15. Assessment of the Thornyhead stock complex in the Gulf of Alaska

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Executive Summary

The Gulf of Alaska (GOA) thornyhead complex includes the shortspine thornyhead *Sebastolobus alascanus* and the longspine thornyhead *S. altivelis*. This complex is assessed on a biennial schedule in even years and is managed as a Tier 5 stock. For this on-cycle year, we incorporate new survey biomass from the 2023 bottom trawl survey, new Relative Population Weights (RPWs) from the 2023 longline survey, and update auxiliary data sources.

The current method for estimating the Acceptable Biological Catch (ABC) uses only shortspine thornyhead caught by Alaska Fisheries Science Center (AFSC) bottom trawl survey (BTS) and longline survey (LLS) in the random effects model (REMA; Hulson et al. 2021, Echave et al. 2022) run with the *rema* package (Sullivan et al. 2022a). Biomass estimates by western, central, and eastern GOA management areas (i.e., WGOA, CGOA, and EGOA) from the REMA model were summed to obtain GOA-wide biomass. The base model (Model 22) estimated three area-specific process errors, one shared scaling coefficient, and additional observation error parameters for each survey (Echave et al. 2022). There were some minor changes to some errors in the BTS, so the updated base model is Model 22.a and is compared to Model 24.2 which estimates a single shared process error.

Summary of Changes in Assessment Inputs

Changes in the Input Data

1. RPWs and errors from 1992 to 2023 GOA LLS were updated.
2. Biomass and errors estimated from the 1990 to 2023 GOA BTS were updated.

Changes in Assessment Methodology

The methodology used to estimate exploitable biomass to calculate ABC and OFL (Over Fishing Limit) values for the 2025 fishery explores transitioning from three area-specific process errors to a single shared process error.

Summary of Results

For the 2025 fishery, we recommend the maximum allowable ABC of 1,338 t for thornyhead rockfish. This ABC is a decrease of 17.8% from the 2024 ABC of 1,628 t. Approximately 81% of this decrease can be attributed to declines in the 2023 abundance indices provided by the BTS and LLS, another 3% related to the data updates, and the remaining 16% is associated with changes in the model structure. The OFL is 1,784 t. Reference values for thornyhead rockfish are summarized in the following table, with the recommended ABC and OFL values in bold. The stock was not being subjected to overfishing last year.

Quantity	As estimated or *specified last* year for: 2024	2025	As estimated or *recommended this* year for: 2025	2026
M (natural mortality rate)	0.03	0.03	0.03	0.03
Tier	5	5	5	5
Biomass (t)	72,349	72,349	59,459	59,459
F_{OFL}	$F = M = 0.03$	$F = M = 0.03$	$F = M = 0.03$	$F = M = 0.03$
$maxF_{ABC}$	$0.75M = 0.0225$	$0.75M = 0.0225$	$0.75M = 0.0225$	$0.75M = 0.0225$
F_{ABC}	0.0225	0.0225	0.0225	0.0225
OFL (t)	2,170	2,170	**1,784**	1,784
maxABC (t)	1,628	1,628	1,338	1,338
ABC (t)	1,628	1,628	**1,338**	1,338
Status	As determined *last* year for: 2022	2023	As determined *this* year for: 2023	2024
Overfishing	No	n/a	No	n/a

Area Allocation of ABC

For apportionment of ABC/OFL, the REMA model was fit to area-specific biomass and RPWs, and subsequent predicted proportions of biomass by area were calculated. The following table shows the author recommended apportionment by regulatory area.

Year	Western	Central	Eastern	Total
2025	206	590	542	1,338
2026	206	590	542	1,338

Status and catch specifications (t) of thornyhead rockfish and projections for 2025 and 2026 are shown in the following table. Biomass for each year corresponds to the projections given in the SAFE report issued in the preceding year. Catch data are current as of October 7, 2024.

Year	Biomass	OFL (t)	ABC (t)	TAC (t)	Catch (t)
2023	72,349	2,170	1,628	1,628	208
2024	72,349	2,170	1,628	1,628	157
2025	59,459	1,784	1,338		
2026		1,784	1,338		

Gulf of Alaska thornyhead 2024–2026 OFLs and ABCs, 2024 TAC, and 2024 catch.

Area	2024 OFL	2024 ABC	2024 TAC	2024 Catch	Author Rec 2025 OFL	Author Rec 2025 ABC	Author Rec 2026 OFL	Author Rec 2026 ABC
W	n/a	314	314	34	n/a	206	n/a	206
C	n/a	693	693	62	n/a	590	n/a	590
E	n/a	621	621	61	n/a	542	n/a	542
Total	**2,170**	**1,628**	**1,628**	**157**	**1,784**	**1,338**	**1,784**	**1,338**

Responses to SSC and Plan Team Comments on Assessments in General

"The SSC appreciates the innovative work being done by the assessment authors through random effects (RE) modeling, by treating area-specific process variation as a random effect to properly weight and, where appropriate, consistently weight, the variation across areas. If not currently included in assessments, the SSC requests full documentation of the justification for the weighting schemes applied. Specific to GOA assessments, the SSC also supports a previous GOA GPT recommendation to use a common process error across the GOA and to compare that approach with the current approach that allows process error to vary by sub-region. If process errors are treated separately by sub-region, then justification for that decision should be provided." (SSC Dec 2022)

Authors agree with the SSC and the GOA Plan Team. This makes biological sense for a long-lived slow growing stock that is primarily non-target, and there is very little change to the biomass estimates related to this change in model structure. In response to this recommendation, we do not have a justification for treating process error separately by area, so we recommend transitioning to a common process error.

Responses to SSC and Plan Team Comments Specific to this Assessment

"The Team recommended the use of a common process error across the GOA, and would like to see a comparison of that approach with the current approach that allows process error to vary by subregion. If process errors are treated separately by sub-region, then justification for that decision should be provided." (Plan Team, Nov 22)

See response above.

Introduction

Thornyheads (*Sebastolobus* species) are groundfish belonging to the family Scorpaenidae, which contains the rockfishes. The family Scorpaenidae is characterized morphologically within the order by venomous dorsal, anal, and pelvic spines, numerous spines in general, and internal fertilization of eggs. Thornyheads are oviparous, releasing fertilized eggs in floating gelatinous masses, and lack a swim bladder, while "true" rockfish in the genus *Sebaste*s are ovoviviparous, live-bearing fish, and have a swim bladder. There are three species in the genus *Sebastolobus*: the shortspine thornyhead *Sebastolobus alascanus*, the longspine thornyhead *S. altivelis*, and the broadfin thornyhead *S. macrochir* (Eschmeyer et al. 1983, Love et al. 2002).

General Distribution

Thornyheads are distributed in deep water habitats throughout the north Pacific Ocean, although juveniles can be found in shallower habitats. The range of the shortspine thornyhead extends from 17 to 1,524 m in depth and along the Pacific Rim from the Seas of Okhotsk and Japan in the western north Pacific, throughout the Aleutian Islands, Bering Sea, GOA, and south to Baja California in the eastern north Pacific (Love et al. 2005). Shortspine thornyheads are considered most abundant from the Northern Kuril Islands to southern California. They are generally concentrated between depths of 150 and 450 m in northern waters and in deeper habitats up to 1,000 m in the southern portion of their range (Love et al. 2002).

The longspine thornyhead is found in the eastern north Pacific Ocean, where it ranges from the Shumagin Islands in the GOA south to Baja California. Longspine thornyheads are generally found in deeper habitats ranging from 201 to 1,756 m (Love et al. 2005). They are most commonly found below 500 m throughout their range. Off the California coast, the longspine thornyhead is a dominant species in the 500 to 1,000-m depth range, which is also a zone of minimal oxygen (Love et al. 2002).

The broadfin thornyhead is found almost entirely in the western north Pacific Ocean, ranging from the Seas of Okhotsk and Japan into the Aleutian Islands and eastern Bering Sea. The depth range of the broadfin thornyhead is 100 to 1,504 m. The broadfin thornyhead is relatively uncommon in the eastern north Pacific Ocean, and historical records of this species from the Bering Sea may have been misidentified shortspine thornyheads.

Life History Information

Shortspine thornyhead are thought to spawn between April and July in the GOA and between December and May along the U.S. west coast. It is unknown when longspine thornyheads spawn in the Alaskan portion of their range, although they are reported to spawn between January and April on the U.S. West coast (Pearson and Gunderson 2003). Thornyheads spawn a bi-lobed mass of fertilized eggs which floats in the water column (Love et al. 2002). Once the pelagic egg masses hatch, larval and juvenile thornyheads spend far more time in a pelagic life stage than the young-of-year rockfish in the genus *Sebastes* (Love et al. 2002). Shortspine thornyhead juveniles spend 14 to 15 months in a pelagic phase, and longspine thornyhead juveniles spend up to 20 months in a pelagic phase before they settle into benthic habitat. While shortspine thornyhead juveniles tend to settle into relatively shallow benthic habitats between 100 and 600 m and then migrate deeper as they grow, longspine thornyhead juveniles settle out into adult longspine habitat depths of 600 to 1,200 m.

Once in benthic habitats, both shortspine and longspine thornyheads associate with hard muddy substrates, sometimes near rocks or gravel, and distribute themselves relatively evenly across this habitat, appearing to prefer minimal interactions with individuals of the same species. Research focusing on non-trawlable habitats found rockfish species often associate with biogenic structure (seafloor relief; Du Preez and Tunnicliffe 2011, Laman et al. 2015), and that thornyhead rockfish are often found in both trawlable and untrawlable habitats (Rooper and Martin 2012, Rooper et al. 2012). Several of these studies are notable as results indicate adult thornyhead biomass may be underestimated by traditional bottom trawl surveys because of issues with extrapolating survey catch estimates to untrawlable habitat (Jones et al. 2012; Rooper et al. 2012). Mean abundance of shortspine thornyheads estimated in submersible surveys were several times higher than those estimated from trawl surveys (Else et al. 2002). They have very sedentary habits and are most often observed resting on the bottom in small depressions, especially longspine thornyheads, which occupy a zone of minimal oxygen at their preferred depths (Love et al. 2002).

Thornyheads are generally longer lived than most other commercially exploited groundfish. Shortspine thornyheads may live upwards of 80 to 100 years with the larger-growing females reaching sizes up to 80-cm fork length (Love et al. 2002). Longspine thornyheads are generally smaller, reaching maximum sizes less than 40 cm and maximum ages of at least 45 years (Love et al. 2002).

Prey and Predators

Diets of shortspine thornyheads are derived from stomach content collections taken in conjunction with GOA trawl surveys. Over 70% of adult shortspine thornyhead diet measured in the early 1990s was shrimp, including both commercial (Pandalid) shrimp and non-commercial (non-Pandalid shrimp) in equal proportions. Other important prey of shortspine thornyheads include crabs, zooplankton, amphipods, and other benthic invertebrates. Juvenile thornyheads have diets similar to adults, but in general prey more on invertebrates.

Shortspine thornyheads are consumed by a variety of piscivores, including arrowtooth flounder, sablefish, "toothed whales" (i.e., sperm whales), and sharks. Although, thornyheads are not a common prey item for these predators and make up less than 2% of their diets in the GOA. Juvenile shortspine thornyheads are thought to be consumed almost exclusively by adult thornyheads.

Stock Structure (see Appendix 15A)

The stock structure of GOA thornyhead was examined and is presented as an appendix in this year's stock assessment (Appendix 15A). There are few data available to differentiate stocks across regions based on demographics, and what is known regarding movement and genetics indicate no stock structure for thornyhead rockfish in the GOA. Thornyhead are long-lived with a long generation time, but there is little information regarding spawning, reproduction, larval dispersal, or behavior. Length-weight relationships are similar among regions in the GOA. Harvest and trend data show consistent fishing effort with abundance distribution. Tagging studies indicate that large movements are possible, at times crossing management boundaries, but that most tagged shortspine thornyhead remain within their tagging location (Echave 2017). No spatial structure was observed in recent genetic analyses utilizing whole genome resequencing in shortspine thornyhead sampled from southeast Alaska to the Bering Sea and Aleutian Islands, providing further evidence that gene flow is high in shortspine thornyhead across relatively large spatial scales. These results indicate that shortspine thronyhead represent a single genetic stock in Alaskan waters (Wes Larson, AFSC, pers. comm.). For rockfish with no stock structure, it is likely that areas that are locally depleted will be replenished by larval transport over longer timescales (decades, 100s of years). But in the short term local depletion could cause reduced abundance because adult movement is low. See Appendix 15A for a more thorough evaluation of the potential stock structure for GOA thornyhead rockfish.

Fishery and Management History

Fishery

History

Shortspine thornyheads are abundant throughout the GOA and are commonly caught by bottom trawls and longline gear. This species was seldom the target of a directed fishery. Thornyheads have probably been caught in the northeastern Pacific Ocean since the late 19th century, when commercial trawling by U.S. and Canadian fishermen began. In the mid-1960s Soviet fleets arrived in the EGOA (Chitwood 1969), where they were soon joined by vessels from Japan and the Republic of Korea. These fleets represented the first directed exploitation of GOA rockfish resources, primarily Pacific ocean perch *Sebastes alutus* and likely resulted in the first substantial catches of thornyheads as well. Today, thornyheads are one of the most valuable rockfish species, with most of the domestic harvest exported to Japan. Despite their high value, they are still managed as a "bycatch only" fishery in the GOA because they are nearly always taken in fisheries directed at sablefish *Anoplopma fimbria* and other rockfish (*Sebastes* spp.). Although the thornyhead fishery is managed operationally as a "bycatch" fishery, the high value and desirability of shortspine thornyheads means they are still considered a "target" species for the purposes of management.

Management Measures

After passage of the Fishery Conservation and Management Act (FCMA) in 1977, thornyheads were placed in the rockfish management group which contained all species of rockfish except Pacific ocean perch (Berger et al. 1986). In 1979, thornyhead rockfish were removed from the rockfish group and placed in the "other fish" group. Thornyhead rockfish became a reported species group in 1980. For the

GOA, the "thornyheads" management unit is currently a species complex which includes shortspine thornyhead and longspine thornyhead. Thornyheads in the GOA have been managed as a single stock since 1980 (Ianelli and Ito 1995, Ianelli et al.1997). In practice, the NPFMC apportions the ABC and TAC for thornyhead rockfish in the GOA into three geographic management areas: the WGOA, CGOA, and EGOA. Bering Sea and Aleutian Islands (BSAI) shortspine thornyheads are managed as a separate stock from GOA thornyheads. Note that in the BSAI FMP, all thornyhead species are managed within the "Other rockfish" species complex.

In 2007, the Central Gulf of Alaska Rockfish Pilot Program was implemented as a five year test program to enhance resource conservation and improve economic efficiency for harvesters and processors who participate in the CGOA rockfish fishery. In 2012, the Central Gulf of Alaska Rockfish Program was authorized for 10 years, and in 2021 this program was reauthorized without a sunset date. This is a rationalization program that provides quota shares to trawl catcher vessel and catcher processor cooperatives. The primary rockfish management groups are northern rockfish *Sebastes polyspinis*, Pacific ocean perch, and dusky rockfish *S. ciliates*. Thornyhead rockfish is a secondary species group that has an allocation of quota share which can be caught while fishing for the primary rockfish management groups, and directed fishing on shortspine thornyheads exclusively is not permitted.

In 2020, Amendment 107 to the Fishery Management Plan for Groundfish required full retention of rockfish by catcher vessels using fixed gear while fishing for groundfish or halibut. A timeline of management measures that have affected thornyhead rockfish, along with corresponding GOA-wide annual catch and OFL/ABC/TAC levels are listed Table 15.1.

Catch

The earliest available records of thornyhead catch begin in 1967, as published in French et al. (1977). Rockfish catch peaked in 1965 when foreign fleets occupied Alaska waters, with nearly 350,000 t removed (Ito 1982). However, records of catch and bycatch from this fishery were insufficient for precise estimation of historical catch for thornyheads. Active data collection began as part of the U.S. Foreign Fisheries Observer Program in 1977, when the thornyhead catch in the GOA was estimated at 1,317 t. Catch estimates from 1977 to 1980 are based on the following reports: Wall et al. (1978, 1979, 1980, and 1981). Beginning in 1983, the observer program also estimated the catches of thornyheads in joint venture fisheries where U.S. catcher vessels delivered catch to foreign processor vessels, and beginning in 1984, thornyheads were identified as a separate entity in the U.S. domestic catch statistics. Data from 1981 to 1989 are based on reported domestic landings extracted from the Pacific Fishery Information Network (PacFIN) database and the reported foreign catch from the NMFS Observer Program. Catches from 1990 to 2002 are based on "blended" fishery observer and industry sources using an algorithm developed by the NMFS Alaska Regional Office (AKRO). Catches from 2003 to 2024 were provided by NMFS Regional Office Catch Accounting System (CAS), and accessed through the Alaska Fishery Information Network (AKFIN) database.

Catch trends for GOA thornyheads appear influenced primarily by management actions rather than from stock fluctuations. Catches of thornyheads in the GOA declined markedly in 1984 and 1985, mainly due to restrictions on foreign fisheries imposed by U.S. management policies. In 1985, the U.S. domestic catch surpassed the foreign catch for the first time. U.S. catches of thornyheads continued to increase, reaching a peak in 1989 with a total removal of 2,616 t. Catches have trended downwards since the early 1990s, with the exception of a relatively higher and stable catch from 2013 to 2018; some of the lowest catches are in recent years (Table 15.1). Catches in recent years have generally been highest in the CGOA (Table 15.2).

