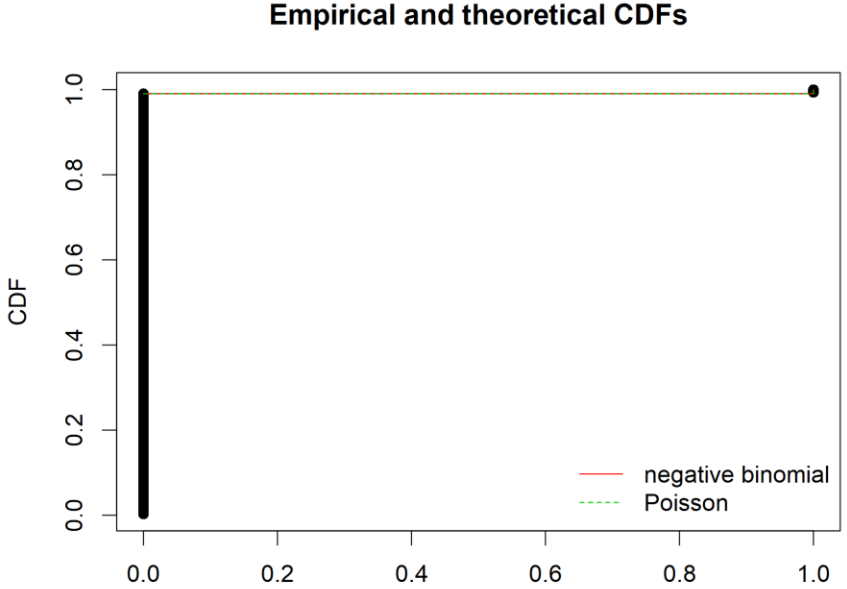


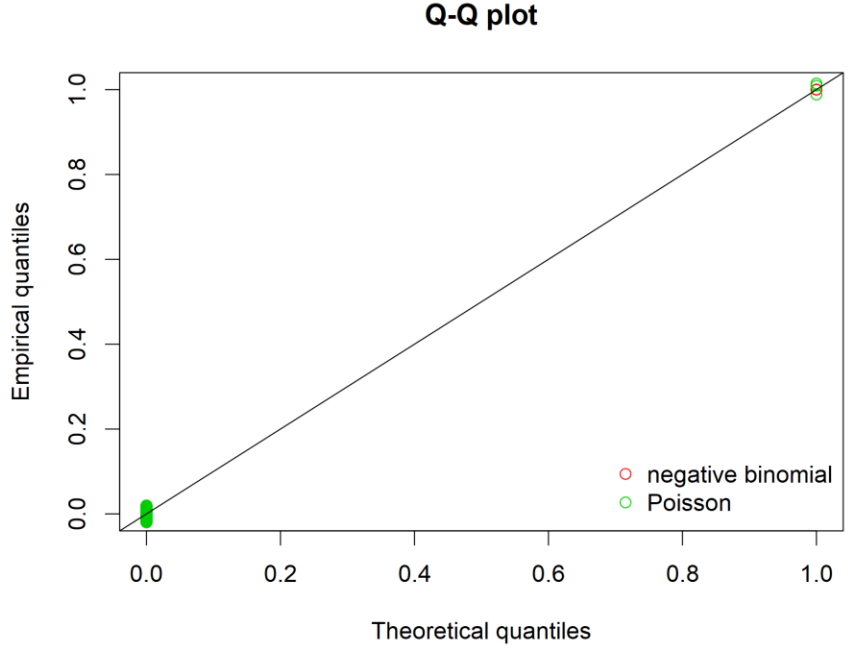


Cabezon - North Coast (FG)

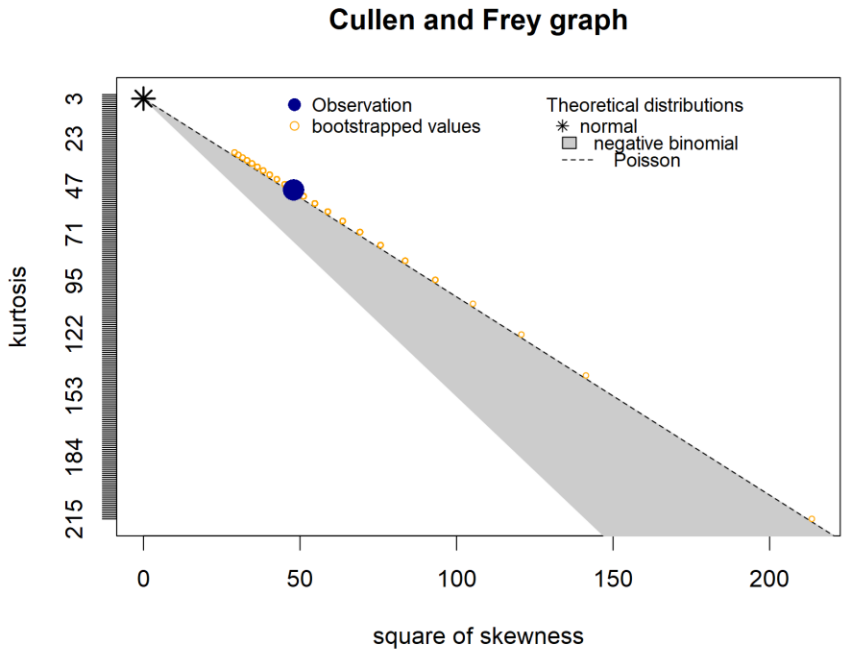


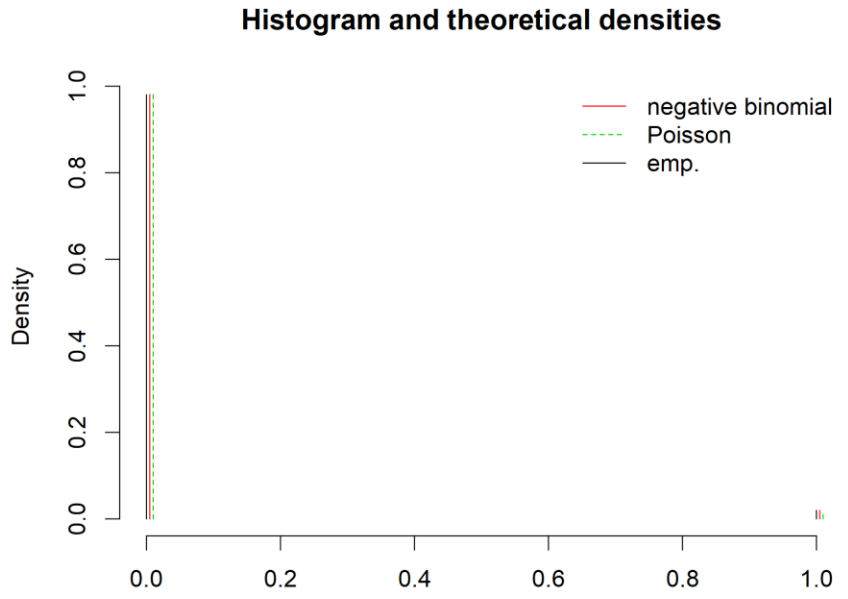


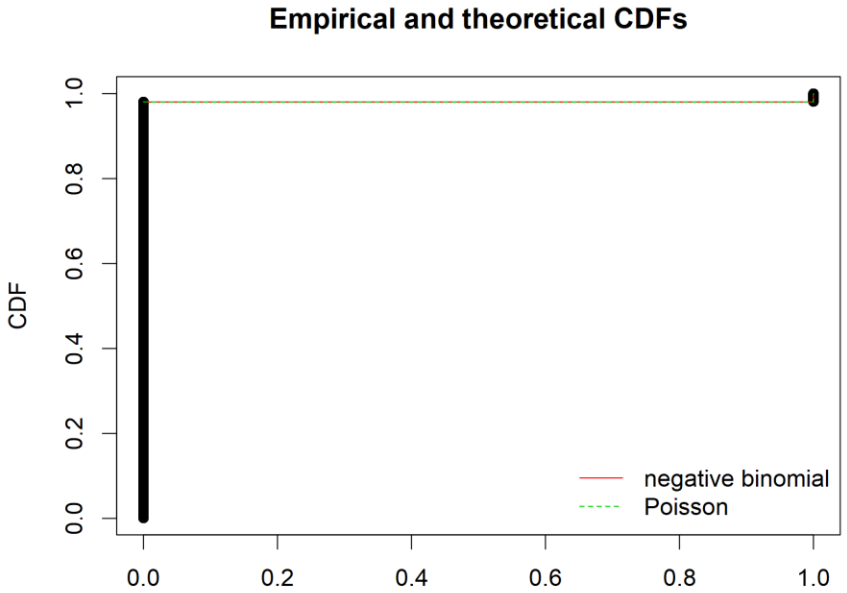


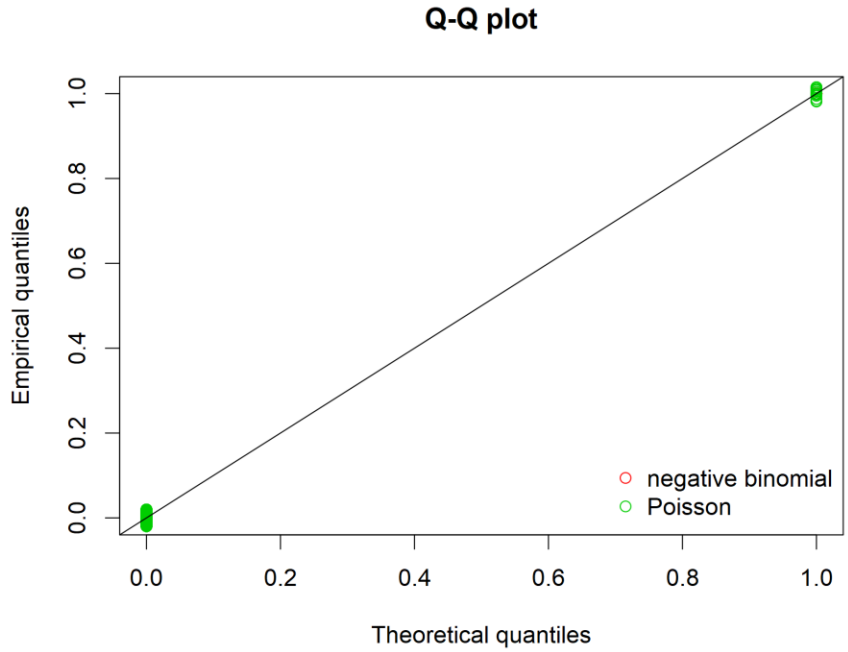


Cabezon - Central Coast (FG, RG, & NG)

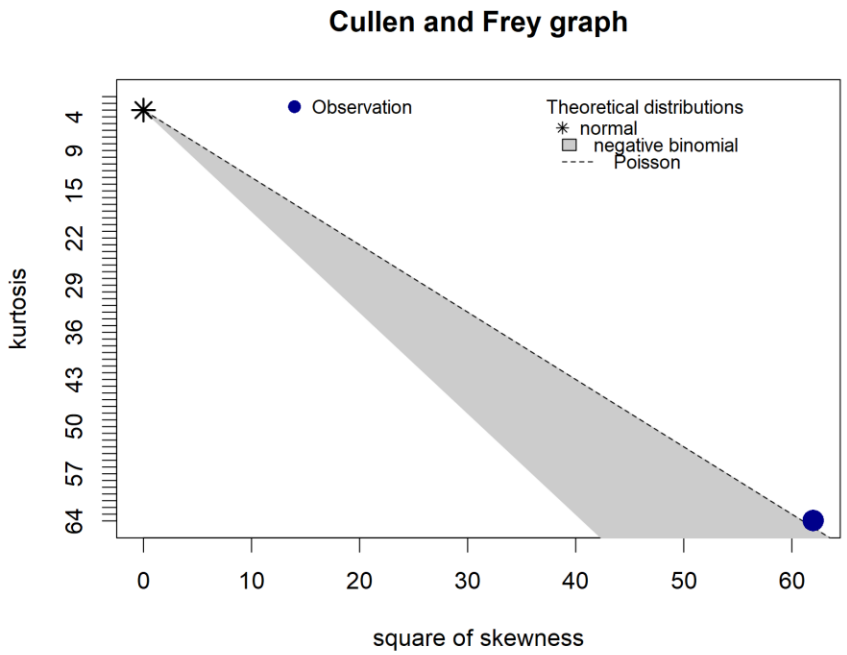


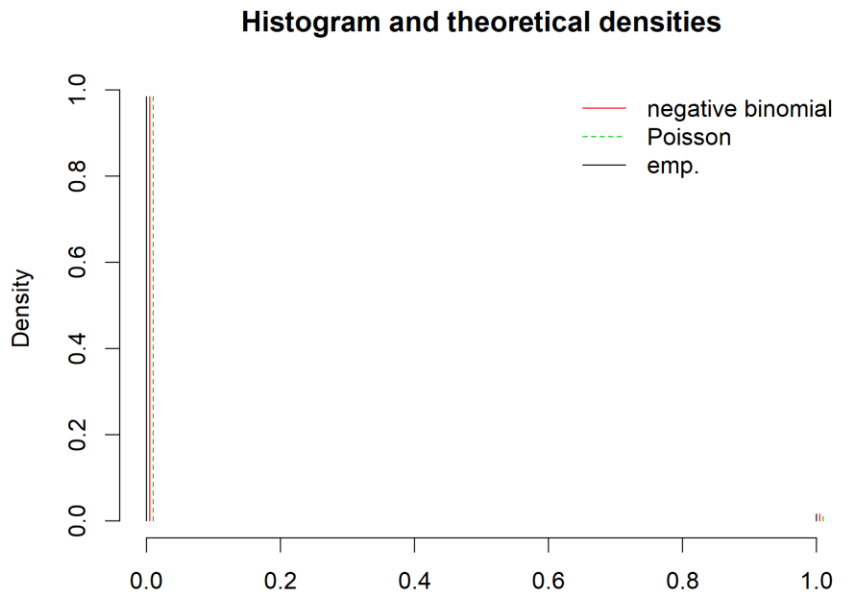


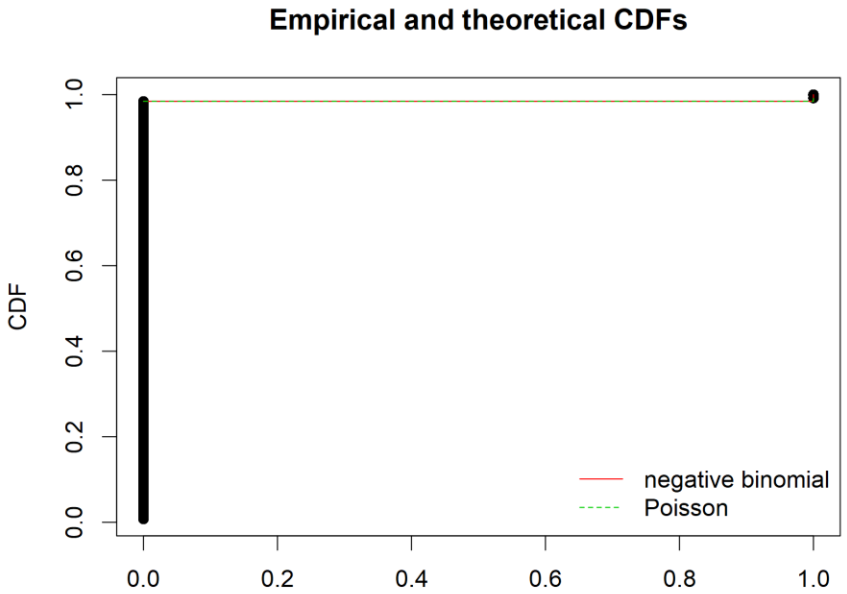


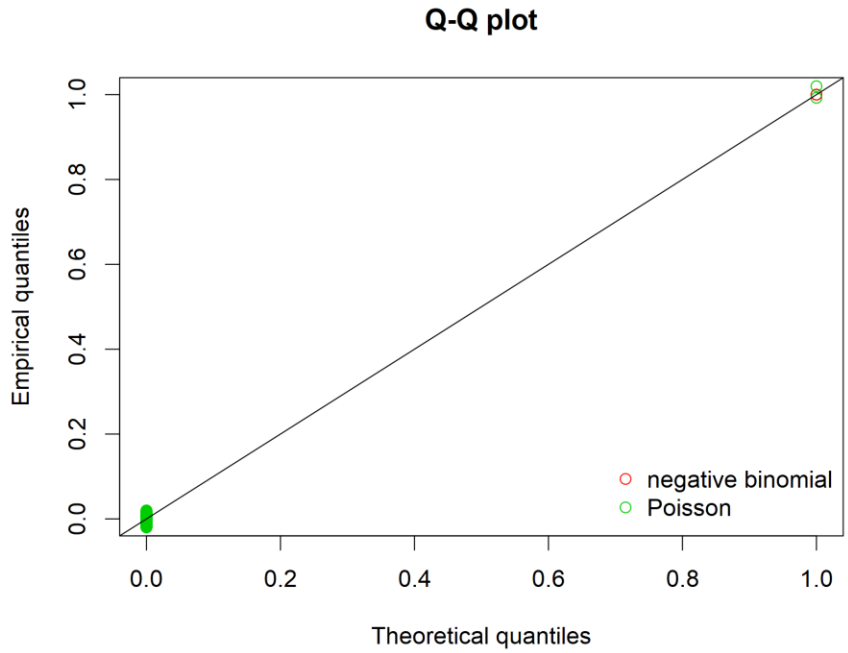


Cabezon - Central Coast (FG)

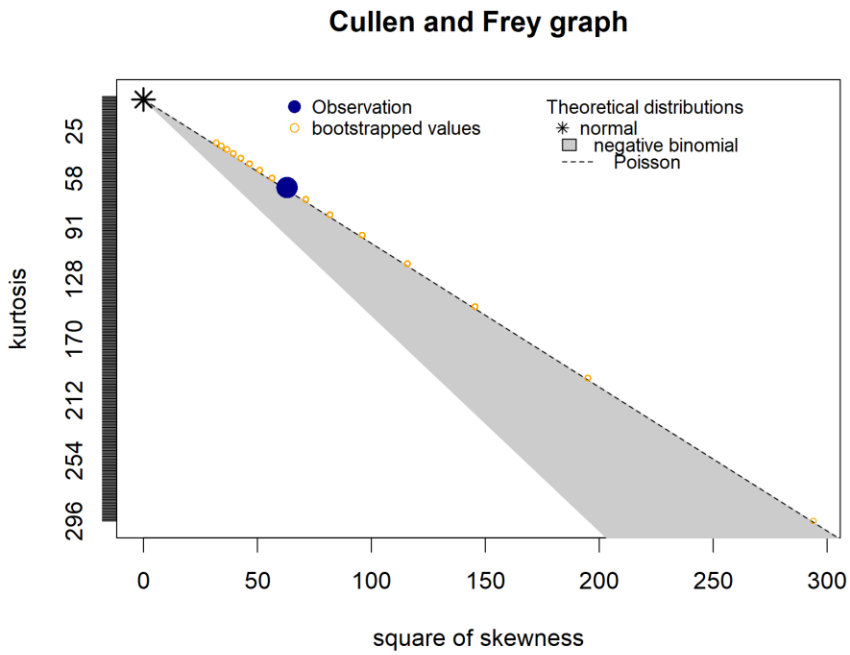


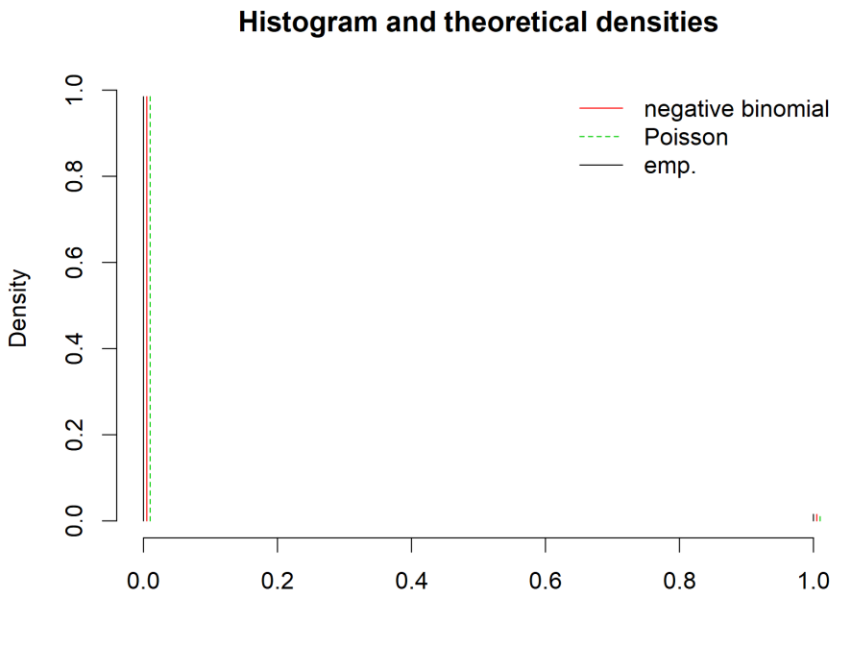


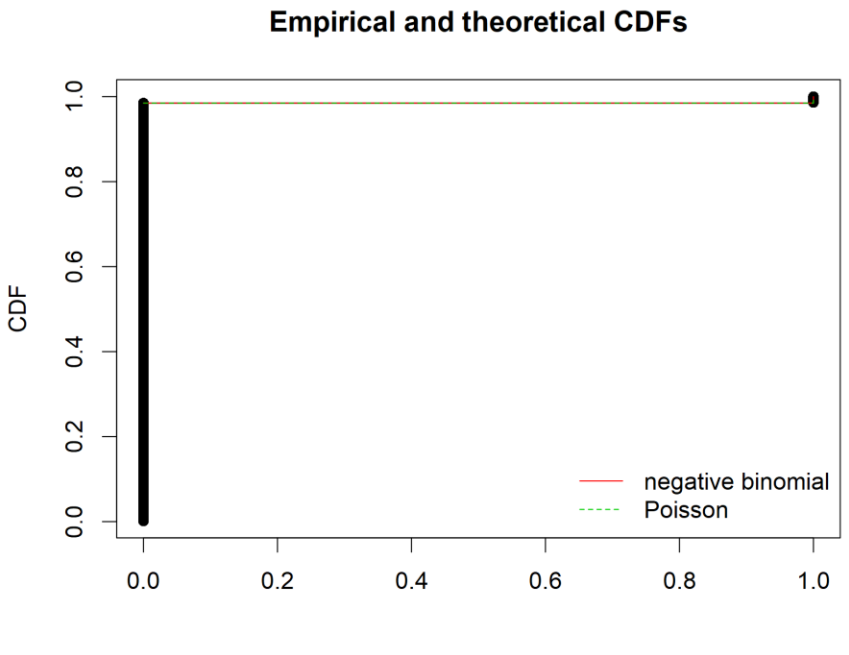


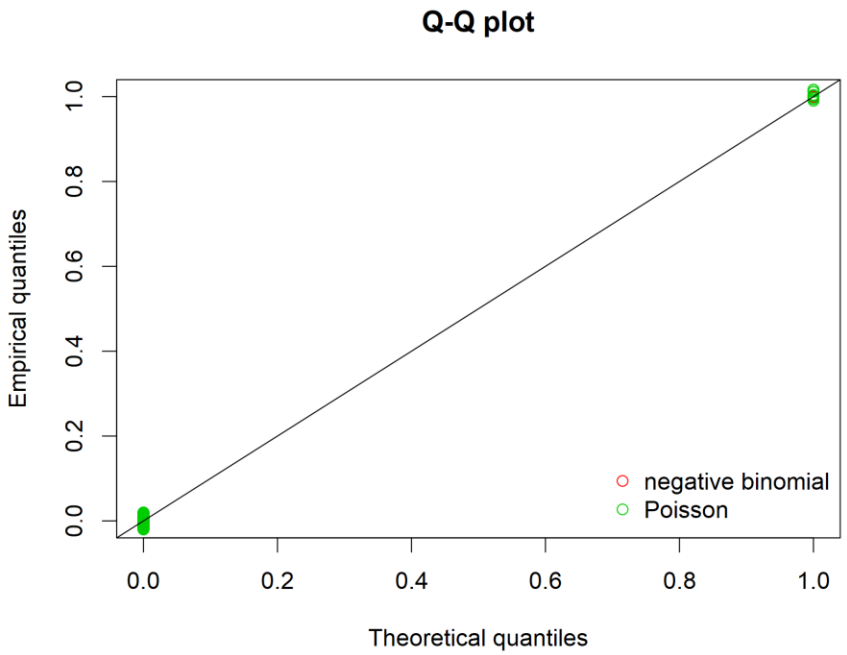


Cabezon - Central Coast (RG)

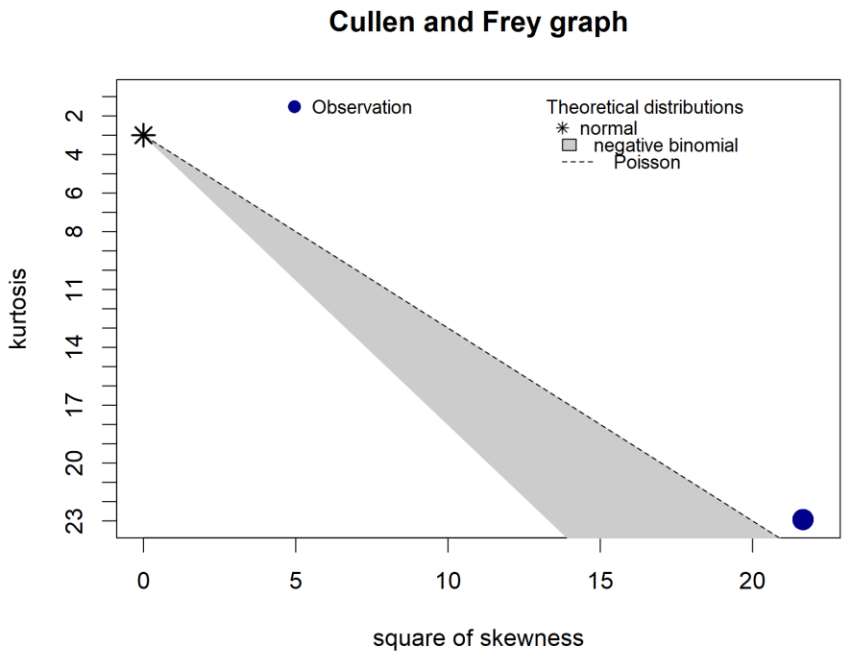


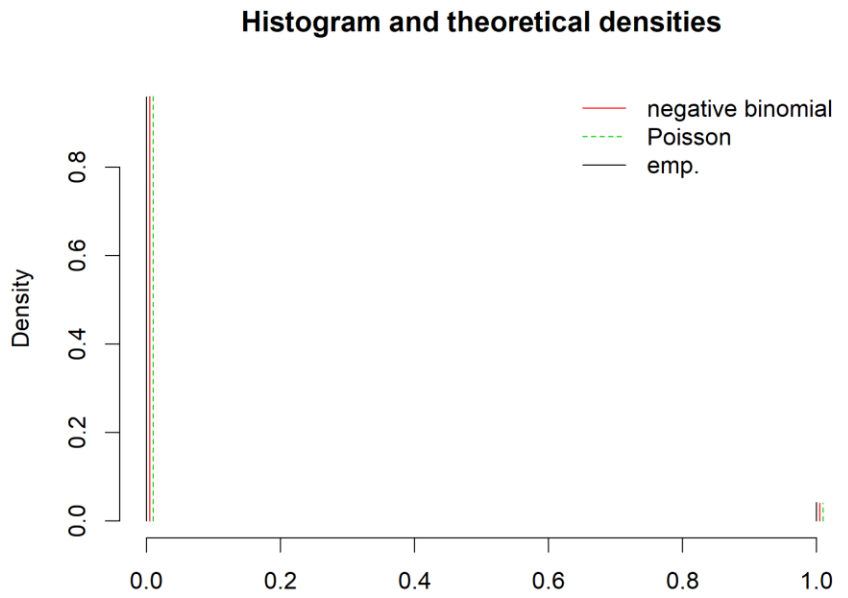


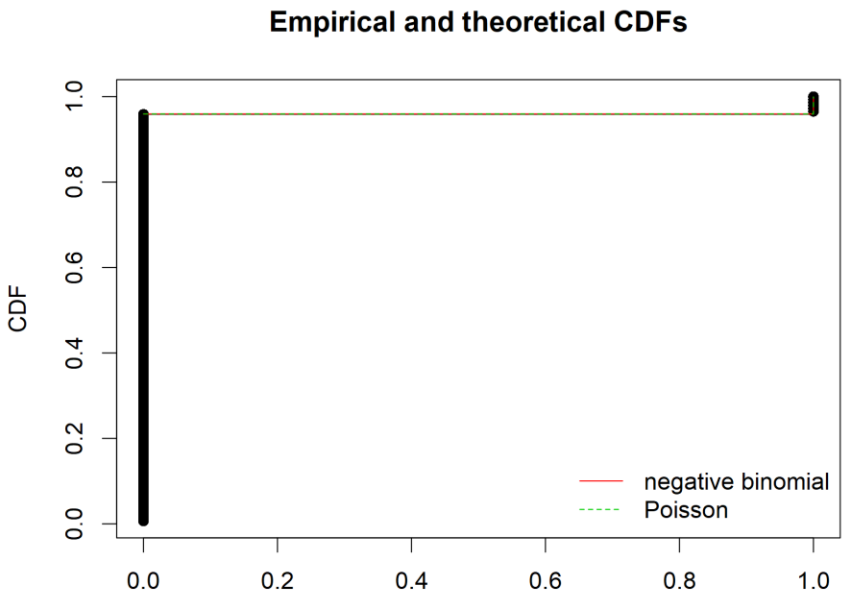


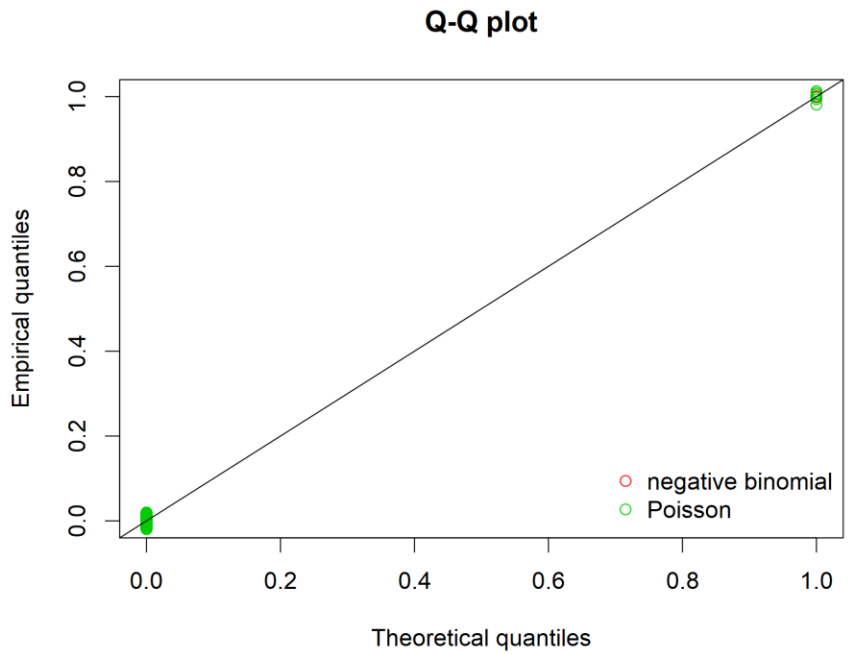


Cabezon - Central Coast (NG)

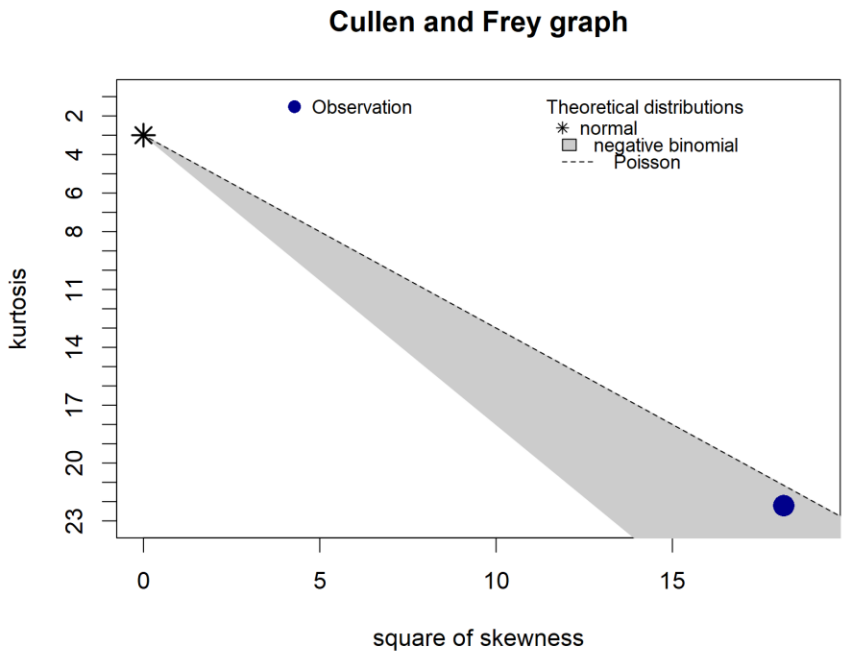


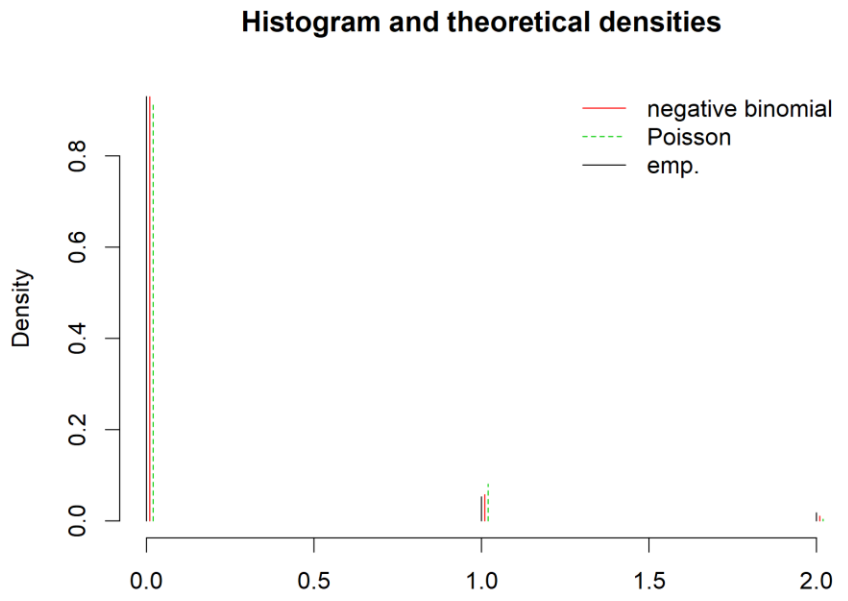


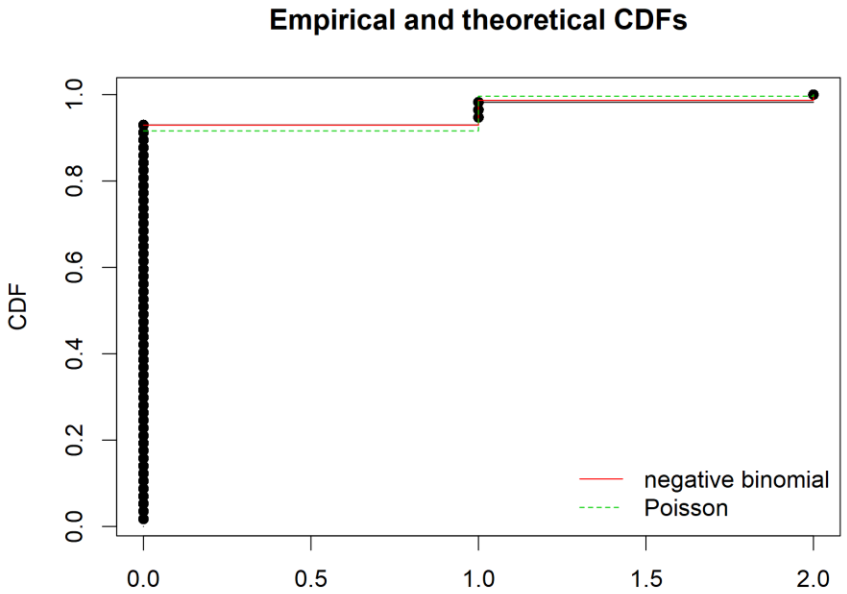


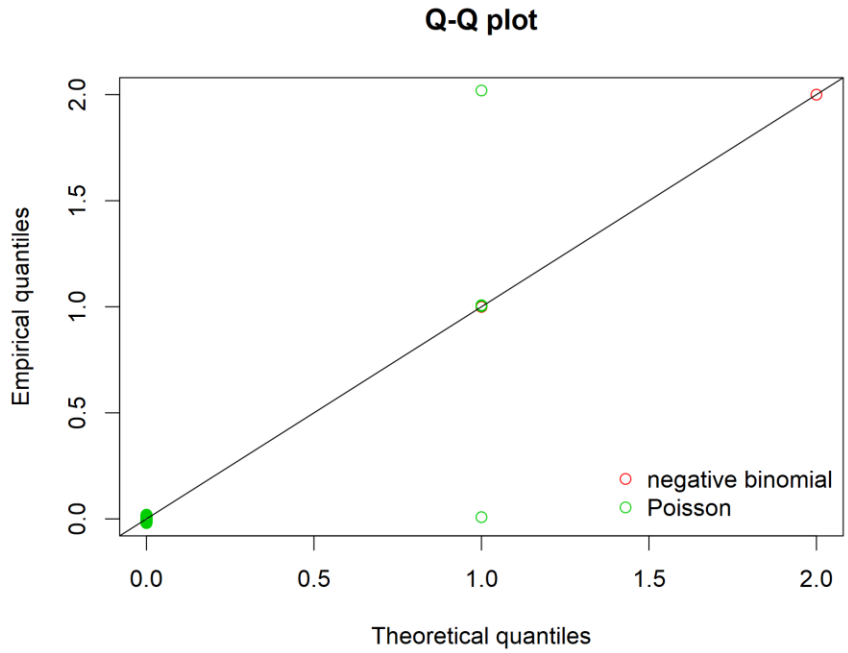


Cabezon - Cape Perpetua (FG)

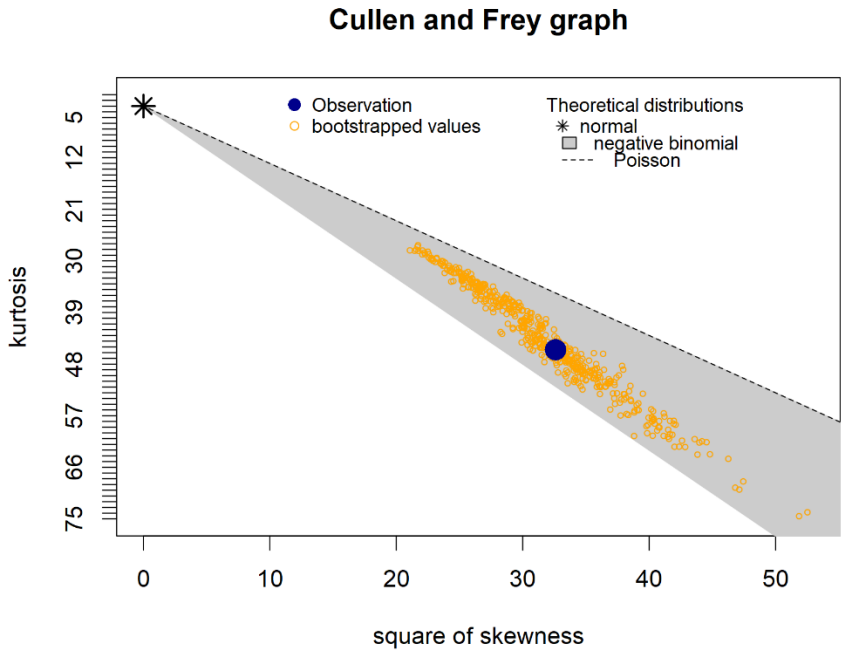


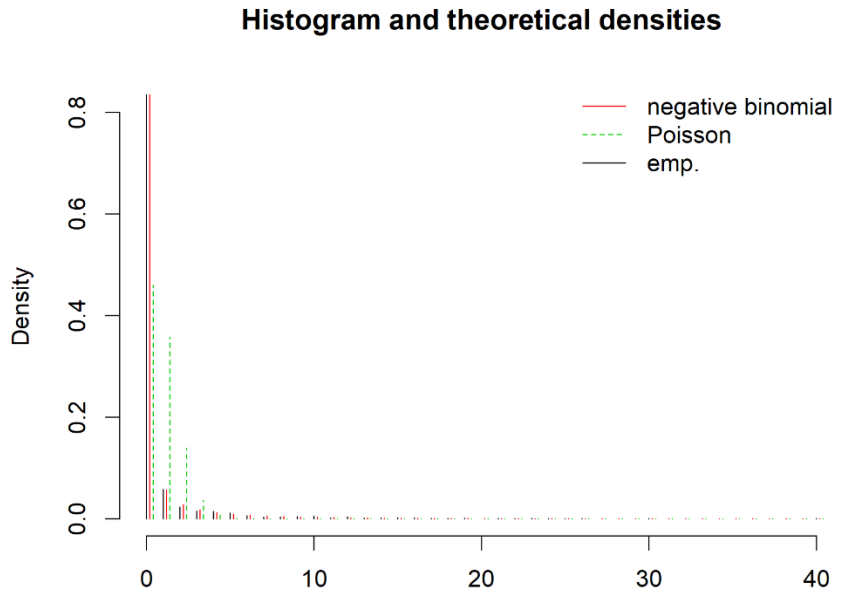


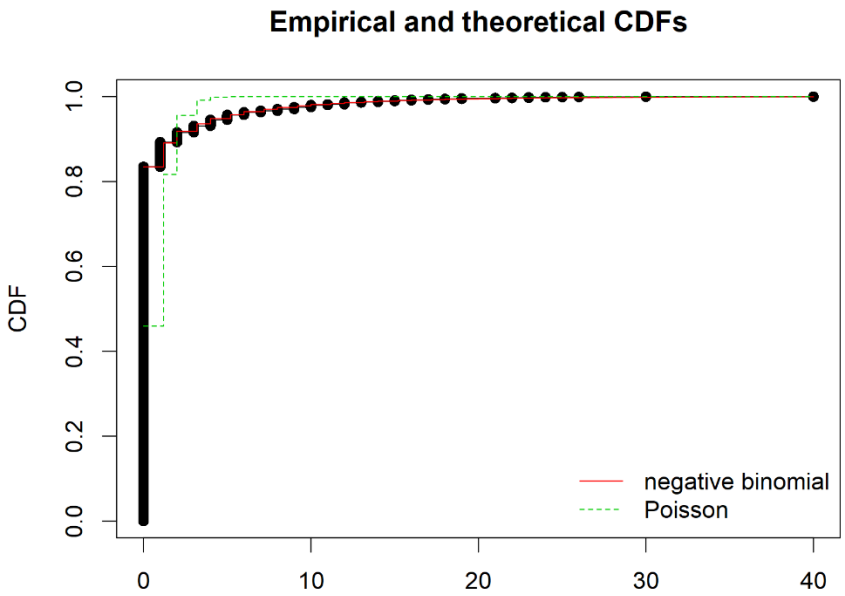


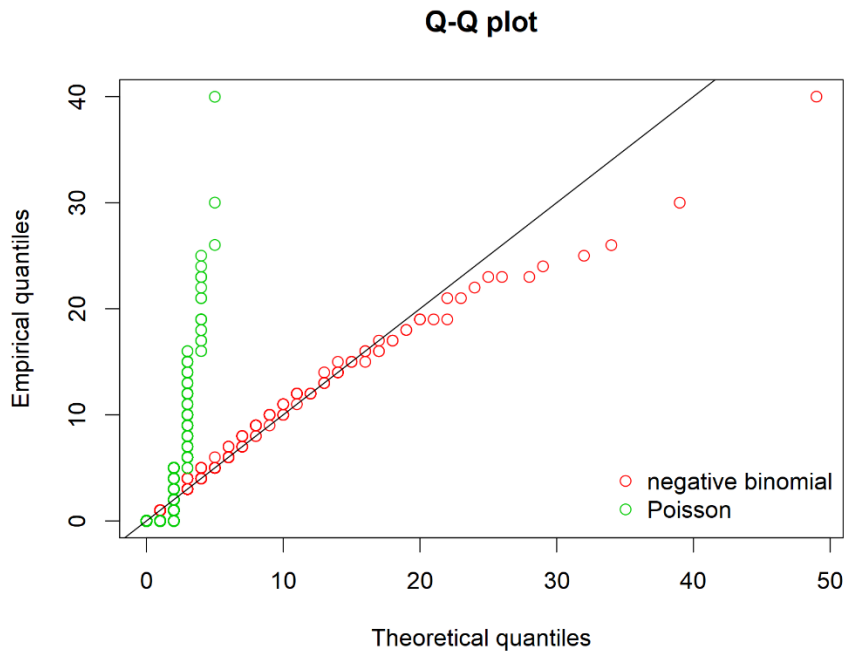


Canary Rockfish - Entire Coast

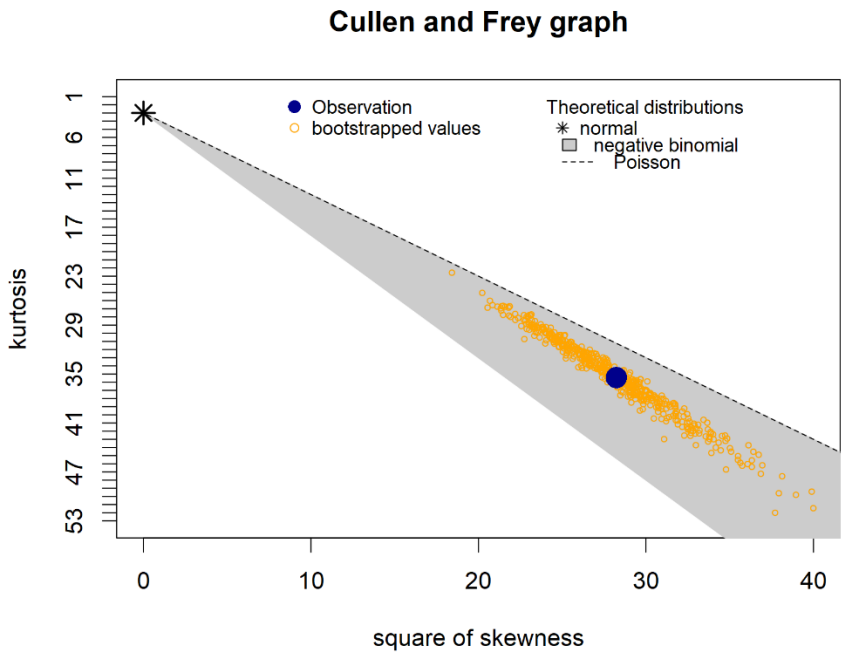


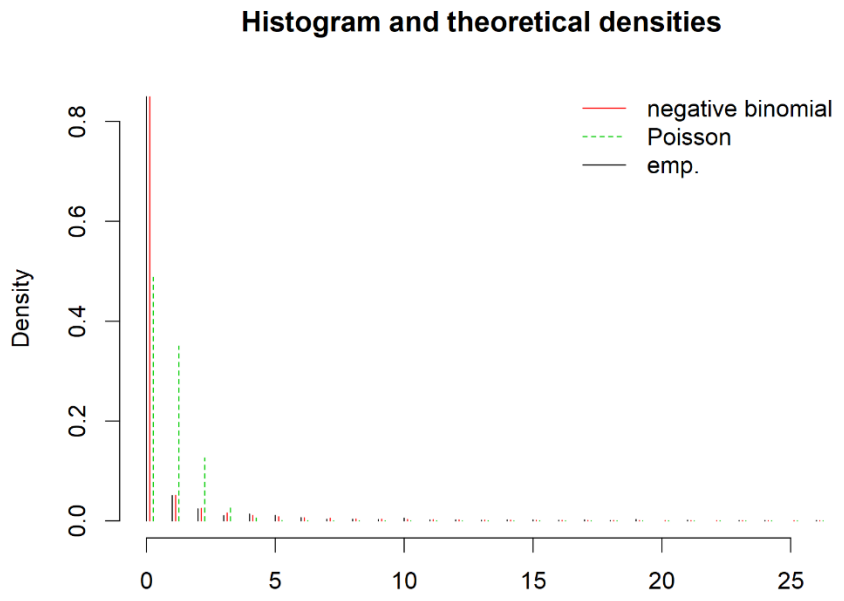


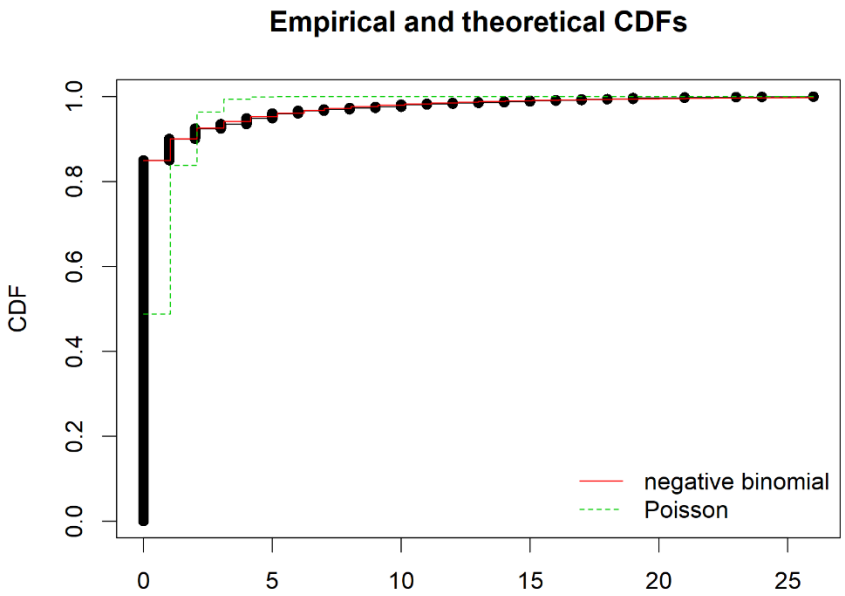


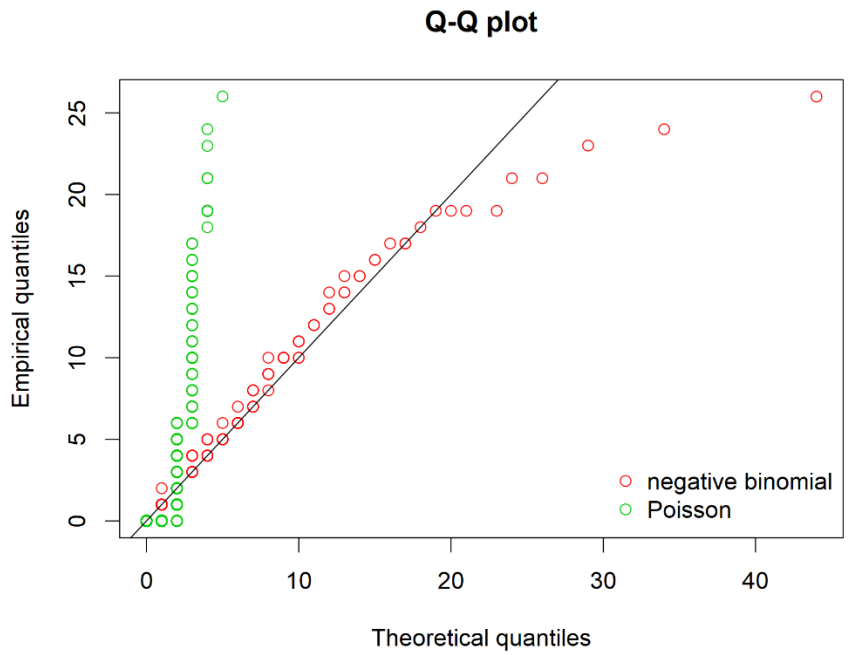


Canary Rockfish - Nearshore

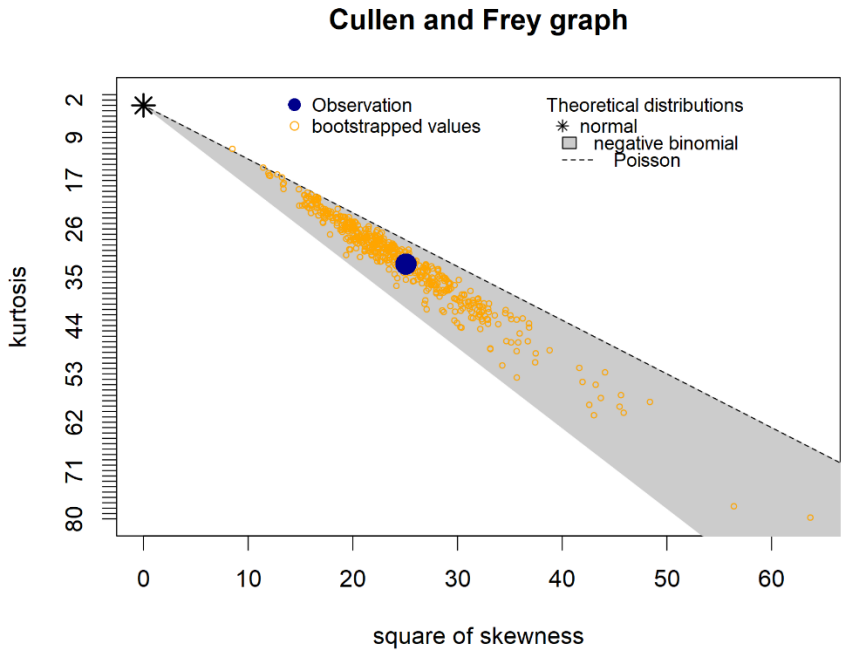


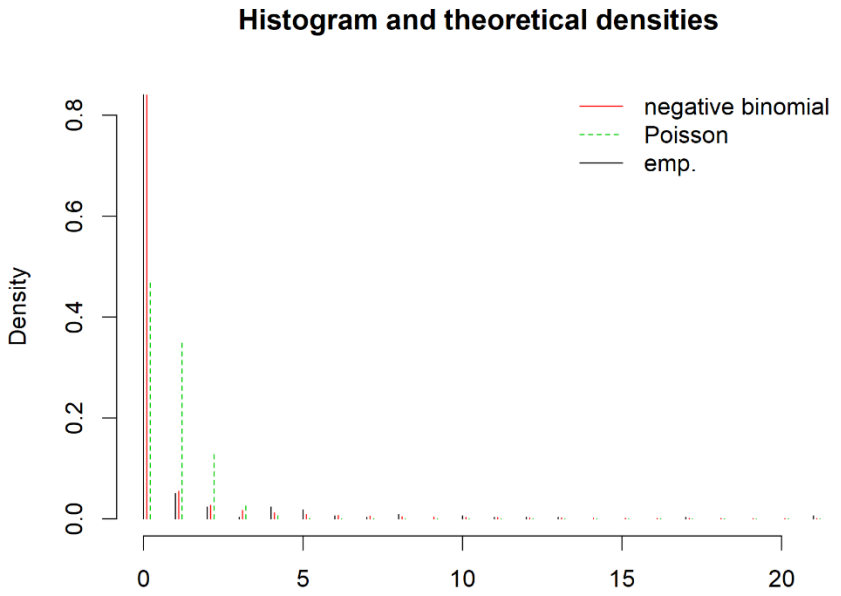


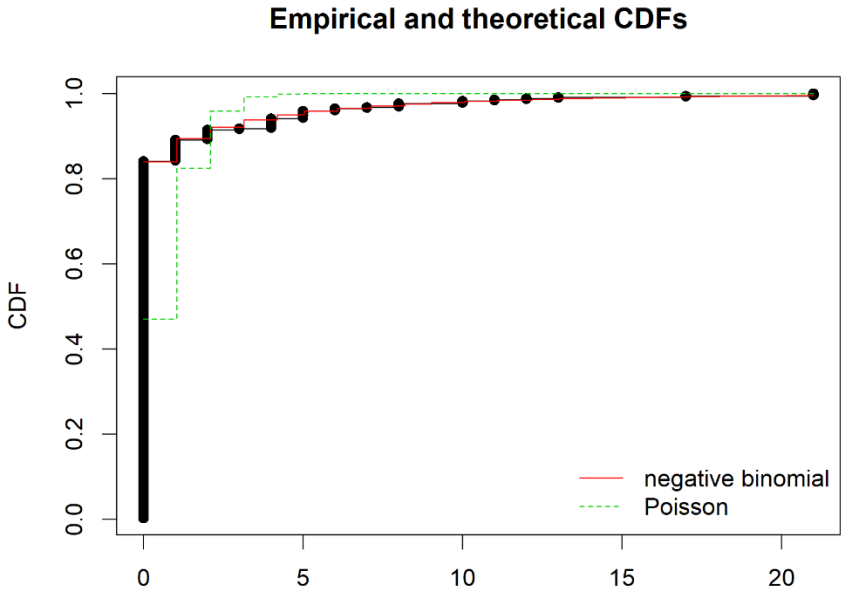


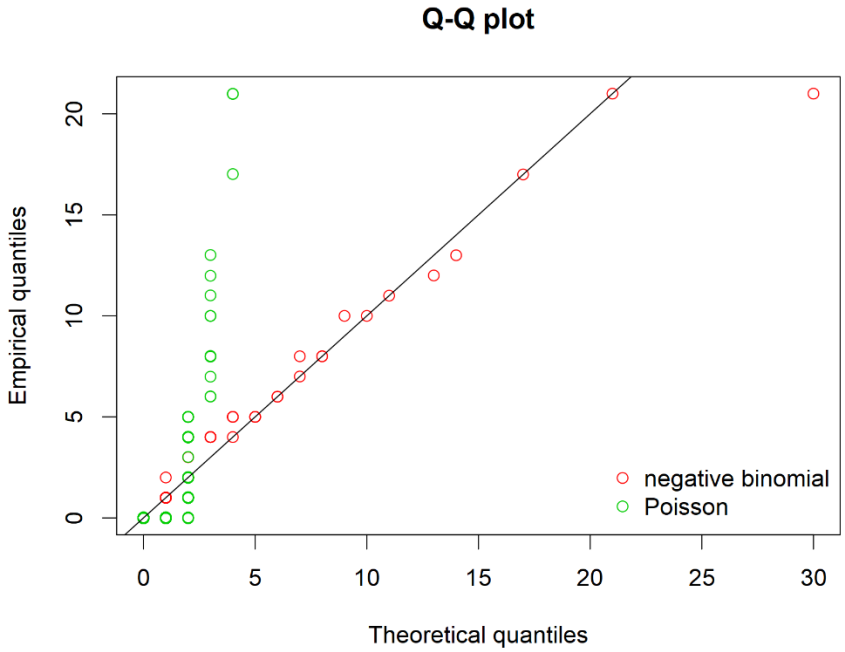


Canary Rockfish - North Coast (FG & RG)

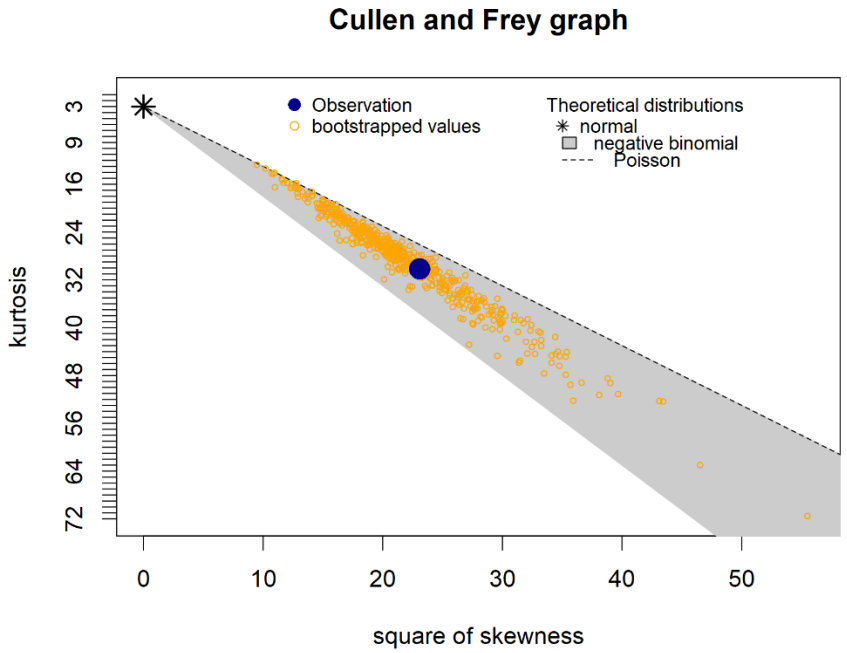


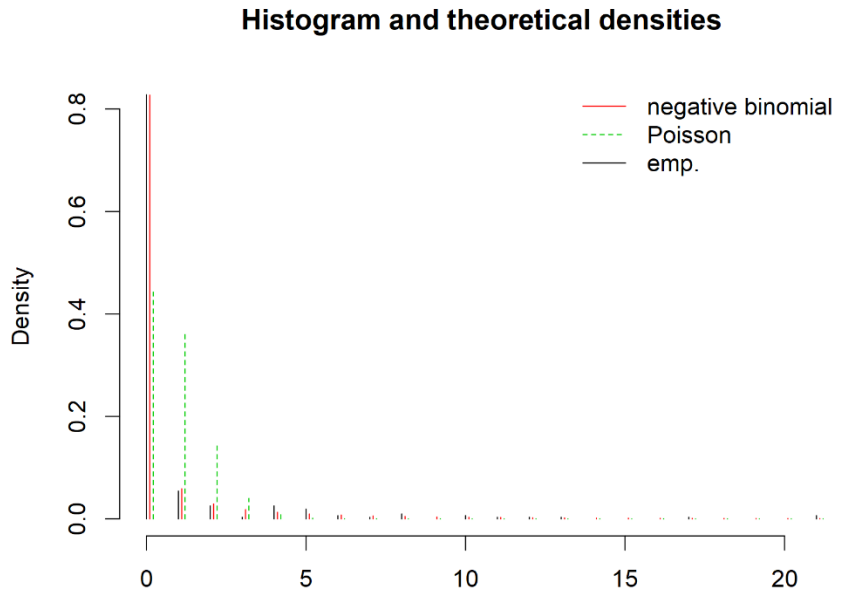


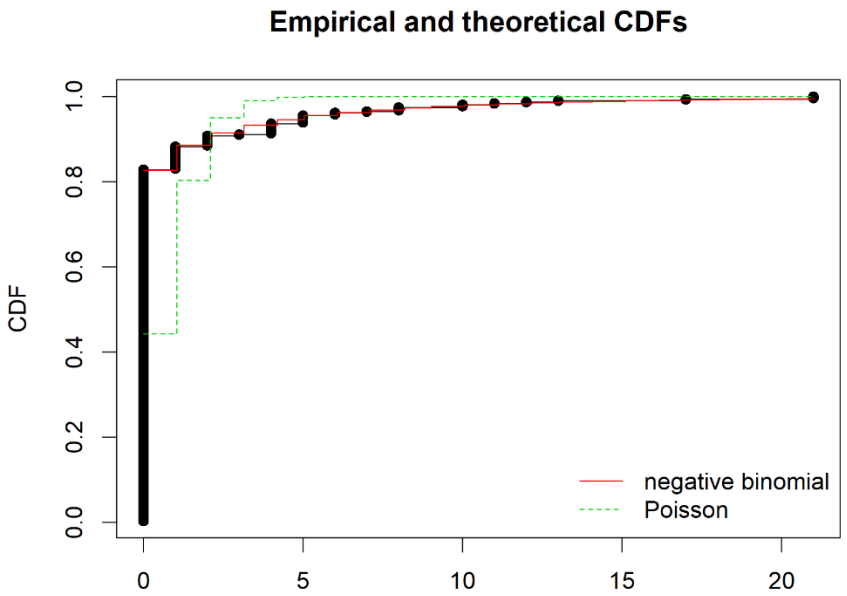


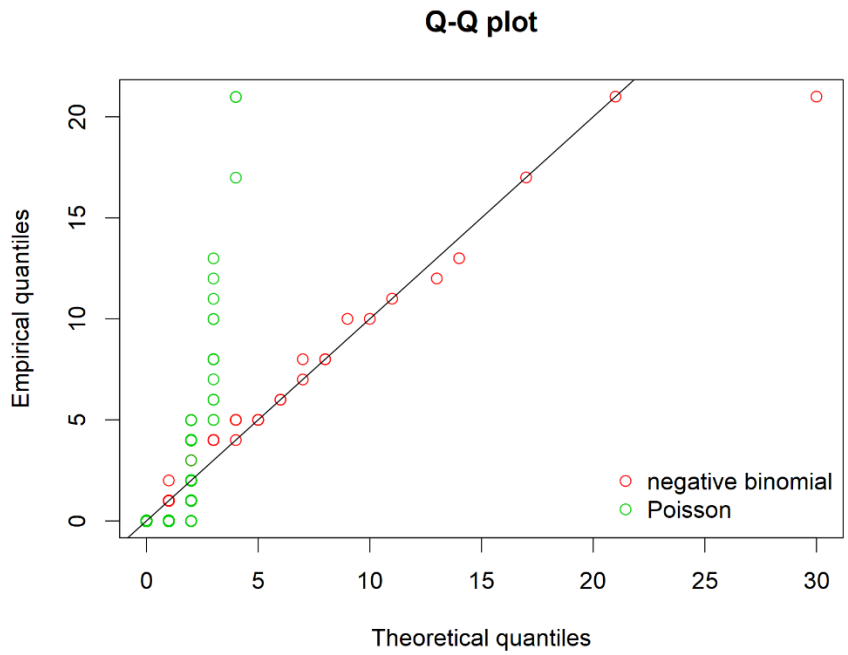


Canary Rockfish - North Coast (FG)

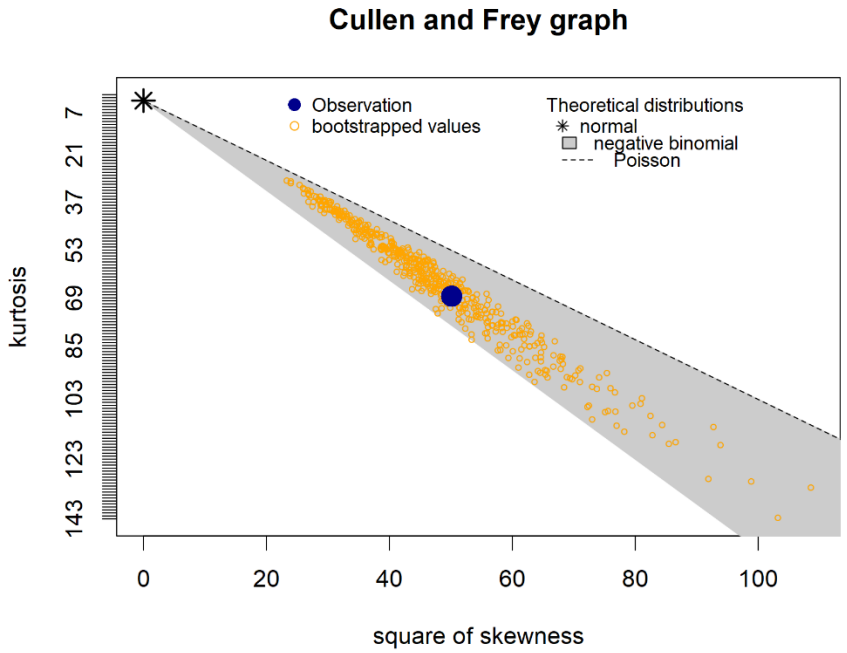


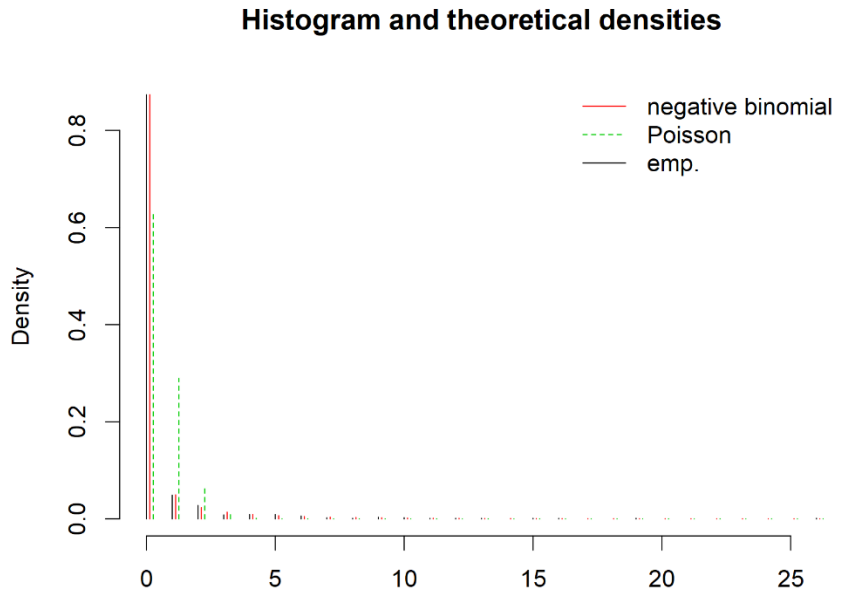


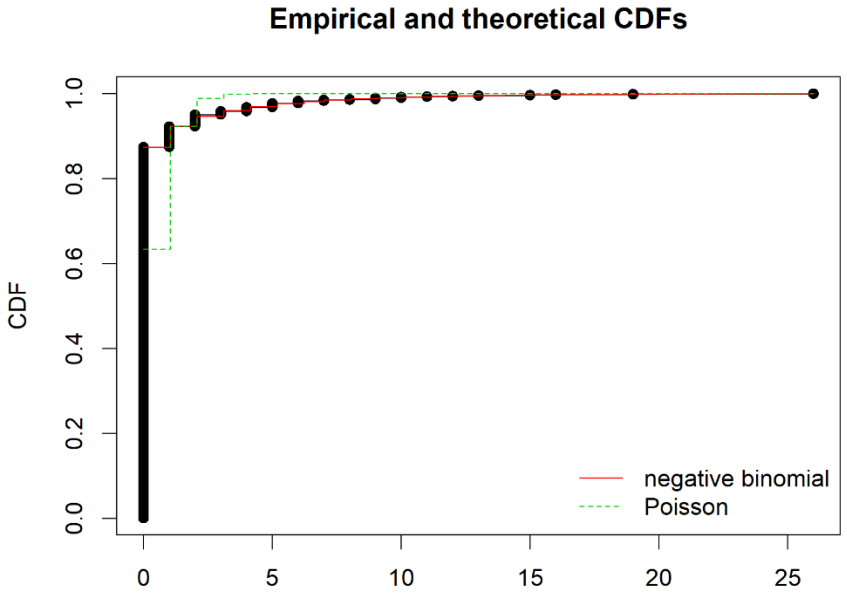


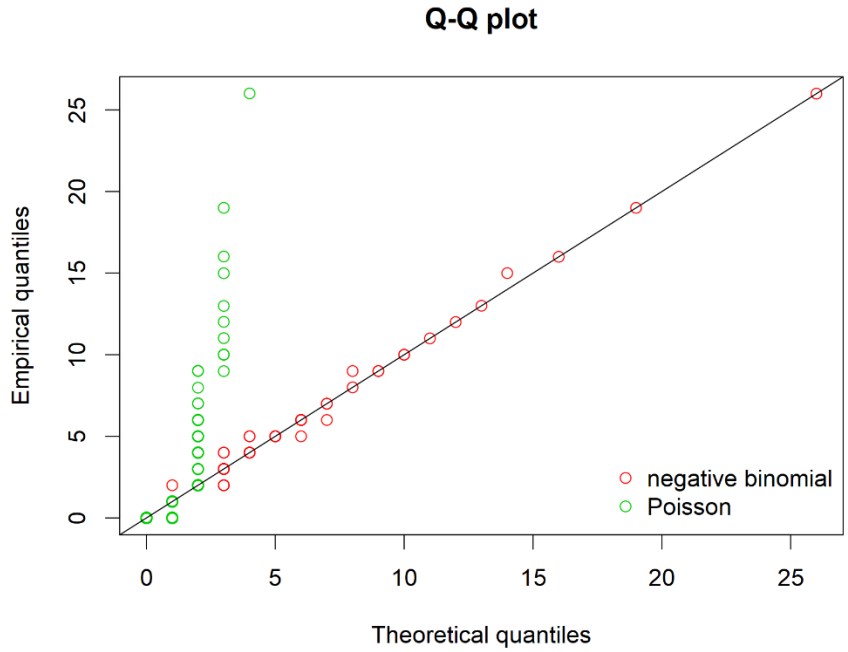


Canary Rockfish - Central Coast (FG, RG, & NG)

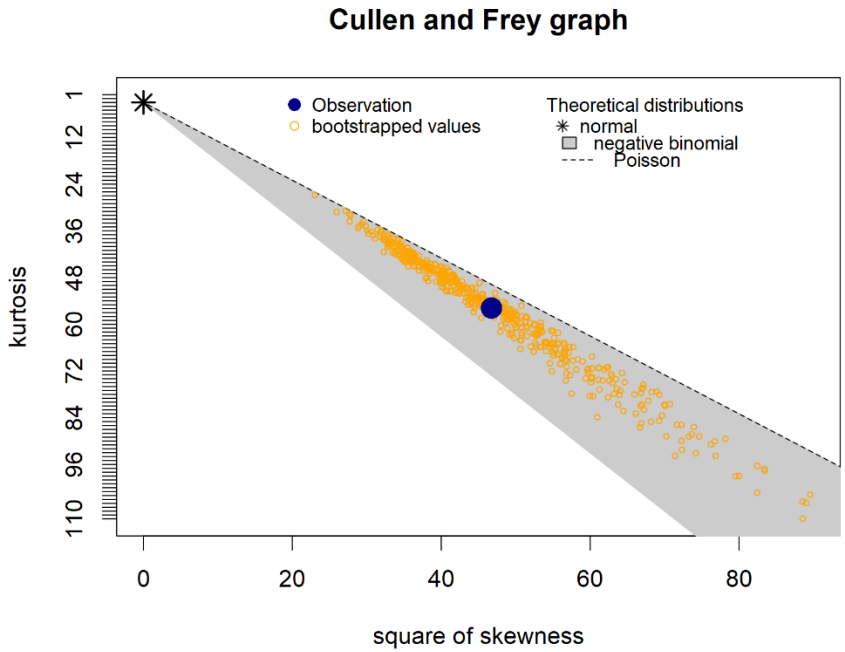


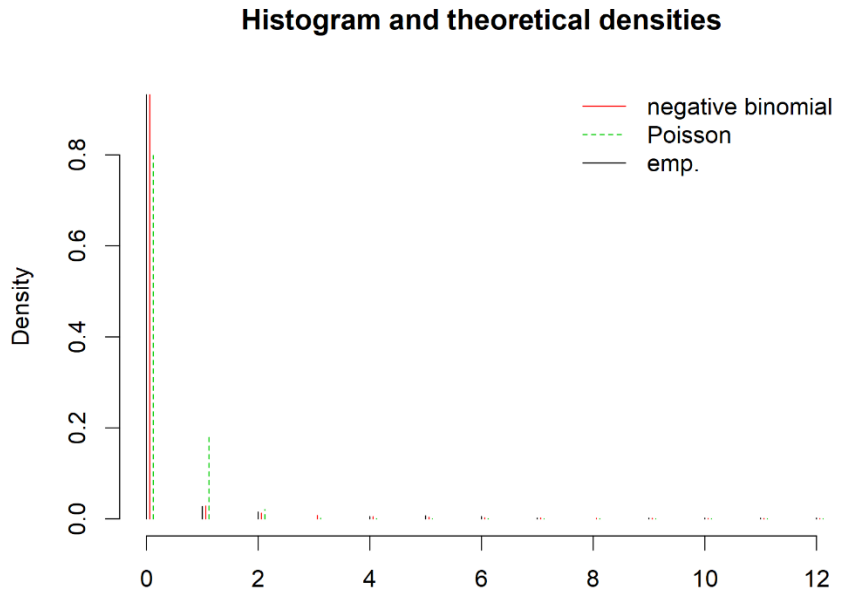


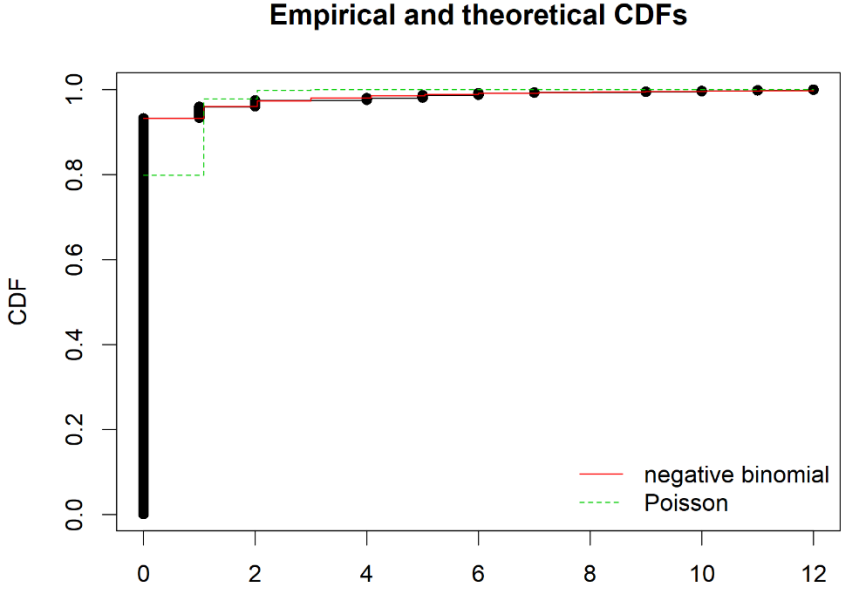


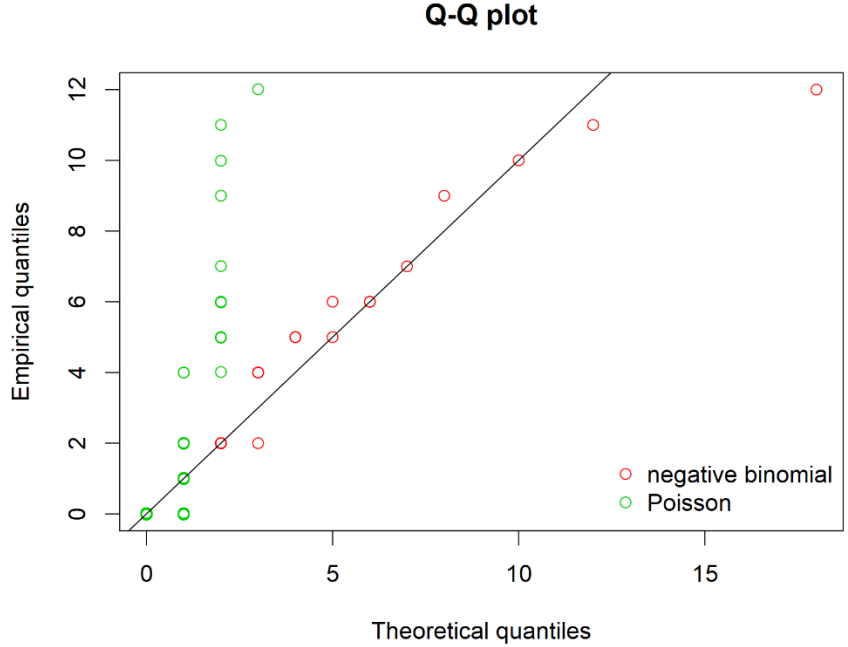


Canary Rockfish - Central Coast (RG)

