

Length-Based Assessment of Data-Poor Multi-Species Deep Grouper Fisheries in Fisheries Management Areas (WPP) 573, 712, 713, 714, 715 & 718 in Indonesia

DRAFT - NOT FOR DISTRIBUTION. TNC-IFCP Technical Paper

Peter J. Mous, Jos S. Pet

FEBRUARY 17, 2018



For inquiries, please contact Dr. Peter Mous at pmous@tnc.org or Dr. Jos Pet at pet.jos@gmail.com

The Nature Conservancy Indonesia Fisheries Conservation Program

Jl. Pura Segara, Pelabuhan Raya Benoa
Denpasar 3012
Bali, Indonesia
Ph. +62-361-244524, fax +62-361-244532

People and Nature Consulting International

Grahalia Tiyng Gading 18, Suite 2
Jalan Tukad Pancoran, Panjer
Denpasar 80225 Bali, Indonesia
Ph. +62-361-257246

Table of contents

1	Introduction	3
2	Materials and methods for data collection, analysis and reporting	7
2.1	SPOT Trace vessel tracking	7
2.2	Crew Operated Data Recording System	7
2.3	I-Fish Community	9
3	Species-specific length-based assessments	13
4	Discussion and conclusions	70
5	References	72

1 Introduction

This report presents a length-based assessment of the status of the most abundant species of grouper caught in the multi-species deep demersal fisheries for snappers, groupers, and emperors in Eastern Indonesia. The gear types in these fisheries include vertical drop lines and bottom set long lines at various scales, ranging from small scale village based fisheries with boats less than 5 GT to medium scale drop line and long line vessels measuring up to well over 100 GT for the largest long line vessels. The drop line fishery is an active vertical hook and line fishery operating at depths from 50 to 500 meters, whereas long lines are set horizontally along the bottom at depths ranging from 50 to 150 meters.

The fisheries included in this report operate in Fisheries Management Areas (WPPs) 573, 712, 713, 714, 715 and 718 including the Northern Indian Ocean, Timor Sea, Java Sea, Makassar Strait, Bali Sea, Flores Sea, Banda Sea, Moluccas Sea, Timor Sea and Arafura Sea. Vessels operating in this region are originating from various ports throughout the country and may also operate in other WPPs at times. Data from 2015 to the present date were accumulated for this assessment.

For a complete overview of the species composition of these drop line and long line fisheries please refer to the ID guide prepared for these fisheries:

CLICK: [Link to on-line E-Book Species ID Guide](#)

For further background on species life history characteristics, and data-poor length based assessment methods, as applied in this report, please refer to the assessment guide that was separately prepared for these fisheries:

CLICK: [Link to on-line E-Book Assessment Guide with Biological Information](#)

Since 2015, all fish in the catch of cooperating vessels were photographed as they were caught. Fish were placed on top of measuring boards to enable sizing as well as identification from images. Photographs were taken by crew participating in our Crew Operated Data Recording System or CODRS. Images were analyzed by staff at our fisheries stations to generate species specific length frequency distributions that served as the input for length based assessments presented in this report.

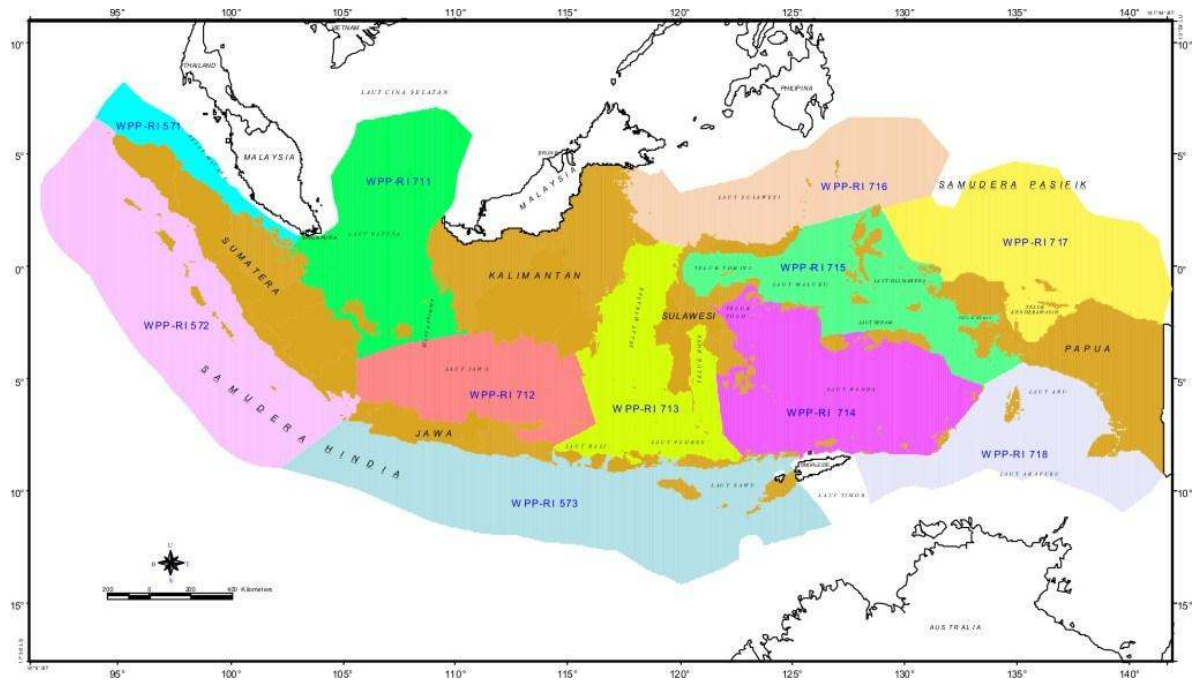


Figure 1. Fisheries Management Areas (WPP) in Indonesian marine waters.

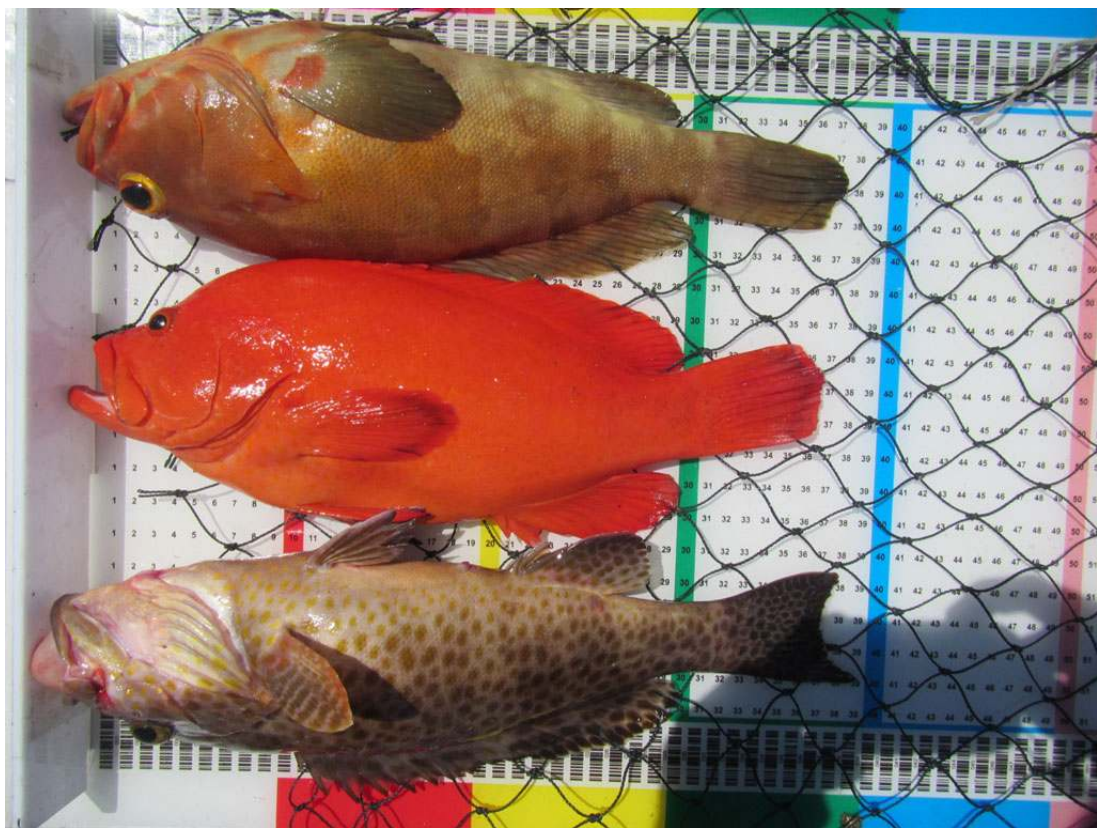


Figure 2. Groupers photographed by fishing crew on board as part of the Crew Operated Data Recording System (CODRS).

Table 1.1: Length-Weight Relationships, Trading Limits and Sample Sizes in the most recent 730 Days for Grouper Species in Deep Water Hook-and-Line Fisheries in East Indonesia

#ID	Species	Reported	W = a L ^b		Length	Converted	Plotted	Sample Sizes
		Trade Limit Weight (g)	a	b	Type for a & b TL-FL-SL	Trade Limit L(cm)	Trade Limit TL(cm)	
36	<i>Saloptia powelli</i>	300	0.008	3.175	FL	27.28	27.28	78
37	<i>Cephalopholis miniata</i>	300	0.026	2.864	TL	26.35	26.35	172
38	<i>Cephalopholis sexmaculata</i>	300	0.027	3.000	SL	22.37	28.24	243
39	<i>Cephalopholis sonnerati</i>	300	0.015	3.058	TL	25.78	25.78	3273
40	<i>Cephalopholis igarashiensis</i>	300	0.049	2.748	FL	23.86	23.86	161
41	<i>Epinephelus latifasciatus</i>	1500	0.010	3.088	TL	48.00	48.00	1457
42	<i>Epinephelus radiatus</i>	300	0.061	2.624	FL	25.59	25.59	618
43	<i>Epinephelus morrhua</i>	300	0.061	2.624	FL	25.59	25.59	2649
44	<i>Epinephelus poecilonotus</i>	500	0.061	2.624	FL	31.09	31.09	385
45	<i>Epinephelus areolatus</i>	300	0.011	3.048	FL	28.18	28.77	44968
46	<i>Epinephelus bleekeri</i>	300	0.009	3.126	TL	28.09	28.09	1397
47	<i>Epinephelus miliaris</i>	300	0.025	3.000	SL	22.74	29.23	158
48	<i>Epinephelus bilobatus</i>	300	0.014	2.990	TL	27.82	27.82	438
49	<i>Epinephelus malabaricus</i>	1500	0.013	3.034	TL	46.85	46.85	245
50	<i>Epinephelus coioides</i>	1500	0.011	3.084	TL	46.94	46.94	1836
51	<i>Epinephelus chlorostigma</i>	500	0.015	2.940	FL	34.62	34.62	1307
52	<i>Epinephelus retouti</i>	300	0.027	3.000	SL	22.37	28.24	103
53	<i>Epinephelus heniochus</i>	300	0.061	2.624	FL	25.59	25.59	1422
54	<i>Epinephelus stictus</i>	300	0.027	3.000	SL	22.37	28.24	730
55	<i>Epinephelus epistictus</i>	1500	0.009	3.126	TL	47.01	47.01	276
56	<i>Epinephelus multinotatus</i>	1500	0.017	2.964	TL	46.90	46.90	380
57	<i>Epinephelus undulosus</i>	1500	0.015	2.940	FL	50.31	50.31	405
58	<i>Epinephelus amblycephalus</i>	1500	0.012	3.057	TL	45.99	45.99	2073
59	<i>Hyporthodus octofasciatus</i>	1500	0.106	2.560	TL	41.82	41.82	252
60	<i>Plectropomus maculatus</i>	500	0.016	3.000	FL	31.76	31.76	265
61	<i>Plectropomus leopardus</i>	500	0.012	3.060	FL	32.56	33.38	932
62	<i>Variola albigarginata</i>	300	0.012	3.079	FL	26.68	30.44	722

Table 1.2: Sample Sizes over the period 2015 to 2026 for Grouper Species in Assessment of Deep Water Hook-and-Line Fisheries in East Indonesia

#ID	Species	'15-'16	'17-'18	'19-'20	'21-'22	'23-'24	'25-'26	Total	%
36	Saloptia powelli	86	25	0	0	0	0	111	0.15
37	Cephalopholis miniata	104	96	0	0	0	0	200	0.27
38	Cephalopholis sexmaculata	178	101	0	0	0	0	279	0.37
39	Cephalopholis sonnerati	1876	1662	0	0	0	0	3538	4.73
40	Cephalopholis igarashiensis	122	74	0	0	0	0	196	0.26
41	Epinephelus latifasciatus	460	1065	0	0	0	0	1525	2.04
42	Epinephelus radiatus	411	309	0	0	0	0	720	0.96
43	Epinephelus morrhua	1970	1255	0	0	0	0	3225	4.31
44	Epinephelus poecilonotus	232	191	0	0	0	0	423	0.57
45	Epinephelus areolatus	25732	25047	0	0	0	0	50779	67.89
46	Epinephelus bleekeri	461	1001	0	0	0	0	1462	1.95
47	Epinephelus miliaris	109	71	0	0	0	0	180	0.24
48	Epinephelus bilobatus	258	190	0	0	0	0	448	0.60
49	Epinephelus malabaricus	95	163	0	0	0	0	258	0.34
50	Epinephelus coioides	800	1077	0	0	0	0	1877	2.51
51	Epinephelus chlorostigma	1260	450	0	0	0	0	1710	2.29
52	Epinephelus retouti	66	48	0	0	0	0	114	0.15
53	Epinephelus heniochus	644	807	0	0	0	0	1451	1.94
54	Epinephelus stictus	404	341	0	0	0	0	745	1.00
55	Epinephelus epistictus	134	157	0	0	0	0	291	0.39
56	Epinephelus multinotatus	245	171	0	0	0	0	416	0.56
57	Epinephelus undulosus	253	156	0	0	0	0	409	0.55
58	Epinephelus amblycephalus	827	1332	0	0	0	0	2159	2.89
59	Hyporthodus octofasciatus	175	124	0	0	0	0	299	0.40
60	Plectropomus maculatus	76	189	0	0	0	0	265	0.35
61	Plectropomus leopardus	503	445	0	0	0	0	948	1.27
62	Variola albimarginata	416	348	0	0	0	0	764	1.02

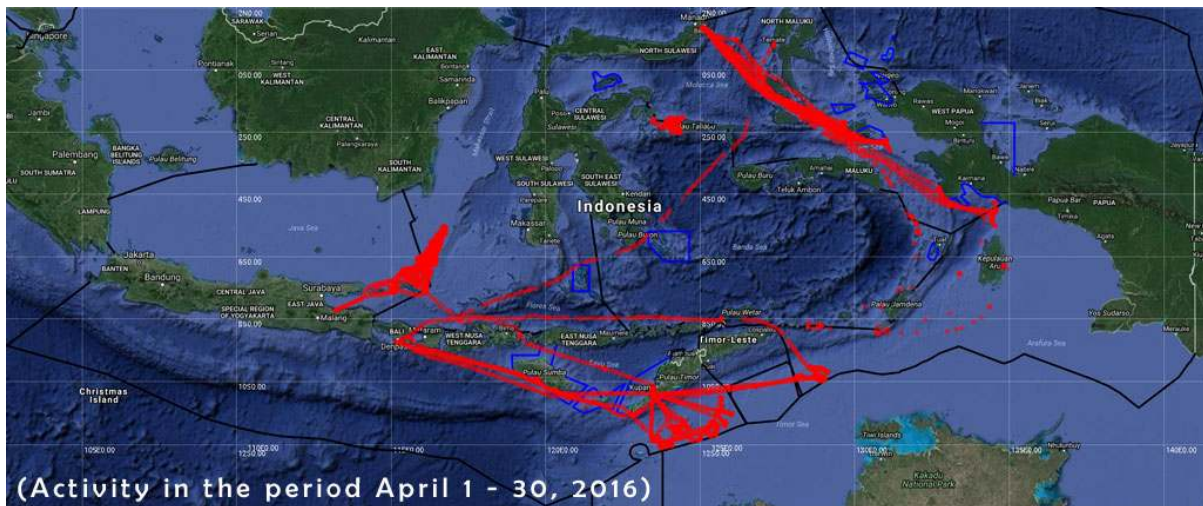


Figure 3. Map with fishing ground bathymetry and tracks (in red) of drop line and bottom long line fishing trips in our area of interest. Black lines are WPP boundaries, blue lines are MPA boundaries.

2 Materials and methods for data collection, analysis and reporting

2.1 SPOT Trace vessel tracking

Fishing grounds are determined by deploying Spot Trace units on various fishing boats. When in motion, Spot Trace units automatically report an hourly location, and when at rest for more than 24 hours, they relay daily status reports. Location and status report messages are automatically recorded in I-Fish Community, an online database running PostgreSQL with a user interface programmed in Java and analysis and reporting procedures in R and Latex.

Fishing vessels with Spot Trace units on board generate accurate data on fishing grounds and specific fishing locations within fishing grounds. Traditionally, fishing ground data were often collected from logbook data or captain interviews. However, logbook and interview data are sometimes unclear, inaccurate and can easily be tampered with. Spot Trace enables us to match catch data with exact fishing locations, while providing additional safety for the fishing vessels. To mitigate IUU fishing accusations, having the Spot Trace onboard can also be used as proof of legal fishing within Indonesian waters.

2.2 Crew Operated Data Recording System

Data on species and size distributions of complete catches are needed for accurate length based stock assessments. Such data on individual fishing trips are collected via Crew Operated Data Recording Systems or CODRS. This catch data is geo-referenced as the CODRS works in tandem with the Spot Trace vessel tracking system. Crews of fishing vessels are contracted to take images on project-supplied digital cameras of all fish in the catch, positioned over measuring boards. This procedure takes place when batches of fish are taken from chiller boxes on deck, before they are packed on ice in the hold. The crew photographs all the fish in this manner and at the end of the trip hands in the storage chip from the camera to a project stage who analysis the images back at the fisheries station. Double checking with owner and trader data on total catches, and comparison with weights as calculated from fish lengths, showed that we were indeed capturing length frequencies of most if not all fish in the catch in this manner. No species or size classes were missing before analysis.