Recent declines in thornyhead catch is related to the transition of the sablefish fishery from hook and line to pots. Use of pots for sablefish in the GOA was legalized in 2017, and by 2020, more sablefish were being caught by pots than hook and line (Cheng et al. 2024). Experimental studies comparing catch between hook and line and slinky pots on the AFSC LLS in 2021 found that slinky pots caught a lower proportion of non-sablefish species. Across all sets, 95–98% of all fish caught in pots were sablefish, whereas 79–87% of fish caught on hook-and-line sets were sablefish. The biggest species composition discrepancies between the two gear types were for giant grenadier and shortspine thornyhead; shortspine thornyhead made up 3 to 7% of the hook-and-line catches and only 0 to 0.2% of pot catches (Sullivan et al. 2022b). The spatial distribution of thornyhead catches in longline fisheries is predominantly in the EGOA (Figure 15.1), while the trawl catches are mainly in the CGOA and occasionally in the WGOA (Figure 15.2). Though hook and line made up a large historical proportion of thornyhead catch, the majority of catch has shifted to trawl gear within the rockfish fishery in recent years (Tables 15.3 and 15.4). The majority of catch in the CGOA in the last few years is in the CGOA Rockfish Program which has been well below their TAC, and the majority of the CGOA TAC that is not given to the CGOA Rockfish Program is not being caught (Table 15.2, Figure 15.3).

Historically, except for the years 1992 to 1994, thornyhead total catch has been less than the ABC and TAC (Table 15.1). The high (relative to the TAC) thornyhead catches in 1992 to 1994 were attributed to high discards in the sablefish longline fishery during the years preceding the implementation of IFQs for sablefish in 1995. From 1980 to 1990, the ABCs and TACs were set at the estimate of maximum sustainable yield for thornyheads which was determined to be 3.8% of the 1987 estimated GOA biomass. The drop in ABC/TAC in 1991 was in response to a large decrease in estimated biomass from the GOA trawl survey. The age-structured assessment model was suspended in 2003 due to uncertainty in the reliability of age and growth information. Consequently, a more conservative Tier 5 biomass-based approach for ABC and OFL specifications was adopted.

Survey catches of all thornyhead species are a very small component of overall removals, and recreational and other catches are assumed negligible. Estimates of non-commercial catches (research and sport) are given in Appendix 15B.

Discards

Discards dropped significantly in 2019, and since 2018 have stabilized at or below 30 t, while the rates have also dropped since 2019 (Table 15.5). This can be somewhat attributed to a transition in sablefish from longline to pots as discussed above and also to the regulatory change in March 2020 requiring full retention of rockfish by catcher vessels using fixed gear while fishing for groundfish or halibut.

Data

Catch

Detailed catch information for thornyhead rockfish is listed in Tables 15-1 and 15-2.

Length and Age Composition

Length composition data from the trawl and longline fisheries (1990–2024) indicate longline fisheries capture larger shortspine thornyheads than trawl fisheries (average length of 39.6 cm versus 28.2 cm), likely related to hook sizes too large for the smallest fish (Figure 15.4). Very few lengths from the GOA fishery have been recorded in recent years. Few age samples for this species have been collected from the fishery, and none have been aged.

Survey Data

Longline Surveys in the Gulf of Alaska

The AFSC LLS has been conducted annually since 1988. This survey samples the continental slope in the GOA, providing data to calculate relative abundance in this area (Rutecki et al. 2016, Siwicke and Malecha 2024). The survey is primarily directed at sablefish, but also catches considerable numbers of thornyhead rockfish. The assessment model uses shortspine thornyhead RPWs beginning in 1992 from the AFSC LLS separated by management region (Table 15.6). The RPWs have declined across all regions in recent years; the exception being a large increase in the 2022 EGOA estimate which reversed in 2023 (Table 15.6). Historically, there has been a considerable amount of fluctuation for thornyhead RPWs between adjacent years, and there was 39% decline in RPW estimate from 2022 to 2023 (Table 15.6). Hook competition on the LLS with the recently abundant sablefish has been discussed as a contributing factor to recent declines in thornyheads (Echave et al. 2022). While thornyhead abundance dropped in 2023 across all GOA regions and depths, there was an increase in hooks with bait returning (Siwicke and Malecha 2024); this is not an expected result if hook competition were a driving factor. Length composition data from the 1992–2023 LLS shows a stable mean length range between 35.2 and 38.3 cm (Figure 15.5). Overall, the LLS has caught shortspine thornyhead with a mean length of 36.4 cm (Figure 15.6). There is certainly selectivity induced from the hook size, limiting the minimum size shortspine thornyhead that can be sampled in the longline survey, and this is not accounted for in the errors reported by the LLS.

Trawl Surveys in the Gulf of Alaska

The AFSC BTS was conducted on a triennial basis in the GOA from 1984 through 1999, and these surveys became biennial starting in 2001. This survey employs standard NMFS Poly-Nor'eastern bottom trawl gear and provided biomass estimates using an "area-swept" methodology described in Wakabayashi et al. (1985). The BTS has covered all areas of the GOA out to a depth of 500 m (in some surveys to 1,000 m), but the 2001 survey did not sample the EGOA. The 1990, 1993, 1996 and 2001 surveys did not survey the depths > 500 m, and the 2003, 2011, 2013, 2017, 2019, 2021, and 2023 surveys did not survey depths > 700 m. It is evident from trawl survey results that a significant portion of the biomass of shortspine thornyheads exists at depths greater than 500 m (Table 15.7). In 1999, 2005, 2007, 2009, and 2015, the surveys had the most extensive survey coverage of the primary thornyhead habitat (all depths sampled to 1,000 m). Biomass estimates for GOA thornyhead rockfish have sometimes shown rather large fluctuations between surveys (Table 15.7). The 2023 GOA biomass estimate decreased by 16% from the 2021 estimate, though much of this decline was in the WGOA and virtually none in the EGOA (Table 15.7). Spatial distributions of catches of thornyhead in the last three GOA trawl surveys indicate these species are rather evenly spread along an offshore band along the continental slope (Figure 15.7). Length compositions for thornyhead rockfish from the 1990–2023 BTS were generally consistent with means between 23.2 and 27.0 cm (Figure 15.8). The overall mean length for shortspine thornyhead captured by the BTS was 26.0 cm, which is smaller than the LLS (Figure 15.6).

Compared with many other rockfish species, the biomass estimates for thornyhead rockfish have historically been relatively precise with low CVs. The low CVs are consistent with this species being relatively evenly distributed on the sea floor. Despite the relatively precise biomass estimates, other factors could impact their reliability. Their main habitat is the upper continental slope at depths of 300–700 m. A considerable portion of this area is untrawlable by the survey's gear because of the area's steep and rocky bottom.

Analytic Approach

General Model Structure

Due to difficulties in ageing thornyheads and issues raised with previous age-based methods using length composition data, this stock complex has reverted to using a biomass-based approach. Both trawl and longline survey data affect the trends used to estimate the ABCs. The application of the REMA model smooths trends in survey estimates. The process errors (step changes) from one year to the next are the random effects that are integrated over, and the process error variance terms are freely estimated. The observations can be irregularly spaced, so for years where data are missing estimates can be made. Specified survey observation error terms (provided each year) effectively weights the survey estimates and can affect the predictions.

The Tier 5 estimate of the OFL is simply *M* multiplied by the estimated exploitable biomass and under the FMP the maximum permissible ABC is 75% of OFL. Here we assume 0.03 as a value for M (see the Parameters Estimates section for how this estimate was derived). For all models considered, input data starts in 1990.

Modeling Selection

Models were presented to the GOA Plan Team in September of 2024 (document and presentation), and following their recommendation, we bring forward the base Model 22, and an alternative Model 24.2. The following table provides the model case name and description of the changes made to the model.

Model case	Description
22	Base Model 22 was accepted in 2022 with three area-specific process errors, one scaling coefficient, and additional observation error estimated for both surveys
22.a	Base model (22) but minor updates to the data for comparison with Model 24.2
24.2	Same as Model 22.a with a single shared process error

A brief description of each model case is provided below.

22 – Base Model

Model 22 is a REMA model that can be represented as a state-space random walk model with added noise. Two surveys are combined in this model, with the AFSC bottom trawl survey providing biomass estimates and uncertainty, and the AFSC longline survey providing RPW estimates and uncertainty. The RPWs contribute trend information to the model, while the trawl biomass contributes both scale and trend information to the model. Each survey contributes an observation error component to the likelihood. The RPWs are scaled to the biomass estimated by a single estimated scaling coefficient (q), and three regional process error components which are shared across surveys ($\sigma_{PE,W}$ for the WGOA, $\sigma_{PE,C}$ for the CGOA, and $\sigma_{PE,E}$ for the EGOA) are estimated. To accommodate trawl surveys that did not always survey all depths in all years, biomass survey estimates are further divided into three depth strata for each region (0–500 m, 501–700 m, and 701–1000 m). This model has three likelihood components: 1) the bottom trawl survey biomass estimate observation error component 2) the longline survey RPW index observation error component, and 3) the shared process error component (which represents the amount of variation across time of the random effect parameters). Process error is shared across depths within each region, but no correlation is assumed across regions.

The first observation model is comprised of an index of log-transformed annual bottom trawl survey biomass data $ln(B_{y,r,d})$ with associated standard deviations $\sigma_{ln\,(B_{y,r,d})}$, where *r* is region (WGOA, CGOA, or EGOA) and *d* is depth strata (0–500 m, 501–700 m, and 701–1000 m), and $\sigma_{ln\,(B_{y,r,d})}$ is approximated using the coefficient of variation of the annual survey biomass by region and depth strata ($\sigma_{B_{y,r,d}}/B_{y,r,d}$), such that:

$$\sigma_{ln(B_{y,r,d})} = \sqrt{ln\left(\left(\frac{\sigma_{B_{y,r,d}}}{B_{y,r,d}}\right)^2 + 1\right)}.$$

The biomass survey measurement or observation equation, which describes the relationship between the observed survey biomass $ln(B_{y,r,d})$ and the latent state variable, estimated population biomass $ln(\hat{B}_{y,r,d})$, is expressed as:

$$ln\left(B_{y,r,d}\right) = ln\left(\hat{B}_{y,r,d}\right) + \epsilon_{y,r,d}, \text{ where } \epsilon_{y,r,d} \sim N(0, \sigma^2_{ln(B_{y,r,d})}).$$

The state equation and associated process error variance $\sigma^2_{PE,r}$ is defined as:

$$ln\left(\hat{B}_{y,r}\right) = ln\left(\hat{B}_{y-1,r}\right) + \eta_{y-1,r}, \text{ where } \eta_{y,r} \sim N(0, \sigma^2_{PE,r}), \text{ and}$$

$$\hat{B}_{y,r} = \sum_{D} e^{ln\left(\hat{B}_{y,r,d}\right)}.$$

The second observation model using the annual/regional longline survey RPW index ($I_{y,r}$) is similarly structured with associated standard deviations $\sigma_{ln(I_{y,r})}$ approximated using the coefficient of variation of the annual survey RPW ($\sigma_{I_{y,r}}/I_{y,r}$), such that:

$$\sigma_{ln(I_{y,r})} = \sqrt{ln\left(\left(\frac{\sigma_{I_{y,r}}}{I_{y,r}}\right)^2 + 1\right)}$$

The longline survey measurement or observation equation is similarly expressed as:

$$ln\left(I_{y,r}\right) = ln\left(\hat{I}_{y,r}\right) + \omega_{y,r}, \text{ where } \omega_{y,r} \sim N(0, \sigma^2_{ln(I_{y,r})}),$$

where the estimated index ($\hat{I}_{y,r}$) is scaled to the estimated population biomass using an estimated scaling coefficient (*q*) such that:

$$\hat{I}_{y,r} = q\hat{B}_{y,r}$$

Model 22 estimates additional observation error. Based on experience gained using alternative observed index estimates (e.g. relative CPUE indices), there appears to be cases where the estimates of observation error variances for the biomass and/or CPUE survey are too low. That is, there is a mismatch between biologically reasonable inter-annual variability and the precision of index estimates. In these instances, the model estimates of the sum of observation errors from the bottom trawl and longline surveys divided by the estimated process error, ($\sigma^2_{B_{y,r}} + \sigma^2_{I_{y,r}}$) / $\sigma^2_{PE,r}$, may be lower than what should be expected based on an individual species' life history traits. For example, if the ratio of observation to process error variation is low, model predictions of population biomass may exhibit high inter-annual variability. This behavior would be unexpected in low productivity species, such as thornyheads, which should exhibit low inter-annual variation in biomass (i.e. low process error variance), especially in situations when fishing exploitation is low. For the biomass survey variance, the extra estimated observation error ($\sigma_{\tau,B}$) is specified as an additional coefficient of variation component:

$$\sigma_{ln(B_{y,r},d)} = \sqrt{ln\left(\left(\frac{\sigma_{B_{y,r,d}}}{B_{y,r,d}}\right)^2 + \sigma_{\tau,B}^2 + 1\right)}.$$

For the longline survey, the extra estimated observation error ($\sigma_{\tau,I}$) is specified as an additional coefficient of variation component:

$$\sigma_{ln(I_{y,r})} = \sqrt{ln\left(\left(\frac{\sigma_{B_{y,r}}}{B_{y,r}}\right)^2 + \sigma_{\tau,I}^2 + 1\right)}.$$

The parameters estimated are q, $\sigma_{PE,W}$, $\sigma_{PE,C}$, $\sigma_{PE,E}$, $\sigma_{\tau,B}$, and $\sigma_{\tau,I}$, in addition to the unobserved population biomass $ln(\hat{B}_y)$ estimated as a vector of random effects.

22.a – Base Model with data update

Model 22.a is exactly the same as Model 22, but small changes to some errors from the BTS are included. For this assessment, biomass estimates and errors from the BTS are aggregated at three depth strata (0–500m, 501–700m, and 701–1000m) for each of the three management areas (WGOA, CGOA, and EGOA) to handle missing survey strata in the time series. In the last assessment there was a single year, area, and depth strata (1999, WGOA, 701–1000m) that had a single haul and thus no reported variance, so the authors' included a CV of 0.1 for this strata. This year, we noticed that some of the survey's finer resolution strata had only a single haul, and therefore, these were not adding any calculated variance when summed to the strata used in the assessment. After discussion with the Groundfish Assessment Program (GAP), we chose to add a variance equivalent to a CV of 0.5 to all of the biomass estimates that came from a sample of one haul before they were summed to the strata used in this assessment. We believe that this increased CV is justified considering that a single haul is being used to extrapolate biomass to entire areas and it is unreasonable to assume they are doing this without any error. Under the new stratification of the GOA BTS, the issue of a single haul in a strata should be resolved beginning in 2025 (Oyafuso et al. 2022). This resulted in the following changes in CV at the assessment strata level:

Year	Strata	CV Old	CV New	CV Diff
1993	EGOA (0-500 m)	0.096	0.101	0.006
1996	EGOA (0-500 m)	0.108	0.118	0.010
1999	WGOA (701-1000 m)	0.100	0.500	0.400
2009	EGOA (701-1000 m)	0.019	0.451	0.432
2011	EGOA (0-500 m)	0.099	0.114	0.015
2015	EGOA (701-1000 m)	0.005	0.452	0.447
2019	CGOA (501-700 m)	0.167	0.340	0.173
2021	EGOA (0-500 m)	0.103	0.104	0.001
2021	EGOA (501-700 m)	0.219	0.409	0.180
2023	EGOA (0-500 m)	0.141	0.146	0.005

24.2 – Common Process Error

The only difference in model structure between Model 24.2 and the base Model 22 is that the process error is shared across regions such that a single process error parameter is estimated instead of three area-specific parameters. The data used in Model 24.2 is the same used in Model 22.a, so these are the models that are compared.

Parameter Estimates

Age and Growth, Maximum Age, and Natural Mortality (M)

Despite a general knowledge of the life history of thornyheads throughout their range, precise information on age, growth, and natural mortality *(M)* remains elusive for shortspine thornyheads in Alaska and is unknown for longspine thornyheads. Miller (1985) estimated shortspine thornyhead natural mortality by the Ricker (1975) procedure to be 0.07. The oldest shortspine thornyhead found was 62 years old in that study. On the U.S. continental west coast, at least one large individual was estimated to have a maximum age of about 150 years (Jacobson 1990). Another study of west coast shortspine thornyheads found a 115 year-old individual using conventional ageing methods and about 100 year-old using radiochemical aging techniques (Kline 1996). These maximum ages would suggest natural mortality rates ranging from 0.027 to 0.036 if we apply the relationship developed by Hoenig (1983). Recent radiometric analyses suggest that the maximum age is between 50 and 100 years (Kastelle et al. 2000, Cailliet et al. 2001), but these have high-variance estimates due to sample pooling and other methodological issues. An analysis of reproductive information for Alaska and west coast populations also indicates that shortspine thornyheads are very long-lived (Pearson and Gunderson 2003). The longevity estimate was based on an empirically derived relationship between gonadosomatic index (GSI) and natural mortality (Gunderson 1997) and suggested much lower natural mortality rates (0.013–0.015) and therefore much higher maximum ages (250–313 years) than had ever been previously reported using any direct ageing method.

Results of an age study completed in August 2009 were limited as shortspine thornyheads are extremely difficult to age (Black 2009). Out of the 428 otoliths included in this study, an age was obtained for just over half of the samples. Approximately a quarter of the total number of otoliths (109 out of 428) were of a high enough clarity for ages to be considered reliable. Ageing confidence was found to decrease with fish age, compounding the difficulty in establishing a reasonable range of maximum ages. Maximum ages in this study were approximately 85 years, with the possibility of 100 years. These maximum ages are in agreement with other studies, including those that employed radiometric validation. All the samples for this study were from specimens >20 cm selected to obtain older aged individuals. The AFSC Age and Growth Lab will continue aging work on smaller specimens, which can be surface read, to compliment the older ages so that a more complete length-at-age data set can be compiled. It is hoped that a full range of ages could provide improved age and growth information specific to the GOA.

Although shortspine thornyheads are extremely difficult to age, studies seem to indicate that Miller's (1985) estimate of maximum age of 62 is low, and an estimate of *M* of 0.07 based on this would be high. Conversely, the maximum ages implied by Pearson and Gunderson (2003, 250–313 years) may be high and infer natural mortality rates that may be inappropriately low. The maximum ages from Kline (1996) and Jacobson (1990) are 115 and 150 years, respectively. The average natural mortality rate from these studies is 0.030. Preliminary results from Black's (2009) work are in line with this estimate of *M*. Assuming *M*=0.03 implies a longevity in the range of 125 years, which is bracketed by estimates derived from Jacobson (1990) and Kline (1996). Until we gather more information on shortspine thornyhead productivity, age, and growth in the GOA, we will continue to assume *M*=0.03 is a reasonable and best available estimate of *M*.