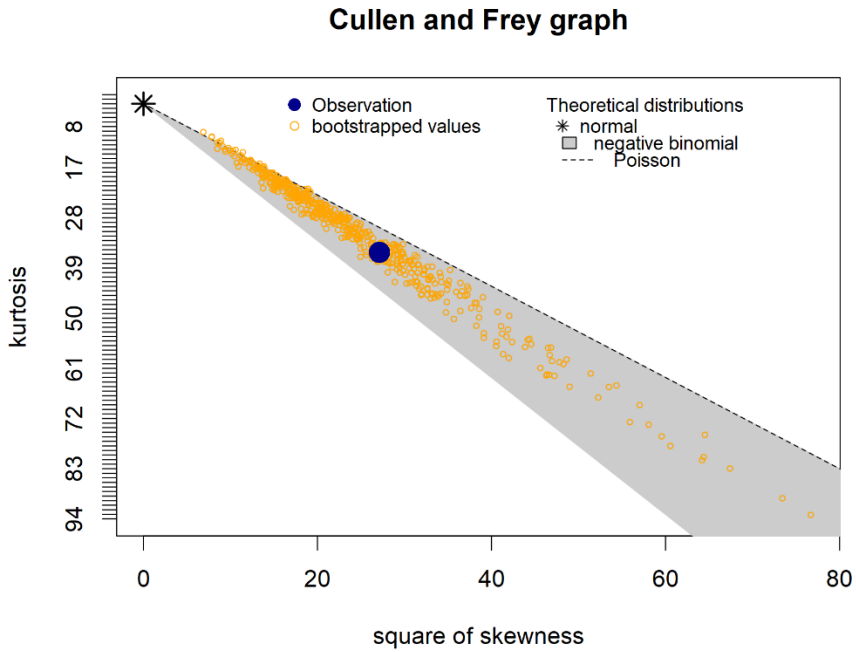


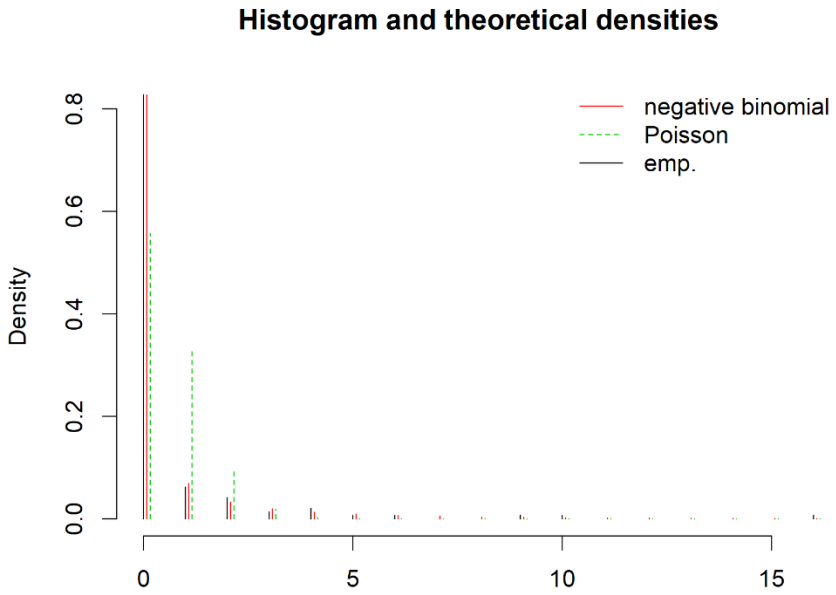


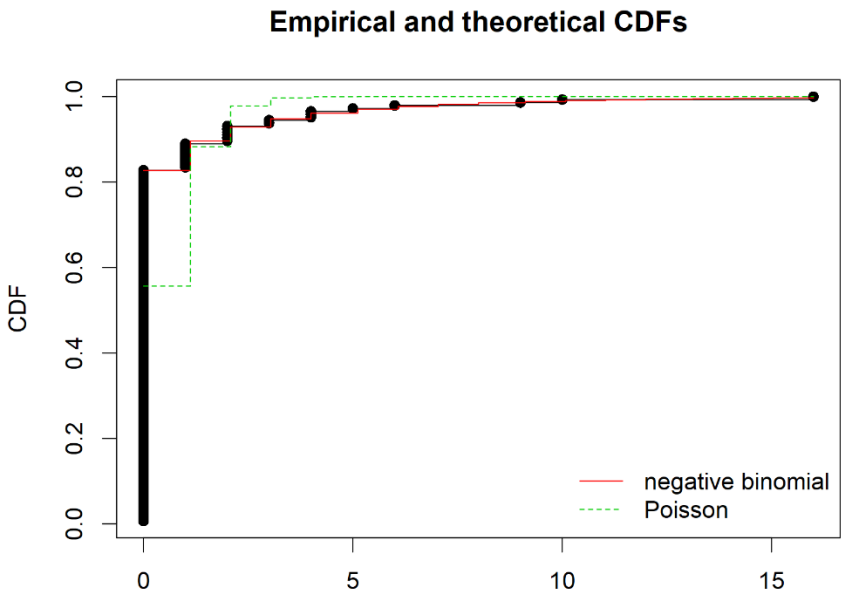


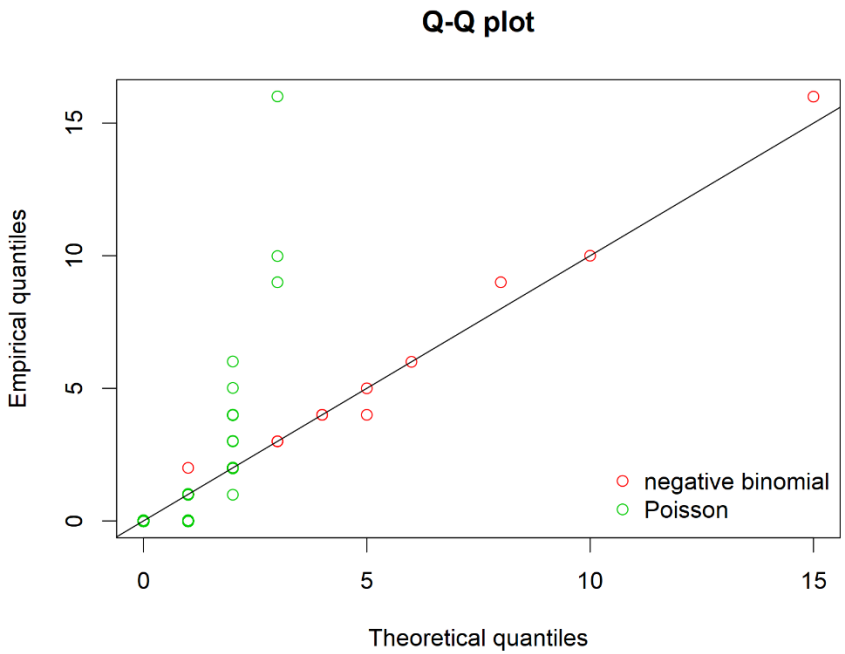


Canary Rockfish - Central Coast (NG)

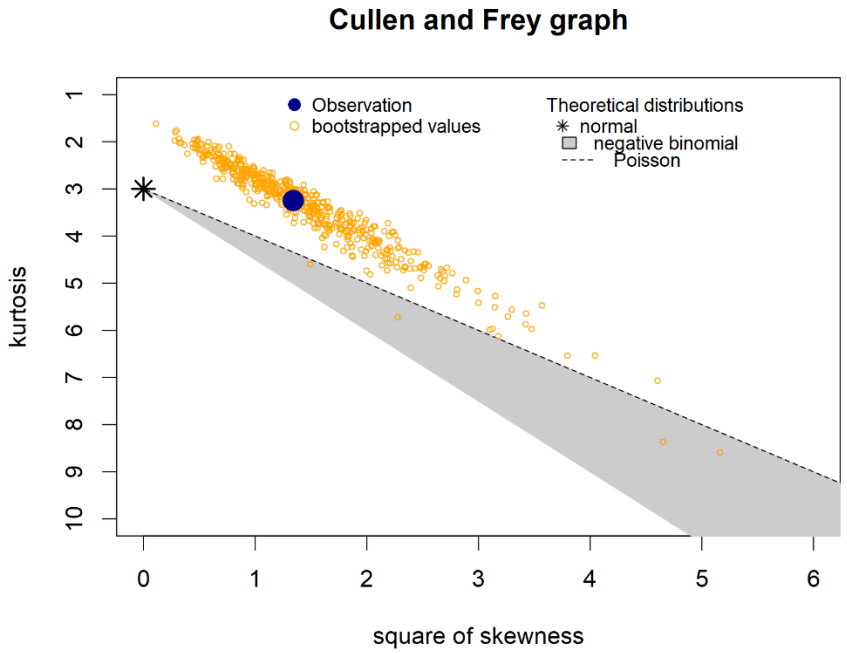


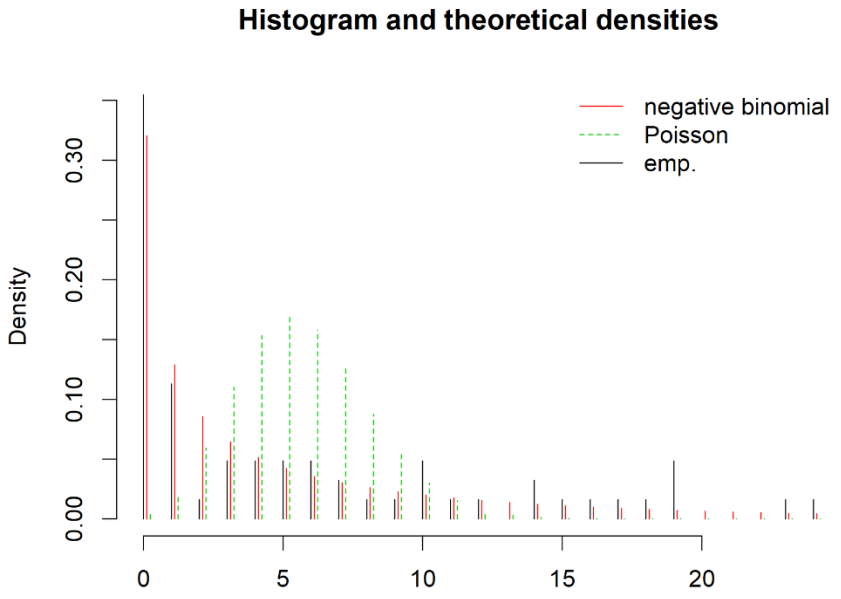


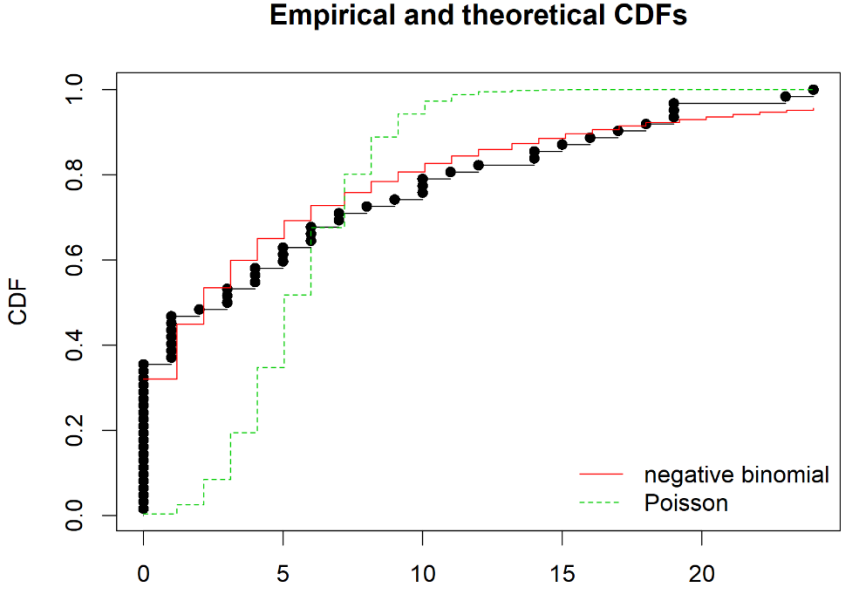


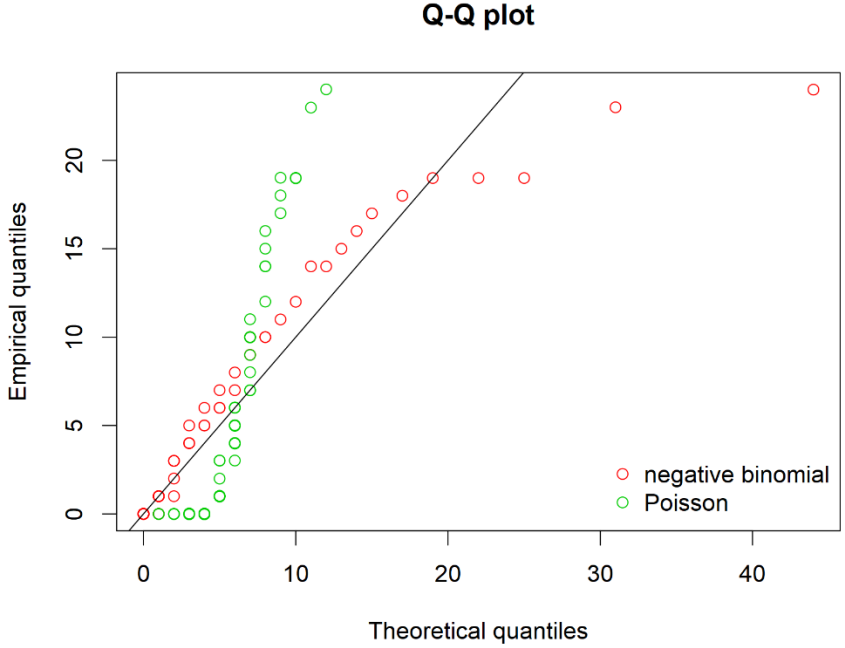


Canary Rockfish - Cape Perpetua (FG & RG)

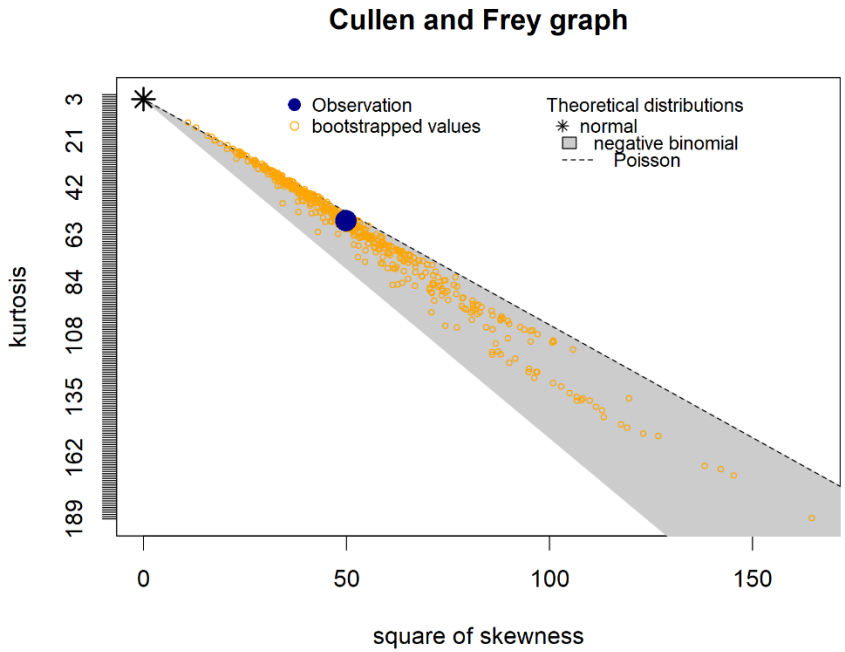


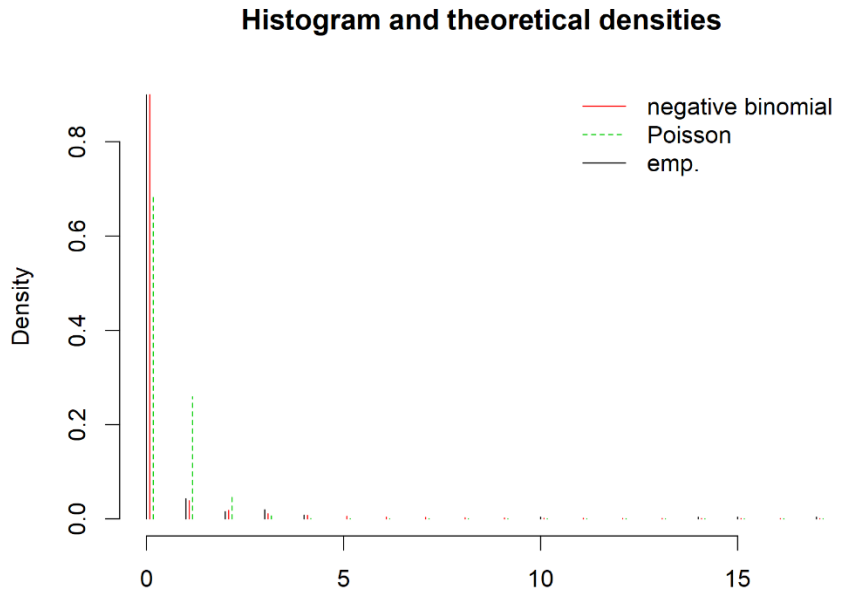


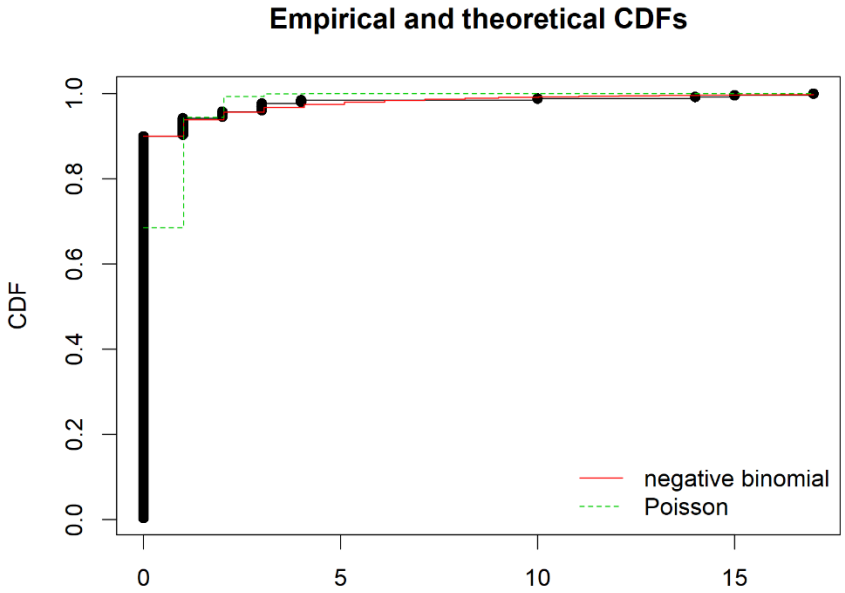


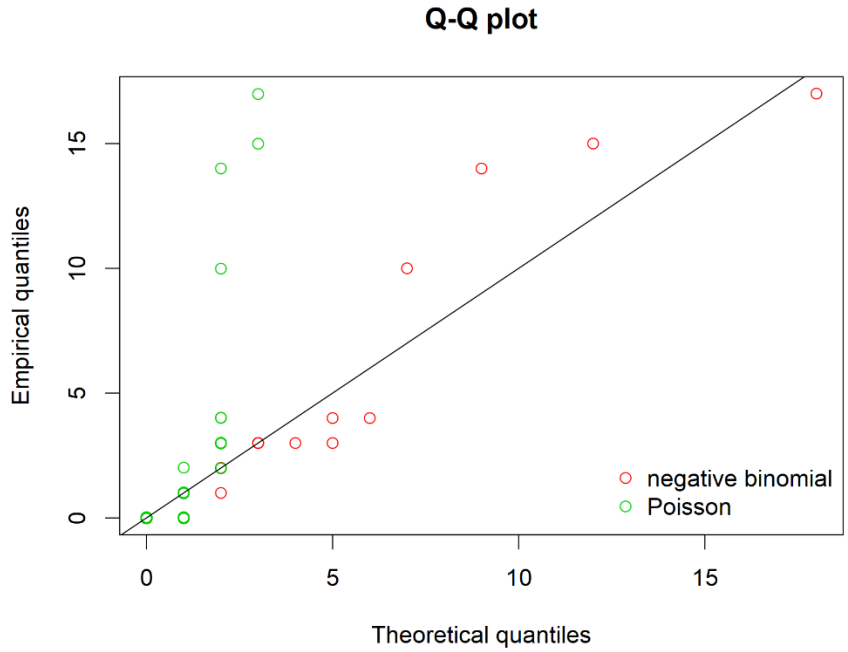


Canary Rockfish - South Coast (RG)

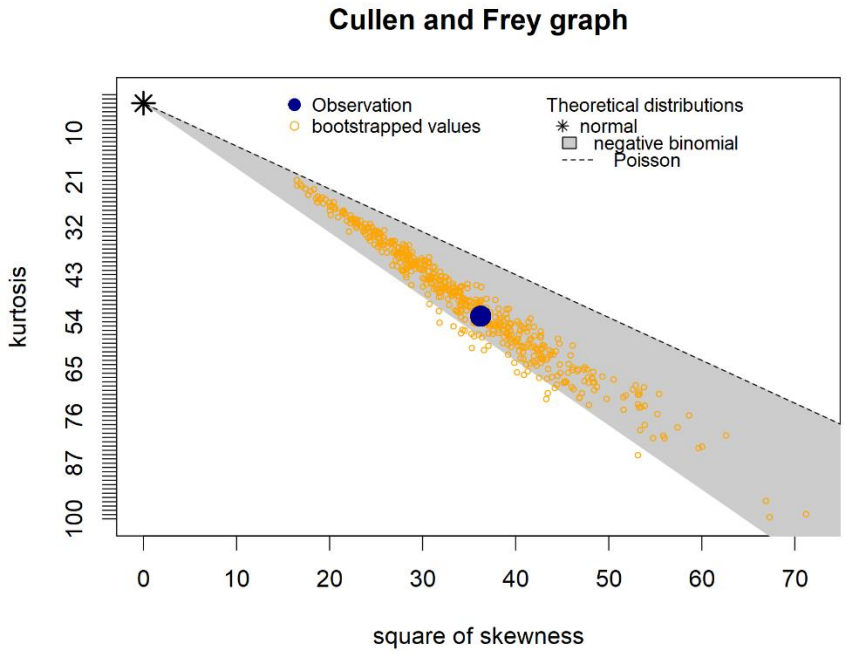


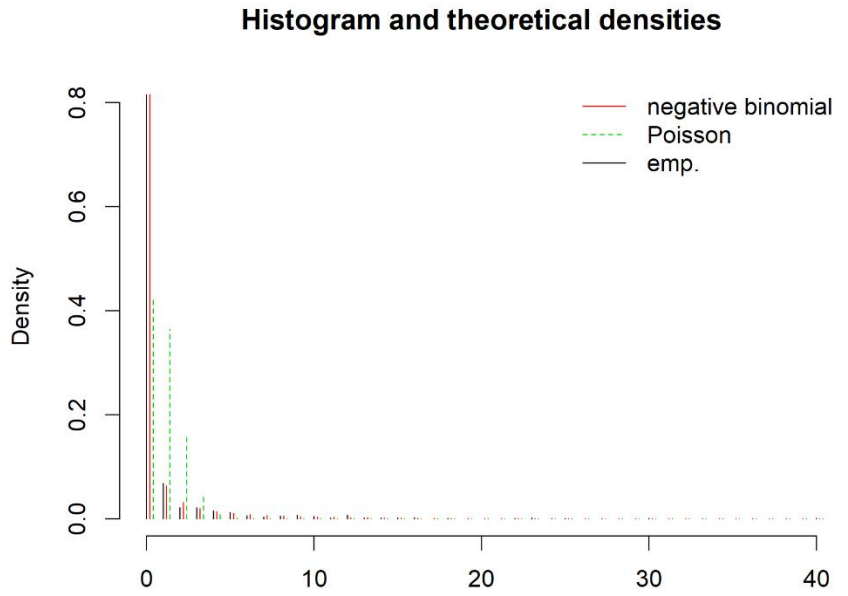


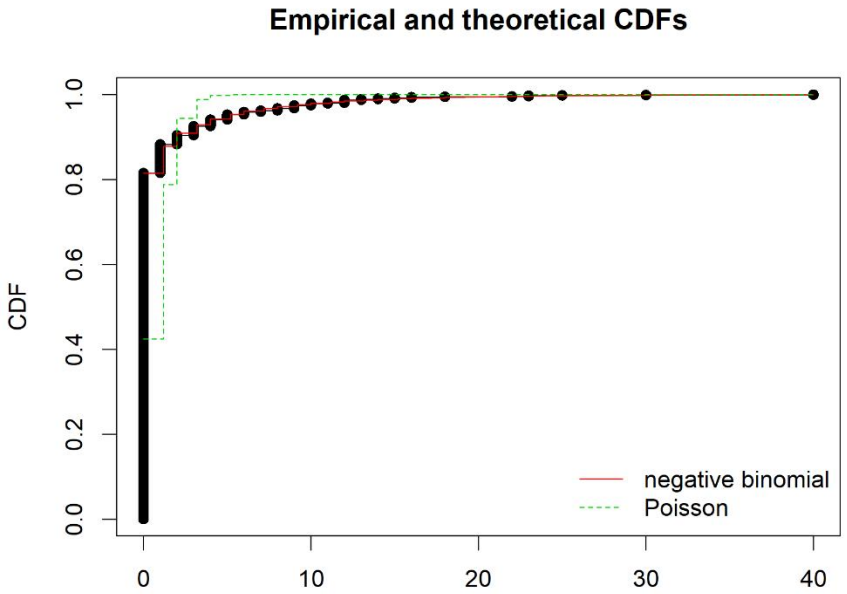


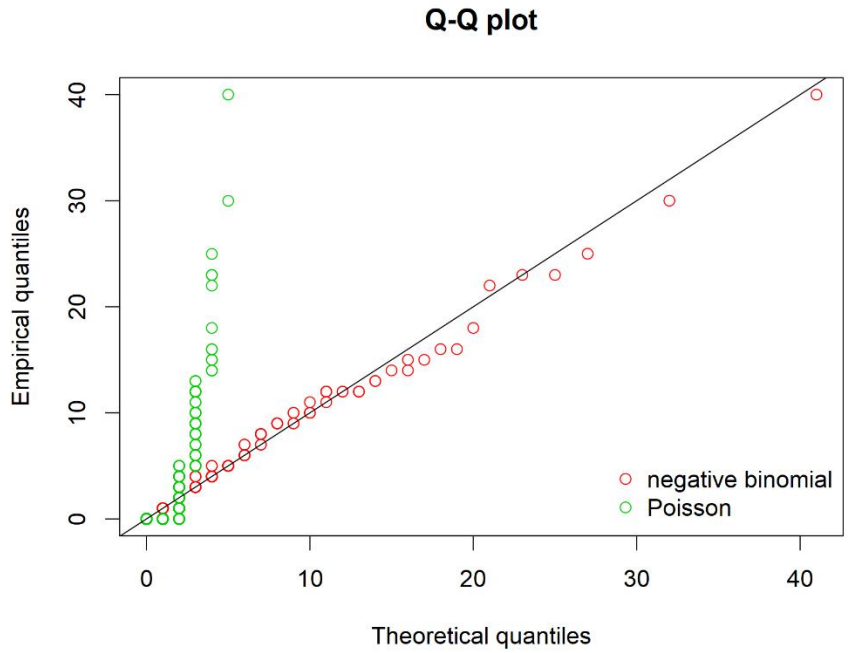


Canary Rockfish - Offshore (FG)

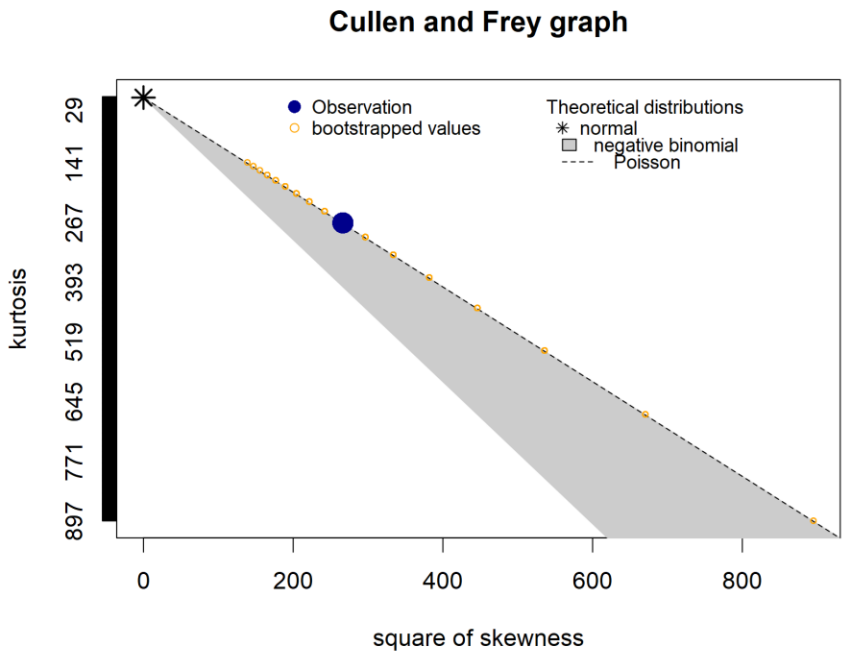


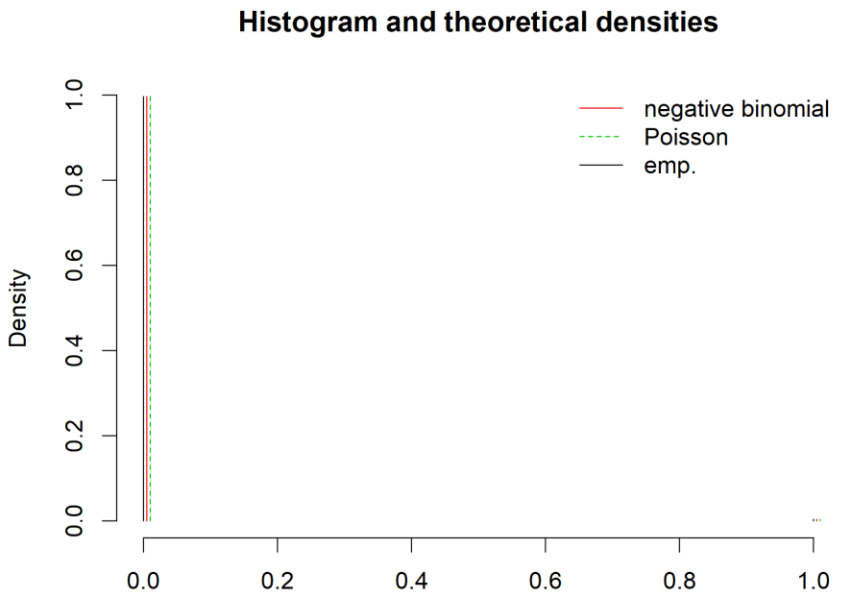


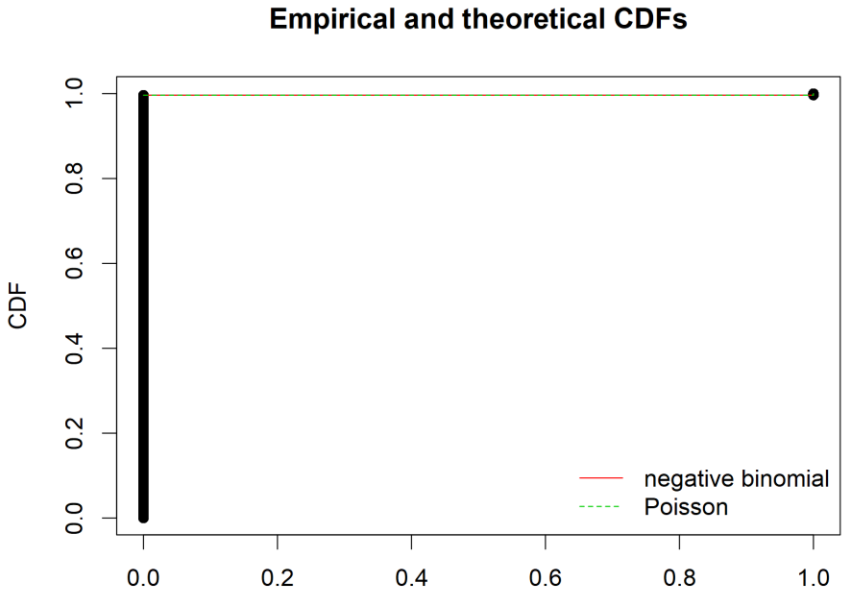


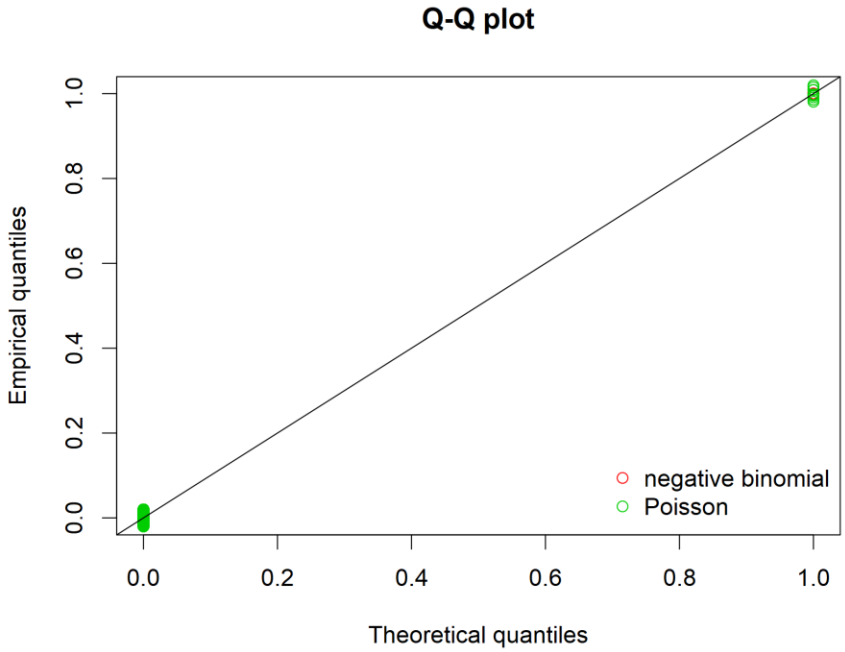


China Rockfish - Entire Coast

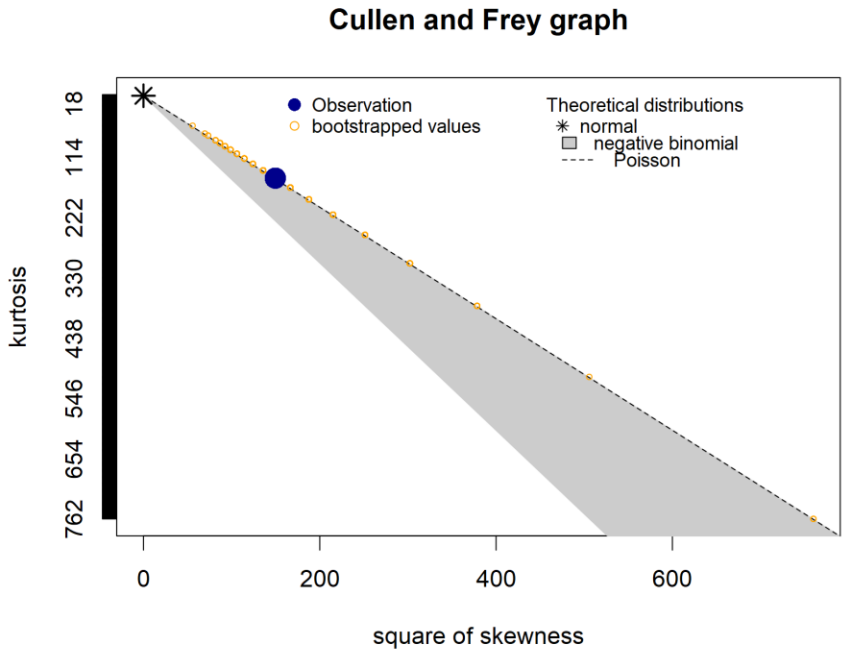


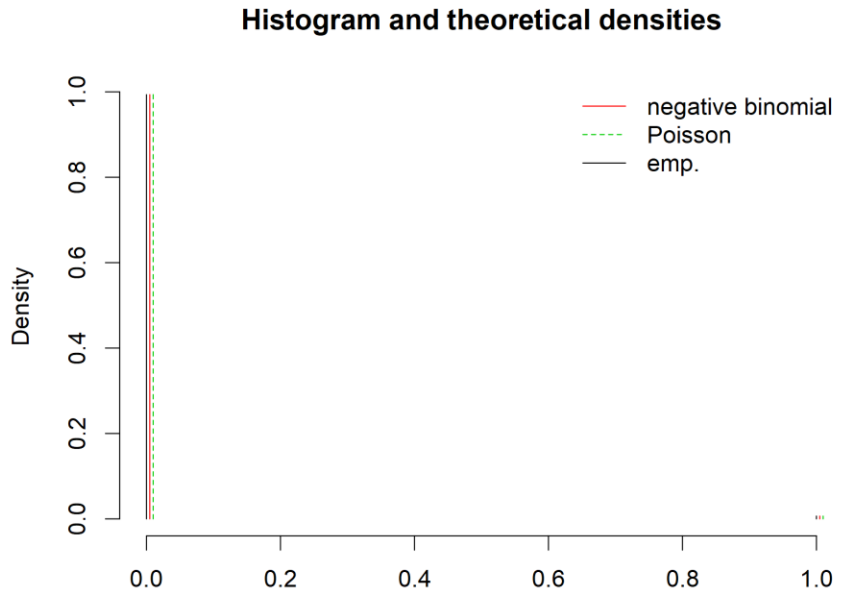


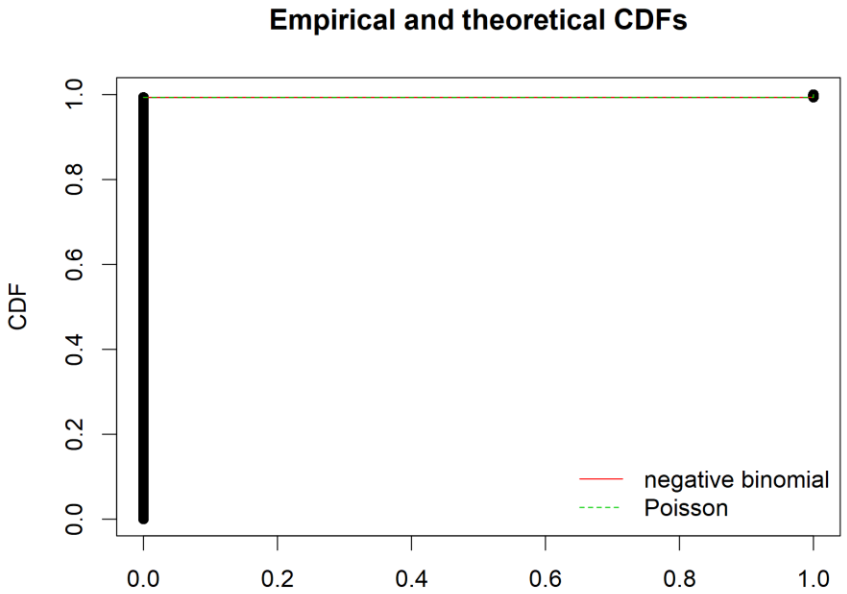


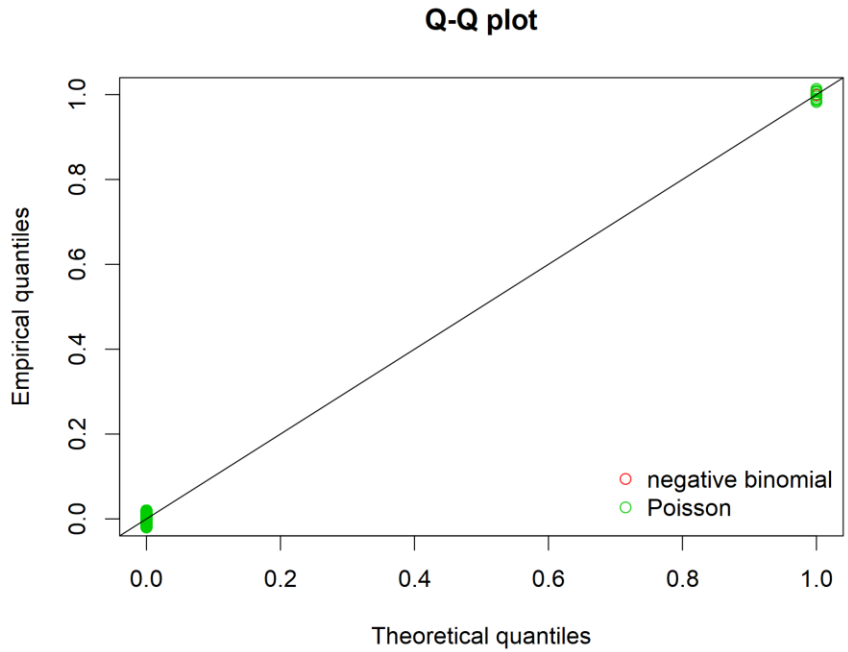


China Rockfish - Nearshore

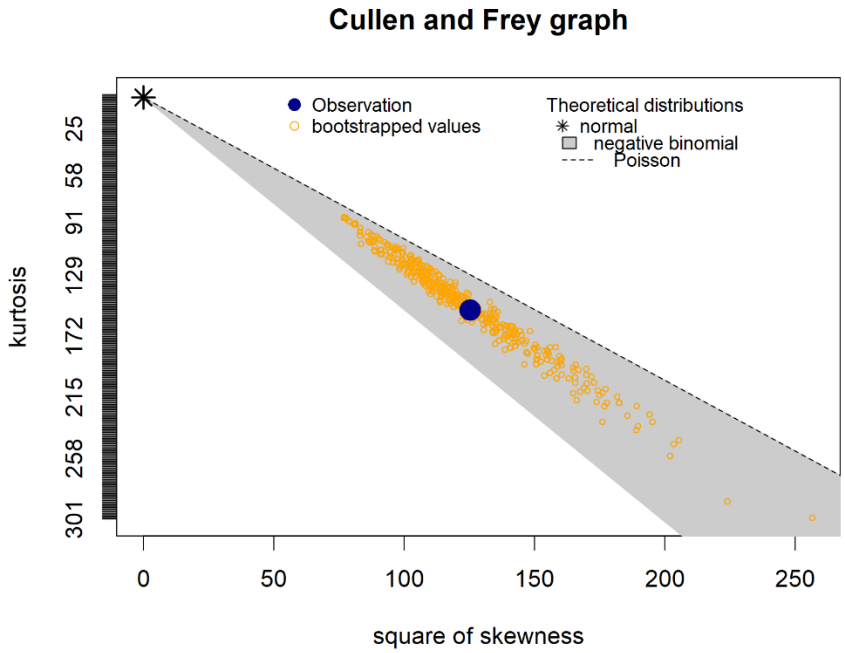


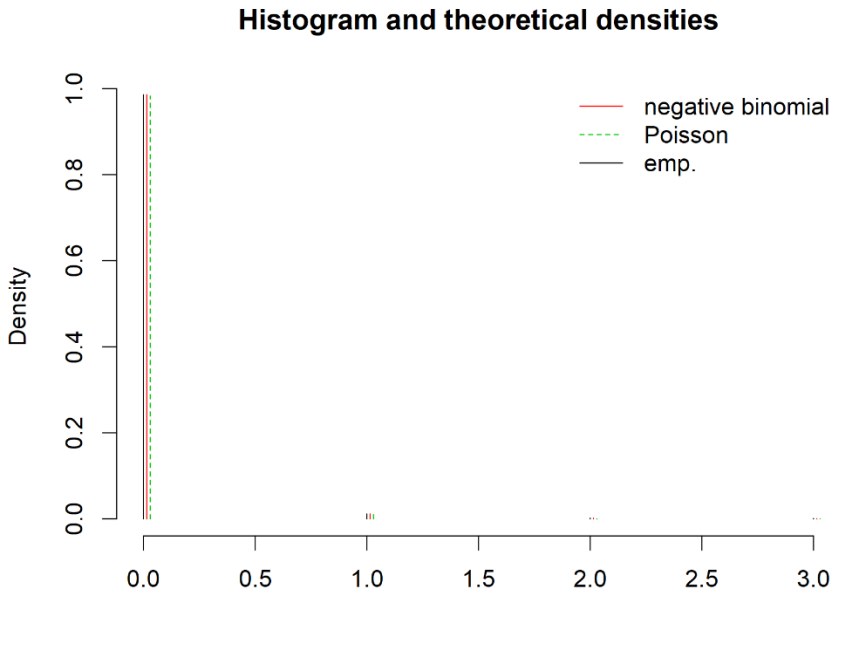


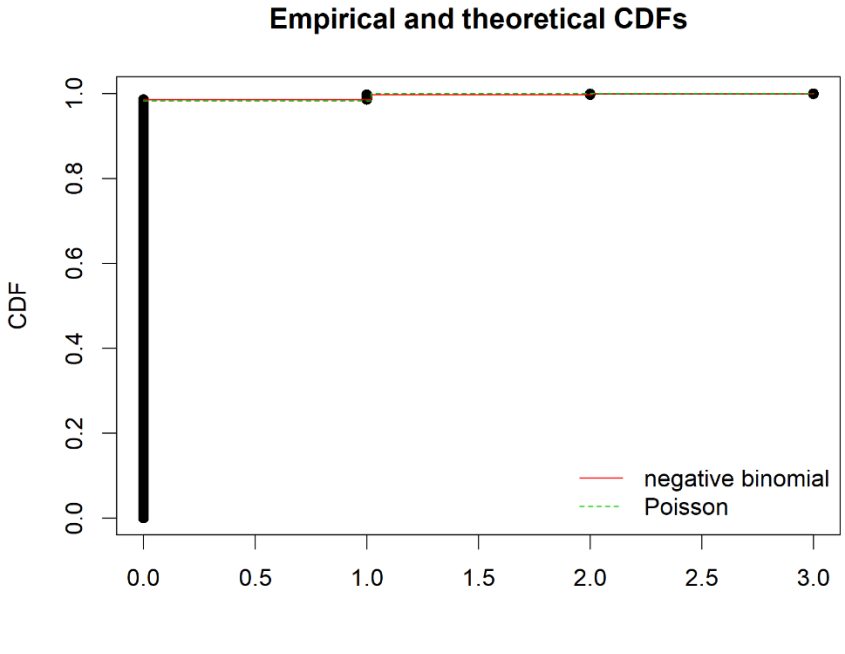


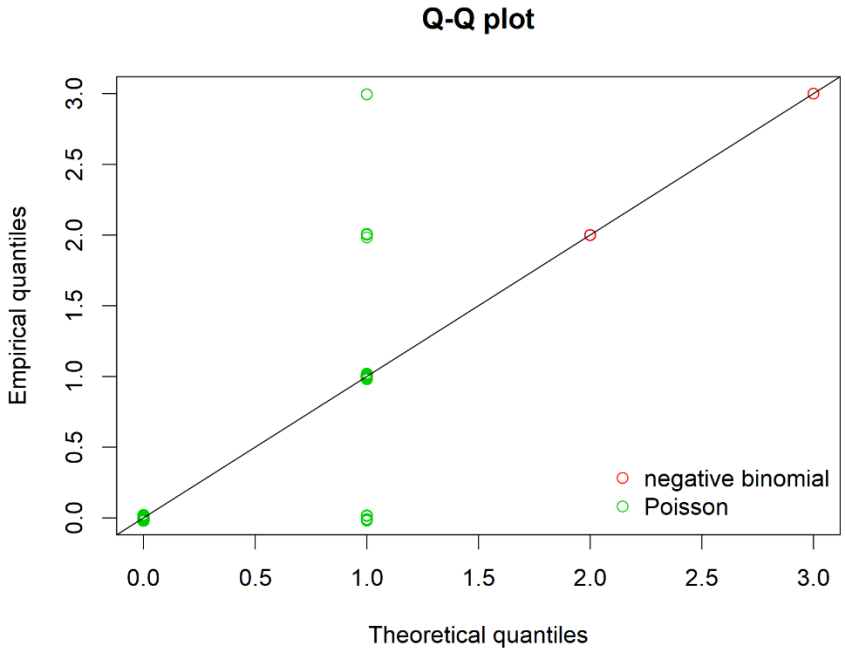


Copper Rockfish - Entire Coast

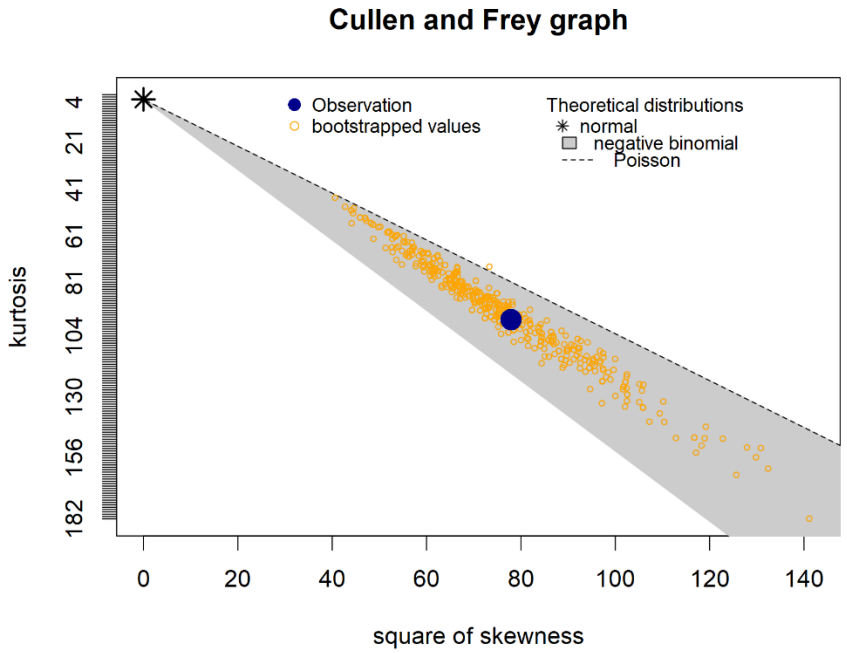


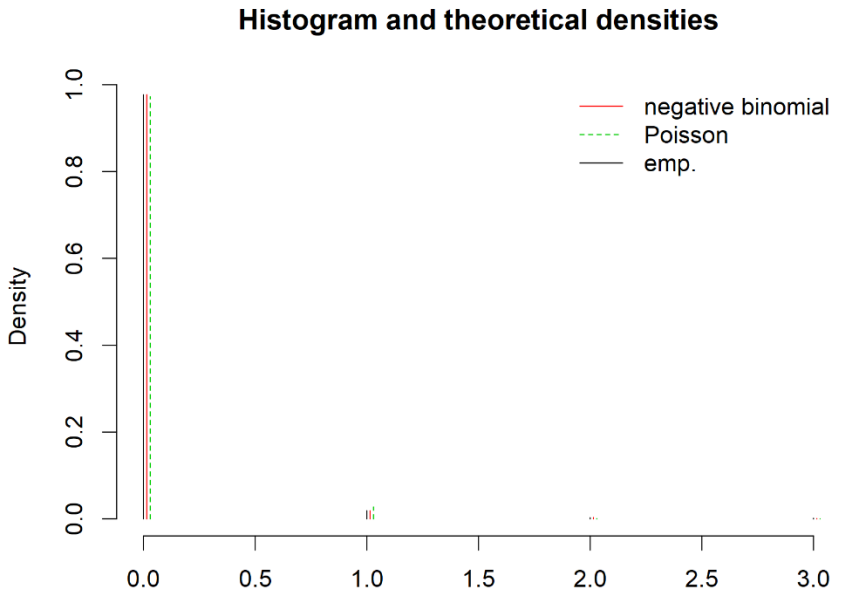


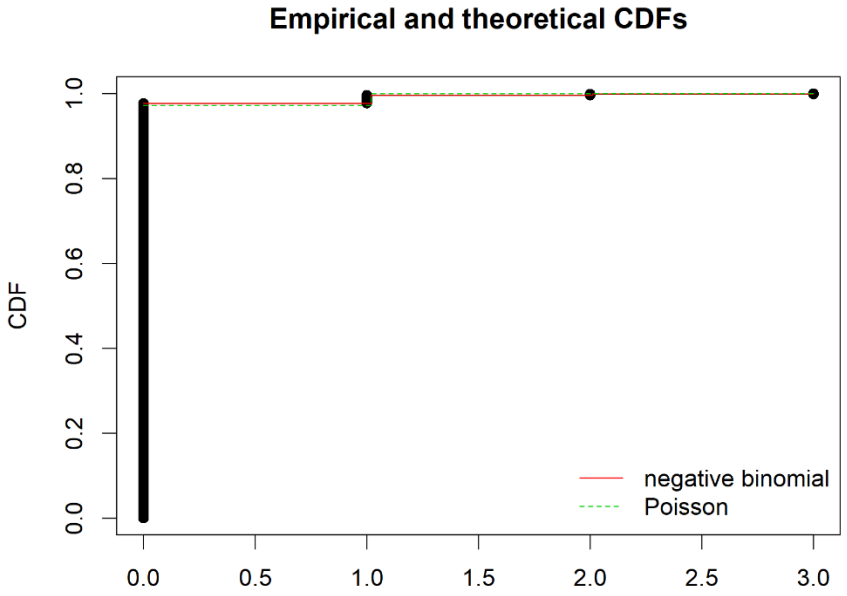


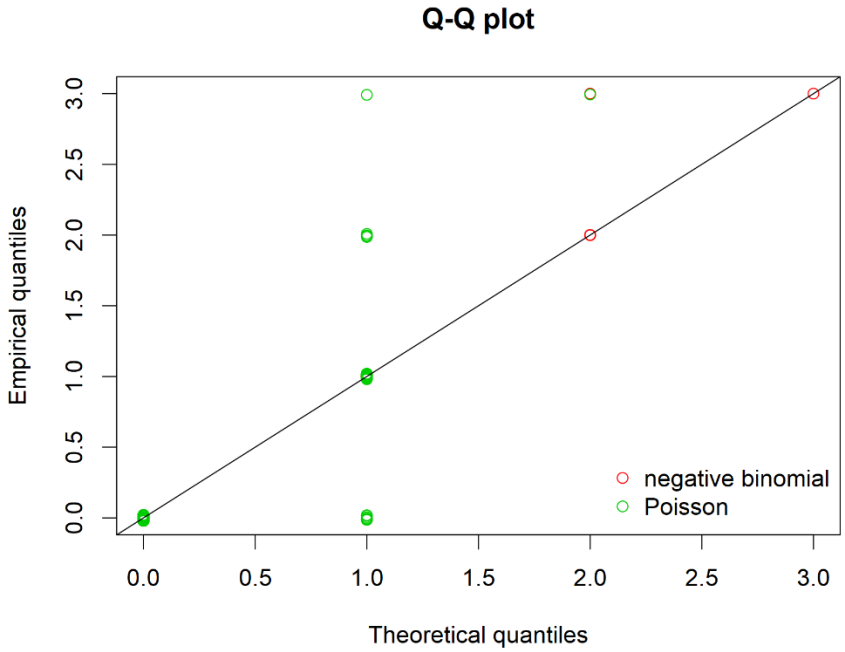


Copper Rockfish - Nearshore

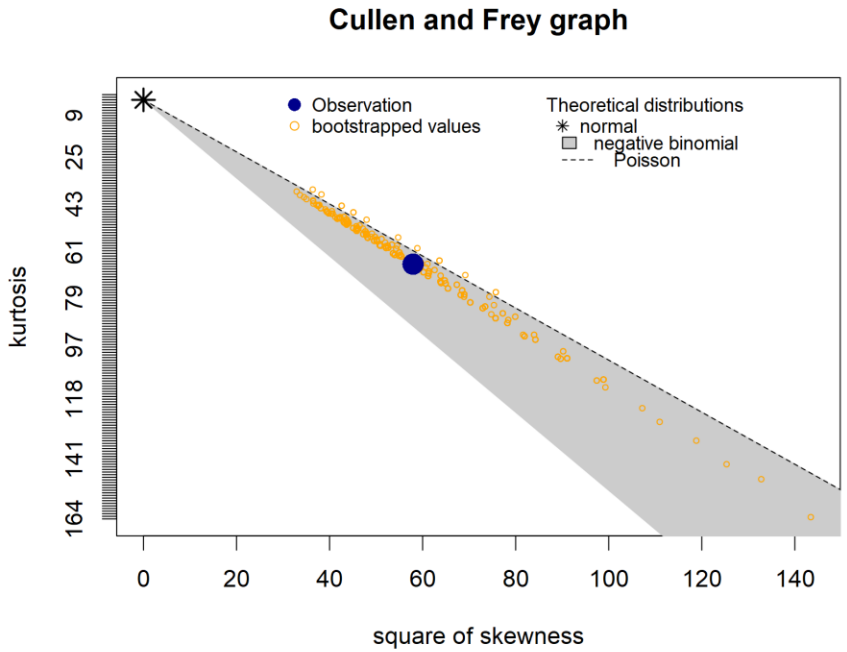


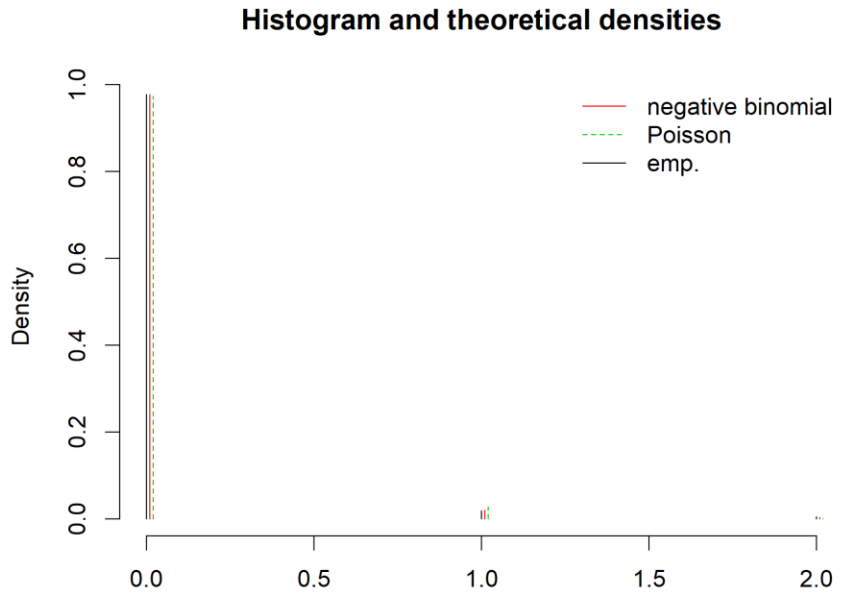


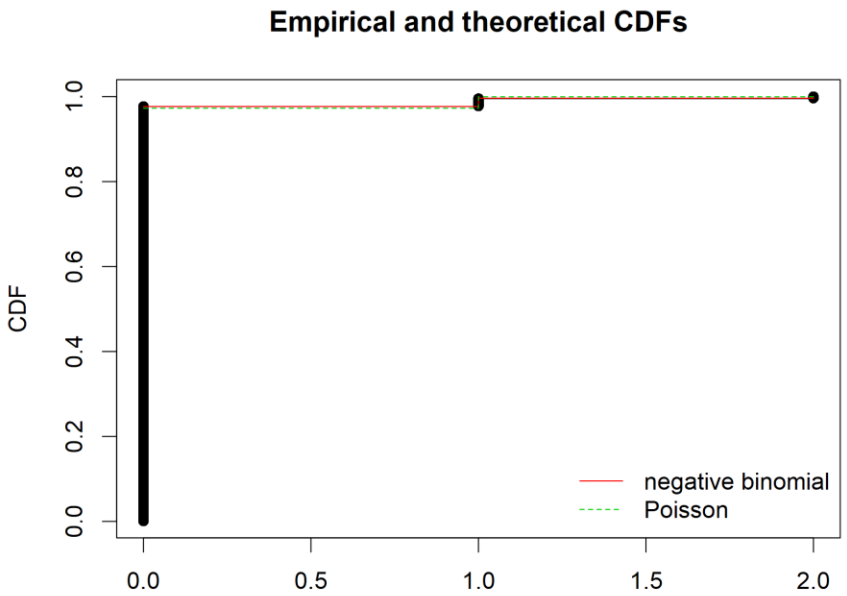


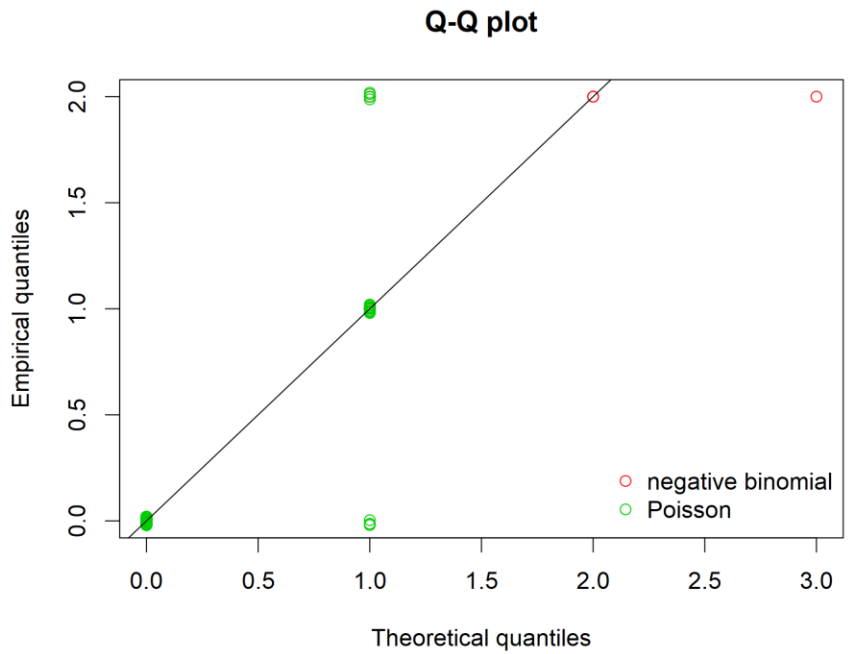


Copper Rockfish -Central Coast (FG, RG, & NG)

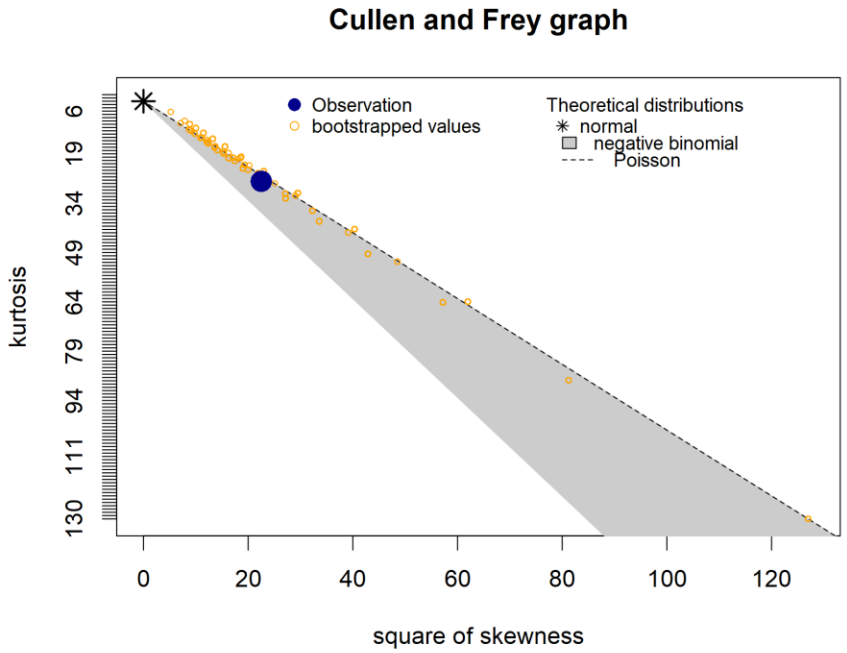


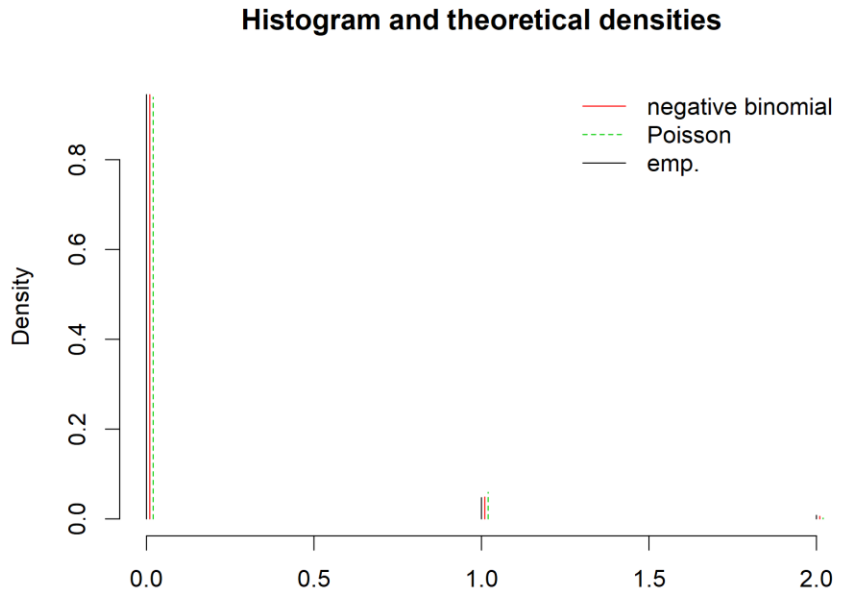


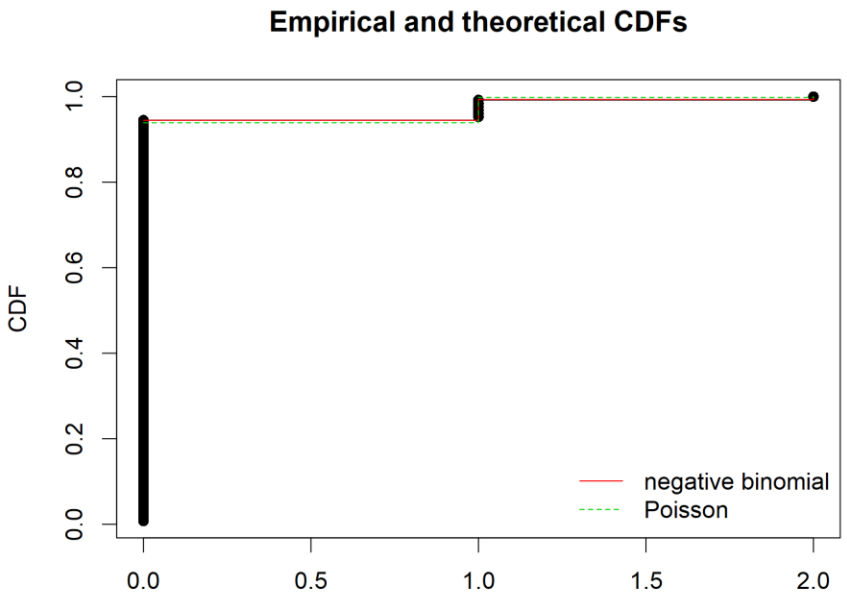


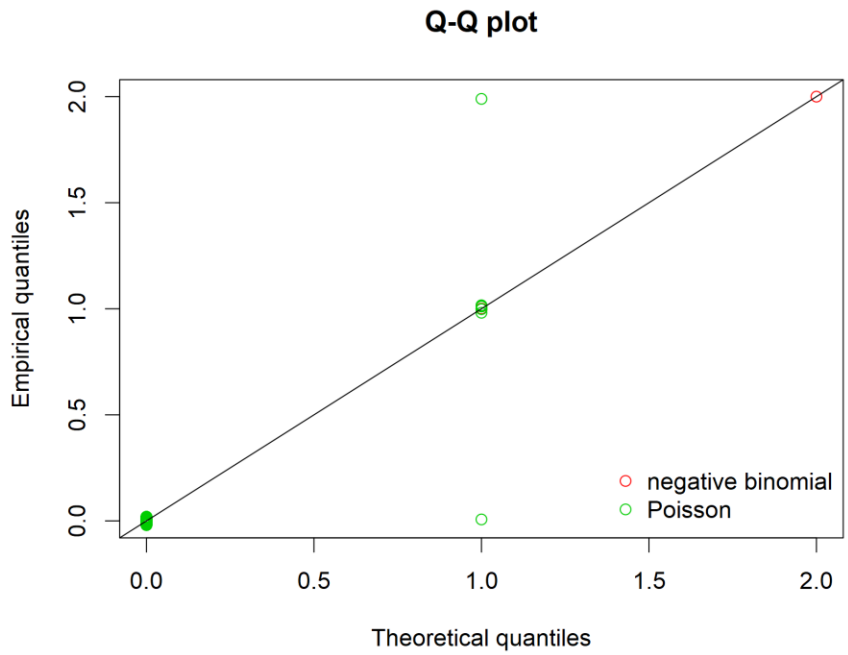


Copper Rockfish - Central Coast (FG)

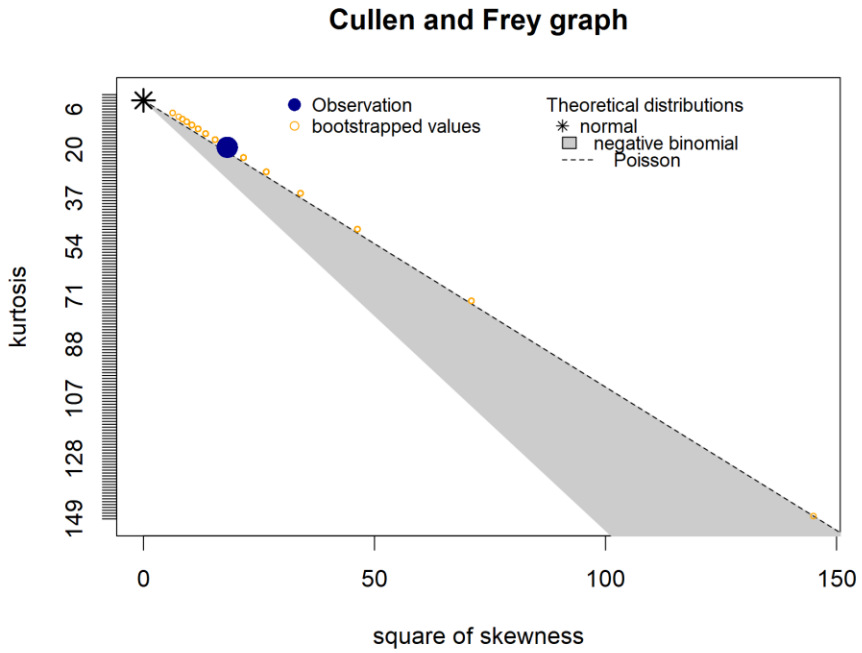


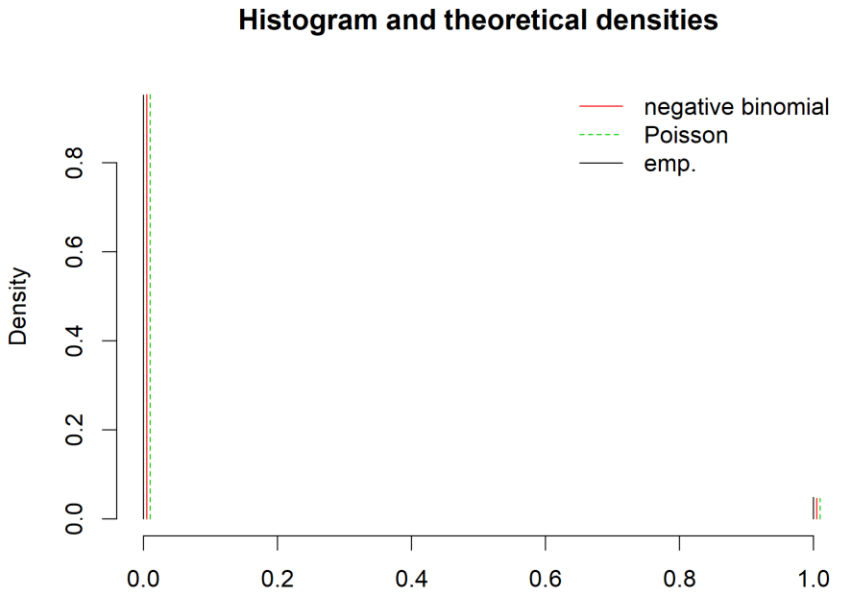


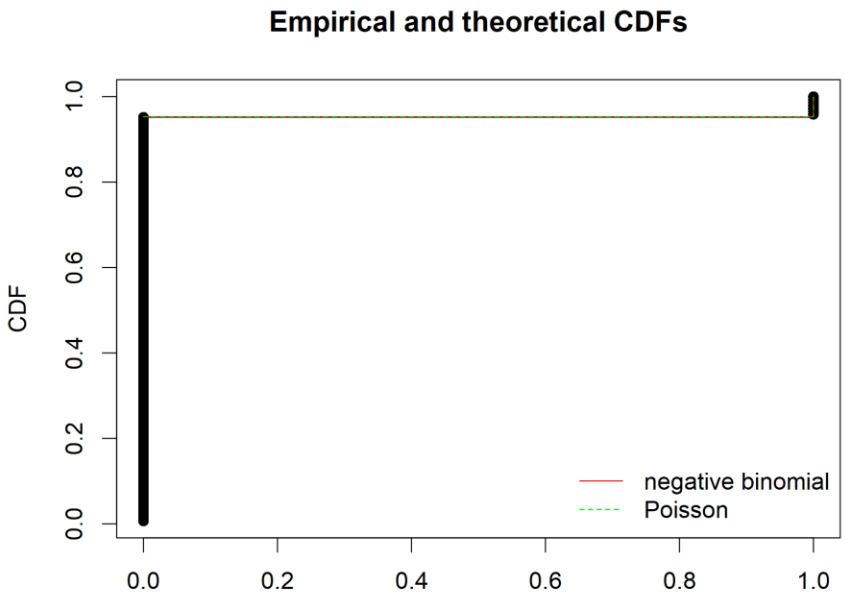


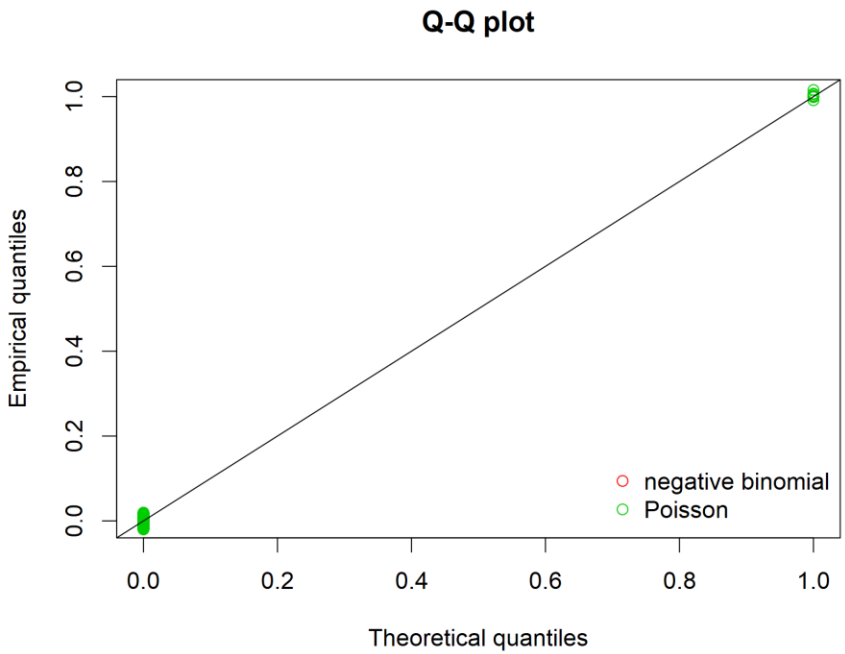


Copper Rockfish - Central Coast (NG)