Analysis of the CODRS images includes ID of the species and reading of the length of the fish as displayed on the measuring board. The image analysis is done by highly trained and experienced project stage and interns, based at our fisheries stations. Data processing, analysis and reporting are done through I-Fish Community, which also receives data on fishing grounds via the Spot Trace units deployed on fishing vessels. All data are stored in real time in the I-Fish Community database, where it is aggregated and analyzed with length-based methods.



Figure 4. Fishing crew preparing fish on a measuring board.



Figure 5. Fish photographed by fishing crew on board as part of CODRS.

2.3 I-Fish Community

I-Fish Community only stores data that are relevant to fisheries management, whereas data on processed volume and sales, from the Smart Weighing and Measuring System, remain on servers at processing companies. Access to the I-Fish Community database is controlled by user name and password. I-Fish Community has different layers of privacy, which is contingent on the user's role in the supply chain. For instance, boat owners may view exact location of their boats, but not of the boats of other owners.

I-Fish Community has an automatic length-frequency distribution reporting system for length-based assessment of the fishery by species. The database generates length frequency distribution graphs for each species, together with life history parameters including length at maturity (L_{mat}), optimum harvest size (L_{opt}), asymptotic length- (L_{inf}), and maximum total length (L_{max}), as well as size limits used in the trade. These "trade limit" lengths are derived from general buying behavior (minimal weight) of processing companies. The weights are converted into lengths by using species-specific length- weight relationships.

Each length frequency distribution is accompanied by an automated length-based assessment on current status of the fishery by species. Any I-Fish Community user can access these graphs and the conclusions from the assessments. The report produces an assessment for the 50 most abundant species in the fishery, based on complete catches from the most recent complete calendar year (to ensure full year data sets). The graphs show the position of the catch length frequency distributions relative to various life history parameter values and trading limits for each species. Relative abundance of specific size groups is plotted for all years for which data are available, to indicate trends in status by species.

Immature fish, small mature fish, large mature fish, and a subset of large mature fish, namely "mega-spawners", which are fish larger than 1.1 times the optimum harvest size (Froese 2004), make up the specific size groups used in our length based assessment. For all fish of each species in the catch, the percentage in each category is calculated for further use in the length based assessment. These percentages are calculated and presented as the first step in the length based assessment as follows: $W\%$ is immature (smaller than the length at maturity), $X\%$ is small matures (at or above size at maturity but smaller than the optimum harvest size), and $Y\%$ is large mature fish (at or above optimum harvest size). The percentage of mega-spawners is $Z\%$.

The automated assessment comprises of six elements from the catch length frequencies. These elements all work with length based indicators of various kinds to draw conclusions from species specific length frequencies in the catch.

1. *Minimum size as traded compared to length and maturity.*

We use a comparison between the trade limit (minimum size accepted by the trade) and the size at maturity as an indicator for incentives from the trade for either unsustainable targeting of juveniles or for more sustainable targeting of mature fish that have spawned at least once. We consider a trade limit at 10% below or above the length at maturity to be significantly different from the length at maturity and we consider trade limits to provide incentives for targeting of specific sizes of fish through price differentiation.

IF "TradeLimit" is lower than $0.9 * L\text{-mat}$ THEN:

"The trade limit is significantly lower than the length at first maturity. This means that the trade encourages capture of immature fish, which impairs sustainability. Risk level is high."

ELSE, IF "TradeLimit" is greater than or equal to $0.9 * L\text{-mat}$ AND "TradeLimit" is lower than or equal to $1.1 * L\text{-mat}$ THEN:

"The trade limit is about the same as the length at first maturity. This means that the trade puts a premium on fish that have spawned at least once, which improves sustainability of the fishery. Risk level is medium."

ELSE, IF "TradeLimit" is greater than $1.1 * L\text{-mat}$ THEN:

"The trade limit is significantly higher than length at first maturity. This means that the trade puts a premium on fish that have spawned at least once. The trade does not cause any concern of recruitment overfishing for this species. Risk level is low."

2. Proportion of immature fish in the catch.

With 0% immature fish in the catch as an ideal target (Froese, 2004), a target of 10% or less is considered a reasonable indicator for sustainable (or safe) harvesting (Fujita et al., 2012; Vasilakopoulos et al., 2011). Zhang et al. (2009) consider 20% immature fish in the catch as an indicator for a fishery at risk, in their approach to an ecosystem based fisheries assessment. Results from meta-analysis over multiple fisheries showed stock status over a range of stocks to fall below precautionary limits at 30% or more immature fish in the catch (Vasilakopoulos et al., 2011). The fishery is considered highly at risk when more than 50% of the fish in the catch are immature (Froese et al, 2016).

IF "% immature" is lower than or equal to 10% THEN:

"At least 90% of the fish in the catch are mature specimens that have spawned at least once before they were caught. The fishery does not depend on immature size classes for this species and is considered safe for this indicator. This fishery will not be causing overfishing through over harvesting of juveniles for this species. Risk level is low."

ELSE, IF "% immature" is greater than 10% AND "% immature" is lower than or equal to 20% THEN:

"Between 10% and 20% of the fish in the catch are juveniles that have not yet reproduced. There is no immediate concern in terms of overfishing through over harvesting of juveniles, but the fishery needs to be monitored closely for any further increase in this indicator and incentives need to be geared towards targeting larger fish. Risk level is medium."

ELSE, IF "% immature" is greater than 20% AND "% immature" is lower than or equal to 30% THEN:

"Between 20% and 30% of the fish in the catch are specimens that have not yet reproduced. This is reason for concern in terms of potential overfishing through overharvesting of juveniles, if fishing pressure is high and percentages immature fish would further rise. Targeting larger fish and avoiding small fish in the catch will promote a sustainable fishery. Risk level is medium."

ELSE, IF "% immature" is greater than 30% AND "% immature" is lower than or equal to 50% THEN:

"Between 30% and 50% of the fish in the catch are immature and have not had a chance to reproduce before capture. The fishery is in immediate danger of overfishing through

overharvesting of juveniles, if fishing pressure is high. Catching small and immature fish needs to be actively avoided and a limit on overall fishing pressure is warranted. Risk level is high."

ELSE, IF "% immature" is greater than 50% THEN:

"The majority of the fish in the catch have not had a chance to reproduce before capture. This fishery is most likely overfished already if fishing mortality is high for all size classes in the population. An immediate shift away from targeting juvenile fish and a reduction in overall fishing pressure is essential to prevent collapse of the stock. Risk level is high."

3. *Current exploitation level.*

We use the current exploitation level expressed as the percentage of fish in the catch below the optimum harvest size as an indicator for fisheries status. We consider a proportion of 65% of the fish (i.e. the vast majority in numbers) in the catch below the optimum harvest size as an indicator for growth overfishing. We also consider a majority in the catch around or above the optimum harvest size as an indicator for minimizing the impact of fishing (Froese et al., 2016). This indicator will be achieved when less than 50% of the fish in the catch are below the optimum harvest size.

IF "% immature + % small mature" is greater than or equal to 65% THEN:

"The vast majority of the fish in the catch have not yet achieved their growth potential. The harvest of small fish promotes growth overfishing and the size distribution for this species indicates that over exploitation through growth overfishing may already be happening. Risk level is high."

ELSE, IF "% immature + % small mature" is lower than or equal to 50% THEN:

"The majority of the catch consists of size classes around or above the optimum harvest size. This means that the impact of the fishery is minimized for this species. Potentially higher yields of this species could be achieved by catching them at somewhat smaller size, although capture of smaller specimen may take place already in other fisheries. Risk level is low."

ELSE, IF "% immature + % small mature" is greater than 50% AND "% immature + % small mature" is lower than 65% THEN:

"The bulk of the catch includes age groups that have just matured and are about to achieve their full growth potential. This indicates that the fishery is probably at least being fully exploited. Risk level is medium."

4. *Proportion of mega spawners in the catch.*

Mega spawners are fish larger than 1.1 times the optimum harvest size. We consider a proportion of 30% or more mega spawners in the catch to be a sign of a healthy population (Froese, 2004), whereas lower proportions are increasingly leading to concerns, with proportions below 20% indicating great risk to the fishery.

IF "% mega spawners" is greater than 30% THEN:

"More than 30% of the catch consists of mega spawners which indicates that this fish population is in good health unless large amounts of much smaller fish from the same population are caught by other fisheries. Risk level is low."

ELSE, IF "% mega spawners" is greater than 20% AND "% mega spawners" is lower than or equal to 30% THEN:

"The percentage of mega spawners is between 20 and 30%. There is no immediate reason for concern, though fishing pressure may be significantly reducing the percentage of mega-spawners, which may negatively affect the reproductive output of this population. Risk level is medium."

ELSE, IF "% mega spawners" is lower than or equal to 20%, THEN:

"Less than 20% of the catch comprises of mega spawners. This indicates that the population may be severely affected by the fishery, and that there is a substantial risk of recruitment overfishing through over harvesting of the mega spawners, unless large numbers of mega spawners would be surviving at other habitats. There is no reason to assume that this is the case and therefore a reduction of fishing effort may be necessary in this fishery. Risk level is high."

5. *Spawning Potential Ratio.*

As an indicator for Spawning Potential Ratio (SPR, Quinn and Deriso, 1999), we used the estimated spawning stock biomass divided by the spawning stock biomass of that population it would have been pristine (see, for example, Meester et al 2001). We calculated SPR on a per-recruit basis from life-history parameters Z, F, K (von Bertalanffy), and Linf. We estimated Z and F as explained above and K from Lopt, using the method presented in Froese and Binohlan 2000.

In a perfect world, fishery biologists would know what the appropriate SPR should be for every harvested stock based on the biology of that stock. Generally, however, not enough is known about managed stocks to be so precise. However, studies show that some stocks (depending on the species of fish) can maintain themselves if the spawning stock biomass per recruit can be kept at 20 to 35% (or more) of what it was in the un-fished stock. Lower values of SPR may lead to severe stock declines (Wallace and Fletcher, 2001). Froese et al. (2016) considered a total population biomass B of half the pristine population biomass B_0 to be the lower limit reference point for stock size, minimizing the impact of fishing. Using SPR and B/ B_0 estimates from our own data set, this Froese et al. (2016) lower limit reference point correlates with an SPR of about 40%, not far from but slightly more conservative than the Wallace and Fletcher (2001) reference point. We chose an SPR of 40% as our reference point for low risk and after similar comparisons we consider and SPR between 25% and 40% to represent a medium risk situation.

IF "SPR" is lower than 25% THEN:

"SPR is less than 25%. The fishery probably over-exploits the stock, and there is a substantial risk that the fishery will cause severe decline of the stock if fishing effort is not reduced. Risk level is high."

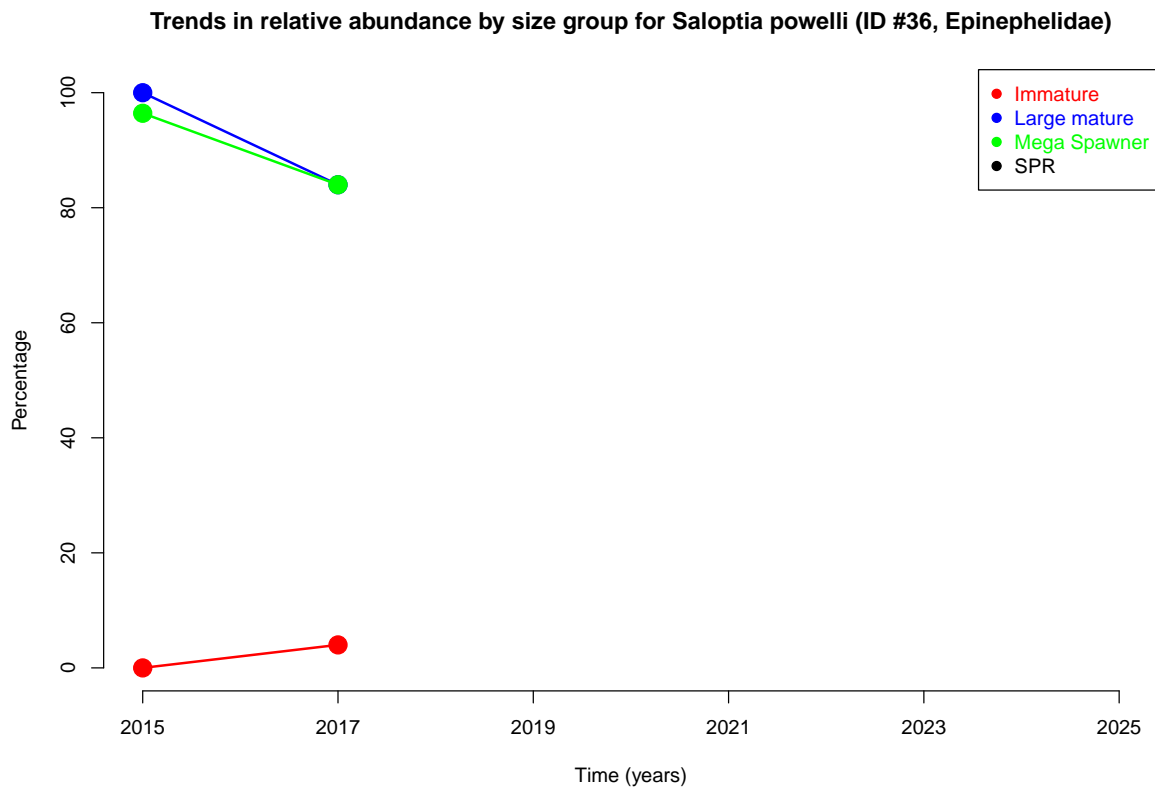
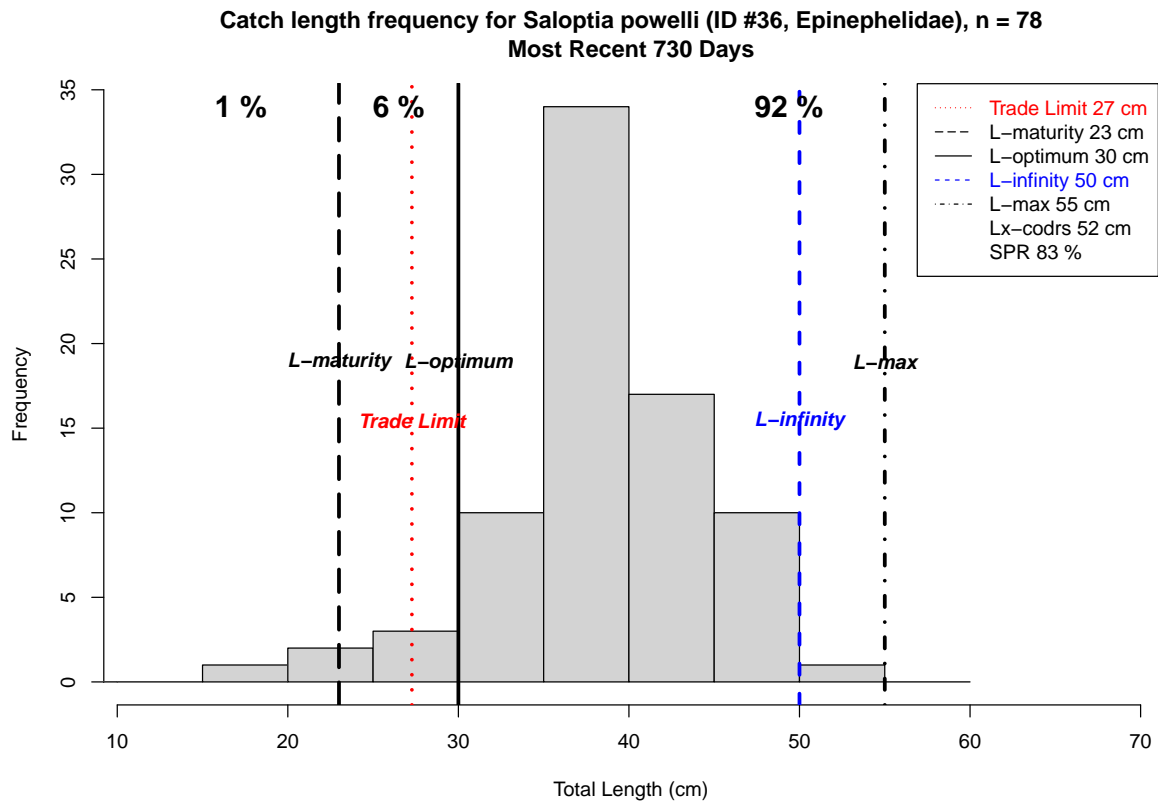
ELSE, IF "SPR" is greater than or equal to 25% AND "SPR" is lower than 40% THEN:

"SPR is between 25% and 40%. The stock is heavily exploited, and there is some risk that the fishery will cause further decline of the stock. Risk level is medium."

ELSE, IF "SPR" is greater than or equal to 40% THEN:

"SPR is more than 40%. The stock is probably not over exploited, and the risk that the fishery will cause further stock decline is small. Risk level is low."

3 Species-specific length-based assessments



The percentages of *Saloptia powelli* (ID #36, Epinephelidae) in most recent 730 days, n=78
Immature (< 23cm): 1%
Small mature (\geq 23cm, < 30cm): 6%
Large mature (\geq 30cm): 92%
Mega spawner (\geq 33cm): 90% (subset of large mature fish)
Spawning Potential Ratio: 83 %

The trade limit is significantly higher than length at first maturity. This means that the trade puts a premium on fish that have spawned at least once. The trade does not cause any concern of recruitment overfishing for this species. Risk level is low.

At least 90% of the fish in the catch are mature specimens that have spawned at least once before they were caught. The fishery does not depend on immature size classes for this species and is considered safe for this indicator. This fishery will not be causing overfishing through over harvesting of juveniles for this species. Risk level is low.