A summary of the estimates of mortality and maximum age for shortspine thornyhead rockfish are listed as follows:

Mortality rate	Maximum age	Ageing method	Area	References
0.07	62	-	AK	1
~0.03	150	-	WC	2
0.027	115	conv	WC	3
0.036	100	radio	WC	3
-	50–100	radio	-	4, 5
0.013-0.015	250–313	GSI	AK, WC	6
-	85–100	conv	-	7

Area indicates location of study: West Coast of U.S. (WC), Alaska (AK)
Conv: conventional ageing method; radio: radiochemical aging technique; GSI: gonadosomatic index
References: 1) Miller 1985; 2) Jacobson 1990; 3) Kline 1996; 4) Kastelle et al. 2000; 5) Cailliet et al. 2001; 6) Pearson and Gunderson 2003; 7) Black 2009.

Fecundity and Maturity at Length

Fecundity at length has been estimated by Miller (1985) and Cooper et al. (2005) for shortspine thornyheads in Alaska. Cooper et al. (2005) found no significant difference in fecundity at length between Alaskan and West Coast shortspine thornyheads. It appeared that fecundity at length in the more recent study was somewhat lower than that found in Miller (1985), but it was unclear whether the difference was attributable to different methodology or to a decrease in stock fecundity over time. Longspine thornyhead fecundity at length was estimated by Wakefield (1990) and Cooper et al. (2005) for the West Coast stocks; it is unknown whether this information is applicable to longspine thornyheads in Alaska.

Size at maturity varies by species as well. The size-at-maturity schedule estimated in Ianelli and Ito (1995) for shortspine thornyheads off the coast of Oregon, suggests that female shortspine thornyheads appear to be 50% mature at about 22 cm. More recent data analyzed in Pearson and Gunderson (2003) confirmed this, estimating length at maturity for Alaska shortspine thornyheads at 21.5 cm (although length at maturity for west coast fish was revised downward to about 18 cm). Male shortspine thornyheads mature at a smaller size than females off Alaska (Love et al. 2002). Longspine thornyheads reach maturity between 13 and 15 cm off the U.S. west coast; it is unknown whether this information applies in the Alaskan portion of the longspine thornyheads range.

Estimates of age- and size-at-50% maturity for thornyhead rockfish are listed below:

Age at maturity	Size at maturity	Species	Sex	Area	References
-	22 cm	shortspine	Female	OR	1
-	21.5 cm	shortspine	Female	AK	2
-	13–15 cm	longspine	Male	WC	3
12	-	shortspine	Male/Female	AK	4

Area indicates location of study: Oregon (OR); West Coast of U.S. (WC), Alaska (AK)
References: 1) Ianelli and Ito 1995; 2) Pearson and Gunderson 2003; 3) Love et al. 2002; 4) Miller 1985.

Results

Model Results

A data update and one model alternative were presented to the GOA Groundfish Plan Team in September 2024. Model 22.a is the base model (Model 22) run with the data updates and used for comparison with Model 24.2. Fits for Models 22.a and 24.2 can be compared at the regional and depth strata level by survey (Figure 15.9), and at the GOA-wide level (Figure 15.10).

Parameter estimates, standard errors (SE), and corresponding lower (LCI) and upper (UCI) 95% confidence intervals from Models 22, Model 22.a, and Model 24.2 are shown in the following table:

	Model 22				Model 22a				Model 24.2			
Parameter	Est.	SE	LCI	UCI	Est.	SE	LCI	UCI	Est.	SE	LCI	UCI
WGOA PE ($\sigma_{PE,W}$)	0.31	0.06	0.21	0.46	0.31	0.06	0.20	0.46				
CGOA PE ($\sigma_{PE,C}$)	0.13	0.04	0.08	0.22	0.13	0.04	0.08	0.22				
EGOA PE ($\sigma_{PE,E}$)	0.11	0.03	0.06	0.19	0.11	0.03	0.06	0.18				
GOA PE (σ_{PE})									0.15	0.03	0.10	0.21
Scaling parameter (q)	0.59	0.02	0.55	0.64	0.60	0.02	0.56	0.64	0.60	0.03	0.56	0.65
Extra BTS OE ($\sigma_{\tau,B}$)	0.15	0.06	0.07	0.33	0.16	0.06	0.08	0.32	0.25	0.05	0.17	0.35
Extra LLS OE ($\sigma_{\tau,I}$)	0.15	0.02	0.11	0.21	0.15	0.02	0.11	0.21	0.14	0.03	0.10	0.20

The parameter estimates remained nearly the same from Model 22 to Model 22.a, though some very slight changes were introduced after updating BTS CVs. Model 24.2 transitioned from three process errors to one. The shared process error estimated by Model 24.2 was slightly higher than the values estimated by Model 24.1 for the CGOA and EGOA, but it was almost half that of the Model 22.a estimated process error for the WGOA. Therefore, the changes in the predicted biomass for the EGOA and CGOA were smaller than the WGOA, where the change lead to a slightly smoother trend (Figure 15.9). Overall, the predicted biomass for the GOA is similar for these models (Figure 15.10). Model 24.2 estimated more additional observation error for the trawl survey compared to Model 22.a, while the additional observation error parameter for the longline survey was similar for both models.

Harvest Recommendations

Presently the Tier 5 approach is based solely on shortspine thornyheads; the rarely occurring longspine thornyheads are ignored. This is defensible because the latter are distributed deeper than where most fisheries operate. Also, the center of longspine thornyhead abundance appears to be off the U.S. West Coast and Alaskan waters may be near the limit of their range. In the future, if fisheries shift to deeper depths along the continental slope, and/or the catch of shortspine thornyheads increases dramatically, specific management measures for longspine thornyheads should be considered.

Amendment 56 Reference Points

We recommend keeping thornyhead rockfish as "Tier 5" in the NPFMC definitions for ABC and OFL based on Amendment 56 to the Gulf of Alaska FMP. The population dynamics information available for Tier 5 species consists of reliable estimates of biomass and natural mortality M, and the definition states that for these species, the fishing rate that determines ABC (i.e., F_{ABC}) is $\leq 0.75*M$. Thus, the recommended F_{ABC} for thornyhead rockfish is 0.0225 (i.e., 0.75 x M, where $M = 0.03$). The overfishing limit for Tier 5 species is defined to occur at a harvest rate of $F = M$. As described in the previous section, the recommended REMA Model 24.2 was fit to the 1990–2023 AFSC GOA BTS time-series of biomass values and estimates of uncertainty by region and depth strata (to account for missing survey data) and regional RPW indices from the 1992–2023 AFSC LLS (with associated estimates of uncertainty; Figure 15.9). These regional biomass estimates from the REMA Model 24.2 were then summed to obtain 2025 GOA-wide biomass of 59,459 t (+/- 95% CI of 47,064 and 75,117; Table 15.8) for thornyhead rockfish (Figure 15.10).

Specification of OFL and Maximum Permissible ABC

Applying the F_{ABC} to the estimate of current exploitable biomass of 59,459 t (+/- 95% CI of 47,064 and 75,117) for thornyhead rockfish results in a GOA-wide ABC of 1,338 t and OFL of 1,784 t for the 2025 fishery.

Risk Table and ABC Recommendation

Assessment Considerations

The GOA thornyhead stock complex assessment-related considerations was scored as Level 1: Normal. This is a Tier 5 species, meaning only reliable biomass estimates are available to calculate ABCs. The GOA thornyhead assessment is one of few Tier 5 assessments in Alaska that is fit to multiple abundance indices (trawl survey biomass estimates and longline survey RPWs). In recent years, the trawl survey depth range has been restricted (the 1996 and 2001 surveys did not survey the depths >500 m, and the 2003, 2011, 2013, 2017, 2019, 2021, and 2023 surveys did not survey depths >700 m), which is a concern for thornyhead rockfish. By including the longline survey RPWs as an abundance index in the random effects model, we are able to get informative biomass estimates for all depths. These two surveys have sometimes shown opposing trends, which is not unexpected due to the differing habitats sampled, but the inclusion of these two data sources has allowed for increased stability of biomass estimates and more consistent regional apportionments across time.

Population Dynamics Considerations

The GOA thornyhead stock complex population dynamics considerations was scored as Level 1: Normal. In general, very little is known regarding the life history of thornyhead, and current techniques do not produce reliable age estimates for the species, thus, we are unable to estimate recruitment with a statistical model. Further, any data collected during larval cruises lump all rockfish species together and do not identify thornyheads to species. Recent trends in thornyhead biomass have declined, though these changes are well within the variability seen throughout the time series with no alarming or sudden changes in population abundance seen.

Ecosystem Considerations

The GOA thornyhead rockfish ecosystem considerations was scored as Level 1: Normal. Benthic thermal conditions for adults in 2024 were approximately average, while larval rockfish growth may have benefited from warm spring/summer EGOA surface waters. The prey base for thornyhead rockfish is potentially limiting with declines in key prey on the shelf, but with little data from adult slope habitat. There is no indication of change in predation and competition, but these interactions are not well known. We document an ongoing concern due to the continued decline of sponges, habitat of known importance to thornyhead rockfish. In general, there is a lack of a mechanistic understanding for the direct and indirect effects of environmental change on the survival and productivity of thornyhead rockfish. This risk table section is informed by cited contributions to the 2023 and 2024 Gulf of Alaska Ecosystem Status Report (Ferriss 2023, 2024).

Benthic thermal conditions for adult thornyheads (shortspine: 100 to 600 m initially and move deeper as they grow, and longspine: 600 to 1,200m) in 2024 were approximately average (~4.5°C), while larval rockfish growth may have benefited from warm spring/summer surface waters (primarily in the EGOA) (Kendrick et al. 2024, Lemagie and Callahan 2024, Danielson and Hopcroft 2024). The 2023/2024 El Niño event brought warmer surface temperatures to the GOA in the winter, but it was moderate and short-lived, resulting in approximately average surface temperatures by spring in the western GOA and continued warm surface waters through the spring in the eastern GOA. Larval surveys in Shelikof Strait in 2023 observed a decline to below average (from 2019 and 2021) of larval rockfish (not identified to species; Rogers and Axler 2023), which may or may not be in response to a cooler 2023 spring and/or reduced zooplankton availability in that year. Surface waters in 2025 are predicted to cool with the development of a weak La Niña (Lemagie and Bell 2024, Danielson and Hopcroft 2024).

A continued multi-year decline (with high uncertainty) in relative abundance of sponges, structural habitat of importance, presents an ongoing concern for thornyhead rockfish. Observations in 2023 from AFSC's fishery-independent bottom trawl survey and fisheries-dependent observer data of non-target catches (both not designed to target structural epifauna) show relative stability until 2015 followed by a continual 9-year decline in the GOA-wide index through 2023 to a historic low value (AFSC bottom trawl, Laman and Downlin 2023b, Observer data, Whitehouse and Gaichas 2023). The declines in sponges appear to be driven by trends in the WGOA (Shumagin and to a lesser extent Kodiak regions).

Declines in key thornyhead prey on the shelf were observed, but with little data from adult slope habitat. Tanner crab biomass in 2024 dropped below average in the ADF&G survey around Kodiak, a decline of the strong year class first observed in 2018 (Worton 2024). Pandalid and non-pandalid shrimp CPUE declined between the 2021 and 2023 NOAA bottom trawl surveys in Chirikof, Kodiak, and Yakutat (Laman and Downlin 2023a). The spring biomass of copepods and euphausiids were above average/above average in central and eastern GOA (Seward Line survey, Hopcroft 2024, and seabird reproductive success, Whelan 2024, Drummond and Renner 2024). Shallow-water flatfish have generally been declining, with some exceptions. Other important prey of shortspine thornyhead rockfish include poorly monitored crabs, amphipods, and other benthic invertebrates (with juveniles more reliant on invertebrates).

Fishery-informed Stock Considerations

The GOA thornyhead stock complex fishery-informed stock considerations was scored as Level 1: Normal. There is no directed fishing of thornyheads, and they can only be retained as "incidentally-caught." Catch of thornyheads in the GOA has remained relatively low in recent years. The primary reason for lower catch is the increase in the use of pot gear within the IFQ sablefish fishery which do not catch thornyheads as effectively as longline gear. Low catch of this non-directed fishery complex has historically remained below the TAC.

Summary and ABC Recommendation

Assessment-related considerations	Population dynamics considerations	Ecosystem considerations	Fishery-informed stock considerations
Level 1: Normal	**Level 1:** Normal	**Level 1:** Normal	**Level 1:** Normal

The summarized results of the risk matrix exercise suggests no need to set the ABC below the maximum permissible.

Area Allocation of ABC

We used the REMA model to estimate area-specific biomass estimates to apportion ABCs among regions. The fit of this model is shown in Figures 15.9 and 15.10. The result is responsive to both the bottom trawl and longline survey indices. For 2025, the estimated distribution of biomass is shown as:

GOA Area	2025 Biomass (t)	Percent of Total Biomass	Area ABC Apportionment (t)
Western	10,514	18%	206
Central	25,643	43%	590
Eastern	23,302	39%	542
Gulfwide Total	59,459	100%	1,338

Status Determination

Based on Amendment 56 of the Gulf of Alaska FMP, overfishing for Tier 5 complex such as thornyheads is defined to occur at a harvest rate of $F = M$. Therefore, applying the estimate of M for thornyhead rockfish (0.03) to the estimate of current exploitable biomass (59,459 t) yields an overfishing catch limit of 1,784 t for 2025. This stock is not being subjected to overfishing.

Ecosystem Considerations

This section focuses on shortspine thornyheads exclusively, because this species overwhelmingly dominates the thornyhead biomass in the GOA. Shortspine thornyheads occupy different positions within the GOA food web depending upon life stage. Adults are generally more piscivorous and are also available to fisheries whereas juveniles prey more on invertebrates and are therefore at a lower trophic level. These food webs were derived from mass balance ecosystem models assembling information on the food habits, biomass, productivity and consumption for all major living components in each system (Aydin et al. 2007). See the 2011 Ecosystem Assessment's ecosystem modeling results section for a description of the methodology for constructing the food web.

Ecosystem Effects on GOA Shortspine Thornyheads

Predators

One simple way to evaluate ecosystem effects relative to fishing effects is to measure the proportions of overall mortality attributable to each source. Apportionment of shortspine thornyhead mortality between fishing, predation, and unexplained mortality from mass balance ecosystem modeling based on information from 1990–1994, indicates that adult shortspine thornyheads experience more fishing mortality than predation mortality, while juvenile thornyheads only experience predation mortality . During these years, approximately 52% of adult GOA shortspine thornyhead exploitation rate was due to the fishery, 22% due to predation, and 26% "unexplained". Since shortspine thornyheads are retained at higher levels in the GOA fisheries relative to the BSAI, it is likely that fishing mortality is a more important component of total mortality for GOA thornyheads than for those populations in the AI and EBS.

Fisheries were annually removing 1,300 metric tons of thornyheads from the GOA on average during the early 1990s (see Fishery section above). While estimates of predator consumption of thornyheads are more uncertain than catch estimates, the ecosystem models incorporate uncertainty in partitioning estimated consumption of shortspine thornyheads between their major predators in each system. Of the

22% of mortality due to predation, 36% (8% of total) is due to arrowtooth flounder, 24% (5.4% of total) due to "toothed whales" (sperm whales), 14% (3% of total) due to sharks, and 6% (1.4% of total) due to sablefish. If converted to tonnages, this translates to between 100 and 300 metric tons of thornyheads consumed annually by arrowtooth flounder during the early 1990s in that ecosystem, followed by "toothed whales" (sperm whales), which consume a similar range of thornyheads annually. Sharks consumed between 50 and 200 metric tons of shortspine thornyheads annually, and sablefish were estimated to consume less than 75 metric tons of adult thornyheads. Juvenile shortspine thornyheads are consumed almost exclusively by adult thornyheads, according to these models. Thornyheads are an uncommon prey in the GOA, as they generally make up less than 2% of even their primary predators' diets.

Prey

Diets of shortspine thornyheads are derived from stomach contents collections taken in conjunction with GOA trawl surveys. Over 70% of adult shortspine thornyhead diet measured in the early 1990s was shrimp, including both commercial (Pandalid) shrimp and non commercial (NP or Non-Pandalid shrimp) in equal measures. This preference for shrimp in the adult thornyhead diet combined with consumption rates estimated from stock assessment parameters and biomass estimated from the trawl survey, results in an annual consumption estimate ranging from 2,000 to 10,000 metric tons of shrimp. Other important prey of shortspine thornyheads include crabs, zooplankton, amphipods, and other benthic invertebrates. Thornyheads are estimated to consume up to an additional 1,000 metric tons of each of these prey annually in the GOA. Juvenile thornyheads have diets similar to adults, but they are estimated to consume far less prey overall than adults, as might be expected when a relatively small proportion of the population is in the juvenile stage at any given time.

Changes in Habitat Quality

There have been changes in structural habitat that may present a concern for thornyhead rockfish: vertical structure, including sponges, corals, and rocky habitat, has experienced multi-year decline (with high uncertainty) across the GOA (AFSC bottom trawl, Laman and Dowlin 2023b; Observer data, Whitehouse and Gaichas 2023). However, the physical habitat requirements for thornyheads are relatively unknown. Furthermore, the ecosystem models employed in this analysis are not designed to incorporate habitat relationships or any effects that human activities might have on habitat.

Fishery Effects on the Ecosystem

It is difficult to evaluate the ecosystem effects of a "thornyhead fishery" since there are no directed thornyhead fisheries in the GOA. As described above, most thornyhead catch comes from fisheries directed at sablefish, rockfish, and flatfish in the GOA. Discussions of the ecosystem effects of these fisheries can be found in their respective stock assessments.

Summary of Ecosystem Effects on GOA Thornyheads and Fisheries Effects on the Ecosystem

Examining the trophic relationships of shortspine thornyheads suggests that the direct effects of fishing on the population which are evaluated with standard stock assessment techniques is likely to be the major ecosystem factors to monitor for this species, because fishing is the dominant source of mortality for shortspine thornyheads in the GOA, and there are currently no major fisheries affecting their primary prey. However, if fisheries on the major prey of thornyheads—shrimp and to a lesser extent deepwater crabs—were to be re-established in the GOA, any potential indirect effects on thornyheads should be considered.