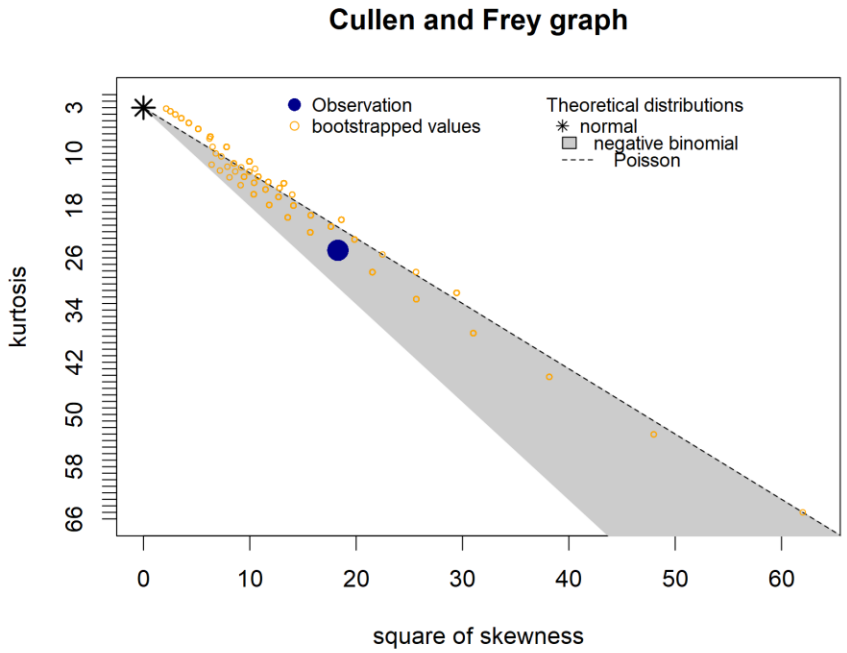


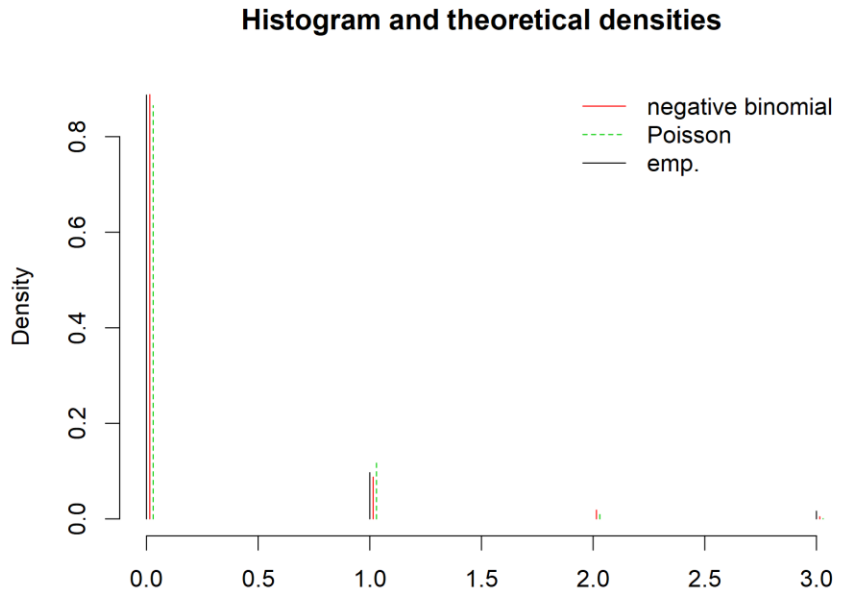


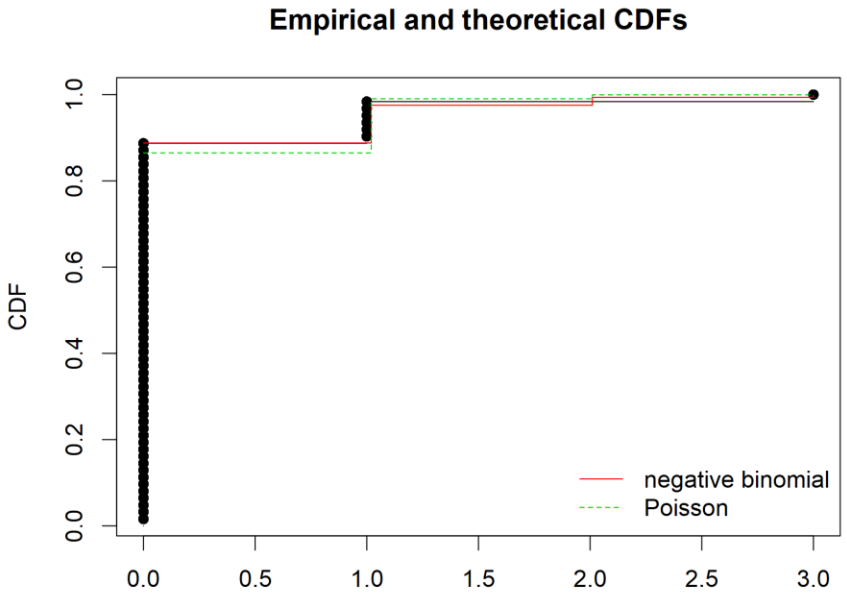


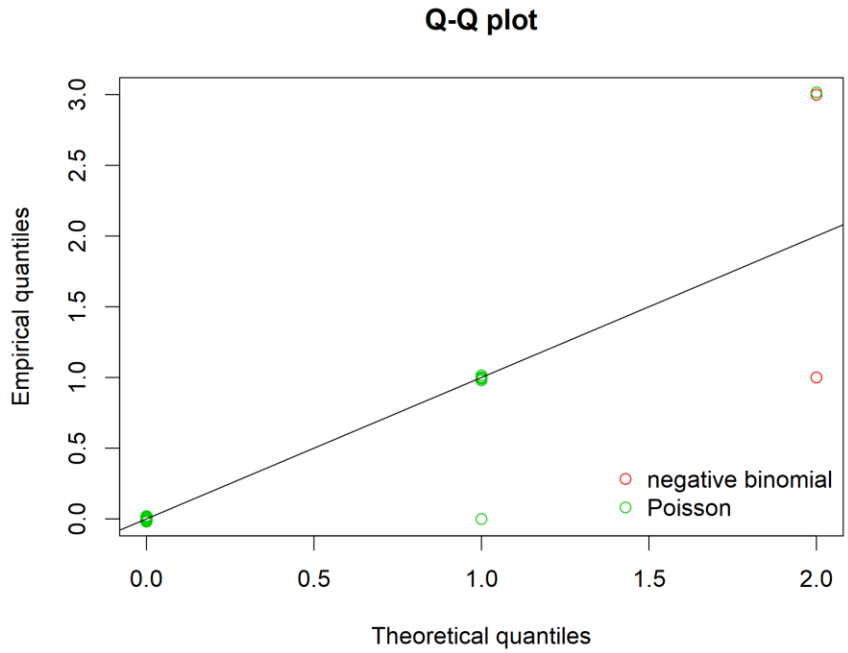


Copper Rockfish - Cape Perpetua (FG & RG)

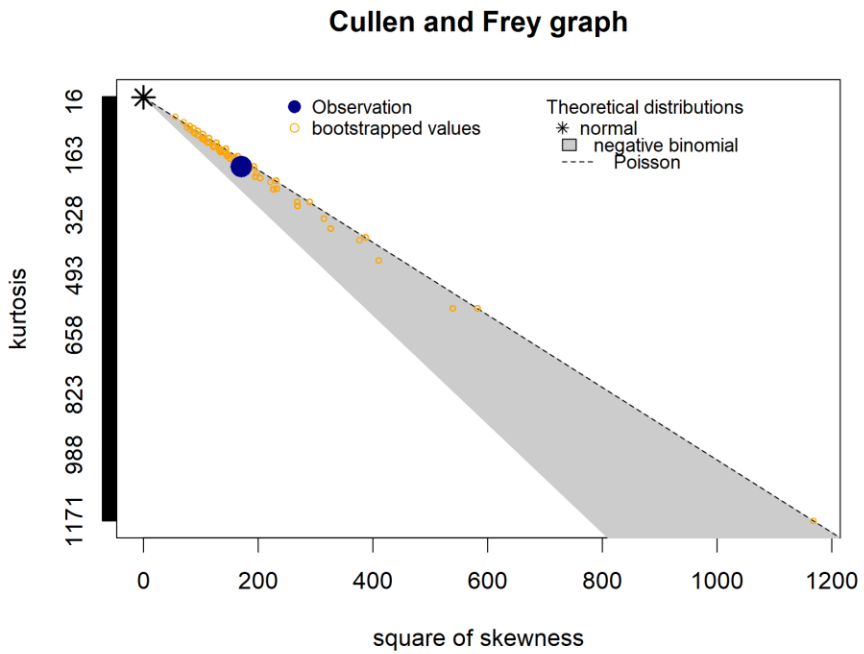


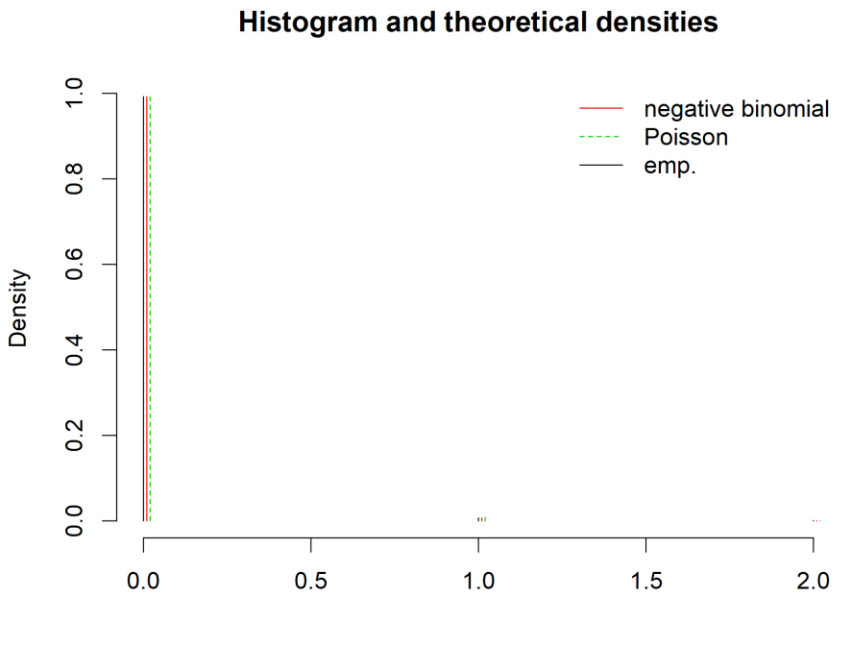


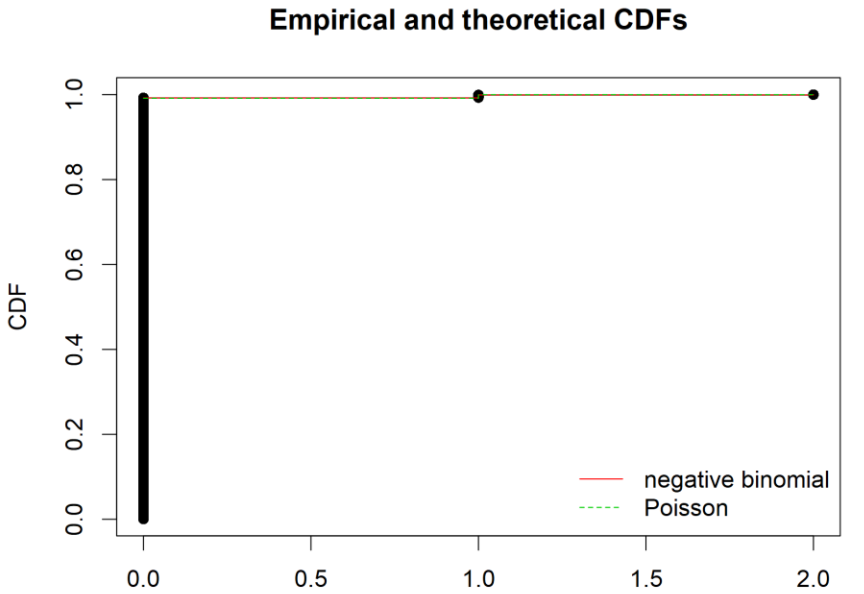


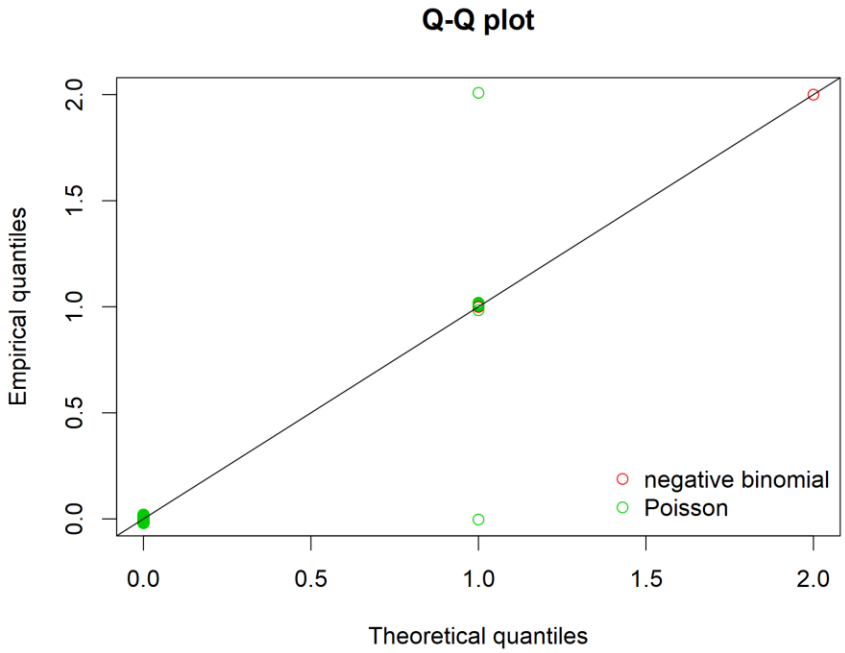


Greenstriped - Offshore (FG)

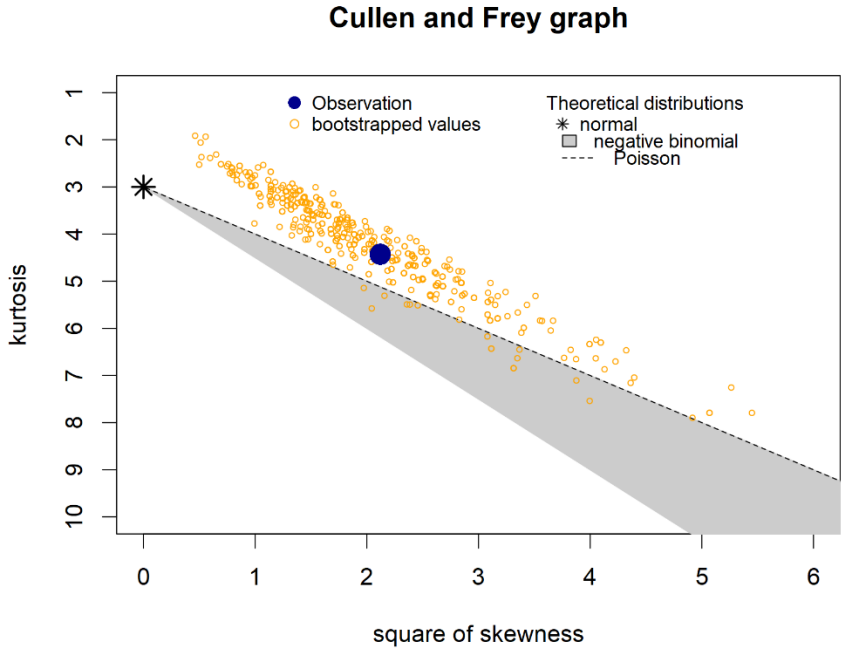


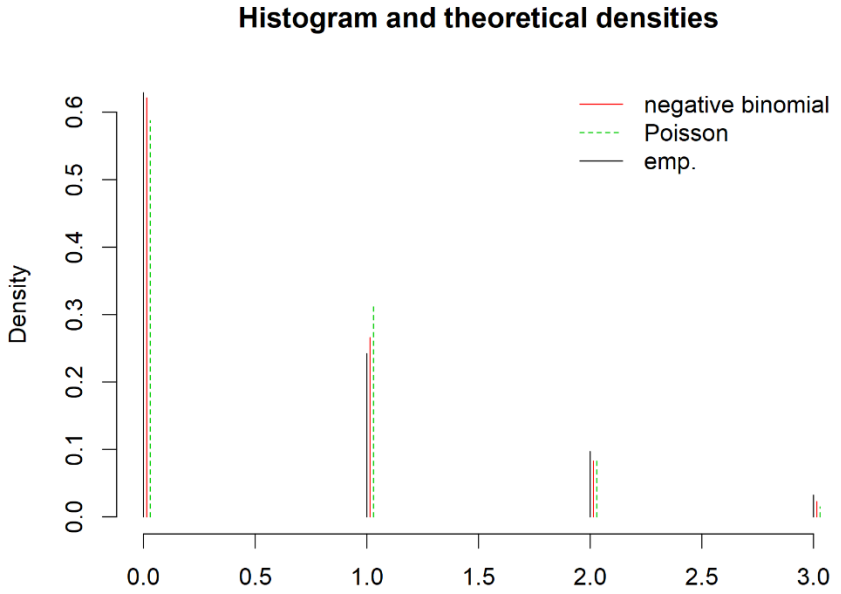


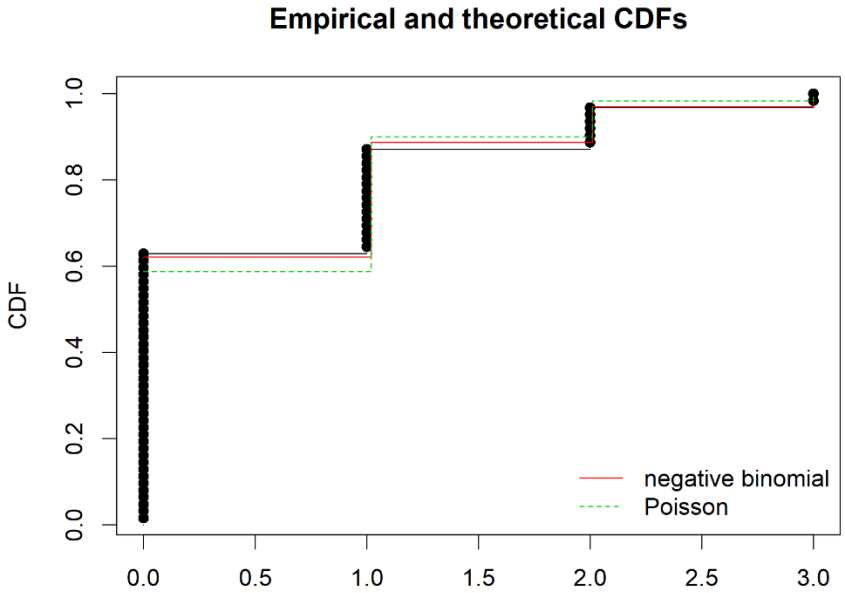


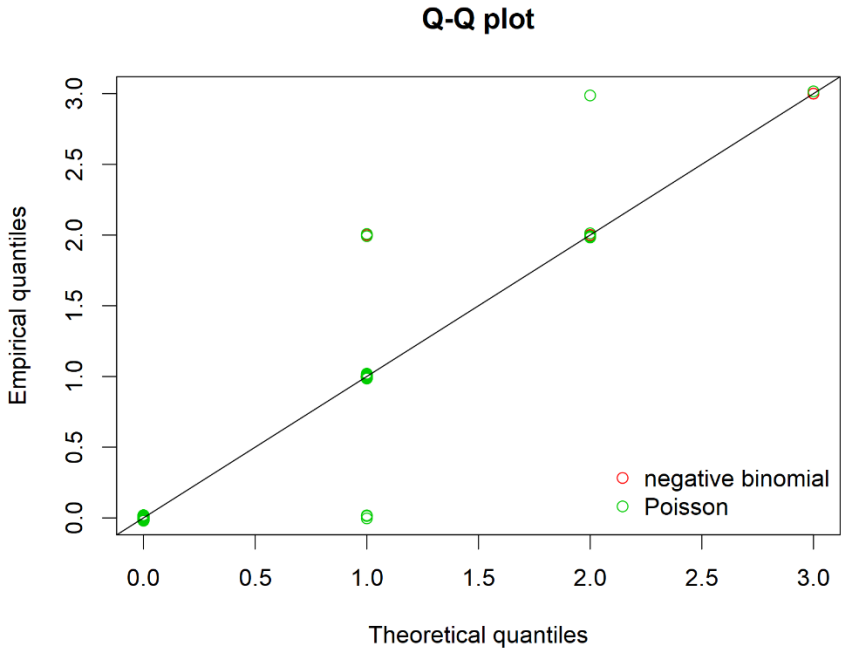


Kelp Greenling - Cape Perpetua (FG & RG)

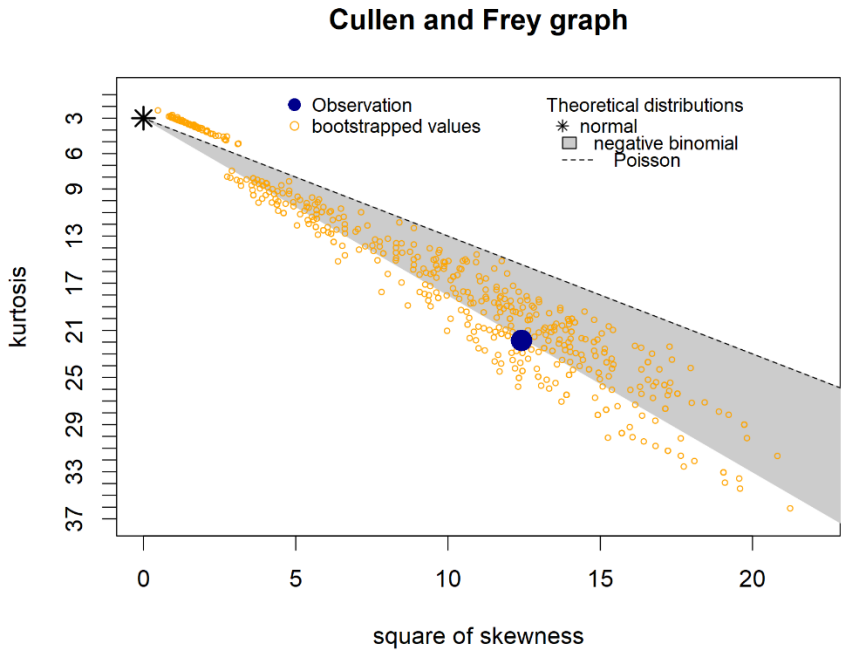


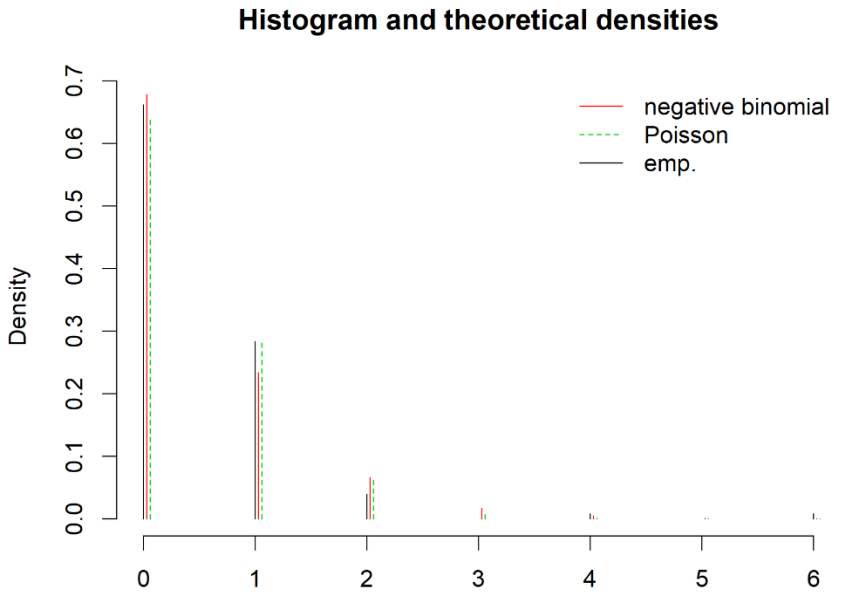


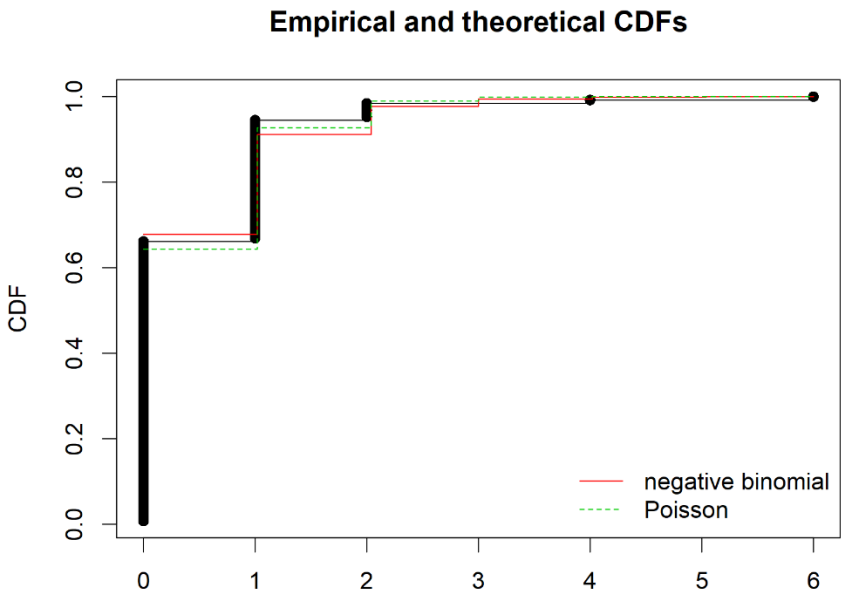


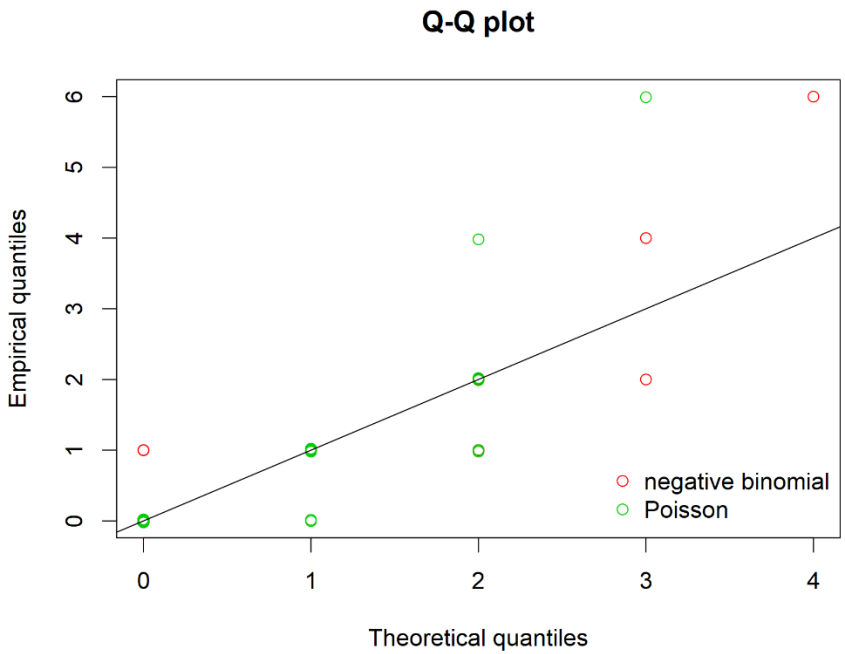


Kelp Greenling - Central Coast (FG)

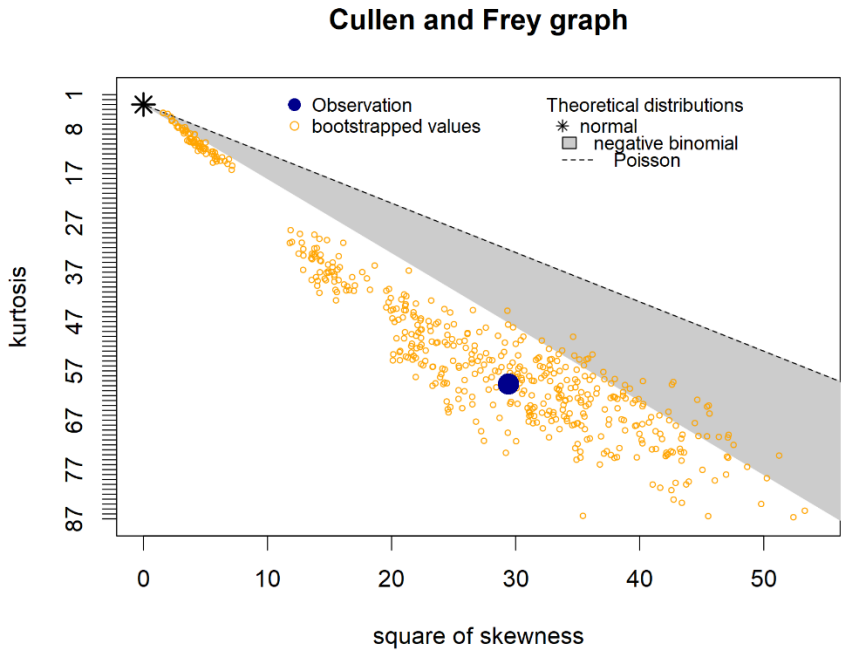


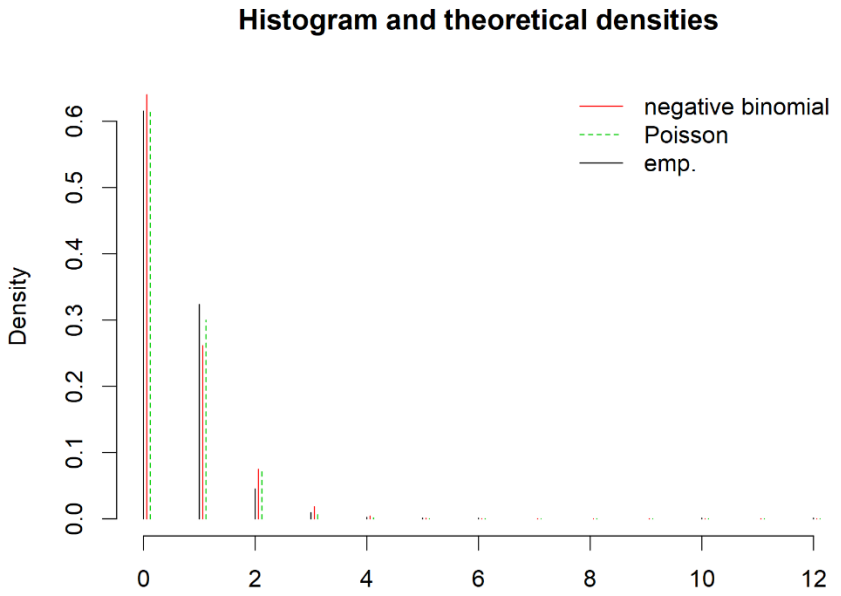


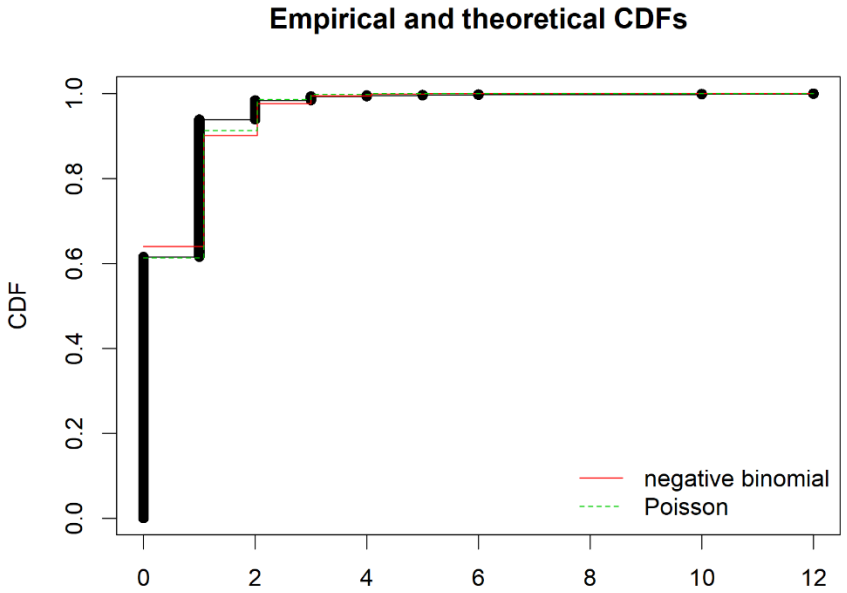


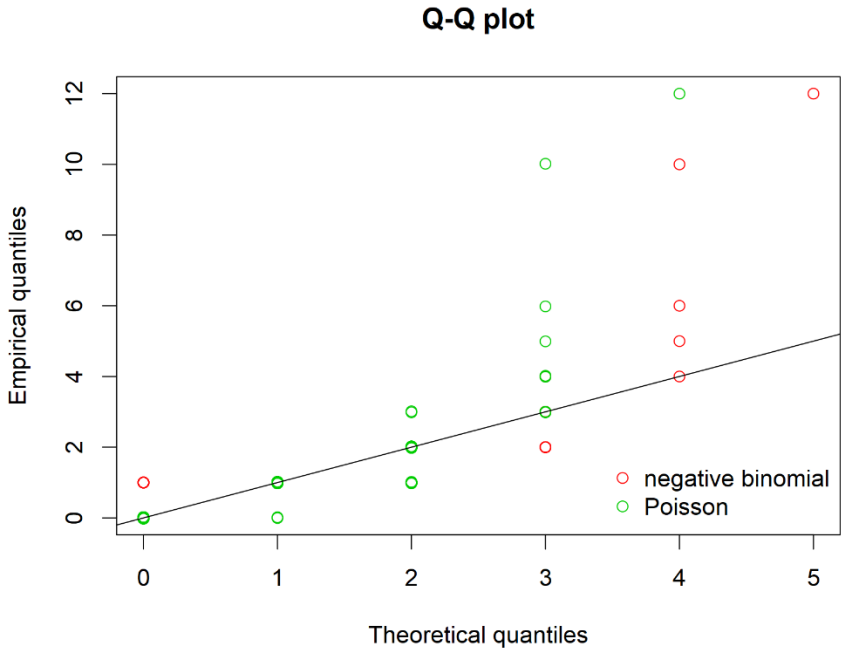


Kelp Greenling - Central Coast (FG, RG, & NG)

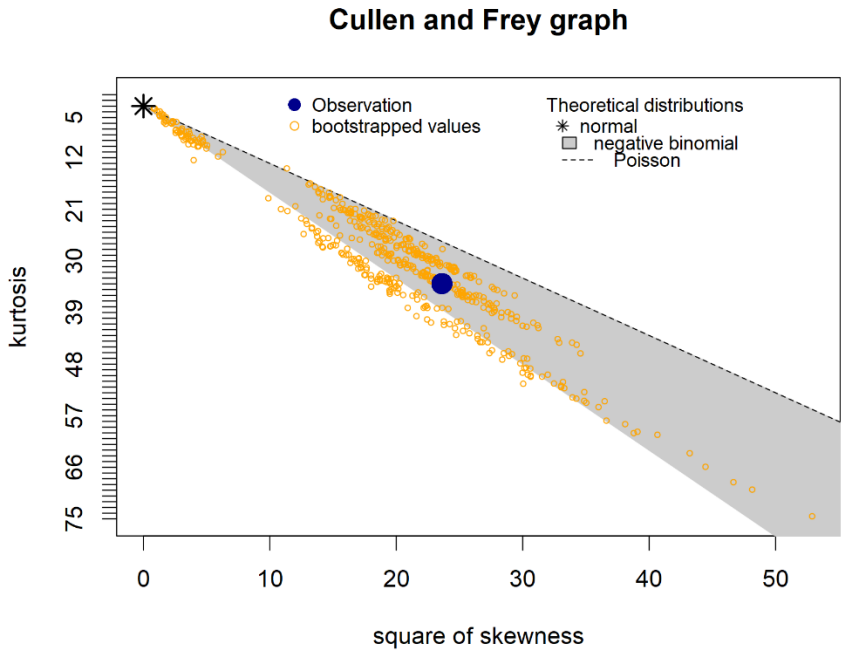


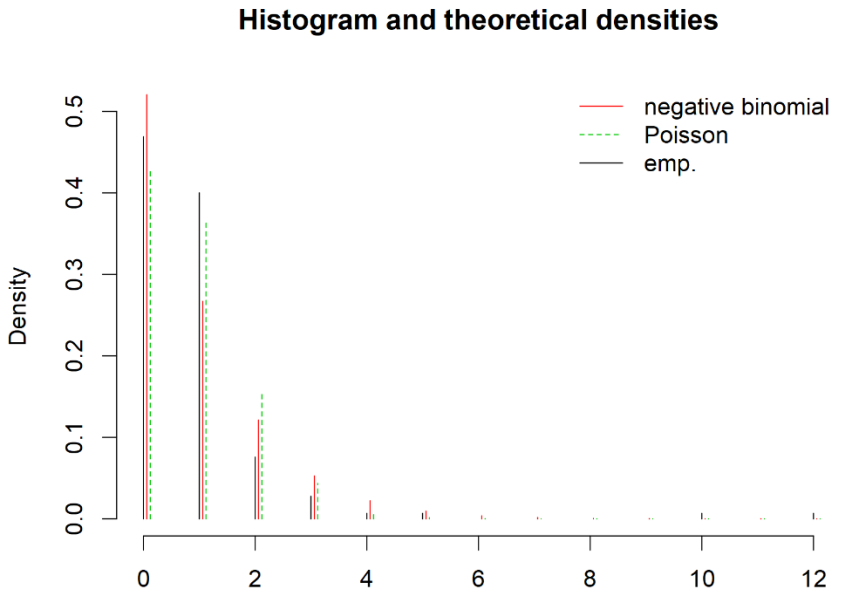


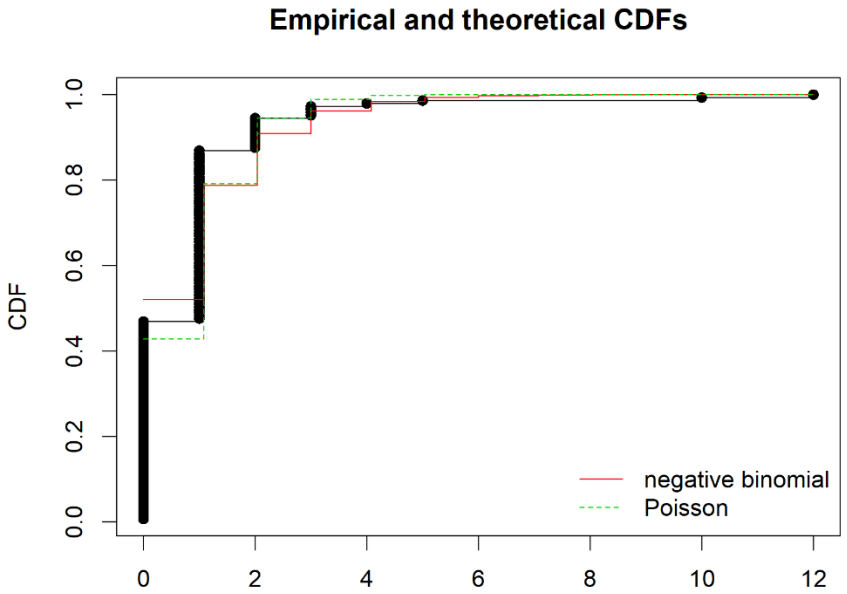


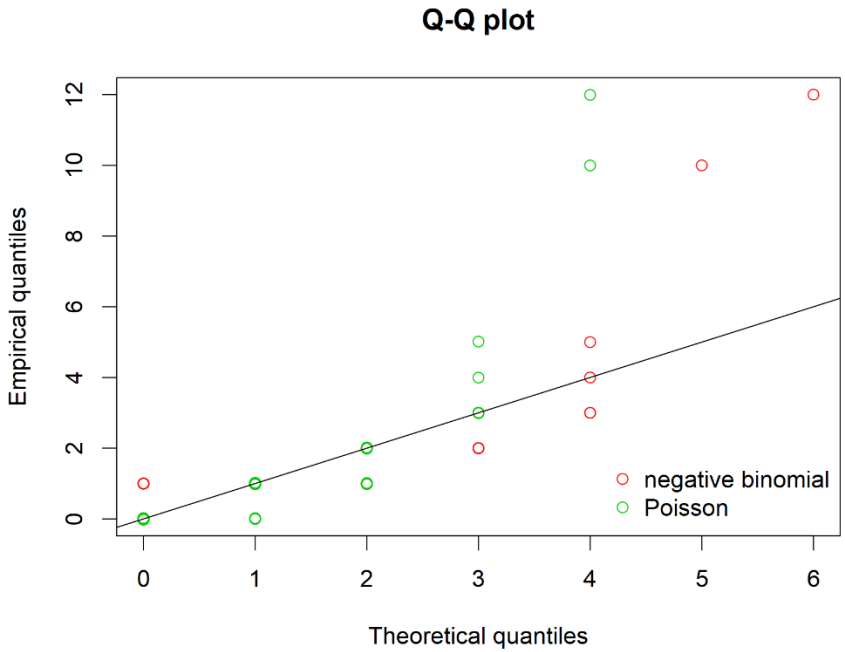


Kelp Greenling - Central Coast (NG)

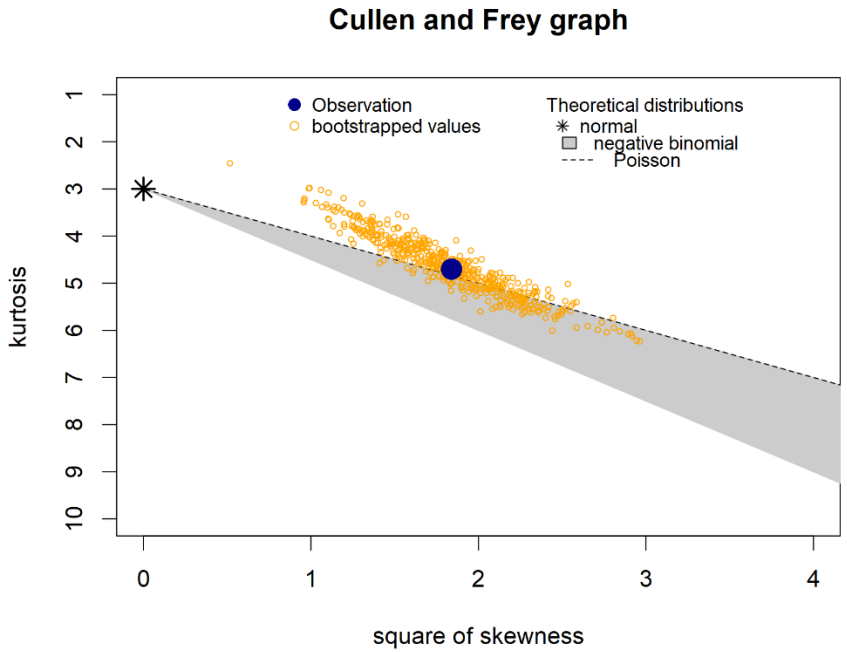


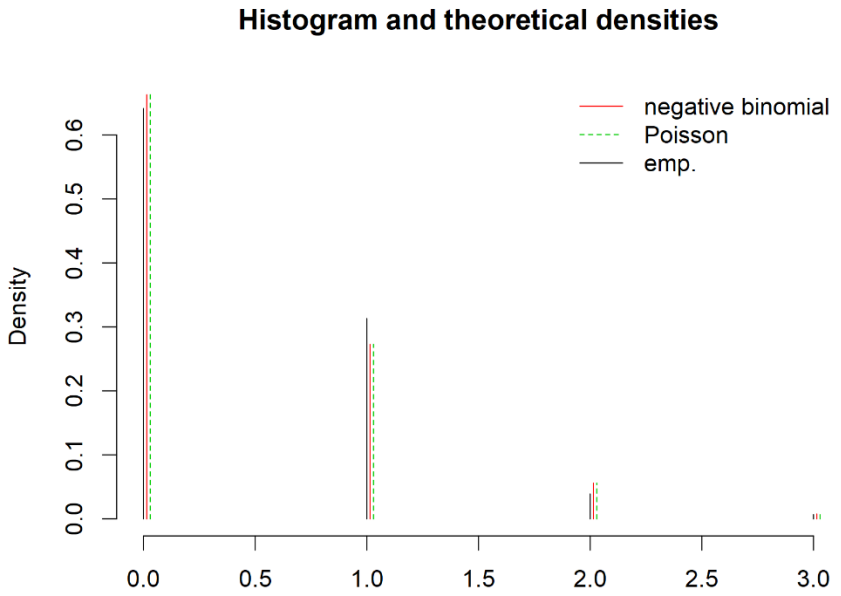


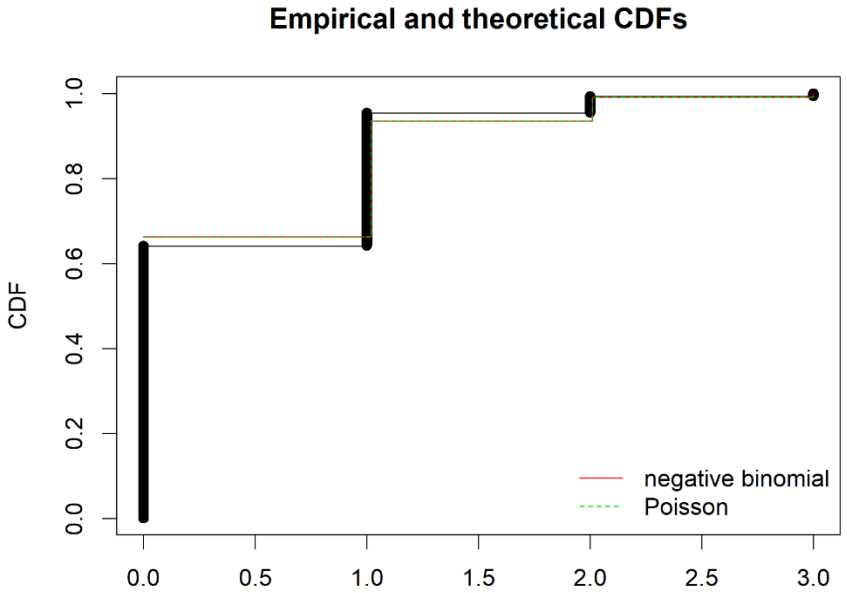


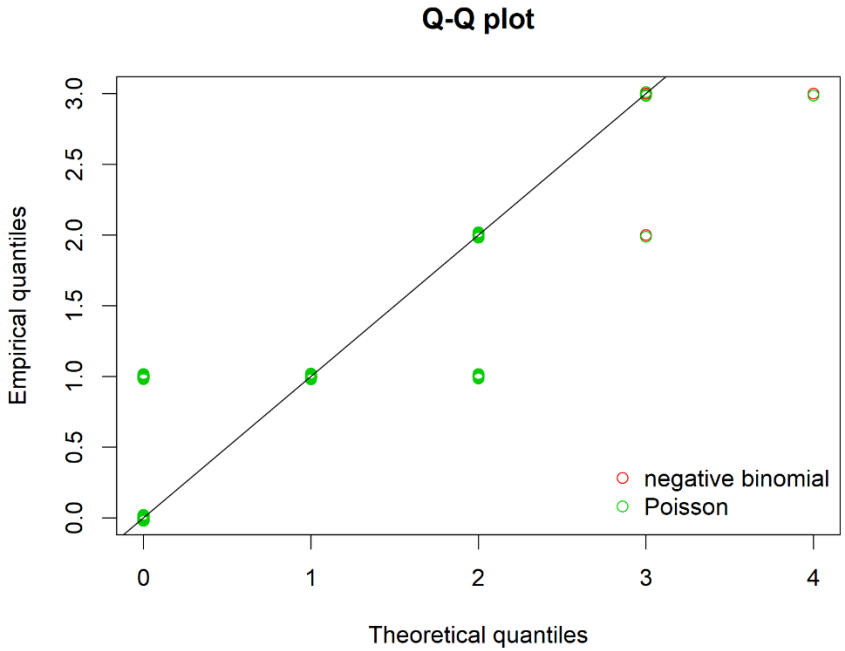


Kelp Greenling - Central Coast (RG)

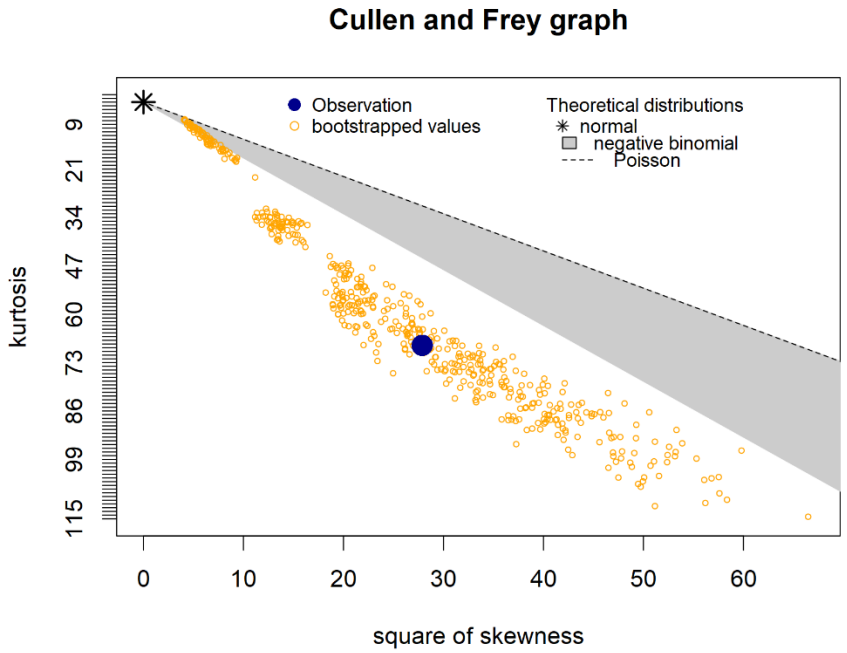


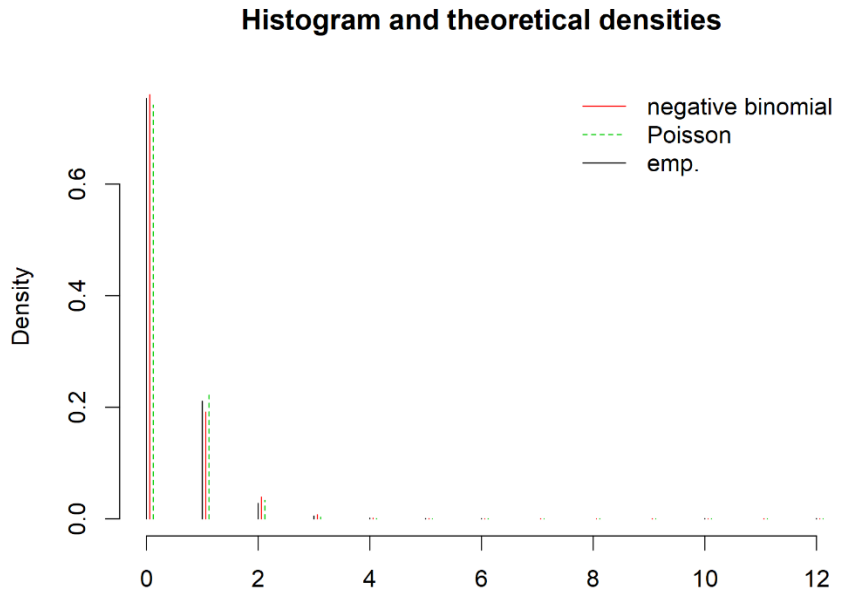


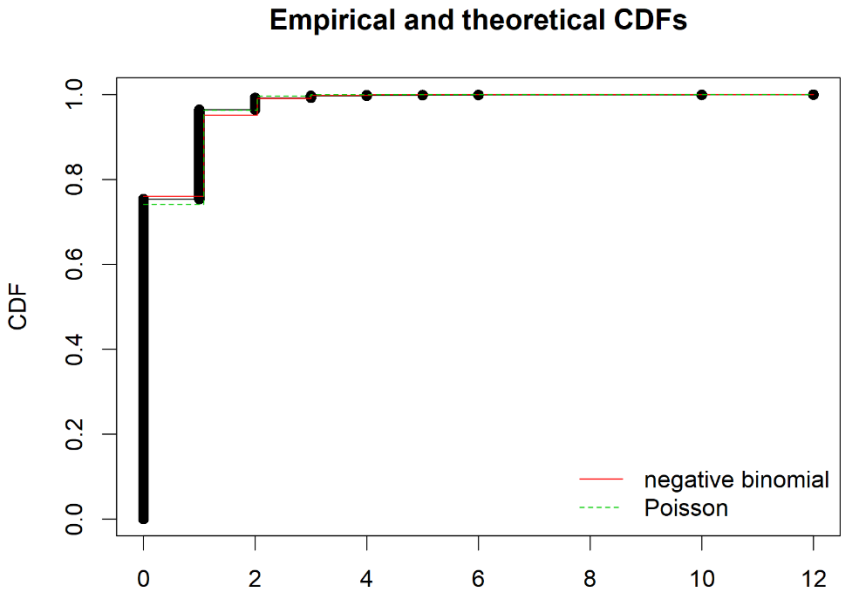


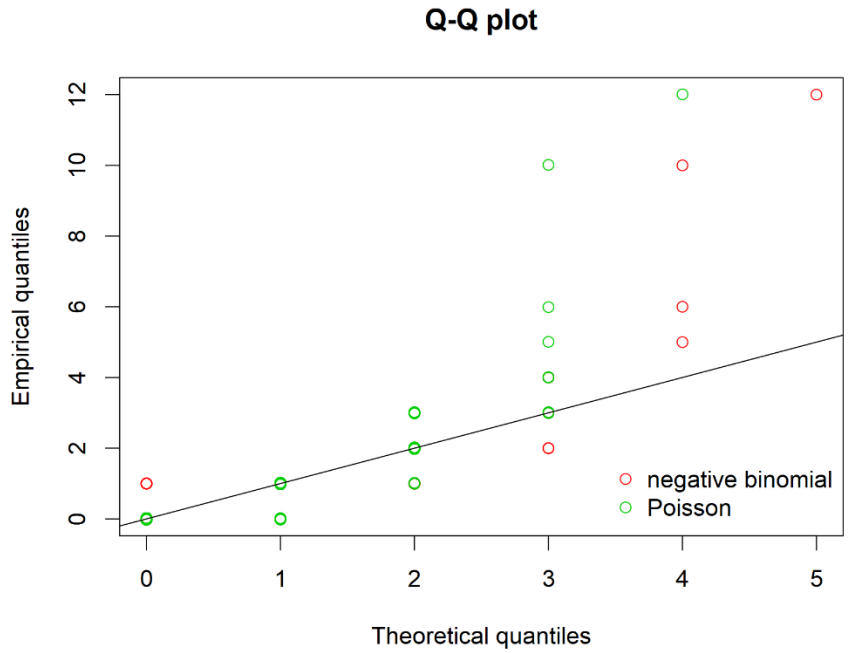


Kelp Greenling - Entire Coast

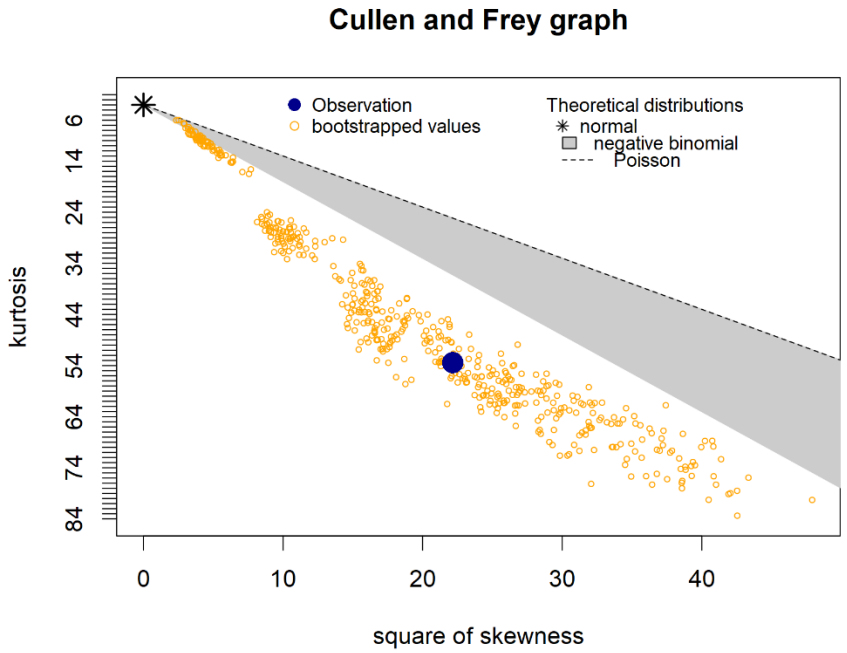


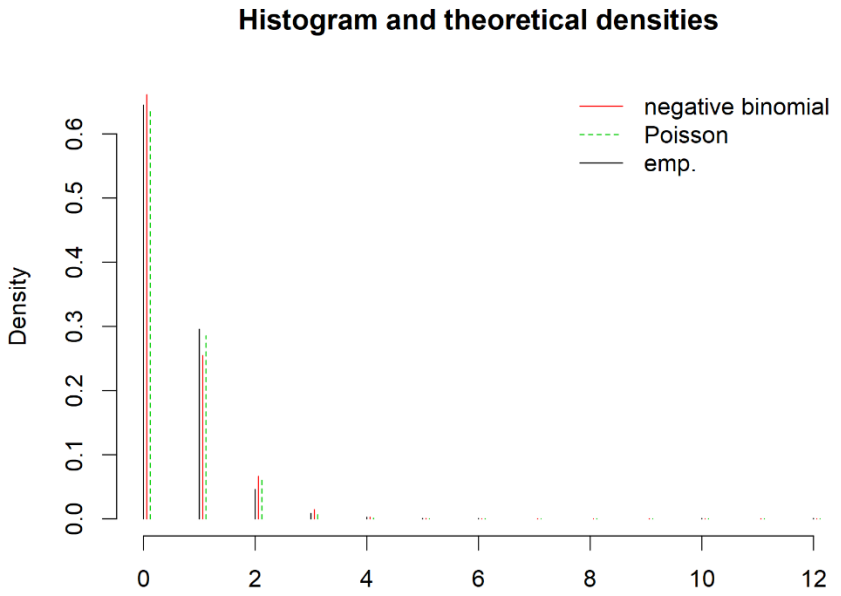


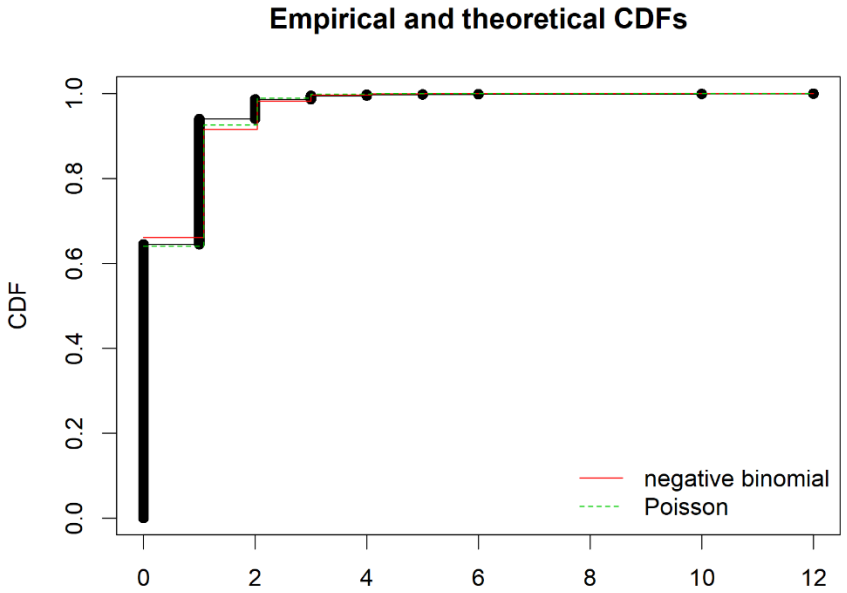


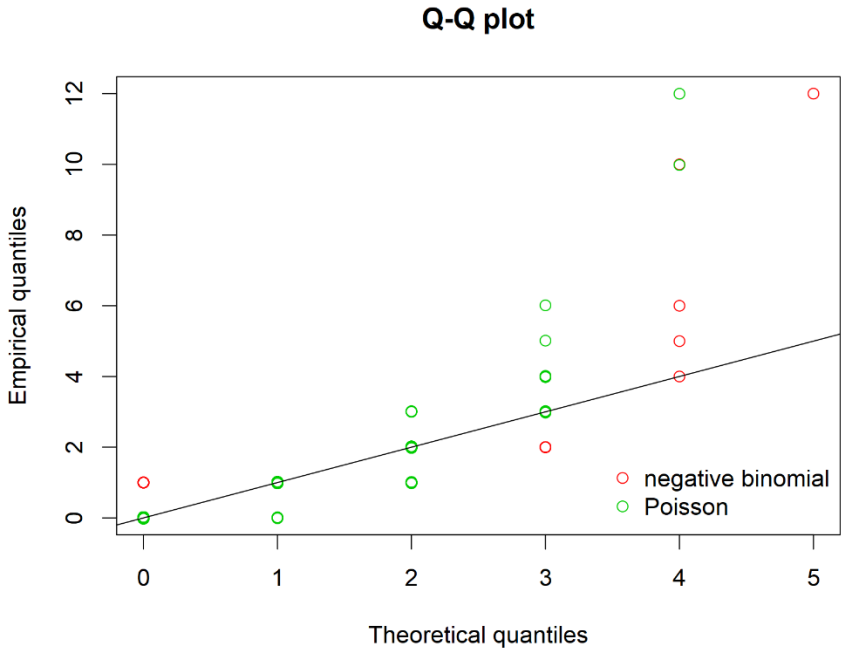


Kelp Greenling - Nearshore

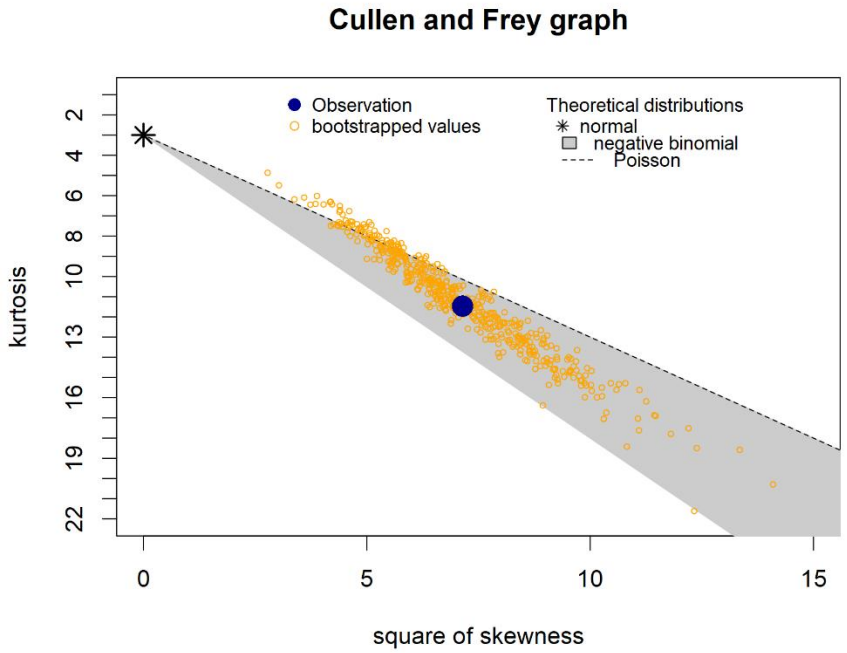


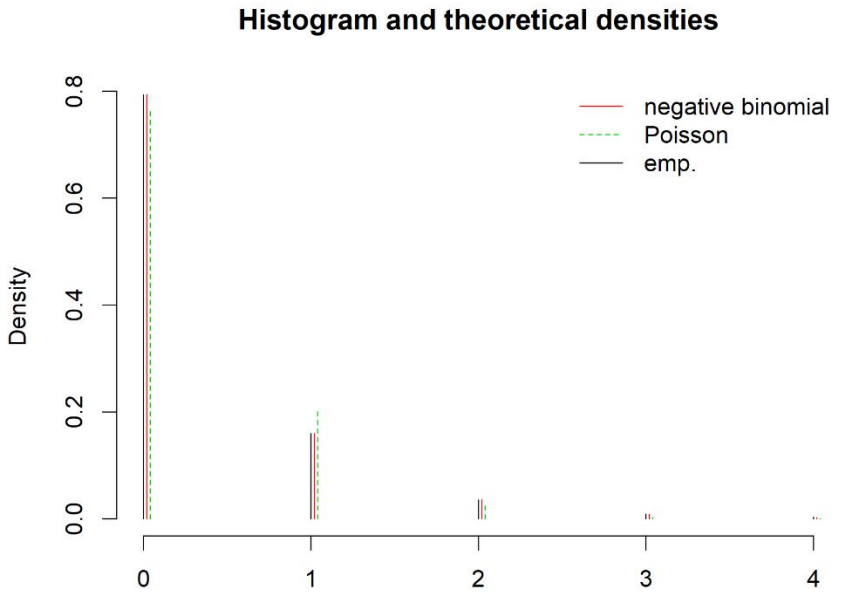


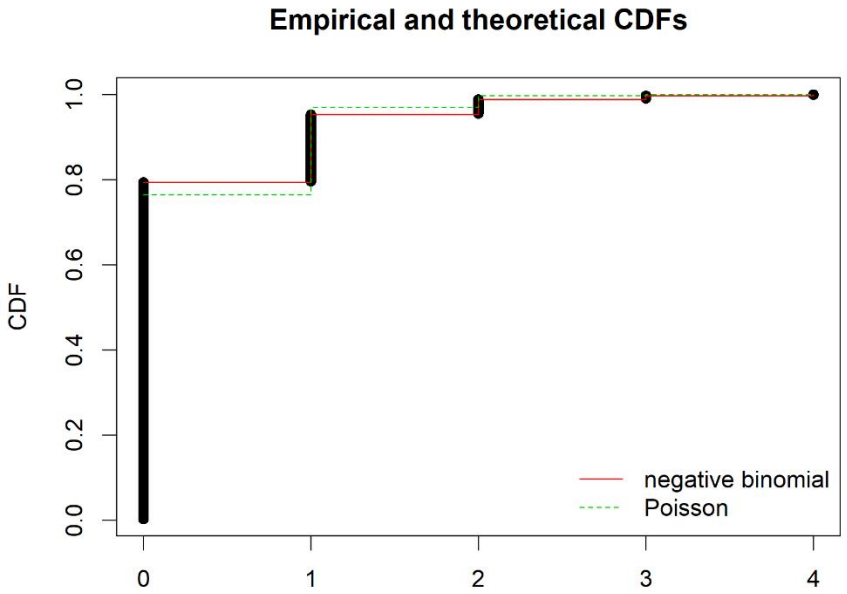


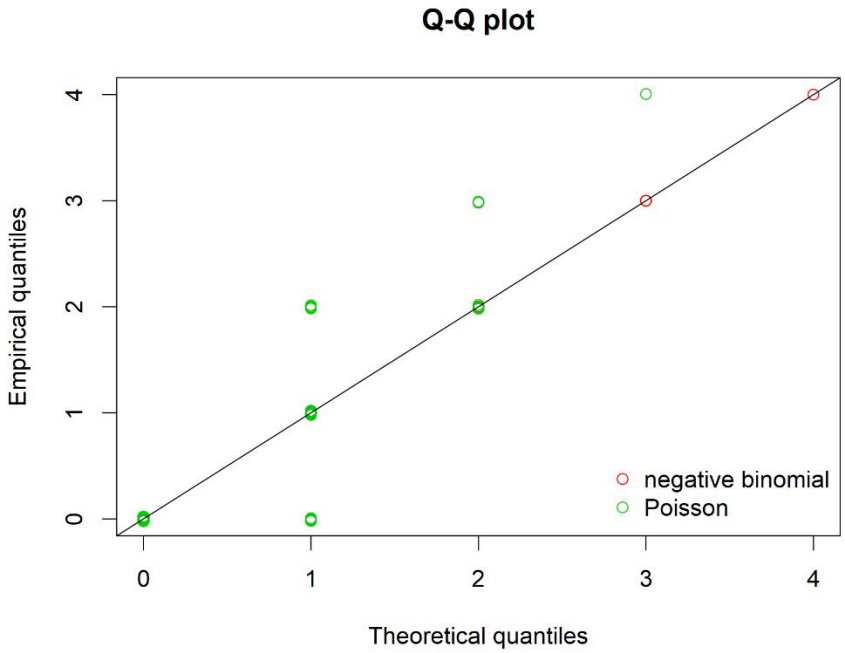


Kelp Greenling - North Coast (FG & RG)

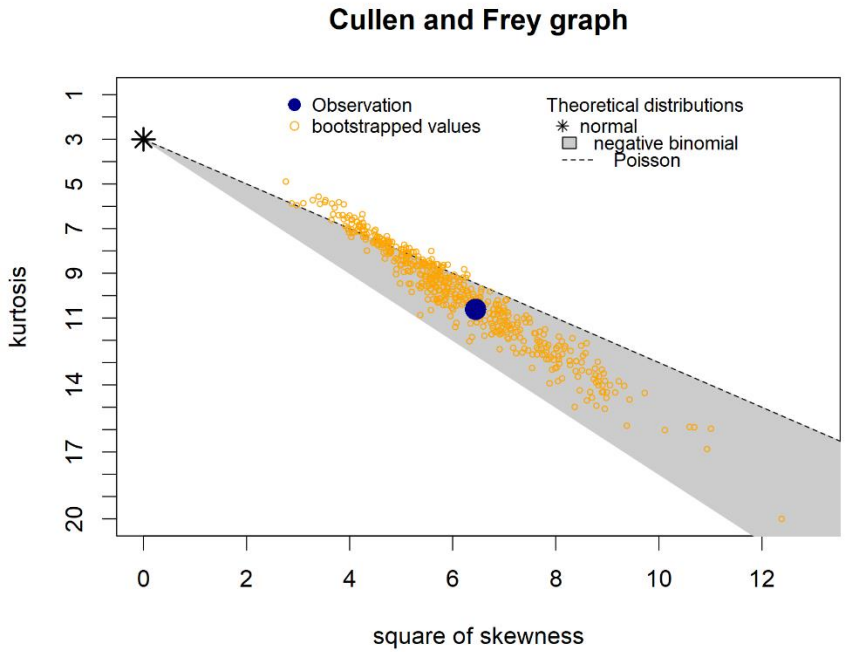


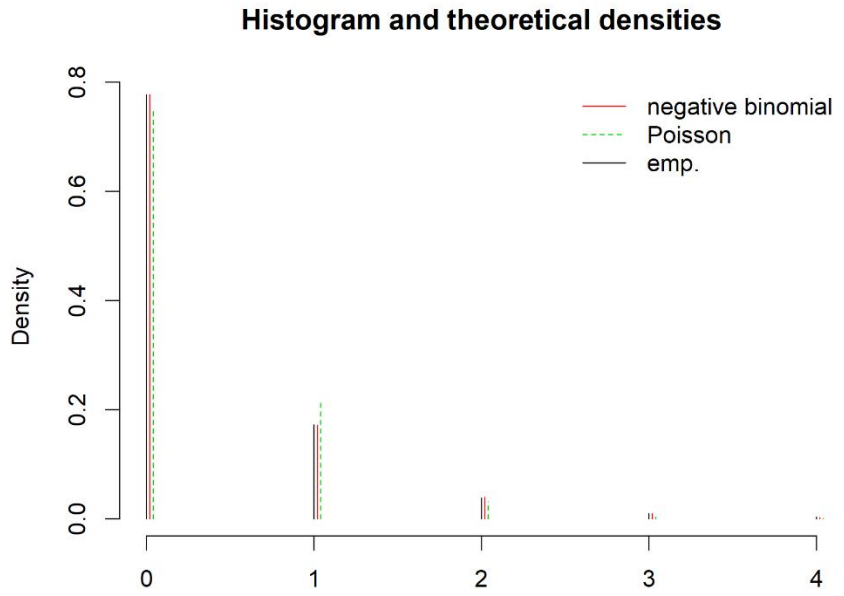


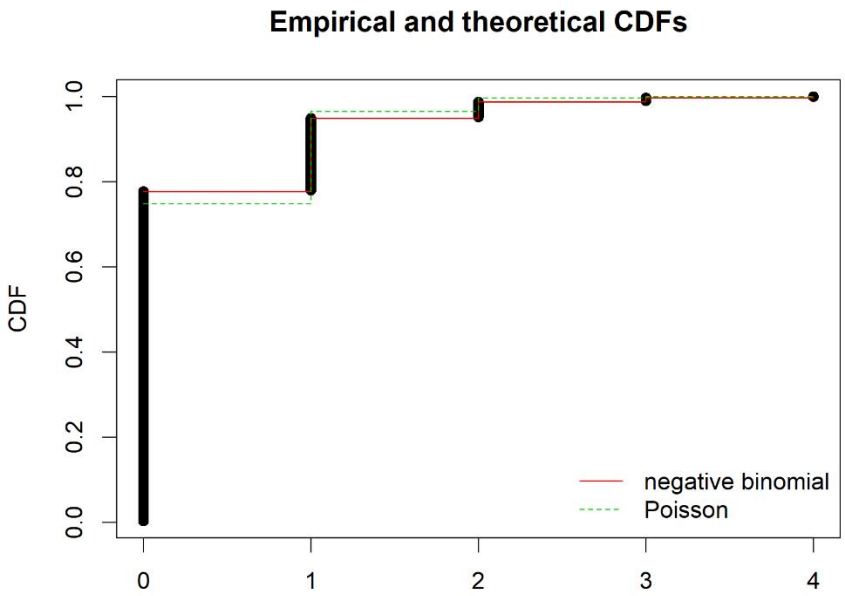


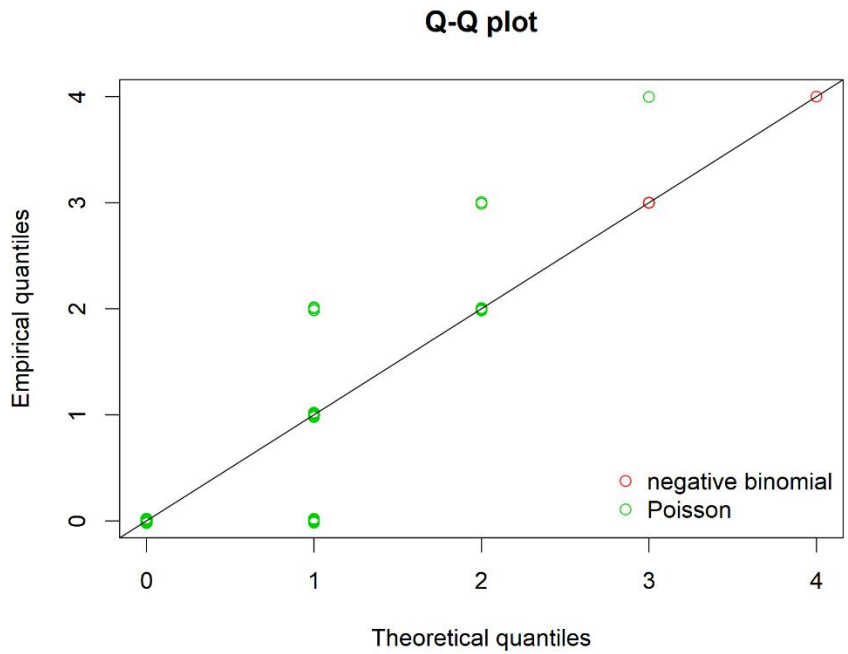


Kelp Greenling - North Coast (FG)