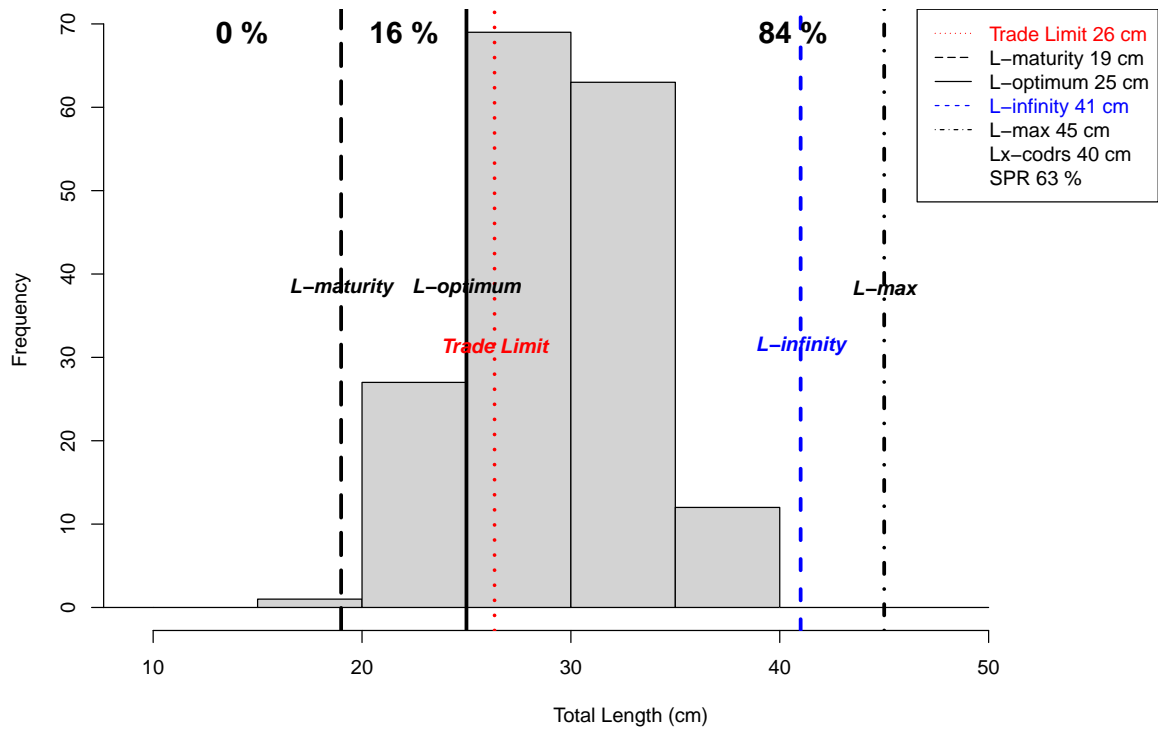
The majority of the catch consists of size classes around or above the optimum harvest size. This means that the impact of the fishery is minimized for this species. Potentially higher yields of this species could be achieved by catching them at somewhat smaller size, although capture of smaller specimen may take place already in other fisheries. Risk level is low.

More than 30% of the catch consists of mega spawners which indicates that this fish population is in good health unless large amounts of much smaller fish from the same population are caught by other fisheries. Risk level is low.

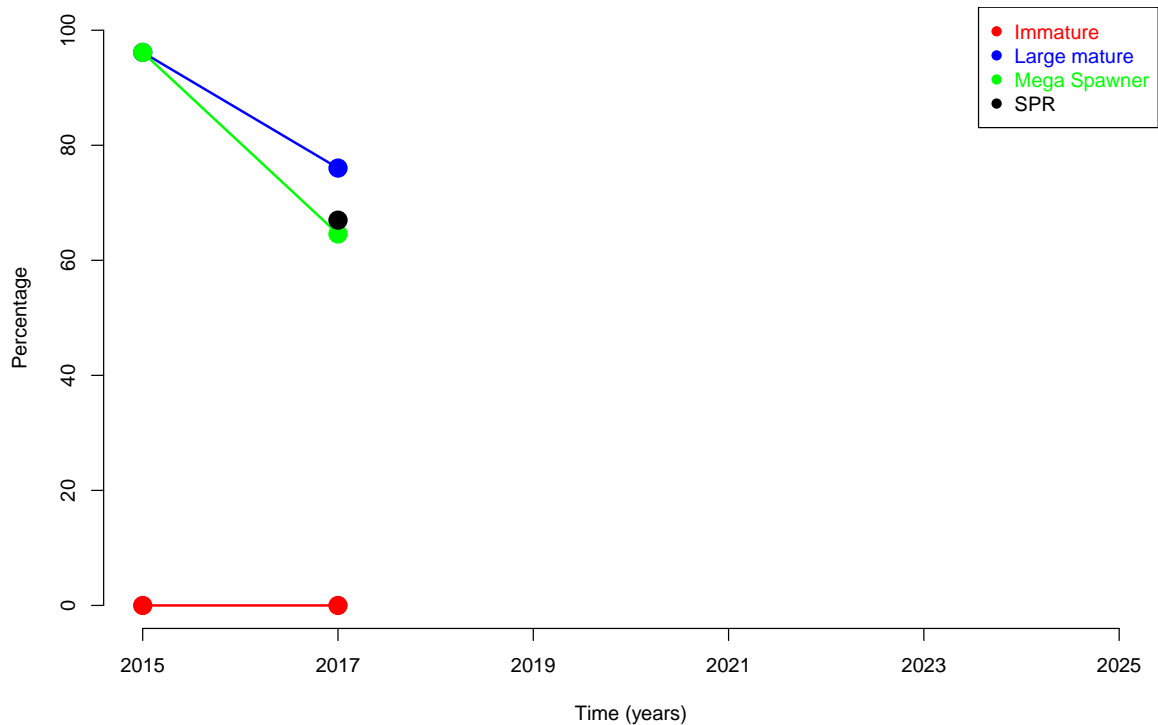
SPR is more than 40%. The stock is probably not over exploited, and the risk that the fishery will cause further stock decline is small. Risk level is low.

Trends in relative abundance by size group for *Saloptia powelli* (ID #36, Epinephelidae), as calculated from linear regressions. The P value indicates the chance that this calculated trend is merely a result of stochastic variance.
% Immature rising over recent years, situation deteriorating. P: not available
% Large Mature falling over recent years, situation deteriorating. P: not available
% Mega Spawner falling over recent years, situation deteriorating. P: not available

Catch length frequency for *Cephalopholis miniata* (ID #37, Epinephelidae), n = 172
 Most Recent 730 Days



Trends in relative abundance by size group for *Cephalopholis miniata* (ID #37, Epinephelidae)



The percentages of *Cephalopholis miniata* (ID #37, Epinephelidae) in most recent 730 days, n=172
Immature (< 19cm): 0%
Small mature (\geq 19cm, < 25cm): 16%
Large mature (\geq 25cm): 84%
Mega spawner (\geq 27.5cm): 72% (subset of large mature fish)
Spawning Potential Ratio: 63 %

The trade limit is significantly higher than length at first maturity. This means that the trade puts a premium on fish that have spawned at least once. The trade does not cause any concern of recruitment overfishing for this species. Risk level is low.

At least 90% of the fish in the catch are mature specimens that have spawned at least once before they were caught. The fishery does not depend on immature size classes for this species and is considered safe for this indicator. This fishery will not be causing overfishing through over harvesting of juveniles for this species. Risk level is low.

The majority of the catch consists of size classes around or above the optimum harvest size. This means that the impact of the fishery is minimized for this species. Potentially higher yields of this species could be achieved by catching them at somewhat smaller size, although capture of smaller specimen may take place already in other fisheries. Risk level is low.

More than 30% of the catch consists of mega spawners which indicates that this fish population is in good health unless large amounts of much smaller fish from the same population are caught by other fisheries. Risk level is low.

SPR is more than 40%. The stock is probably not over exploited, and the risk that the fishery will cause further stock decline is small. Risk level is low.

Trends in relative abundance by size group for *Cephalopholis miniata* (ID #37, Epinephelidae), as calculated from linear regressions. The P value indicates the chance that this calculated trend is merely a result of stochastic variance.

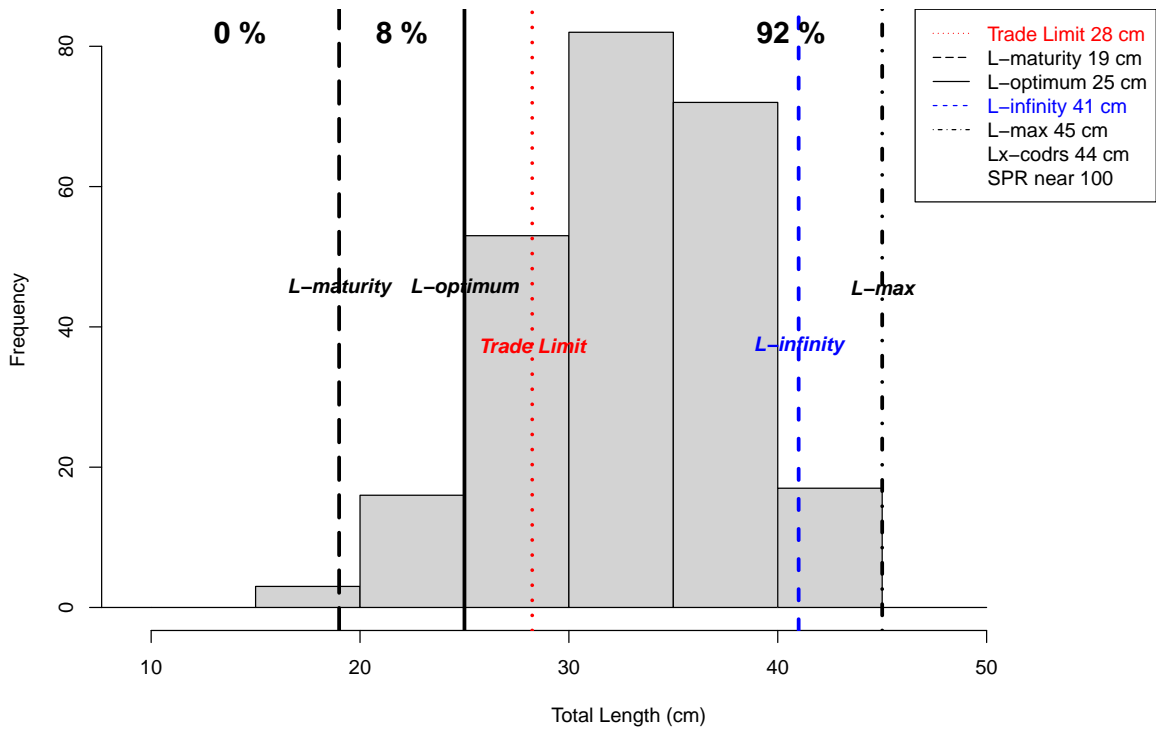
% Immature no trend over recent years, situation stable. P: not available

% Large Mature falling over recent years, situation deteriorating. P: not available

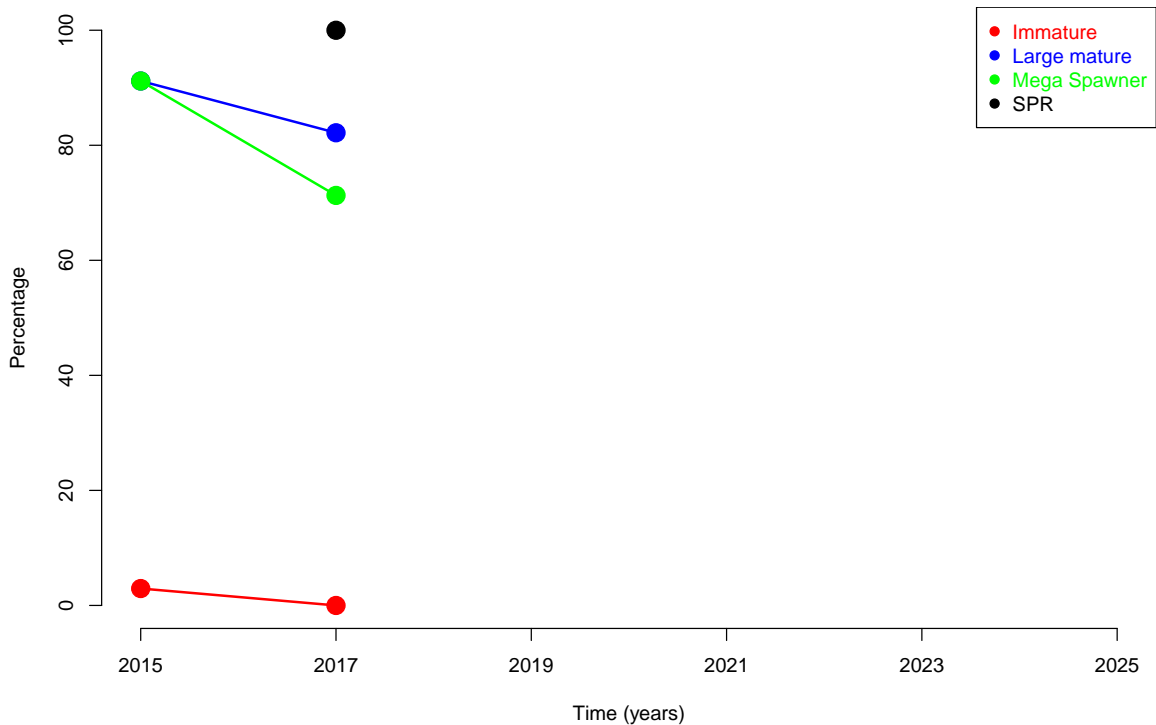
% Mega Spawner falling over recent years, situation deteriorating. P: not available

% SPR no trend over recent years, situation stable. P: not available

Catch length frequency for *Cephalopholis sexmaculata* (ID #38, Epinephelidae), n = 243
 Most Recent 730 Days



Trends in relative abundance by size group for *Cephalopholis sexmaculata* (ID #38, Epinephelidae)



The percentages of *Cephalopholis sexmaculata* (ID #38, Epinephelidae) in most recent 730 days, n=243

Immature (< 19cm): 0%

Small mature (>= 19cm, < 25cm): 8%

Large mature (>= 25cm): 92%

Mega spawner (>= 27.5cm): 84% (subset of large mature fish)

Spawning Potential Ratio: near 100

The trade limit is significantly higher than length at first maturity. This means that the trade puts a premium on fish that have spawned at least once. The trade does not cause any concern of recruitment overfishing for this species. Risk level is low.

At least 90% of the fish in the catch are mature specimens that have spawned at least once before they were caught. The fishery does not depend on immature size classes for this species and is considered safe for this indicator. This fishery will not be causing overfishing through over harvesting of juveniles for this species. Risk level is low.

The majority of the catch consists of size classes around or above the optimum harvest size. This means that the impact of the fishery is minimized for this species. Potentially higher yields of this species could be achieved by catching them at somewhat smaller size, although capture of smaller specimen may take place already in other fisheries. Risk level is low.

More than 30% of the catch consists of mega spawners which indicates that this fish population is in good health unless large amounts of much smaller fish from the same population are caught by other fisheries. Risk level is low.

SPR is more than 40%. The stock is probably not over exploited, and the risk that the fishery will cause further stock decline is small. Risk level is low.

Trends in relative abundance by size group for *Cephalopholis sexmaculata* (ID #38, Epinephelidae), as calculated from linear regressions. The P value indicates the chance that this calculated trend is merely a result of stochastic variance.

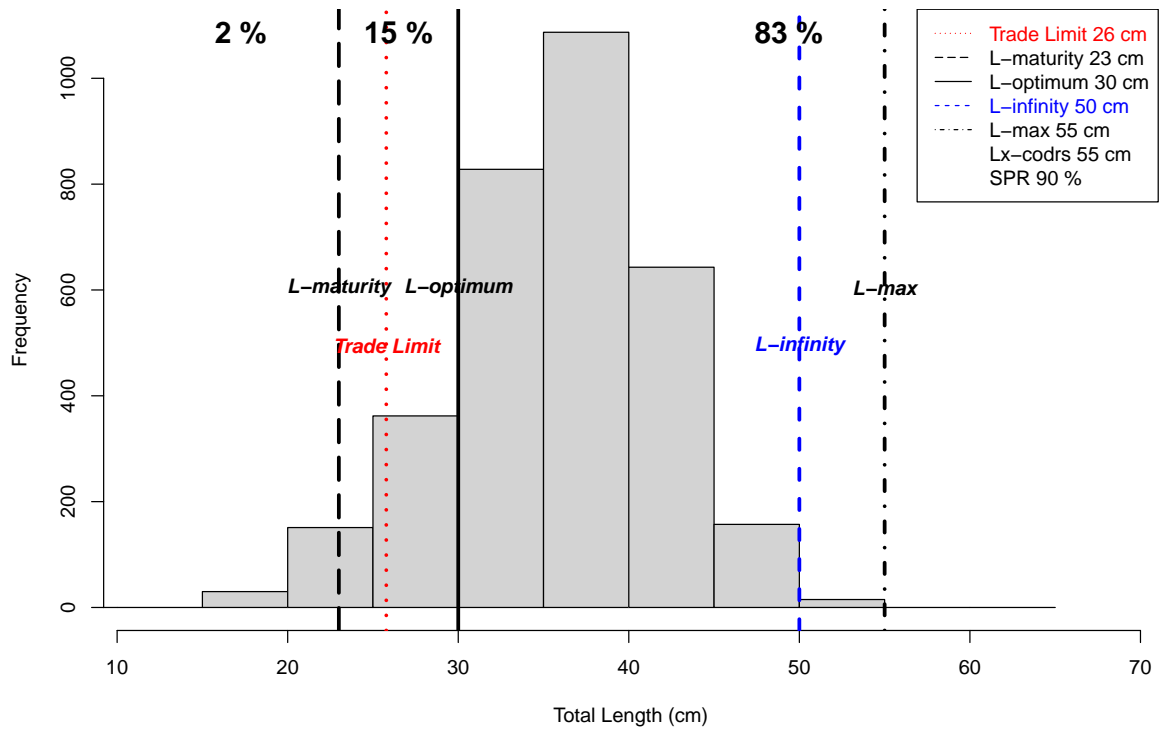
% Immature falling over recent years, situation improving. P: not available