Data Gaps and Research Priorities

Because fishing mortality appears to be a larger proportion of adult thornyhead mortality in the GOA than predation mortality, highest priority research should continue to focus on direct fishing effects on shortspine thornyhead populations. The most important component of this research is to fully evaluate the age and growth characteristics of GOA thornyheads to re-institute the age-structured population dynamics model with adequate information. Additionally, mark recapture studies should continue since in the long term this may provide insight on mortality and growth rates and continue to monitor the effect of hook competition with faster growing species such as sablefish. We also hope to explore alternative parameterizations and methods to estimate additional observation error in the *rema* package in the future.

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Tables

Table 15.1. History of management measures with associated time series of catch (t), Over fishing Limit (OFL, t), Allowable Biological Catch (ABC, t), and Total Allowable Catch (TAC, t) for Gulf of Alaska (GOA) thornyheads updated through October 7, 2024.

Year	Catch	OFL	ABC	TAC	Management measure
1980	1,485		3,750	3,750	Thornyheads became a reported species group and managed as a single stock, while previously they were in the rockfish management group (1977) and then "other fish" (1979), with the TAC set GOA wide starting in 1979
1981	1,340		3,750	3,750	
1982	787		3,750	3,750	
1983	729		3,750	3,750	
1984	208		3,750	3,750	
1985	82		3,750	3,750	
1986	714		3,750	3,750	
1987	1,877		3,750	3,750	
1988	2,181		3,750	3,750	
1989	2,616		3,800	3,800	
1990	1,576		3,800	3,800	
1991	1,535		1,798	1,398	
1992	2,025	2,440	1,798	1,798	
1993	1,337	1,441	1,180	1,062	
1994	1,236	1,440	1,180	1,180	The NPFMC apportions the ABC and TAC into three geographic management areas: the Western, Central, and Eastern GOA
1995	1,027	2,660	1,900	1,900	
1996	1,013	2,200	1,560	1,248	
1997	1,109	2,400	1,700	1,700	
1998	1,149	2,840	2,000	2,000	
1999	1,113	2,800	1,990	1,990	
2000	1,134	2,820	2,360	2,360	Amendment 41 became effective which prohibited trawling in the Eastern GOA east of 140 degrees W
2001	995	2,770	2,310	2,310	
2002	1,046	2,330	1,990	1,990	
2003	1,133	3,050	2,000	2,000	Age-structured assessment model was suspended due to unreliability
2004	823	2,590	1,940	1,940	
2005	720	2,590	1,940	1,940	
2006	781	2,945	2,209	2,209	
2007	798	2,945	2,209	2,209	Amendment 68 creates the Central Gulf Rockfish Pilot Program
2008	736	2,540	1,910	1,910	
2009	665	2,540	1,910	1,910	
2010	568	2,360	1,770	1,770	
2011	629	2,360	1,770	1,770	
2012	739	2,220	1,665	1,665	The Central Gulf Rockfish Program is permanently put into place
2013	1,117	2,220	1,665	1,665	
2014	1,116	2,454	1,841	1,841	
2015	1,008	2,454	1,841	1,841	
2016	1,111	2,615	1,961	1,961	
2017	1,002	2,615	1,961	1,961	
2018	1,179	2,717	2,038	2,038	

Table 15.1. cont.

Year	Catch	OFL	ABC	TAC	Management Measure
2019	763	2,688	2,016	2,016	
2020	453	2,688	2,016	2,016	Amendment 107 requires GOA wide full retention of rockfish by catcher vessels using pot, hook-and-line, and jig gear while fishing for groundfish or halibut.
2021	273	2,604	1,953	1,953	
2022	359	2,604	1,953	1,953	
2023	208	2,170	1,628	1,628	
2024*	157	2,170	1,628	1,628	

*Catch not complete for 2024.

Table 15.2. Total Allowable Catch (TAC) and catch (t) by management area in the Gulf of Alaska (GOA) for thornyheads, including the limits and catch in the Central GOA Rockfish Program (RP). Catch data updated through October 7, 2024.

Year	WGOA		CGOA				EGOA	
	TAC	Catch	TAC	RP Limit	Catch	RP Catch	TAC	Catch
1991		689			596			250
1992		249			1015			761
1993		110			849			378
1994		162			733			341
1995		158			603			267
1996		177			595			241
1997		148			716			244
1998	250	238	710		716		1,040	195
1999	260	283	700		583		1,030	247
2000	430	340	990		551		940	244
2001	420	276	970		523		920	196
2002	360	372	840		505		790	169
2003	360	317	840		715		800	101
2004	410	276	1,010		409		520	138
2005	410	190	1,010		391		520	140
2006	513	197	989		400		707	184
2007	513	342	989	235	258	69	707	197
2008	267	270	860	194	299	58	783	167
2009	267	235	860	193	276	39	783	154
2010	425	140	637	194	278	81	708	151
2011	425	159	637	193	303	81	708	167
2012	150	171	766	263	345	84	749	222
2013	150	293	766	263	519	132	749	305
2014	235	239	875	300	660	189	731	217
2015	235	225	875	300	573	205	731	210
2016	291	198	988	339	691	295	682	221
2017	291	141	988	339	613	276	682	248
2018	344	172	921	316	684	264	773	322
2019	326	121	911	313	379	87	779	264
2020	326	49	911	313	206	113	779	198
2021	352	42	910	312	101	78	691	130
2022	352	110	910	312	173	112	691	76
2023	314	59	693	238	91	75	621	58
2024*	314	34	693	238	62	51	621	61
2025	206		590	203			542	

*Catch not complete for 2024.

Table 15.3. Estimated catch retained and discarded of Gulf of Alaska thornyheads (t) by gear type updated through October 7, 2024.

	Trawl gear			Longline gear		
Year	Retained	Discarded	Total	Retained	Discarded	Total
1981	1,139	-	1,139	201	-	201
1982	669	-	669	118	-	118
1983	620	-	620	109	-	109
1984	177	-	177	31	-	31
1985	70	-	70	12	-	12
1986	607	-	607	107	-	107
1987	1,863	-	1,863	14	-	14
1988	2,132	-	2,132	49	-	49
1989	2,547	-	2,547	69	-	69
1990	1,233	38	1,271	284	20	304
1991	1188	60	1248	233	53	287
1992	1041	129	1169	499	356	855
1993	489	173	663	377	297	674
1994	488	222	710	250	277	527
1995	471	165	635	315	77	391
1996	435	170	606	313	94	407
1997	567	224	791	269	50	319
1998	625	112	737	363	49	412
1999	597	197	794	277	42	320
2000	557	92	649	397	75	472
2001	479	52	532	425	37	462
2002	500	89	589	410	46	457
2003	705	70	775	321	36	357
2004	414	66	480	314	30	343
2005	333	27	360	319	41	360
2006	297	60	357	387	37	424
2007	368	11	379	370	49	419
2008	318	29	347	330	59	390
2009	252	25	277	320	69	388
2010	179	15	193	316	59	375
2011	215	31	245	324	59	384
2012	141	57	197	426	115	542
2013	199	17	216	477	424	901
2014	461	16	477	457	182	639
2015	317	27	344	459	205	664
2016	411	69	480	454	177	631
2017	379	26	406	434	161	596
2018	424	51	474	494	209	703
2019	294	18	312	377	73	451
2020	192	11	203	225	18	243
2021	137	9	147	109	11	120
2022	254	23	277	69	6	75
2023	130	8	139	52	11	63
2024*	97	14	112	37	6	42

*Catch not complete for 2024.

Table 15.4. Estimated catch (t) of thornyhead rockfish in the Gulf of Alaska by target fishery updated through October 7, 2024.

Year	Rockfish	Sablefish	Flatfish	Halibut	Other
2005	322	337	35	21	6
2006	312	386	52	31	1
2007	300	398	50	42	8
2008	248	389	62	30	8
2009	177	371	69	40	8
2010	106	367	57	32	6
2011	161	381	52	26	10
2012	129	539	45	23	4
2013	108	898	62	40	9
2014	244	634	143	33	62
2015	220	655	61	41	31
2016	337	620	27	38	89
2017	363	555	20	33	31
2018	362	711	55	45	6
2019	177	429	12	31	2
2020	138	246	55	14	0
2021	113	121	24	12	3
2022	215	88	40	10	6
2023	123	67	1	8	9
2024*	88	57	3	8	2

*Catch not complete for 2024.

Table 15.5. Estimated Gulf of Alaska (GOA) thornyhead discards (t) by target fishery updated through October 7, 2024.

Year	Rockfish	Sablefish	Flatfish	Halibut	Other	GOA Total	GOA Rate
2005	23	38	4	2	0	68	9.5%
2006	56	36	3	< 1	< 1	97	12.4%
2007	4	40	5	11	< 1	60	7.5%
2008	16	63	8	< 1	1	88	12.0%
2009	18	64	2	9	< 1	94	14.1%
2010	7	57	5	4	< 1	73	12.9%
2011	19	62	7	< 1	1	90	14.3%
2012	21	119	31	0	< 1	172	23.3%
2013	5	419	2	10	5	441	39.5%
2014	10	176	2	8	2	198	17.8%
2015	11	199	6	12	5	232	23.0%
2016	7	179	2	5	53	246	22.1%
2017	23	149	3	6	7	188	18.7%
2018	20	231	< 1	9	< 1	260	22.1%
2019	13	70	4	4	< 1	92	12.0%
2020	8	19	3	< 1	< 1	30	6.7%
2021	6	12	1	2	< 1	21	7.95%
2022	12	11	4	1	2	30	8.45%
2023	5	6	1	2	7	21	9.95%
2024*	10	5	1	3	2	21	13.3%

*Discards not complete for 2024.

Table 15.6. Design-based estimates with coefficient of variation (CV) of Gulf of Alaska shortspine thornyhead relative population weight (RPW) by management region. These are inputs in the assessment model provided by the Alaska Fisheries Science Center longline survey.

Year	WGOA	CGOA	EGOA
1992	11,390 (0.122)	20,697 (0.123)	11,508 (0.092)
1993	8,308 (0.146)	16,337 (0.206)	16,280 (0.087)
1994	8,849 (0.198)	16,017 (0.162)	11,420 (0.097)
1995	8,585 (0.143)	13,043 (0.164)	15,391 (0.095)
1996	10,650 (0.122)	17,215 (0.156)	17,773 (0.091)
1997	5,721 (0.113)	15,449 (0.173)	20,537 (0.082)
1998	7,712 (0.101)	18,083 (0.104)	17,280 (0.058)
1999	6,309 (0.148)	23,834 (0.114)	18,512 (0.102)
2000	6,043 (0.158)	16,954 (0.162)	18,619 (0.100)
2001	7,352 (0.176)	31,076 (0.137)	23,071 (0.075)
2002	13,157 (0.282)	23,109 (0.115)	16,872 (0.083)
2003	8,807 (0.178)	22,861 (0.103)	16,468 (0.087)
2004	7,566 (0.164)	14,944 (0.087)	12,631 (0.107)
2005	9,922 (0.306)	19,580 (0.151)	17,418 (0.098)
2006	7,514 (0.170)	19,550 (0.113)	19,307 (0.090)
2007	7,676 (0.204)	18,925 (0.144)	19,878 (0.065)
2008	9,943 (0.233)	27,239 (0.130)	25,211 (0.104)
2009	11,290 (0.155)	19,802 (0.195)	18,339 (0.080)
2010	14,504 (0.254)	24,000 (0.132)	26,361 (0.090)
2011	9,208 (0.210)	23,041 (0.122)	21,823 (0.074)
2012	6,860 (0.168)	26,388 (0.099)	22,553 (0.092)
2013	12,085 (0.116)	31,873 (0.134)	26,493 (0.058)
2014	12,420 (0.155)	27,897 (0.213)	21,839 (0.093)
2015	12,389 (0.159)	27,130 (0.107)	19,669 (0.076)
2016	13,473 (0.170)	19,793 (0.076)	22,031 (0.093)
2017	13,429 (0.177)	25,866 (0.077)	21,605 (0.115)
2018	13,652 (0.223)	19,637 (0.097)	22,453 (0.085)
2019	18,104 (0.285)	19,329 (0.117)	18,684 (0.050)
2020	9,469 (0.158)	18,657 (0.203)	13,300 (0.062)
2021	7,885 (0.093)	16,328 (0.104)	11,081 (0.059)
2022	6,740 (0.230)	16,028 (0.105)	20,701 (0.093)
2023	5,192 (0.153)	10,805 (0.144)	10,699 (0.076)

Table 15.7. Design-based estimates with coefficient of variation (CV) of Gulf of Alaska shortspine thornyhead biomass (t) by management region. These are inputs in the assessment model provided by the Alaska Fisheries Science Center bottom trawl survey.

Year	WGOA			CGOA			EGOA		
	0–500 m	501–700 m	701–1000 m	0–500 m	501–700 m	701–1000 m	0–500 m	501–700 m	701–1000 m
1990	1,679 (0.401)	-	-	5,941 (0.250)	-	-	11,996 (0.105)	-	-
1993	3,706 (0.222)	-	-	12,508 (0.164)	-	-	16,800 (0.101)	-	-
1996	8,043 (0.150)	-	-	19,030 (0.102)	-	-	24,911 (0.118)	-	-
1999	7,029 (0.232)	5,389 (0.153)	1,679 (0.500)	22,935 (0.085)	6,725 (0.141)	2,930 (0.153)	25,890 (0.102)	2,838 (0.214)	1,922 (0.344)
2001	8,753 (0.171)	-	-	19,908 (0.082)	-	-	-	-	-
2003	15,035 (0.176)	5,887 (0.290)	-	42,787 (0.141)	10,462 (0.413)	-	22,393 (0.079)	5,011 (0.235)	-
2005	12,351 (0.163)	6,377 (0.080)	3,277 (0.239)	27,429 (0.068)	6,728 (0.124)	8,262 (0.197)	22,729 (0.065)	5,108 (0.176)	2,408 (0.256)
2007	7,619 (0.140)	2,590 (0.145)	1,943 (0.096)	20,909 (0.091)	8,962 (0.176)	7,736 (0.145)	25,819 (0.110)	4,858 (0.203)	4,241 (0.191)
2009	12,464 (0.207)	5,605 (0.222)	719 (0.549)	19,722 (0.088)	5,365 (0.225)	3,469 (0.361)	19,809 (0.067)	6,820 (0.139)	4,821 (0.451)
2011	3,546 (0.163)	2,272 (0.664)	-	21,172 (0.109)	6,885 (0.134)	-	24,971 (0.114)	4,334 (0.184)	-
2013	6,476 (0.203)	2,739 (0.085)	-	23,868 (0.123)	8,195 (0.262)	-	25,030 (0.113)	3,569 (0.121)	-
2015	9,653 (0.163)	2,733 (0.195)	1,147 (0.986)	33,025 (0.125)	4,666 (0.126)	7,214 (0.091)	22,743 (0.114)	4,374 (0.302)	3,686 (0.452)
2017	12,196 (0.201)	2,740 (0.387)	-	28,591 (0.110)	4,845 (0.172)	-	27,820 (0.132)	4,301 (0.150)	-
2019	10,785 (0.135)	7,992 (0.480)	-	27,598 (0.107)	6,015 (0.340)	-	22,253 (0.138)	3,827 (0.176)	-
2021	10,424 (0.369)	4,269 (0.201)	-	21,385 (0.139)	7,601 (0.191)	-	19,104 (0.104)	5,442 (0.409)	-
2023	5,081 (0.200)	971 (0.031)	-	19,672 (0.289)	7,196 (0.435)	-	18,760 (0.146)	5,605 (0.082)	-

Table 15.8. Time series of estimated exploitable biomass using the random effects Model (24.2) for the Western Gulf of Alaska (WGOA), Central Gulf of Alaska (CGOA), Eastern Gulf of Alaska (EGOA), and the GOA-wide total (GOA Total), with 95% lower (LCI) and upper confidence intervals (UCI).