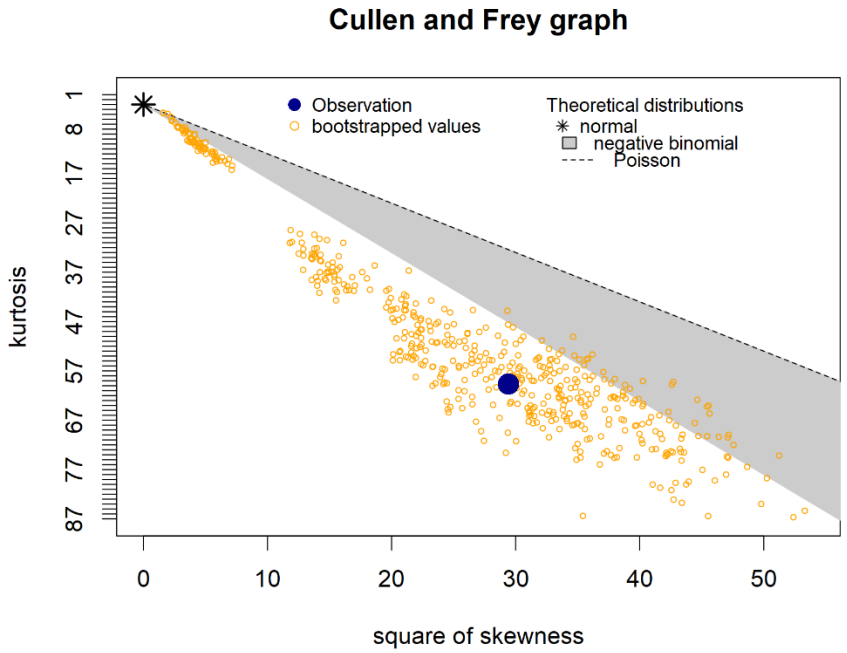


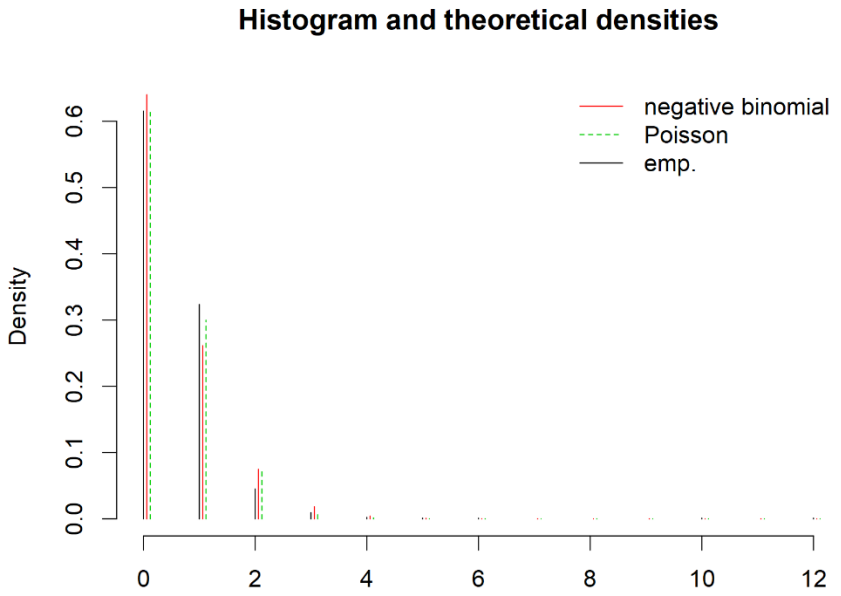


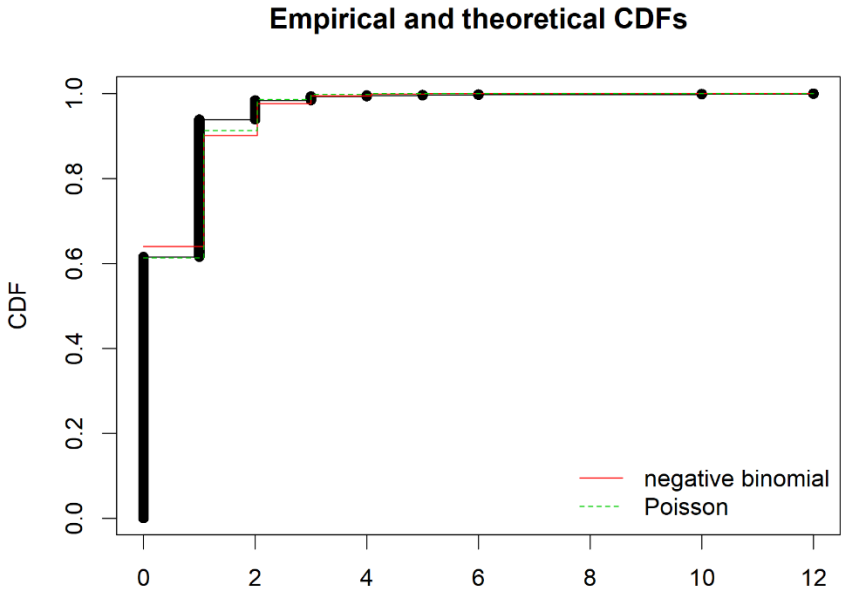


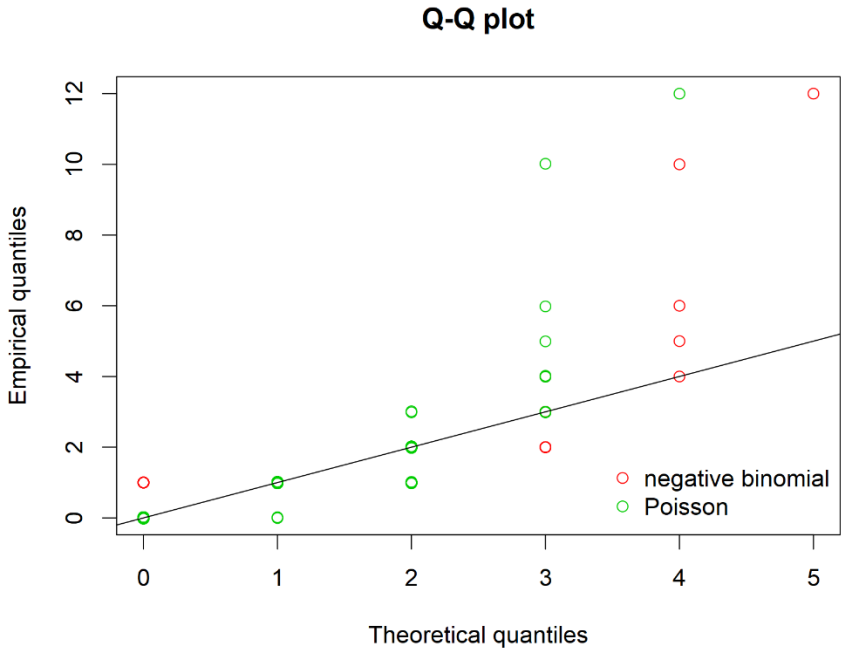


Kelp Greenling - Central Coast (FG, RG, & NG)

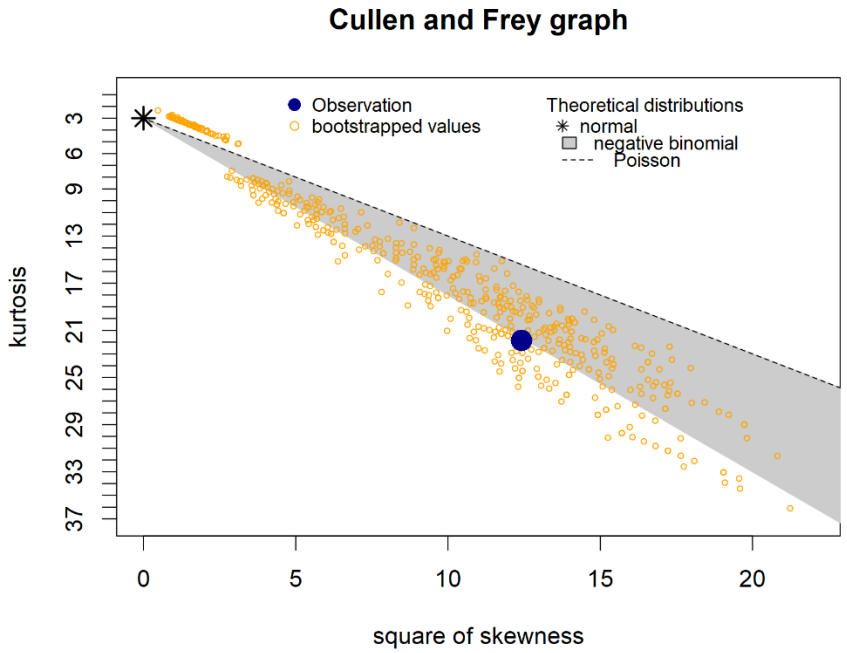


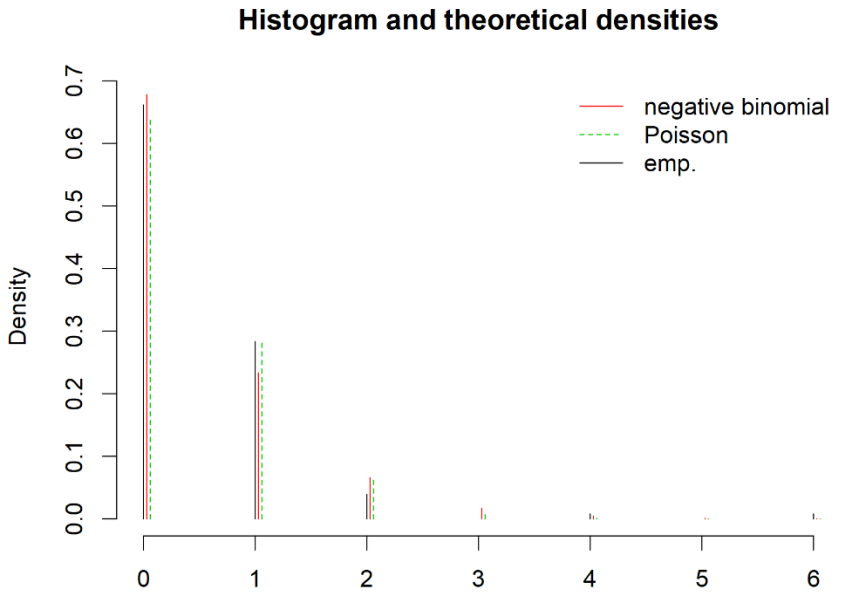


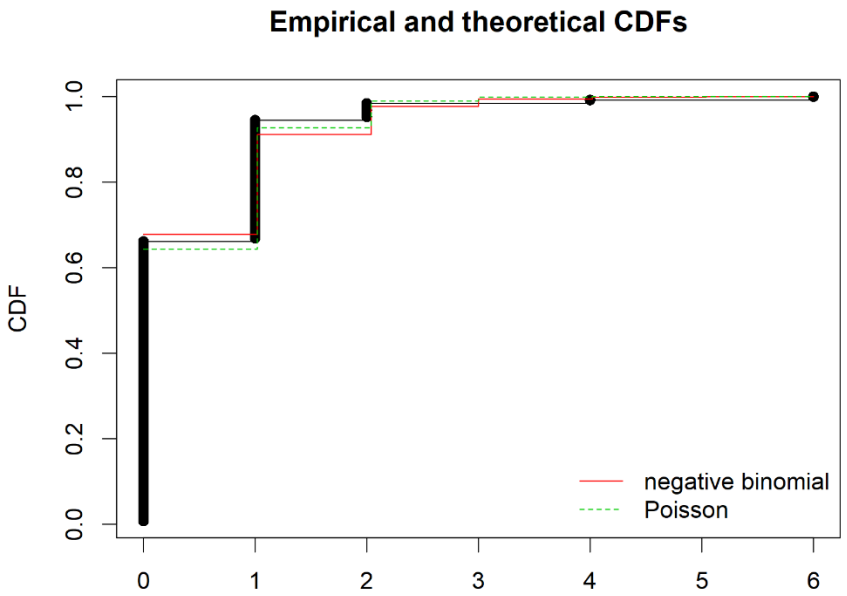


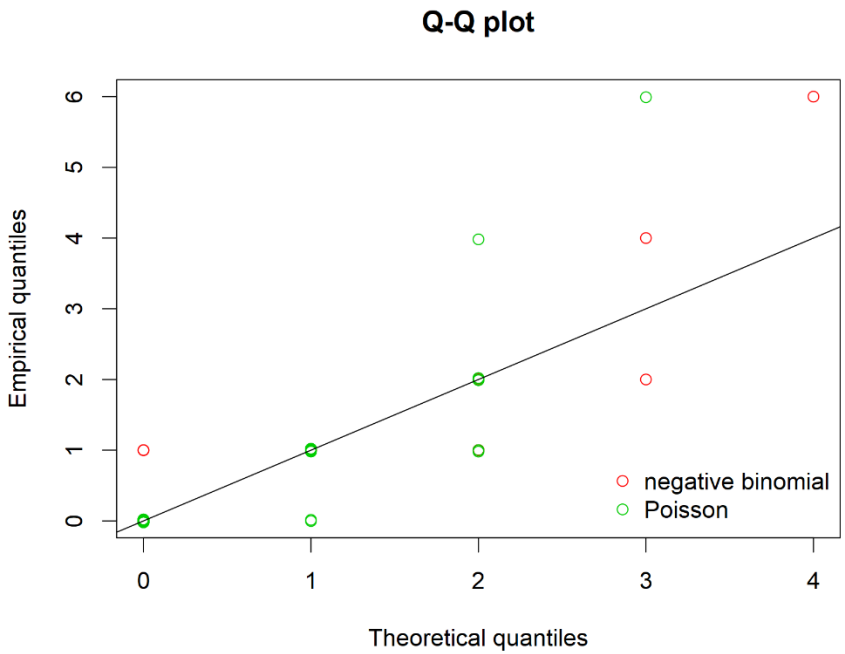


Kelp Greenling - Central Coast (FG)

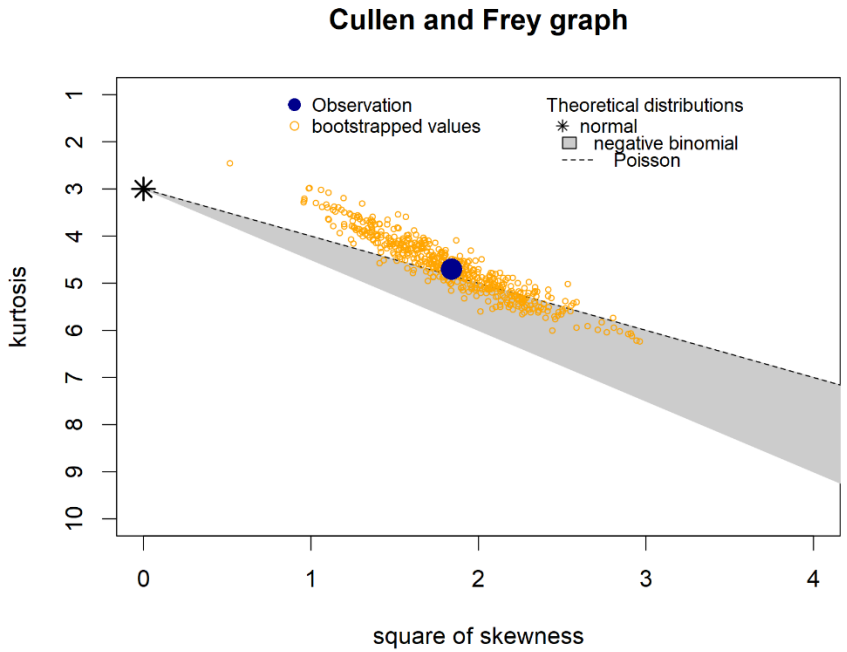


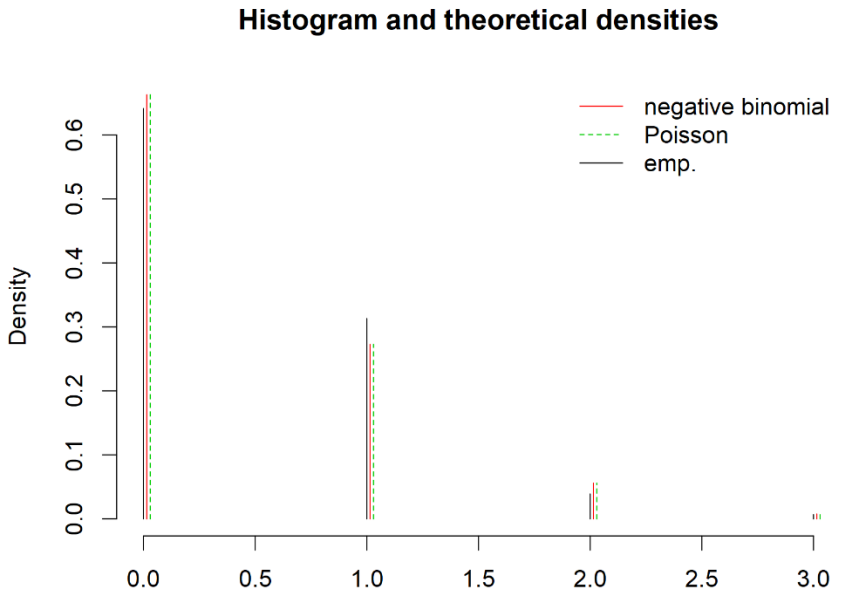


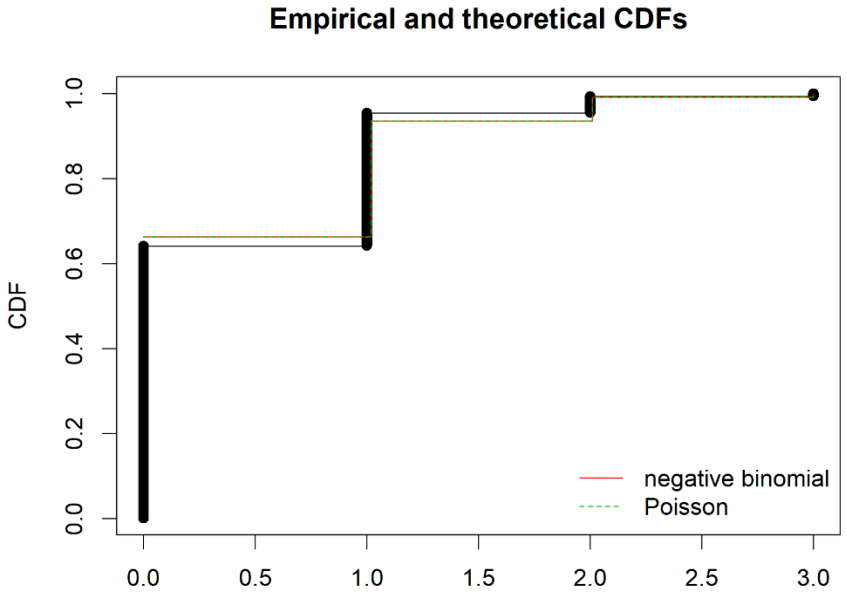


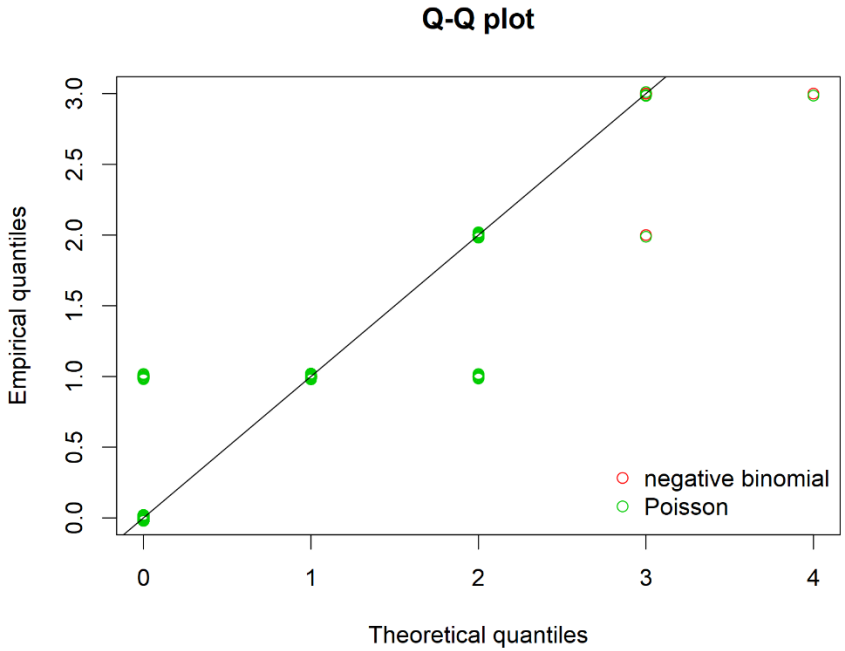


Kelp Greenling - Central Coast (RG)

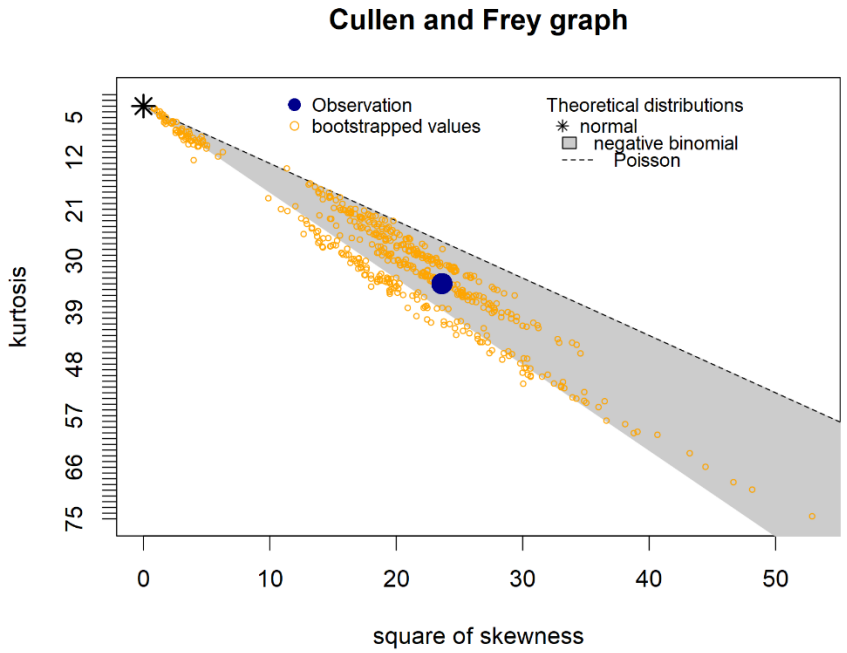


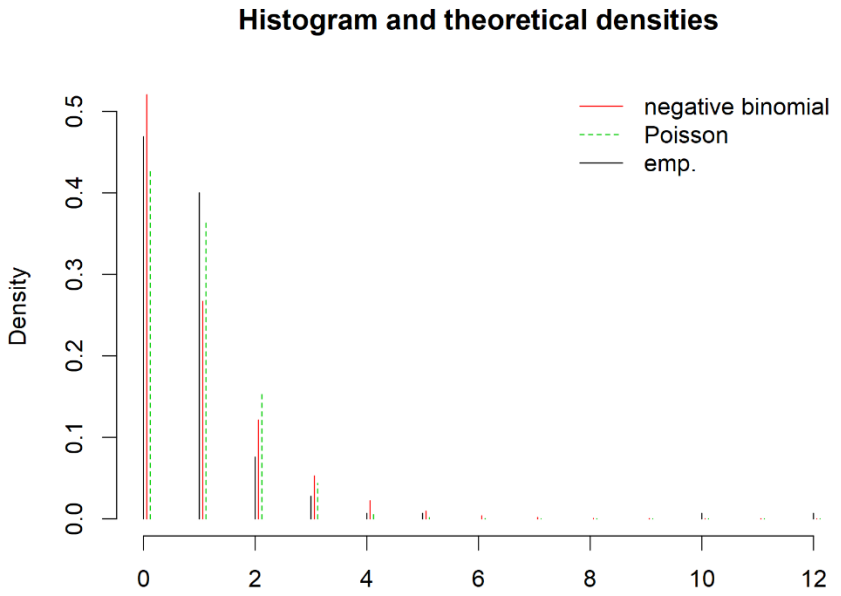


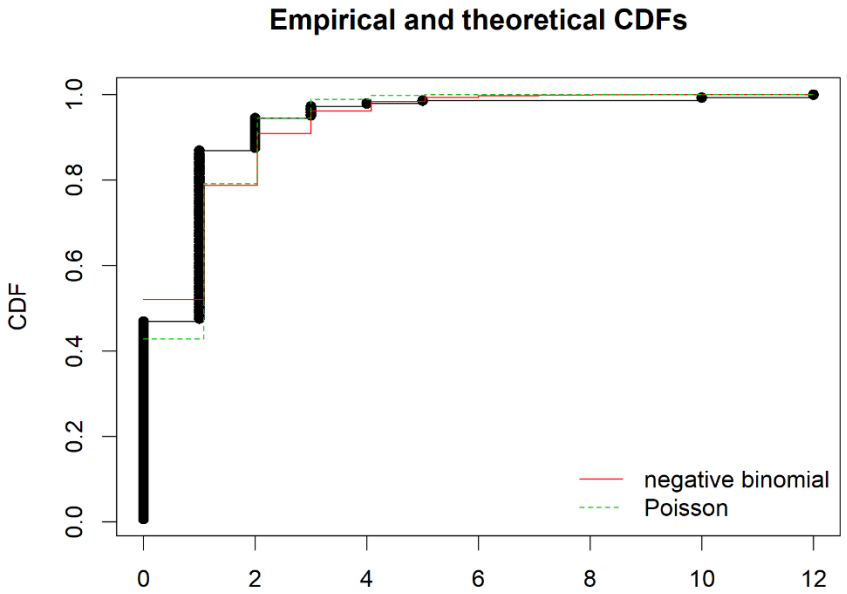


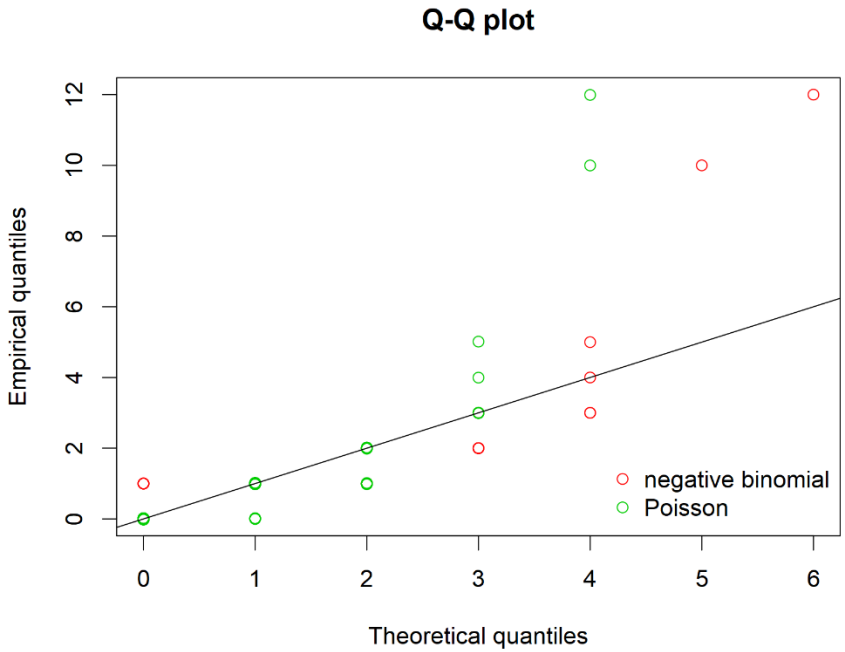


Kelp Greenling - Central Coast (NG)

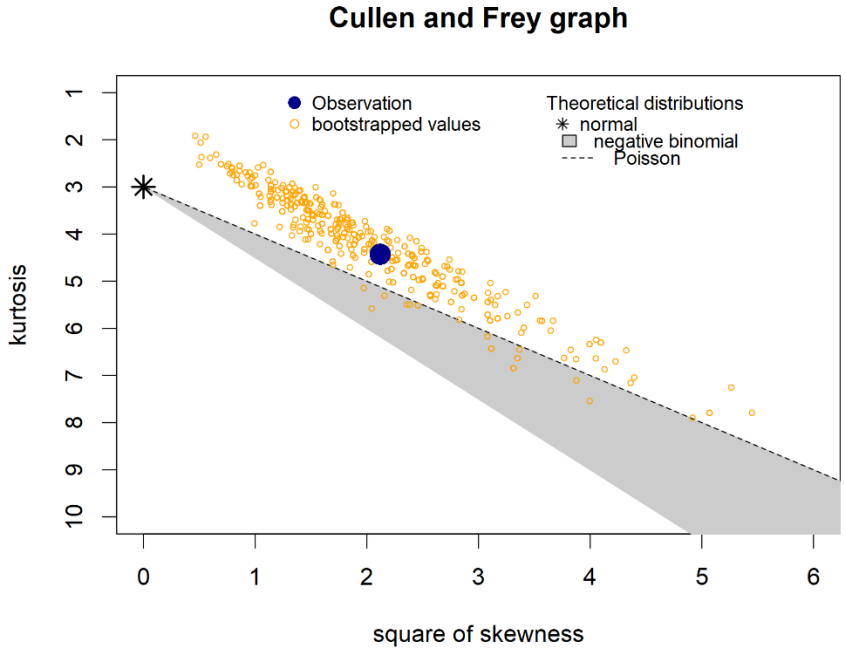


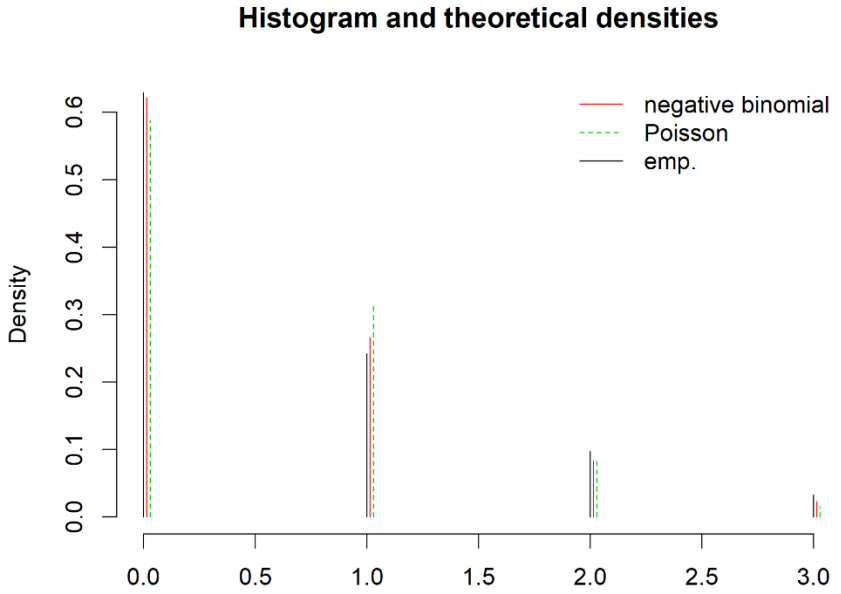


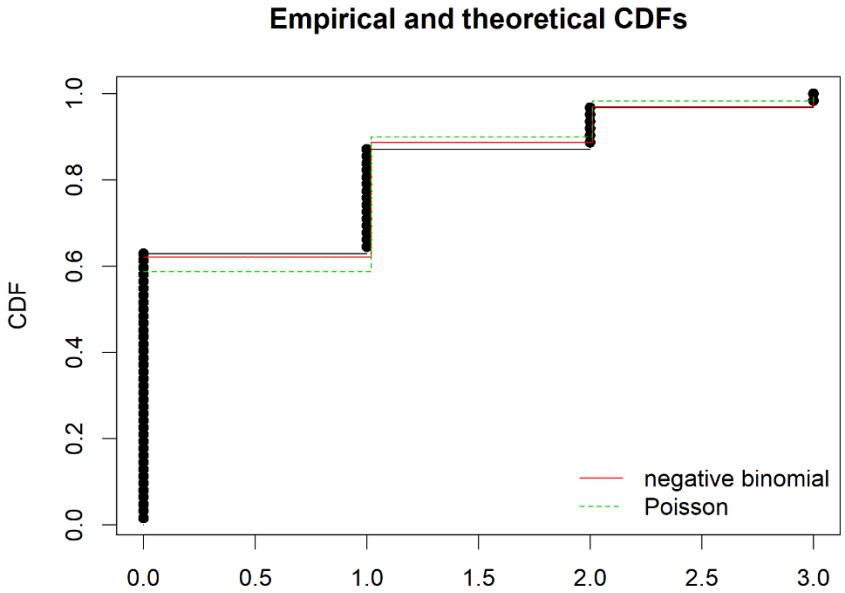


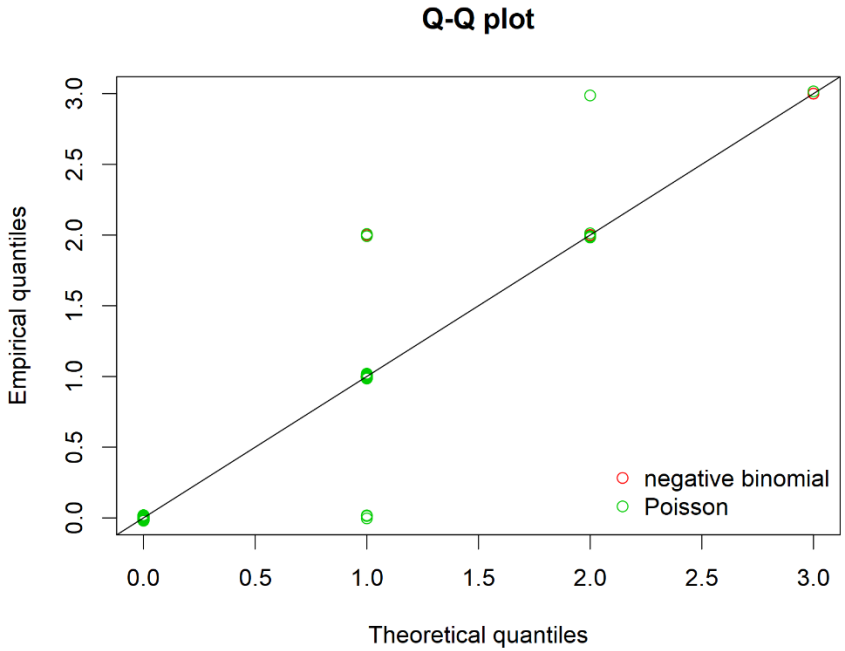


Kelp Greenling - Cape Perpetua (FG & RG)

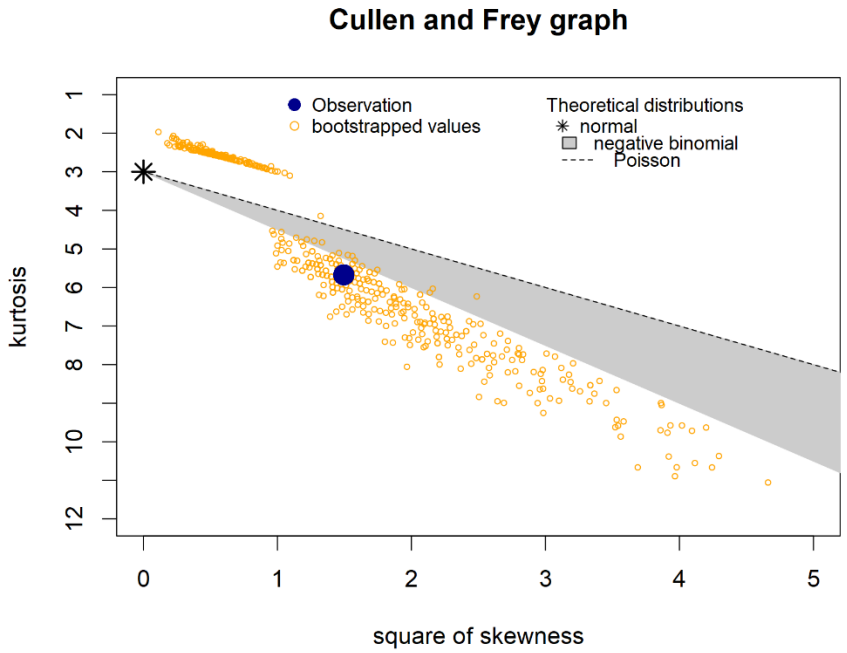


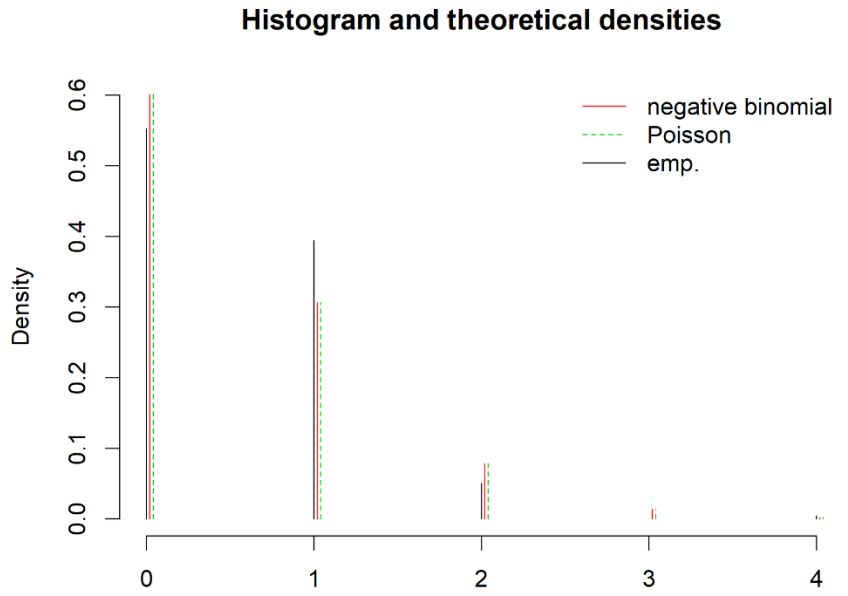


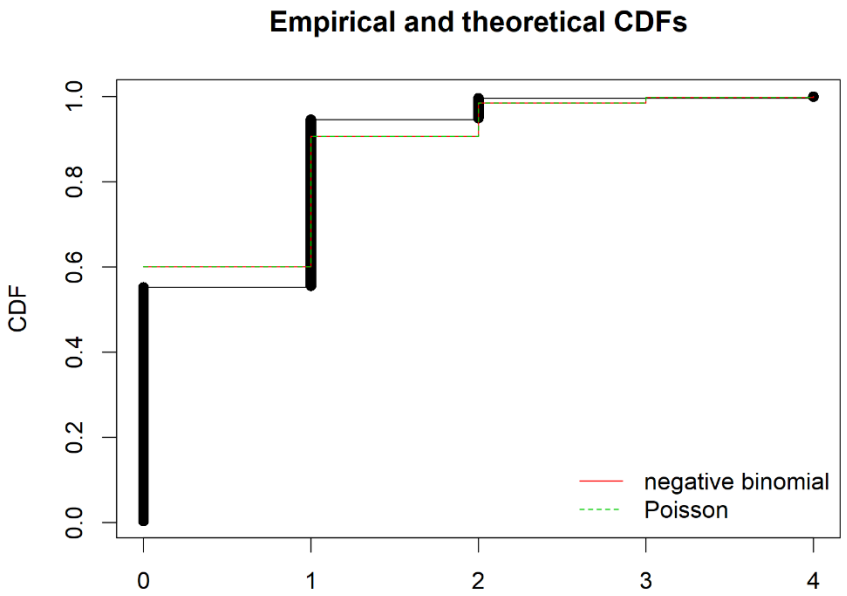


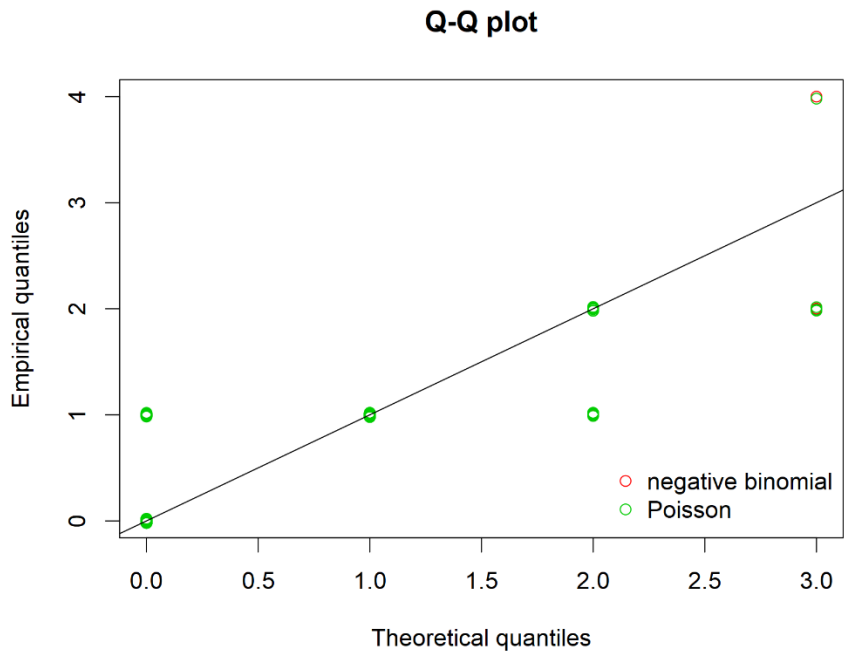


Kelp Greenling - South Coast (RG)

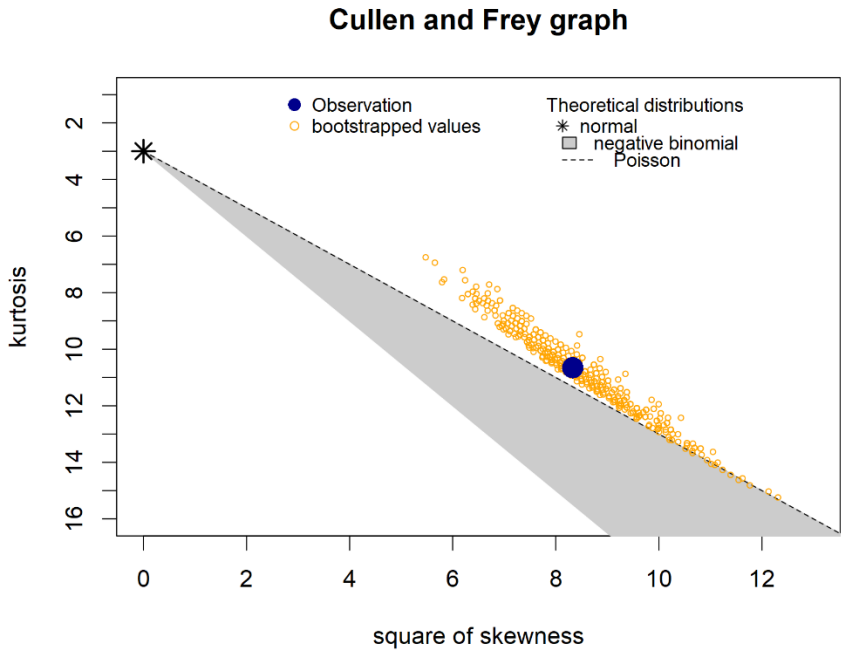


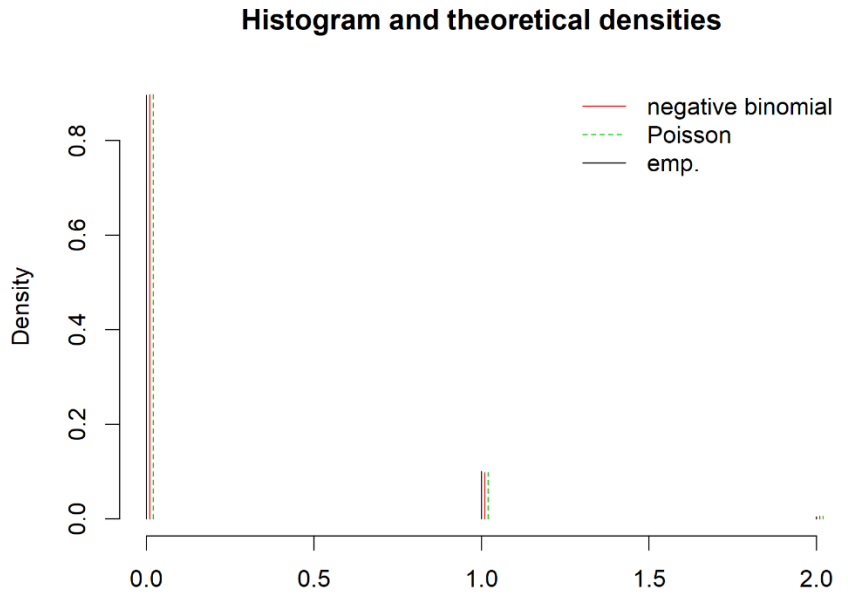


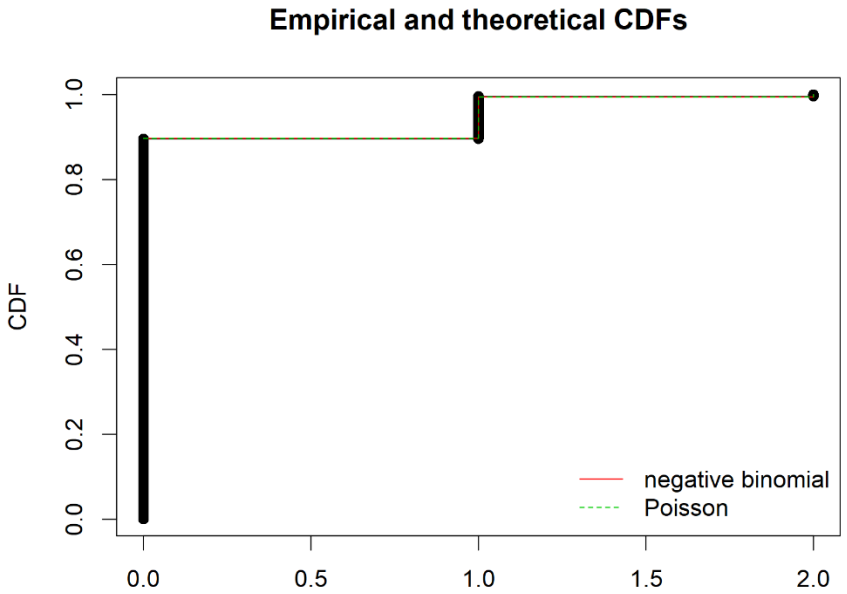


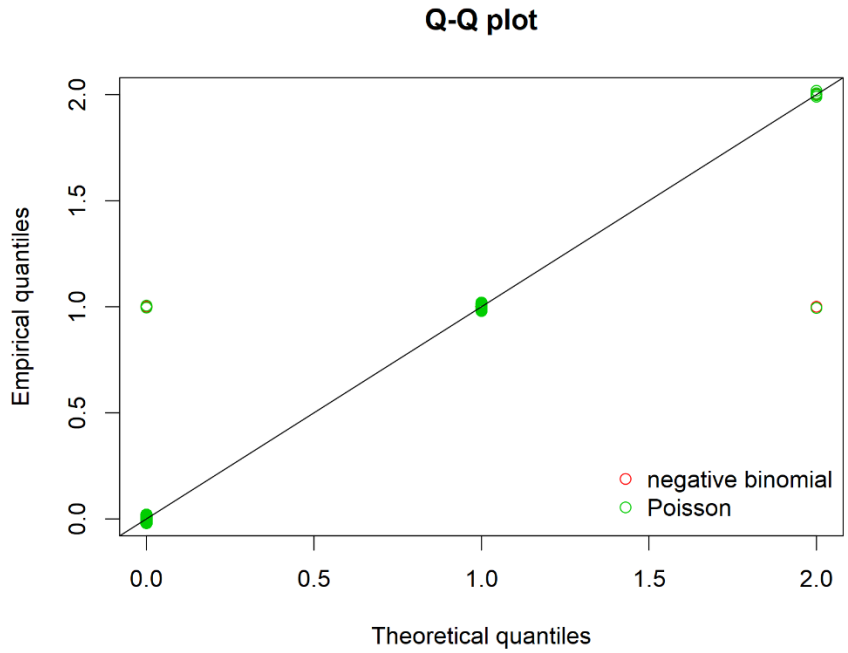


Kelp Greenling - Offshore (FG)

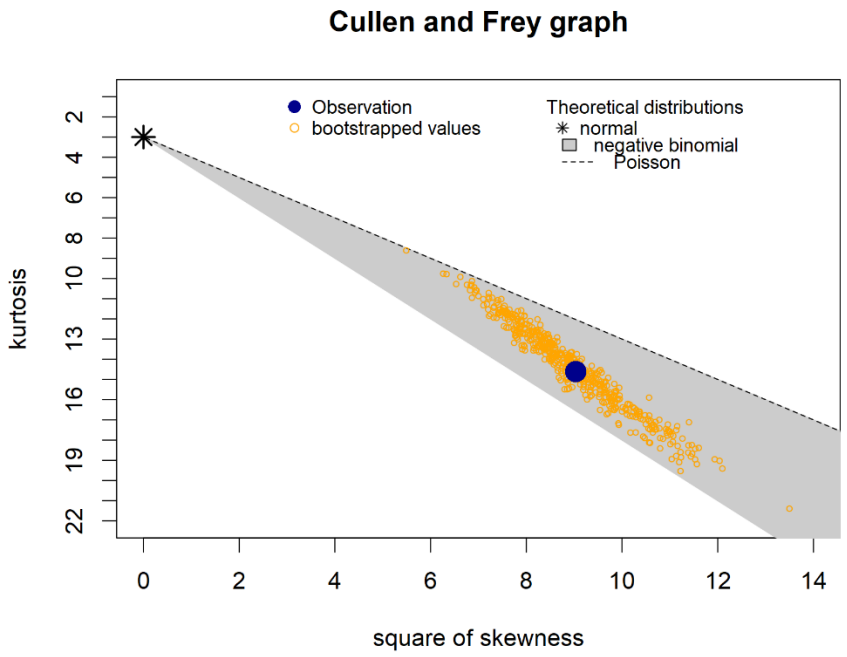


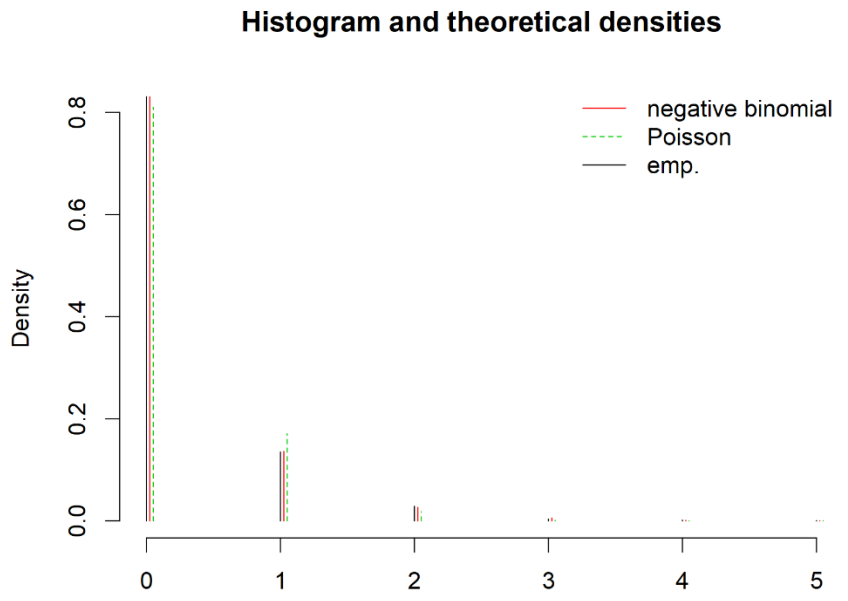


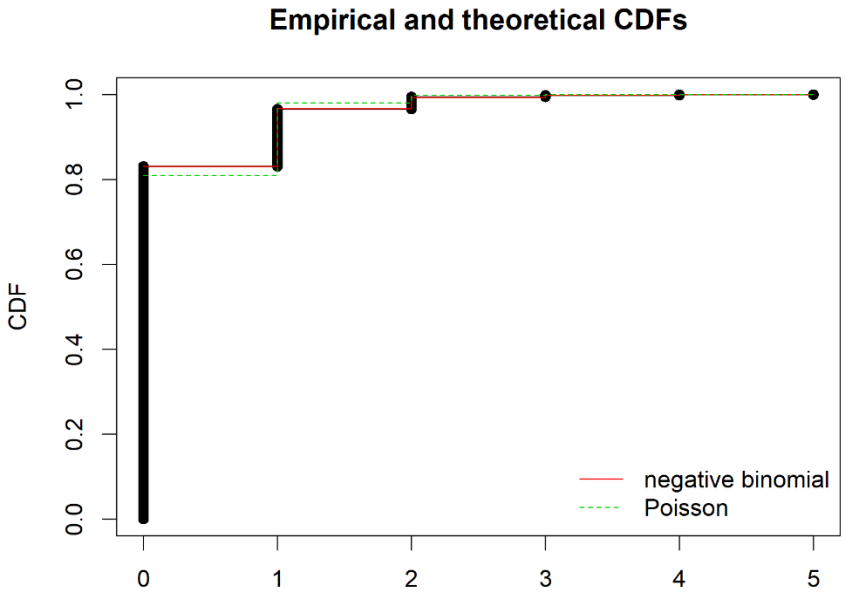


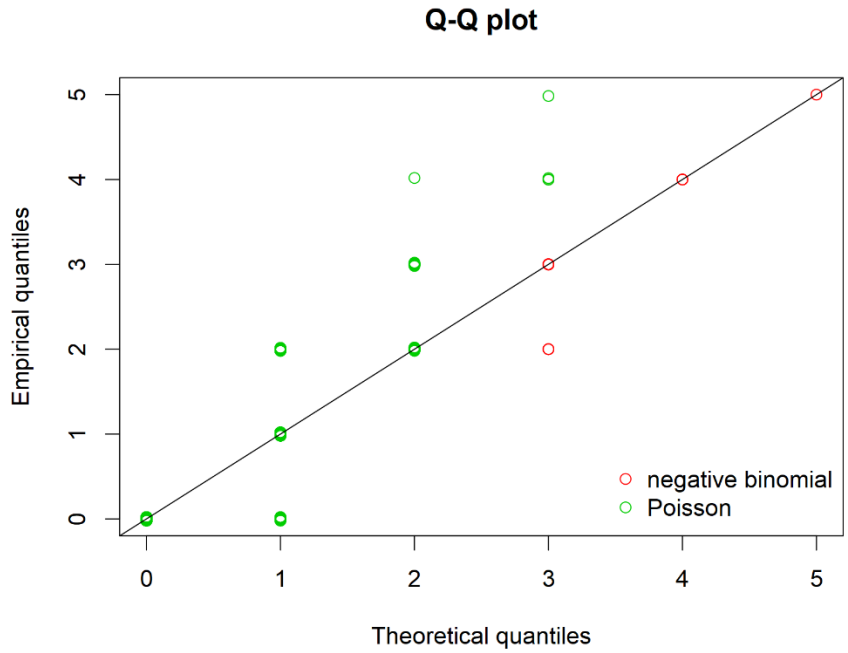


Lingcod - Entire Coast

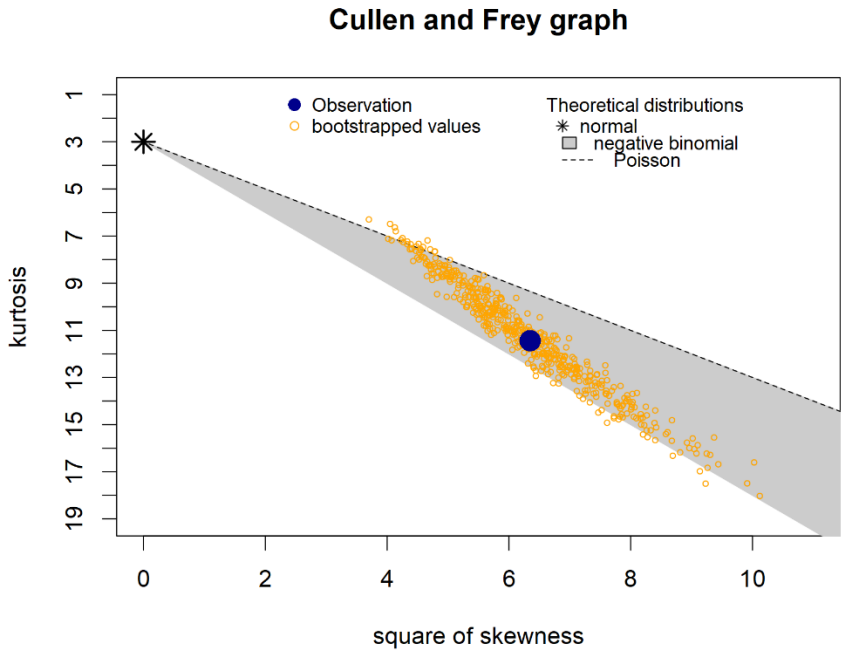


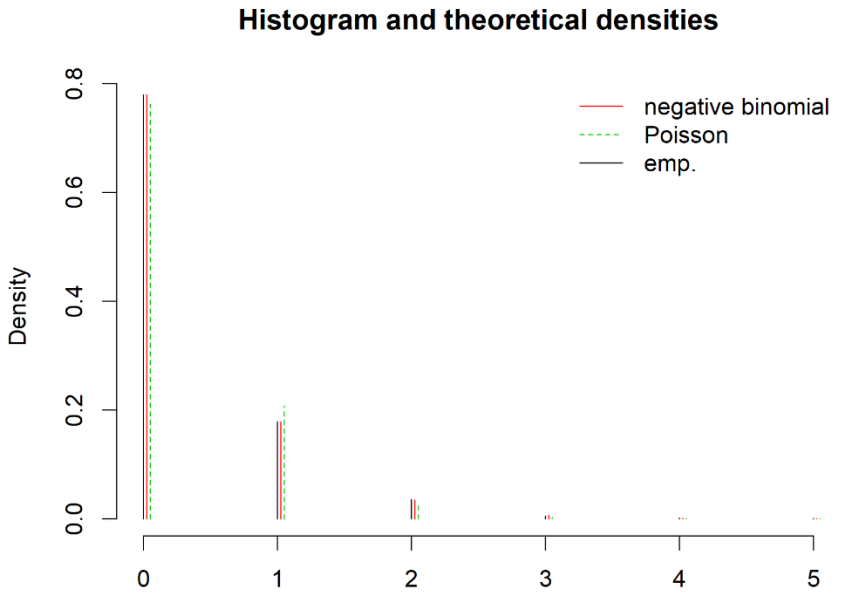


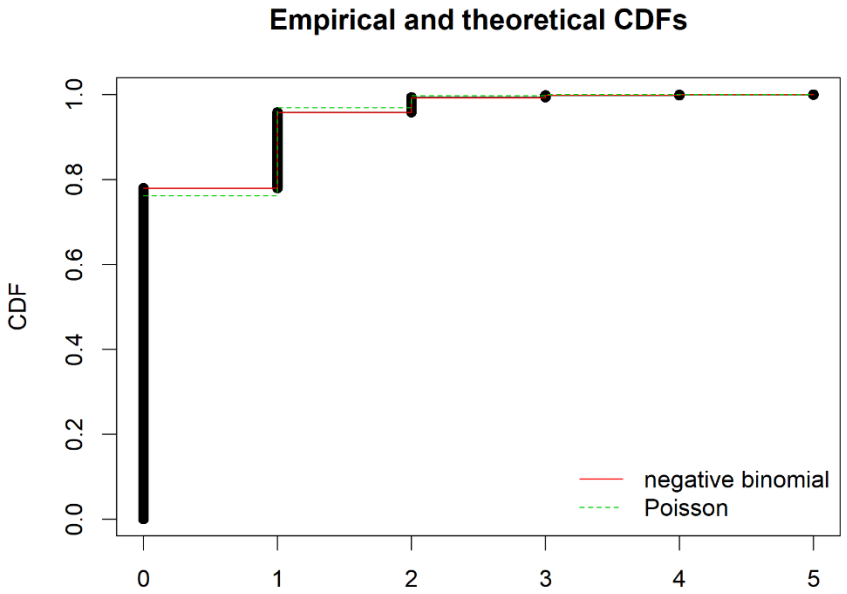


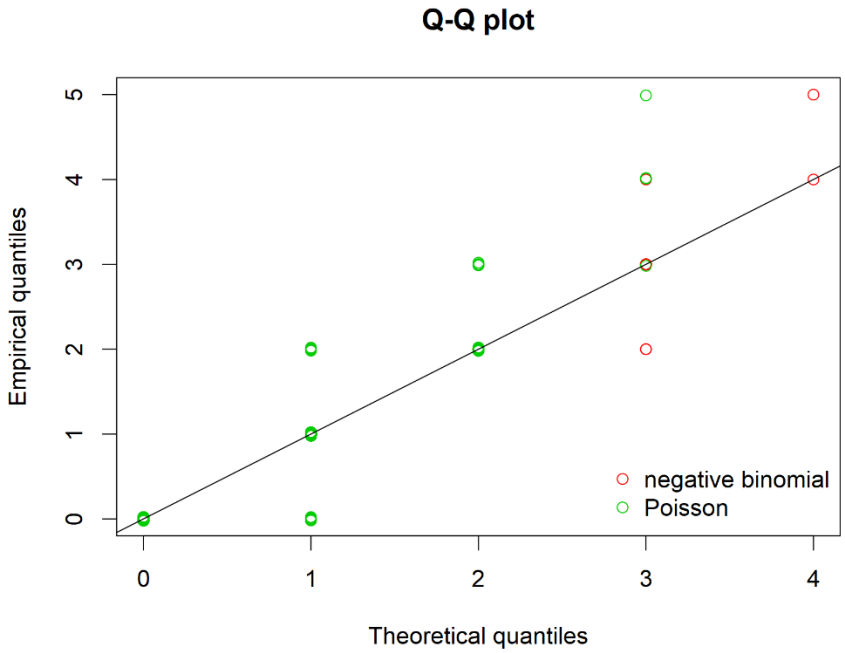


Lingcod - Nearshore

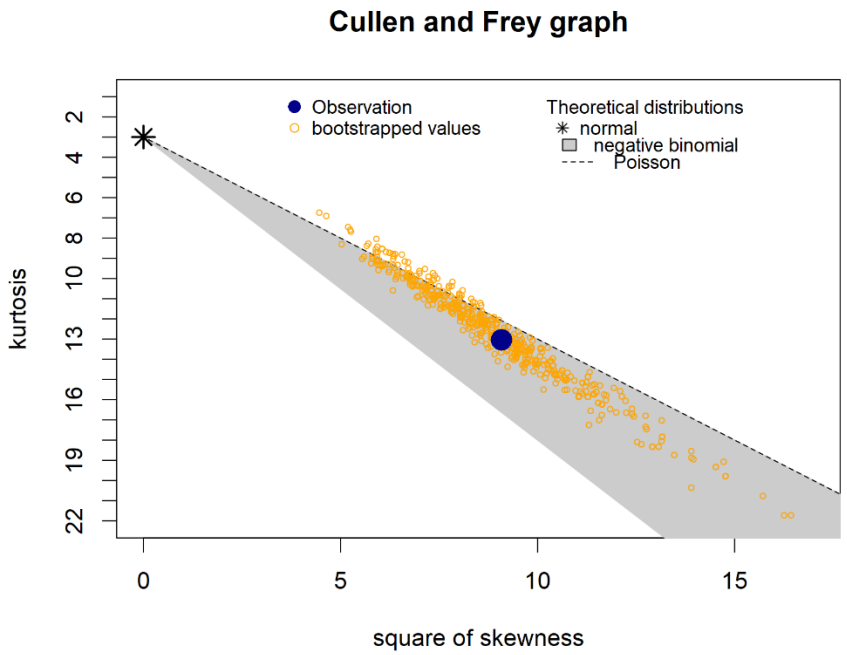


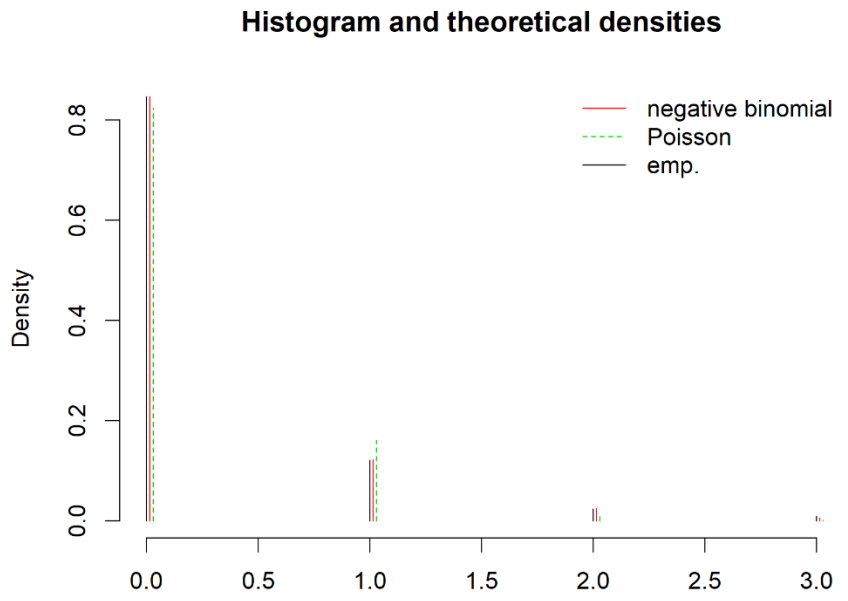


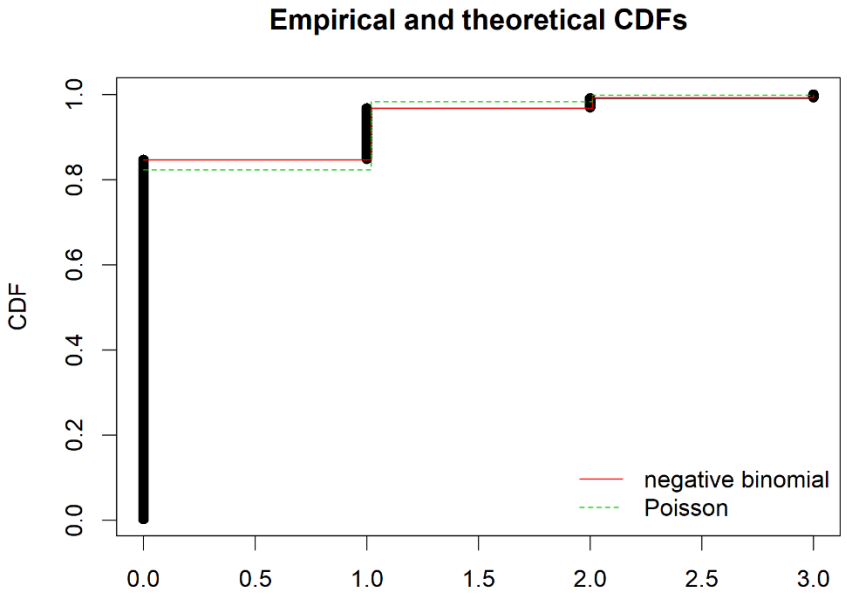


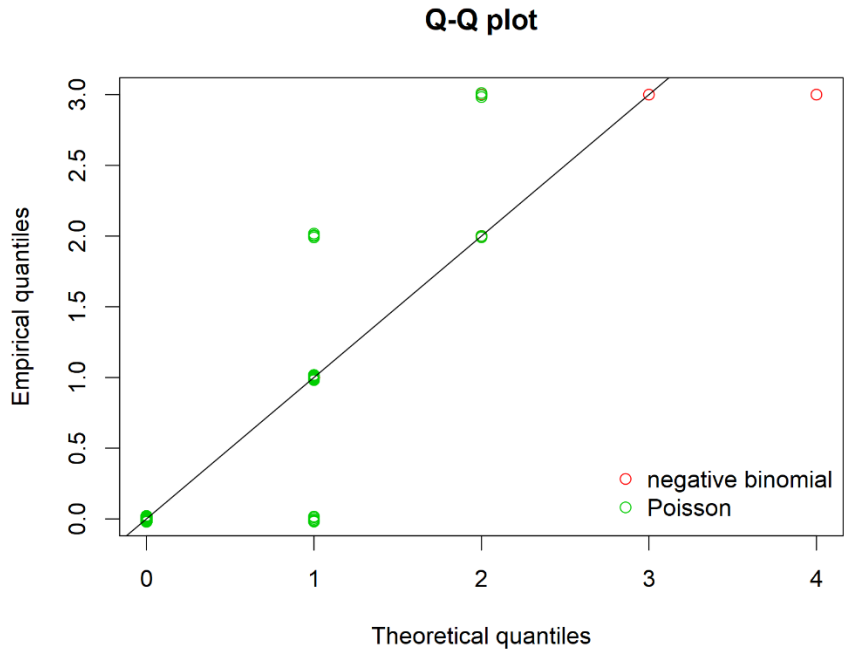


Lingcod - North Coast (FG & RG)

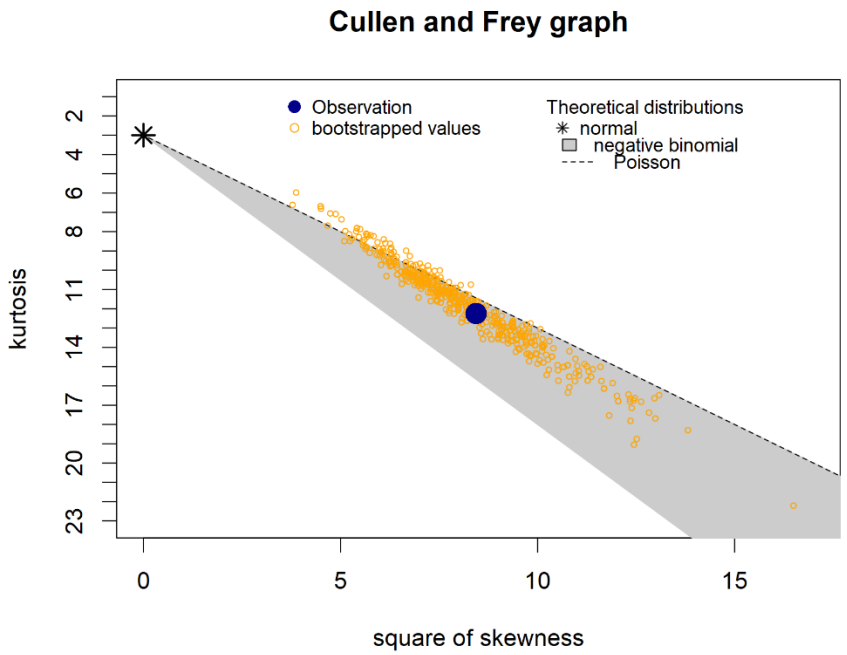


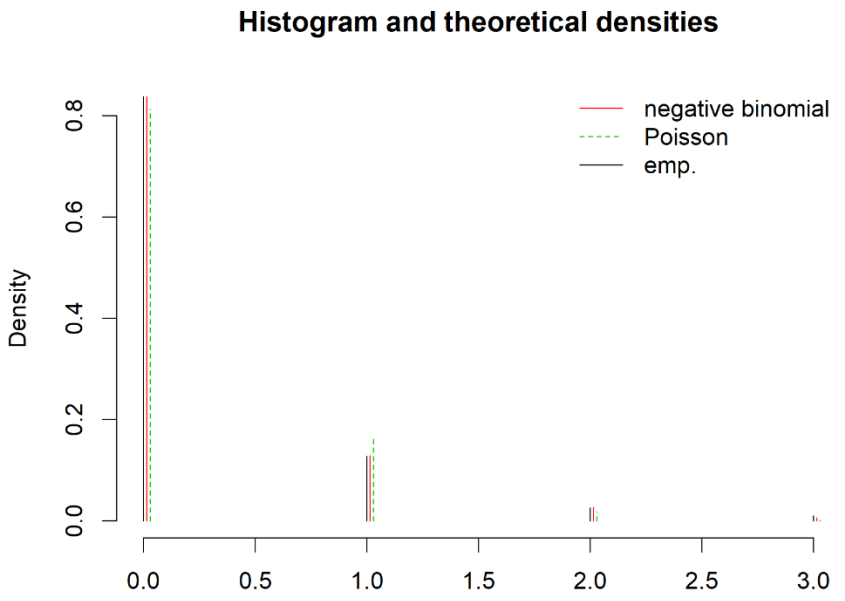


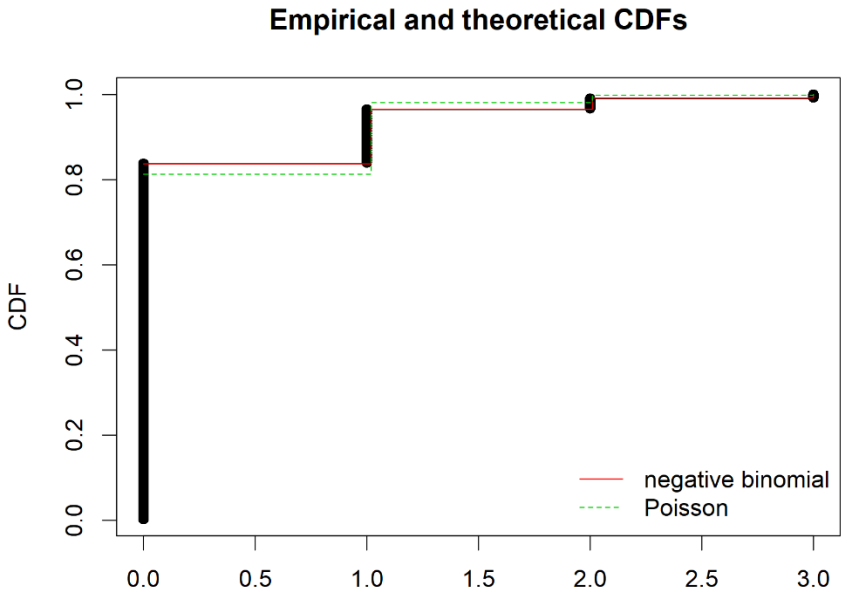


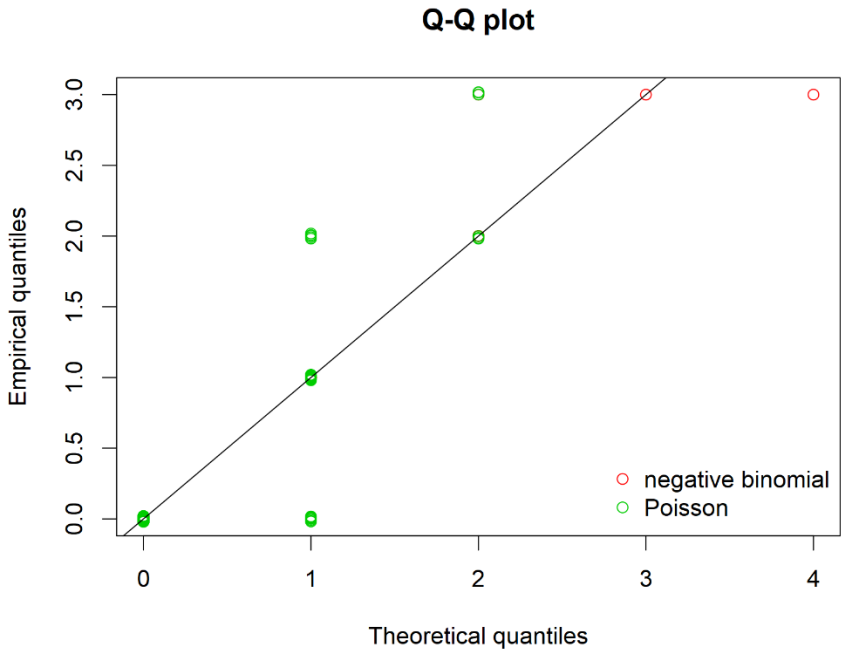


Lingcod - North Coast (FG)

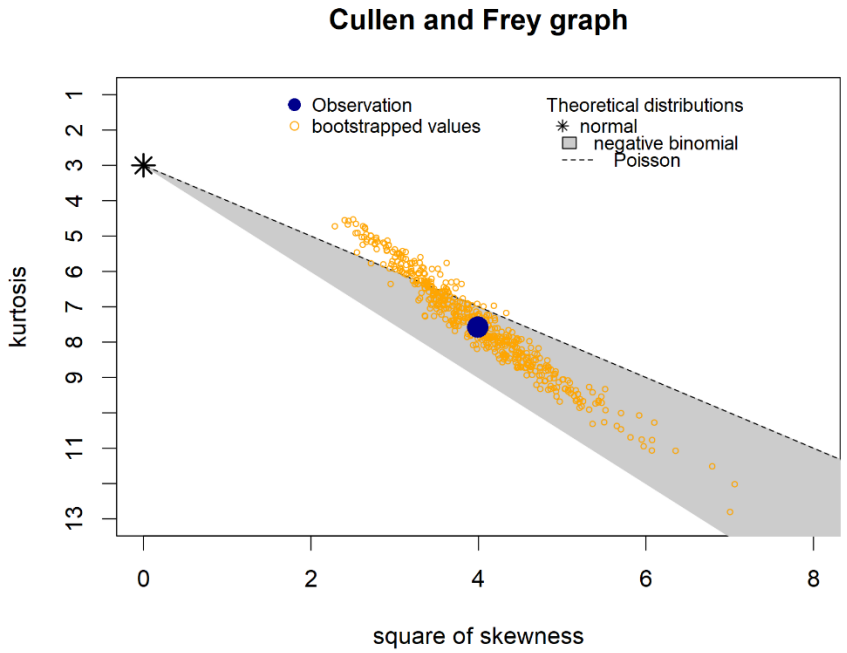


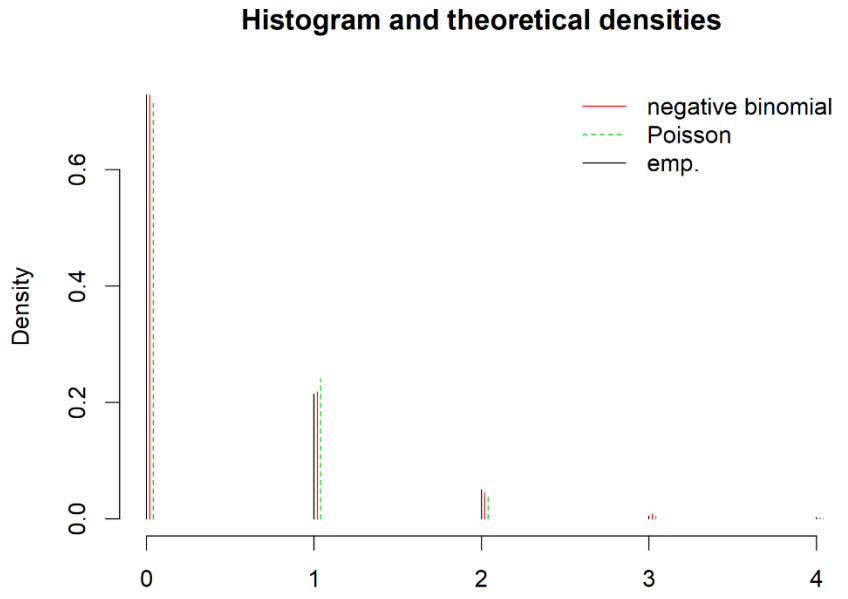


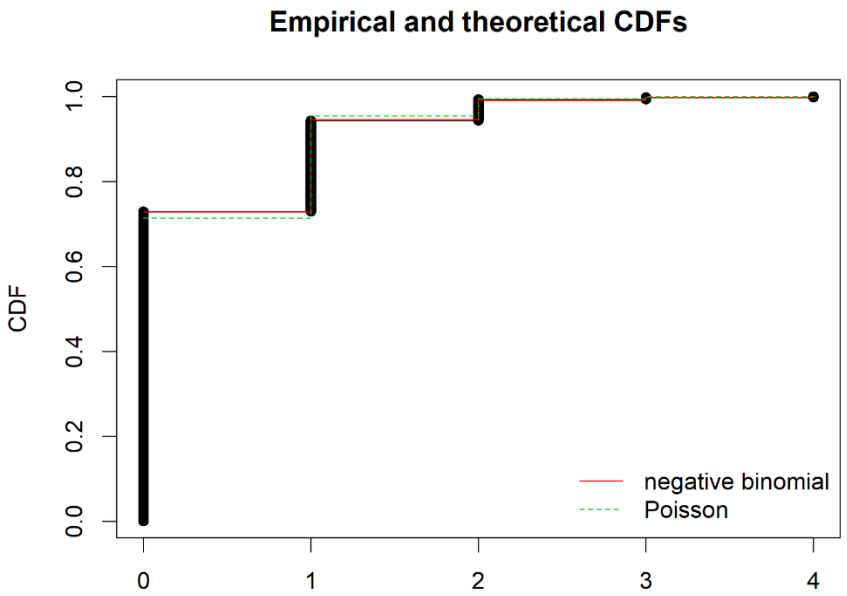


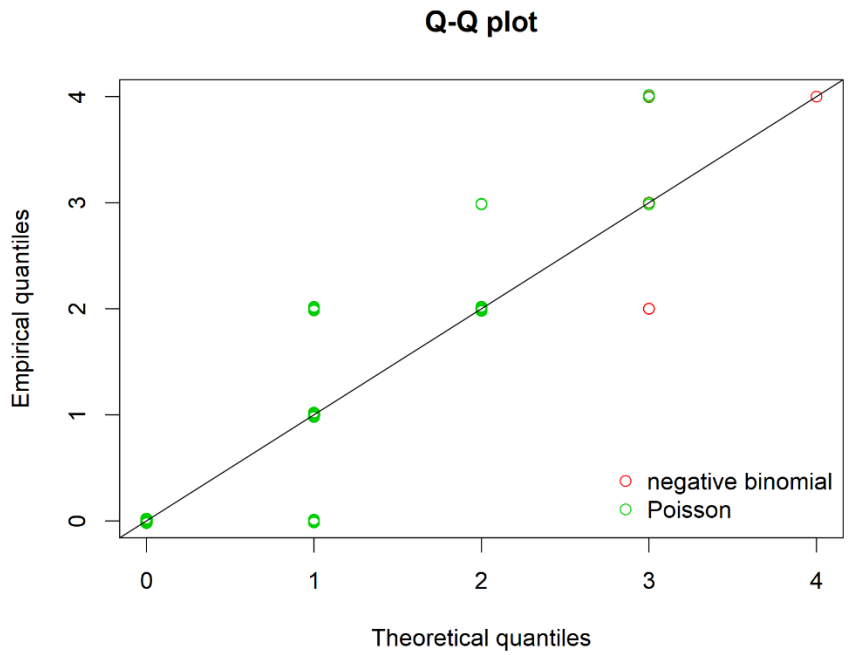


Lingcod - Central Coast (FG, RG, & NG)