% Large Mature falling over recent years, situation deteriorating. P: not available

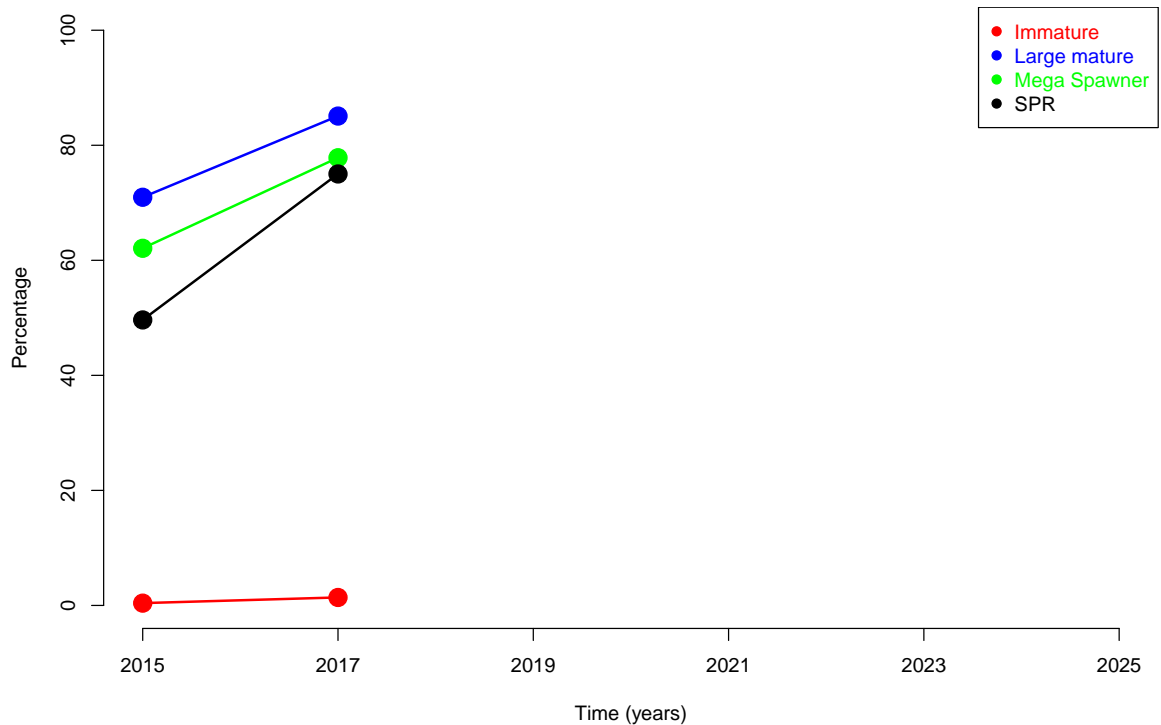
% Mega Spawner falling over recent years, situation deteriorating. P: not available

% SPR no trend over recent years, situation stable. P: not available

Catch length frequency for *Cephalopholis sonnerati* (ID #39, Epinephelidae), n = 3,273
 Most Recent 730 Days



Trends in relative abundance by size group for *Cephalopholis sonnerati* (ID #39, Epinephelidae)



The percentages of *Cephalopholis sonnerati* (ID #39, Epinephelidae) in most recent 730 days, n=3,273
Immature (< 23cm): 2%
Small mature (\geq 23cm, < 30cm): 15%
Large mature (\geq 30cm): 83%
Mega spawner (\geq 33cm): 77% (subset of large mature fish)
Spawning Potential Ratio: 90 %

The trade limit is significantly higher than length at first maturity. This means that the trade puts a premium on fish that have spawned at least once. The trade does not cause any concern of recruitment overfishing for this species. Risk level is low.

At least 90% of the fish in the catch are mature specimens that have spawned at least once before they were caught. The fishery does not depend on immature size classes for this species and is considered safe for this indicator. This fishery will not be causing overfishing through over harvesting of juveniles for this species. Risk level is low.

The majority of the catch consists of size classes around or above the optimum harvest size. This means that the impact of the fishery is minimized for this species. Potentially higher yields of this species could be achieved by catching them at somewhat smaller size, although capture of smaller specimen may take place already in other fisheries. Risk level is low.

More than 30% of the catch consists of mega spawners which indicates that this fish population is in good health unless large amounts of much smaller fish from the same population are caught by other fisheries. Risk level is low.

SPR is more than 40%. The stock is probably not over exploited, and the risk that the fishery will cause further stock decline is small. Risk level is low.

Trends in relative abundance by size group for *Cephalopholis sonnerati* (ID #39, Epinephelidae), as calculated from linear regressions. The P value indicates the chance that this calculated trend is merely a result of stochastic variance.

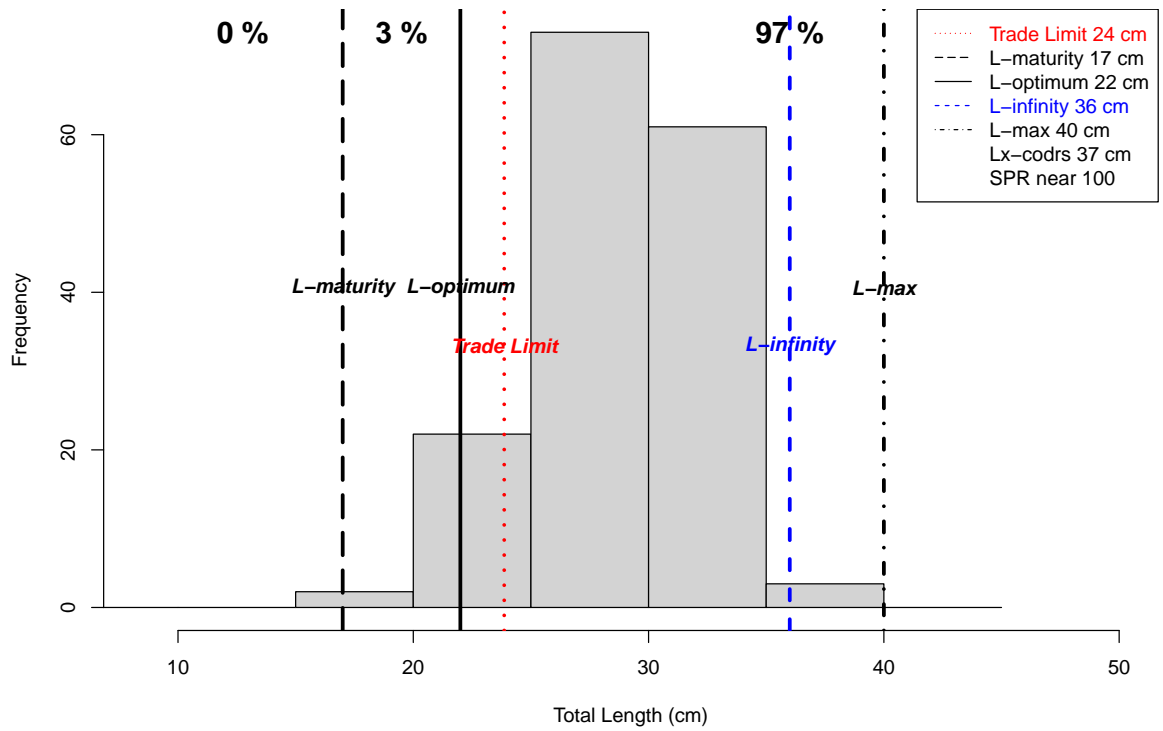
% Immature rising over recent years, situation deteriorating. P: not available

% Large Mature rising over recent years, situation improving. P: not available

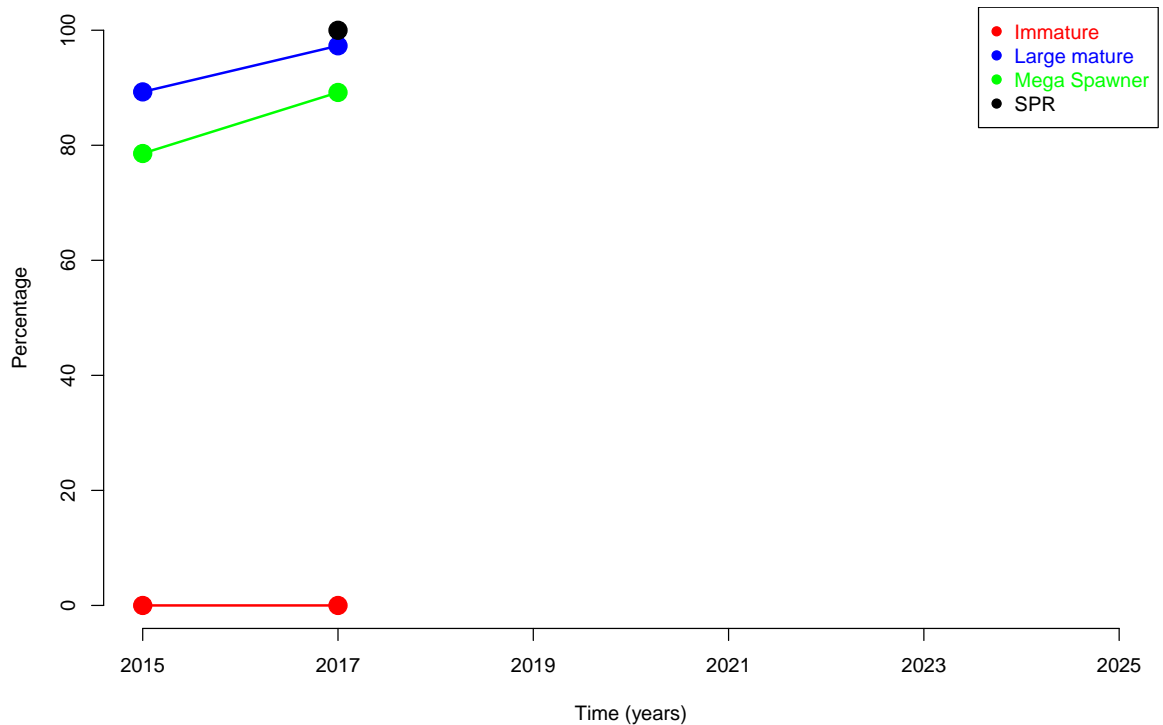
% Mega Spawner rising over recent years, situation improving. P: not available

% SPR rising over recent years, situation improving. P: not available

Catch length frequency for *Cephalopholis igarashiensis* (ID #40, Epinephelidae), n = 161
 Most Recent 730 Days



Trends in relative abundance by size group for *Cephalopholis igarashiensis* (ID #40, Epinephelidae)



The percentages of *Cephalopholis igarashiensis* (ID #40, Epinephelidae) in most recent 730 days, n=161

Immature (< 17cm): 0%

Small mature (>= 17cm, < 22cm): 3%

Large mature (>= 22cm): 97%

Mega spawner (>= 24.2cm): 88% (subset of large mature fish)

Spawning Potential Ratio: near 100

The trade limit is significantly higher than length at first maturity. This means that the trade puts a premium on fish that have spawned at least once. The trade does not cause any concern of recruitment overfishing for this species. Risk level is low.

At least 90% of the fish in the catch are mature specimens that have spawned at least once before they were caught. The fishery does not depend on immature size classes for this species and is considered safe for this indicator. This fishery will not be causing overfishing through over harvesting of juveniles for this species. Risk level is low.

The majority of the catch consists of size classes around or above the optimum harvest size. This means that the impact of the fishery is minimized for this species. Potentially higher yields of this species could be achieved by catching them at somewhat smaller size, although capture of smaller specimen may take place already in other fisheries. Risk level is low.

More than 30% of the catch consists of mega spawners which indicates that this fish population is in good health unless large amounts of much smaller fish from the same population are caught by other fisheries. Risk level is low.

SPR is more than 40%. The stock is probably not over exploited, and the risk that the fishery will cause further stock decline is small. Risk level is low.

Trends in relative abundance by size group for *Cephalopholis igarashiensis* (ID #40, Epinephelidae), as calculated from linear regressions. The P value indicates the chance that this calculated trend is merely a result of stochastic variance.

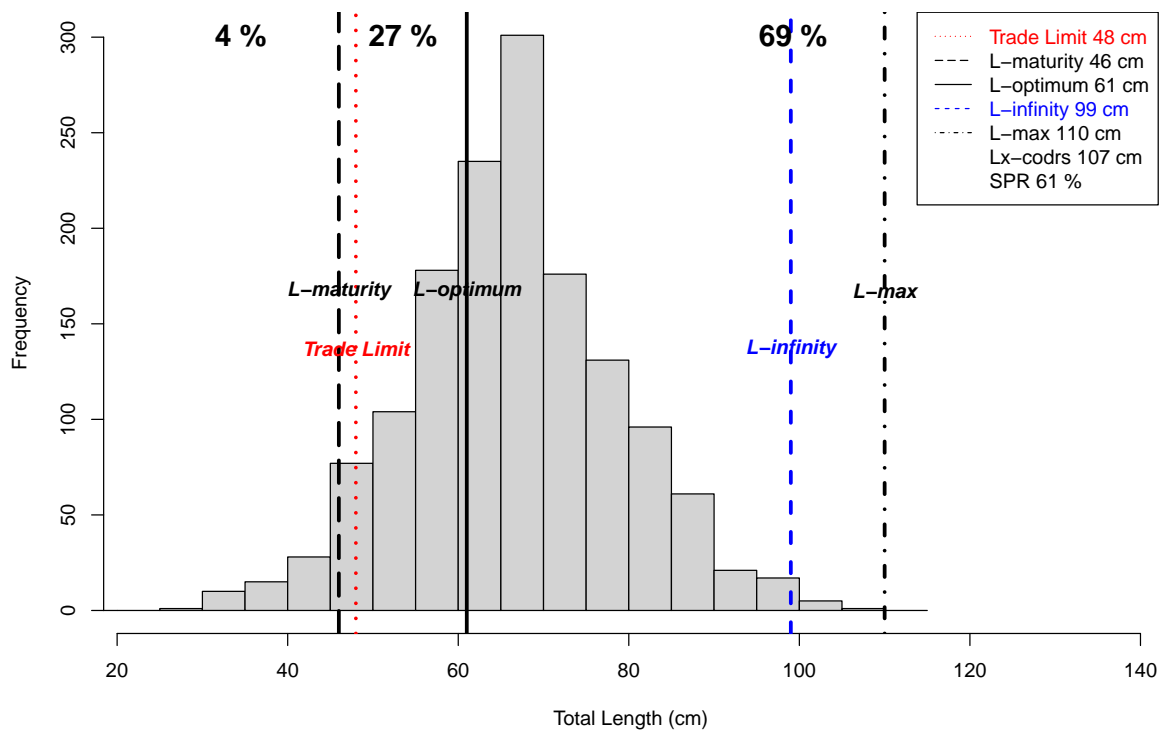
% Immature no trend over recent years, situation stable. P: not available

% Large Mature rising over recent years, situation improving. P: not available

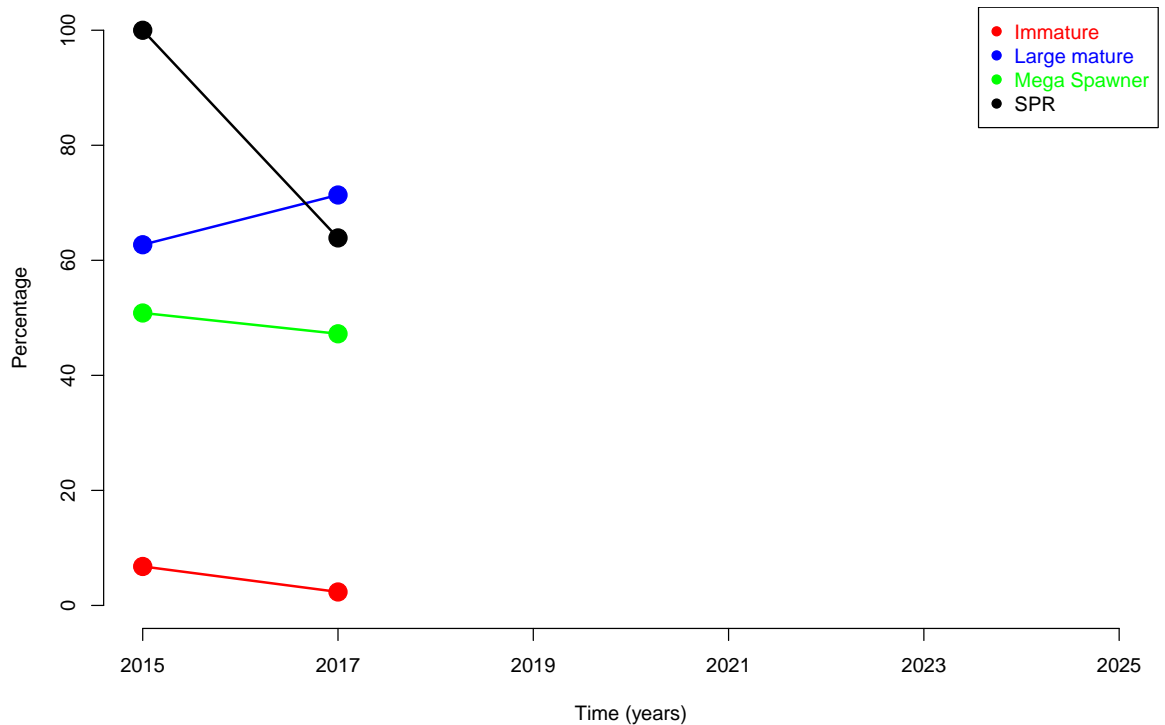
% Mega Spawner rising over recent years, situation improving. P: not available

% SPR no trend over recent years, situation stable. P: not available

Catch length frequency for *Epinephelus latifasciatus* (ID #41, Epinephelidae), n = 1,457
 Most Recent 730 Days



Trends in relative abundance by size group for *Epinephelus latifasciatus* (ID #41, Epinephelidae)



The percentages of *Epinephelus latifasciatus* (ID #41, Epinephelidae) in most recent 730 days, n=1,457
Immature (< 46cm): 4%
Small mature (\geq 46cm, < 61cm): 27%
Large mature (\geq 61cm): 69%
Mega spawner (\geq 67.1cm): 46% (subset of large mature fish)
Spawning Potential Ratio: 61 %

The trade limit is about the same as the length at first maturity. This means that the trade puts a premium on fish that have spawned at least once, which improves sustainability of the fishery. Risk level is medium.