Year	WGOA	CGOA	EGOA	GOA Total	LCI	UCI
1990	14,280	24,361	19,697	58,338	47,266	72,002
1991	14,612	25,562	20,391	60,566	50,238	73,017
1992	14,975	26,901	21,120	62,996	53,864	73,676
1993	14,413	26,699	22,927	64,039	55,686	73,645
1994	14,274	26,753	23,117	64,145	56,020	73,448
1995	14,159	26,911	25,574	66,644	58,364	76,099
1996	14,114	28,389	28,385	70,888	62,398	80,532
1997	12,889	29,231	30,178	72,299	63,337	82,528
1998	12,812	31,001	29,985	73,798	64,916	83,894
1999	12,767	33,355	30,671	76,793	67,976	86,754
2000	12,994	34,156	31,240	78,389	68,770	89,355
2001	13,985	36,694	32,010	82,689	72,385	94,459
2002	15,157	37,337	29,654	82,148	72,064	93,643
2003	15,864	37,670	28,395	81,929	72,311	92,825
2004	15,549	34,126	27,301	76,976	67,714	87,506
2005	15,947	35,119	29,335	80,401	71,461	90,460
2006	14,946	34,837	31,382	81,164	71,863	91,669
2007	14,552	35,366	33,260	83,178	74,196	93,247
2008	15,297	36,616	34,955	86,868	76,469	98,682
2009	15,918	35,681	33,980	85,579	76,107	96,231
2010	15,309	37,290	36,605	89,204	78,370	101,537
2011	13,947	38,230	36,220	88,397	78,272	99,831
2012	14,372	40,670	36,898	91,940	80,655	104,804
2013	15,630	42,089	37,355	95,074	83,423	108,353
2014	17,027	42,011	35,823	94,861	82,764	108,726
2015	17,690	41,207	34,179	93,076	82,313	105,245
2016	18,618	38,125	34,628	91,370	80,402	103,835
2017	18,733	37,849	34,166	90,748	79,826	103,164
2018	18,356	35,089	32,690	86,135	75,447	98,337
2019	17,352	33,559	29,292	80,203	70,903	90,724
2020	15,417	31,302	25,508	72,227	63,501	82,153
2021	13,655	29,321	24,062	67,039	59,157	75,971
2022	11,904	27,287	25,258	64,450	56,351	73,711
2023	10,514	25,643	23,302	59,459	50,898	69,459
2024	10,514	25,643	23,302	59,459	48,753	72,515
2025	10,514	25,643	23,302	59,459	47,064	75,117

Figures

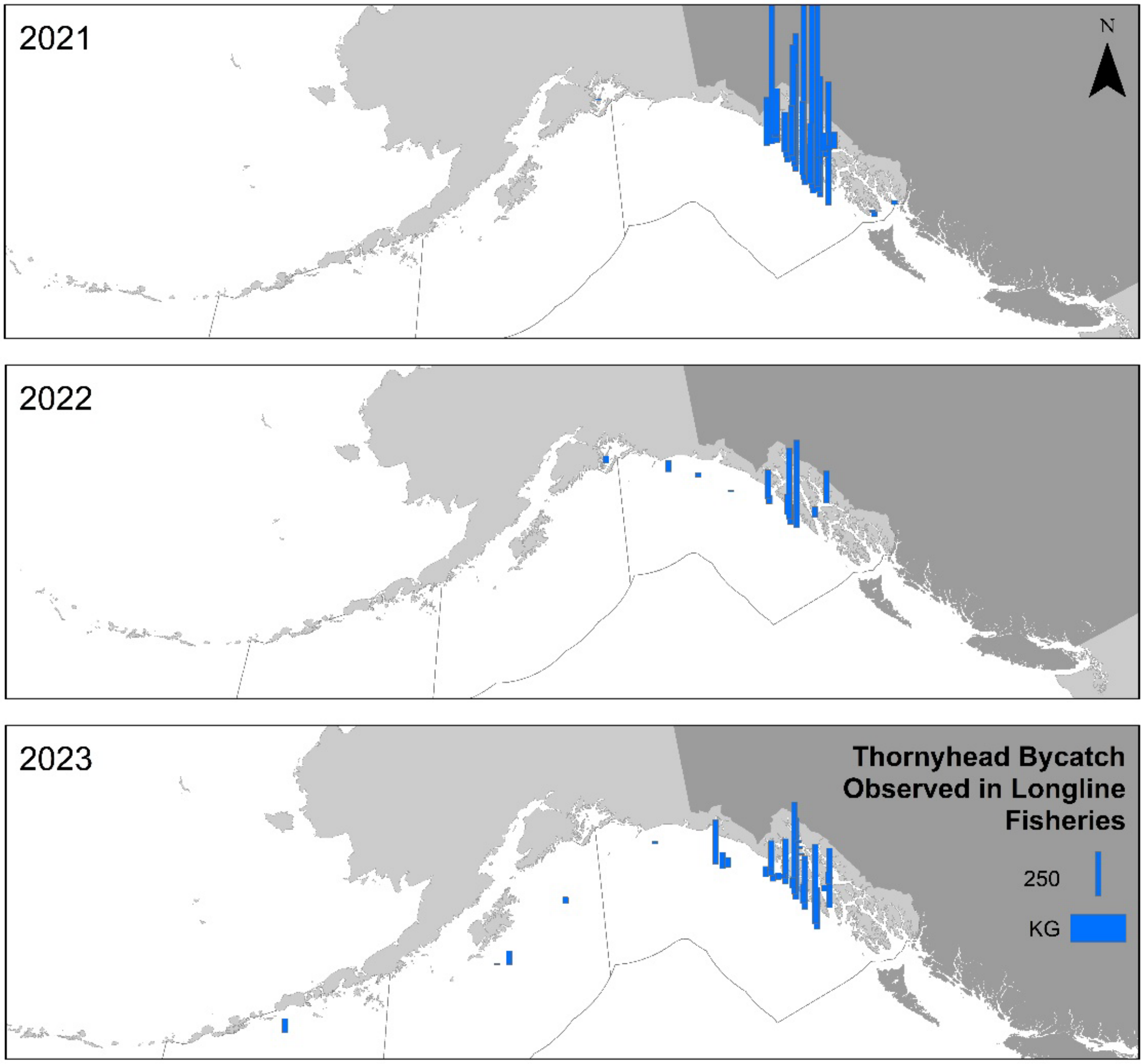

Figure 15.1. Spatial distribution of observed thornyhead rockfish catch in longline fisheries in the GOA from 2021 to 2023. Height of the bar represents the catch in kilograms. Each bar represents non-confidential catch data summarized into 400km^2 grids. Note that catch within the inside waters of Southeast are not within federal waters. Data provided by the Fisheries Monitoring and Analysis division website, queried October 10, 2024 (https://www.fisheries.noaa.gov/resource/map/alaska-groundfish-fishery-observer-data-map).

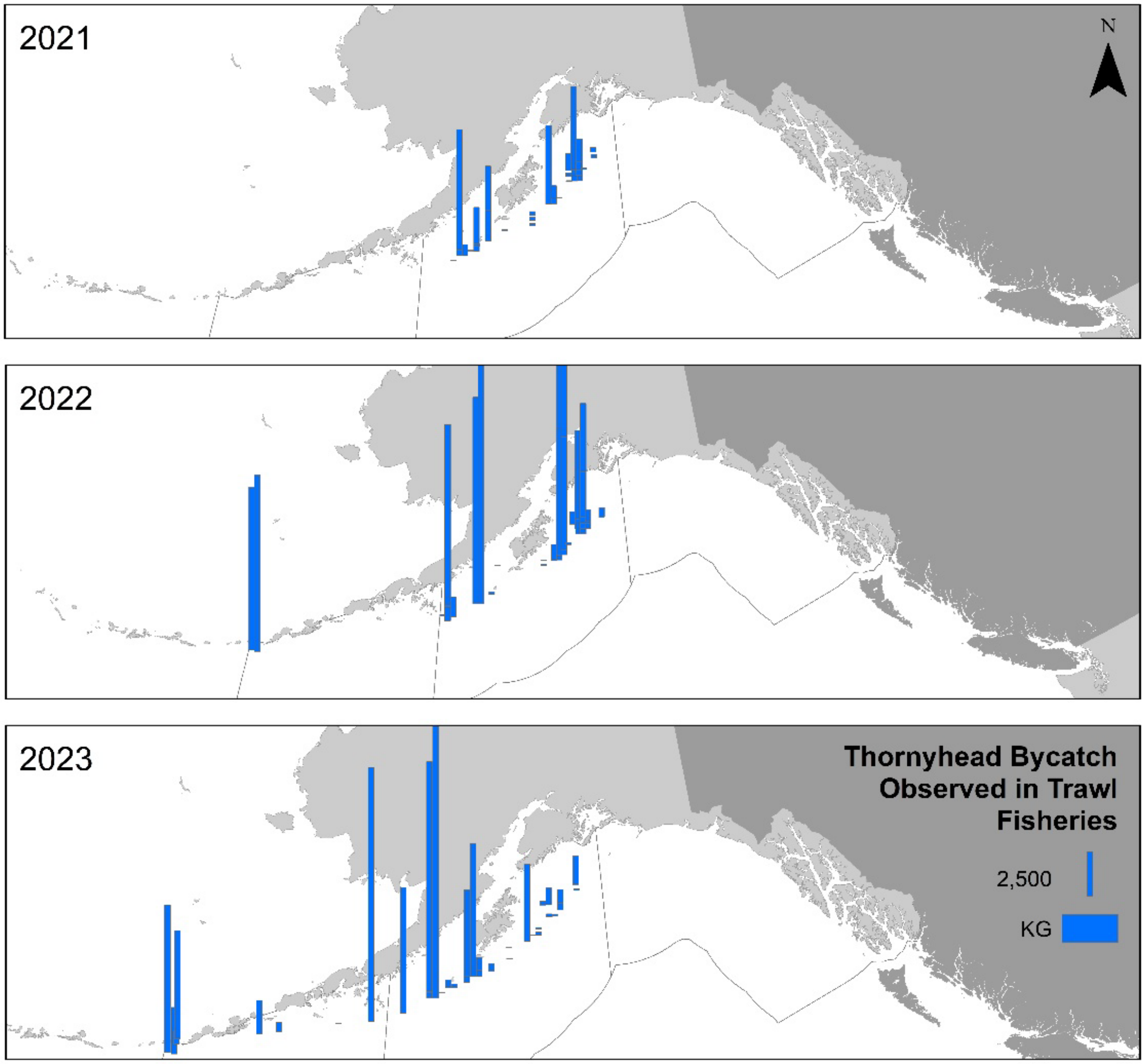

Figure 15.2. Spatial distribution of observed thornyhead rockfish catch in trawl fisheries in the GOA from 2021 to 2023. Height of the bar represents the catch in kilograms. Each bar represents non-confidential catch data summarized into 400km^2 grids. Data provided by the Fisheries Monitoring and Analysis division website, queried October 10, 2024 https://www.fisheries.noaa.gov/resource/map/alaska-groundfish-fishery-observer-data-map).

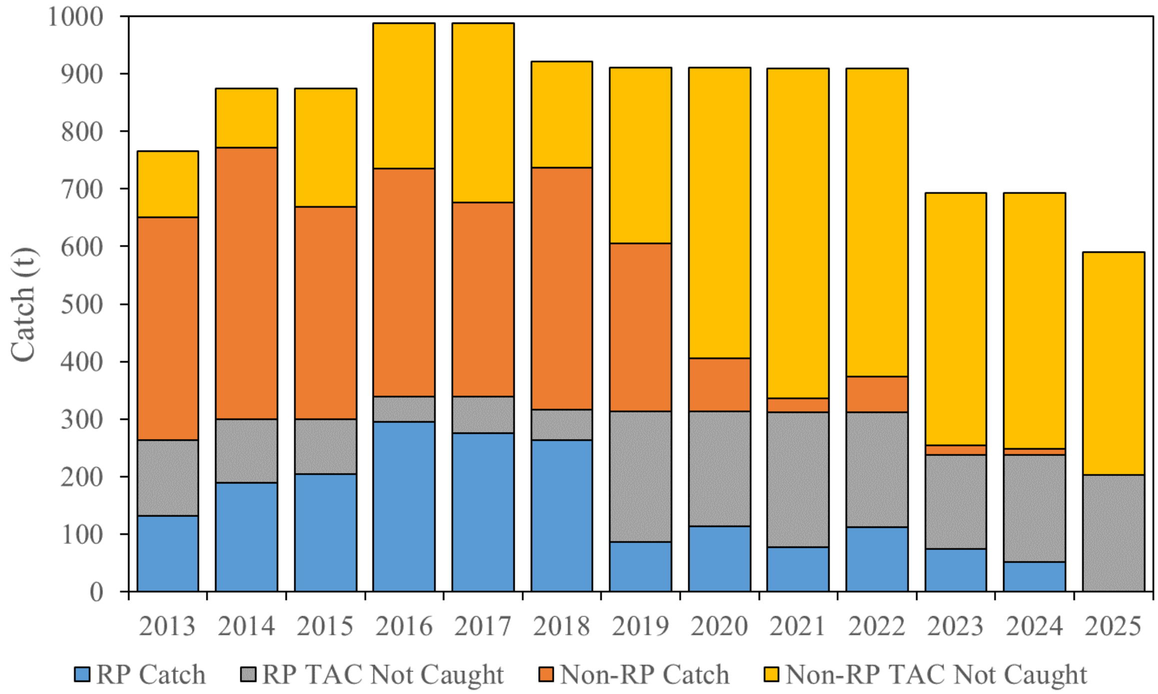

Figure 15.3. Total allowable catch (TAC) of thornyhead in the Central Gulf of Alaska (CGOA) separated by catch in the CGOA Rockfish Program (RP Catch, blue), CGOA Rockfish Program TAC not caught (RP TAC Not Caught, grey), catch outside of the CGOA Rockfish Program (Non-RP catch, orange), and TAC not caught outside of the CGOA Rockfish Program (Non-RP TAC Not Caught, yellow).

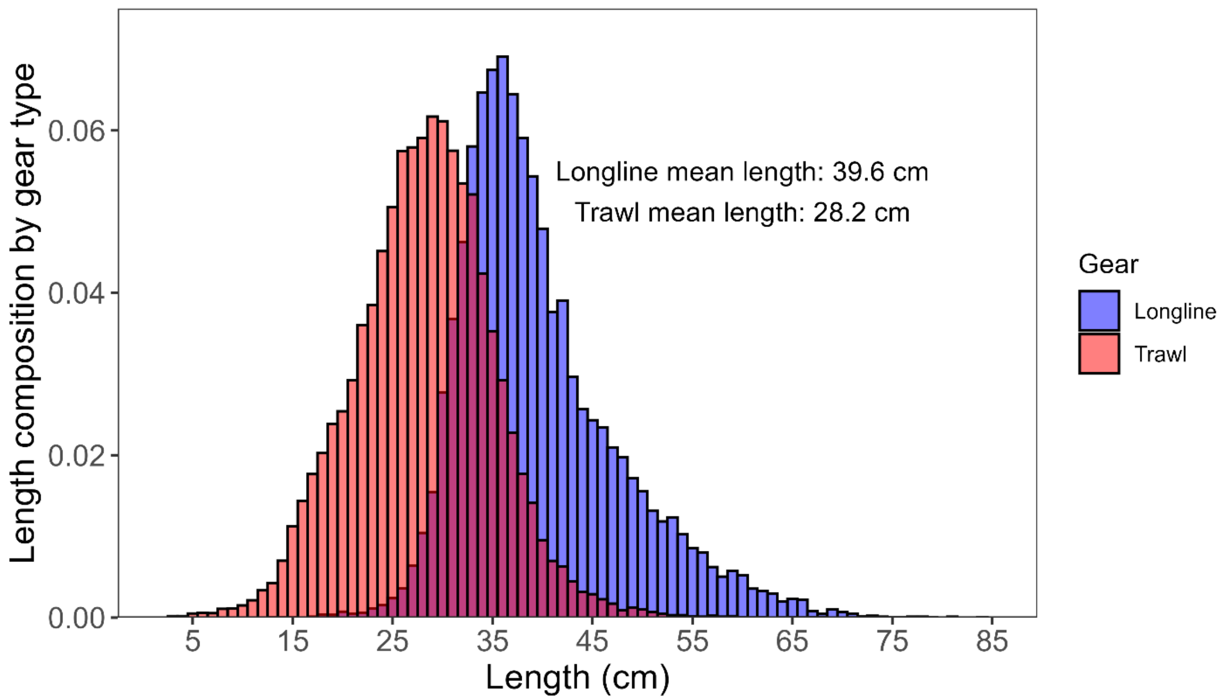

Figure 15.4. Comparison of shortspine thornyhead length composition from trawl (red) and longline (blue) fisheries using data from 1990 to 2024.

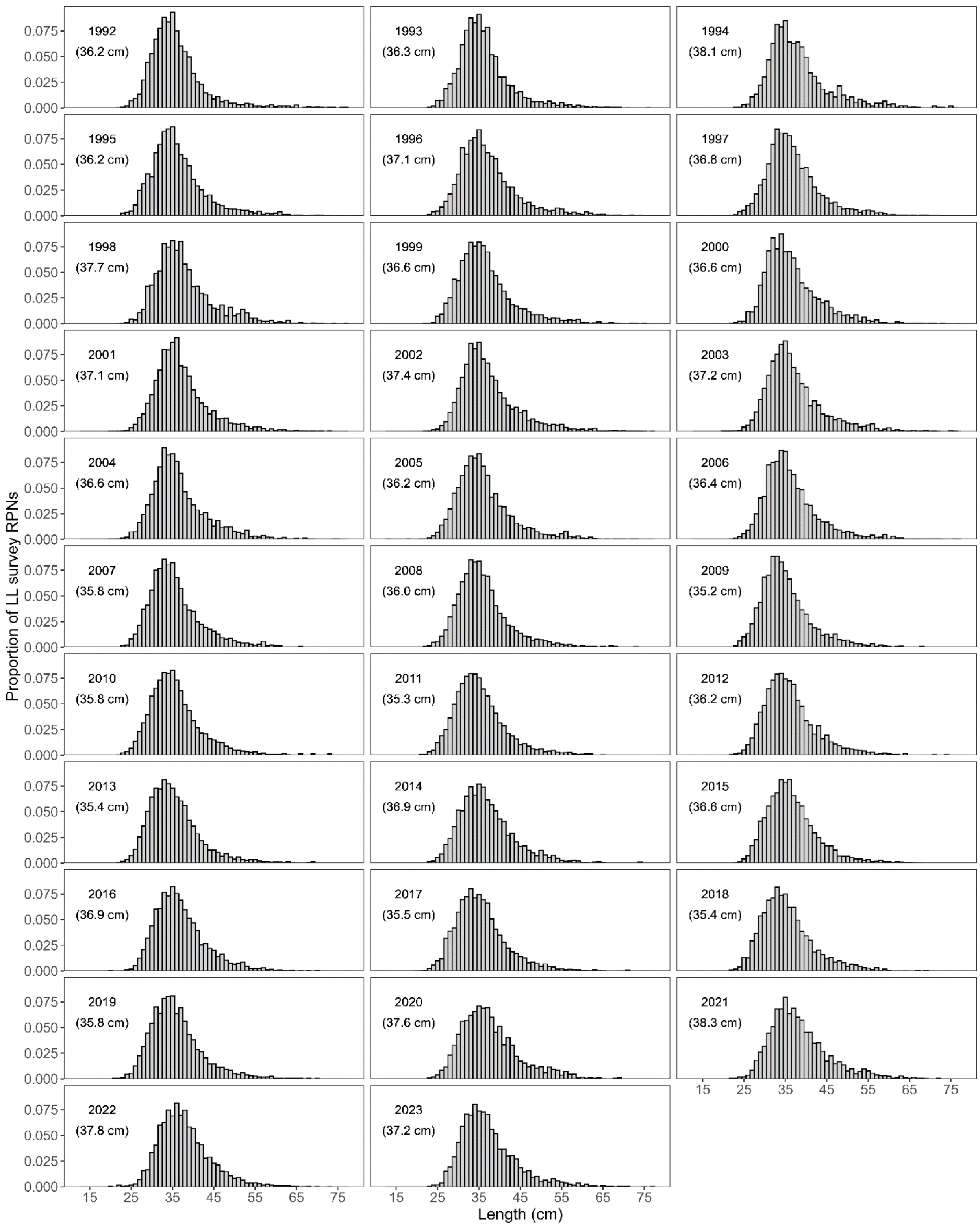

Figure 15.5. Size composition of the estimated population of shortspine thornyhead in the Gulf of Alaska based on the Alaska Fisheries Science Center longline surveys conducted between 1992 and 2023, and annual mean lengths shown in parentheses.