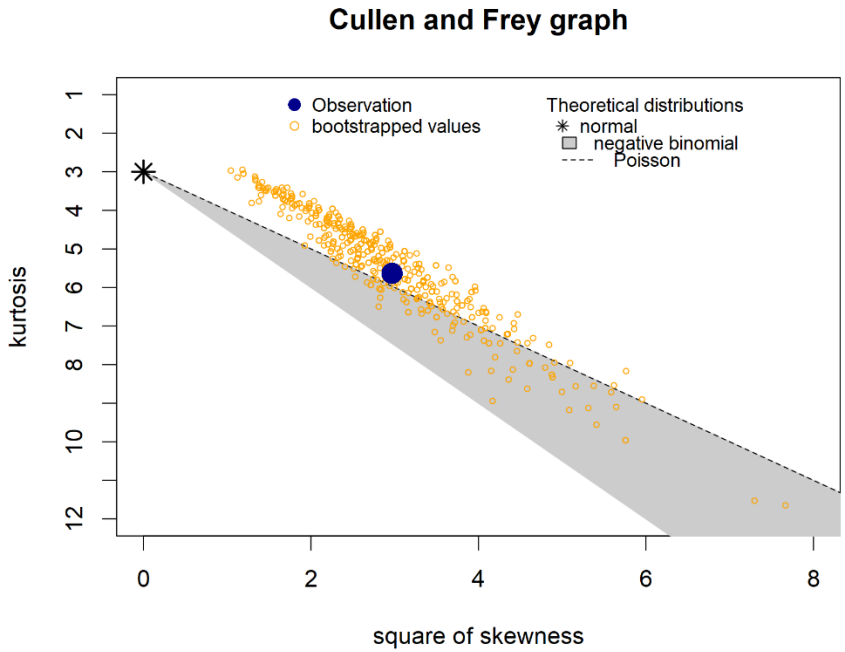


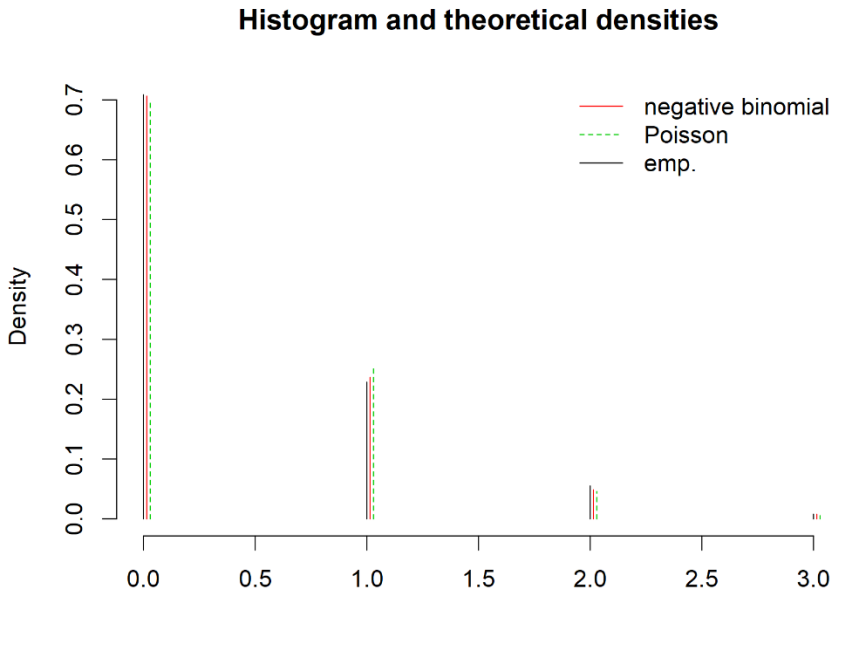


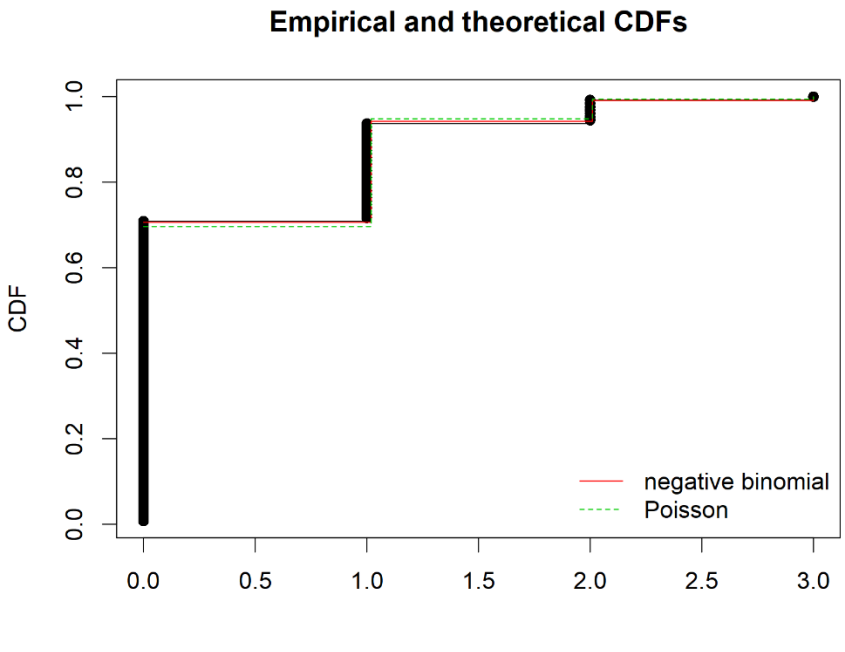


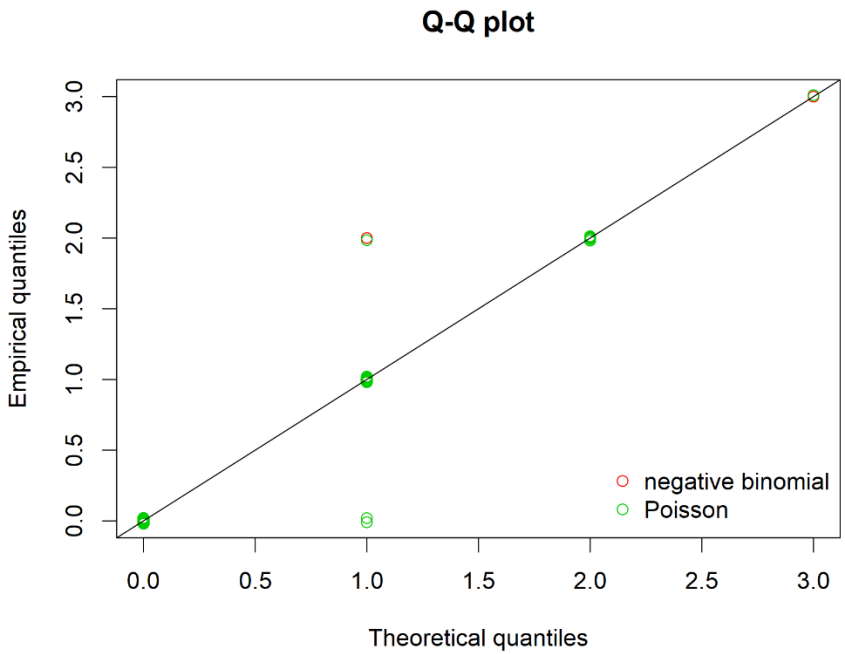


Lingcod - Central Coast (FG)

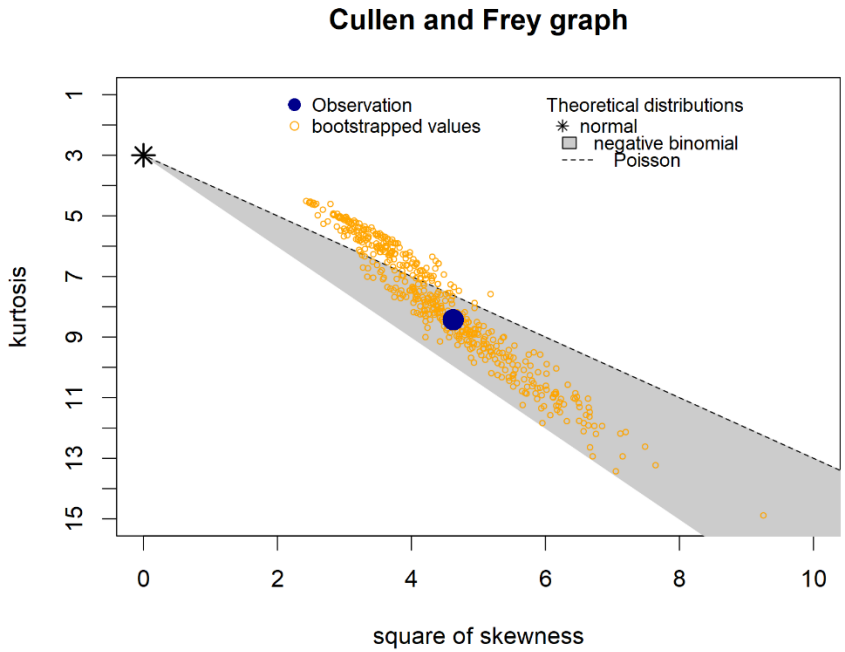


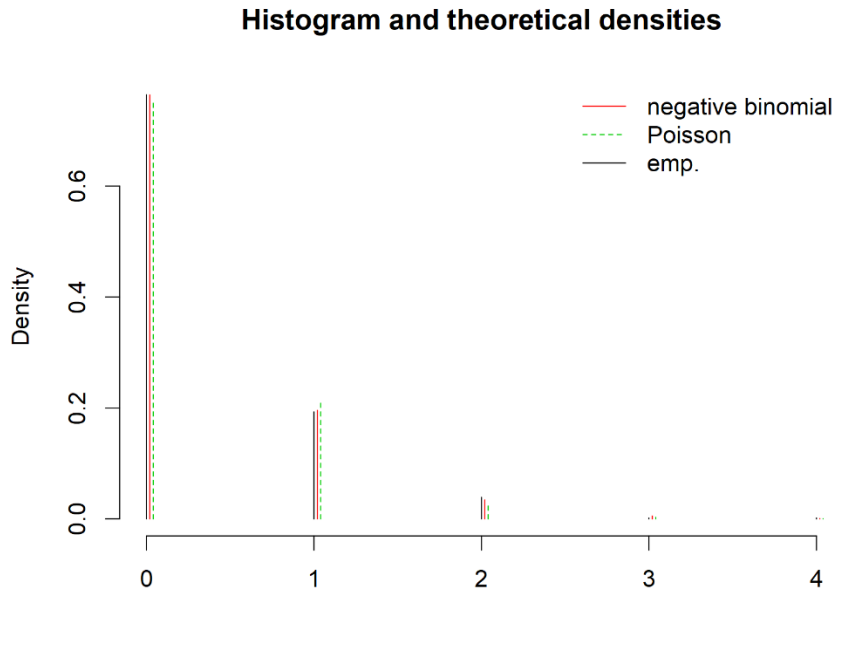


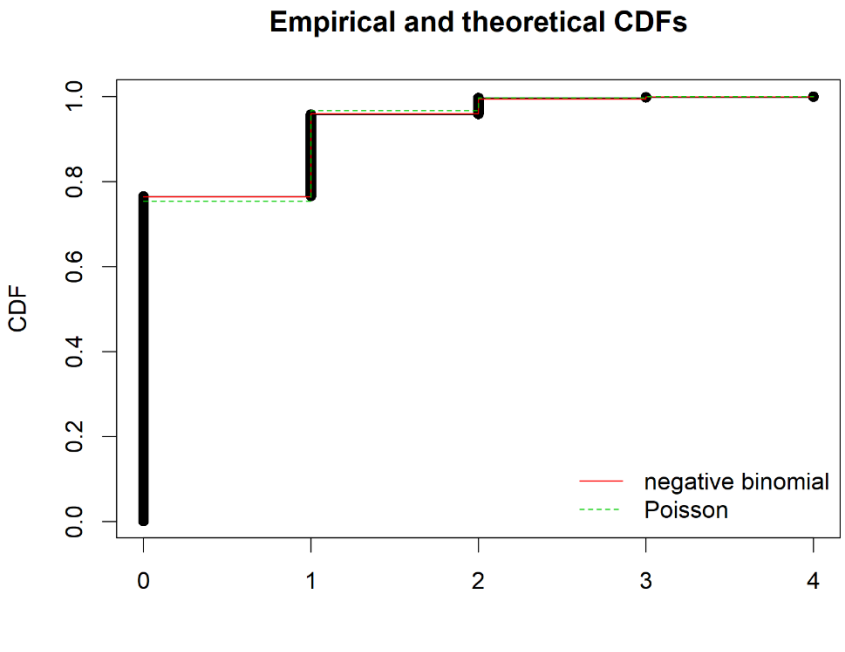


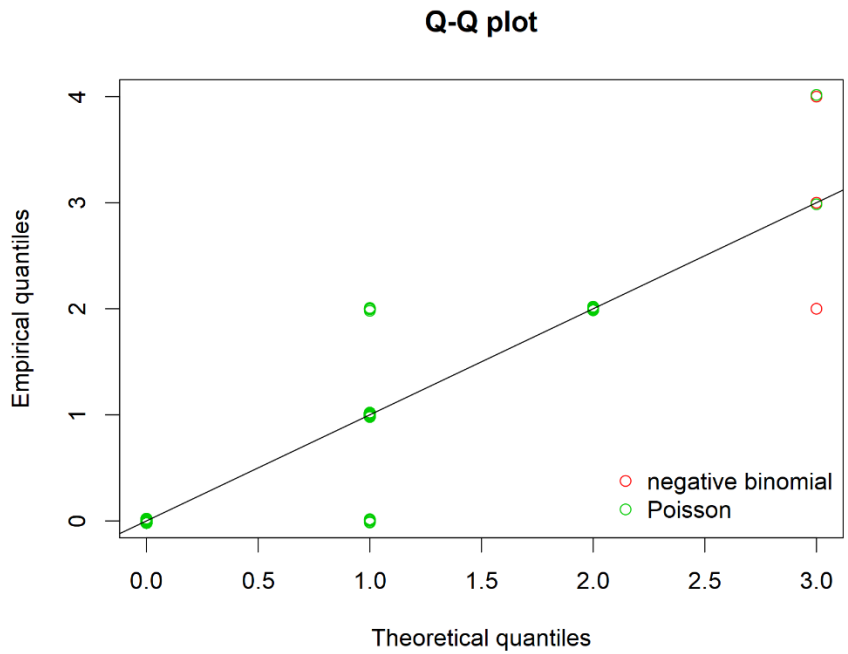


Lingcod - Central Coast (RG)

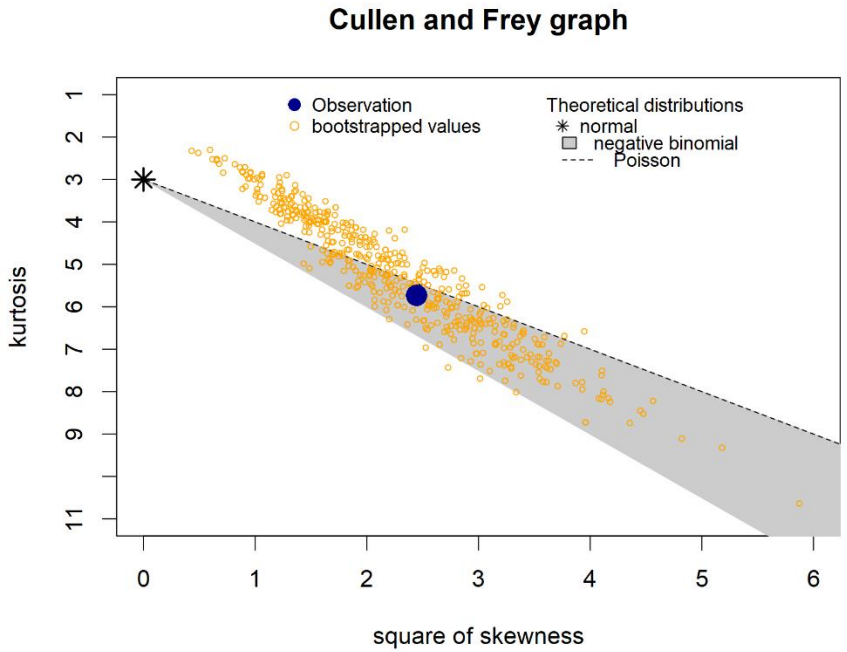


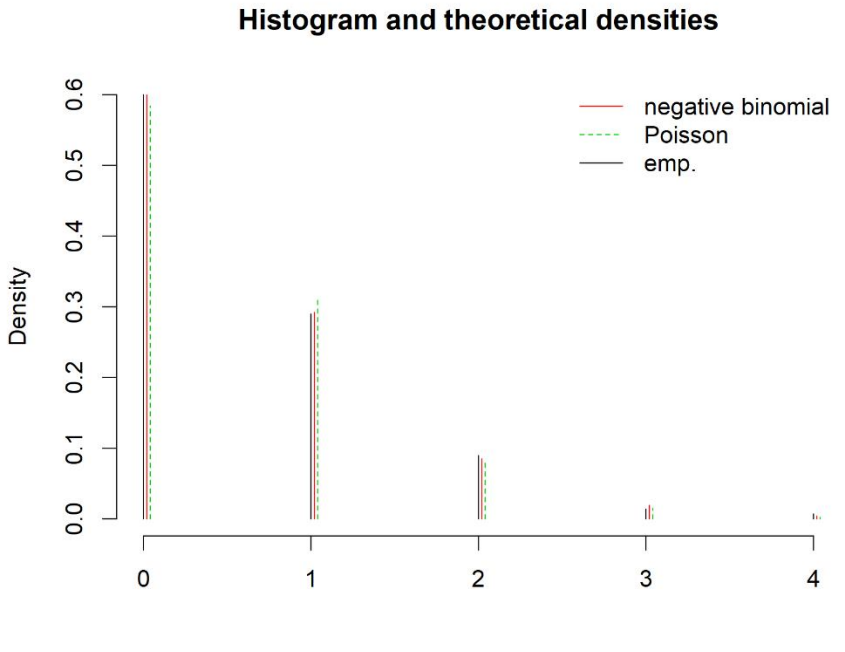


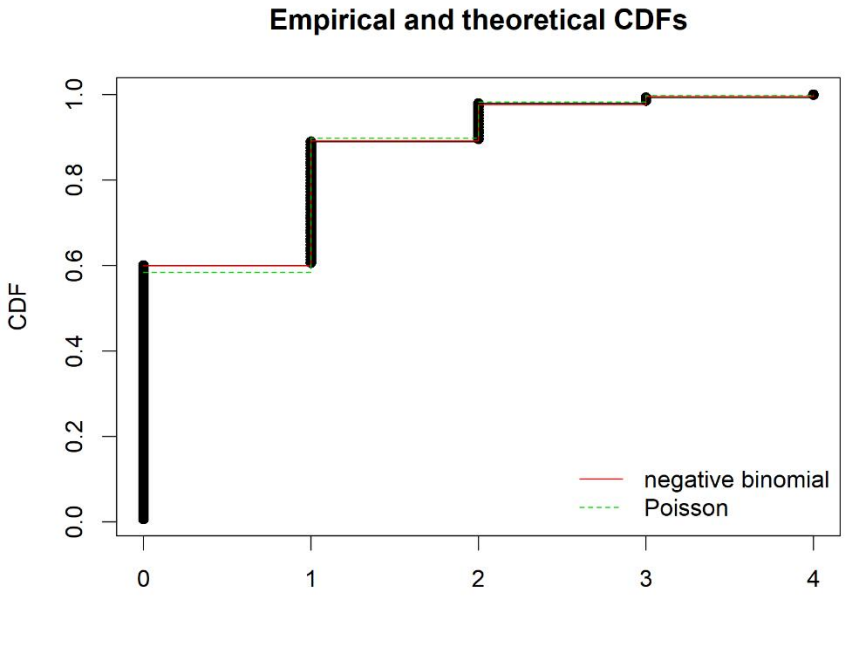


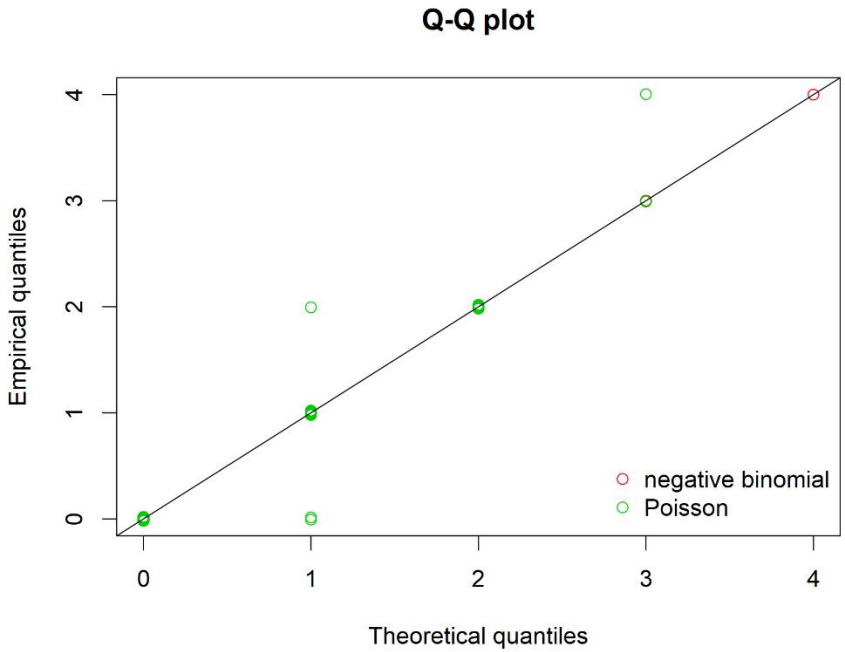


Lingcod - Central Coast (NG)

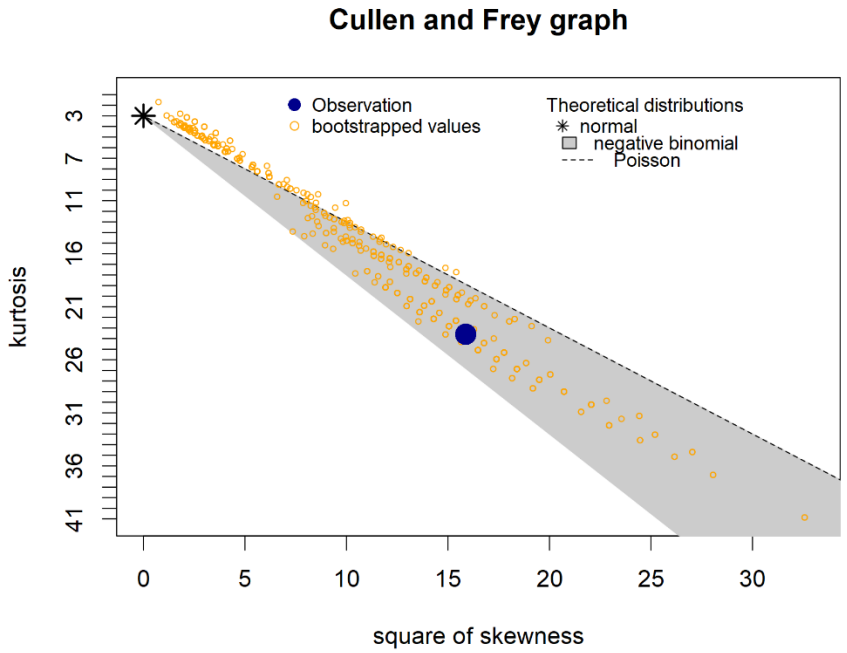


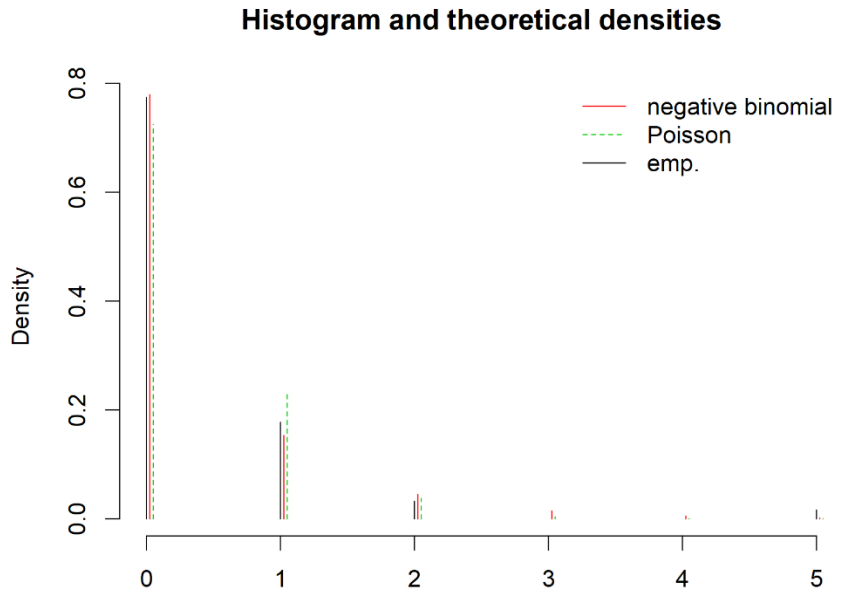


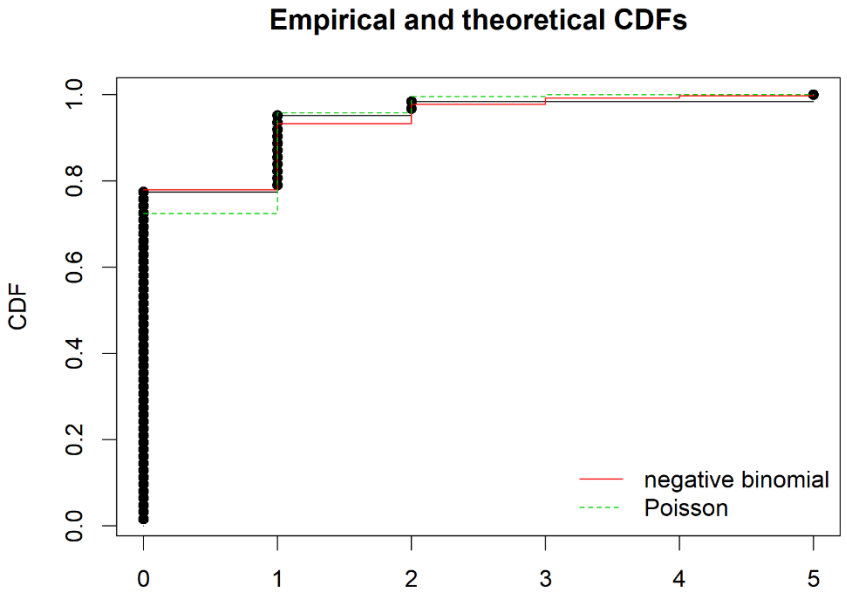


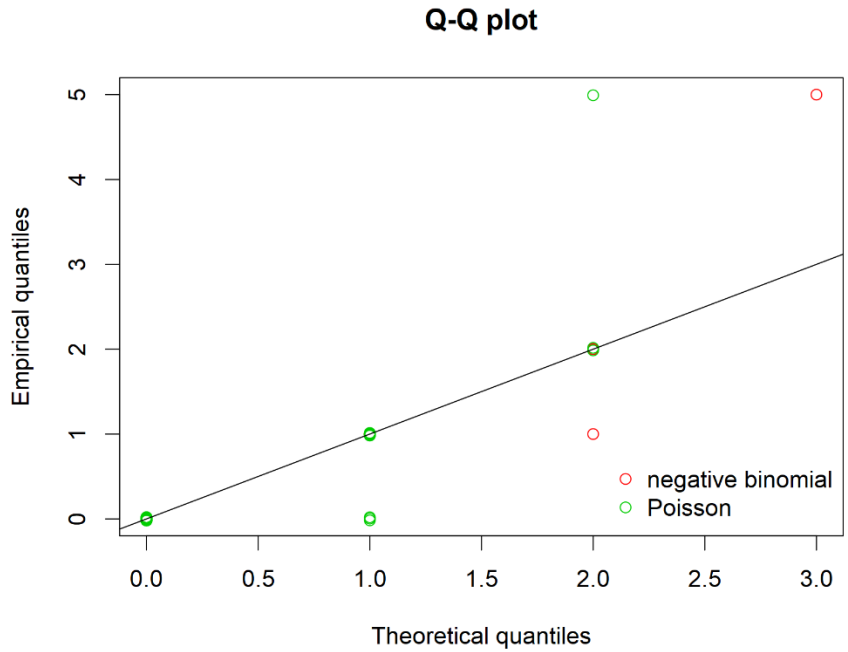


Lingcod - Cape Perpetua (FG & RG)

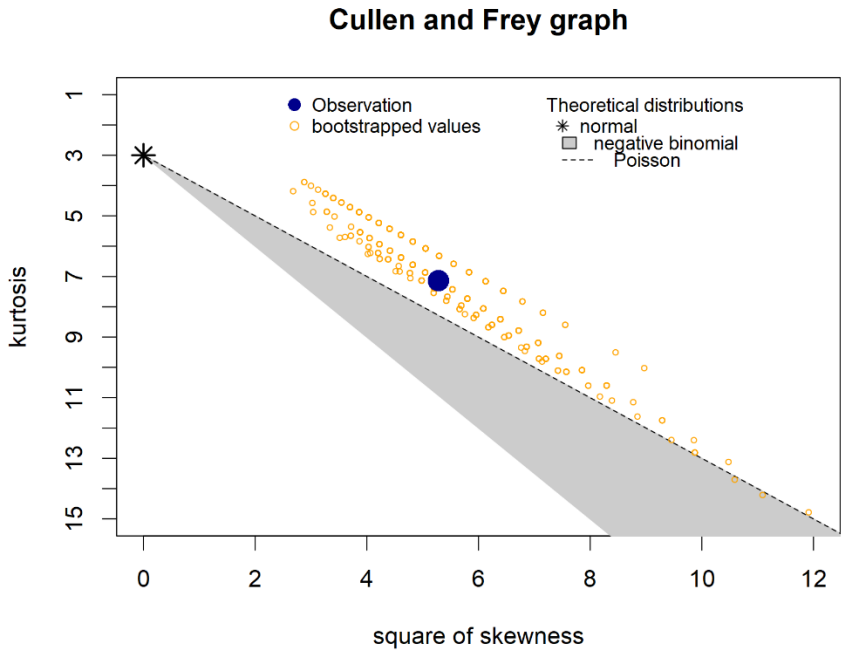


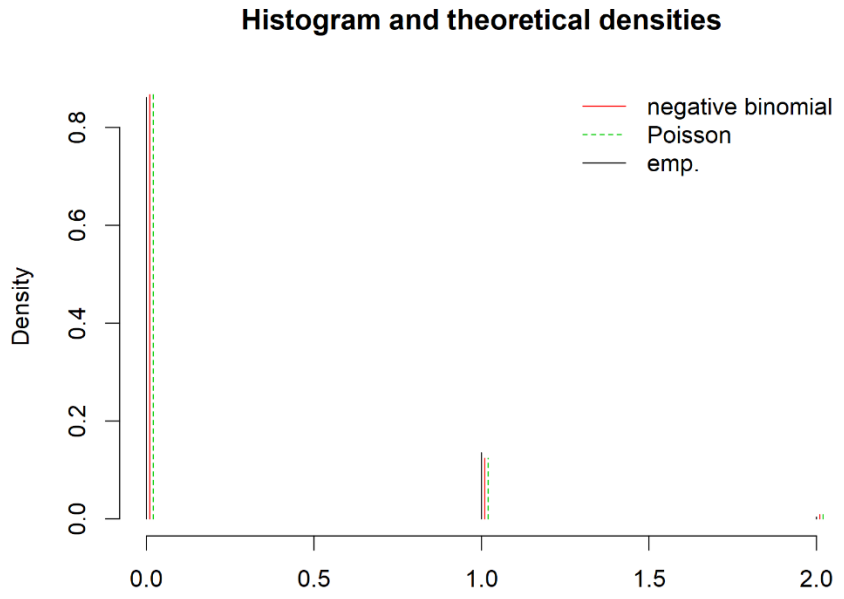


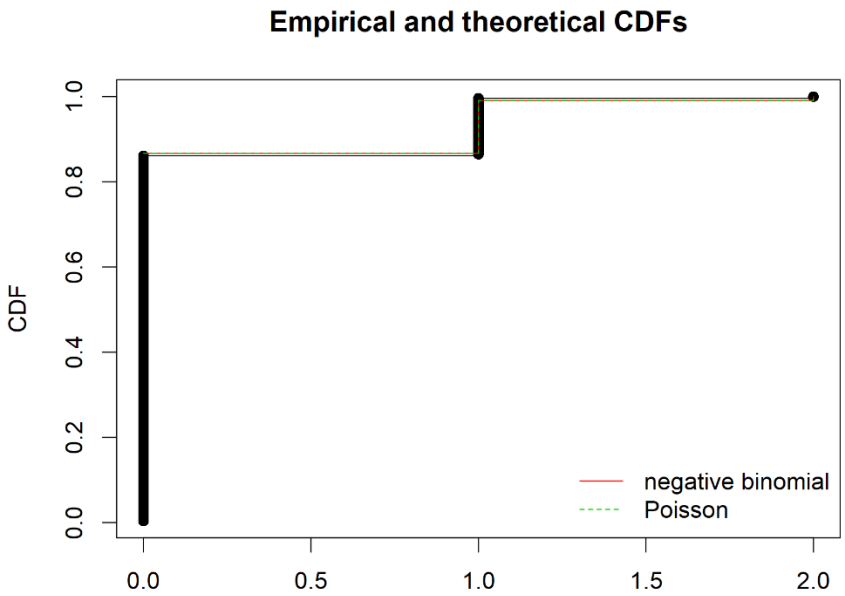


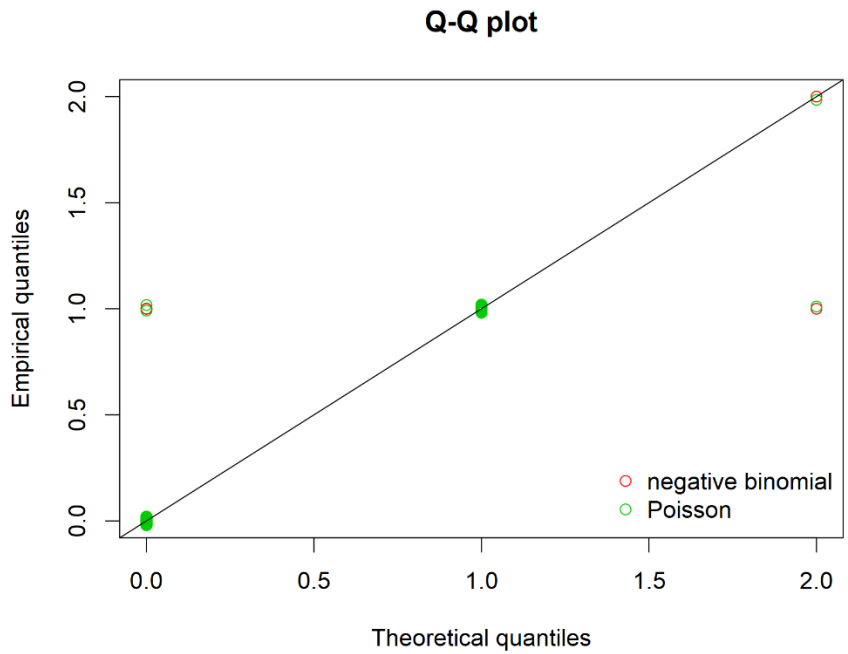


Lingcod - South Coast (RG)

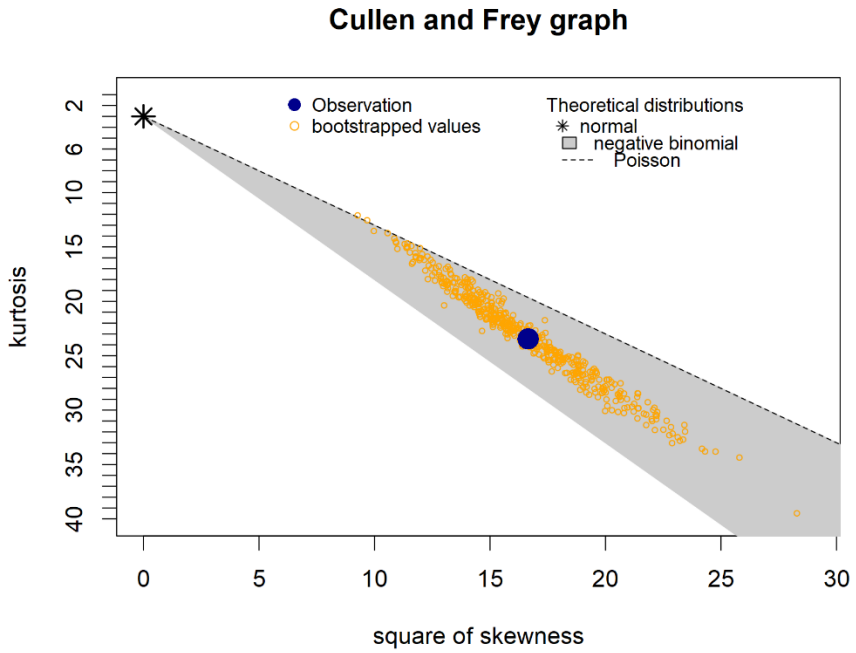


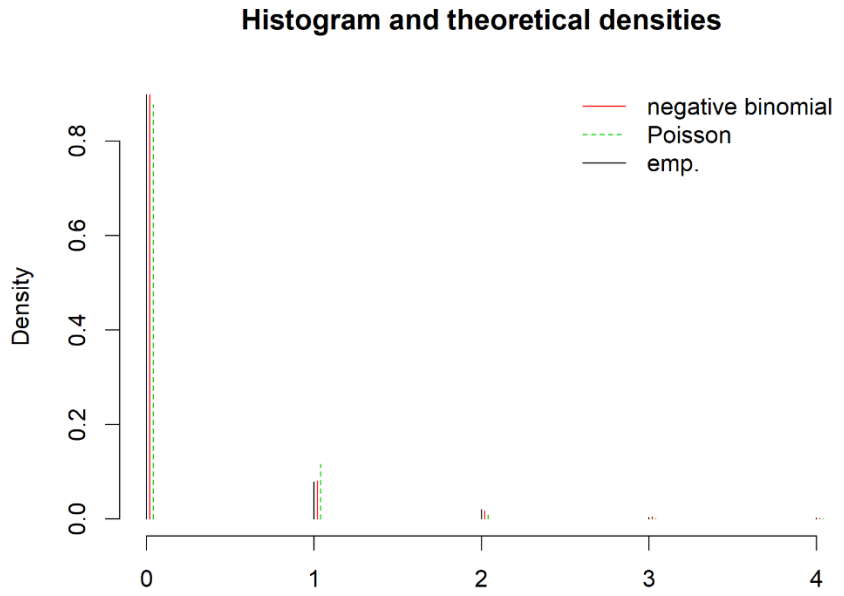


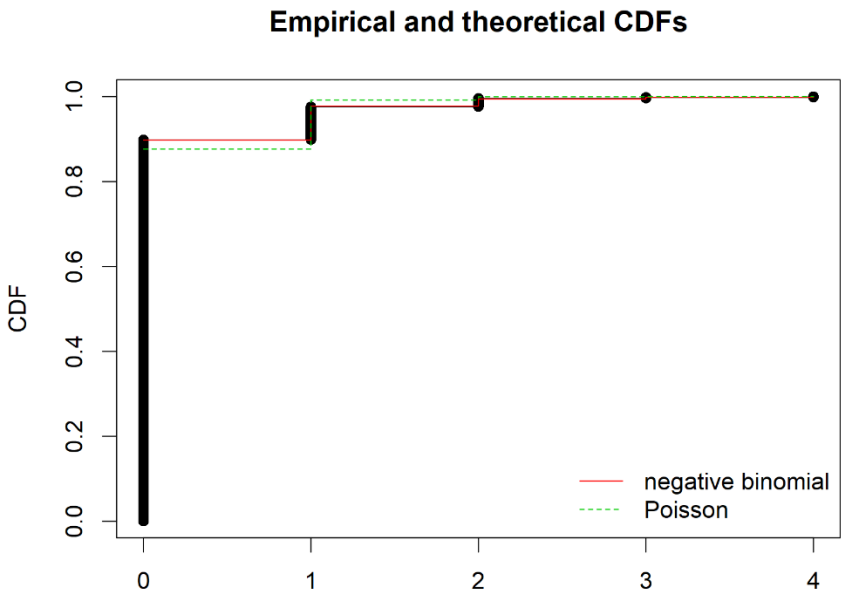


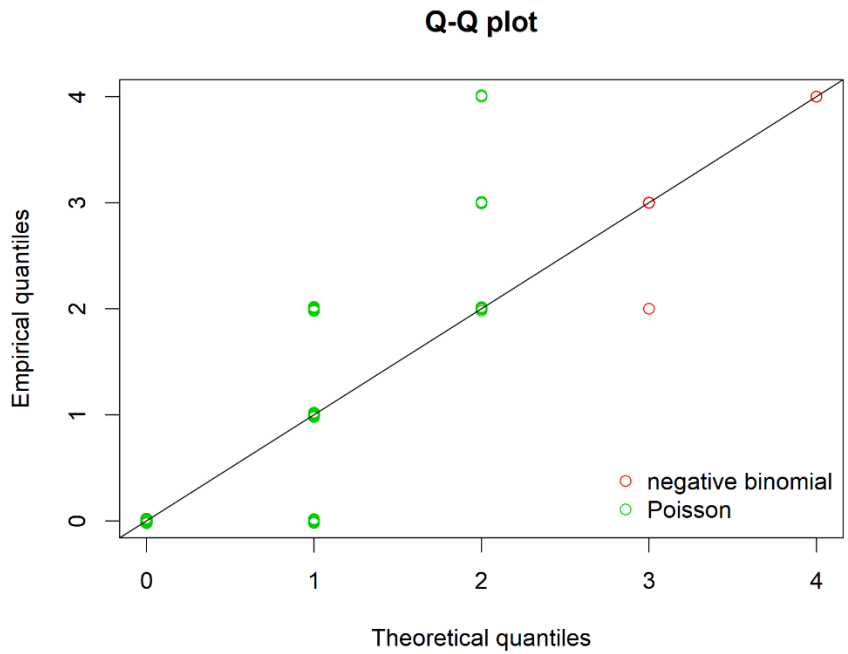


Lingcod - Offshore (FG)

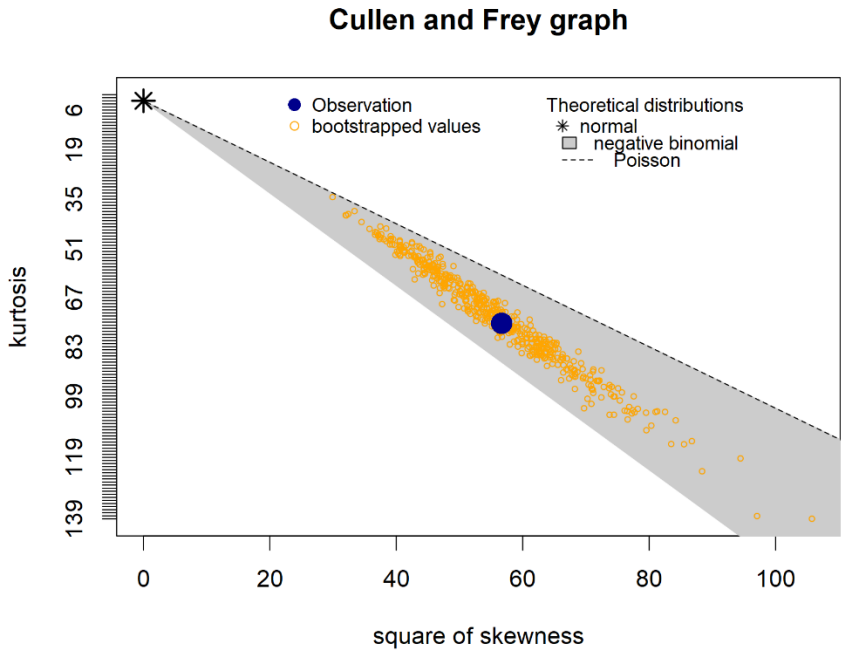


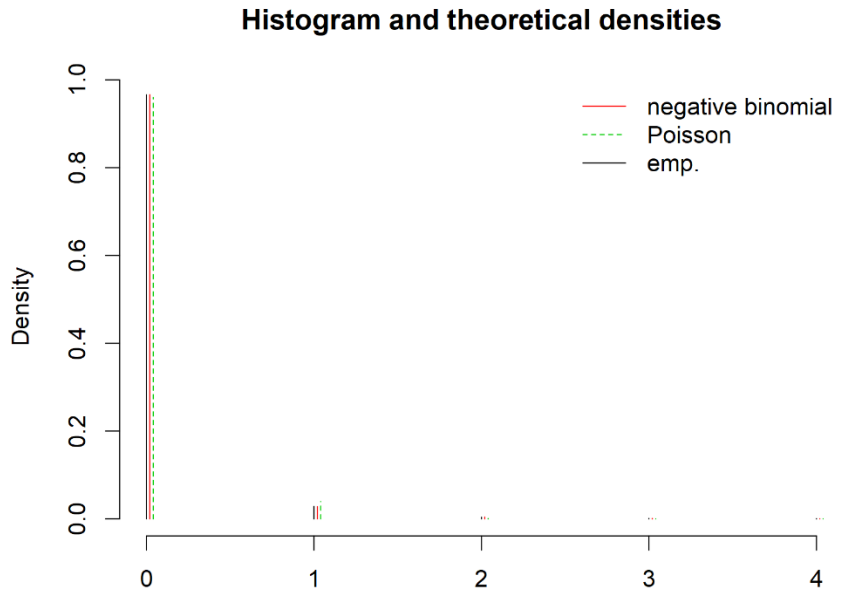


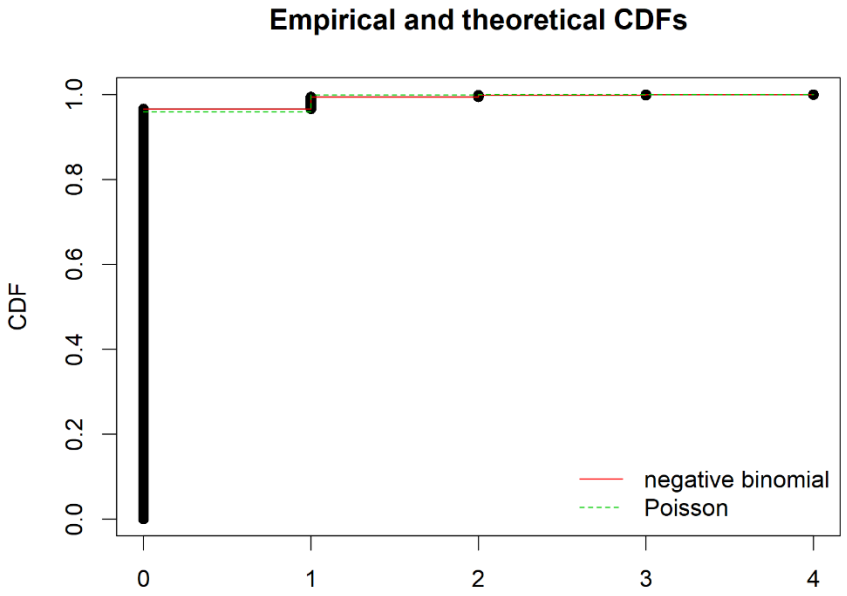


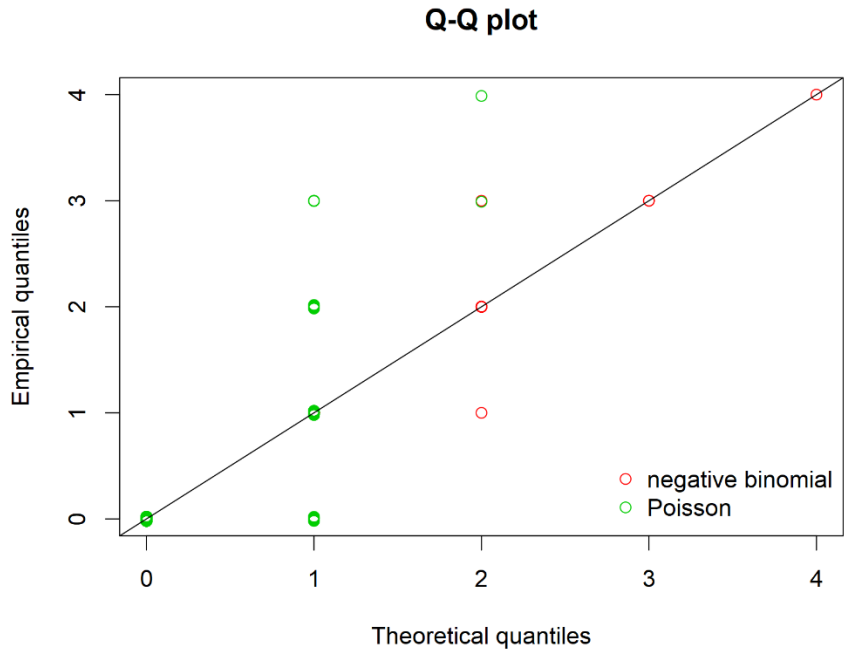


Quillback Rockfish - Entire Coast

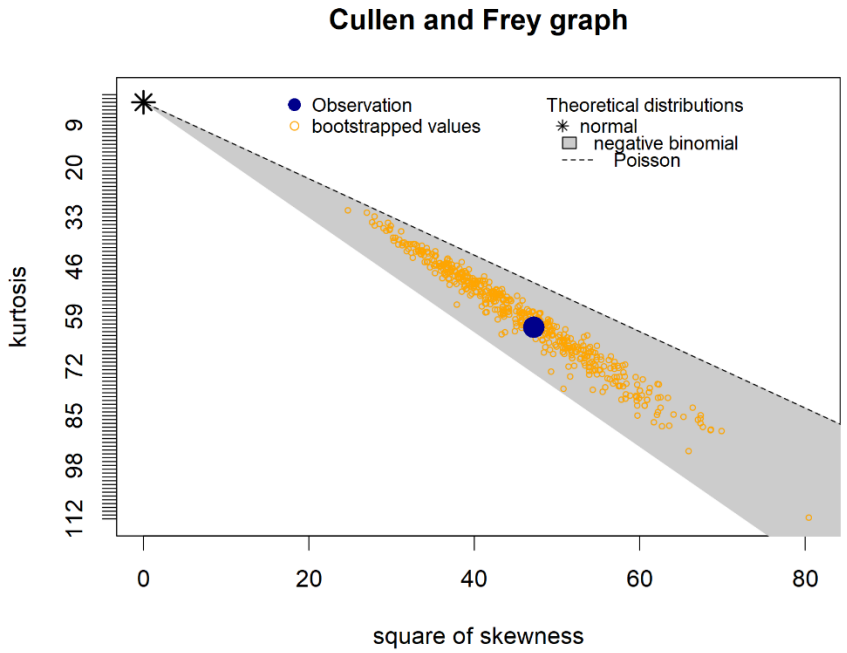


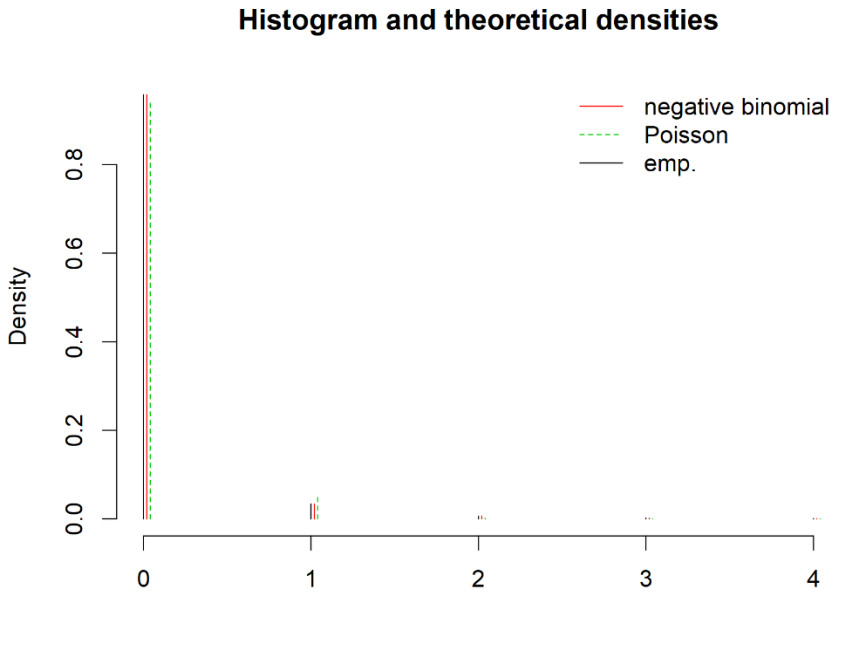


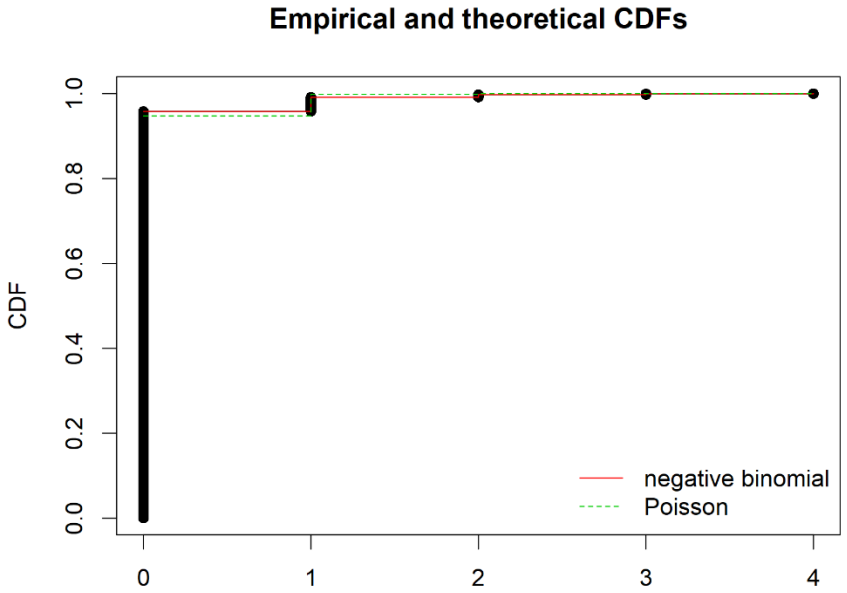


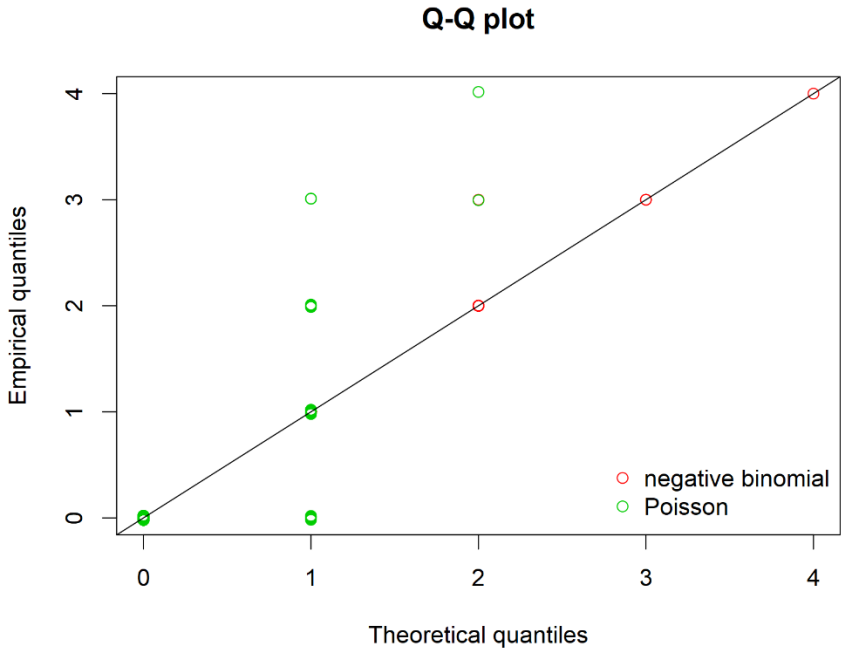


Quillback Rockfish - Nearshore

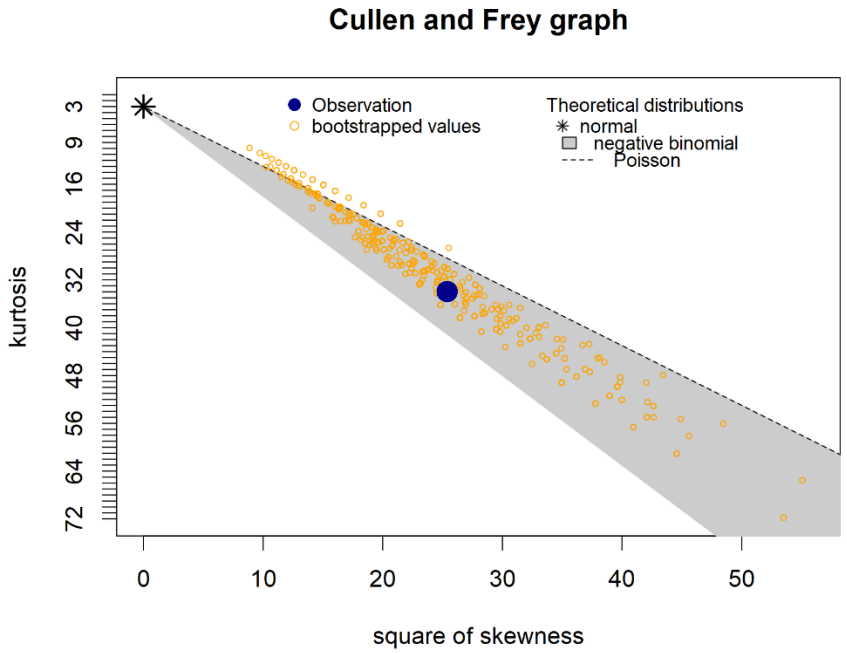


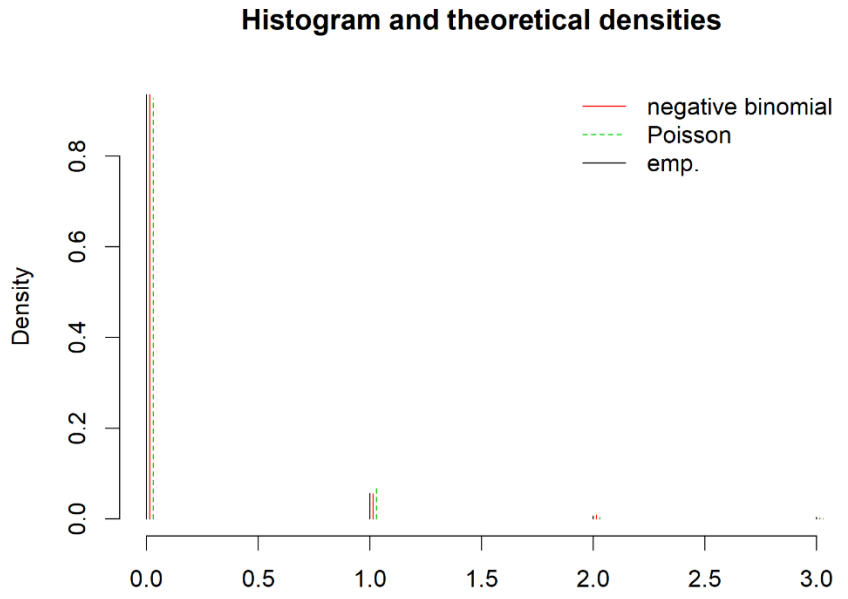


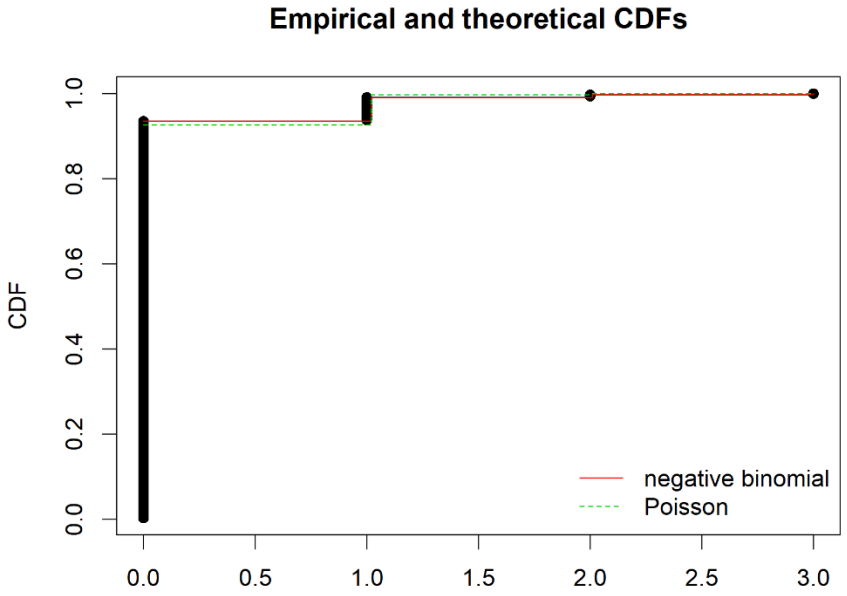


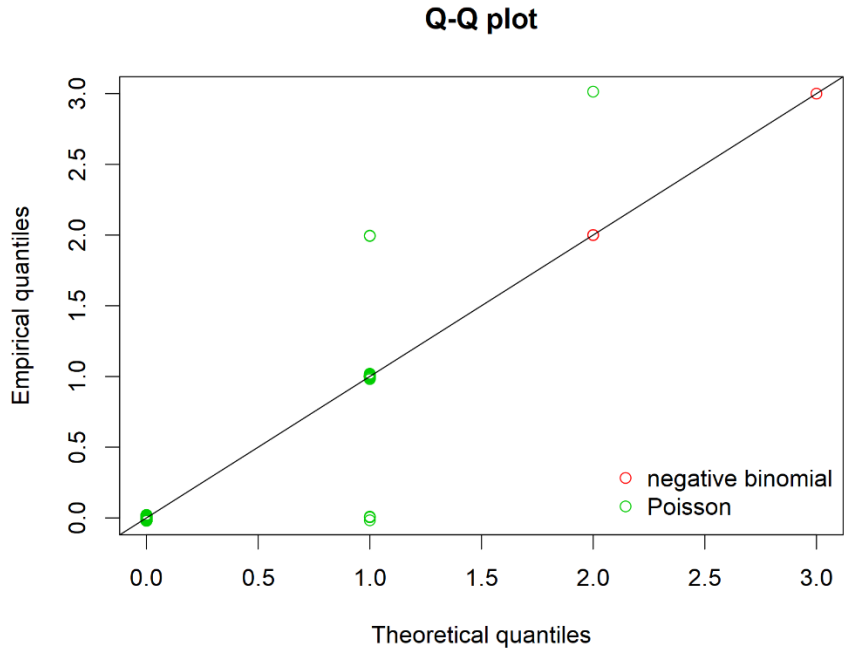


Quillback Rockfish - North Coast (FG & RG)

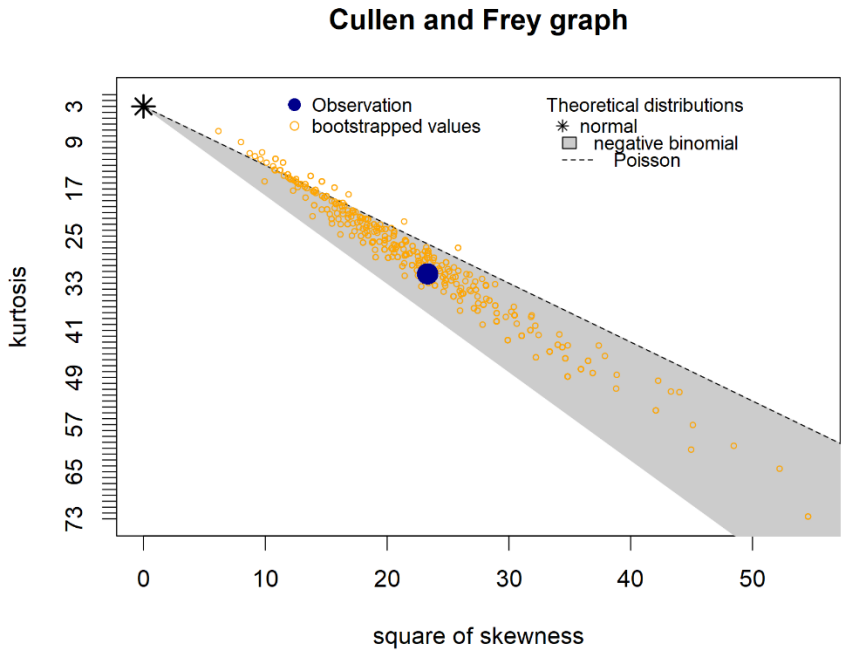


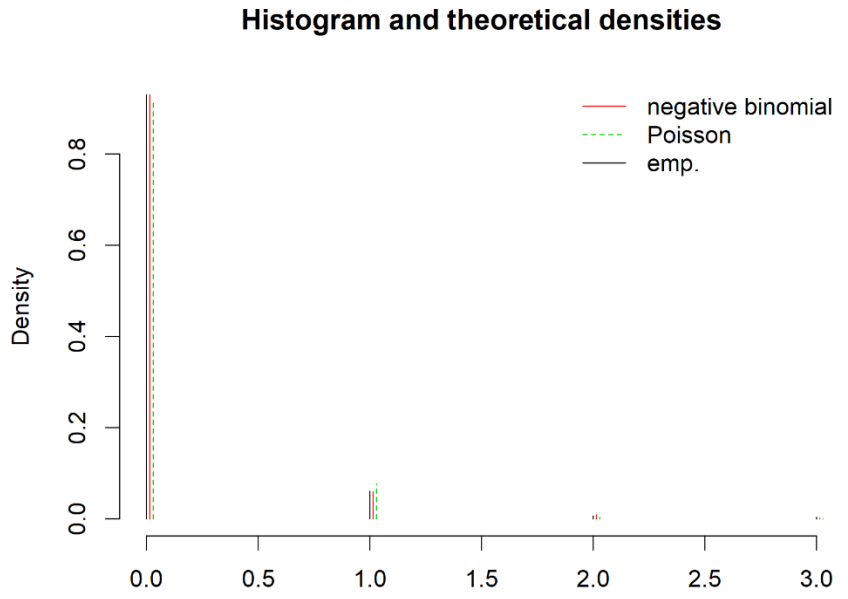


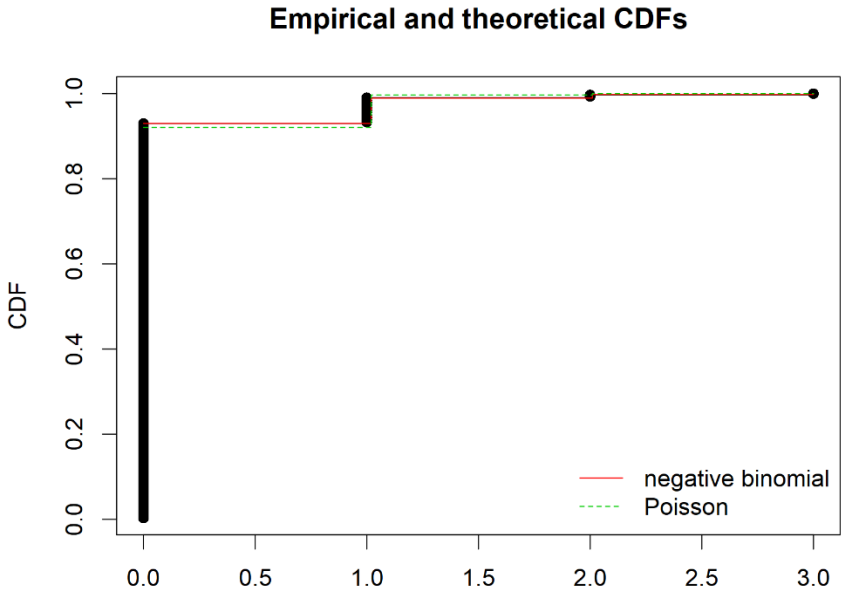


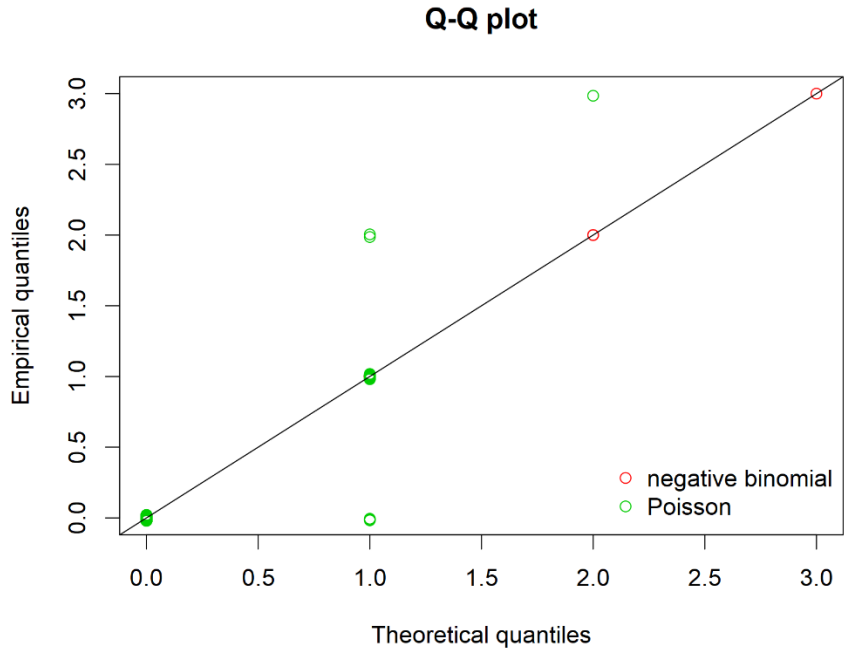


Quillback Rockfish - North Coast (FG)

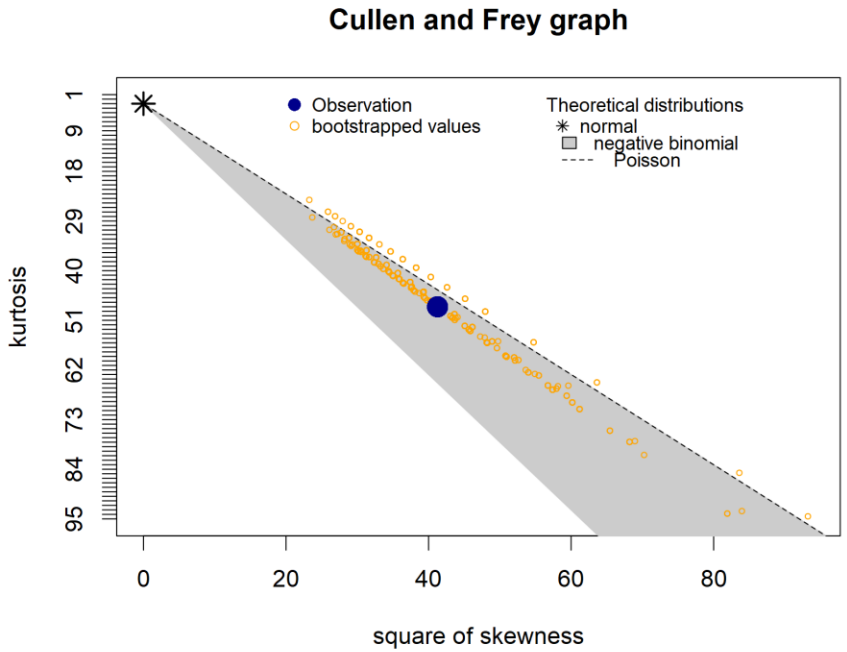


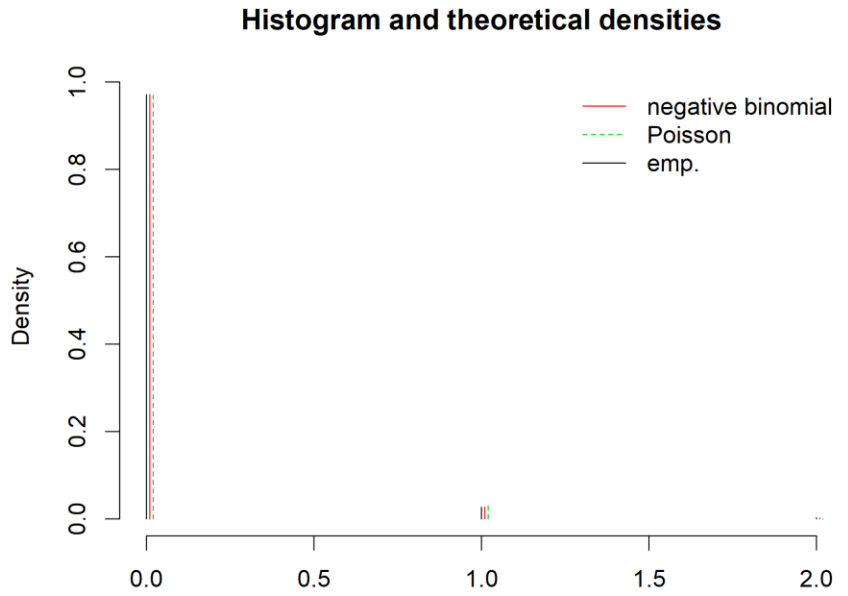


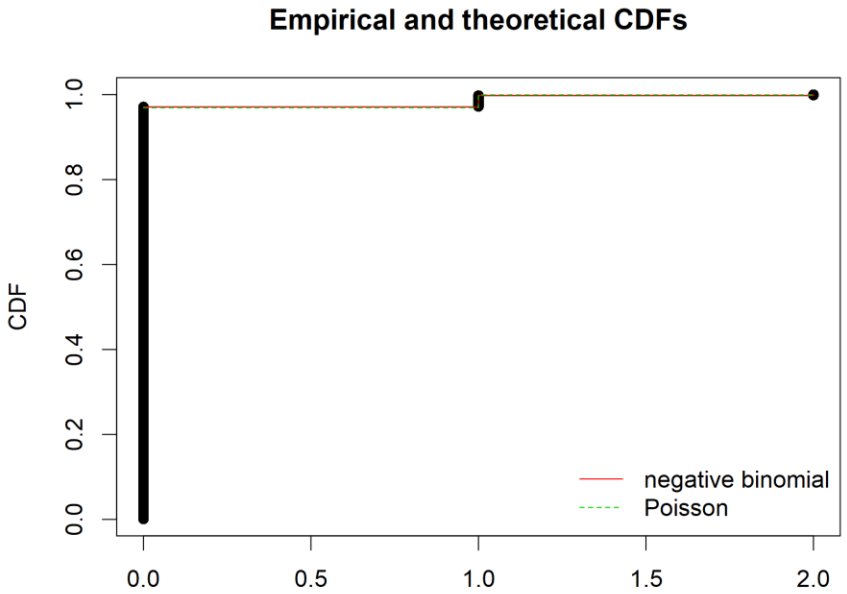


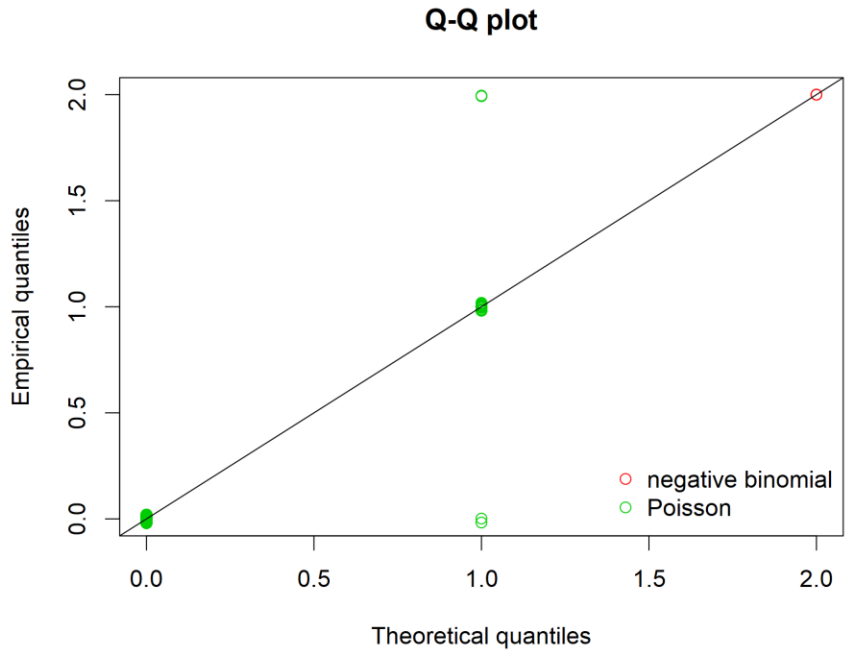


Quillback Rockfish - Central Coast (FG, RG, & NG)