At least 90% of the fish in the catch are mature specimens that have spawned at least once before they were caught. The fishery does not depend on immature size classes for this species and is considered safe for this indicator. This fishery will not be causing overfishing through over harvesting of juveniles for this species. Risk level is low.

The majority of the catch consists of size classes around or above the optimum harvest size. This means that the impact of the fishery is minimized for this species. Potentially higher yields of this species could be achieved by catching them at somewhat smaller size, although capture of smaller specimen may take place already in other fisheries. Risk level is low.

More than 30% of the catch consists of mega spawners which indicates that this fish population is in good health unless large amounts of much smaller fish from the same population are caught by other fisheries. Risk level is low.

SPR is more than 40%. The stock is probably not over exploited, and the risk that the fishery will cause further stock decline is small. Risk level is low.

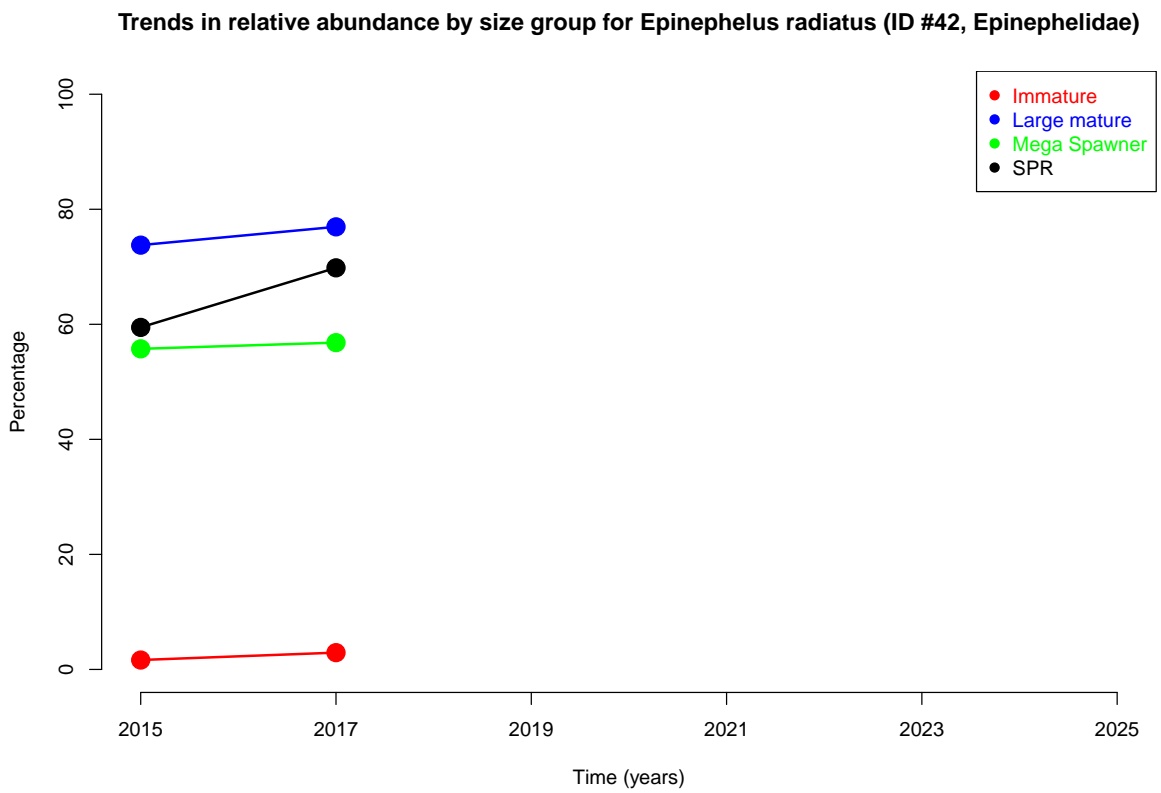
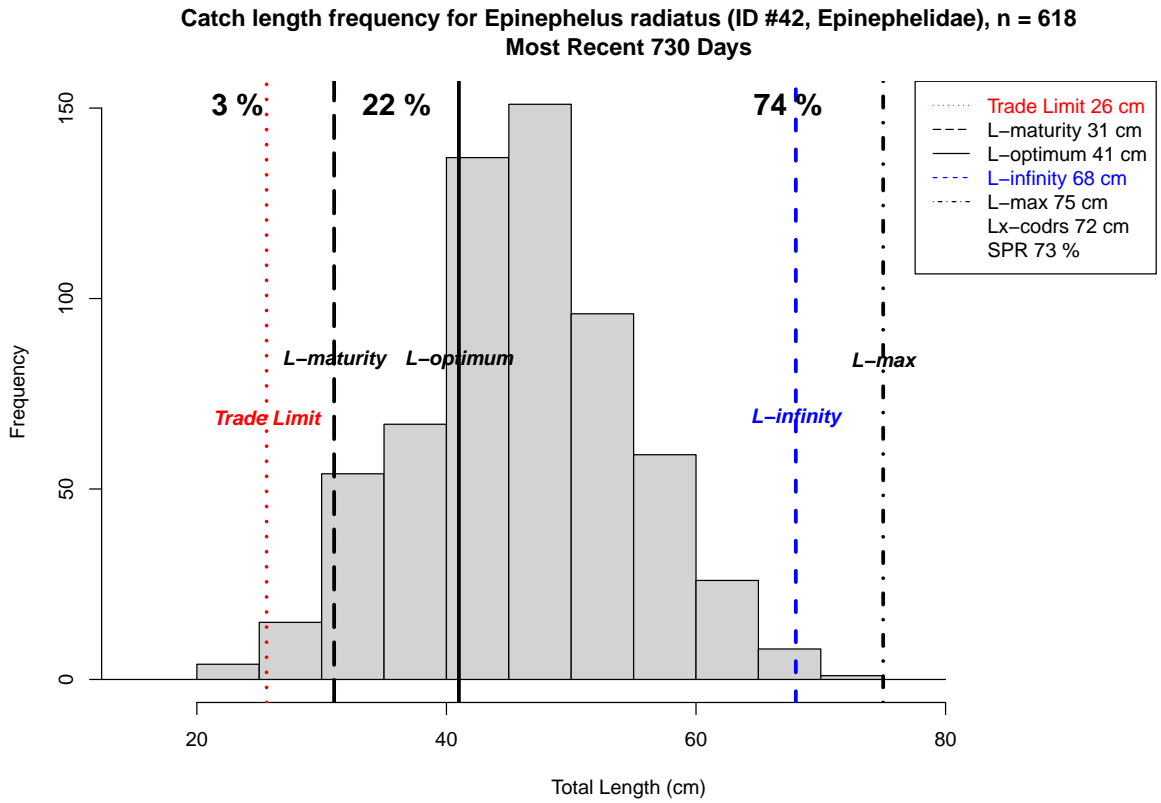
Trends in relative abundance by size group for *Epinephelus latifasciatus* (ID #41, Epinephelidae), as calculated from linear regressions. The P value indicates the chance that this calculated trend is merely a result of stochastic variance.

% Immature falling over recent years, situation improving. P: not available

% Large Mature rising over recent years, situation improving. P: not available

% Mega Spawner falling over recent years, situation deteriorating. P: not available

% SPR falling over recent years, situation deteriorating. P: not available



The percentages of *Epinephelus radiatus* (ID #42, Epinephelidae) in most recent 730 days, n=618
Immature (< 31cm): 3%
Small mature ($\geq 31\text{cm}$, < 41cm): 22%
Large mature ($\geq 41\text{cm}$): 74%
Mega spawner ($\geq 45.1\text{cm}$): 55% (subset of large mature fish)
Spawning Potential Ratio: 73 %

The trade limit is significantly lower than the length at first maturity. This means that the trade encourages capture of immature fish, which impairs sustainability. Risk level is high.

At least 90% of the fish in the catch are mature specimens that have spawned at least once before they were caught. The fishery does not depend on immature size classes for this species and is considered safe for this indicator. This fishery will not be causing overfishing through over harvesting of juveniles for this species. Risk level is low.

The majority of the catch consists of size classes around or above the optimum harvest size. This means that the impact of the fishery is minimized for this species. Potentially higher yields of this species could be achieved by catching them at somewhat smaller size, although capture of smaller specimen may take place already in other fisheries. Risk level is low.

More than 30% of the catch consists of mega spawners which indicates that this fish population is in good health unless large amounts of much smaller fish from the same population are caught by other fisheries. Risk level is low.

SPR is more than 40%. The stock is probably not over exploited, and the risk that the fishery will cause further stock decline is small. Risk level is low.

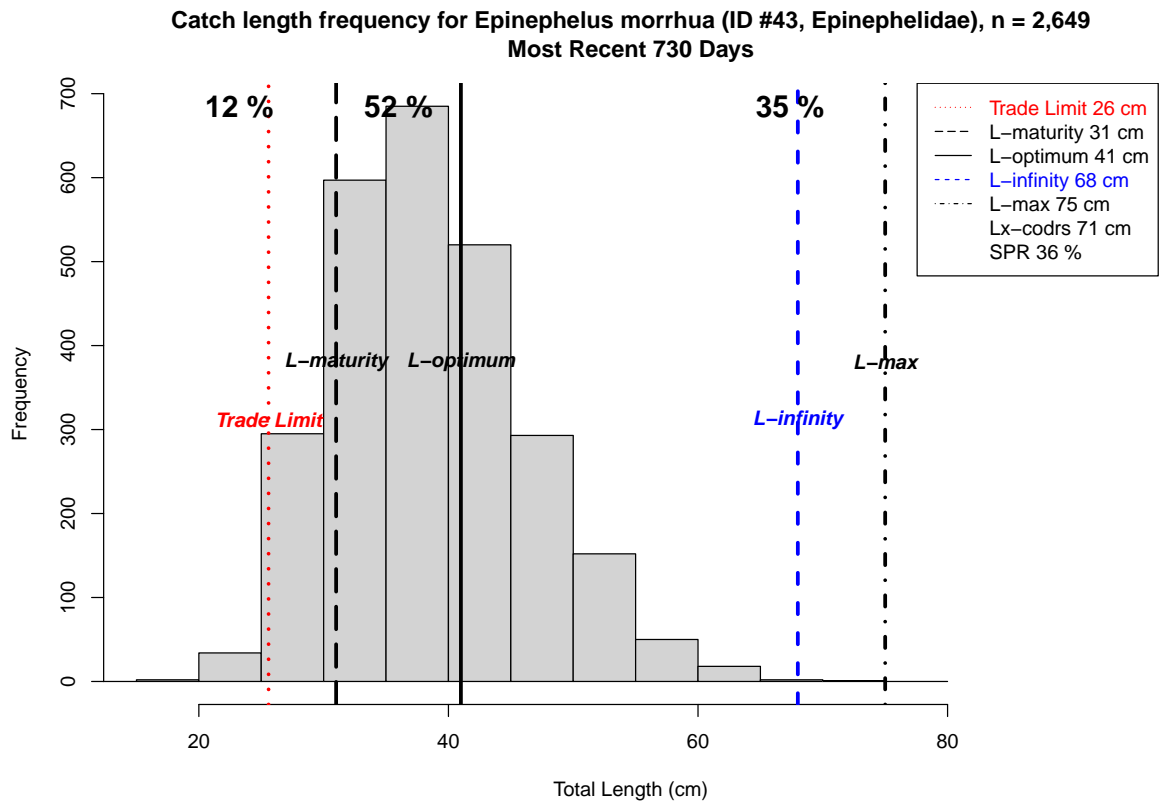
Trends in relative abundance by size group for *Epinephelus radiatus* (ID #42, Epinephelidae), as calculated from linear regressions. The P value indicates the chance that this calculated trend is merely a result of stochastic variance.

% Immature rising over recent years, situation deteriorating. P: not available

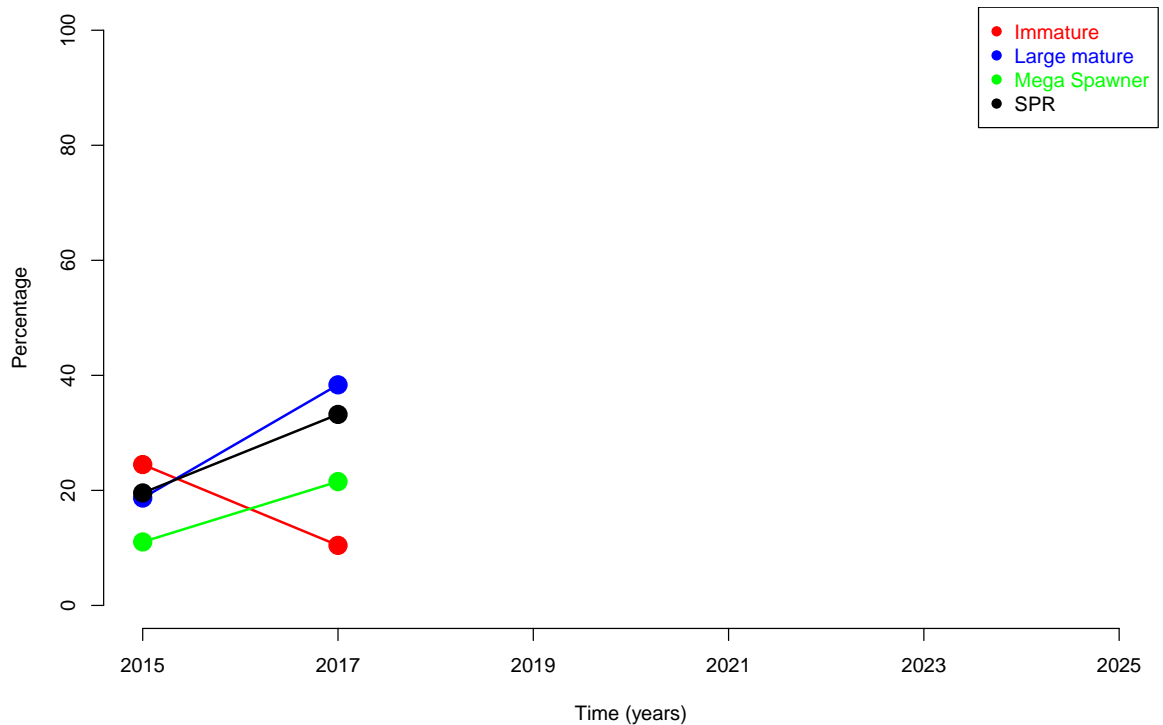
% Large Mature rising over recent years, situation improving. P: not available

% Mega Spawner rising over recent years, situation improving. P: not available

% SPR rising over recent years, situation improving. P: not available



Trends in relative abundance by size group for *Epinephelus morrhua* (ID #43, Epinephelidae)



The percentages of *Epinephelus morrhua* (ID #43, Epinephelidae) in most recent 730 days, n=2,649
Immature (< 31cm): 12%
Small mature ($\geq 31\text{cm}$, < 41cm): 52%
Large mature ($\geq 41\text{cm}$): 35%
Mega spawner ($\geq 45.1\text{cm}$): 19% (subset of large mature fish)
Spawning Potential Ratio: 36 %

The trade limit is significantly lower than the length at first maturity. This means that the trade encourages capture of immature fish, which impairs sustainability. Risk level is high.

Between 10% and 20% of the fish in the catch are juveniles that have not yet reproduced. There is no immediate concern in terms of overfishing through over harvesting of juveniles, but the fishery needs to be monitored closely for any further increase in this indicator and incentives need to be geared towards targeting larger fish. Risk level is medium.

The bulk of the catch includes age groups that have just matured and are about to achieve their full growth potential. This indicates that the fishery is probably at least being fully exploited. Risk level is medium.

Less than 20% of the catch comprises of mega spawners. This indicates that the population may be severely affected by the fishery, and that there is a substantial risk of recruitment overfishing through over harvesting of the mega spawners, unless large numbers of mega spawners would be surviving at other habitats. There is no reason to assume that this is the case and therefore a reduction of fishing effort may be necessary in this fishery. Risk level is high.

SPR is between 25% and 40%. The stock is heavily exploited, and there is some risk that the fishery will cause further decline of the stock. Risk level is medium.

Trends in relative abundance by size group for *Epinephelus morrhua* (ID #43, Epinephelidae), as calculated from linear regressions. The P value indicates the chance that this calculated trend is merely a result of stochastic variance.