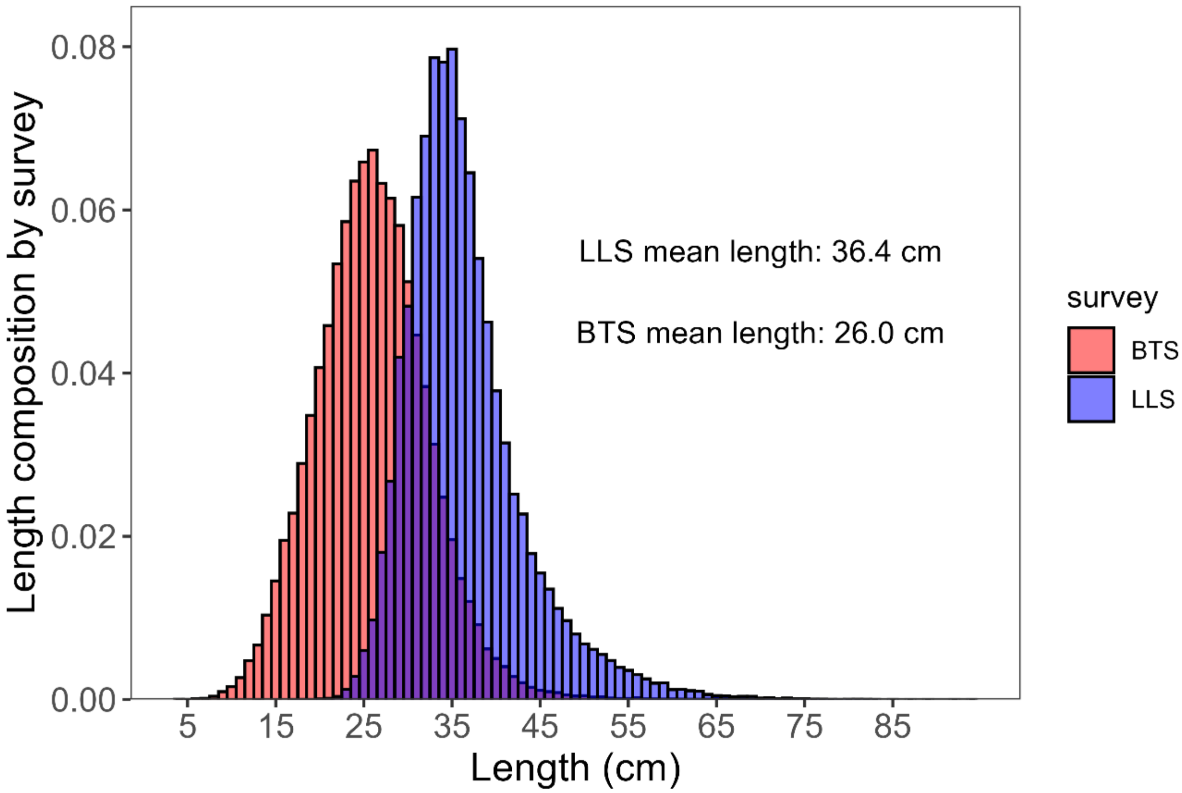

Figure 15.6. Comparison of size composition of the estimated population of shortspine thornyhead in the Gulf of Alaska based on Alaska Fisheries Science Center bottom trawl survey (BTS, red) and longline survey (LLS, blue).

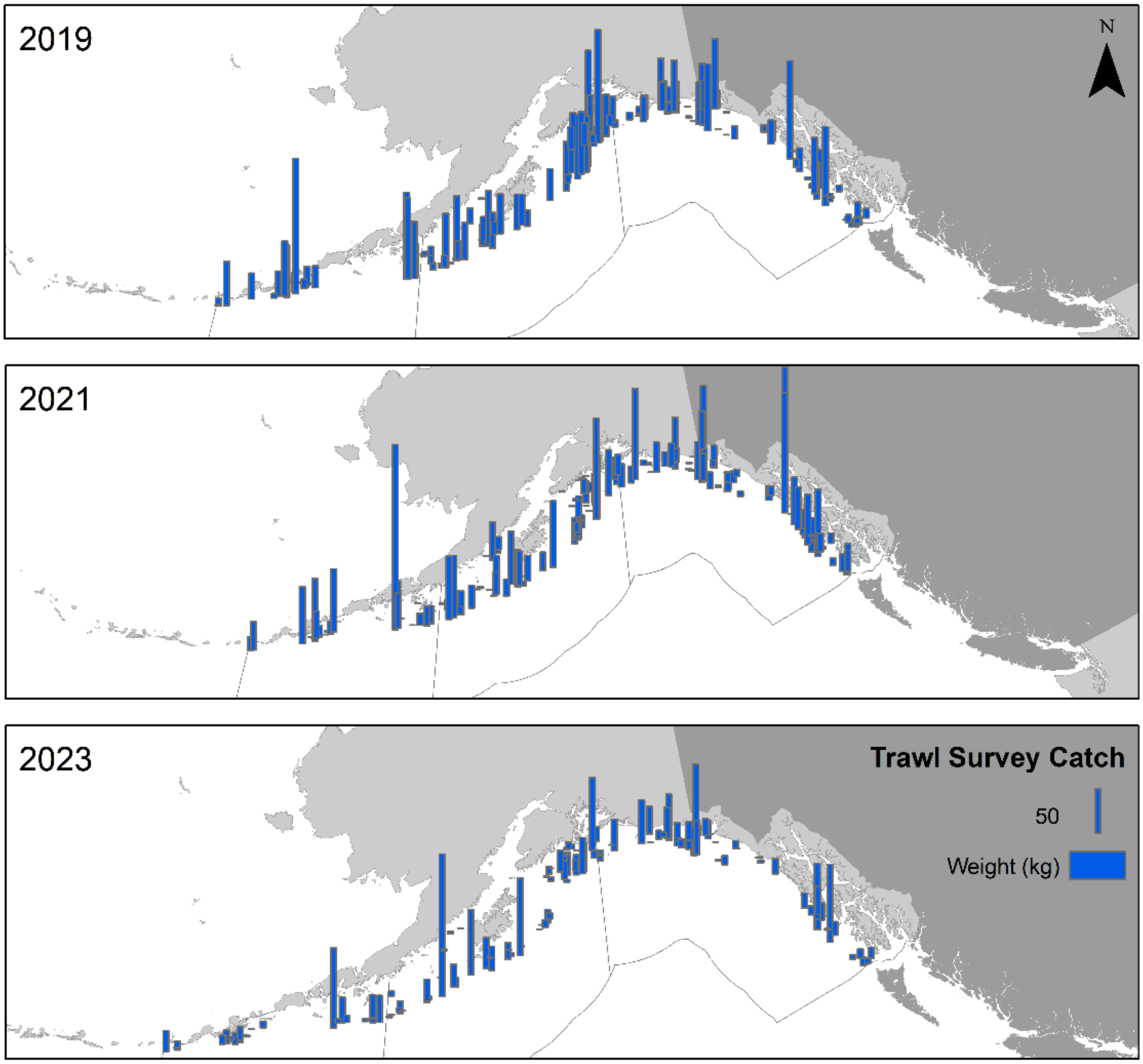

Figure 15.7. Spatial distribution of thornyhead rockfish catches (kg) in the Gulf of Alaska 2019, 2021, and 2023 NMFS bottom trawl survey.

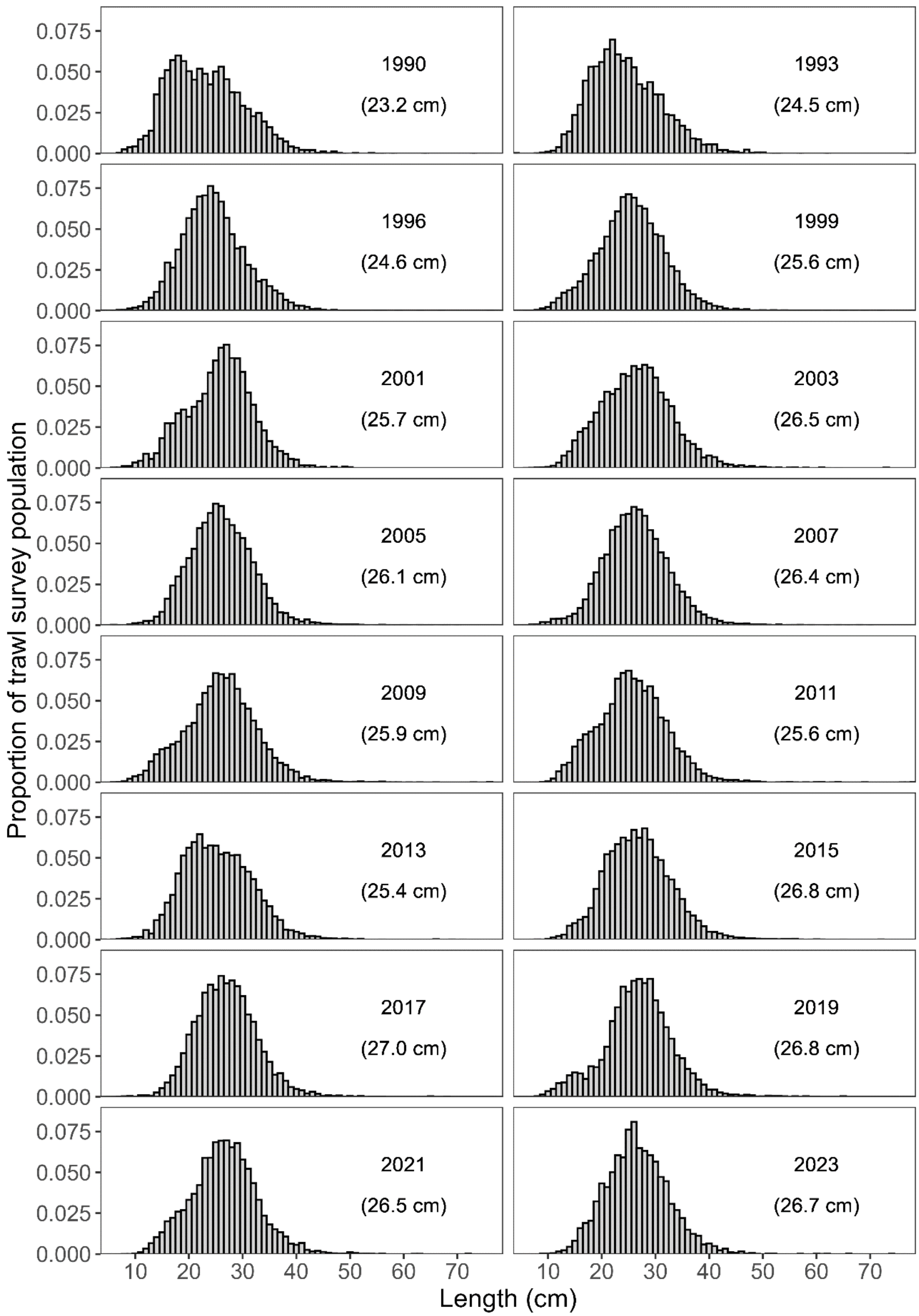

Figure 15.8. Size composition of the estimated population of shortspine thornyhead in the Gulf of Alaska based on Alaska Fisheries Science Center bottom trawl surveys conducted between 1990 and 2023, and annual mean lengths shown in parentheses.

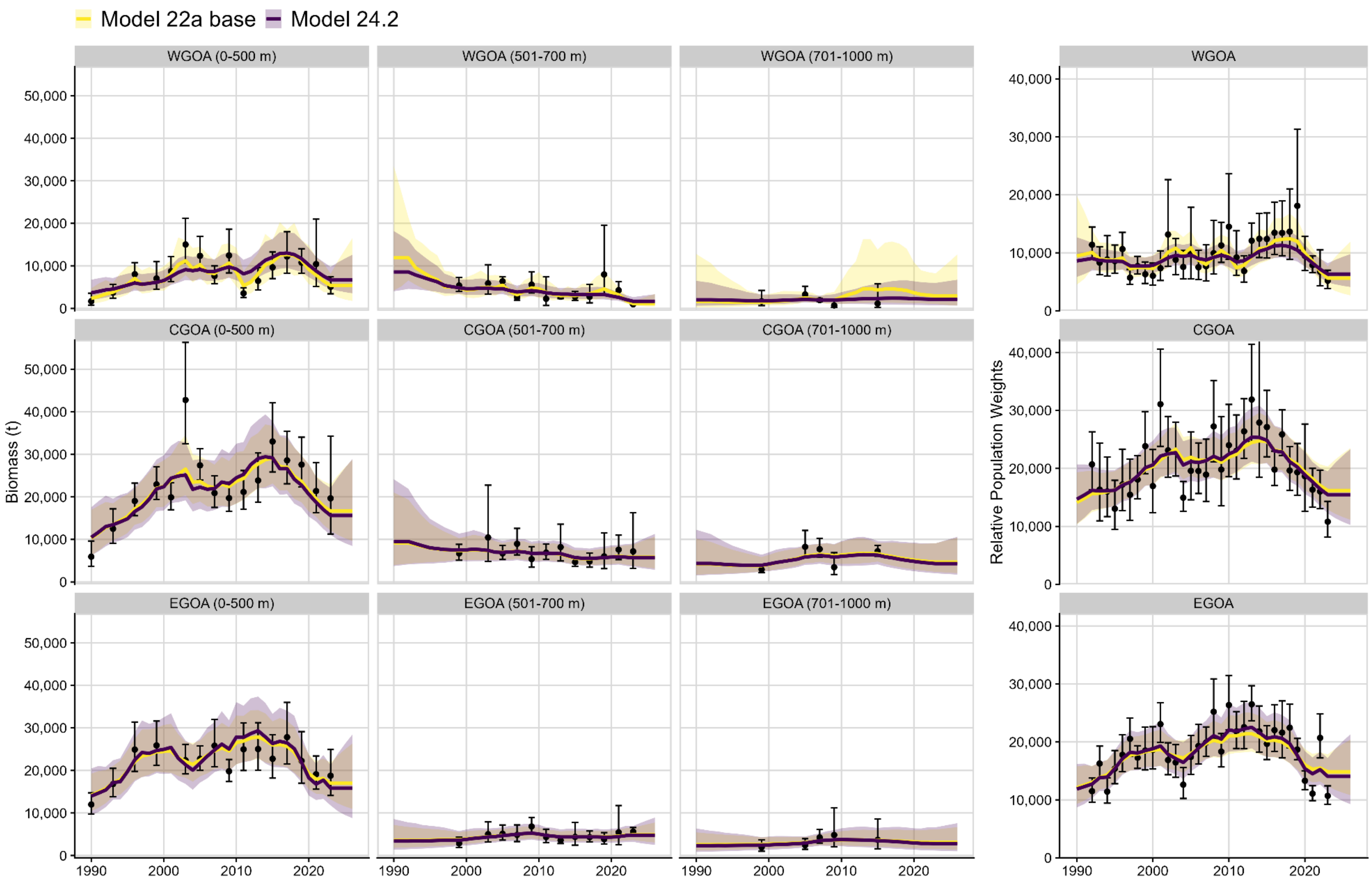

Figure 15.9. Gulf of Alaska shortspine thornyhead random effects model results (solid lines with 95% confidence intervals in shaded regions) for status quo model Model 22.a (yellow) and the recommended Model 24.2 (purple). Fits are to design-based survey estimates from the Alaska Fisheries Science Center bottom trawl survey (biomass by region and depth strata, 9 panels on the left) and longline survey (relative population weight, 3 panels on the right), where filled black circles are design-based estimates with error bars for the 95% confidence intervals.

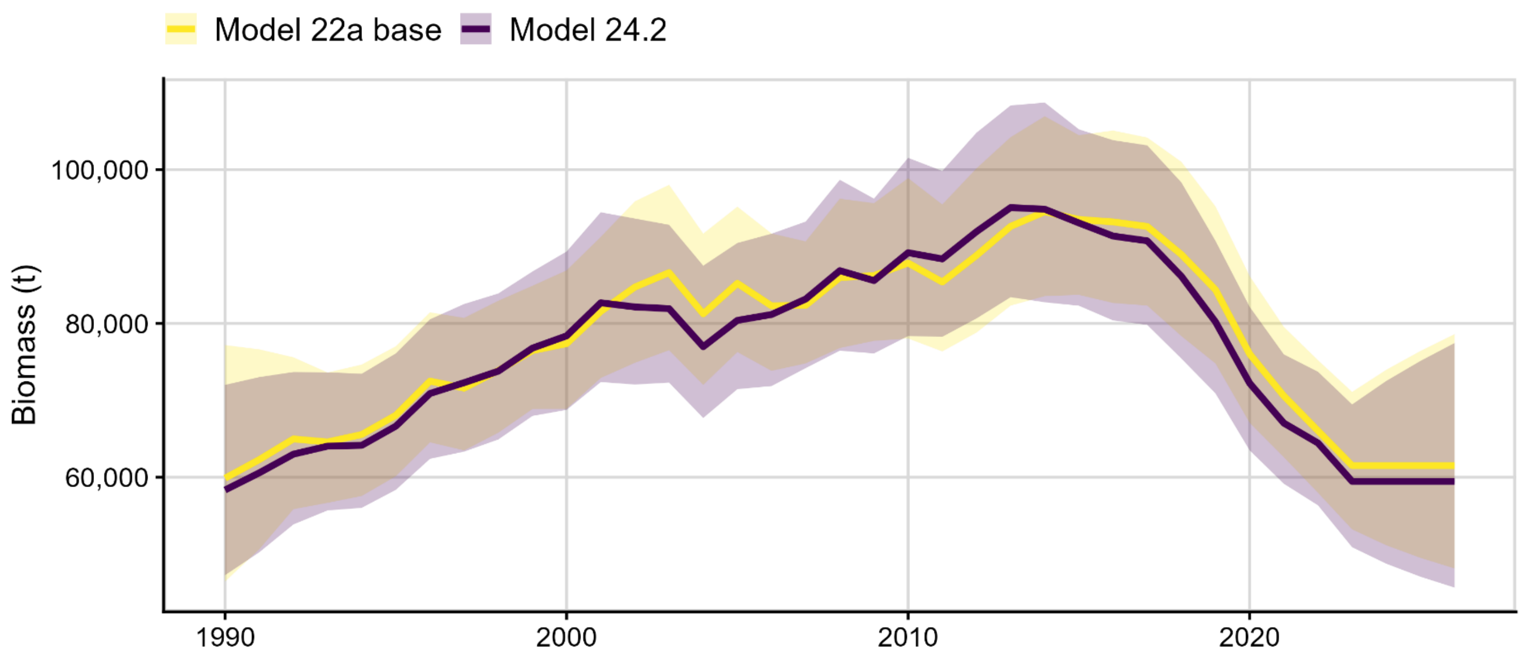

Figure 15.10. Gulf of Alaska shortspine thornyhead random effects model results (solid lines with 95% confidence intervals in shaded regions) for status quo model Model 22.a (yellow) and the recommended Model 24.2 (purple).