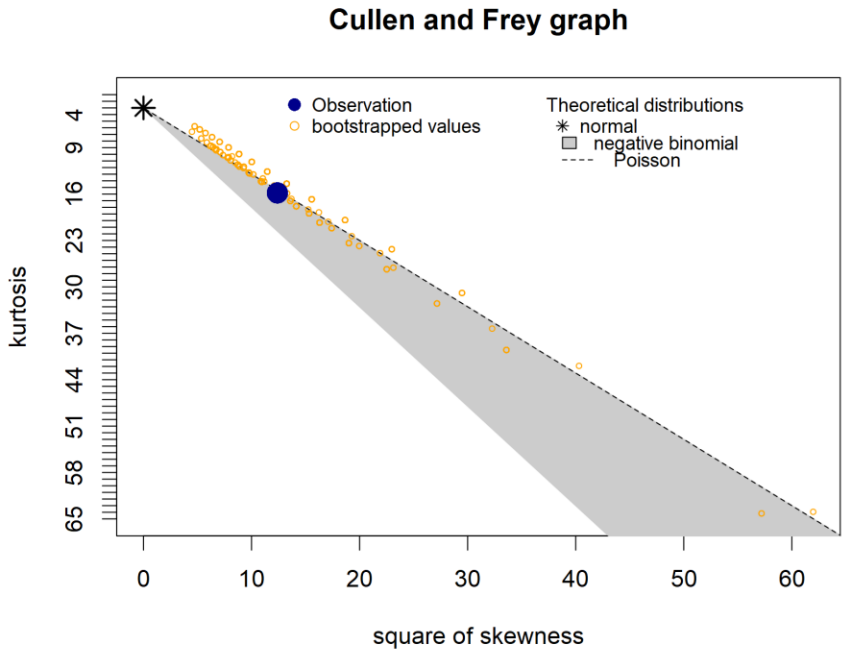


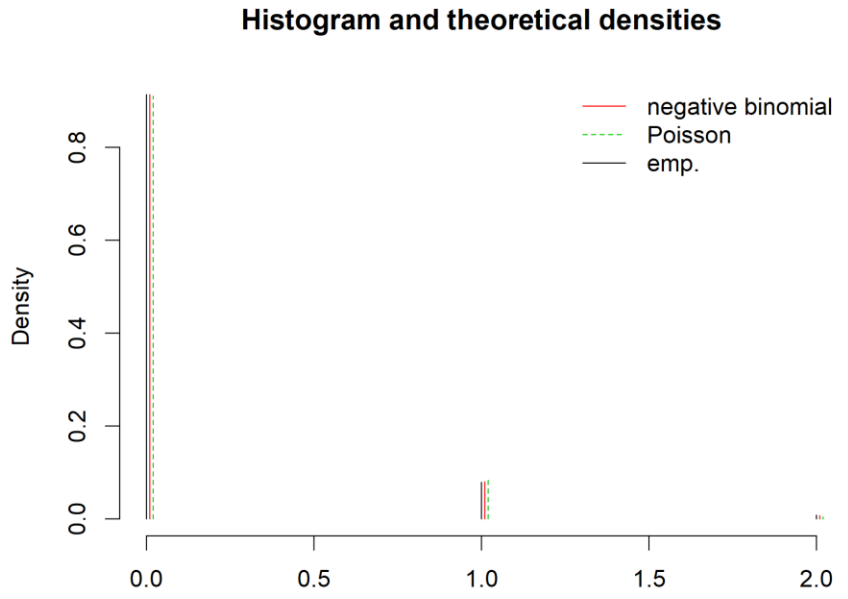


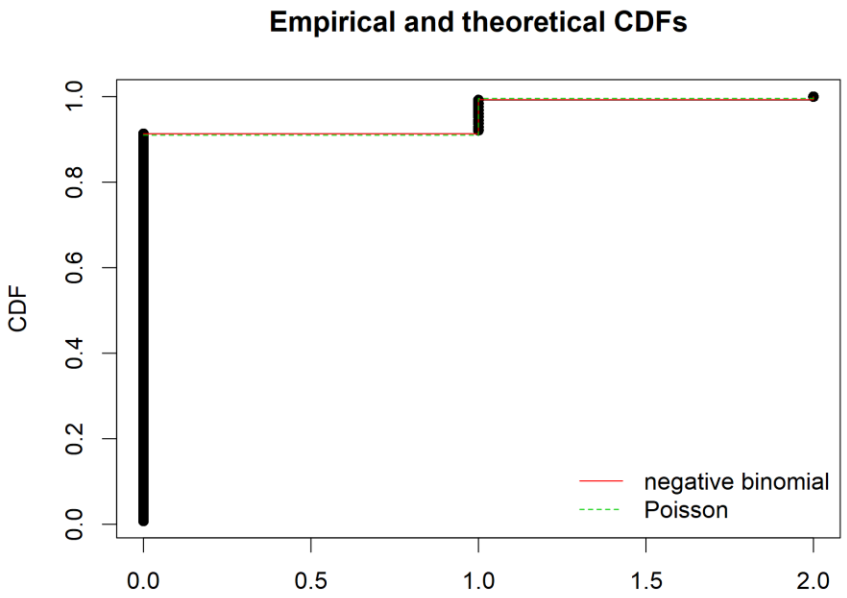


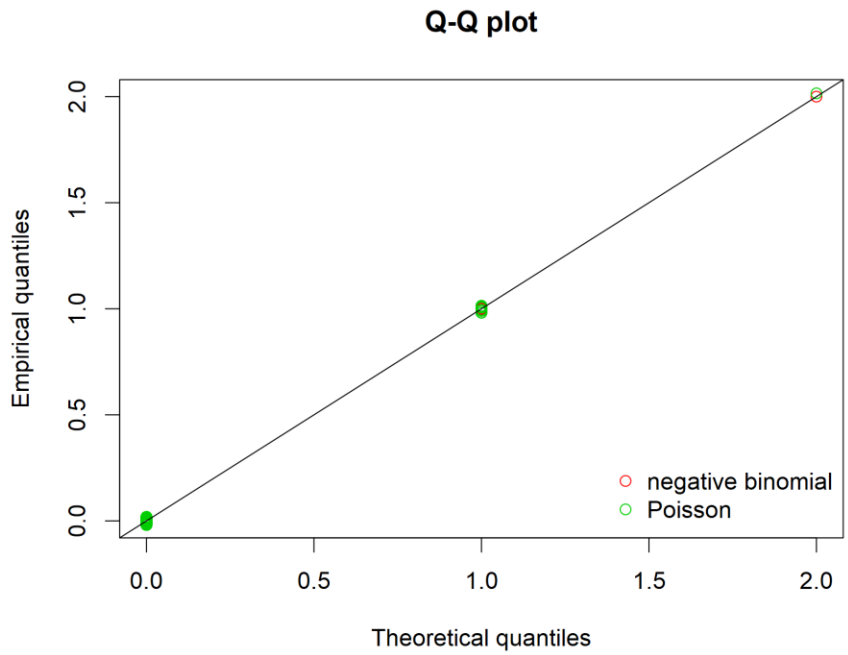


Quillback Rockfish - Central Coast (FG)

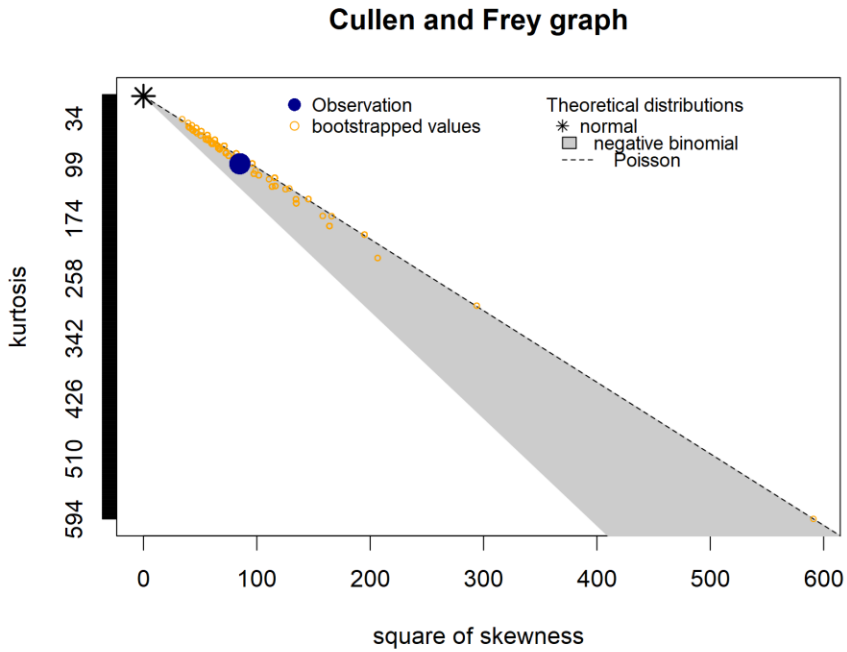


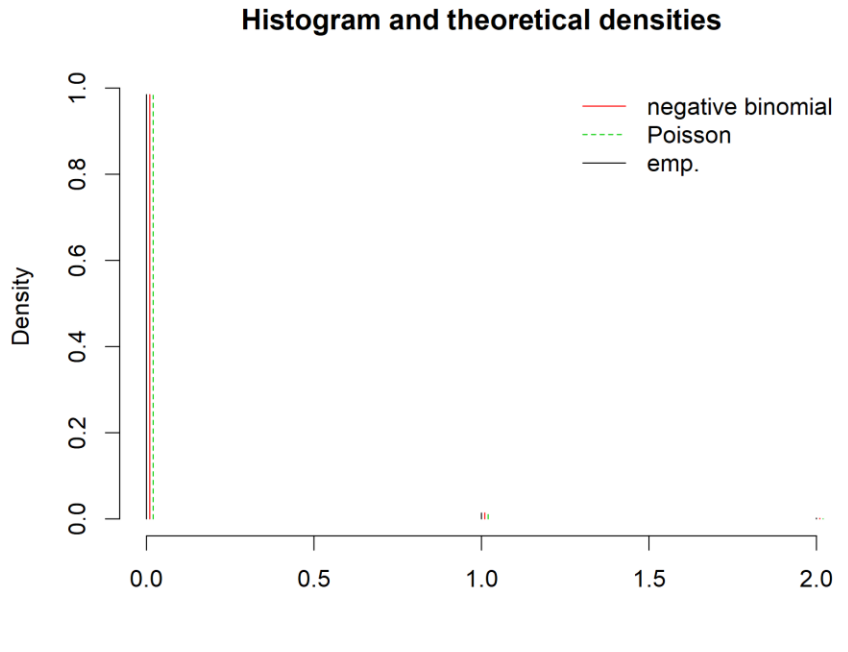


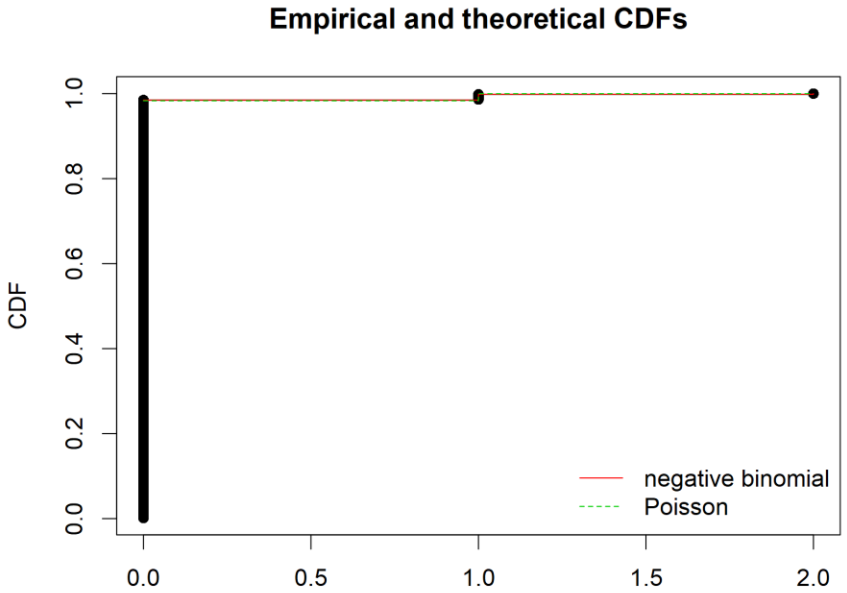


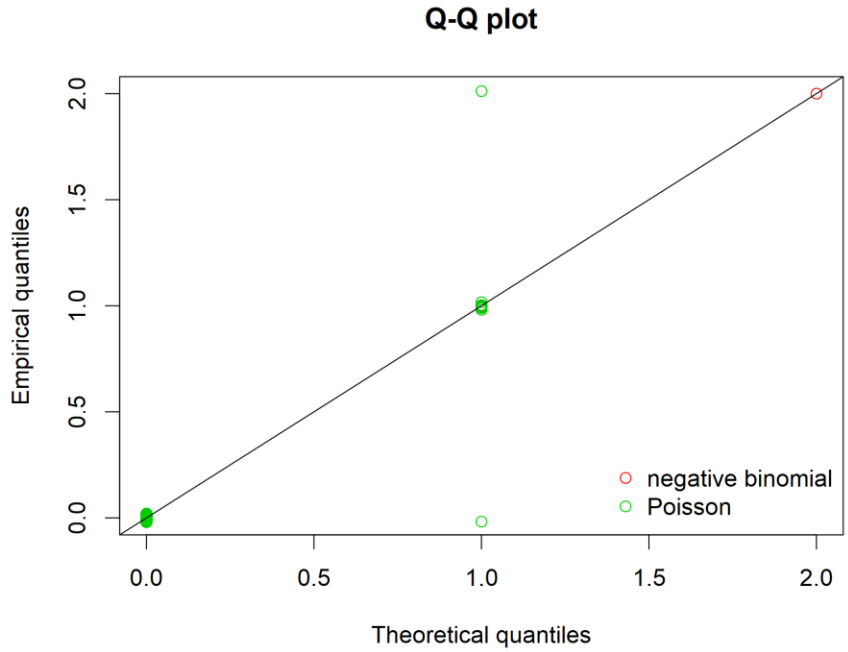


Quillback Rockfish - Central Coast (RG)

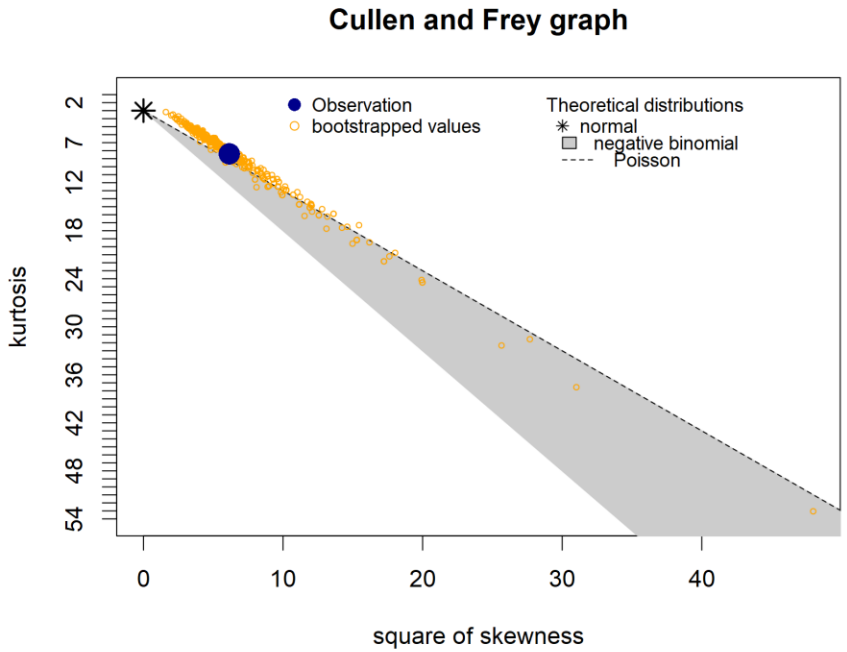


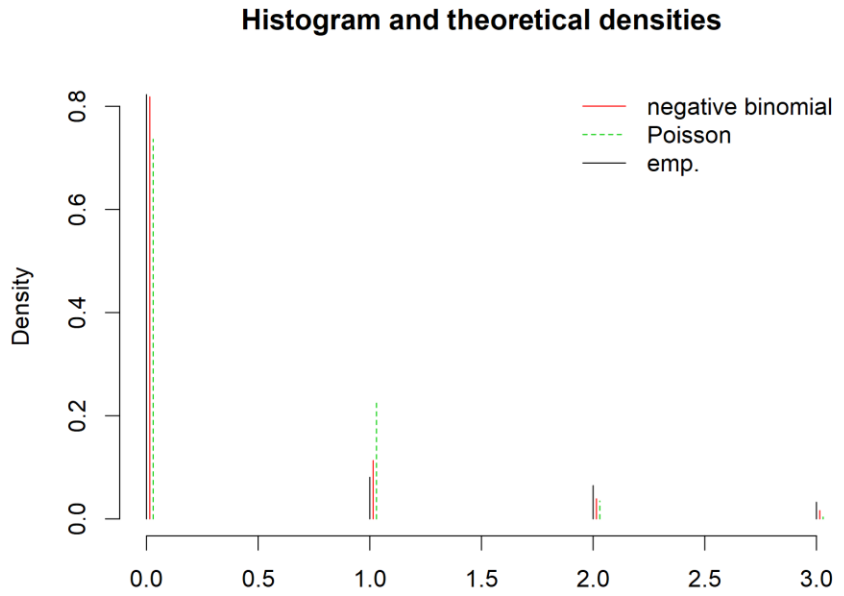


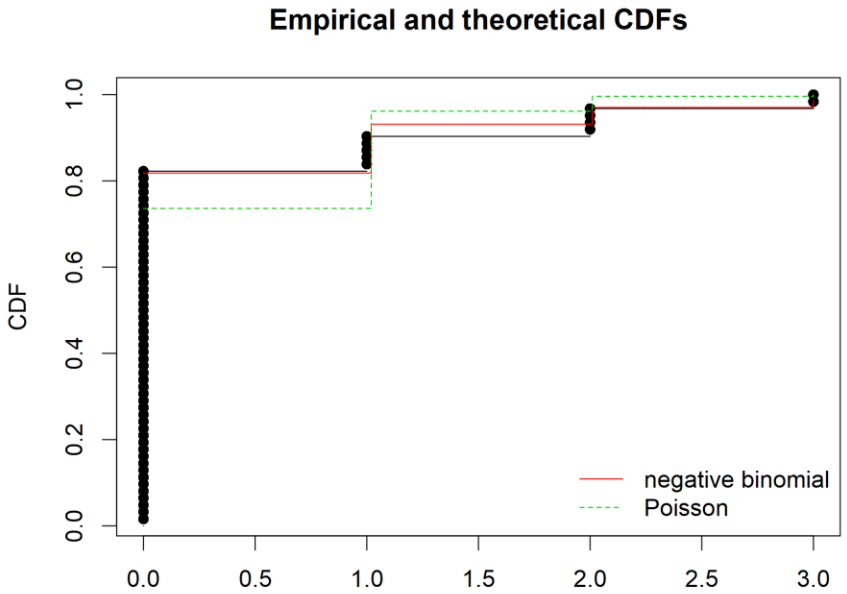


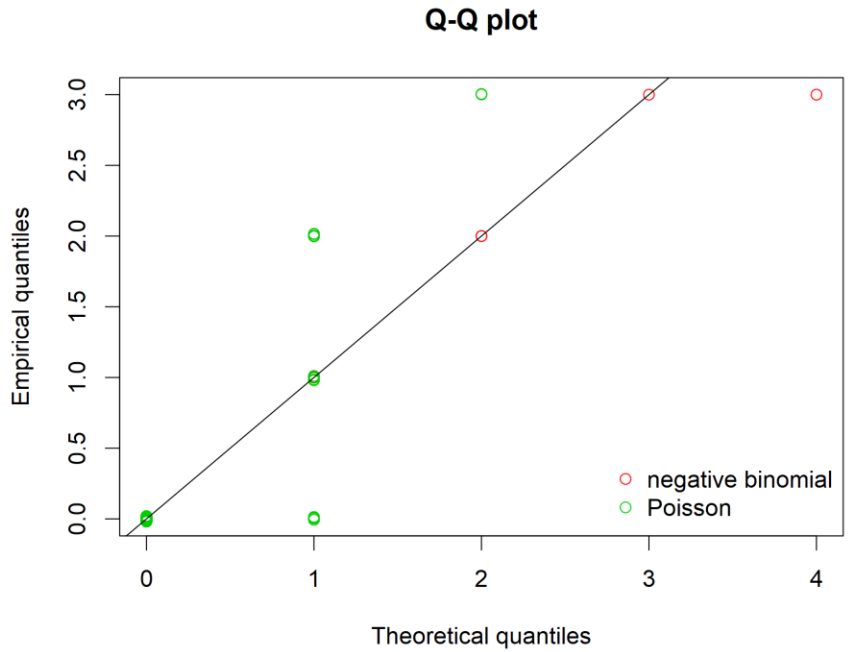


Quillback Rockfish - Cape Perpetua (FG & RG)

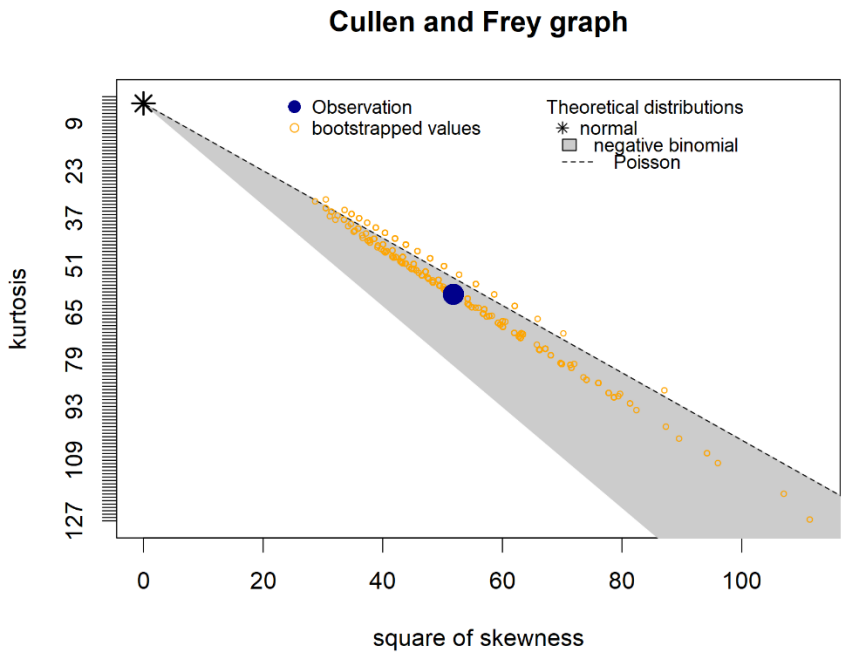


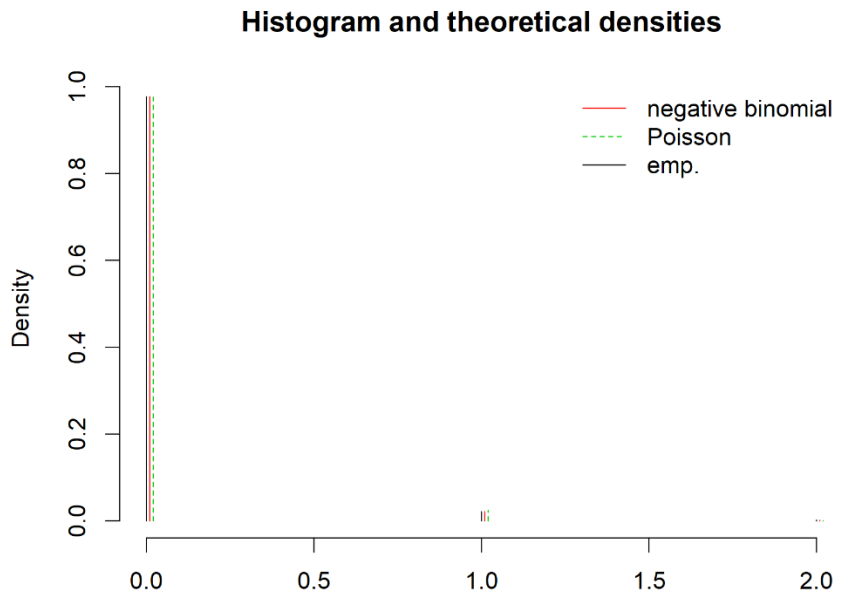


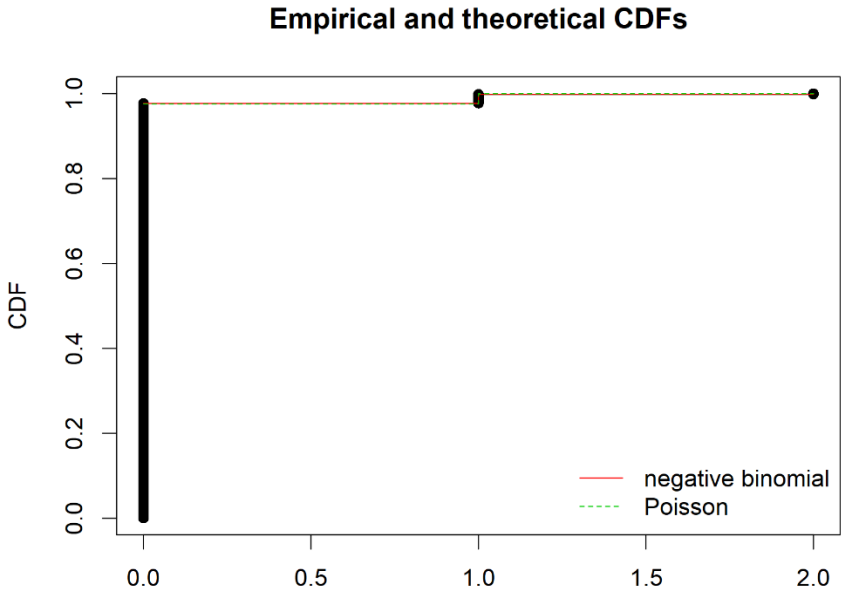


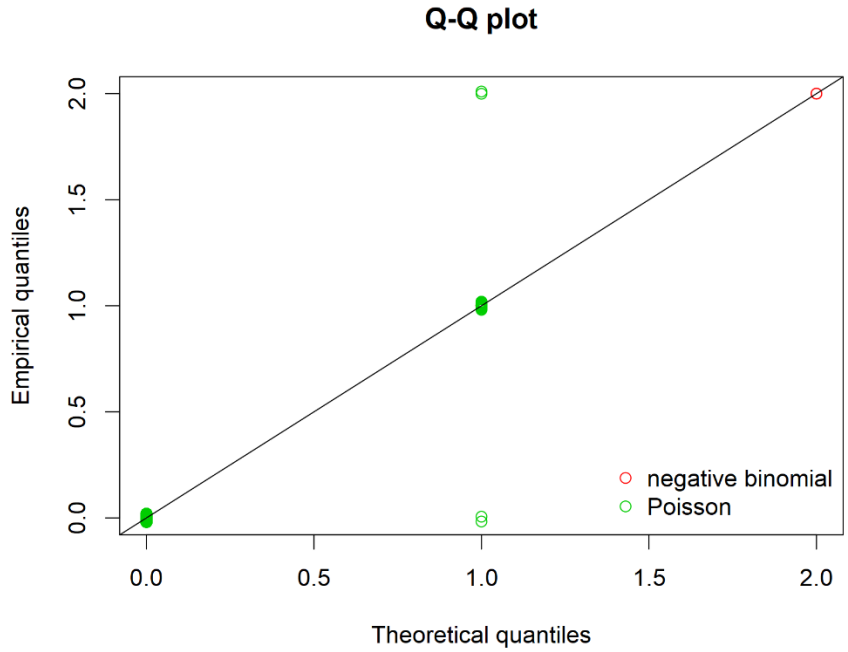


Quillback Rockfish - Offshore (FG)

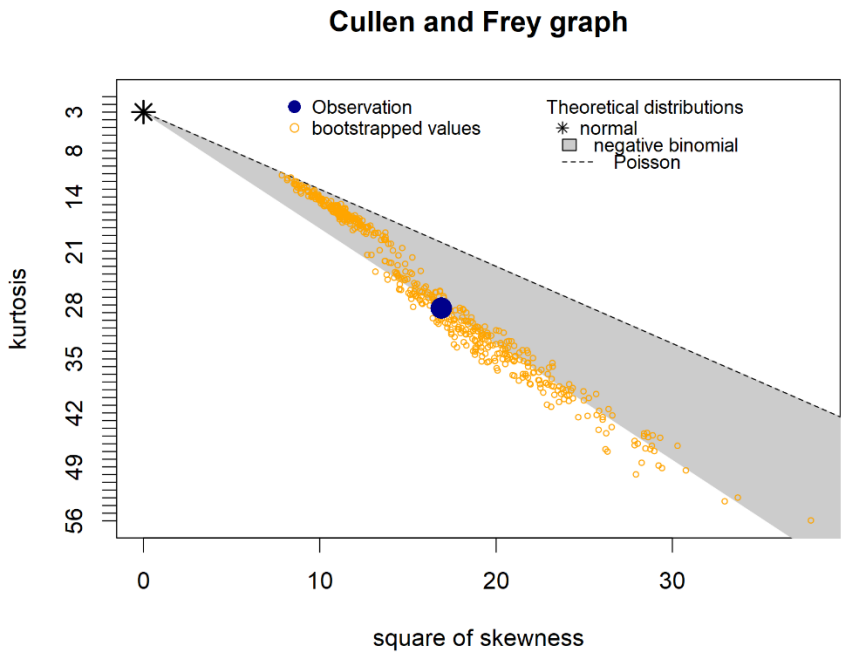


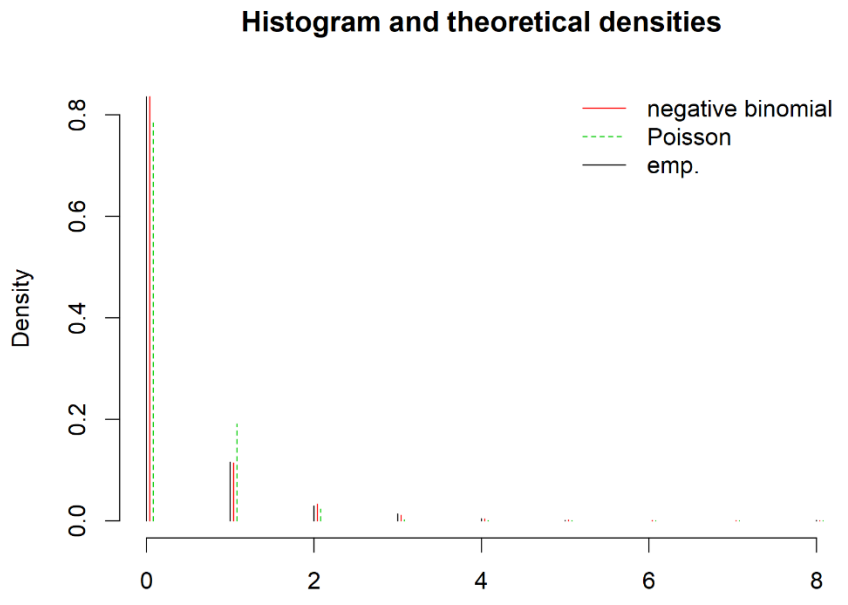


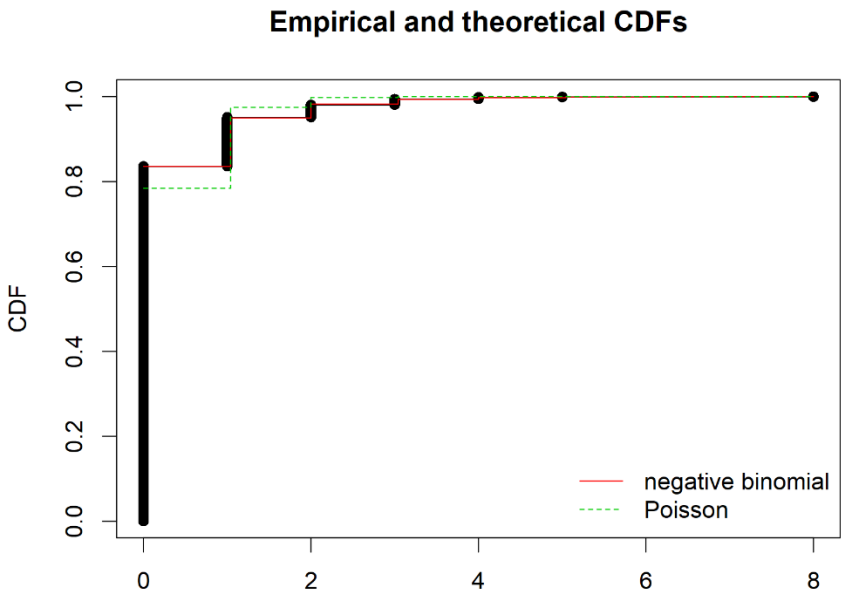


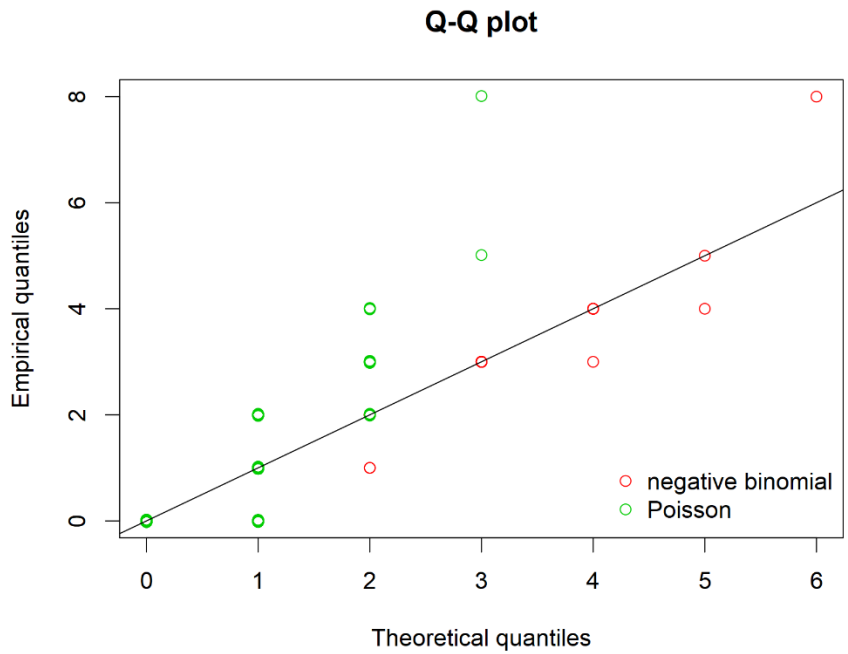


Rosethorn Rockfish - Offshore (FG)

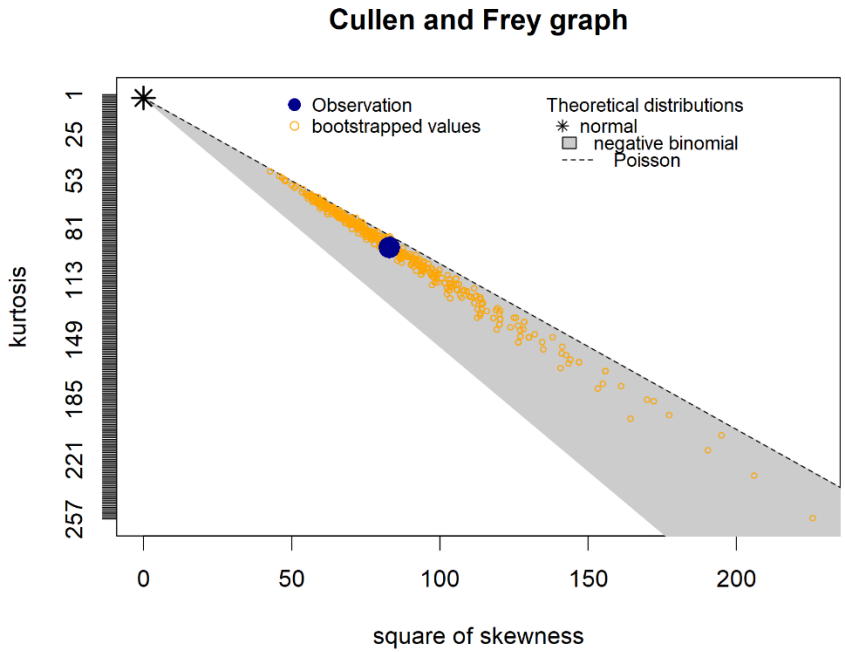


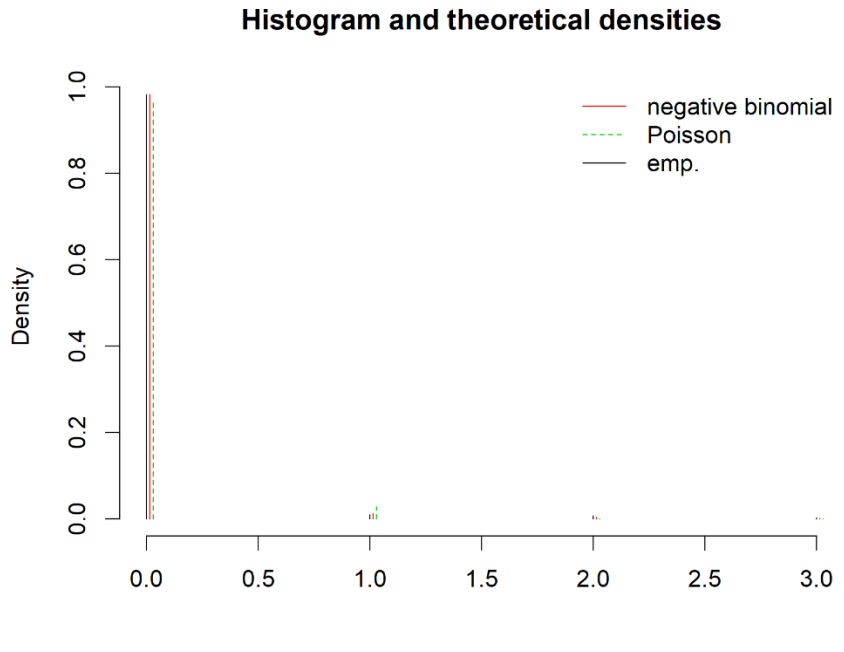


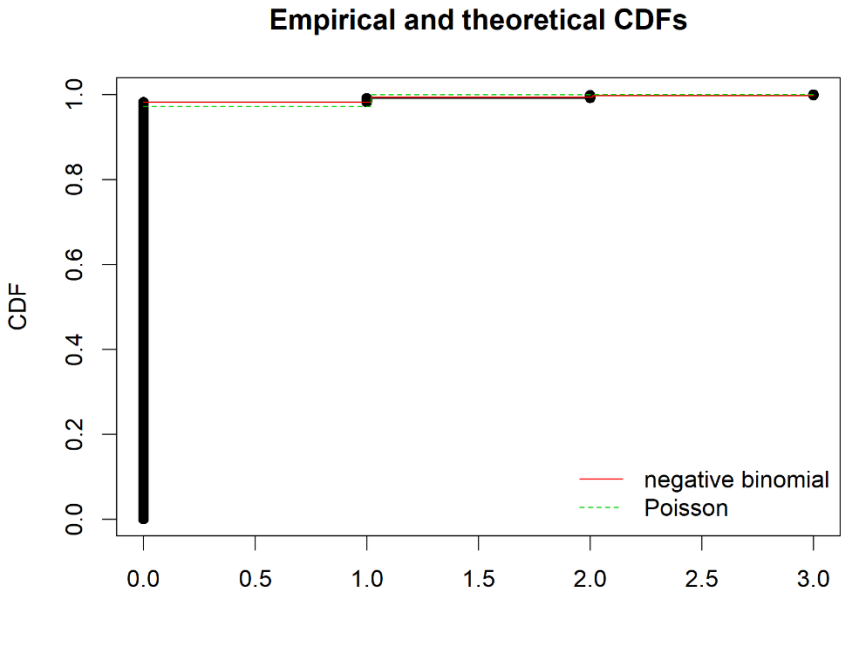


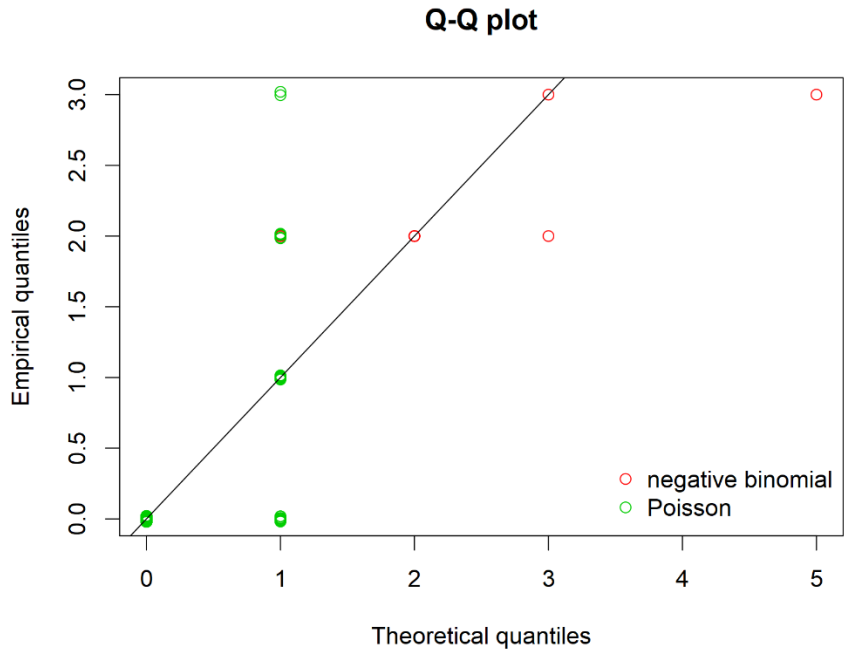


Silvergray_Bocaccio Rockfish - Offshore (FG)

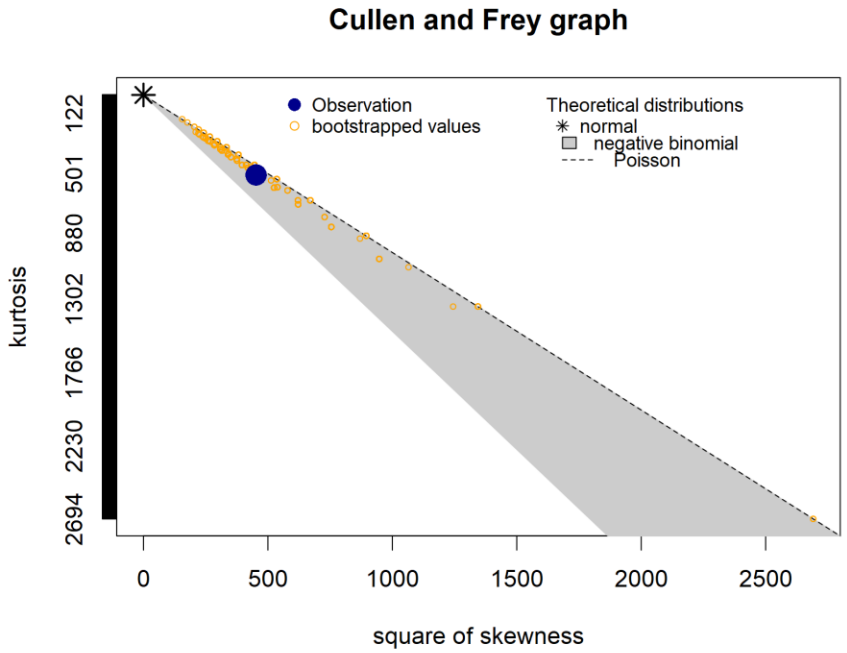


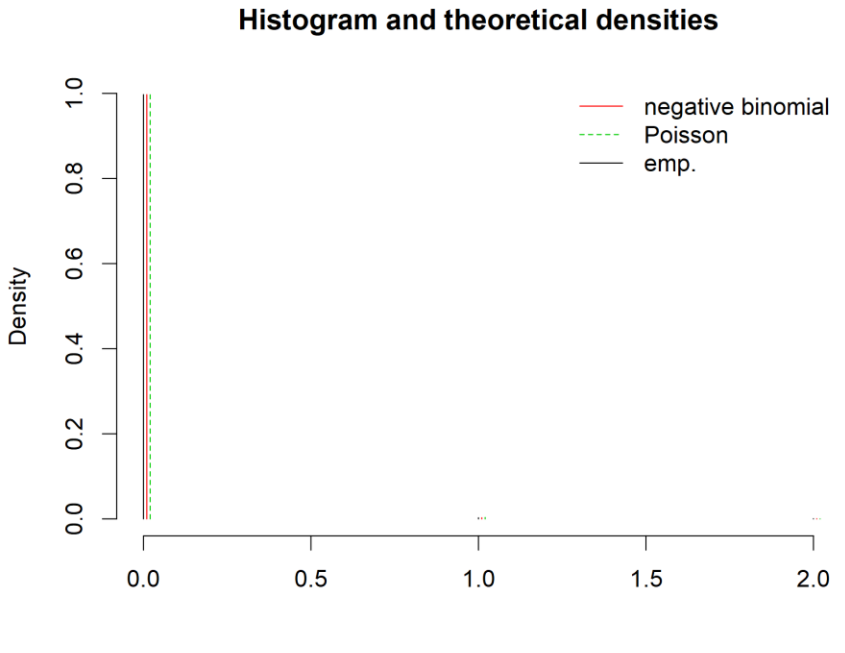


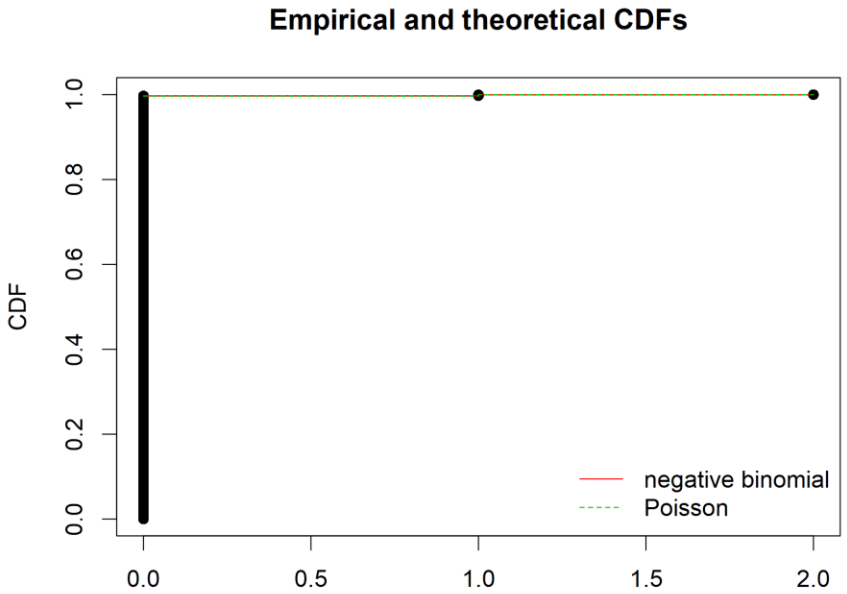


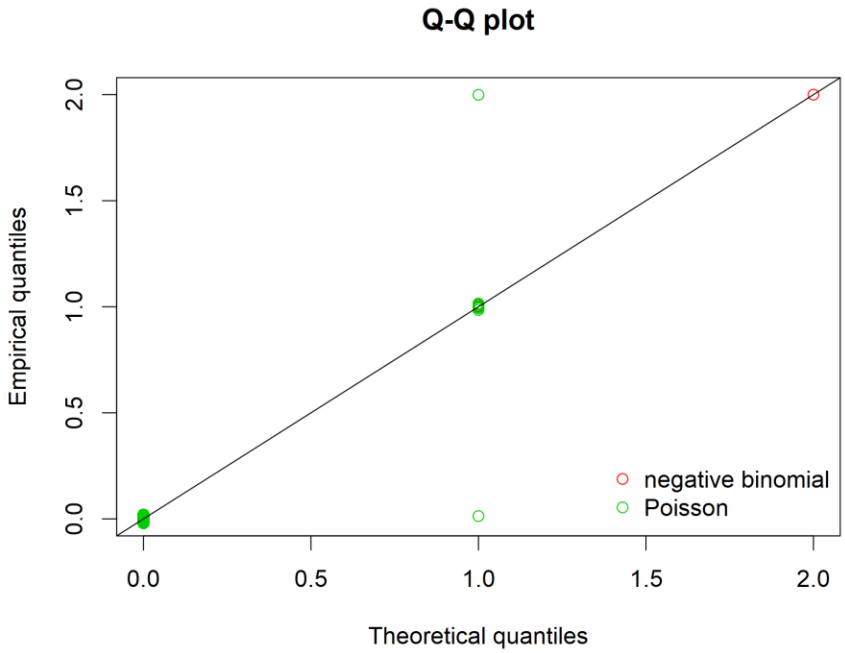


Tiger Rockfish - Entire Coast

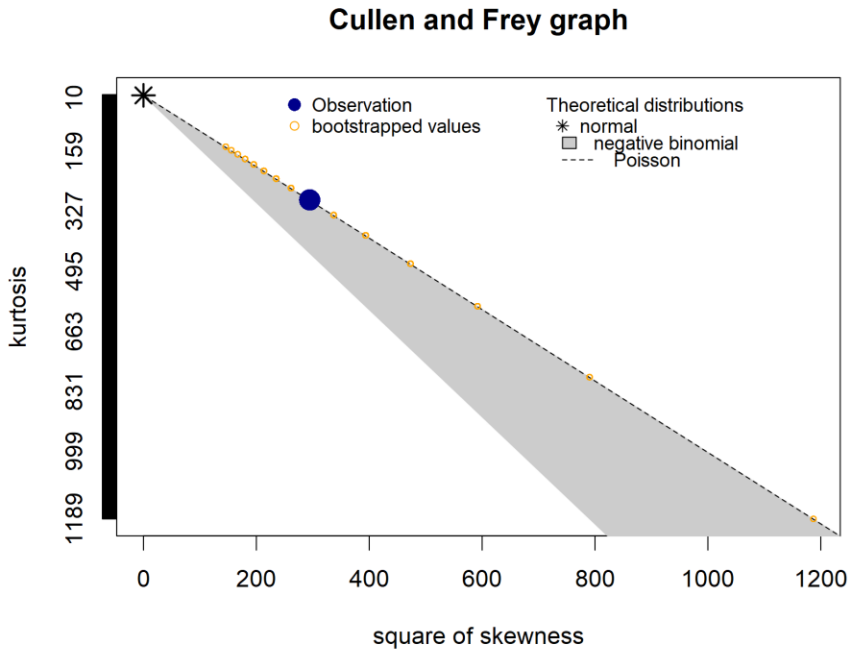


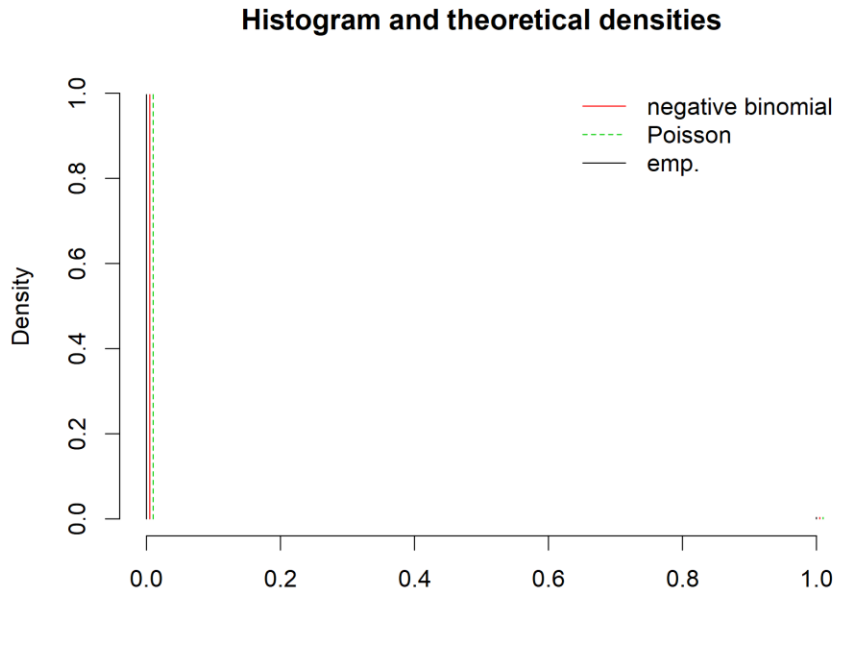


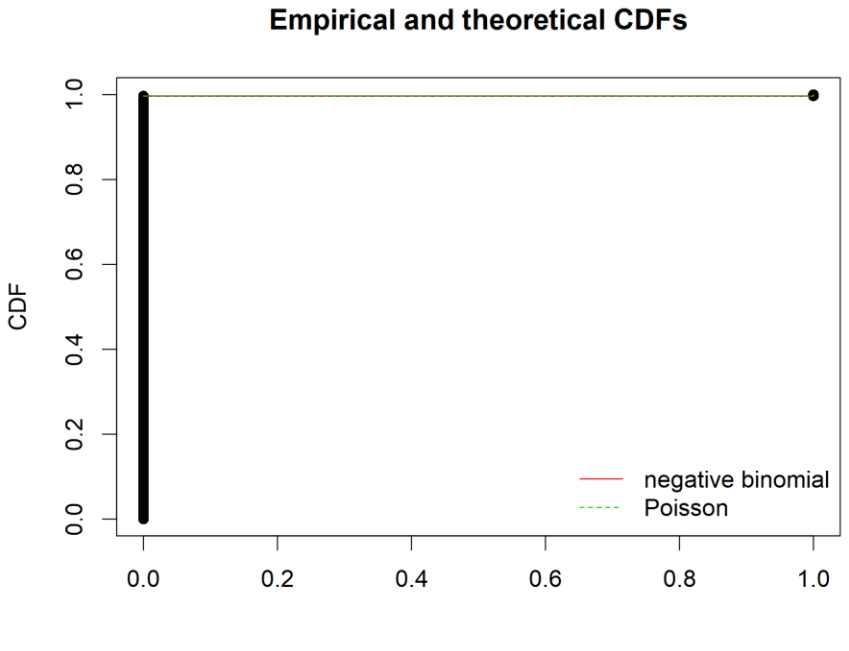


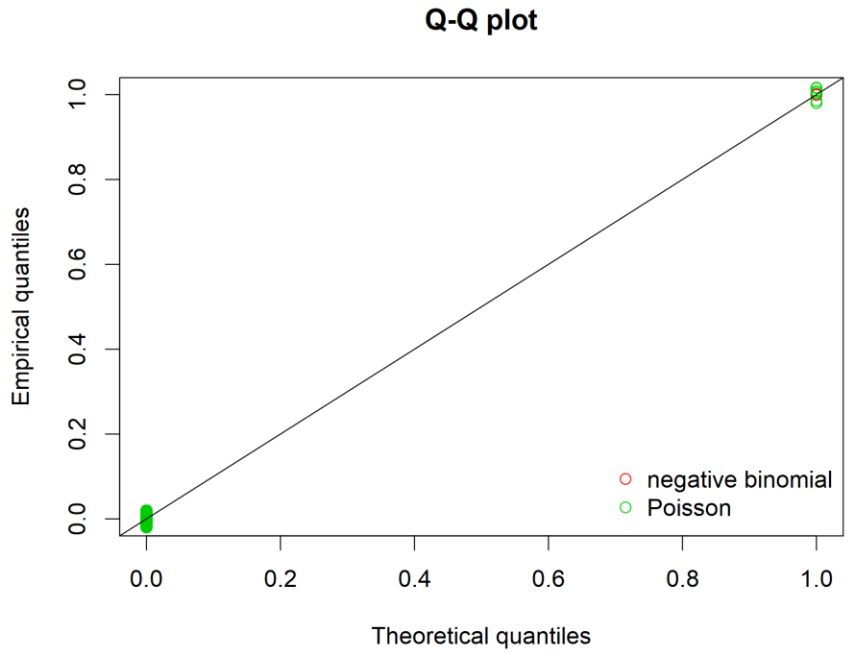


Vermilion Rockfish - Entire Coast

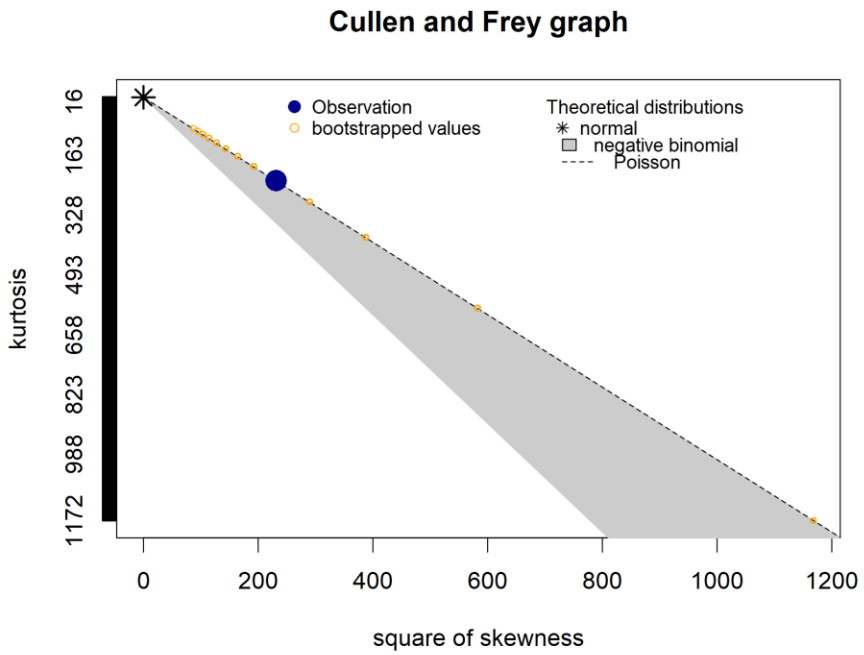


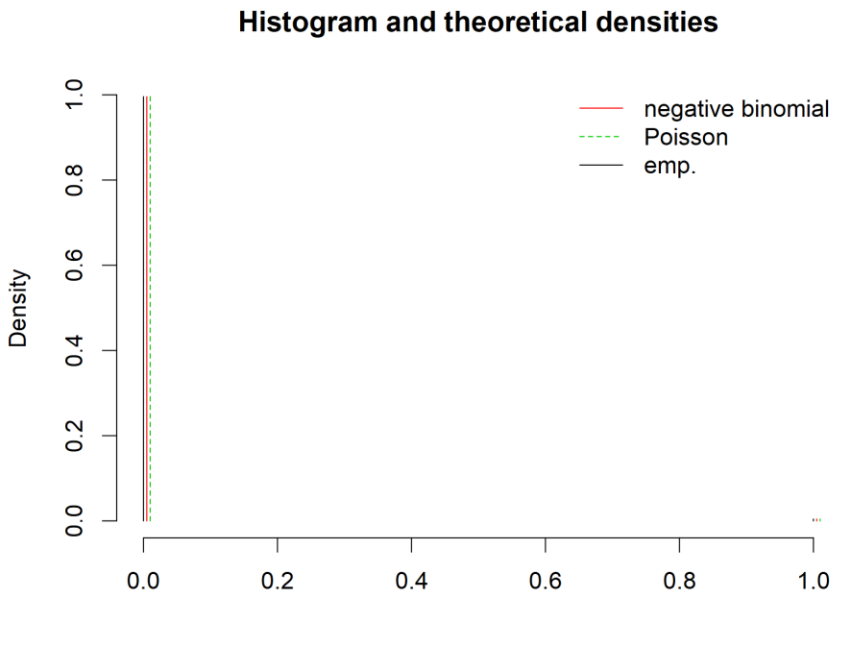


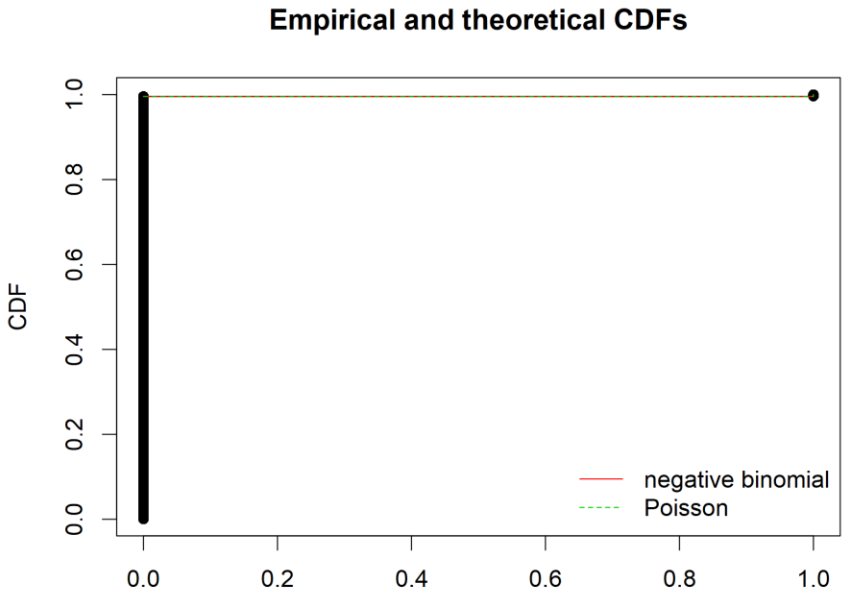


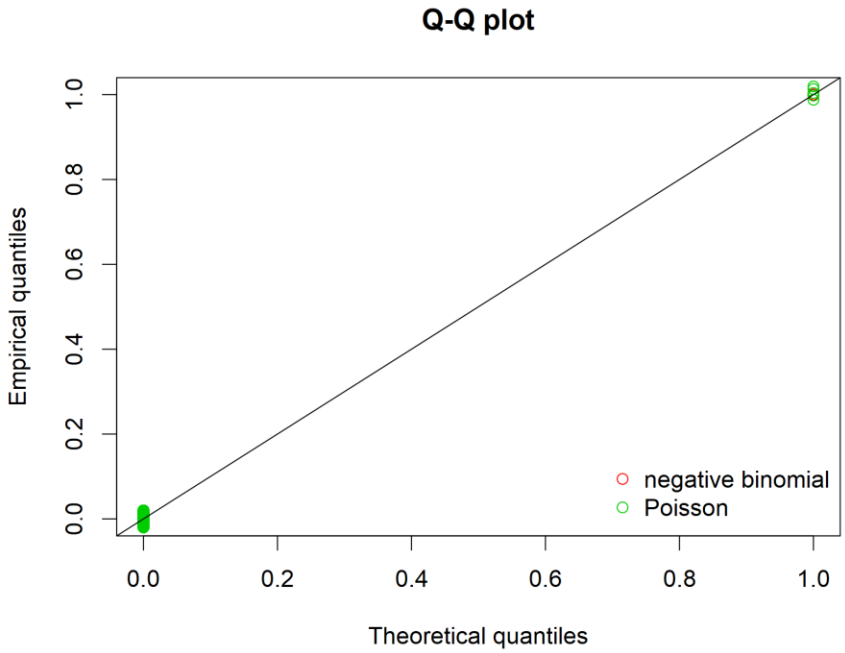


Vermilion Rockfish - Offshore (FG)

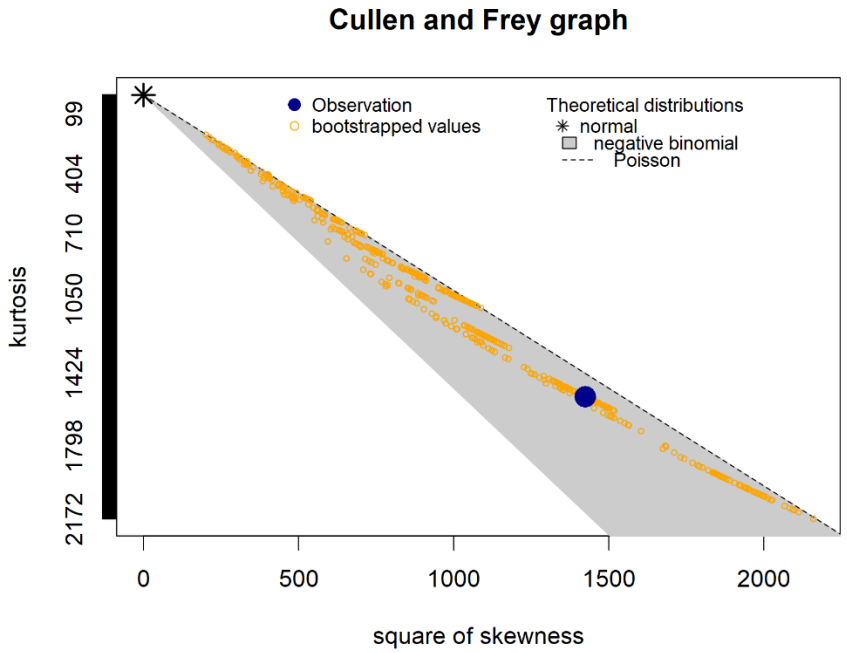


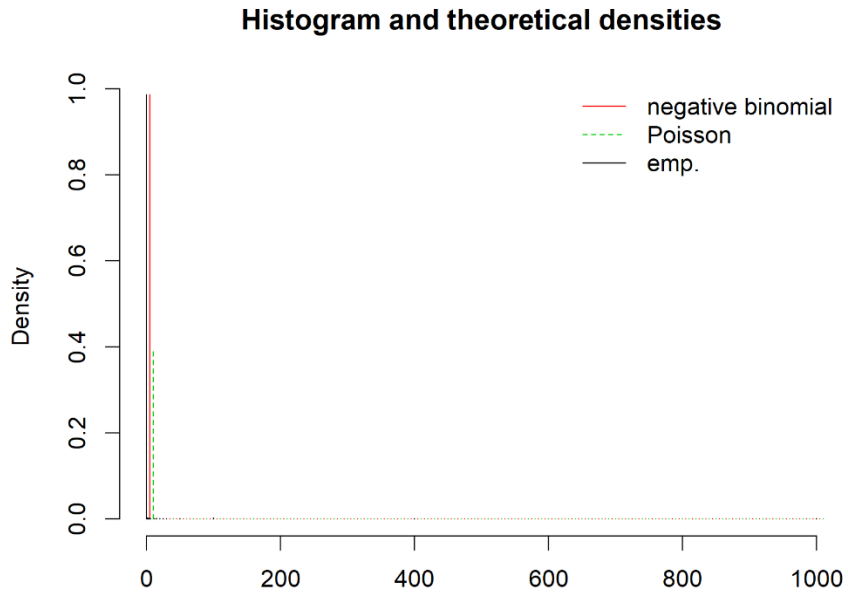


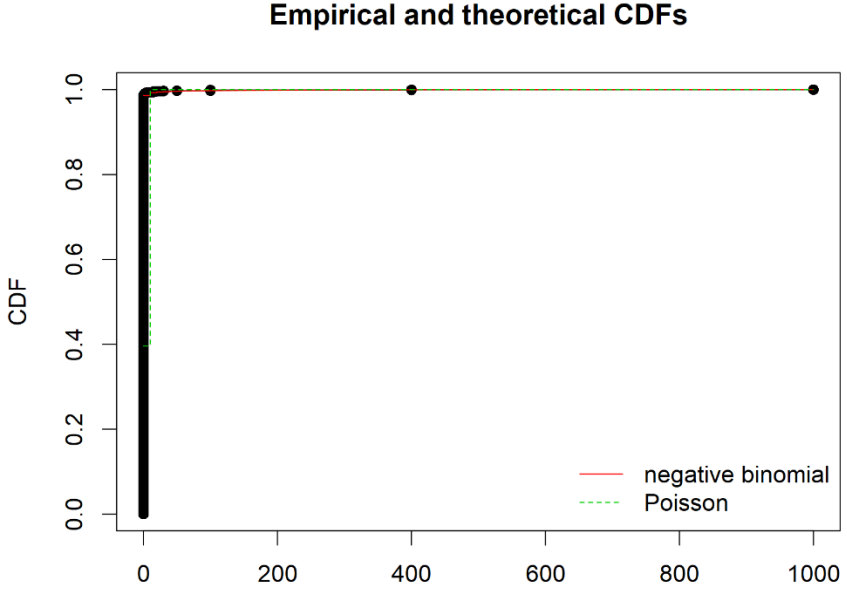


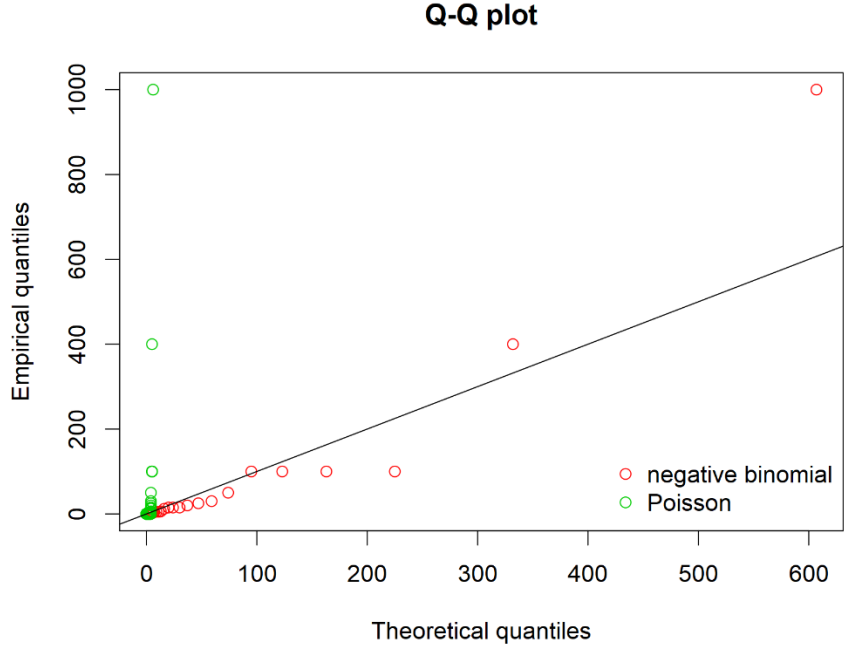


Widow Rockfish - Entire Coast

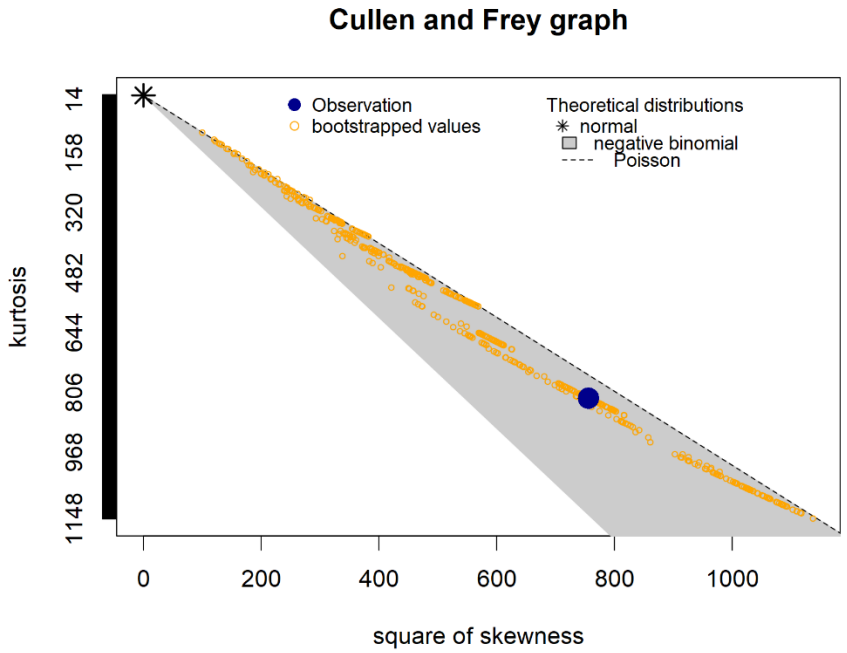


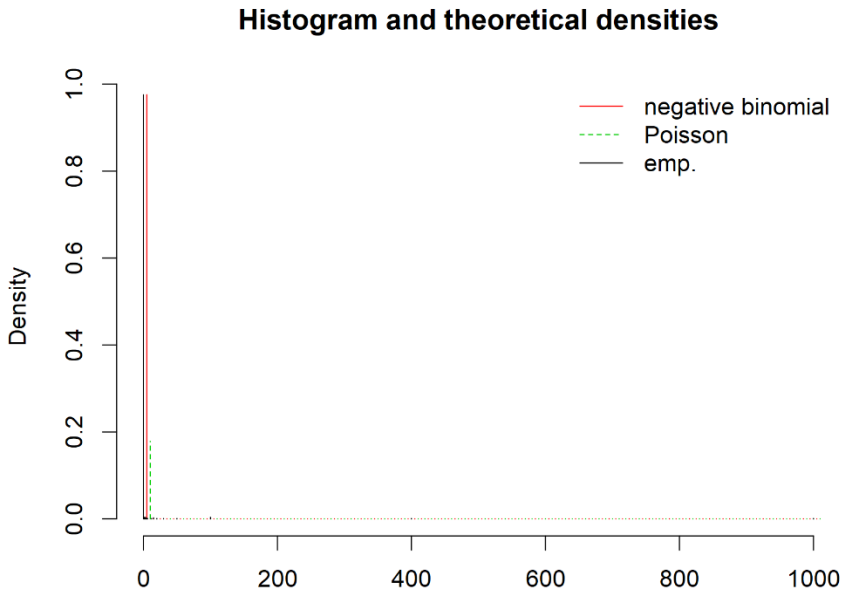


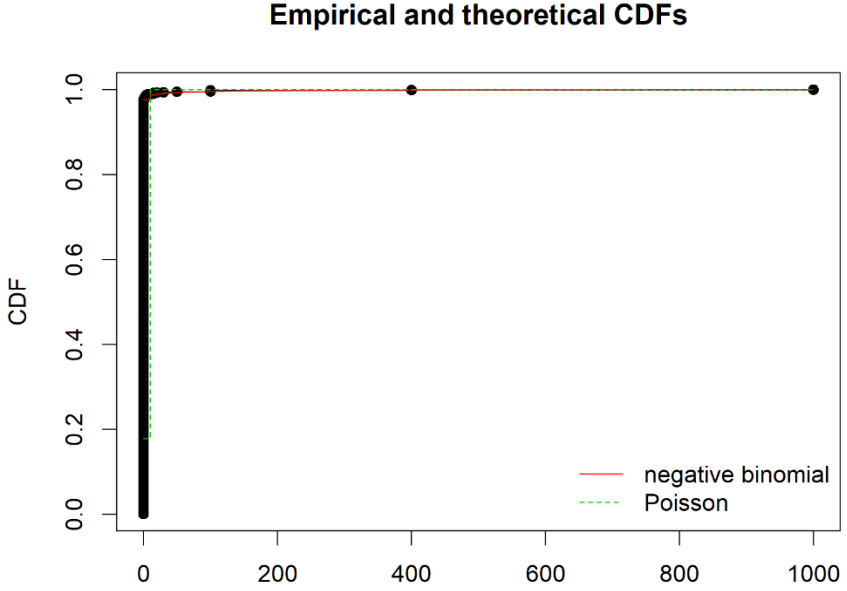


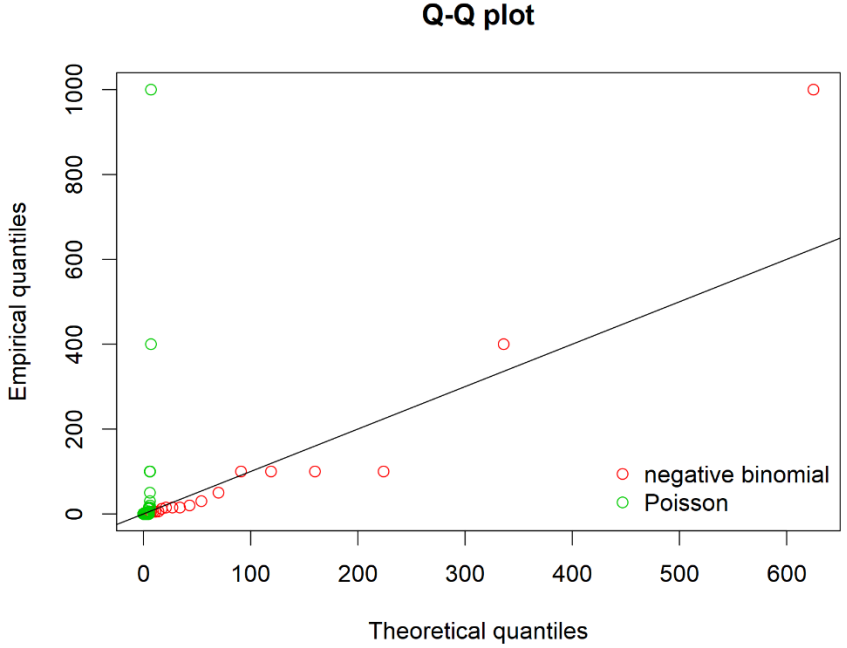


Widow Rockfish - Offshore (FG)