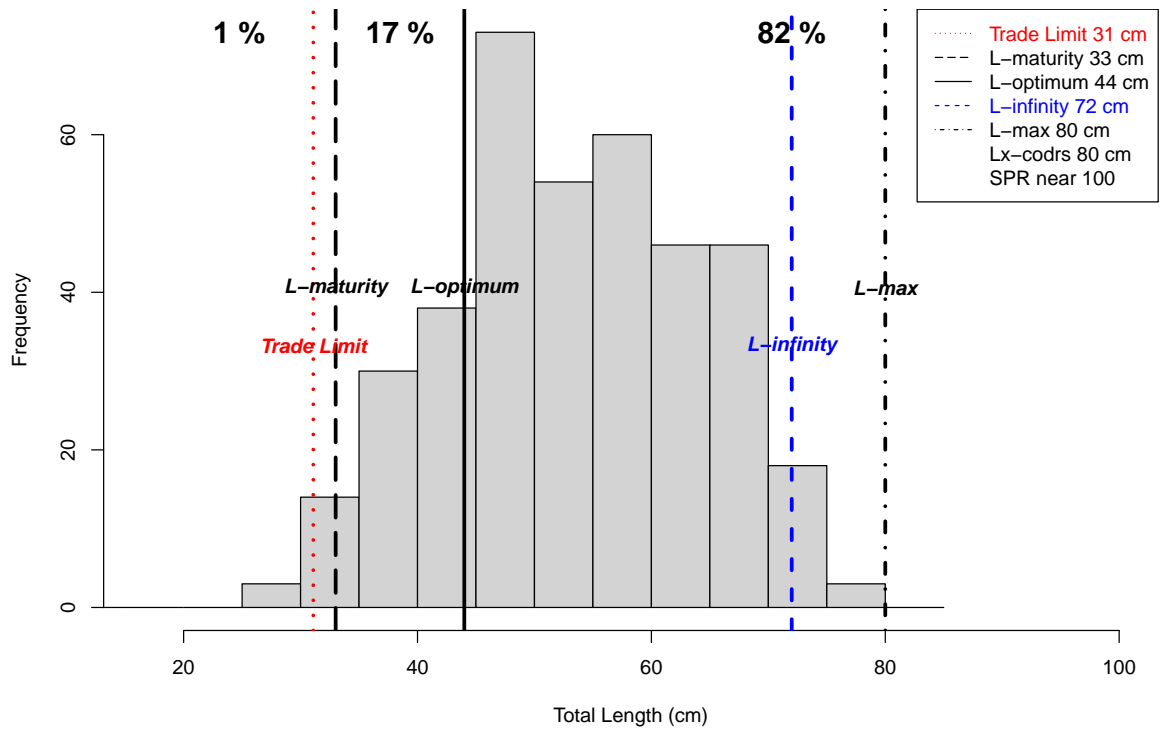
% Immature falling over recent years, situation improving. P: not available

% Large Mature rising over recent years, situation improving. P: not available

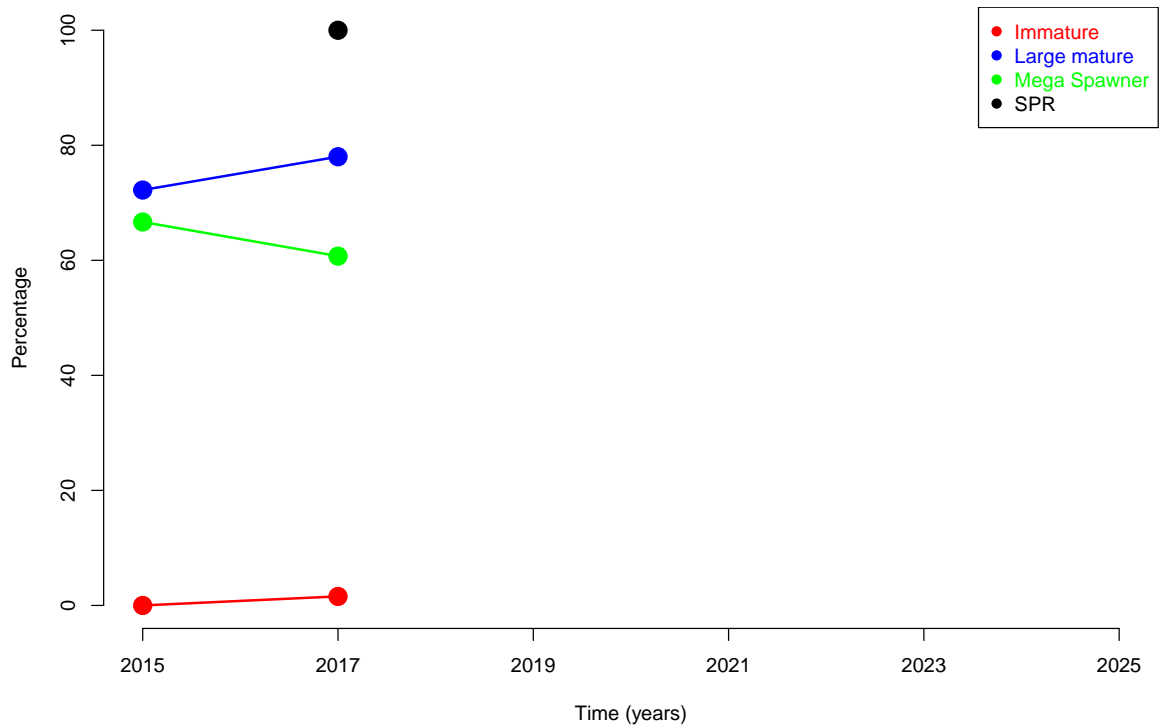
% Mega Spawner rising over recent years, situation improving. P: not available

% SPR rising over recent years, situation improving. P: not available

**Catch length frequency for *Epinephelus poecilonotus* (ID #44, Epinephelidae), n = 385
 Most Recent 730 Days**



Trends in relative abundance by size group for *Epinephelus poecilonotus* (ID #44, Epinephelidae)



The percentages of *Epinephelus poecilonotus* (ID #44, Epinephelidae) in most recent 730 days, n=385
Immature (< 33cm): 1%
Small mature (\geq 33cm, < 44cm): 17%
Large mature (\geq 44cm): 82%
Mega spawner (\geq 48.4cm): 68% (subset of large mature fish)
Spawning Potential Ratio: near 100

The trade limit is about the same as the length at first maturity. This means that the trade puts a premium on fish that have spawned at least once, which improves sustainability of the fishery. Risk level is medium.

At least 90% of the fish in the catch are mature specimens that have spawned at least once before they were caught. The fishery does not depend on immature size classes for this species and is considered safe for this indicator. This fishery will not be causing overfishing through over harvesting of juveniles for this species. Risk level is low.

The majority of the catch consists of size classes around or above the optimum harvest size. This means that the impact of the fishery is minimized for this species. Potentially higher yields of this species could be achieved by catching them at somewhat smaller size, although capture of smaller specimen may take place already in other fisheries. Risk level is low.

More than 30% of the catch consists of mega spawners which indicates that this fish population is in good health unless large amounts of much smaller fish from the same population are caught by other fisheries. Risk level is low.

SPR is more than 40%. The stock is probably not over exploited, and the risk that the fishery will cause further stock decline is small. Risk level is low.

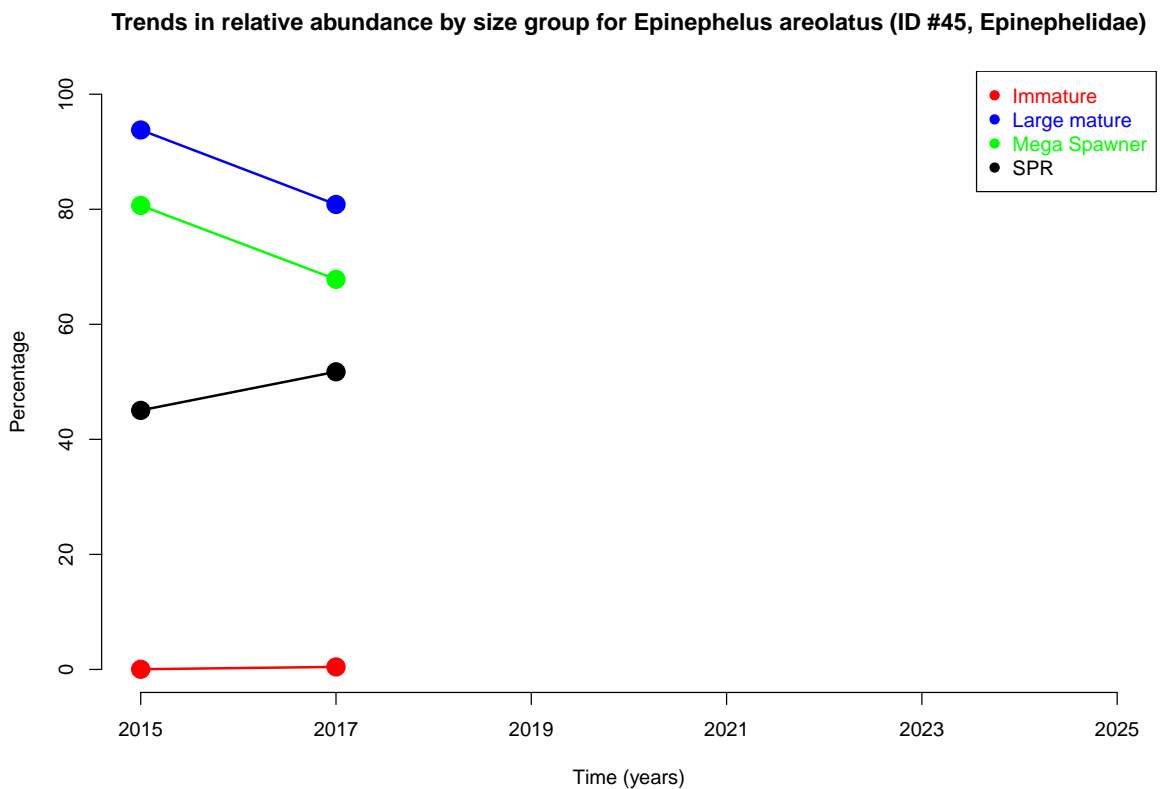
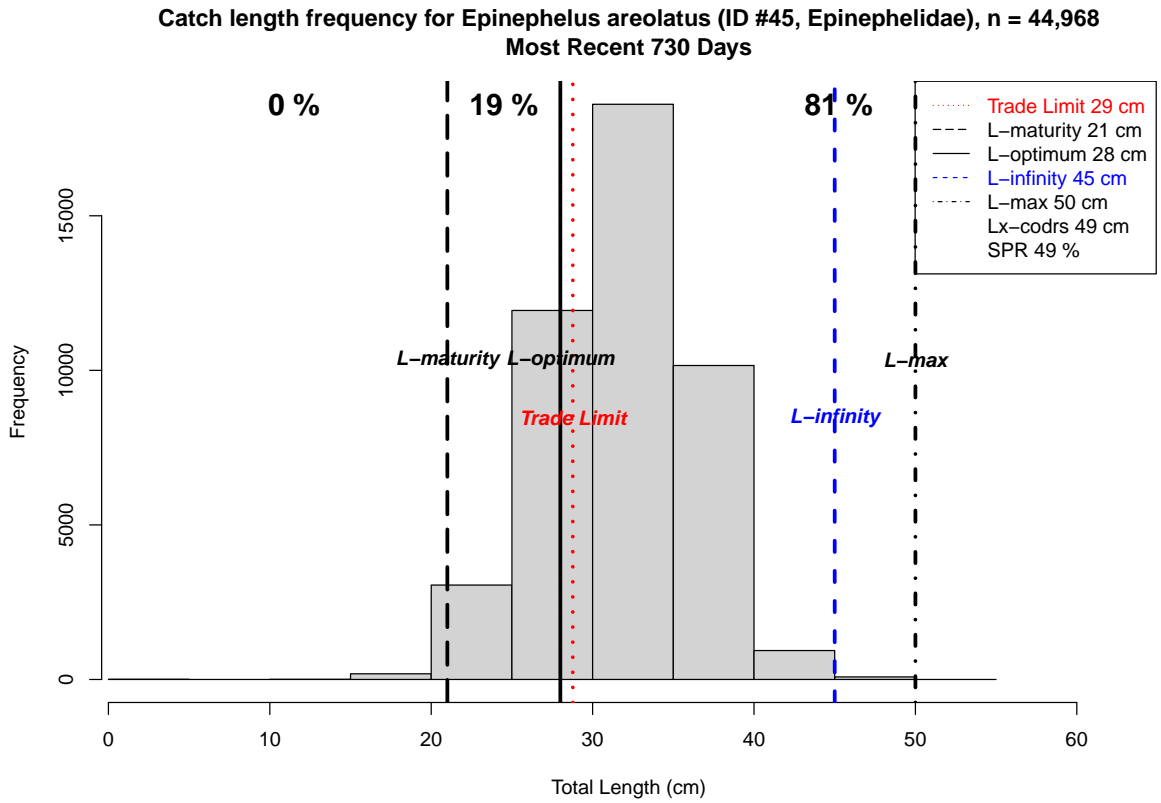
Trends in relative abundance by size group for *Epinephelus poecilonotus* (ID #44, Epinephelidae), as calculated from linear regressions. The P value indicates the chance that this calculated trend is merely a result of stochastic variance.

% Immature rising over recent years, situation deteriorating. P: not available

% Large Mature rising over recent years, situation improving. P: not available

% Mega Spawner falling over recent years, situation deteriorating. P: not available

% SPR no trend over recent years, situation stable. P: not available



The percentages of *Epinephelus areolatus* (ID #45, Epinephelidae) in most recent 730 days, n=44,968
Immature (< 21cm): 0%
Small mature (\geq 21cm, < 28cm): 19%
Large mature (\geq 28cm): 81%
Mega spawner (\geq 30.8cm): 66% (subset of large mature fish)
Spawning Potential Ratio: 49 %

The trade limit is significantly higher than length at first maturity. This means that the trade puts a premium on fish that have spawned at least once. The trade does not cause any concern of recruitment overfishing for this species. Risk level is low.

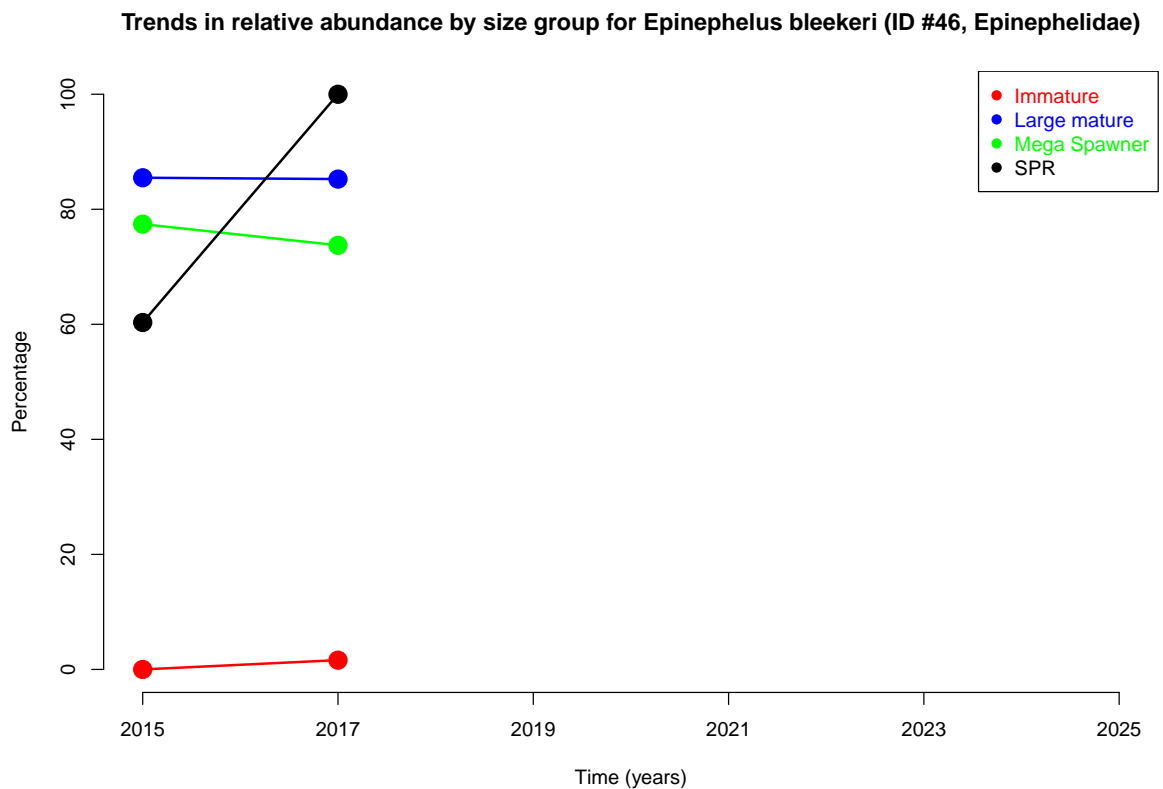
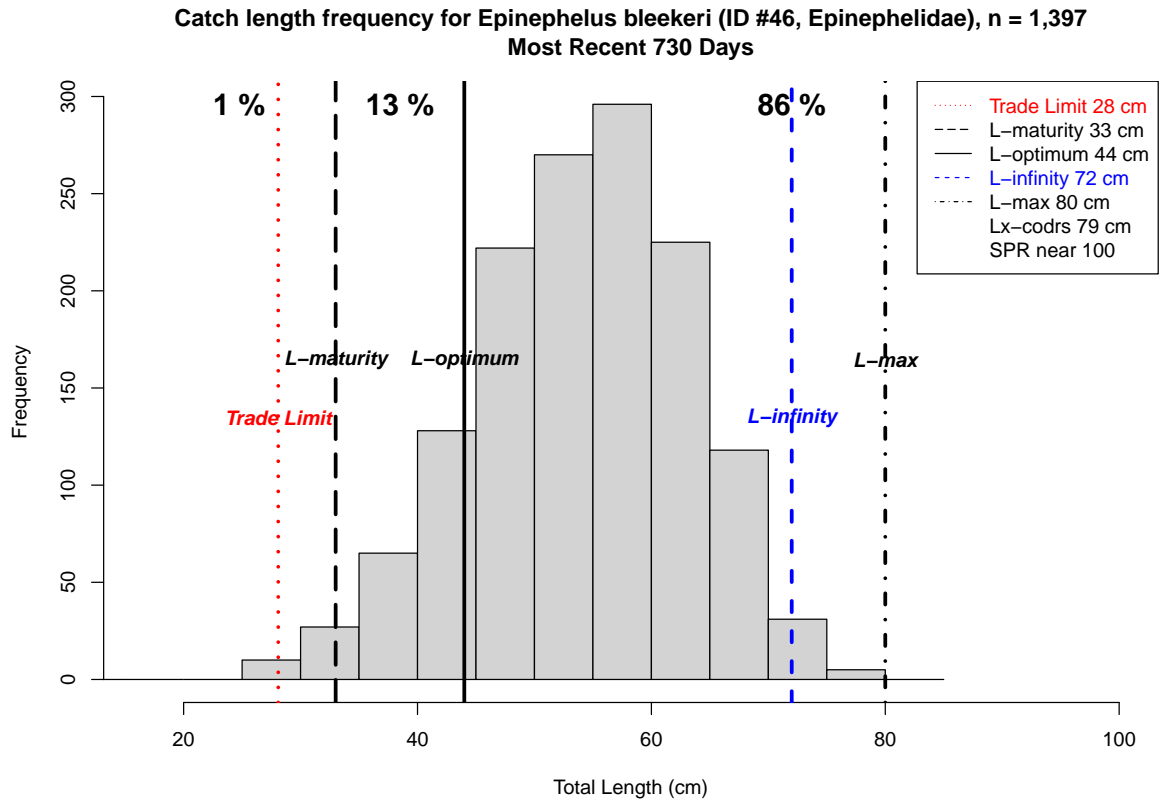
At least 90% of the fish in the catch are mature specimens that have spawned at least once before they were caught. The fishery does not depend on immature size classes for this species and is considered safe for this indicator. This fishery will not be causing overfishing through over harvesting of juveniles for this species. Risk level is low.