Appendix 15A: Evaluation of stock structure for Gulf of Alaska Thornyhead Stock Complex

Katy B. Echave and Kevin A. Siwicke

Executive Summary

We present various types of information on the Gulf of Alaska (GOA) thornyhead stock complex to evaluate potential stock structure for this species. We follow the stock structure template recommended by the Stock Structure Working Group (SSWG) and elaborate on each category within this framework. Available information on movement, demographics, and genetics indicates no stock structure for thornyhead rockfish in the GOA. Thornyhead are long-lived with a long generation time, but there is little information regarding spawning, reproduction, larval dispersal, or behavior. Length-weight relationships are similar among regions in the GOA. Harvest and trend data show declining trends, but consistent fishing effort with abundance distribution. Tagging studies show that large movements are possible, at times crossing management boundaries, but that most tagged fish remain within their tagging location (Echave 2017). Recent genetic analysis indicates no spatial structure in shortspine thornyhead (thornyhead) rockfish, indicating that thornyhead rockfish represent a single genetic stock in Alaskan waters (W. Larson, pers. comm.). The best scientific information available indicates no stock structure for thornyhead rockfish in the GOA.

Currently, the GOA thornyhead stock complex is managed as a Tier 5 stock with area-specific Acceptable Biological Catch (ABC) and gulf-wide Overfishing Level (OFL). Given that ABCs are set at 0.75 of a very low natural mortality rate, and thornyhead catches are near 17% of maximum permissible, the risk of overfishing is low. However, the subarea ABC has been exceeded at times in the WGOA (2014). We continue to recommend the current management specifications for thornyhead rockfish.

Introduction

The Stock Structure Working Group (SSWG) was formed in 2009 to develop a set of guidelines to assist stock assessment authors in providing recommendations on stock structure for Alaska stocks. The framework was presented at the September 2009 joint Groundfish Plan Team and a report was drafted shortly thereafter that included a template for presenting various scientific data for inferring stock structure. In November 2010, the Gulf of Alaska Groundfish Plan Team (GOA GPT) discussed the advantages of having all stock assessment authors evaluate stock structure characteristics of specific stocks.

The thornyhead (*Sebastolobus* species) complex is managed as a Tier 5 stock with area-specific ABC and gulf-wide OFL recommendations. There are three species in the genus *Sebastolobus*, including the shortspine thornyhead *Sebastolobus alascanus*, the longspine thornyhead *S. altivelis*, and the broadfin thornyhead *S. macrochir* (Eschmeyer et al. 1983, Love et al. 2002). Broadfin thornyhead occurs rarely in the Aleutian Islands but does not appear to inhabit the GOA. Longspine thornyheads do occur in the GOA but are much less common than the shortspine thornyheads. Consequentially, in the assessment and this stock structure document, we focus on shortspine thornyheads and monitor available information on longspine thornyheads from GOA trawl surveys and fishery sampling. Refer to the 2024 stock assessment for information related to thornyhead distribution, life history, fishery and management history for the GOA thornyhead complex. The following sections are a summary of what is known about thornyhead rockfish in the GOA relevant to stock structure concerns along with an evaluation of the stock structure template, author recommendations, and potential management implications to be considered.

Application of Stock Structure Template

To address stock structure concerns, we utilize the existing framework for defining spatial management units introduced by Spencer et al. (2010) (Table 15A.1). In the following sections, we elaborate on the available information used to respond to specific factors and criterion for defining thornyhead rockfish stock structure.

Harvest and trends

Fishing mortality

Thornyhead rockfish are Tier 5, thus a fishing mortality rate (*F*) is difficult to estimate. Directed fishing is not allowed for thornyhead in the GOA, and the fish can only be retained as "incidentally-caught" species. Gulfwide discard rates (% of the total catch discarded within a management category) of thornyhead have ranged between 7% and 40%, but have dropped significantly since 2020 due to regulatory changes requiring full retention of rockfish by catcher vessels using fixed gear (Echave et al. 2022). Discard mortality is assumed to be 100%, and thus all catch is considered mortality in the assessment.

Population trends

Gulfwide biomass estimates for thornyhead provided by the trawl surveys are variable, sometimes showing rather large fluctuations between surveys. For example, gulfwide biomass was 33,014 t in 1993 and then increased to 51,984 t in 1996 (Echave et al. 2022). Thornyhead rockfish are a long lived species, however, and an actual increase in abundance would not be seen in such a short time period. While the trawl survey may not sample this species well, trend information may still be inferred. There has been a general decreasing trend in gulfwide biomass estimates since 2015, which has been seen in all areas (Figure 15.9 in SAFE).

Gulfwide relative abundance estimates (RPWs) for shortspine thornyhread provided by the longline surveys are variable as well, but have also shown a general gulfwide downward trend since 2013. All areas have shown decreasing trends, with the largest seen in the Central GOA (Figure 15.9 in SAFE).

Spatial overlap of fishery and survey data

We utilized survey and observed fishery data by trawl and longline gear to generate spatial distribution maps of thornyhead concentrations. We first created a base layer by interpolating mean trawl survey thornyhead catch by weight from 1990 to 2023 to 5 x 5-km grid cells for the survey footprint. We then overlaid mean trawl fishery catches aggregated to 0.5 x 0.5 degrees and available from 1993 to 2023. Another base layer was interpolated for the mean longline survey thornyhead catch by numbers from 1993 to 2023 to the same grid and area as the trawl survey, and we overlaid the calculated mean longline fishery catches from 1993 to 2023. All fishery data was filtered to only include aggregated cells which had more than 100 hauls during the entire time period to reflect where the fishery was occurring and exclude areas that were rarely fished. Based on survey data, thornyhead are rather evenly spread gulfwide in a band along the continental slope, with pockets of higher abundance in the CGOA and the West Yakutat area of the Eastern GOA (Figure 15A.1). In general, the mean catches for the observed trawl fishery were primarily distributed throughout a narrow band along the continental slope in the Western and Central GOA, while longline catches occured along the entire GOA continental slope (Figure 15A.1). There was not as much trawl effort in the EGOA, primarily due to regulations restricting trawl gear east of 140°W longitude, but high catch was evident around Yakutat Valley (Figure 15A.1).

In order to provide a direct visual comparison of the spatial distribution of thornyhead catch between the two surveys, we mapped catch in number from both the trawl and longline surveys in 2023, with 2023 observed fishery catch overlaid. In general, both of the surveys display similar abundance and spatial trends: even distribution throughout the gulf, with pockets of higher abundance in the West Yakutat area of the Eastern GOA, and lowest abundance in the Western GOA, with the exception of one large haul on the trawl survey (Figure 15A.2). Observed fishery catch of thornyhead in 2023 matched the survey distribution: high catch near Yakutat Valley, with the remainder along a narrow band of the continental slope throughout the Central and Western GOA. In general, the survey distribution and fishery effort are similar Gulfwide.

Barriers and phenotypic characters

Generation time

Rockfish in the GOA are typically slow growing and long-lived. Despite a general knowledge of the life history of thornyheads throughout their range, precise information on age, growth, and natural mortality *(M)* remains elusive for shortspine thornyhead in Alaska and is unknown for longspine thornyhead. Reported values for maximum age of shortspine thornyhead in the GOA employing various ageing methods range from 50 (Jacobson 1990) to 313 years (Gunderson 1997). However, most studies agree on a maximum age between 100 and 150 years (Miller 1985, Kastell et al. 2000, Cailliet et al. 2001, Black 2009). Estimates of natural mortality range from 0.013 to 0.07 (Miller 1985, Gunderson 1997). Although shortspine thornyhead are extremely difficult to age, studies seem to indicate that Miller's (1985) estimate of maximum age of 62 is low, and an estimate of M of 0.07 based on this would be high. Conversely, the maximum ages implied by Pearson and Gunderson (2003, 250–313 years) may be high and infer natural mortality rates that may be inappropriately low. The maximum ages from Kline (1996) and Jacobson (1990) are 115 and 150 years, respectively. Assuming $M = 0.03$ implies a longevity in the range of 125 years, which is bracketed by estimates derived from Jacobson (1990) and Kline (1996). Until we gather more information on shortspine thornyhead productivity, age, and growth in the GOA, we will continue to assume $M = 0.03$ is a reasonable and best available estimate of M. While we are unable to estimate generation time for shortspine thornyhead, a similar species in maximum age and natural mortality is the rougheye rockfish, which has an estimated generation time of 52 years (Shotwell et al. 2015).

Physical limitations

General circulation patterns of the GOA are well documented. However, how these interact on small spatial scales in association with bathymetric features is largely unknown. In addition, larval and post-larval distribution of thornyhead is poorly understood so interpreting physical limitations are difficult. Abundance of thornyhead is lowest in the Western GOA, and highest in the Eastern GOA followed by the Central GOA, but what determines these abundances is unknown in regards to physical limitations.

Growth differences

Length-weight relationships of thornyhead are similar across regions. There is insufficient age data to evaluate growth at age differences in thornyhead rockfish by management region. In addition, the limited age data available has only been partially validated.

Age/size structure

Despite a general knowledge of the life history of thornyhead throughout their range, precise information on age and growth remains elusive for shortspine thornyhead in Alaska and is unknown for longspine thornyhead. Both shortspine and longspine thornyhead are long-lived, relatively slow-growing fishes, but shortspine appear to have greater longevity. Various ageing studies utilizing different methodologies have agreed that shortspine thornyhead may live 80–150 years with the larger-growing females reaching sizes up to 80-cm fork length (Jacobson 1990, Kline 1996, Kastelle et al. 2000, Calilliet et al. 2001, Love et al. 2002, Black 2009). Longspine thornyhead are generally smaller, reaching maximum sizes less than 40 cm and maximum ages of at least 45 years.

The best available knowledge on the size structure of thornyhead in the GOA comes from bottom trawl and longline survey data. Survey length compositions suggest that recruitment of shortspine thornyhead is a relatively infrequent event. Length compositions on the longline survey are relatively stable across all years and have displayed a mean from 35.2 to 38.3 cm. Length compositions for thornyhead rockfish from the trawl surveys were generally consistent with means between 23.2 and 27.0 cm. For all survey years combined, shortspine thornyhead mean length was larger on the longline survey (mean length of 36.4 cm) than the bottom trawl survey (mean length of 26.0 cm), suggesting that the two surveys may capture different parts of thornyhead population (Figure 15.6 in SAFE).

At this time, production aging has been suspended for thornyhead. Due to the high variability in recruitment events it is uncertain if there has been size or age truncation in this population or if there are significant differences among regions.

Spawning time differences

Life history information on thornyhead rockfish is extremely sparse. Shortspine thornyhead spawning takes place in the late spring and early summer, between April and July in the GOA and between December and May along the U.S. West Coast. It is unknown when longspine thornyhead spawn in the Alaskan portion of their range, although they are reported to spawn between January and April on the U.S. West coast (Pearson and Gunderson 2003). There is insufficient information to evaluate spawning time differences in thornyhead rockfish by management region in the GOA.

Maturity-at age/length differences

Fecundity at length has been estimated by Miller (1985) and Cooper et al. (2005) for shortspine thornyhead in Alaska. Cooper et al. (2005) found no significant difference in fecundity at length between Alaskan and West Coast shortspine thornyhead. It appeared that fecundity at length in the more recent study was somewhat lower than that found in Miller (1985), but it was unclear whether the difference was attributable to different methodology or to a decrease in stock fecundity over time. Longspine thornyhead fecundity at length was estimated by Wakefield (1990) and Cooper et al. (2005) for the West Coast stocks; it is unknown whether this information is applicable to longspine thornyhead in Alaska.

Size at maturity varies by species as well. The size at maturity schedule estimated in Ianelli and Ito (1995) for shortspine thornyhead off the coast of Oregon suggests that female shortspine thornyhead appear to be 50% mature at about 22 cm. More recent data analyzed in Pearson and Gunderson (2003) confirmed this, estimating length at maturity for Alaska shortspine thornyhead at 21.5 cm (although length at maturity for West Coast fish was revised downward to about 18 cm). Male shortspine thornyhead mature at a smaller size than females off Alaska (Love et al. 2002). Longspine thornyhead reach maturity between 13 and 15 cm off the U.S. West Coast; it is unknown whether this information applies in the Alaskan portion of the longspine thornyhead range. Sufficient data for comparison of maturity at age or length among regions within the GOA or through time is not available.

Morphometrics

Regional variation in morphometric measurements have not been studied for this species.

Meristics

Regional variation in meristics have not been studied for this species.

Behavior and movement

Spawning site fidelity

Little is known regarding the spawning habits of thornyhead in the GOA. There is no information on when males inseminate females or if migrations occur for spawning/breeding. Harvest or catch data from this time period (fall/winter) is sparse from fisheries or surveys so annual distribution changes are difficult to detect.

Mark-recapture data

The National Marine Fisheries Service (NMFS) Auke Bay Laboratory (ABL) has released 15,512 tagged shortspine thornyhead in Alaska waters since 1992, and ~300 of those fish have been recovered by members of the fishing industry (to date). A review of this tagging data show that the majority of tagged shortspines show little to no movement: 19% traveled < 2 nautical miles (nm) between tagging and recovery location, 36% traveled 2–5 nm, 18% traveled 6–10 nm, 12% traveled 11–50 nm, 4% traveled 51–100 nm, and 11% traveled >100 nm (Echave 2017). The amount of movement varied by tagging location, as did the direction of movement. However, there was no significant difference in movement by fish size, and all fish included in the analysis were assumed mature. The majority of fish that moved generally traveled east/southeast, and fish that were tagged and released in the Eastern GOA were more inclined to move than fish from other areas. These regional differences in recapture patterns may highlight an actual propensity for movement from the Eastern GOA, or reflect geographic differences in fishing effort, particularly at depth. Shortspine thornyhead released in the Eastern GOA displayed the most movement. Of the 102 recoveries that were released in the Eastern GOA, 76% remained within the Eastern GOA, 18% were recovered in British Columbia, Canada (BC), 5% were recovered in the Central GOA, and 1% were recovered on the West Coast (WC). Overall, the majority of recovered shortspine thornyhead remained within their management area of release, and very near their actual release location. While a small percentage of tagged shortspine thornyhead traveled large distances, at times crossing management and international boundaries, when defining the stock structure of shortspine thornyhead in Alaska waters, one may conclude that this species displays little movement, but that large movements are possible (Echave 2017).

Natural tags

While there have not been any studies addressing otolith microchemistry of thornyhead rockfish in the GOA, otolith microchemistry has been applied to immature shortspine thornyhead along the eastern Pacific coast (California, Oregon, and Washington) in order to validate the assumption that shortspine thornyhead are a demographically homogeneous stock off the West Coast. Results of that study suggest that shortspine thornyhead conduct complex ontogenetic movements related to bathymetry (settlement at depth by age), but no separation among samples collected from the five collection sites along the coast. In summary, shortspine thornyhead represent a single genetic stock along the U.S. West Coast and display ontogenetic movement from shallower to deeper waters (Dorval et al. 2022). Parasite infestation has been used as a natural occurring tag in some rockfish species in the GOA (Moles et al. 1998). However, no studies have addressed parasite tags in thornyhead rockfish.

Genetics

Population genetics, phylogeography, and systematics of thornyhead were discussed by Stepien et al. (2000). Genetic variation using mtDNA was analyzed for shortspine thornyhead from seven sites off the West Coast, but only included one Alaska site off Seward. Longspine thornyhead were sampled from five sites off the Washington-Oregon-California coast, and a single site off Abashiri, Japan was sampled for broadfin thornyhead. Significant population structure was found in this study that was previously undetected with allozymes (Siebenaller 1978). Gene flow was substantial among some locations and diverged significantly in other locations. Significant genetic differences among some sampling sites for shortspine and longspine thornyhead indicated barriers to gene flow. Genetic divergences among sampling sites for shortspine thornyhead indicated an isolation-by-geographic-distance pattern. In contrast, population genetic divergences of longspine thornyheads were unrelated to geographic distances and suggested larval retention in currents and gyres (Pearcy et al. 1977, Stepien et al. 2000). Differences in geographic genetic patterns between the species are attributed to movement patterns as juveniles and adults. While not a part of this complex, another *Sebastolobus* species, the broadbanded thornyhead, was part of an age and population genetic structure study in North Japan (Sakaguchi et al. 2014). While significant differences in body size (growth) was detected between certain year classes off the Pacific coast of Tohoku and off Abashiri, the Sea of Okhotsk, Japan, it appears that broadbanded thornyhead do not migrate extensively after settlement and subsist on food within the settled environment. At the same time, no genetic isolation was observed between the populations at the two sites. Sakaguchi et al. (2014) concluded that it was highly likely that its pelagic eggs, larvae and juveniles widely disperse and migrate before settlement.