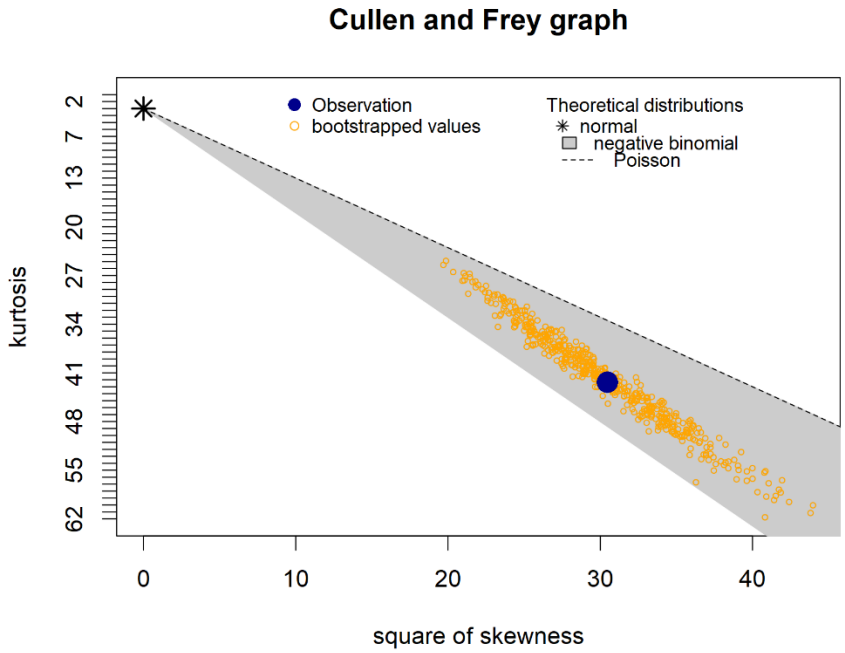


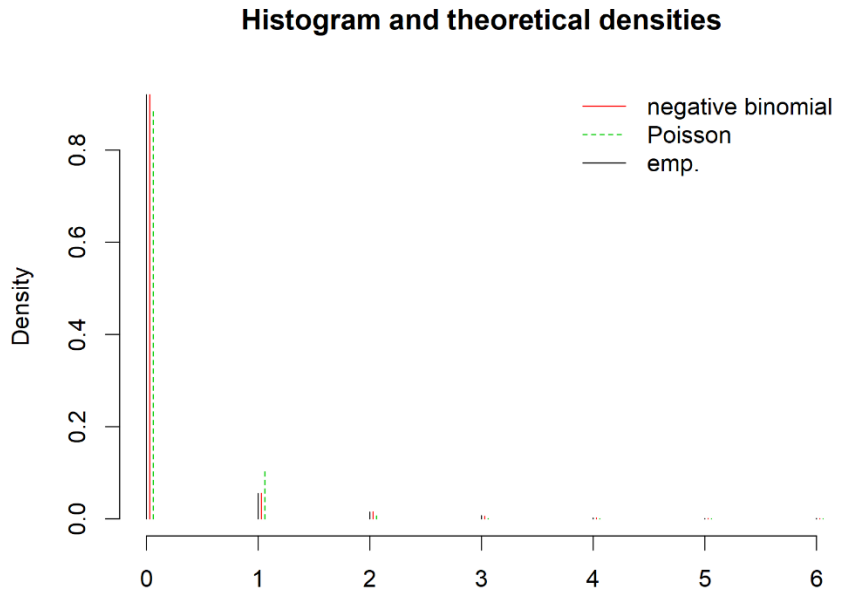


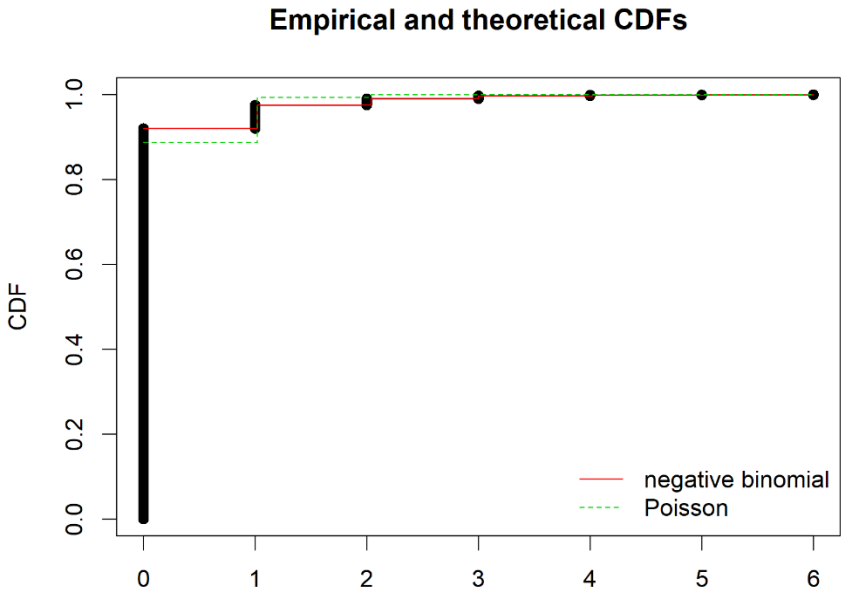


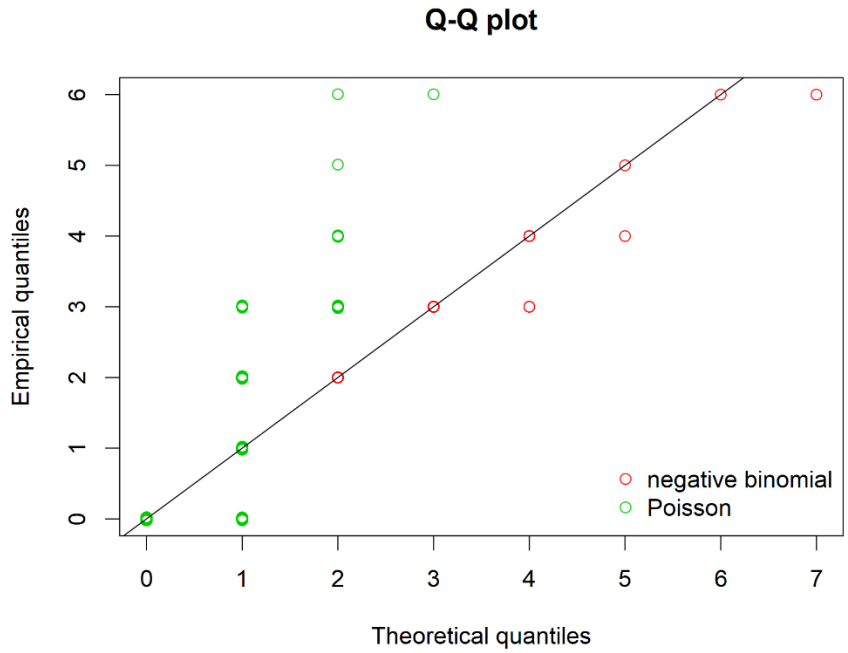


Yelloweye Rockfish - Entire Coast

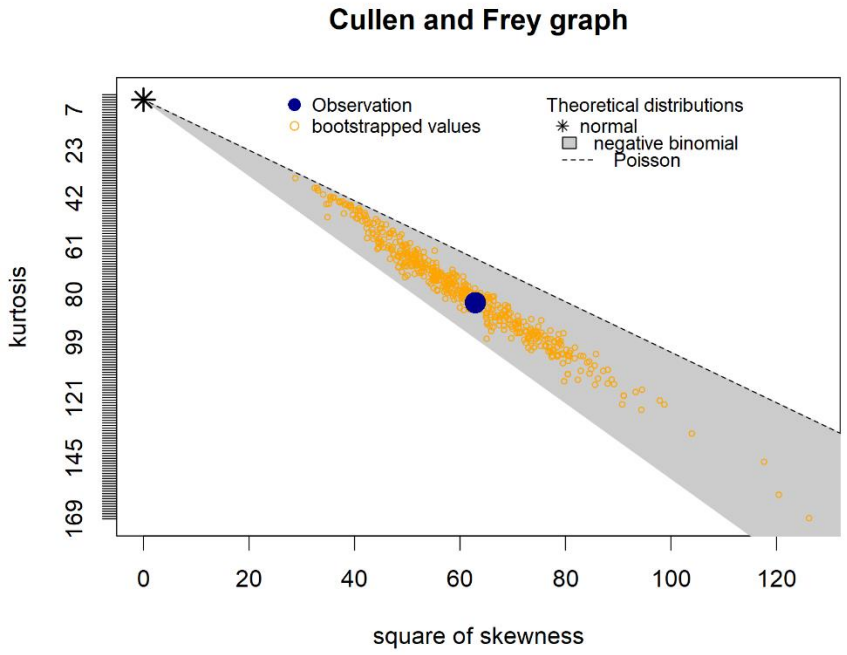


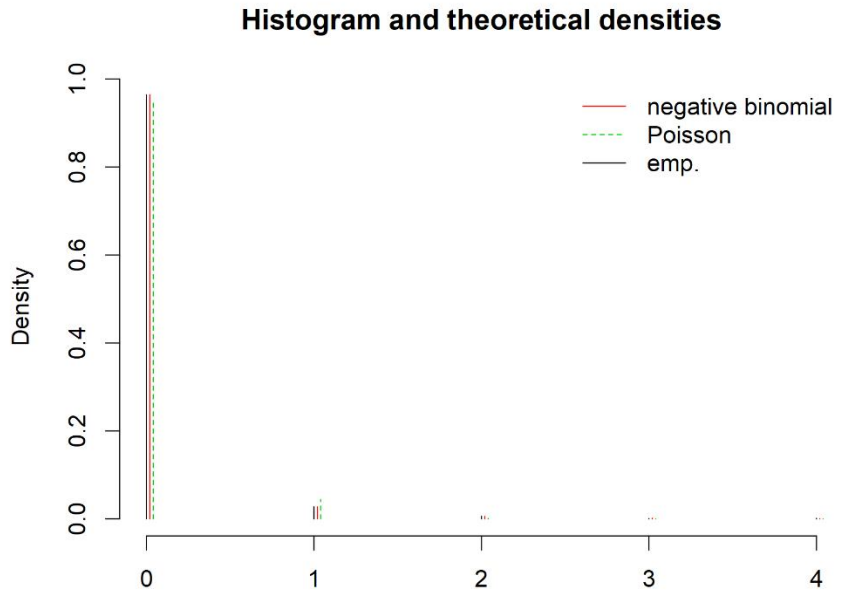


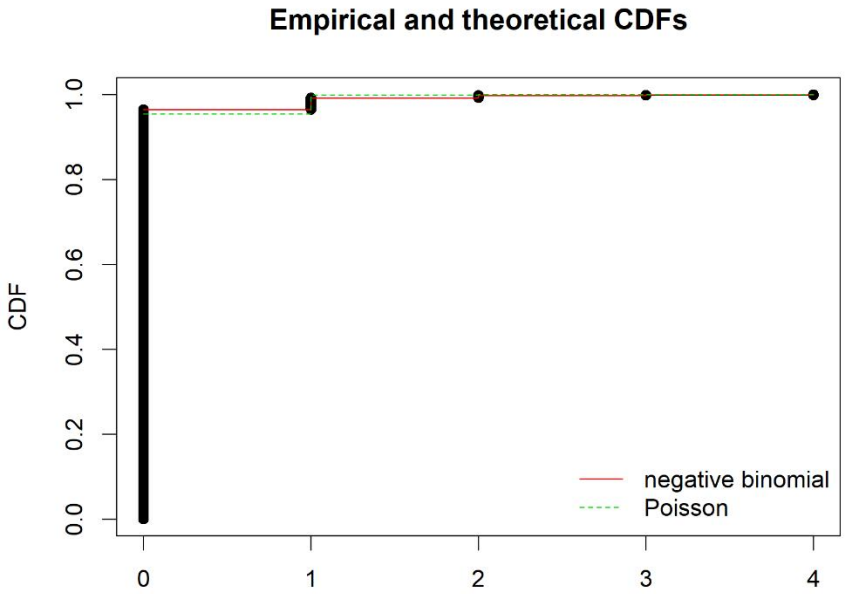


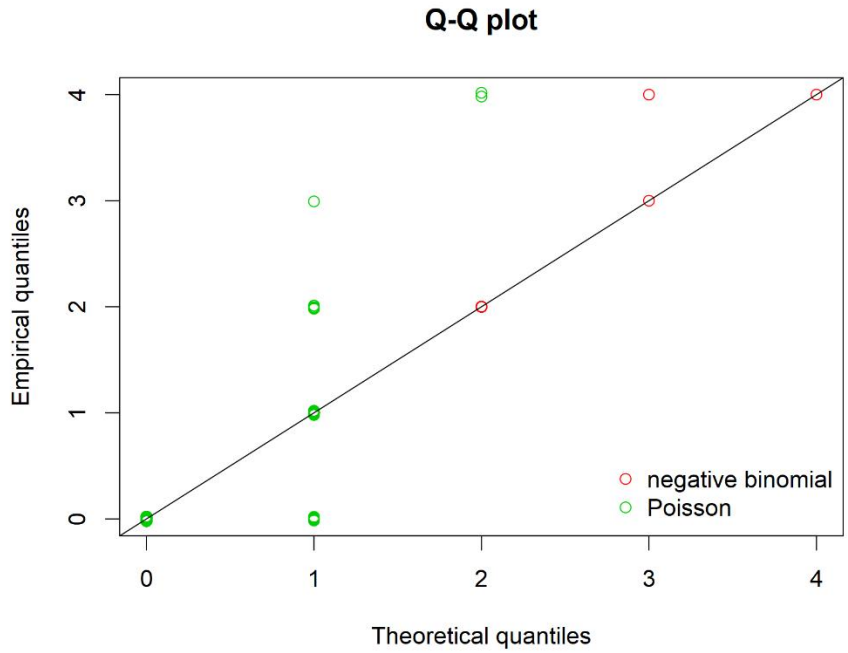


Yelloweye Rockfish - Nearshore

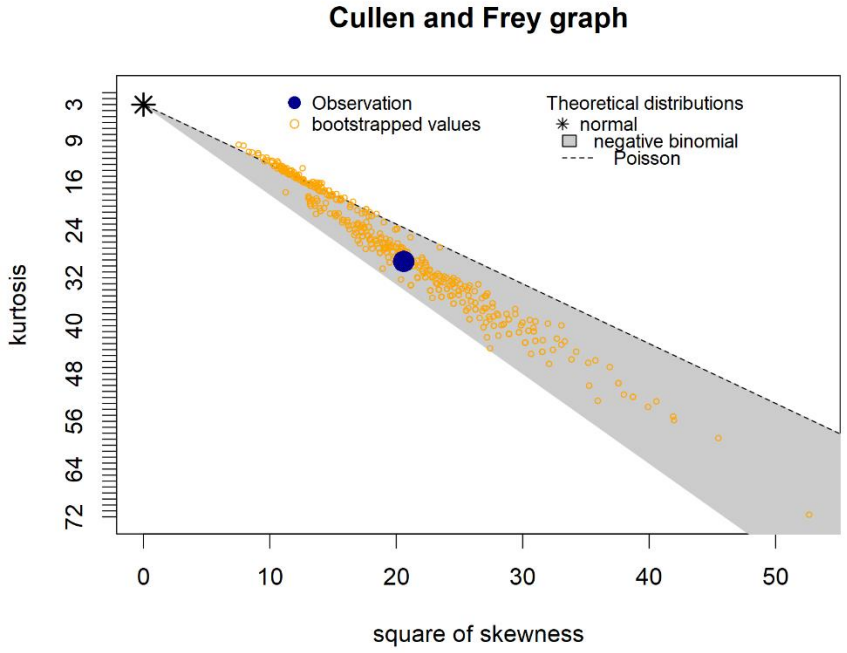


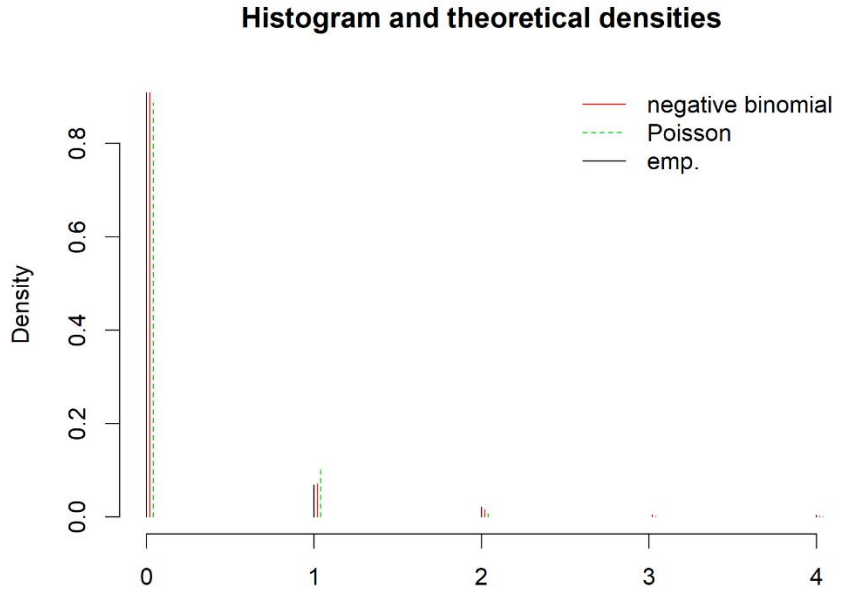


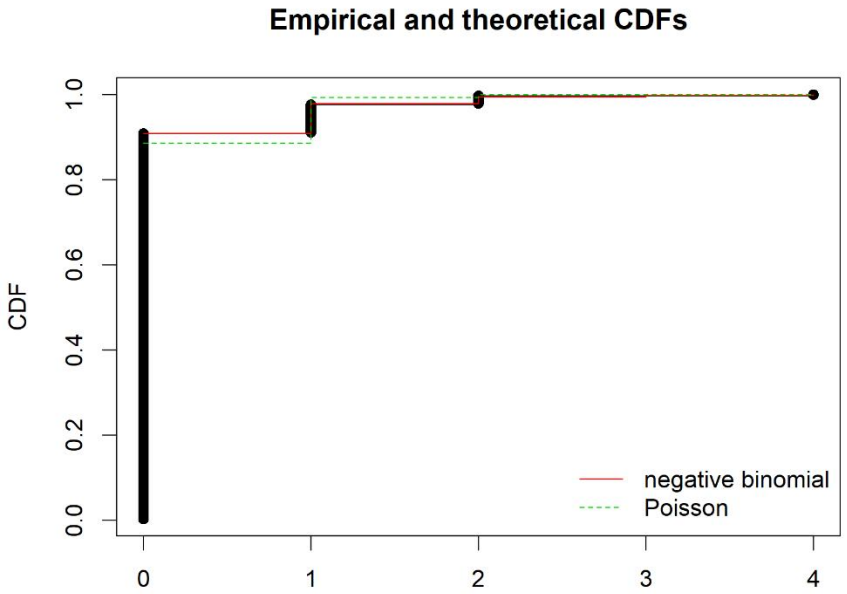


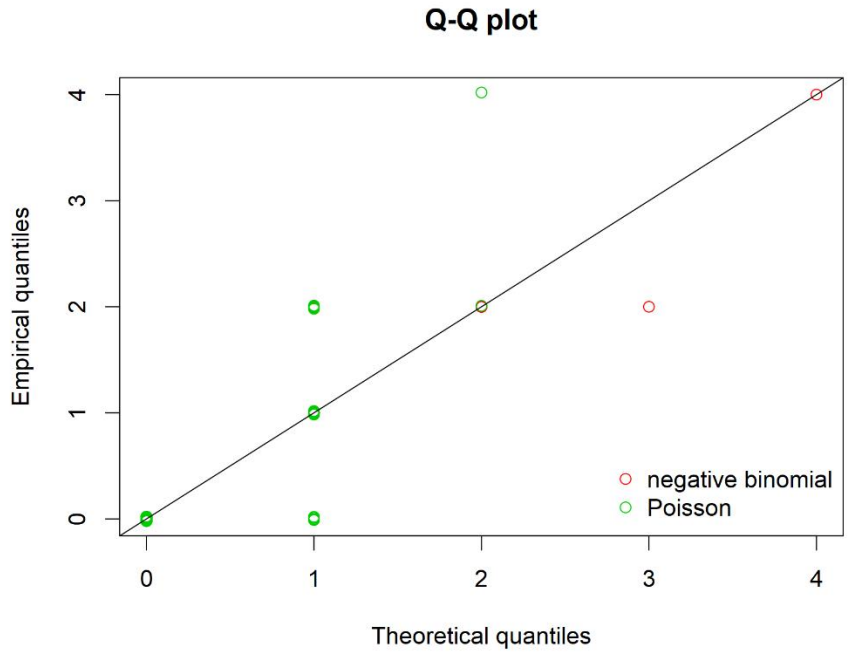


Yelloweye Rockfish - North Coast (FG & RG)

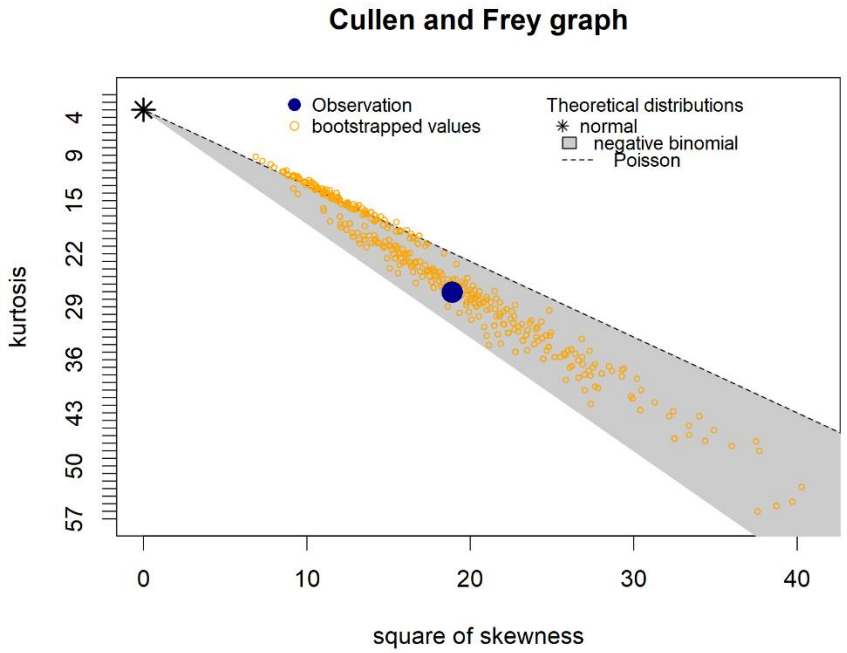


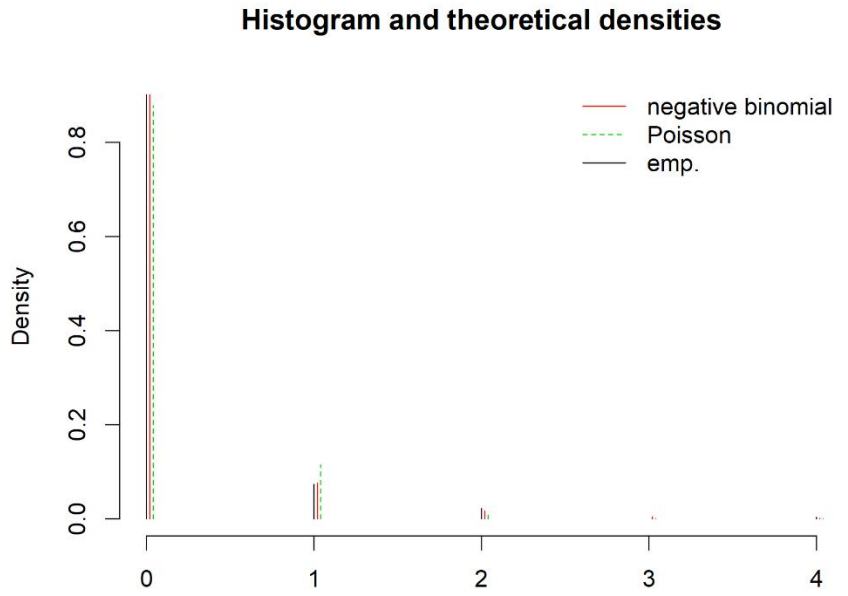


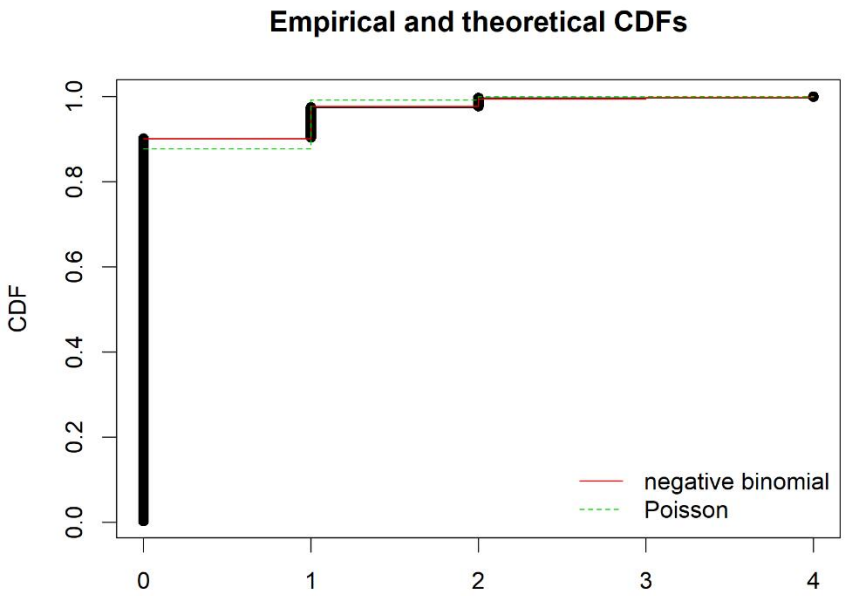


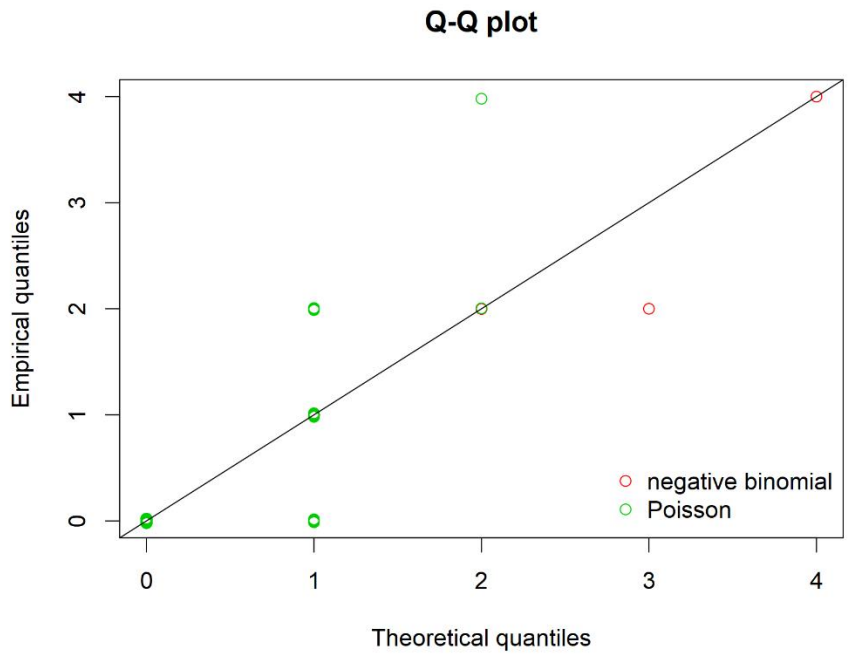


Yelloweye Rockfish - North Coast (FG)

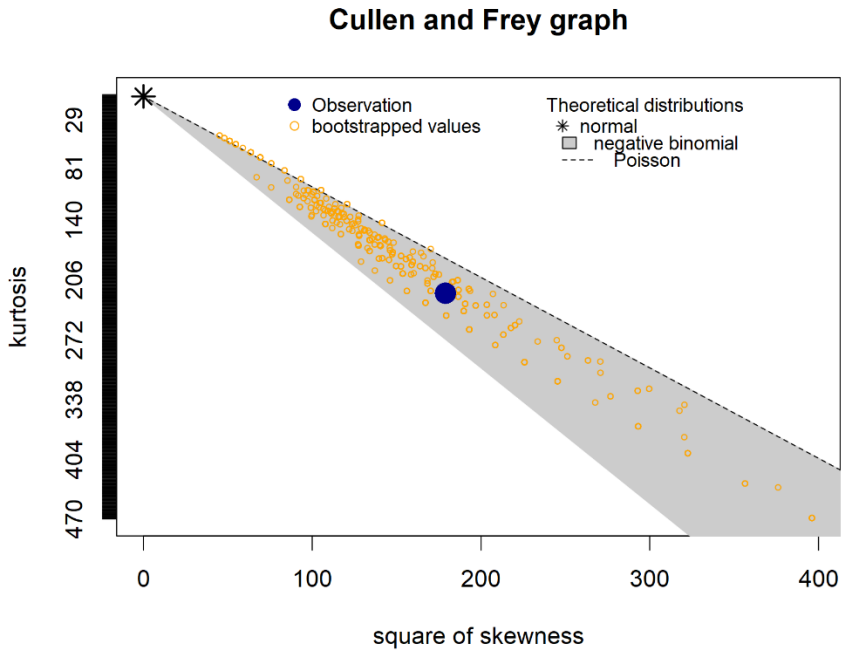


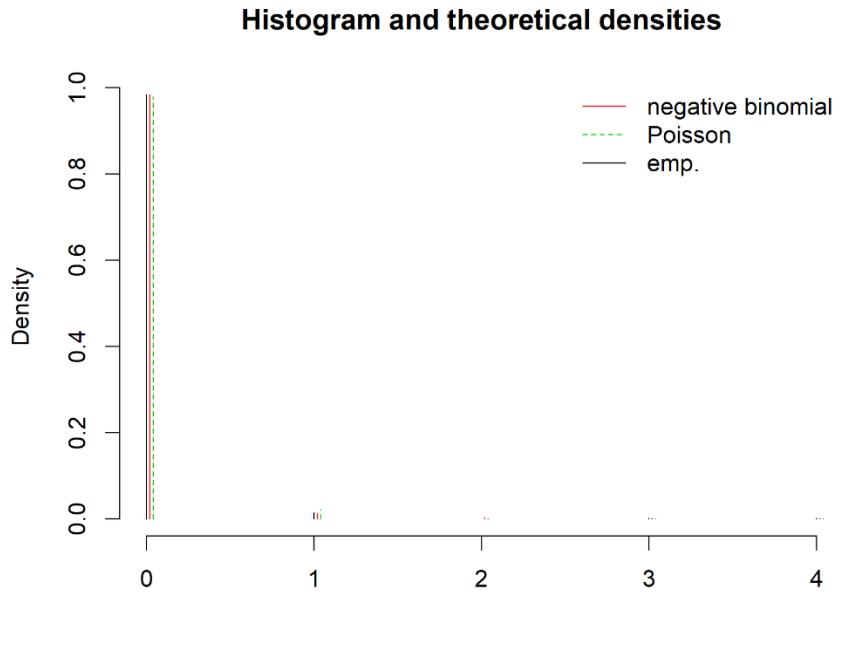


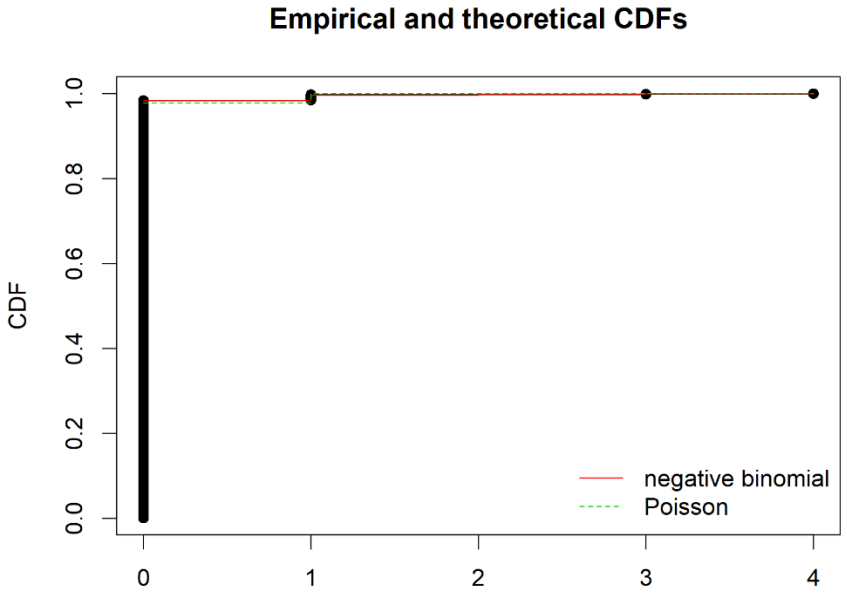


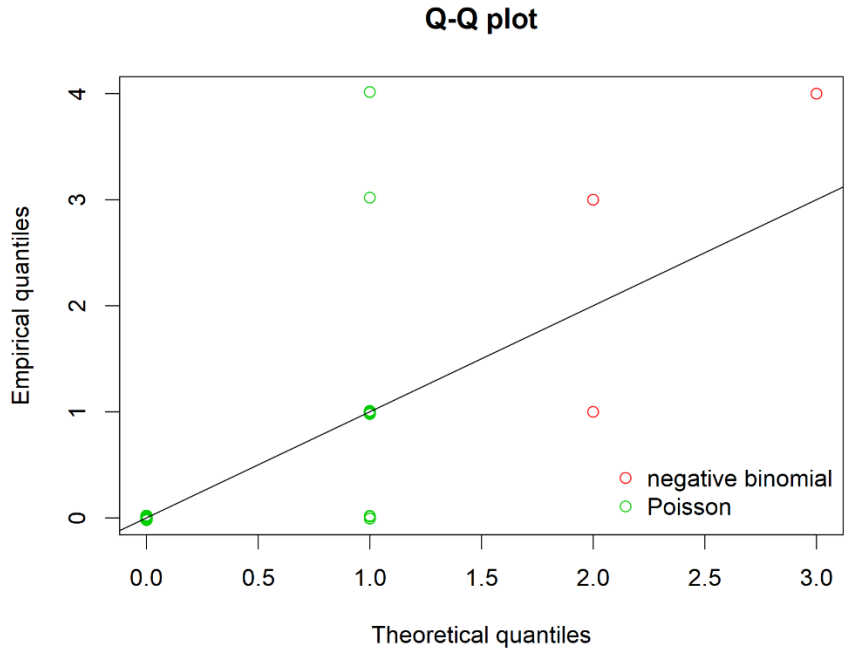


Yelloweye Rockfish - Central Coast (FG, RG, & NG)

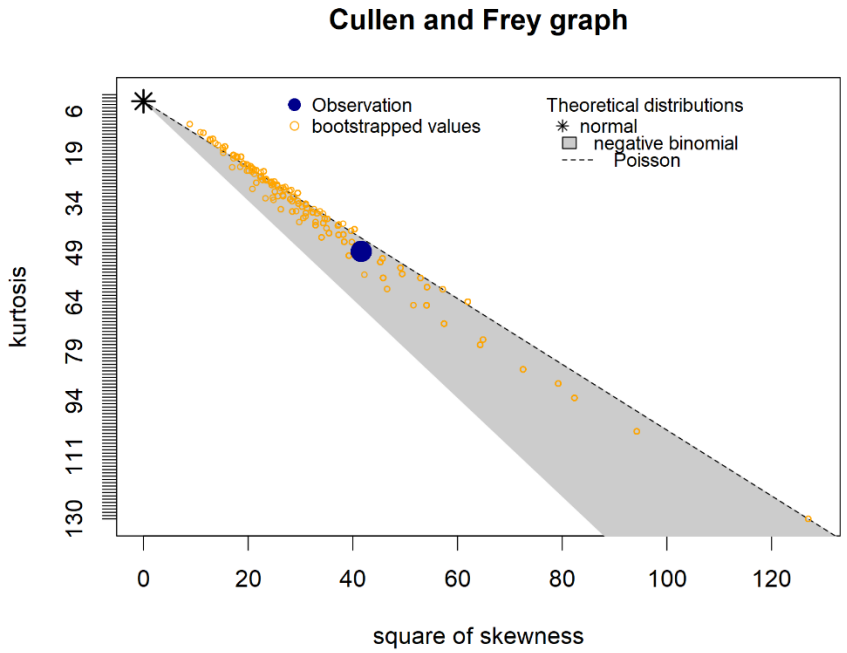


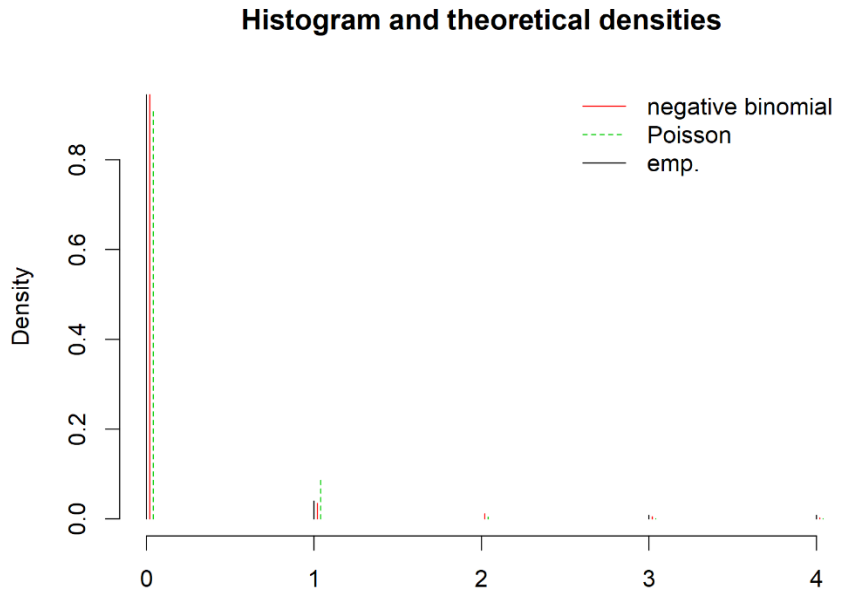


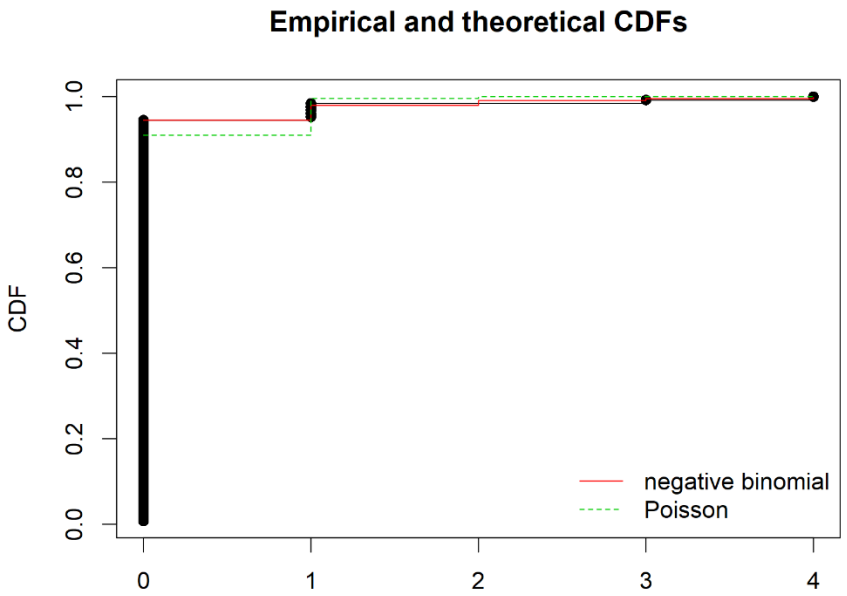


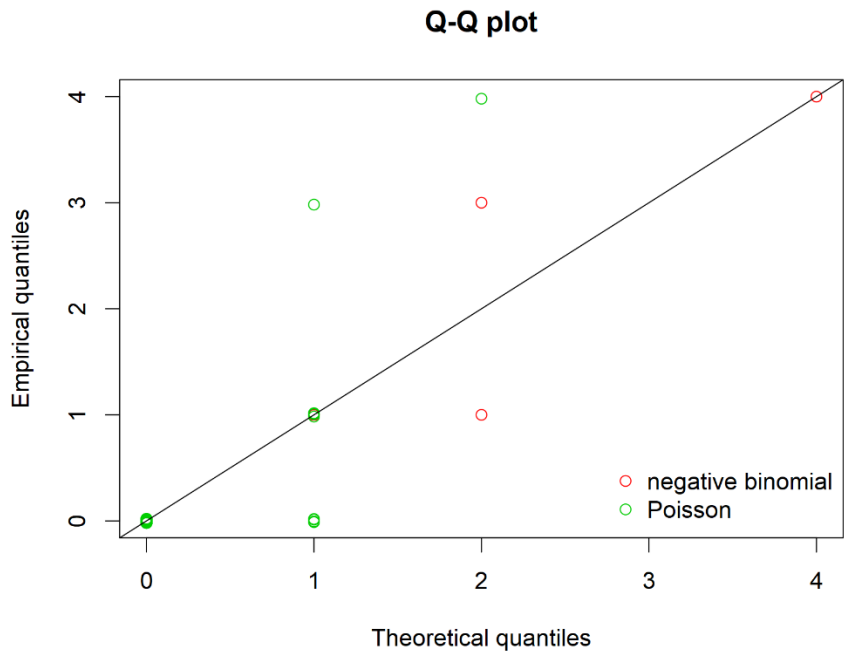


Yelloweye Rockfish - Central Coast (FG)

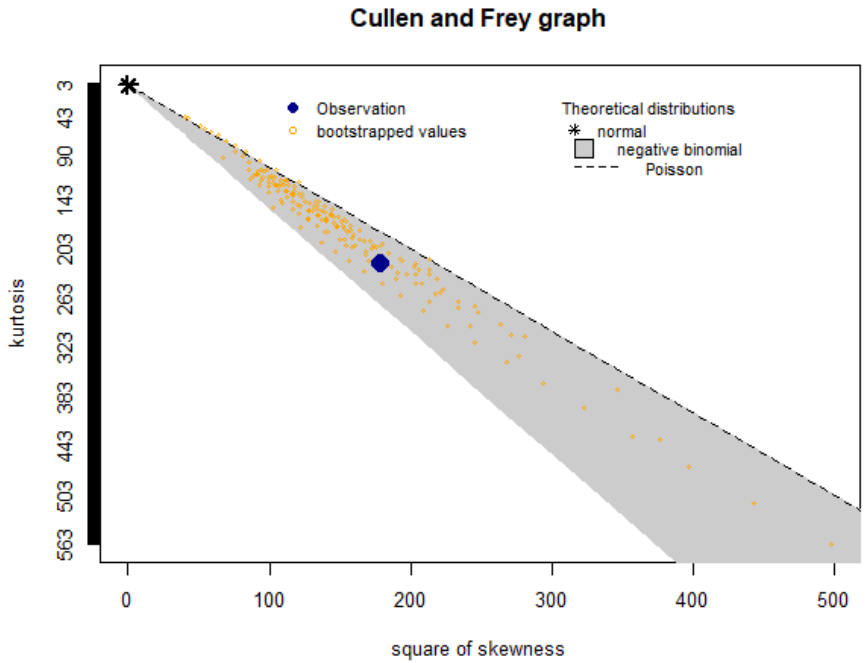


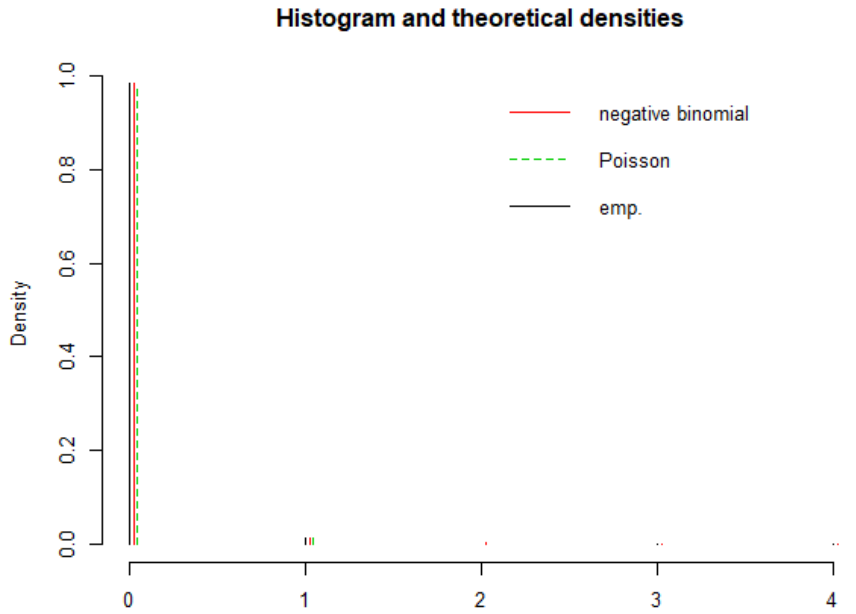


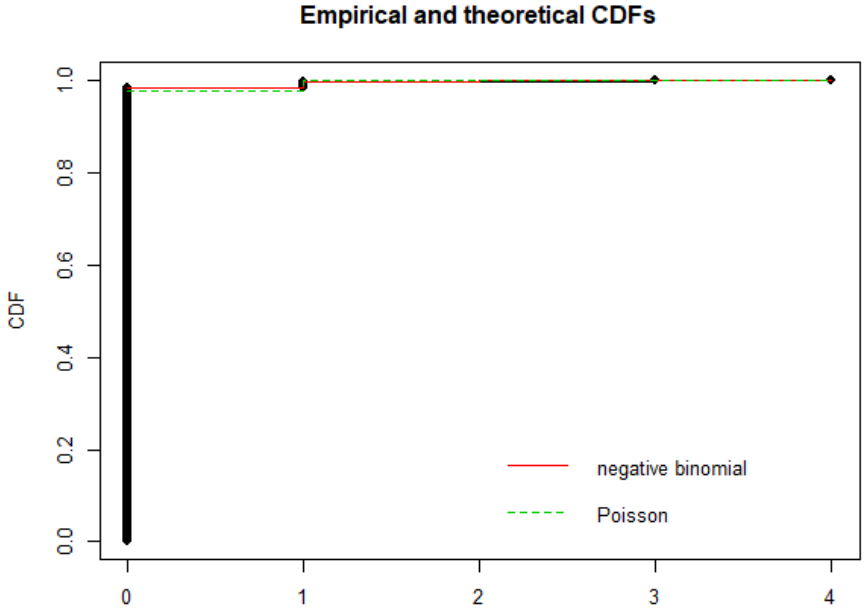


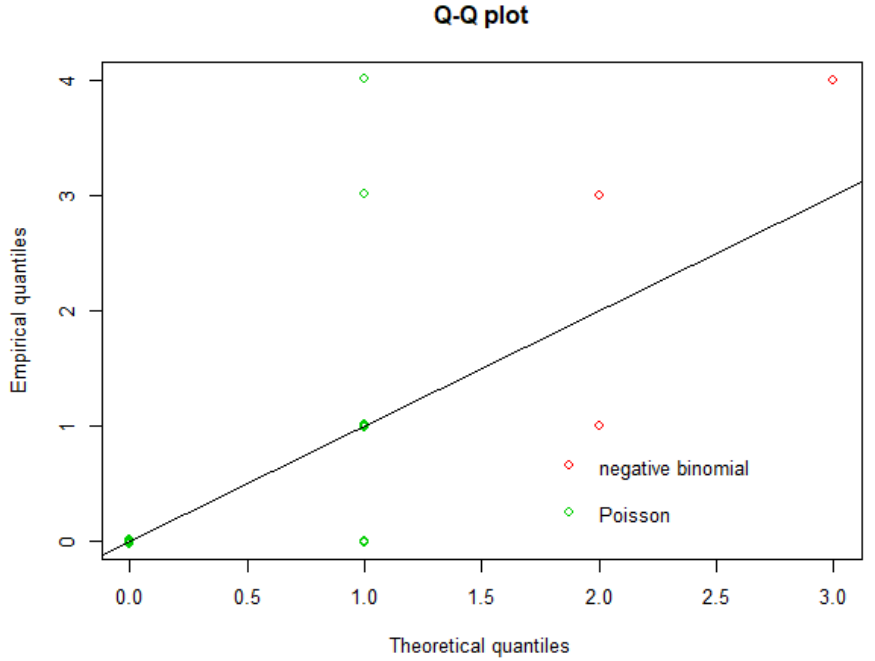


Yelloweye Rockfish - Central Coast (RG)

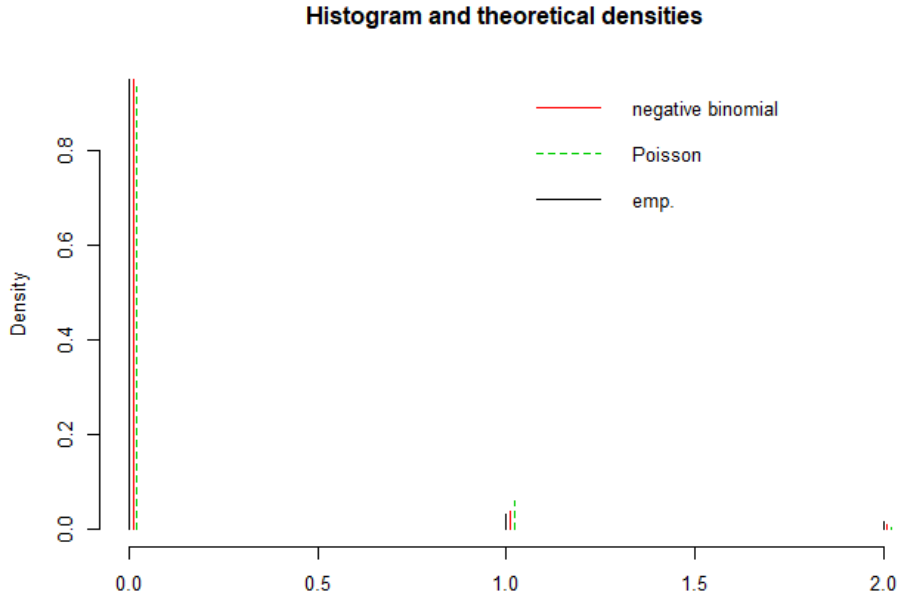


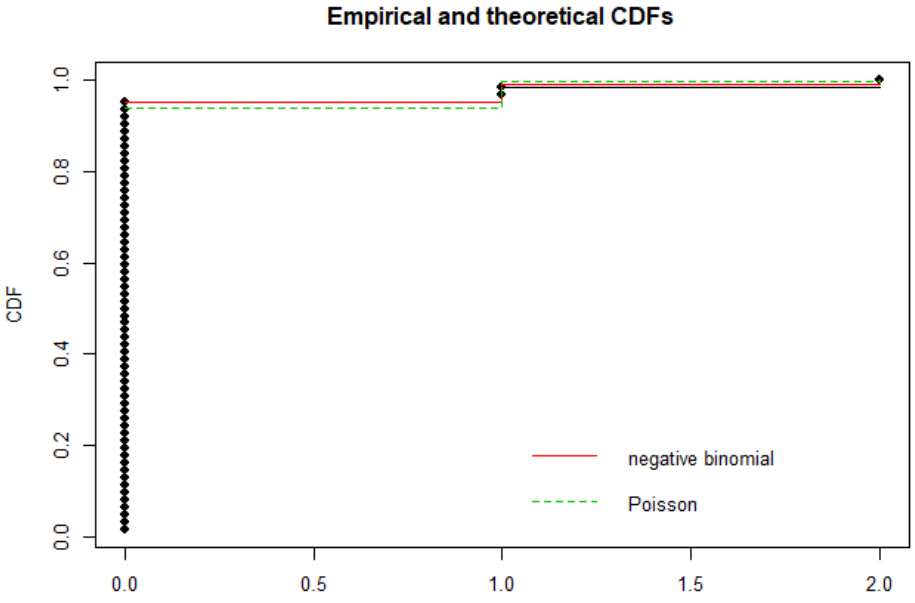


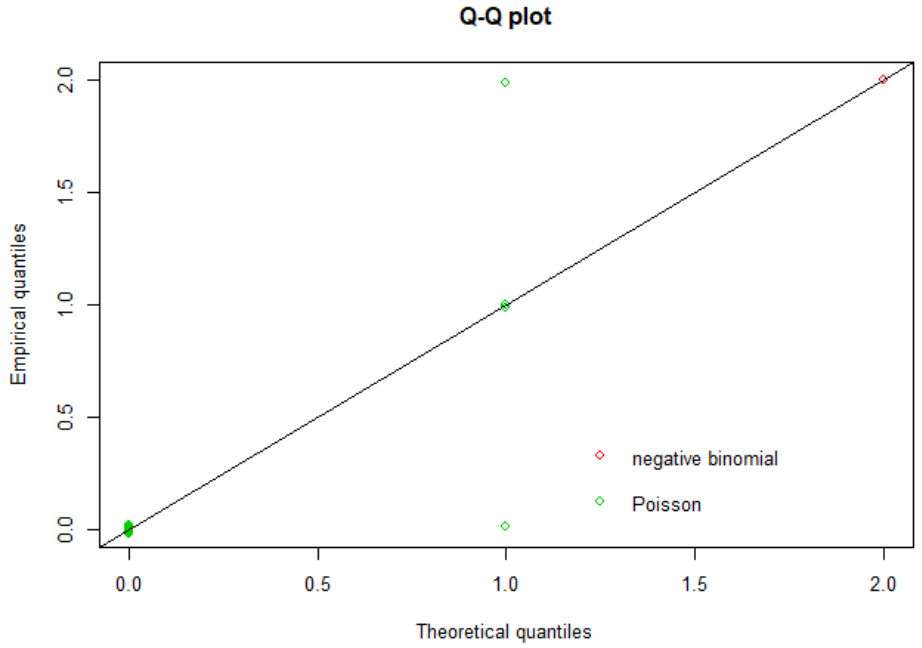




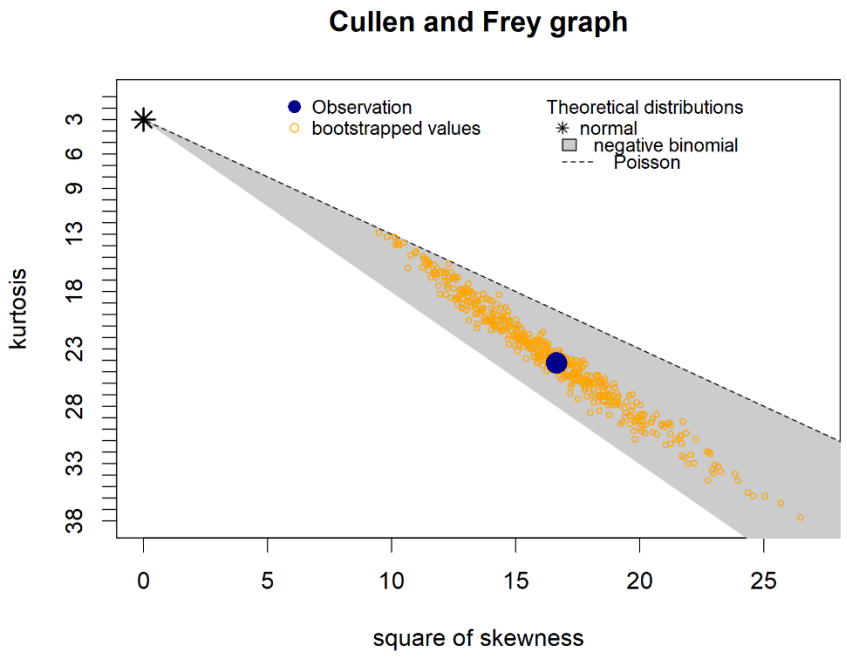
Yelloweye Rockfish - Cape Perpetua (FG & RG)

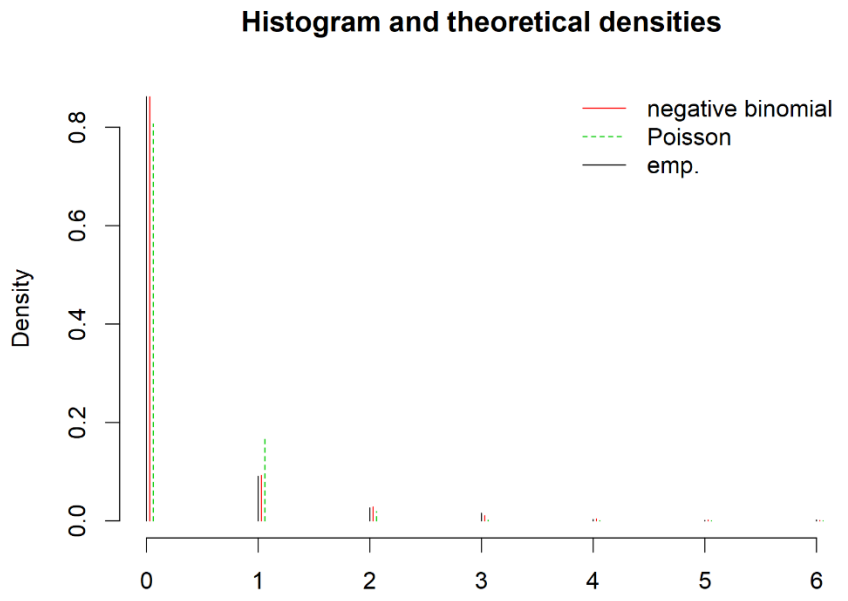


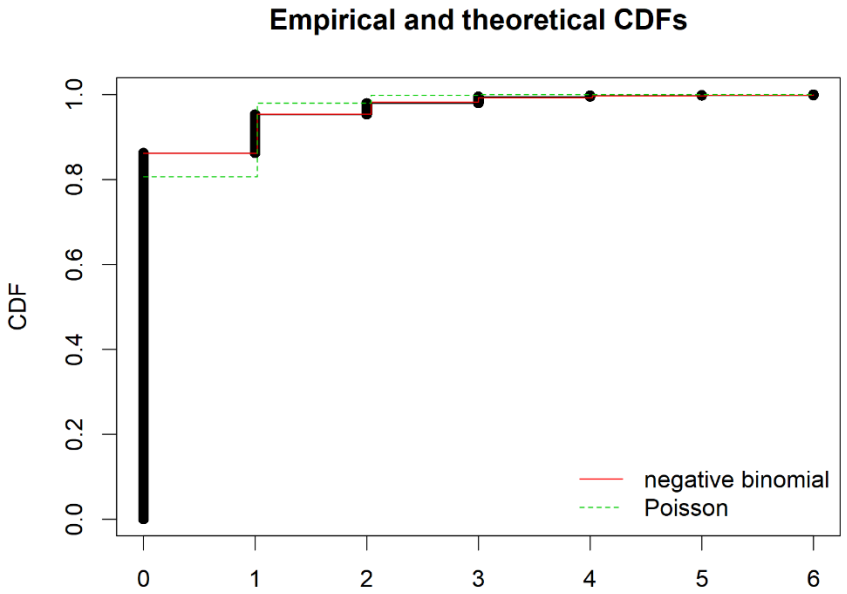


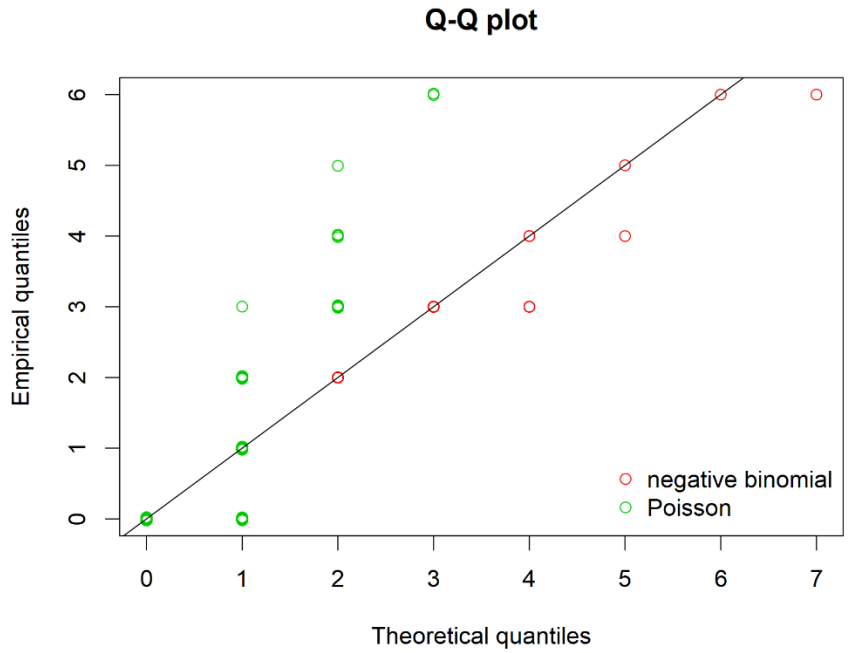


Yelloweye Rockfish - Offshore (FG)

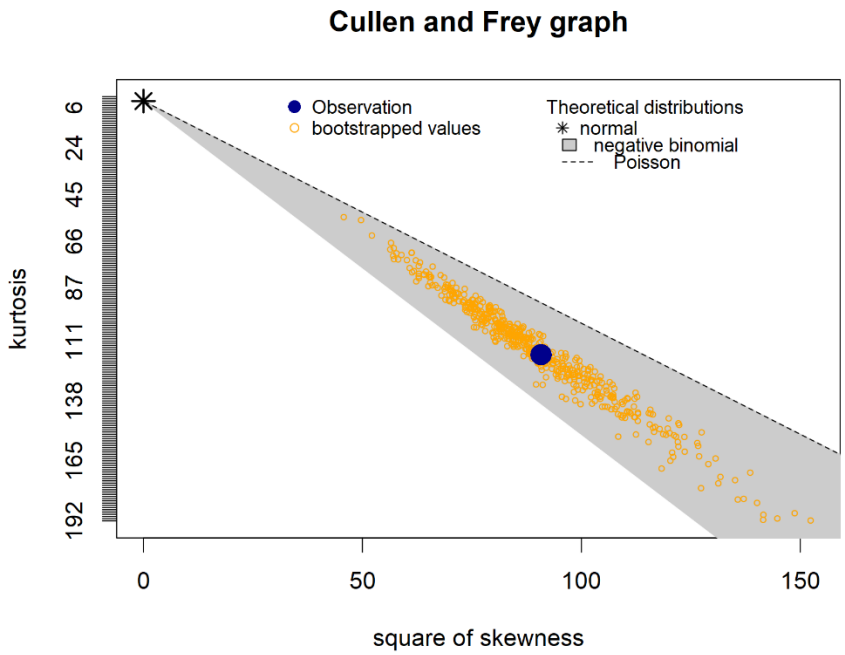


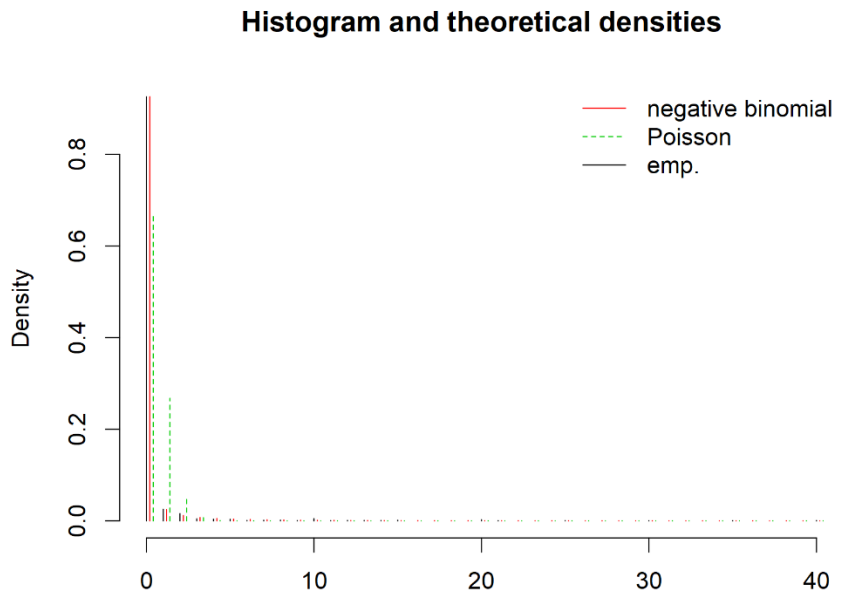


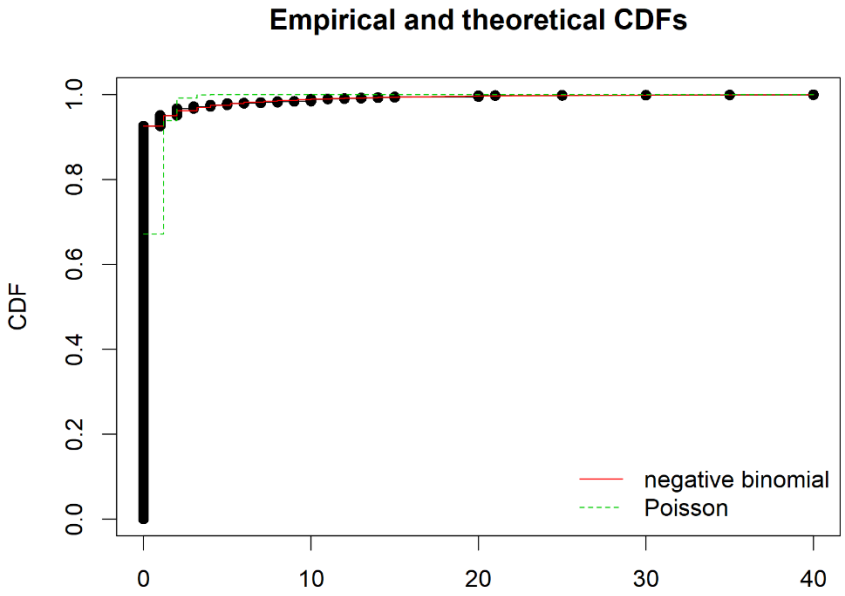


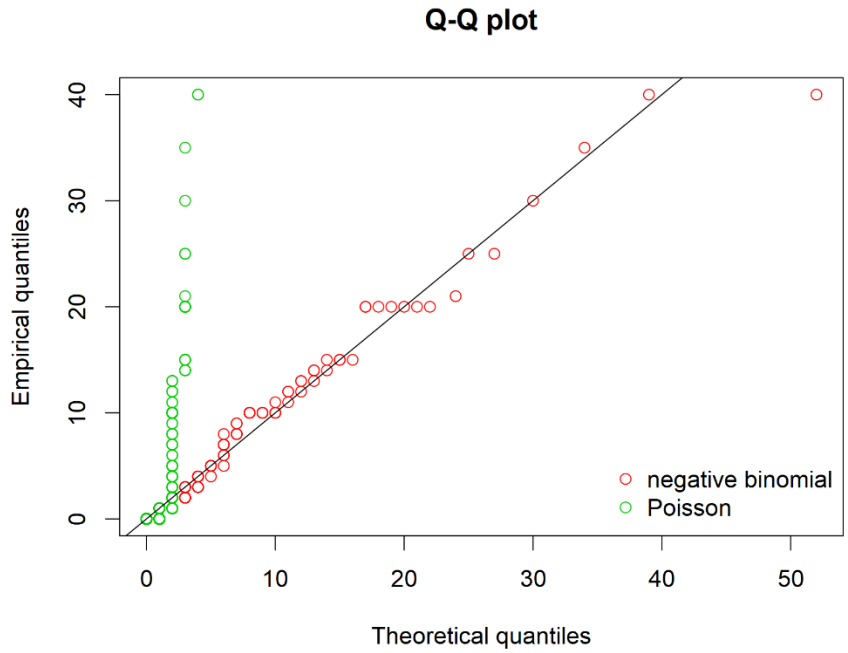


Yellowtail Rockfish - Entire Coast

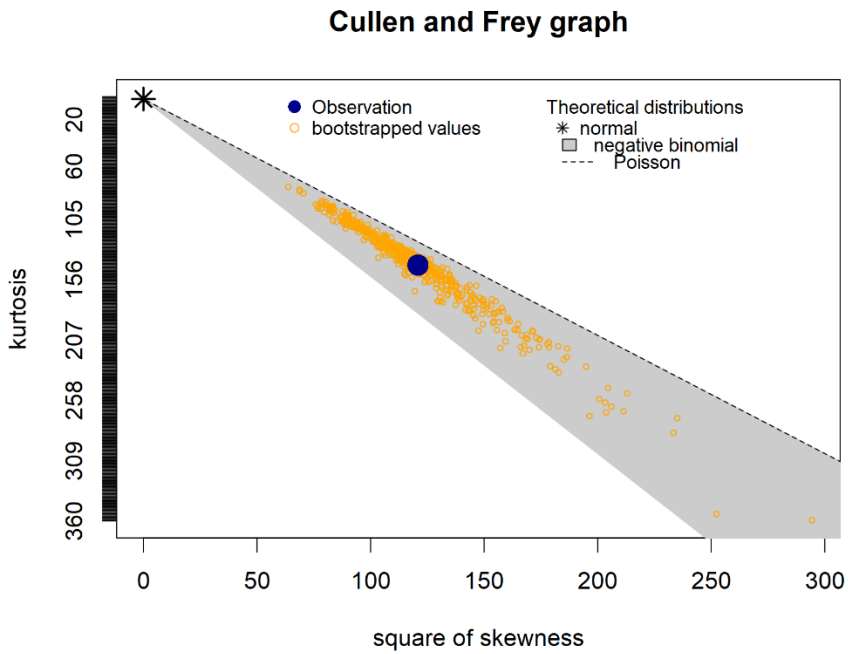


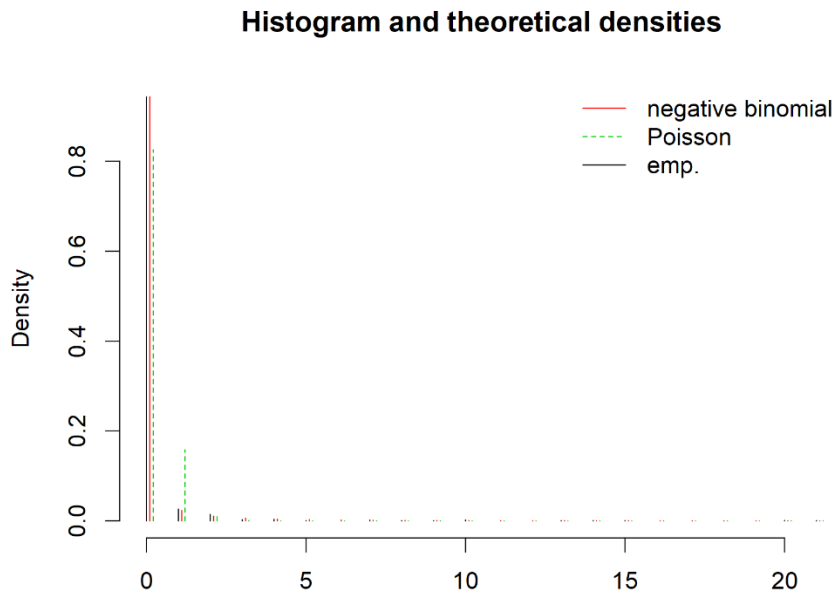


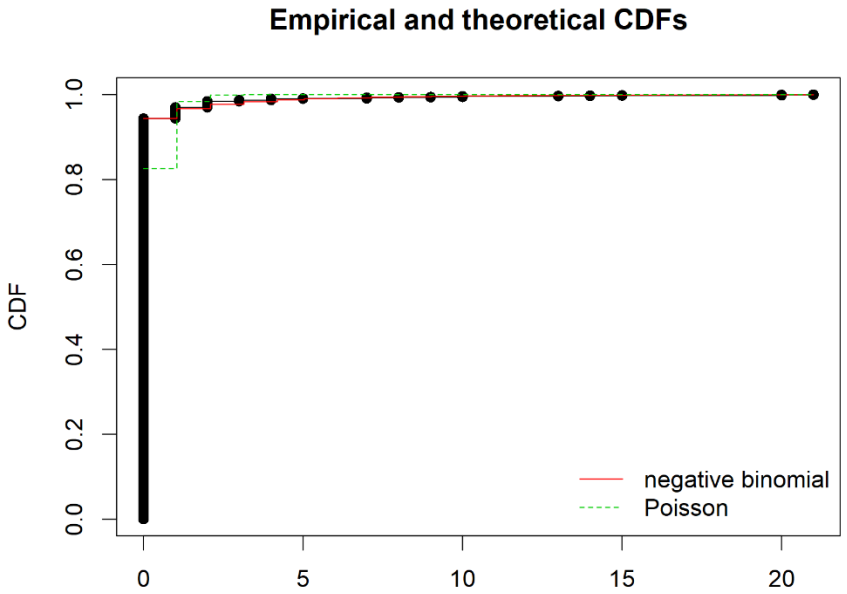


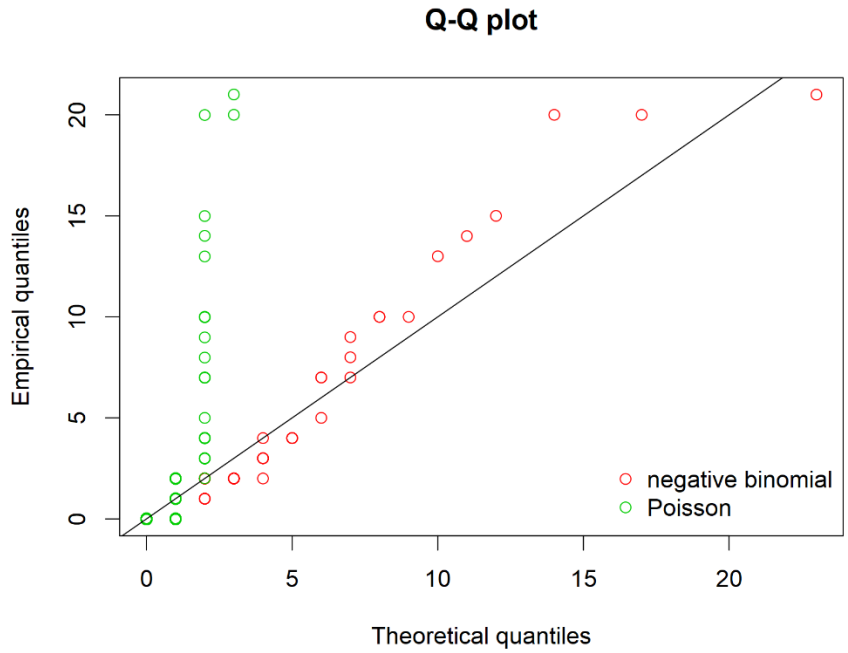


Yellowtail Rockfish - Nearshore

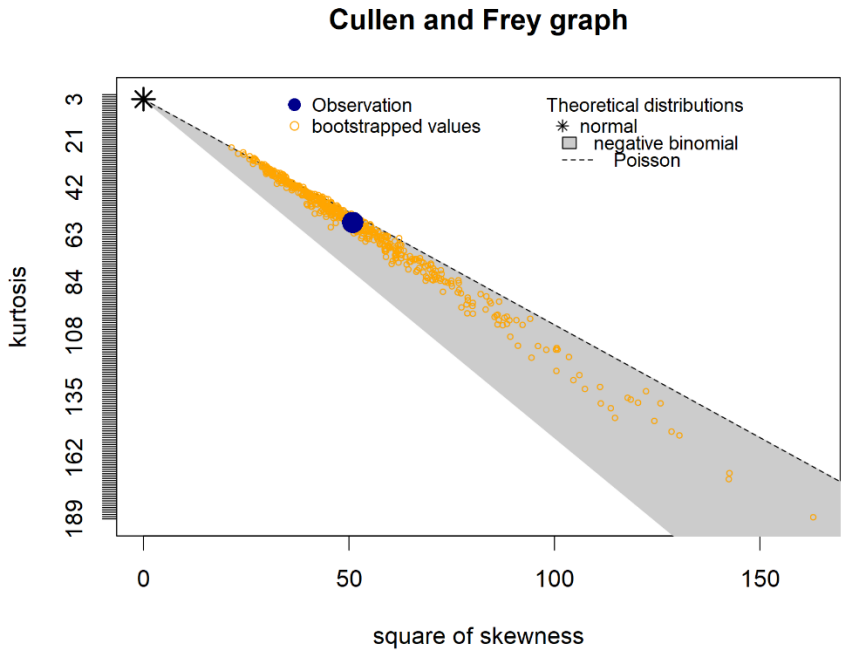


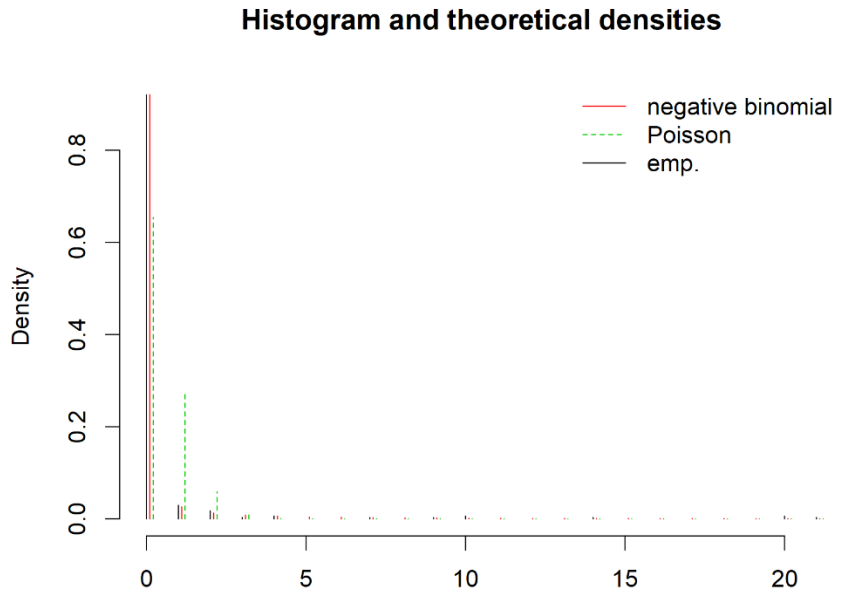


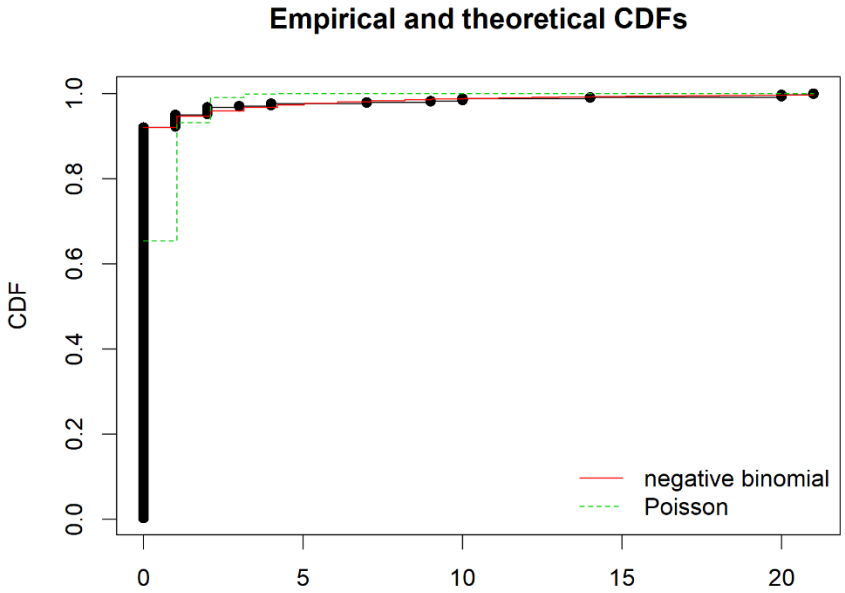


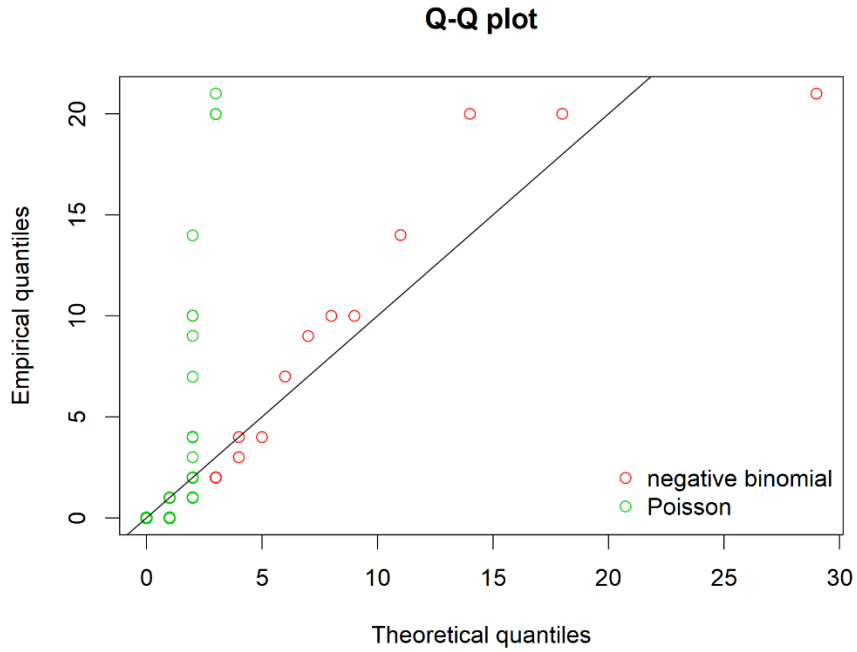


Yellowtail Rockfish - North Coast (FG & RG)