The majority of the catch consists of size classes around or above the optimum harvest size. This means that the impact of the fishery is minimized for this species. Potentially higher yields of this species could be achieved by catching them at somewhat smaller size, although capture of smaller specimen may take place already in other fisheries. Risk level is low.

More than 30% of the catch consists of mega spawners which indicates that this fish population is in good health unless large amounts of much smaller fish from the same population are caught by other fisheries. Risk level is low.

SPR is more than 40%. The stock is probably not over exploited, and the risk that the fishery will cause further stock decline is small. Risk level is low.

Trends in relative abundance by size group for *Epinephelus areolatus* (ID #45, Epinephelidae), as calculated from linear regressions. The P value indicates the chance that this calculated trend is merely a result of stochastic variance.
% Immature rising over recent years, situation deteriorating. P: not available
% Large Mature falling over recent years, situation deteriorating. P: not available
% Mega Spawner falling over recent years, situation deteriorating. P: not available
% SPR rising over recent years, situation improving. P: not available



The percentages of *Epinephelus bleekeri* (ID #46, Epinephelidae) in most recent 730 days, n=1,397
Immature (< 33cm): 1%
Small mature (\geq 33cm, < 44cm): 13%
Large mature (\geq 44cm): 86%
Mega spawner (\geq 48.4cm): 74% (subset of large mature fish)
Spawning Potential Ratio: near 100

The trade limit is significantly lower than the length at first maturity. This means that the trade encourages capture of immature fish, which impairs sustainability. Risk level is high.

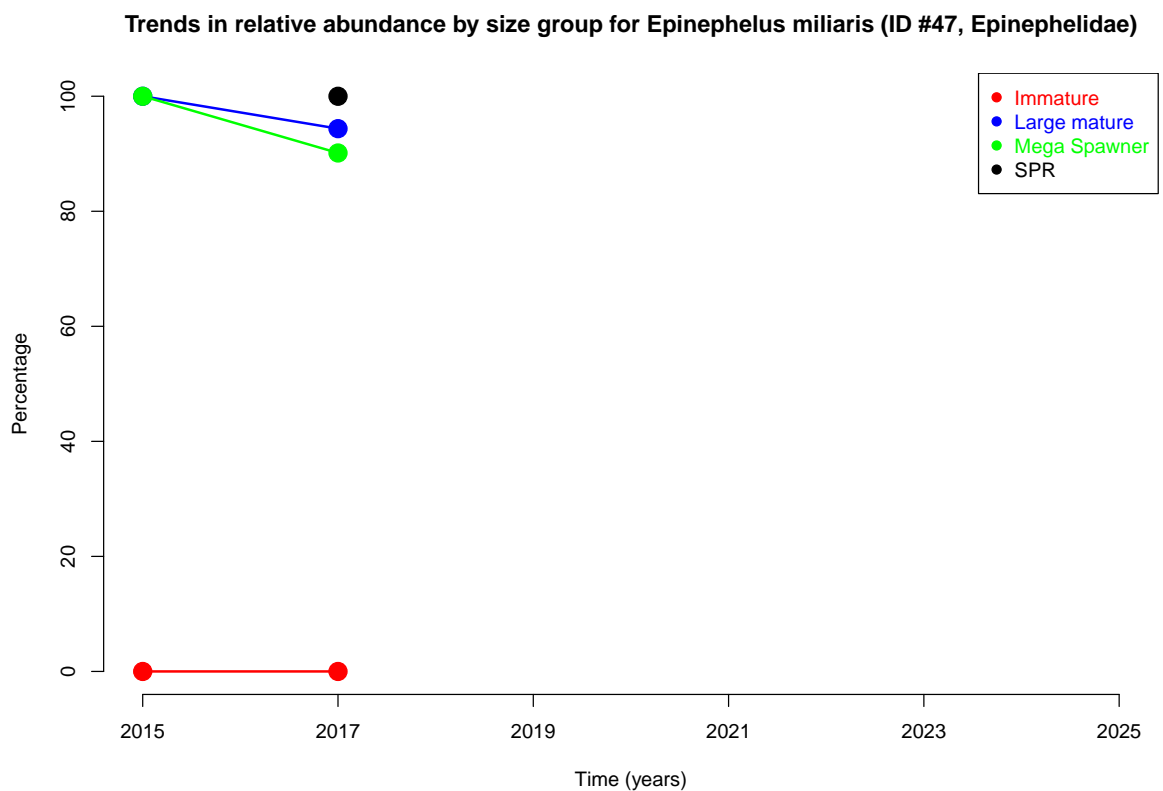
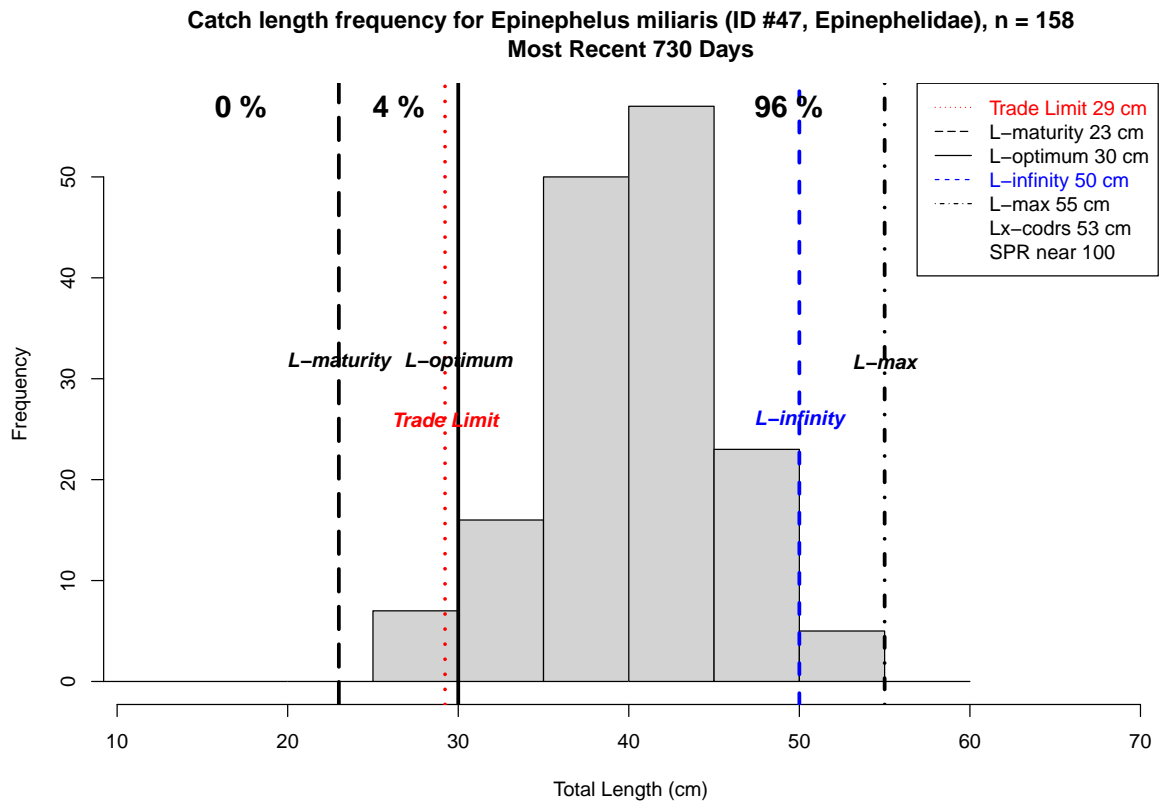
At least 90% of the fish in the catch are mature specimens that have spawned at least once before they were caught. The fishery does not depend on immature size classes for this species and is considered safe for this indicator. This fishery will not be causing overfishing through over harvesting of juveniles for this species. Risk level is low.

The majority of the catch consists of size classes around or above the optimum harvest size. This means that the impact of the fishery is minimized for this species. Potentially higher yields of this species could be achieved by catching them at somewhat smaller size, although capture of smaller specimen may take place already in other fisheries. Risk level is low.

More than 30% of the catch consists of mega spawners which indicates that this fish population is in good health unless large amounts of much smaller fish from the same population are caught by other fisheries. Risk level is low.

SPR is more than 40%. The stock is probably not over exploited, and the risk that the fishery will cause further stock decline is small. Risk level is low.

Trends in relative abundance by size group for *Epinephelus bleekeri* (ID #46, Epinephelidae), as calculated from linear regressions. The P value indicates the chance that this calculated trend is merely a result of stochastic variance.
% Immature rising over recent years, situation deteriorating. P: not available
% Large Mature falling over recent years, situation deteriorating. P: not available
% Mega Spawner falling over recent years, situation deteriorating. P: not available
% SPR rising over recent years, situation improving. P: not available



The percentages of *Epinephelus miliaris* (ID #47, Epinephelidae) in most recent 730 days, n=158
Immature (< 23cm): 0%
Small mature (\geq 23cm, < 30cm): 4%
Large mature (\geq 30cm): 96%
Mega spawner (\geq 33cm): 94% (subset of large mature fish)
Spawning Potential Ratio: near 100

The trade limit is significantly higher than length at first maturity. This means that the trade puts a premium on fish that have spawned at least once. The trade does not cause any concern of recruitment overfishing for this species. Risk level is low.

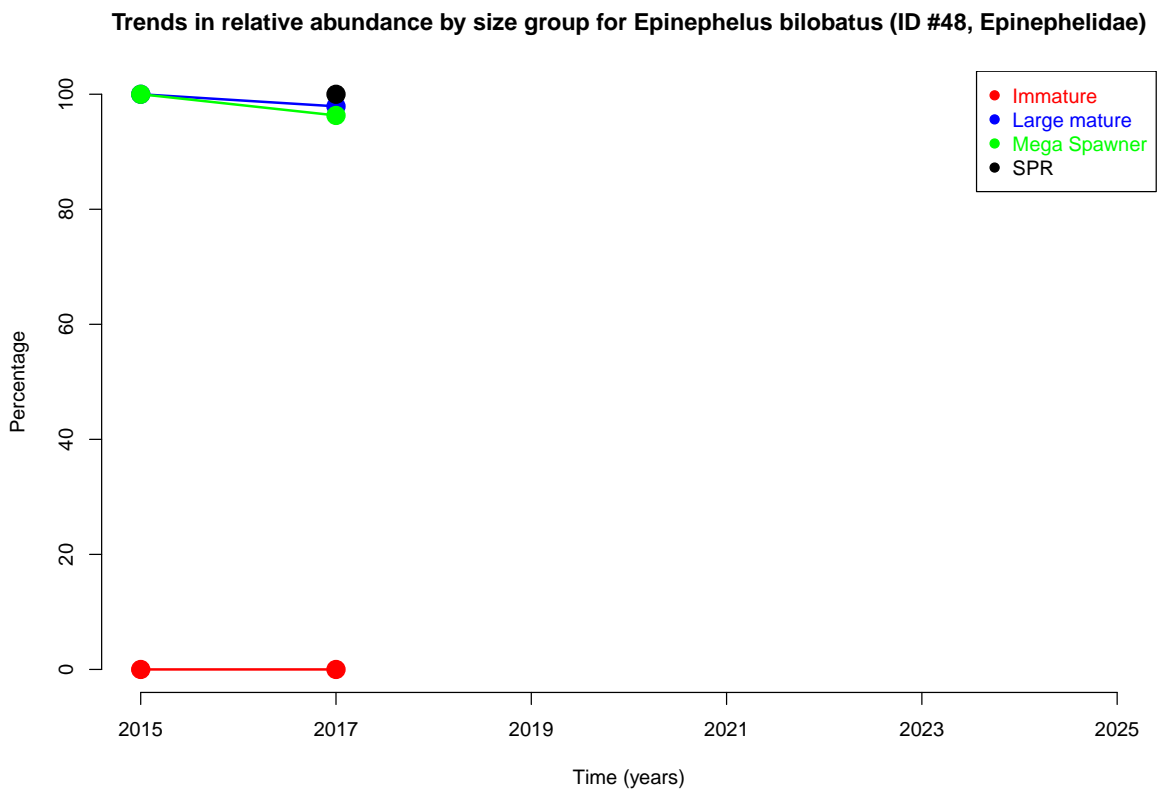
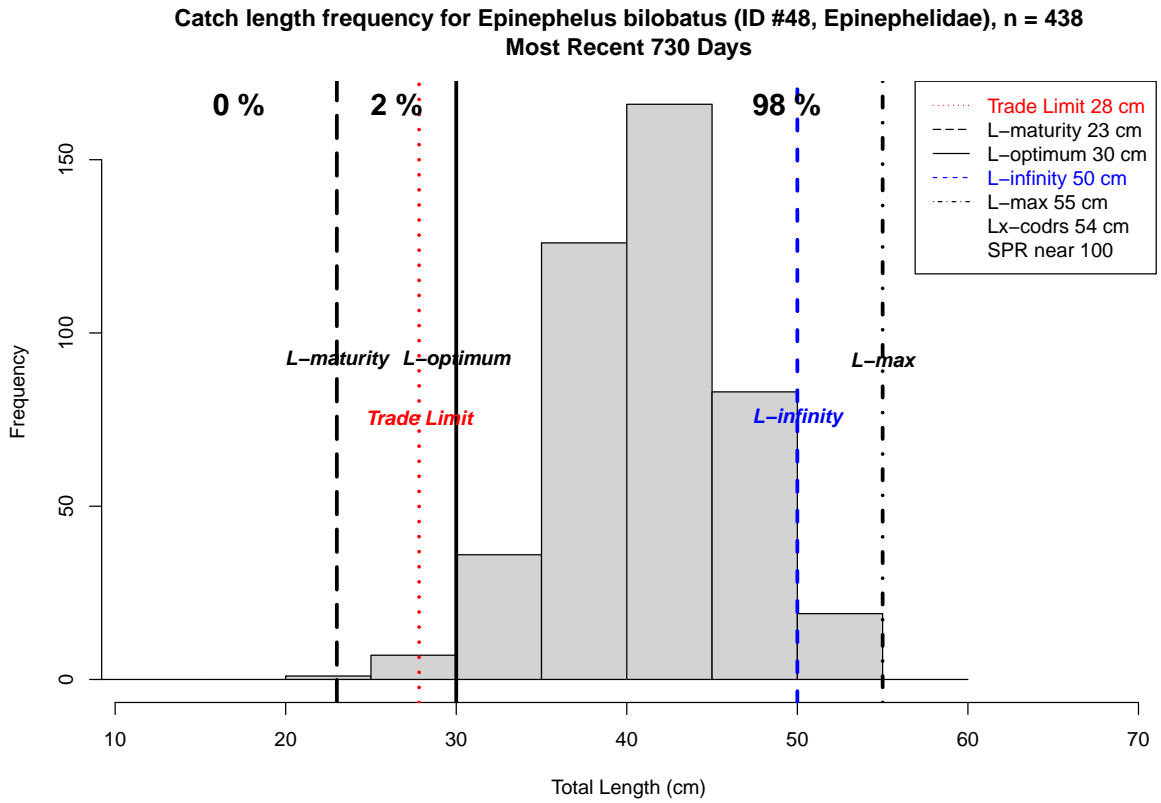
At least 90% of the fish in the catch are mature specimens that have spawned at least once before they were caught. The fishery does not depend on immature size classes for this species and is considered safe for this indicator. This fishery will not be causing overfishing through over harvesting of juveniles for this species. Risk level is low.

The majority of the catch consists of size classes around or above the optimum harvest size. This means that the impact of the fishery is minimized for this species. Potentially higher yields of this species could be achieved by catching them at somewhat smaller size, although capture of smaller specimen may take place already in other fisheries. Risk level is low.

More than 30% of the catch consists of mega spawners which indicates that this fish population is in good health unless large amounts of much smaller fish from the same population are caught by other fisheries. Risk level is low.

SPR is more than 40%. The stock is probably not over exploited, and the risk that the fishery will cause further stock decline is small. Risk level is low.

Trends in relative abundance by size group for *Epinephelus miliaris* (ID #47, Epinephelidae), as calculated from linear regressions. The P value indicates the chance that this calculated trend is merely a result of stochastic variance.
% Immature no trend over recent years, situation stable. P: not available
% Large Mature falling over recent years, situation deteriorating. P: not available
% Mega Spawner falling over recent years, situation deteriorating. P: not available
% SPR no trend over recent years, situation stable. P: not available



The percentages of *Epinephelus bilobatus* (ID #48, Epinephelidae) in most recent 730 days, n=438
Immature (< 23cm): 0%
Small mature (\geq 23cm, < 30cm): 2%
Large mature (\geq 30cm): 98%
Mega spawner (\geq 33cm): 97% (subset of large mature fish)
Spawning Potential Ratio: near 100

The trade limit is significantly higher than length at first maturity. This means that the trade puts a premium on fish that have spawned at least once. The trade does not cause any concern of recruitment overfishing for this species. Risk level is low.

At least 90% of the fish in the catch are mature specimens that have spawned at least once before they were caught. The fishery does not depend on immature size classes for this species and is considered safe for this indicator. This fishery will not be causing overfishing through over harvesting of juveniles for this species. Risk level is low.

The majority of the catch consists of size classes around or above the optimum harvest size. This means that the impact of the fishery is minimized for this species. Potentially higher yields of this species could be achieved by catching them at somewhat smaller size, although capture of smaller specimen may take place already in other fisheries. Risk level is low.