More recent research by the AFSC Auke Bay Genetics Laboratory screened millions of genetic markers in shortspine thornyhead sampled from southeast Alaska to the Bering Sea and Aleutian Islands as far west 180° W. The whole genome resequencing approach that was used has substantially more power to detect structure than previously used methods (allozymes or mtDNA). No spatial structure was observed in this dataset, providing further evidence that gene flow is high in shortspine thornyhead across relatively large spatial scales. This recent genetic research indicates that shortspine thornyhead represent a single genetic stock in Alaskan waters (Wes Larson, pers. comm.).

Factors and criterion specific to genetics of thornyhead are:

Isolation by distance

No significant isolation by distance (W. Larson, pers. comm.)

Dispersal distance

Not Available

Pairwise genetic differences

Not significant (W. Larson, pers. comm.)

Summary, Implications, and Recommendations

We summarized the available information on stock structure for thornyhead rockfish in the GOA in Table 15A.2. Even with decreasing harvest and trend data, distribution of fishery effort appears to be consistent with abundance (Figures 15A-1 and 15A-2). Fishing is broadly spread throughout a narrow band along the continental slope. Gulfwide fishing mortality in recent years is below maximum permissible *F*.

Typical of rockfish species, thornyhead rockfish are long-lived and have a long generation time. Little information is available regarding reproduction and mechanisms responsible for larval dispersion, but thornyhead rockfish are found throughout the GOA in varying levels of abundance. Growth differences (length-weight) among regions in the GOA are insignificant. While it is unknown if spawning movements or inter-annual movement occur, tagging studies indicate that shortspine thornyhead display little movement, but that large movements are possible (Echave 2017). Most recent genetic research indicates no spatial structure, indicating that thornyhead rockfish represent a single genetic stock in Alaskan waters (Wes Larson, pers. comm.).

The current management regime apportions the stock and catch into three large geographical regions. Survey and fishery information indicates that abundance levels differ among the regions, but are spatially distributed throughout the entire gulf. Thornyhead are capable of movement and it is hypothesized that the high gene flow observed in these rockfish is attributed to long distance larval dispersal, however, the amount of mixing and dispersal of fish among areas is unknown; therefore the capacity of the population for repopulating small spatial areas is unknown. For rockfish with no genetic structure, it is likely that areas that are locally depleted will be replenished by larval transport over longer (i.e., evolutionary) timescales, but in the short term, local depletion could cause reduced abundance because adult movement is low. While thornyhead rockfish consist within a narrow depth band along the continental slope, they have a relatively even distribution, and no available data indicates that stock structure is at risk under the current management regime.

Current management practices apportion ABC by management area but use a gulf-wide OFL. Thornyhead rockfish catches in the GOA are near 17% of maximum permissible and risk of overfishing is low. Based on available data, initiating area-specific OFL’s is not recommended as there are multiple levels of precaution built into the current management recommendations and overharvest is unlikely. Given the available evidence on GOA thornyhead rockfish stock structure, the current resolution of spatial management is likely adequate and consistent with management goals.

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Tables

Table 15A.1. Framework of types of information to consider when defining spatial management units (from Spencer et al. 2010).

Factor and criterion	Justification
	Harvest and trends
Fishing mortality (5-year average percent of F_{abc} or F_{ofl})	If this value is low, then conservation concern is low
Spatial concentration of fishery relative to abundance (Fishing is focused in areas << management areas)	If fishing is focused on very small areas due to patchiness or convenience, localized depletion could be a problem.
Population trends (Different areas show different trend directions)	Differing population trends reflect demographic independence that could be caused by different productivities, adaptive selection, differing fishing pressure, or better recruitment conditions
	Barriers and phenotypic characters
Generation time (e.g., >10 years)	If generation time is long, the population recovery from overharvest will be increased.
Physical limitations (Clear physical inhibitors to movement)	Sessile organism; physical barriers to dispersal such as strong oceanographic currents or fjord stocks
Growth differences (Significantly different LAA, WAA, or LW parameters)	Temporally stable differences in growth could be a result of either short term genetic selection from fishing, local environmental influences, or longer-term adaptive genetic change.
Age/size-structure (Significantly different size/age compositions)	Differing recruitment by area could manifest in different age/size compositions. This could be caused by different spawning times, local conditions, or a phenotypic response to genetic adaptation.
Spawning time differences (Significantly different mean time of spawning)	Differences in spawning time could be a result of local environmental conditions, but indicate isolated spawning stocks.
Maturity-at-age/length differences (Significantly different mean maturity-at-age/ length)	Temporally stable differences in maturity-at-age could be a result of fishing mortality, environmental conditions, or adaptive genetic change.
Morphometrics (Field identifiable characters)	Identifiable physical attributes may indicate underlying genotypic variation or adaptive selection. Mixed stocks w/ different reproductive timing would need to be field identified to quantify abundance and catch
Meristics (Minimally overlapping differences in counts)	Differences in counts such as gillrakers suggest different environments during early life stages.
	Behavior & movement
Spawning site fidelity (Spawning individuals occur in same location consistently)	Primary indicator of limited dispersal or homing
Mark-recapture data (Tagging data may show limited movement)	If tag returns indicate large movements and spawning of fish among spawning grounds, this would suggest panmixia
Natural tags (Acquired tags may show movement smaller than management areas)	Otolith microchemistry and parasites can indicate natal origins, showing amount of dispersal
	Genetics
Isolation by distance (Significant regression)	Indicator of limited dispersal within a continuous population
Dispersal distance (<<Management areas)	Genetic data can be used to corroborate or refute movement from tagging data. If conflicting, resolution between sources is needed.
Pairwise genetic differences (Significant differences between geographically distinct collections)	Indicates reproductive isolation.

Table 15A.2. Summary of available data on stock structure evaluation of GOA thornyhead rockfish. Template from Spencer et al. 2010.

Factor and criterion	Justification
	Harvest and trends
Fishing mortality (5-year average percent of F_{abc} or F_{ofl})	Recent years have low fishing mortality rates and catches are below gulfwide ABC.
Spatial concentration of fishery relative to abundance (Fishing is focused in areas << management areas)	Fishing effort is distributed gulfwide around the continental slope with areas of high catch near Kodiak Island and in the Yakutat Area. Trawl survey abundance is distributed gulfwide with highest abundance seen in the EGOA near Yakutat.
Population trends (Different areas show different trend directions)	Overall population trend is decreasing. Biomass estimates for the Western and Central GOA have been trending downward. Changes in biomass by region may be due to high variability of survey.
	Barriers and phenotypic characters
Generation time (e.g., >10 years)	Generation time is long.
Physical limitations (Clear physical inhibitors to movement)	No physical limitations known, but larval dispersal poorly understood.
Growth differences (Significantly different LAA, WAA, or LW parameters)	No major differences in growth (LW) among the Eastern GOA, Central GOA, and Western GOA.
Age/size-structure (Significantly different size/age compositions)	Size structures driven by major recruitment events. Ageing is unavailable.
Spawning time differences (Significantly different mean time of spawning)	Unknown
Maturity-at-age/length differences (Significantly different mean maturity-at-age/ length)	Unknown
Morphometrics (Field identifiable characters)	Unknown
Meristics (Minimally overlapping differences in counts)	Unknown
	Behavior & movement
Spawning site fidelity (Spawning individuals occur in same location consistently)	Unknown
Mark-recapture data (Tagging data may show limited movement)	Tagging data shows that large scale movement is possible, at times crossing management lines, but most tagged fish were recovered within their tagging location.
Natural tags (Acquired tags may show movement smaller than management areas)	Otolith microchemistry applied to immature shortspine thornyhead along the eastern Pacific coast showed ontogenetic movement from shallower to deeper waters (Dorval et al. 2022).
	Genetics
Isolation by distance (Significant regression)	No significant isolation by distance (W. Larson, pers. comm.)
Dispersal distance (<<Management areas)	Not available
Pairwise genetic differences (Significant differences between geographically distinct collections)	Not significant (W. Larson, pers. comm.)

Figures

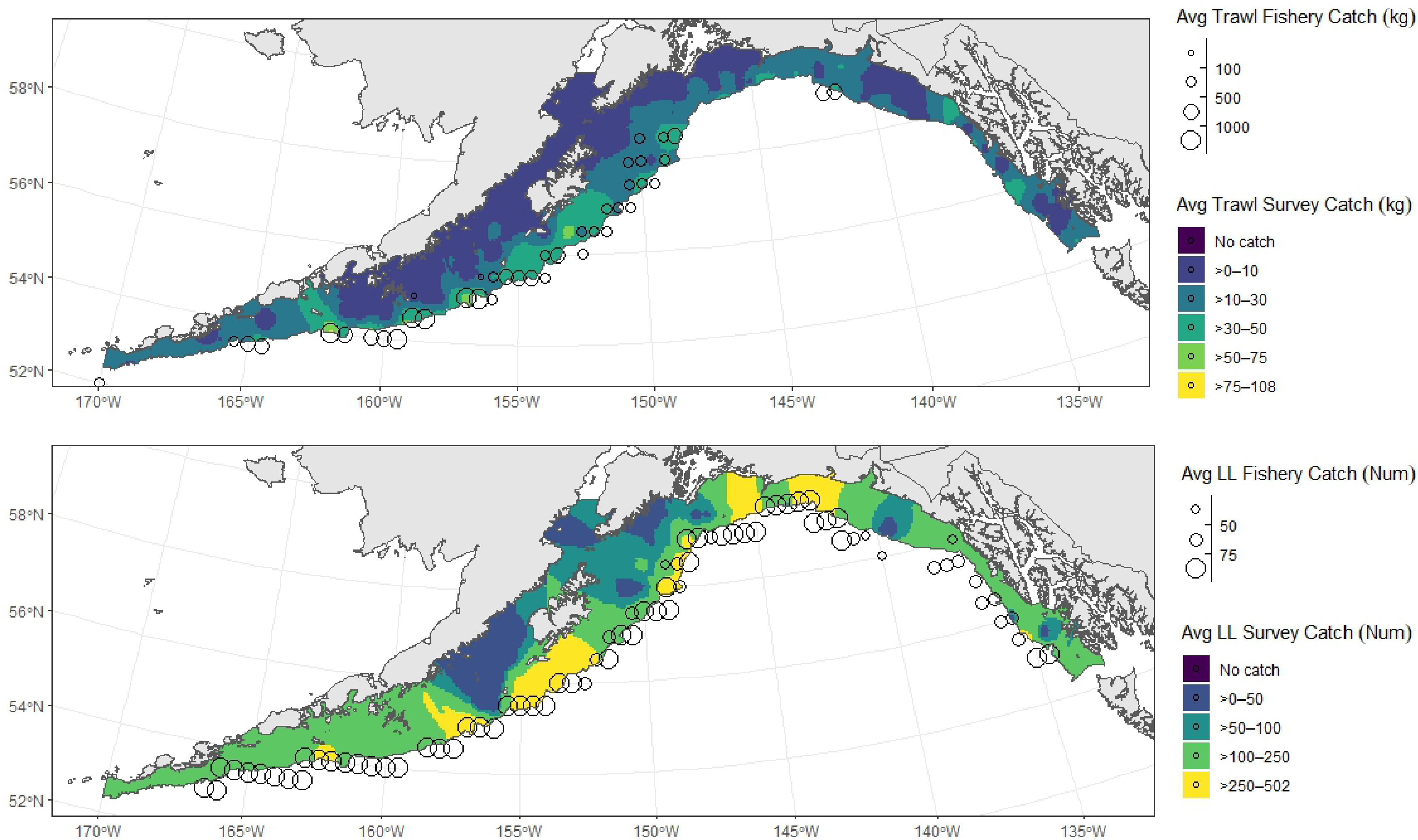

Figure 15A.1. Distribution maps of shortspine thornyhead mean fishery catch (circles) overlain on interpolated mean survey catch from 1993 to 2023 by trawl (top) and longline (bottom). Note the extents of both surveys are shown on the footprint of the bottom trawl survey, and fishery data is only shown when more than 100 hauls occurred over the entire time period.

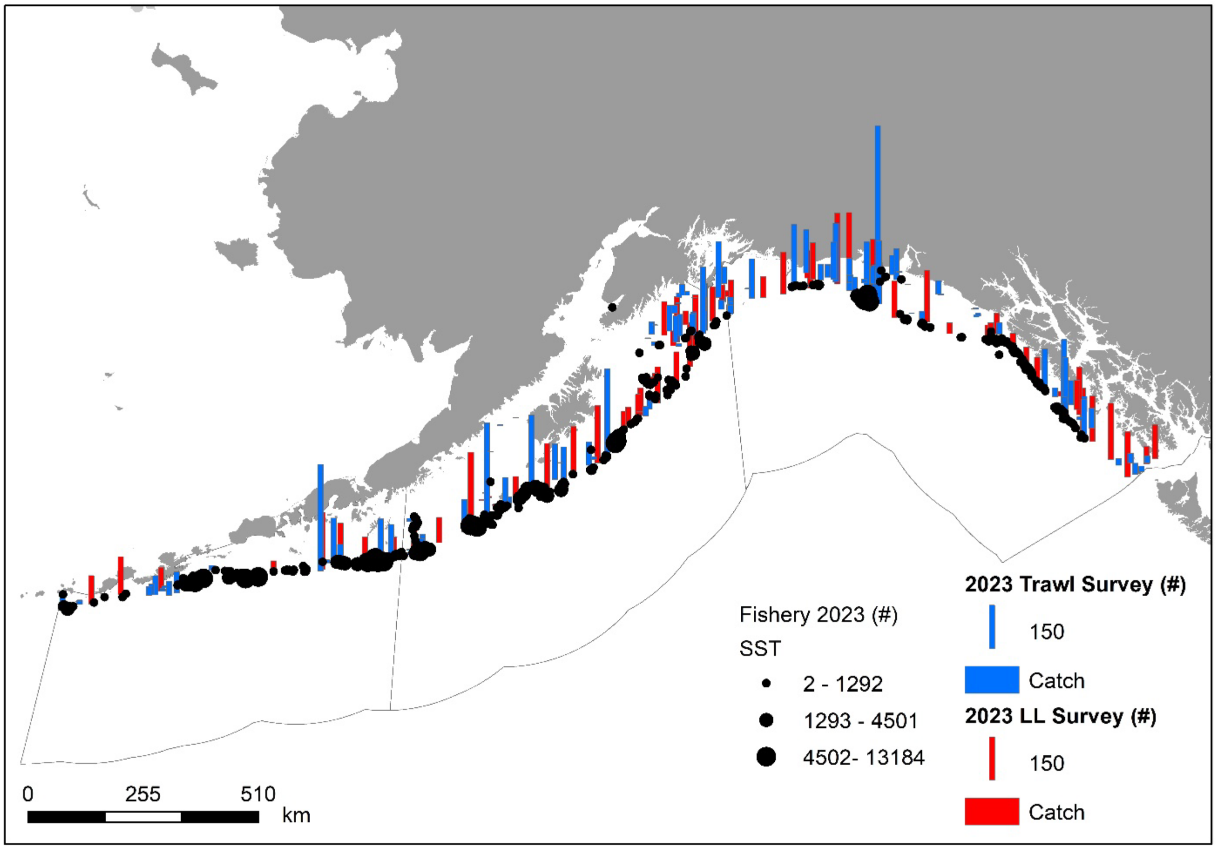

Figure 15A.2. Distribution map of shortspine thornyhead catch (number) on the trawl (blue bars) and longline (red bars) surveys in 2023, and the observed fishery catch (filled black circles, number).

Appendix 15B: Supplemental Catch Data

In order to comply with the Annual Catch Limit (ACL) requirements, non-commercial removals in the Gulf of Alaska (GOA) are presented. Non-commercial removals are estimated total removals that do not occur during directed groundfish fishing activities (Table 15B.1). This includes removals incurred during research, subsistence, personal use, recreational, and exempted fishing permit activities, but does not include removals taken in fisheries other than those managed under the groundfish FMP. These estimates represent additional sources of removals to the existing Catch Accounting System estimates.

Research catches of thornyhead rockfish for the years 1979–2023 are listed in Table 15B.1. Although data are not available for a complete accounting of all research catches, the values in the table indicate that generally these catches have been modest. The majority of research removals of thornyhead rockfish are taken by the Alaska Fisheries Science Center's (AFSC) annual longline survey. Other research activities that harvest minor amounts of thornyhead rockfish include other trawl research activities conducted by the AFSC, the Alaska Department of Fish and Game (ADFG), and the International Pacific Halibut Commission's (IPHC) longline survey. There are no records of recreational harvest or harvest that was non-research related. The non-commercial removals show that a total of approximately 8 t of thornyhead rockfish was taken in 2023 during research cruises (Table 15B.1). This total is approximately 0.5% of the ABC (1,628 t) and 3.8% of the commercial catch (208 t) for thornyhead rockfish in 2023. Therefore, this presents no risk to the stock especially because commercial catches in recent years have been much less than ABCs.

Table 15B.1. Research catches of GOA thornyheads (t). Estimates from IPHC survey and "other" sources only available since 2010.

Year	AFSC LLS	AFSC BTS	Japan/US LLS	IPHC LLS	Other	Total
1979		5	3			8
1980		1	5			6
1981		10	5			14
1982		6	4			10
1983		1	4			5
1984		24	3			27
1985		12	4			16
1986		2	4			5
1987		17	4			20
1988	2	0	5			7
1989	3	0	5			8
1990	3	4	4			11
1991	4		3			7
1992	5		4			9
1993	5	5	4			14
1994	4		5			9
1995	5					5
1996	6	6				12
1997	6					6
1998	6	9				15
1999	6	23				29
2000	5					5
2001	7	2				9
2002	5					5
2003	5	7				12
2004	4					4
2005	5	9				14
2006	5					5
2007	5	9				14
2008	7					7
2009	6	7				13
2010	9	<1		<1	<1	9
2011	10	4		<1	<1	14
2012	9			<1	<1	9
2013	13	4		<1	<1	17
2014	10			<1	<1	10
2015	10	8		0.5		18.5
2016	9			<1		9
2017	11	5		<1	<1	16
2018	9			<1	<1	9
2019	9	4		1	<1	14
2020	7			<1	<1	7
2021	6	4		<1	<1	10
2022	9			<1	<1	9
2023	5	2		<1	<1	8