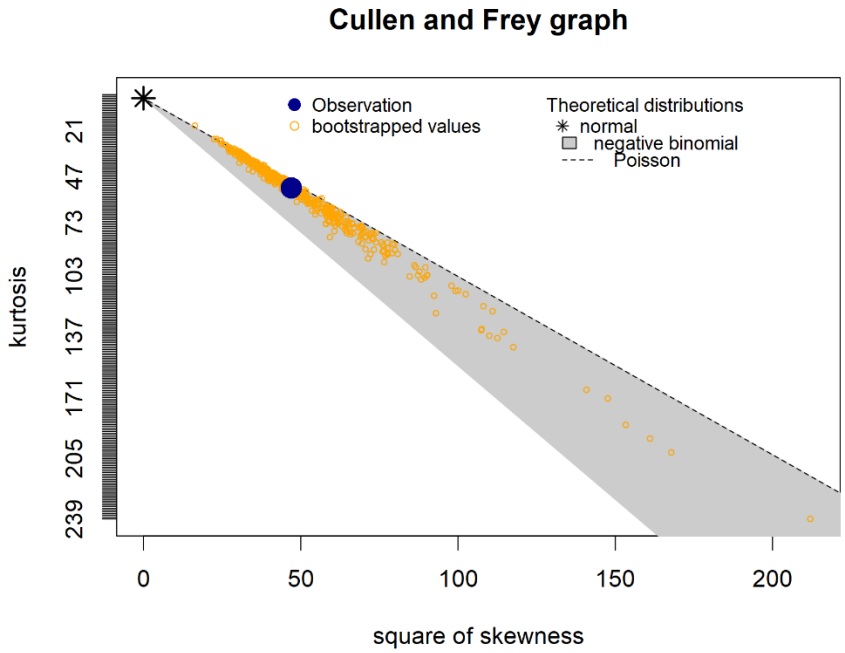


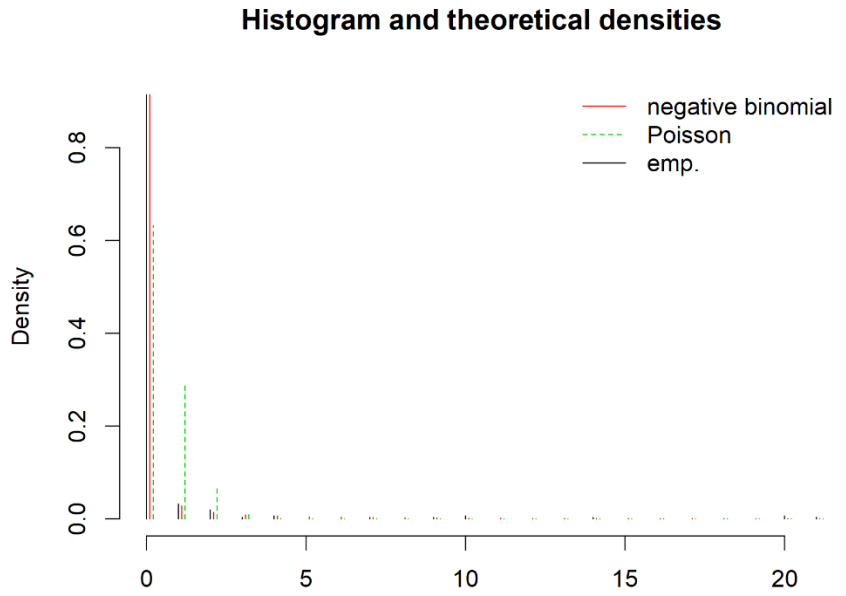


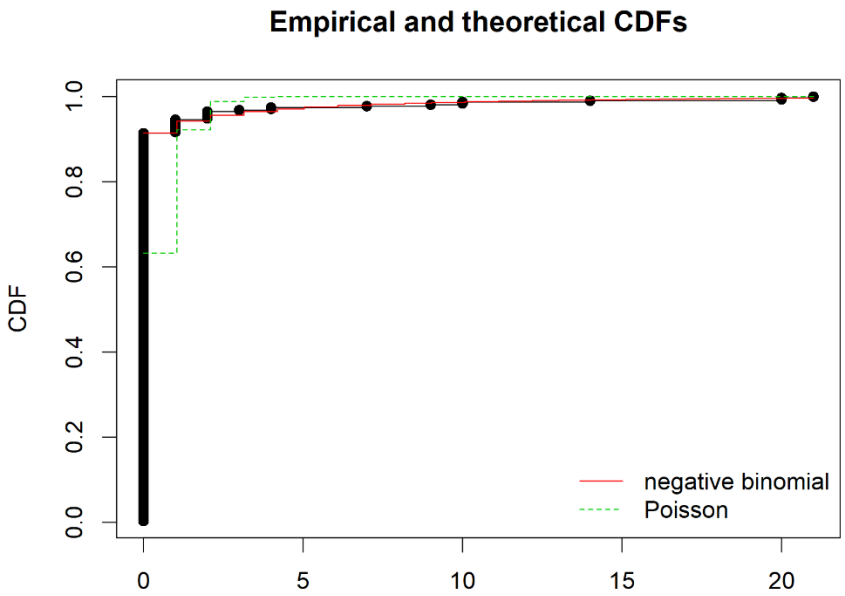


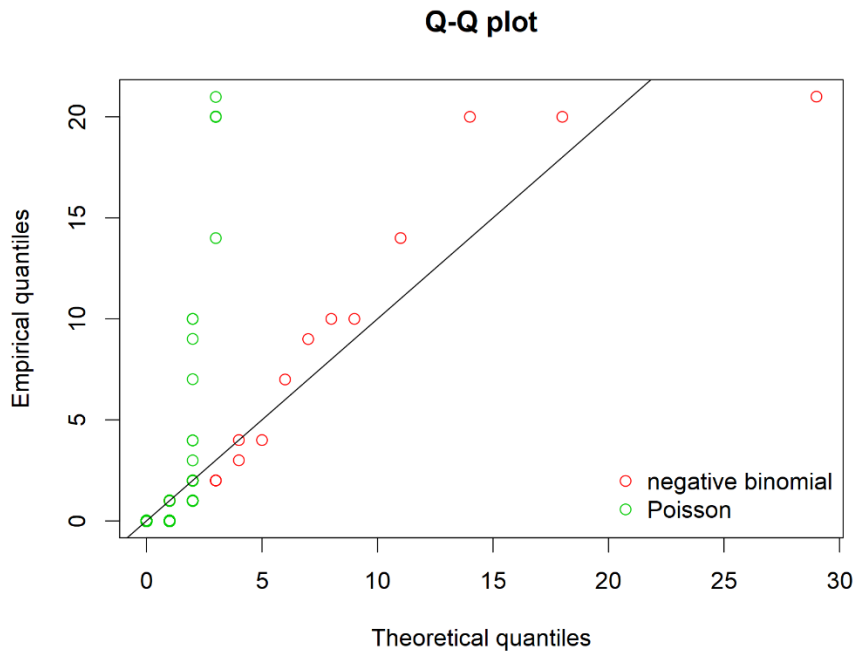


Yellowtail Rockfish - North Coast (FG)

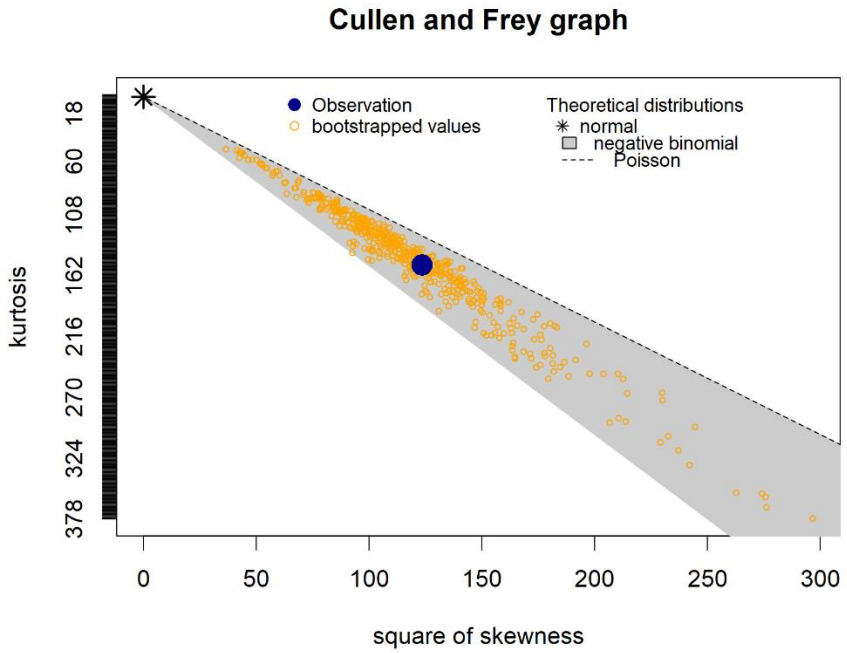


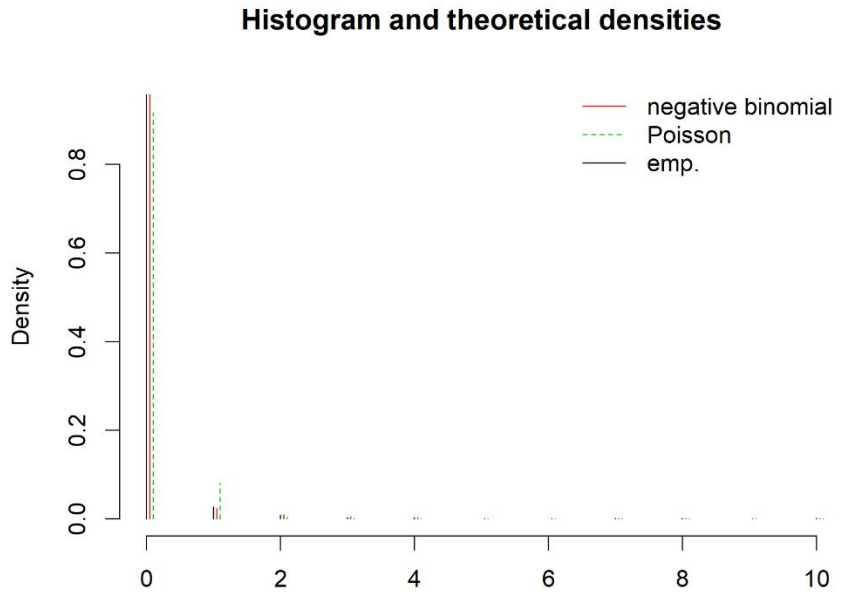


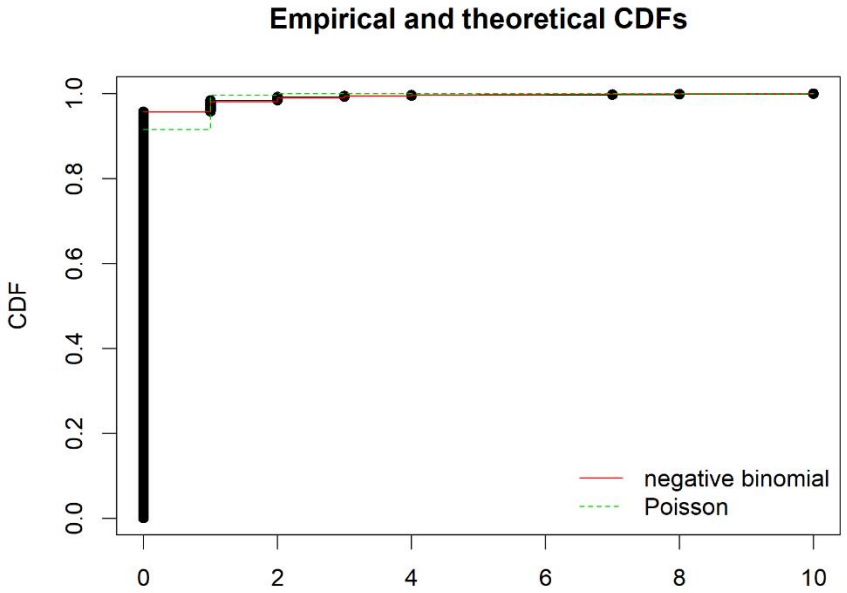


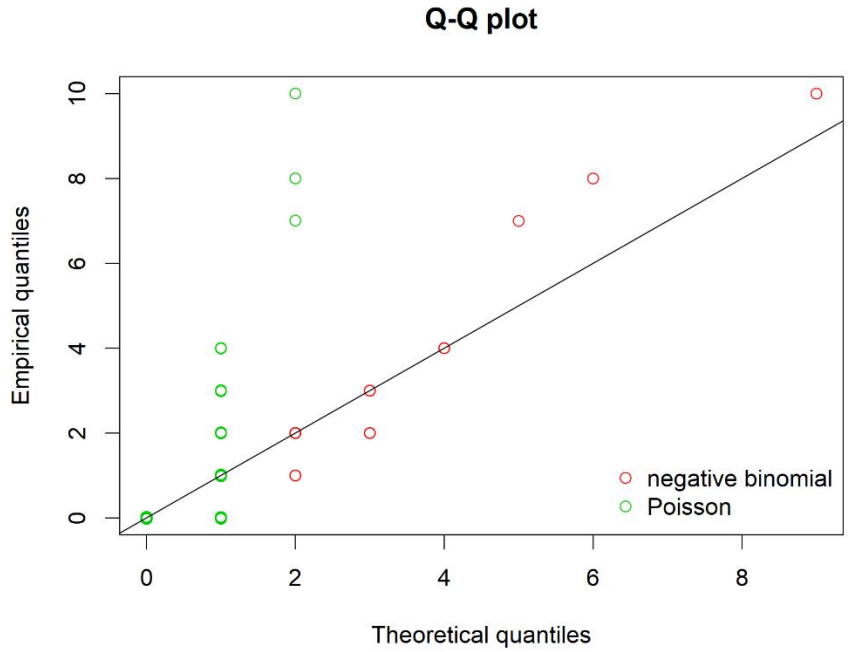


Yellowtail Rockfish - Central Coast (FG, RG, & NG)

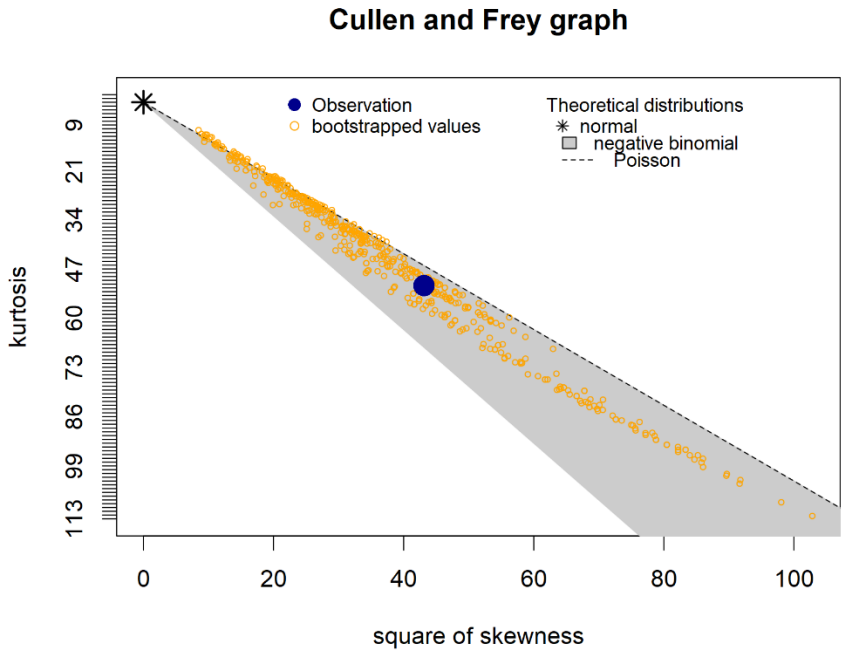


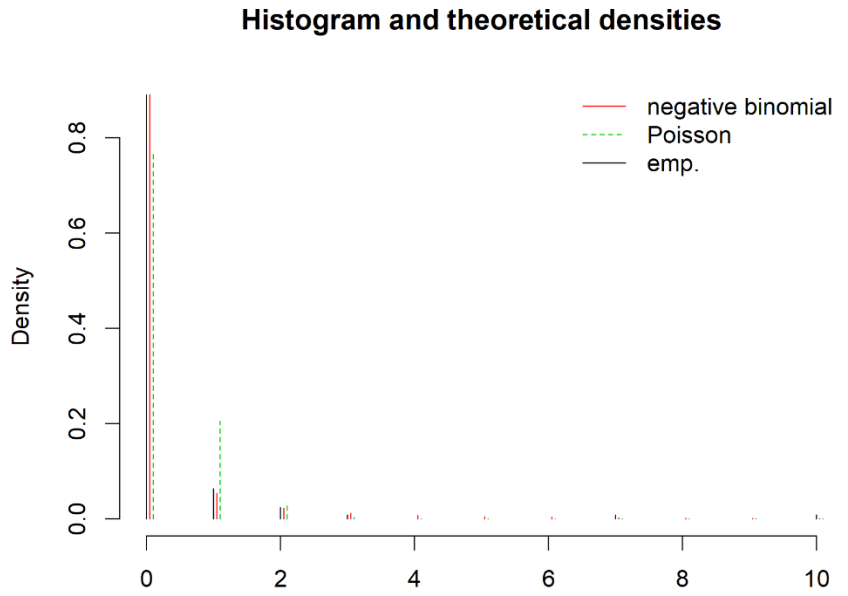


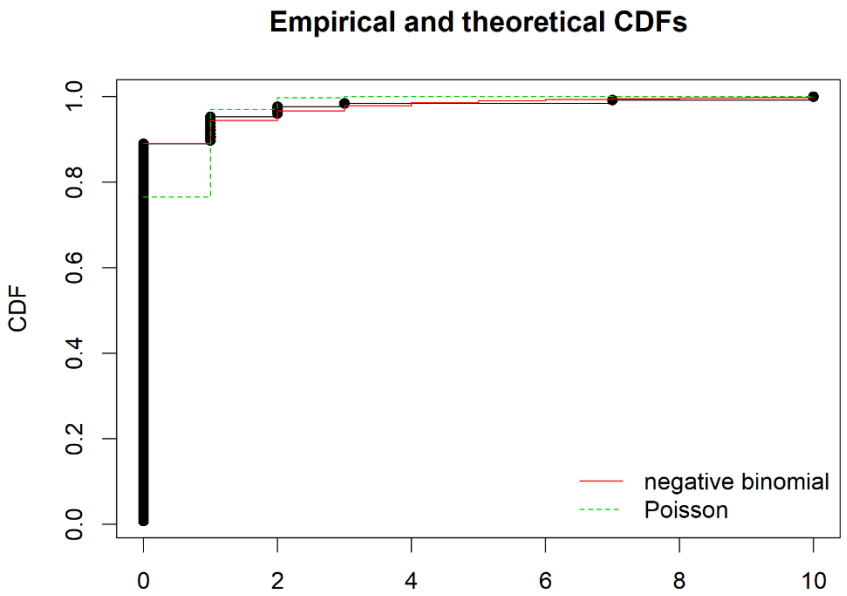


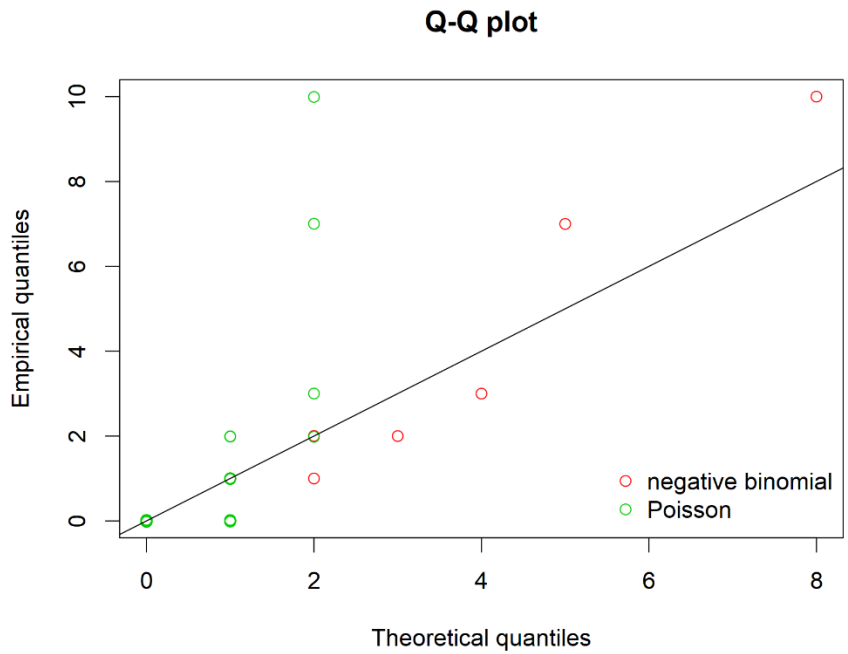


Yellowtail Rockfish - Central Coast (FG)

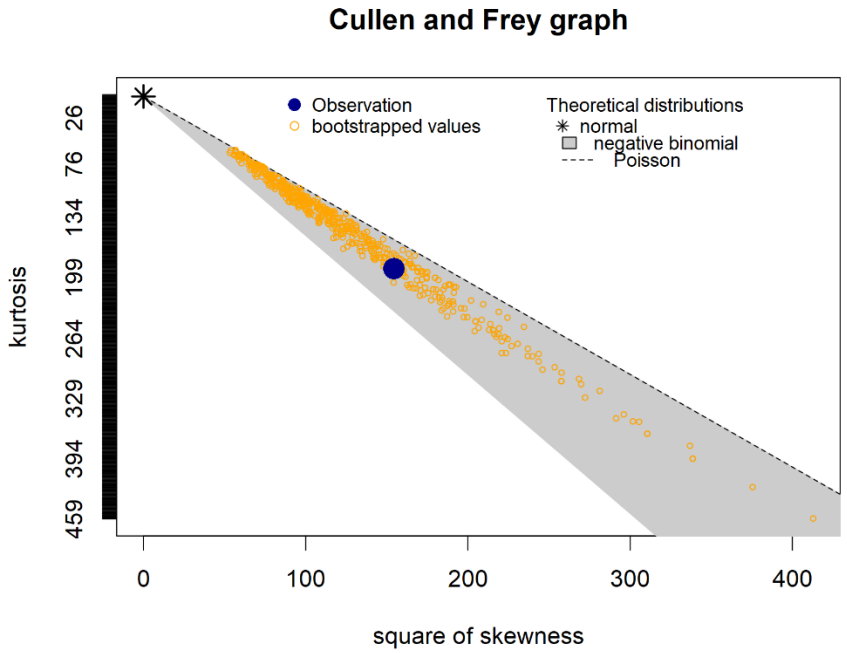


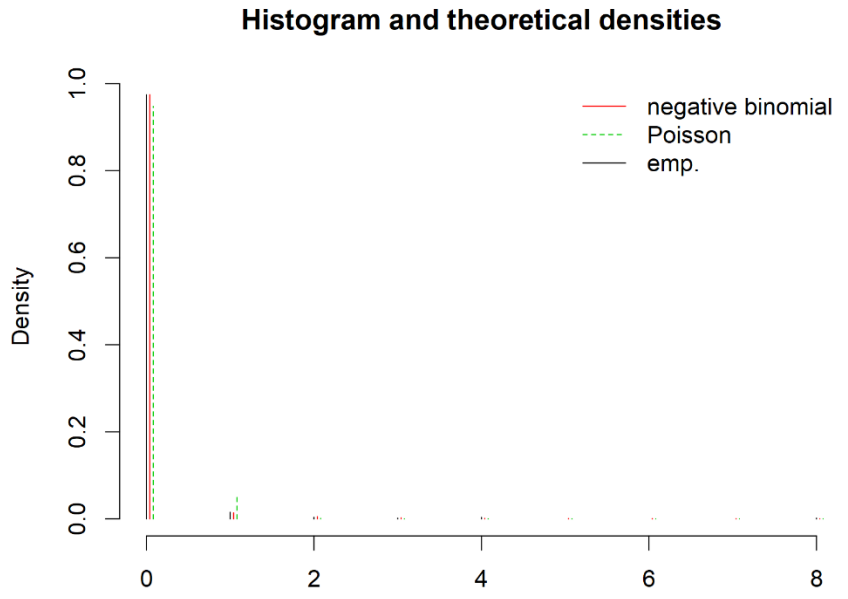


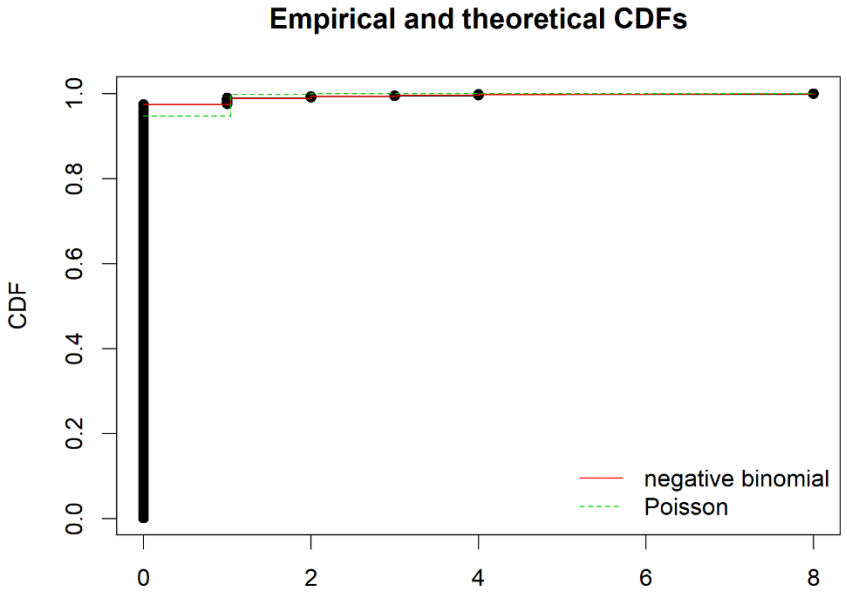


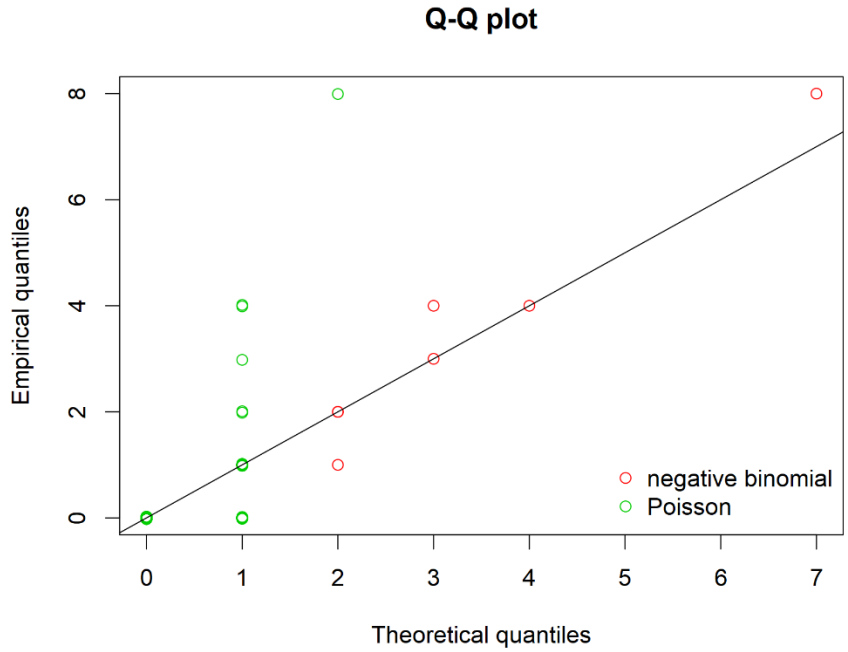


Yellowtail Rockfish - Central Coast (RG)

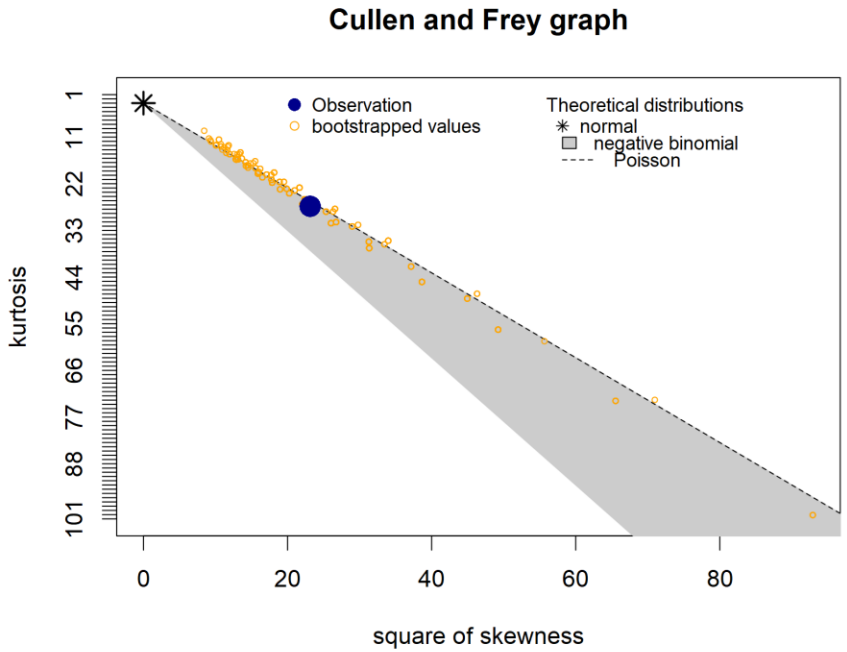


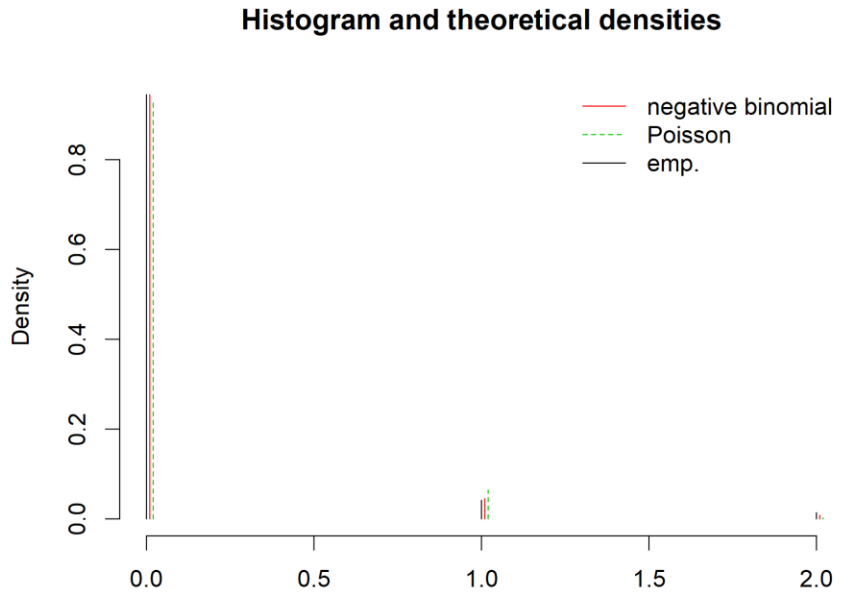


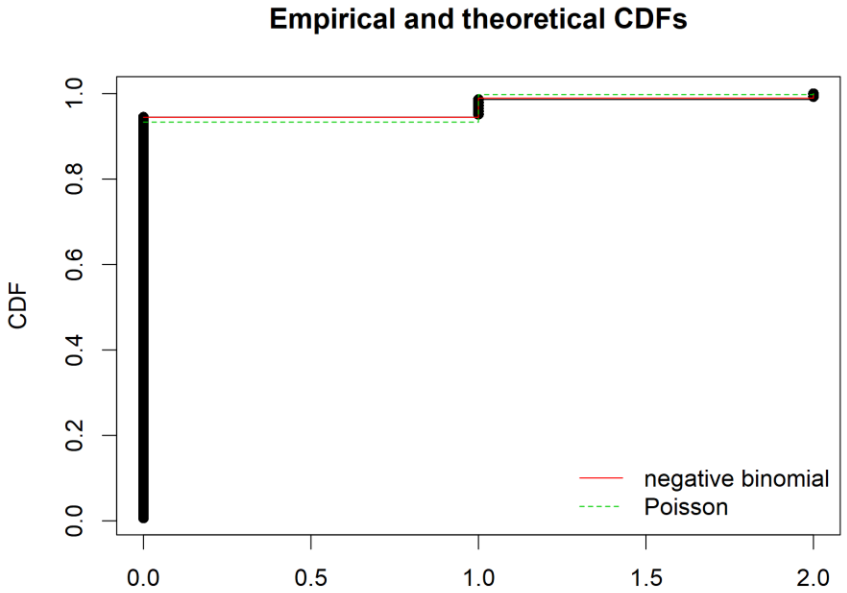


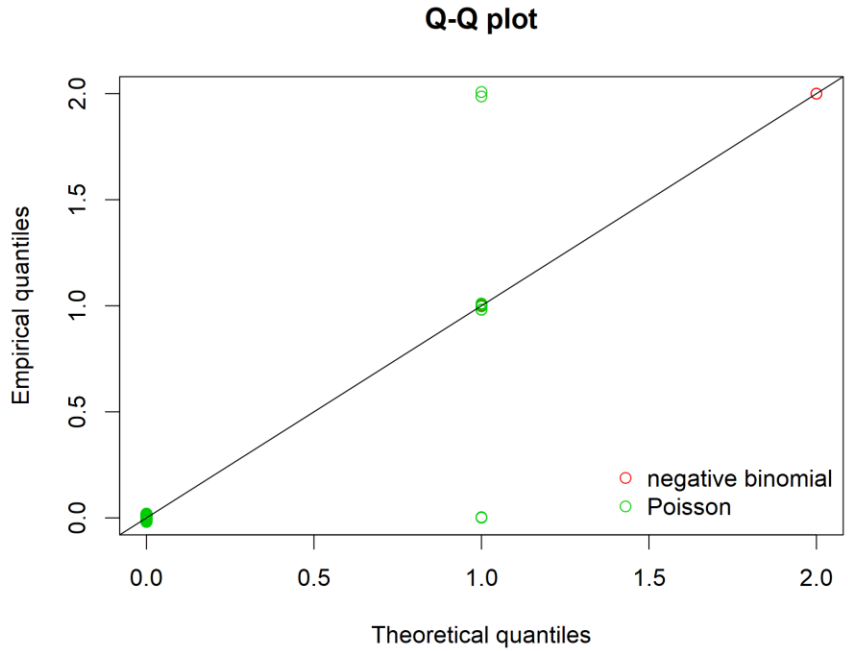


Yellowtail Rockfish - Central Coast (NG)

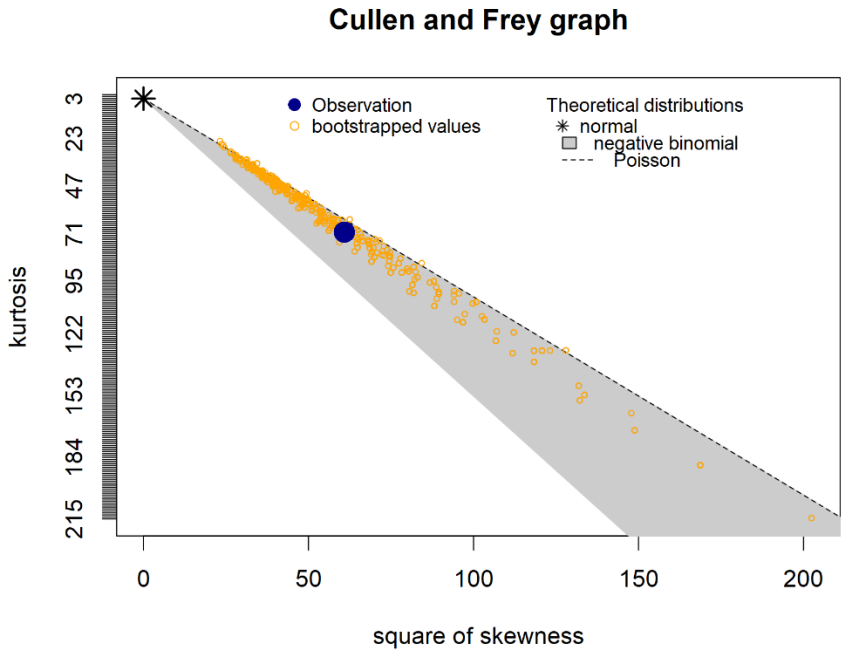


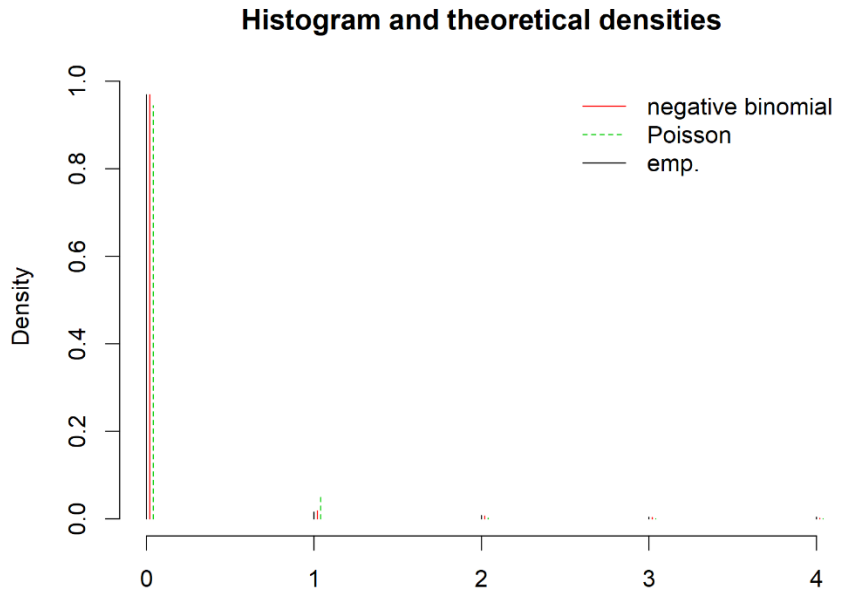


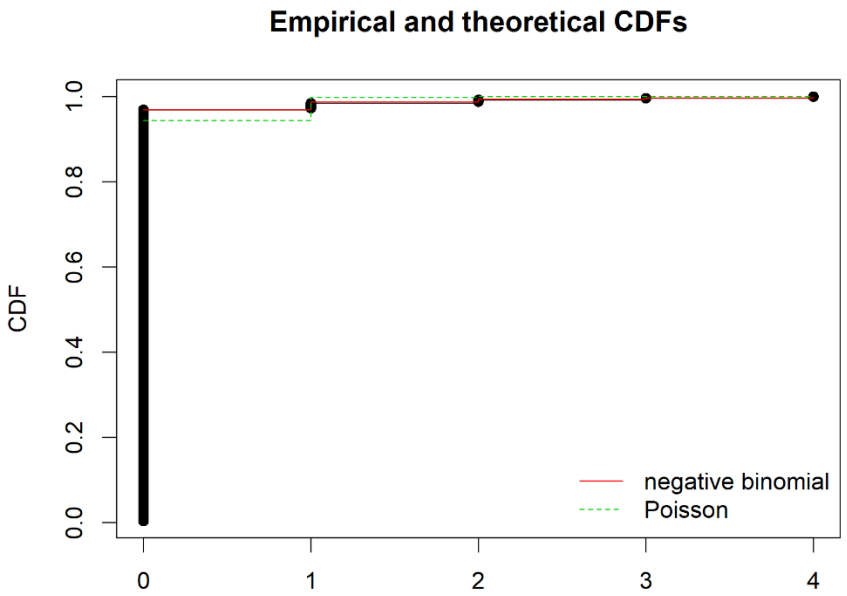


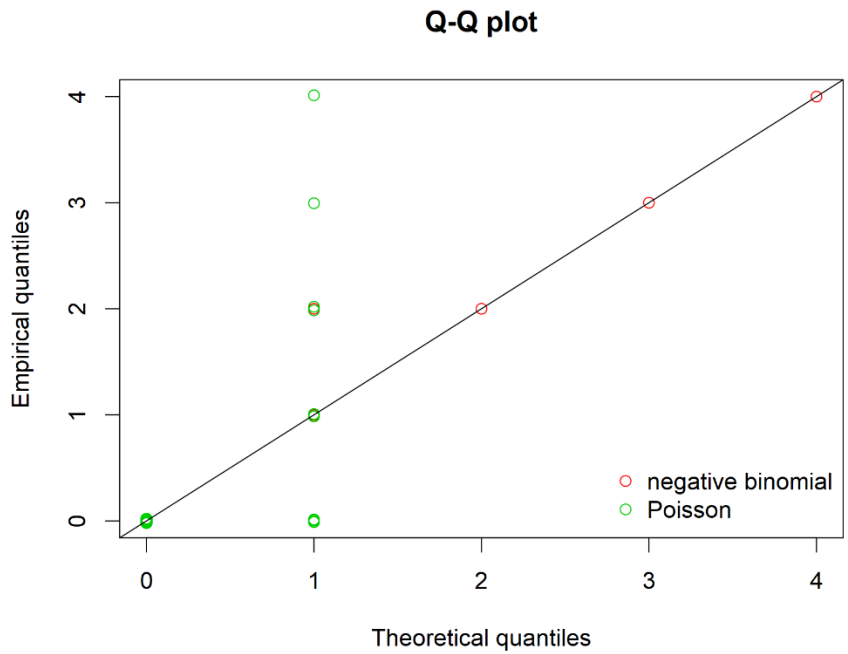


Yellowtail Rockfish - South Coast (RG)

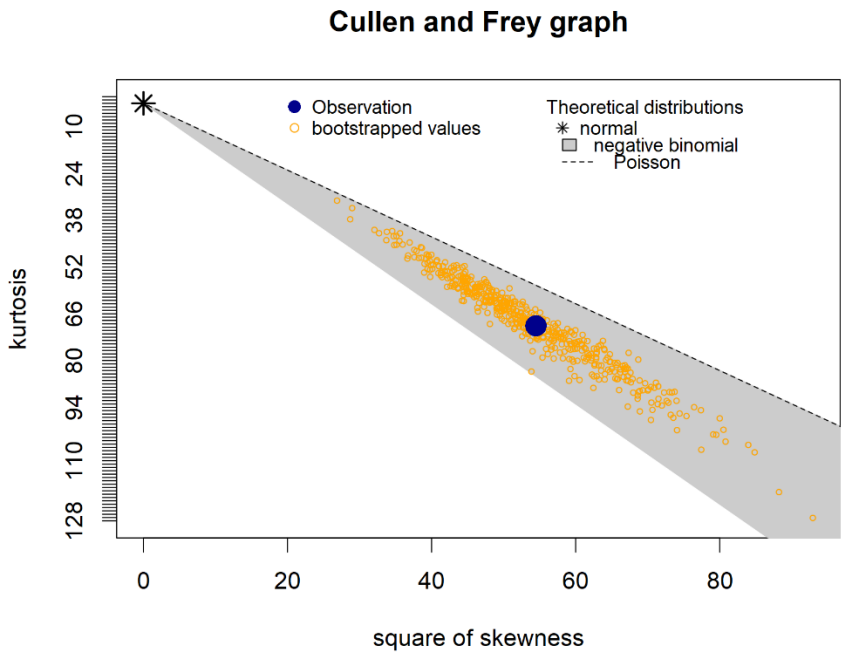


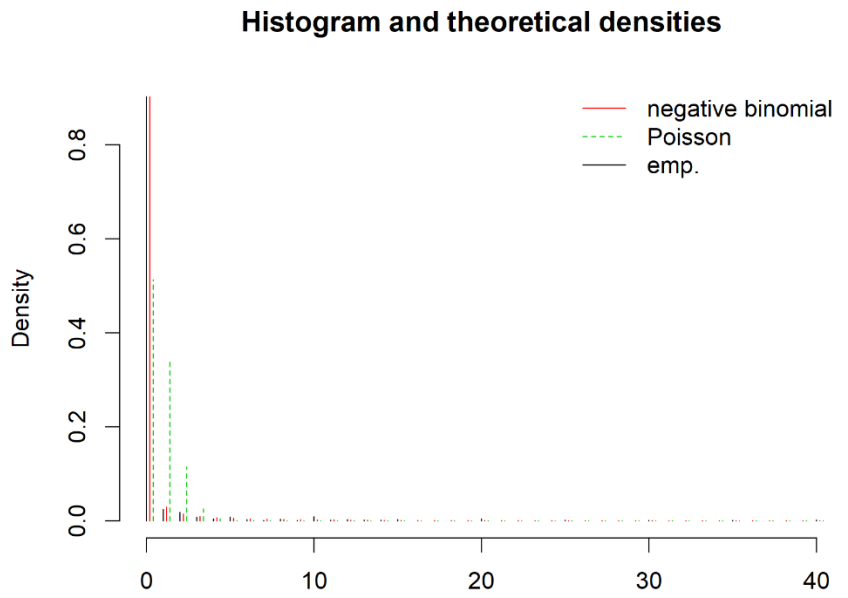


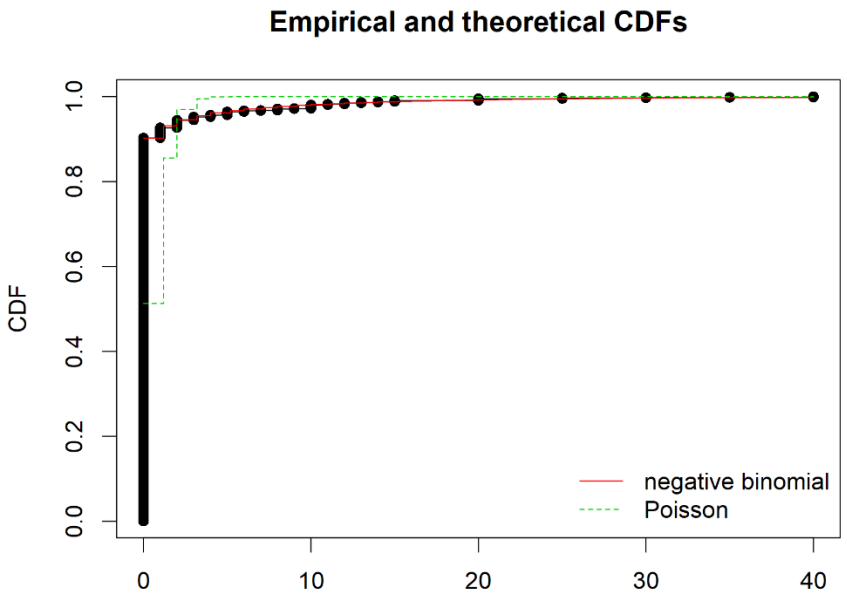


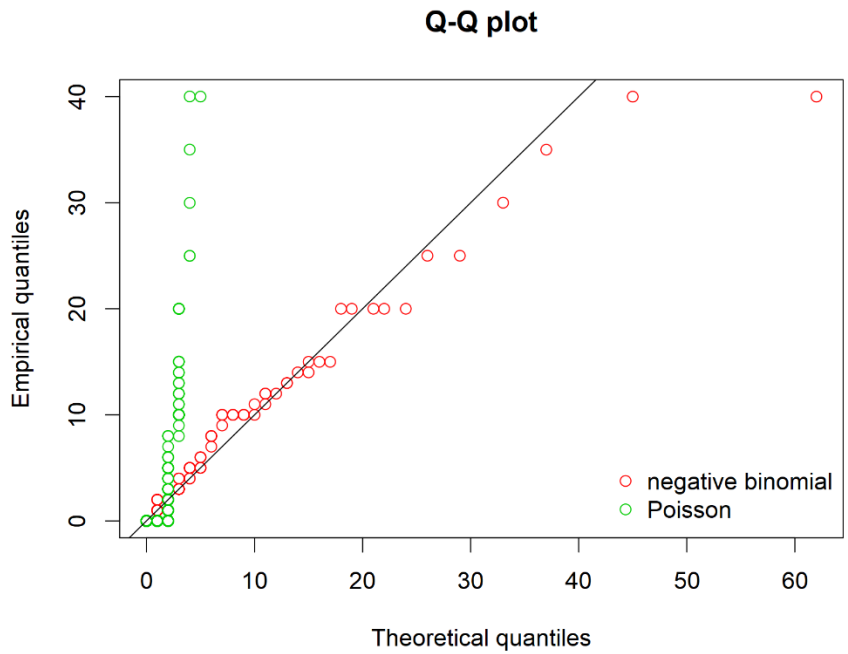


Yellowtail Rockfish - Offshore (FG)









Appendix D. Design simulations of a Yelloweye Rockfish video lander survey

Leif K. Rasmuson & Kelly A. Lawrence

Statement of the problem:

Yelloweye Rockfish (*Sebastes ruberrimus)* is a rebuilding species on the U.S. West Coast with a low annual catch limit which constrains the ability of recreational and commercial fishers to prosecute their fisheries in Oregon's waters. Accurate estimates of biomass and productivity are critical, and a fishery independent survey of Yelloweye Rockfish abundance is needed to create indices of abundance for future stock assessments. Here, we use underwater video lander data, collected by the Fisheries Group, to parameterize a variety of simulations of an annual synoptic fishery independent survey for Yelloweye Rockfish, and we provide a table of estimated uncertainty and cost.

Methods and Results

Our survey design is based on the video lander survey methodology employed by the National Marine Fisheries Service in the Gulf of Mexico (Gledhill et al. 2010). In short, the survey design is one or more random video lander deployments within a regular sampling grid. The implications of different survey designs were tested in the following simulations.

Step 1: Use observation data to determine simulation parameters

We first modeled Yelloweye Rockfish count data with a negative binomial distribution using the "Fitdistrplus" package in R (Fig. D1). The mean and size parameters were generated using the "rnorm" function in R in conjunction with the count values, and the "fitdistrplus" function. Our estimates suggested that Yelloweye were described by a mean of 0.184 ± 0.015 and size (overdispersion) 0.188 ± 0.029. These parameter estimates, and their associated uncertainty, were then used to simulate Yelloweye distributions throughout Oregon's continental shelf waters.

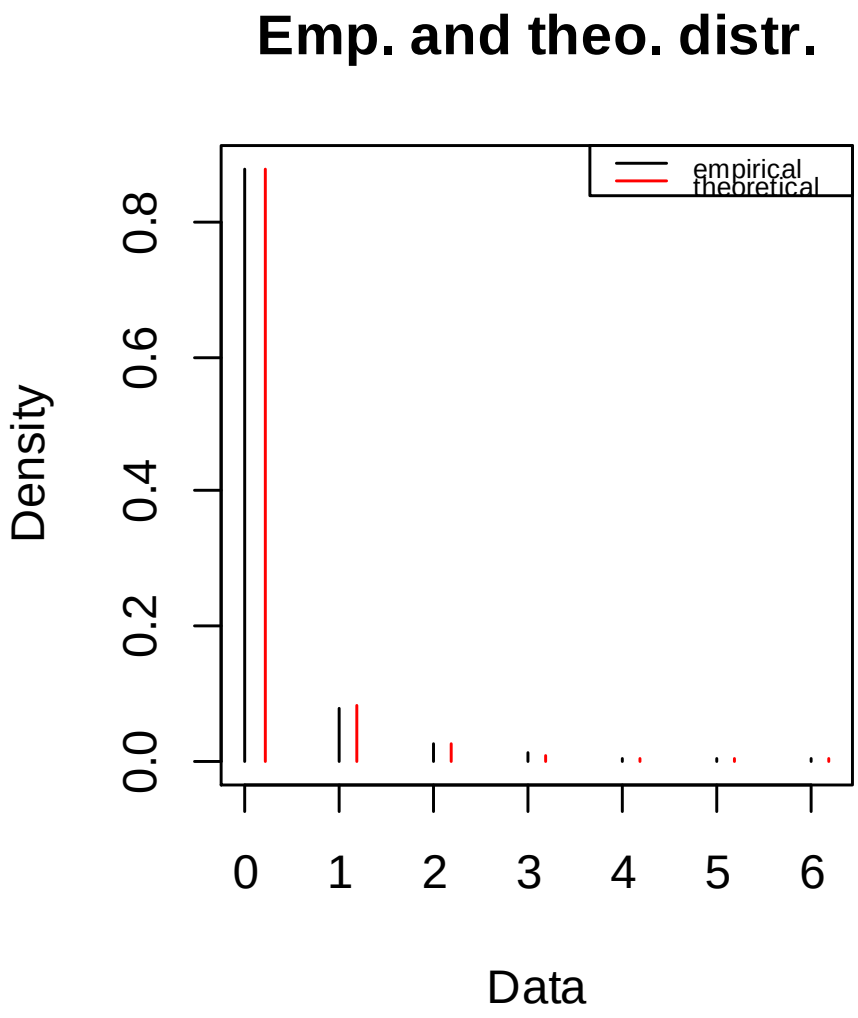


Figure D1. Empirical vs. theoretical fits of negative binomial data to Yelloweye Rockfish observation data (raw counts) acquired from lander video collected by the Fisheries Group.

Step 2: Create survey study area

We designed the survey to only occur in water depths ranging from 20 – 200 m based on the known distributions of Yelloweye Rockfish (Love et al. 2002). Our study area was therefore bounded by the 20 and 200 m depth contours to the east and west respectively, as well as the California border to the south, and Washington border to the north. We then divided this sampling area into a series of five sampling grids, each with cells of increasing resolutions. The five sampling grid resolutions were: 0.25, 0.5, 1, 5, and 10 mi square grid cells. The remaining steps of the simulation were performed on each of the five sampling grids.

Step 3: Determine expected relative uncertainty

Using the average mean and size estimates and their associated uncertainties determined in Step 1, and the rnegbin function in R, we simulated 1,000 surveys within each of the five sampling

grids. For this initial simulation we assumed a rectangular survey area of 6,000 mi^2 (300 mi x 20 mi) roughly based on the length of the Oregon coast and width of the continental shelf. These methods were repeated with 1, 2, 3, … and 8 individual lander deployments per grid cell. We then determined the mean and standard deviation of Yelloweye Rockfish counted for each grid cell/number of deployments combination. For each combination we calculated the relative uncertainty as

$$Relative\ Uncertainty = \frac{(\sigma^2_{obs} - \sigma^2_{min})}{(\sigma^2_{max} - \sigma^2_{min})} \quad \text{D1}$$

where σ^2 denotes the standard deviation. The subscript denotes: *min*, overall minimum standard deviation; *max*, overall maximum standard deviation; and *obs*, the specific grid cell size/number of deployments standard deviation.

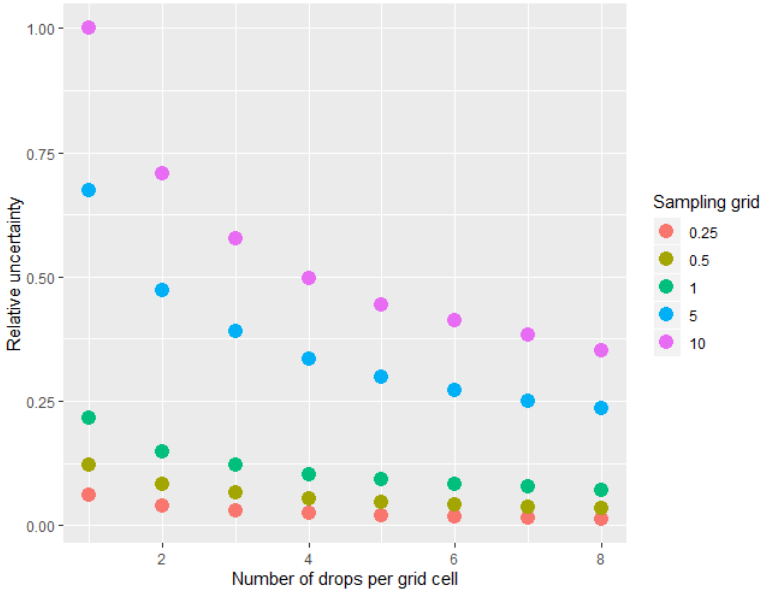


Figure D2. Relative uncertainty in fish count data for increasing number of drops in each grid cell, for each sampling grid. Relative uncertainty is negatively associated with the number of deployments per grid cell and positively associated with the size of the sampling grid.

We observed an overall reduction in uncertainty by increasing the number of deployments per grid cell (Fig. D2). However, we also observed a significant decrease in relative uncertainty for ≤1 mi square grid cells. Therefore, due to the much lower uncertainty for smaller grid cell sizes (≤1 mi), subsequent analysis focused only on the 0.25-1 mi sampling grids.

Step 4: Filtering by habitat type and number of deployments

The Primary Lithology (Lith1) classification in the Surficial Geologic Habitat Map Version 4.0 (Goldfinger et al. 2014) was used to determine the relative composition (percentage) of substrate types for each grid cell. From this, we calculated the number of grid cells that would remain in each sampling grid if we filtered grid cells based on the percentage of rock occurring in each grid cell (Table D1).

For this step we assumed only one deployment per grid cell, therefore the number of grid cells is equal to the number of deployments. Previous research has shown that one limiting factor of video lander surveys is amount of time required for video review. Video review is time consuming and cost prohibitive, and therefore limits the maximum number of video lander deployments feasible for a statewide survey. In order to complete video review in a timely manner, the number of videos collected for this statewide survey simulation has been limited to approximately 2,000 deployments.

Table D1. Number of grid cells in each sampling grid (0.25, 0.5 and 1 mi) for different rock cover percentages. We assumed one deployment per grid cell, therefore the number of grid cells is equal to the number of deployments. Rows shaded red denote where the number of deployments conducted would result in collecting >2,000 videos.

Percentage of cell that is rock	0.25 mi grid	0.5 mi grid	1 mi grid
>0	14,874	4,533	1,490
≥25	12,050	3,184	866
≥50	10,662	2,715	684
≥75	9,416	2,217	510
=100	7,389	1,458	241

Due to the exceedingly large number of deployments that would need to be completed, based on the above simulation, we were able to eliminate the entire 0.25 mi sampling grid, and all of the 0.5 mi grid cells with less than 100% rock coverage from further analysis. We also see that in order to keep sampling effort below 2,000 deployments, the 0.5 mi grid cells with 100% rock coverage, and the 1 mi grid cell with >0% rock coverage, could not exceed one deployment per grid cell.

Step 5. Examining the implications of each decision

Our next step was to examine how the selection of different filters based on percentage rock would affect the survey design. First, we looked at the distribution of rock cover for both the 0.5 and 1 mi sampling grids, excluding grid cells with zero rock coverage. We observe that the majority have 100% rock substrate, but the number of grid cells with small percentages of rock increases as grid cell size increases (Fig. D3).

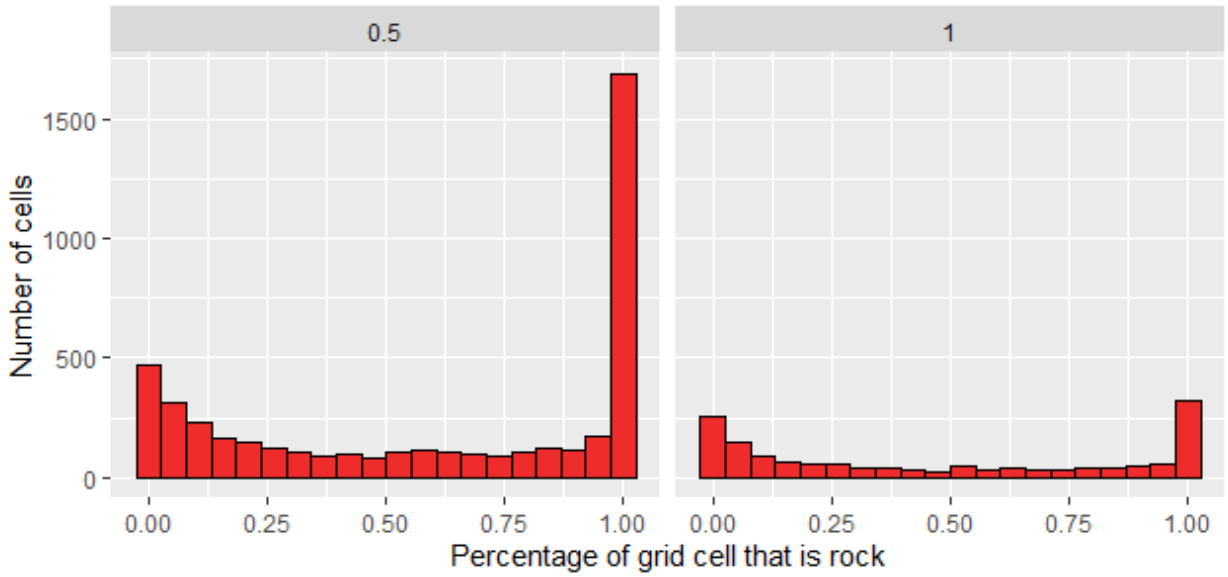


Figure D3. Distribution of rock percentages in grid cell sizes of 0.5 and 1 mi excluding grid cells with no rock coverage.

Second, we examined how changing the percentage of rock in the grid cell would influence the deployment location. Specifically, we examined the latitudinal and depth effects (Fig. D4-5). As grid cell size increased from 0.5 to 1 mi, the grid cells became concentrated at a depth of ~100 m and a latitude of 44.25° N. Expressly, the survey effort is concentrated on Heceta Bank and Stonewall Bank. This is due to the fact that on the continental shelf, these two reefs represent the largest continuous reef tracts. Maps of these effects are presented at the end of this appendix (Fig. D6-7).

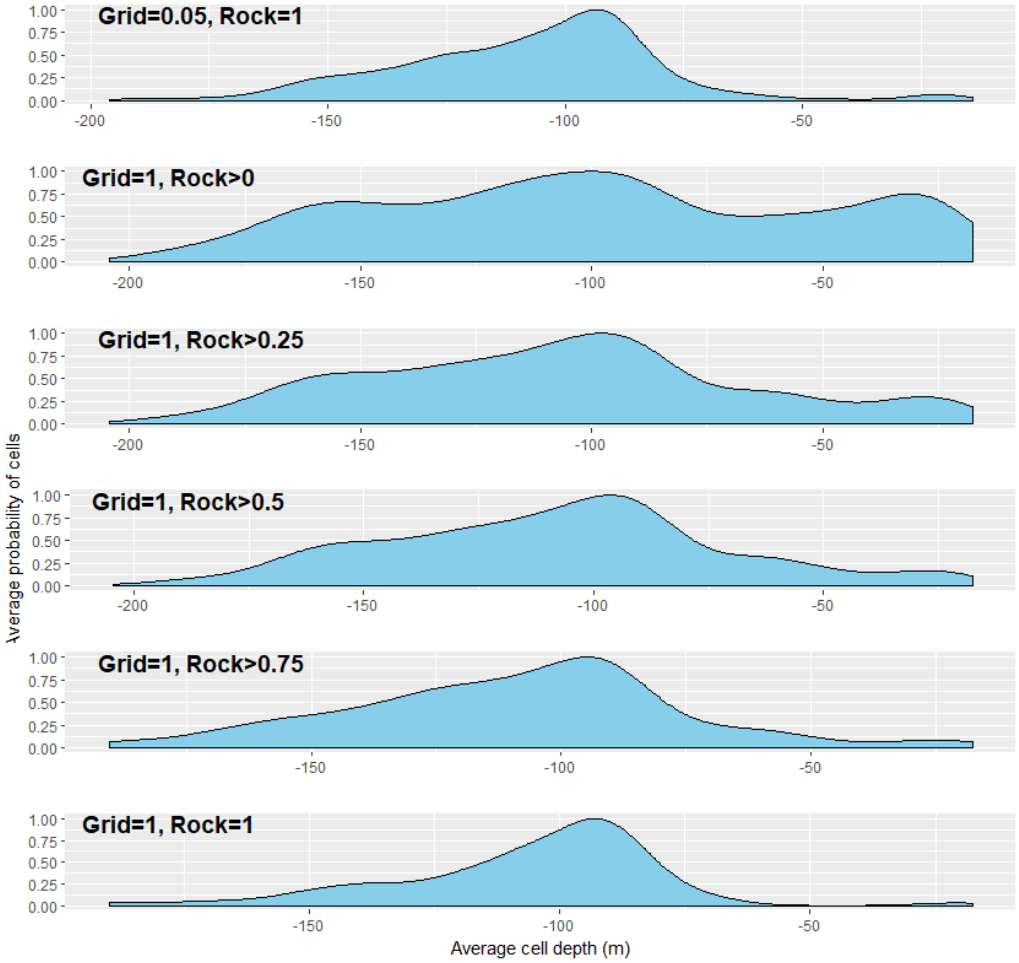


Figure D4. Probability density distribution function for average grid cell depth for each sampling grid cell size, and percentage of the grid cell area that is rock.

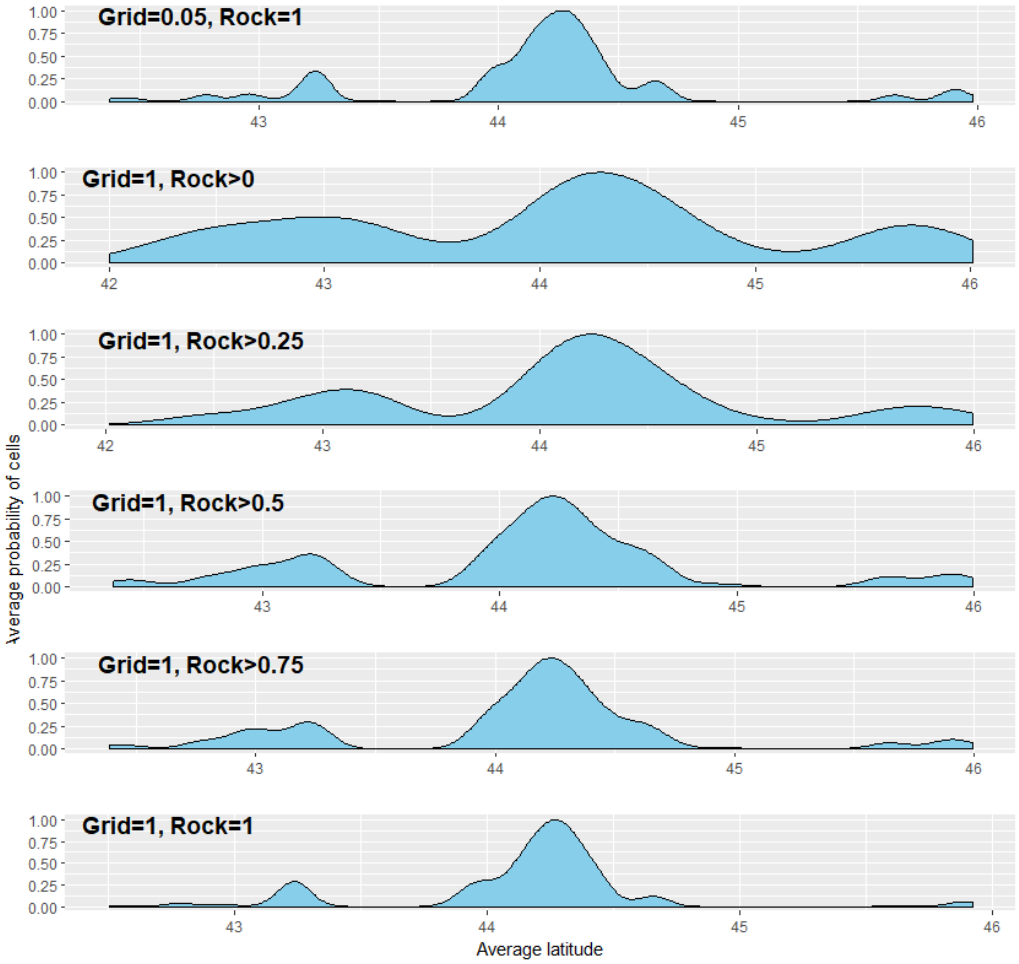


Figure D5. Probability density distribution function for average grid cell latitude for each sampling grid cell size and percentage of the grid cell area that is rock.

Step 6: Days at sea vs. data collected cost/benefit analysis

We then used the Atlantic Oceanographic Meteorological Laboratory (AOML) cruise design program (R. Smith, AOML) to determine how many days would be spent at sea for each survey design. This program was informed by the latitude and longitude of the center-point of each grid cell, and the number of deployments to be conducted in each grid cell. We assumed survey operations were only conducted during daylight hours, each deployment took 25 minutes, the vessel traveled at 8 knots, and the vessel cost $6,000 per day. The calculated number of days at sea could then be scaled to a total survey cost. These data were then ranked based on the survey cost, total number of drops conducted, and the relative uncertainty from equation D1 (Table D2).

Ultimately, this decision table can be used to balance the need for low uncertainty with the overall cost of conducting a survey. Using this decision table, it is clear that the survey method with the lowest projected uncertainty is not the most expensive survey, but rather, is the only survey slightly above the average cost of all surveys, and results in less than the self-imposed limit of 2,000 deployments (Table D2).

Table D2. Decision table based on parameters for each survey type based on number of drops, grid cell size, and amount of rock in each cell. Green shaded rows denote the top three ranking survey designs based on cost, total number of deployments, or uncertainty. The uncertainty in the results data in this table has been scaled on a 0-1 scale to demonstrate anticipated relative differences in the uncertainty of the data. Data were scaled using the formula D-1.

Sample grid cell size (mi^2)	% cell that is rock	# of deployments per cell	# survey days	Survey cost	Total # of deployments	Uncertainty in results	Survey day /Cost ranking	# deployments ranking	Uncertainty ranking
0.5	100 %	1	30	$180,000	1458	0.339	8	7	5
1	> 0 %	1	46	$276,000	1490	1	11	6	9
1	> 25 %	1	35	$210,000	866	1	10	13	9
1	> 50 %	1	17	$102,000	684	1	4	15	9
1	> 75 %	1	13	$78,000	510	1	3	16	9
1	100 %	1	7	$42,000	241	1	1	18	9
1	> 25 %	2	46	$276,000	1732	0.529	11	3	8
1	> 50 %	2	27	$162,000	1368	0.529	7	9	8
1	> 75 %	2	20	$120,000	1020	0.529	5	11	8
1	100 %	2	10	$60,000	482	0.529	2	17	8
1	> 75 %	3	27	$162,000	1530	0.346	7	5	6
1	100 %	3	13	$78,000	723	0.346	3	14	6
1	> 75 %	4	34	$204,000	2040	0.208	9	1	4
1	100 %	4	17	$102,000	964	0.208	4	12	4
1	100 %	5	20	$120,000	1205	0.141	5	10	3
1	100 %	6	23	$138,000	1446	0.078	6	8	2
1	100 %	7	27	$162,000	1687	0.374	7	4	7
1	100 %	8	30	$180,000	1928	0	8	2	1

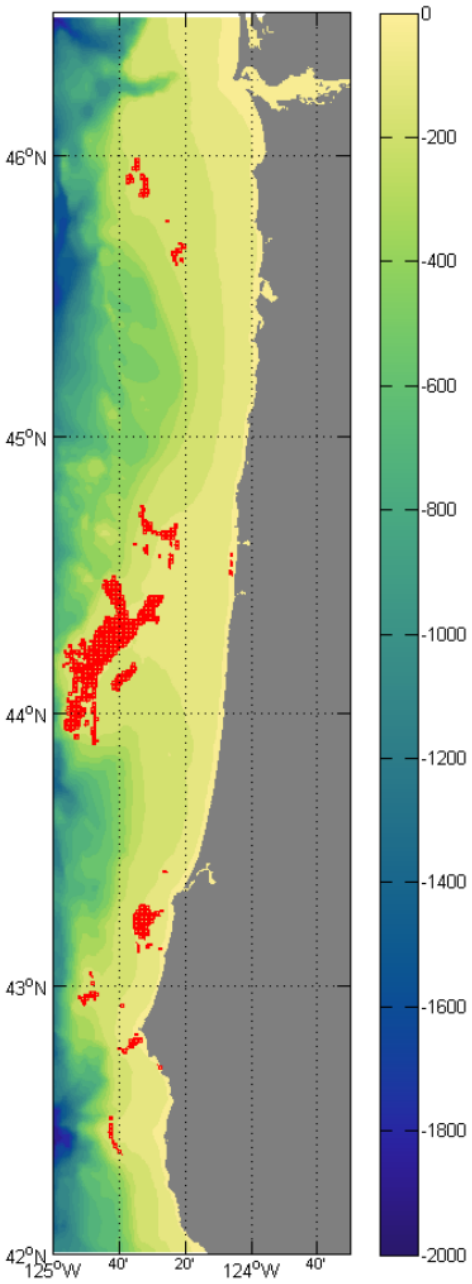


Figure D6. Distribution of grid cells (red) with 100% rock coverage for 0.5 mi sampling grid. Blues denote deeper depths and yellows shallower depths.

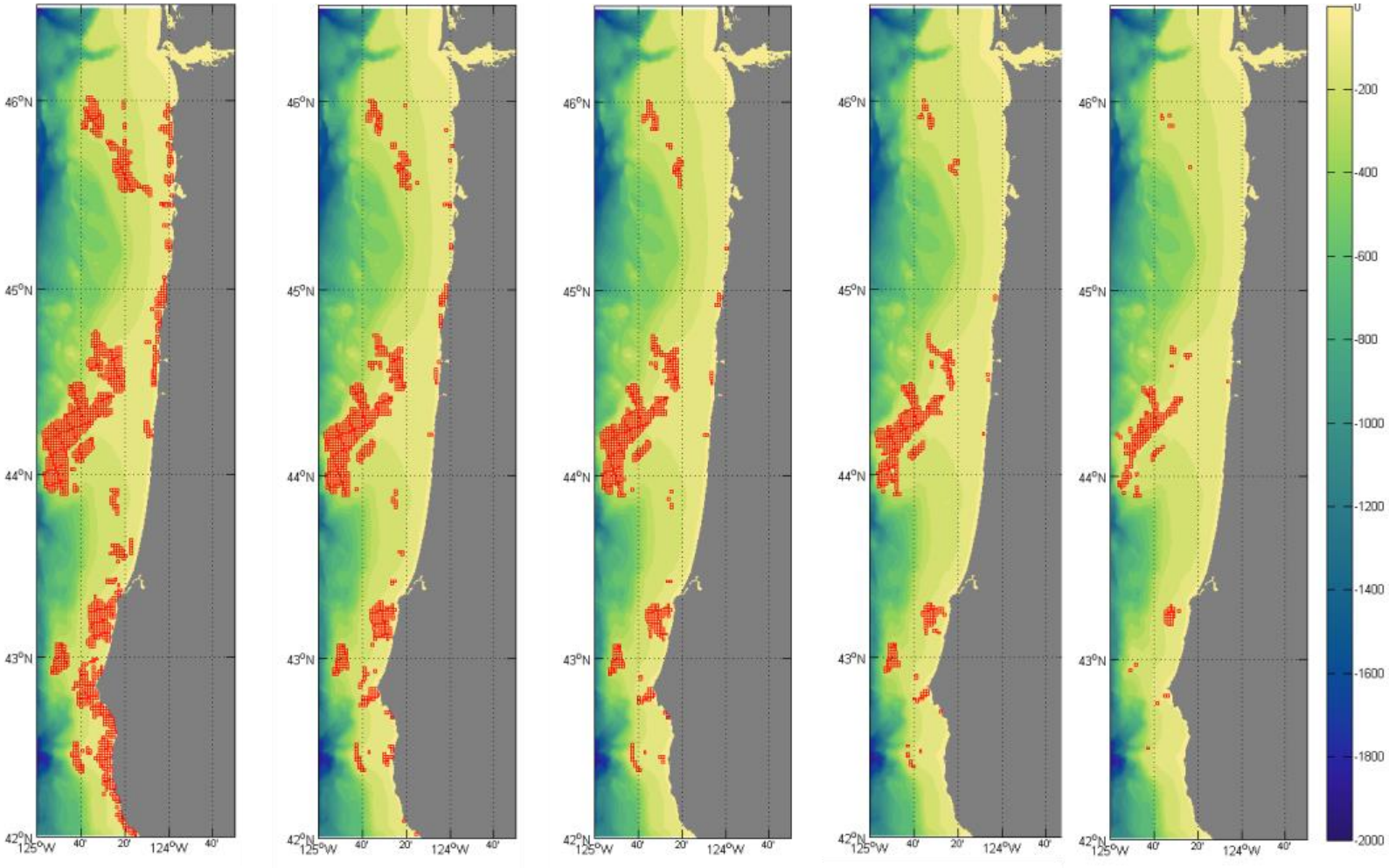


Figure D7. Distribution of grid cells (red) with >0%, ≥25%, ≥50%, ≥75% and =100% rock coverage (ordered from left to right) for 1 mi sampling grid.

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