More than 30% of the catch consists of mega spawners which indicates that this fish population is in good health unless large amounts of much smaller fish from the same population are caught by other fisheries. Risk level is low.

SPR is more than 40%. The stock is probably not over exploited, and the risk that the fishery will cause further stock decline is small. Risk level is low.

Trends in relative abundance by size group for *Epinephelus bilobatus* (ID #48, Epinephelidae), as calculated from linear regressions. The P value indicates the chance that this calculated trend is merely a result of stochastic variance.

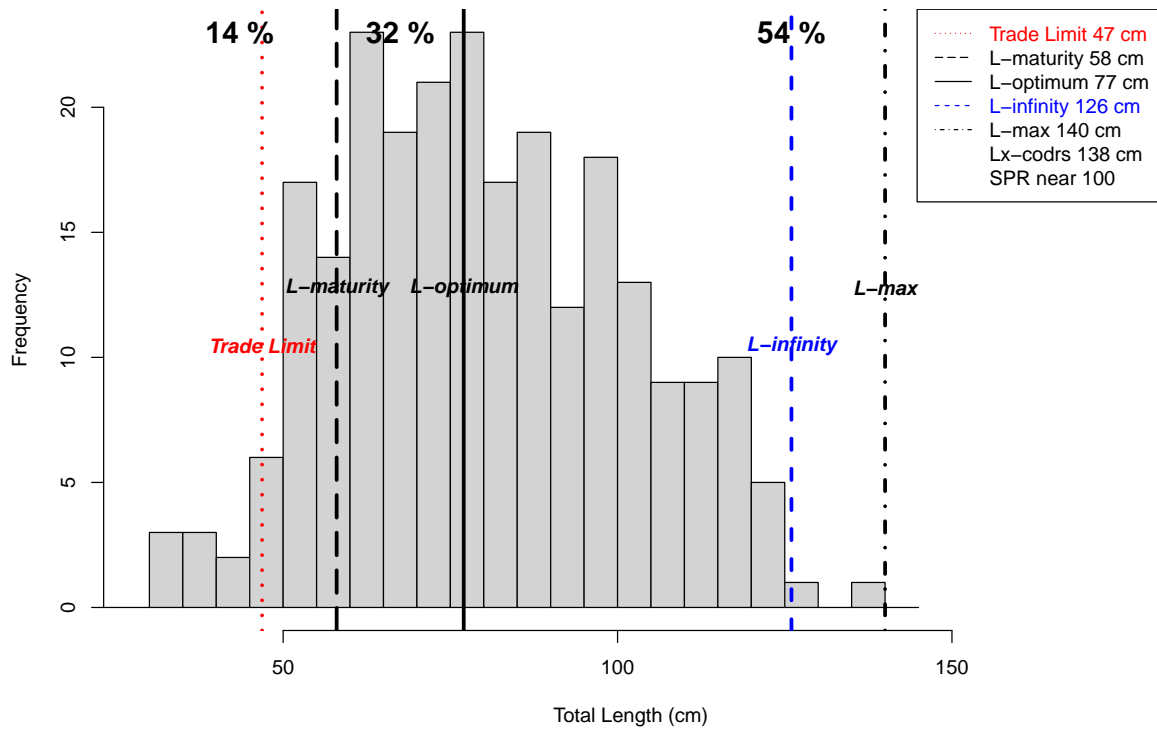
% Immature no trend over recent years, situation stable. P: not available

% Large Mature falling over recent years, situation deteriorating. P: not available

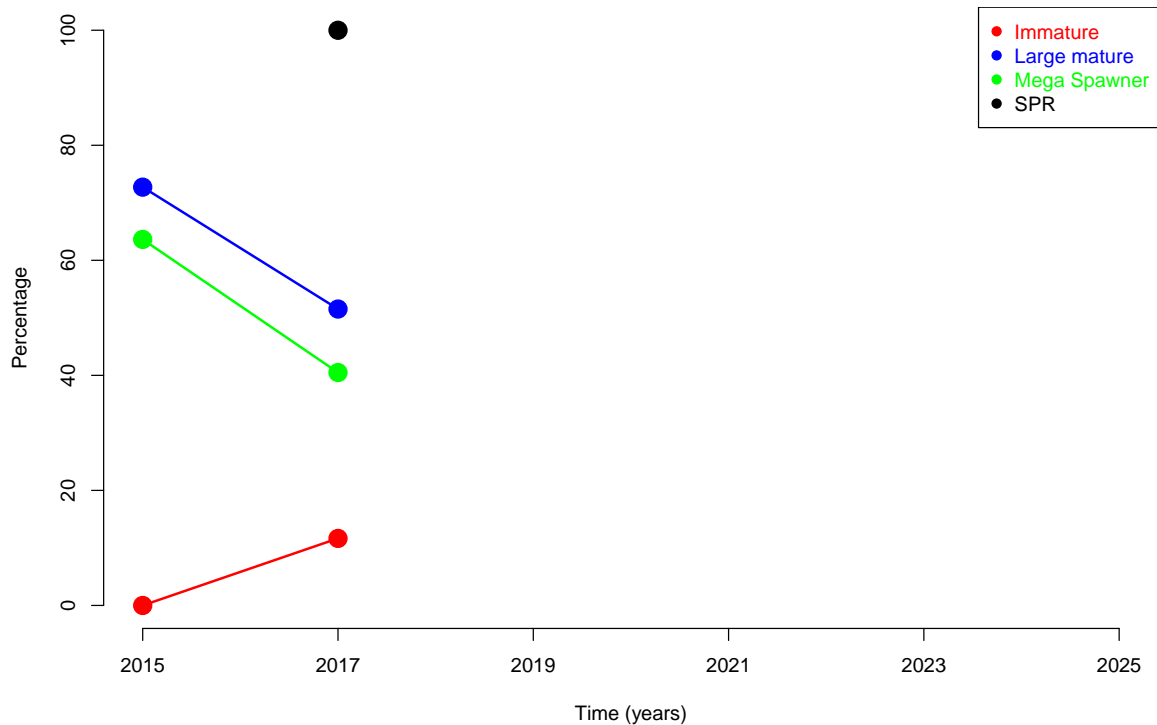
% Mega Spawner falling over recent years, situation deteriorating. P: not available

% SPR no trend over recent years, situation stable. P: not available

Catch length frequency for *Epinephelus malabaricus* (ID #49, Epinephelidae), n = 245
 Most Recent 730 Days



Trends in relative abundance by size group for *Epinephelus malabaricus* (ID #49, Epinephelidae)



The percentages of *Epinephelus malabaricus* (ID #49, Epinephelidae) in most recent 730 days, n=245
Immature (< 58cm): 14%
Small mature ($\geq 58\text{cm}$, < 77cm): 32%
Large mature ($\geq 77\text{cm}$): 54%
Mega spawner ($\geq 84.7\text{cm}$): 42% (subset of large mature fish)
Spawning Potential Ratio: near 100

The trade limit is significantly lower than the length at first maturity. This means that the trade encourages capture of immature fish, which impairs sustainability. Risk level is high.

Between 10% and 20% of the fish in the catch are juveniles that have not yet reproduced. There is no immediate concern in terms of overfishing through over harvesting of juveniles, but the fishery needs to be monitored closely for any further increase in this indicator and incentives need to be geared towards targeting larger fish. Risk level is medium.

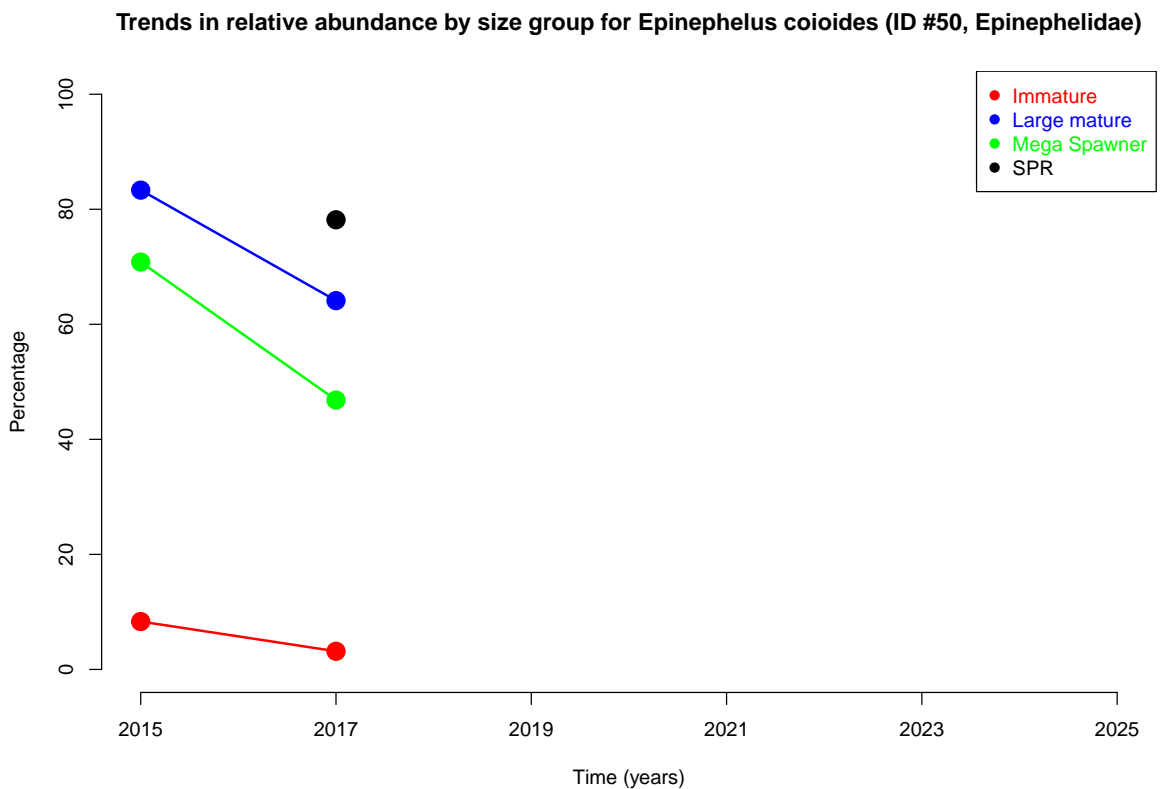
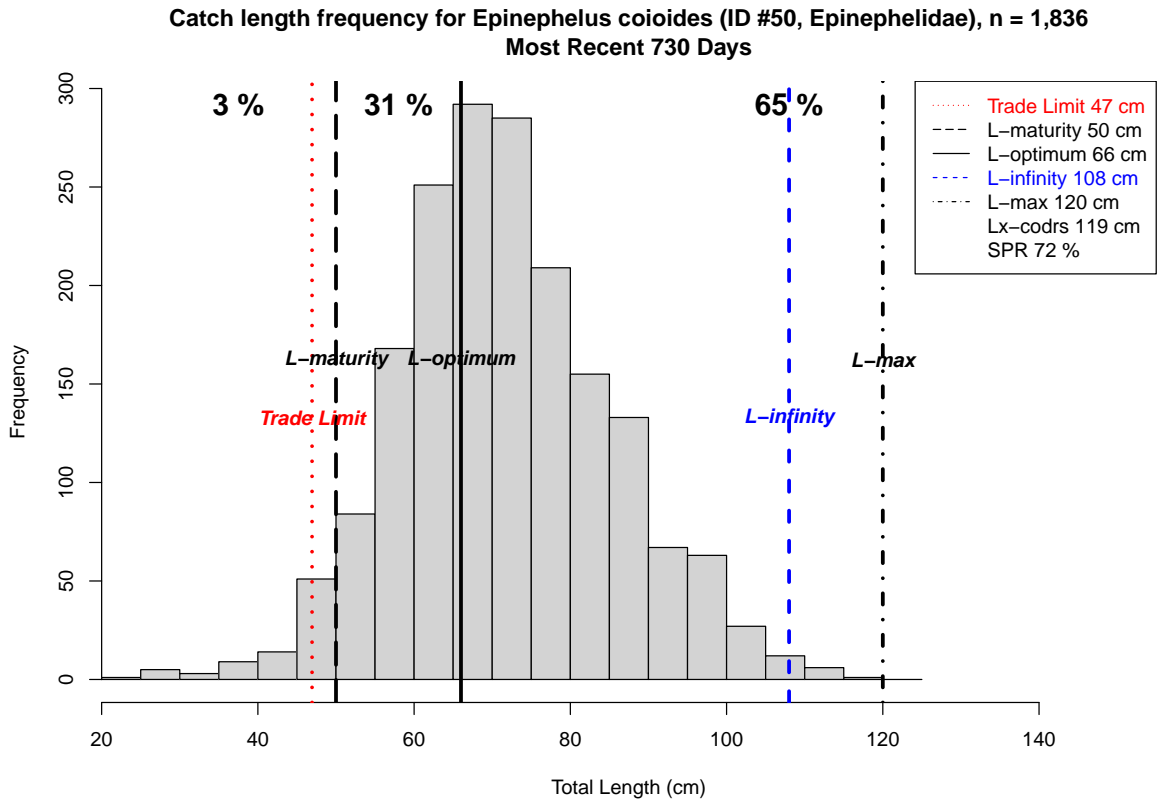
The majority of the catch consists of size classes around or above the optimum harvest size. This means that the impact of the fishery is minimized for this species. Potentially higher yields of this species could be achieved by catching them at somewhat smaller size, although capture of smaller specimen may take place already in other fisheries. Risk level is low.

More than 30% of the catch consists of mega spawners which indicates that this fish population is in good health unless large amounts of much smaller fish from the same population are caught by other fisheries. Risk level is low.

SPR is more than 40%. The stock is probably not over exploited, and the risk that the fishery will cause further stock decline is small. Risk level is low.

Trends in relative abundance by size group for *Epinephelus malabaricus* (ID #49, Epinephelidae), as calculated from linear regressions. The P value indicates the chance that this calculated trend is merely a result of stochastic variance.

% Immature rising over recent years, situation deteriorating. P: not available
% Large Mature falling over recent years, situation deteriorating. P: not available
% Mega Spawner falling over recent years, situation deteriorating. P: not available
% SPR no trend over recent years, situation stable. P: not available



The percentages of *Epinephelus coioides* (ID #50, Epinephelidae) in most recent 730 days, n=1,836
Immature (< 50cm): 3%
Small mature (\geq 50cm, < 66cm): 31%
Large mature (\geq 66cm): 65%
Mega spawner (\geq 72.6cm): 47% (subset of large mature fish)
Spawning Potential Ratio: 72 %

The trade limit is about the same as the length at first maturity. This means that the trade puts a premium on fish that have spawned at least once, which improves sustainability of the fishery. Risk level is medium.

At least 90% of the fish in the catch are mature specimens that have spawned at least once before they were caught. The fishery does not depend on immature size classes for this species and is considered safe for this indicator. This fishery will not be causing overfishing through over harvesting of juveniles for this species. Risk level is low.

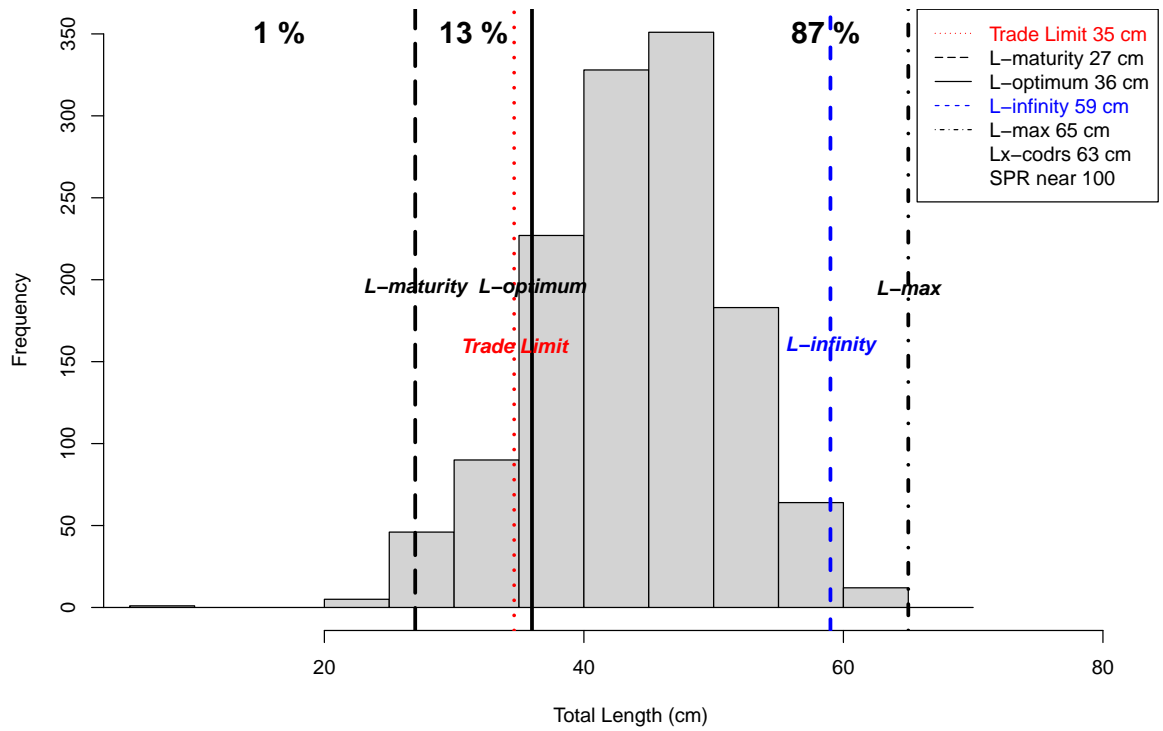
The majority of the catch consists of size classes around or above the optimum harvest size. This means that the impact of the fishery is minimized for this species. Potentially higher yields of this species could be achieved by catching them at somewhat smaller size, although capture of smaller specimen may take place already in other fisheries. Risk level is low.

More than 30% of the catch consists of mega spawners which indicates that this fish population is in good health unless large amounts of much smaller fish from the same population are caught by other fisheries. Risk level is low.

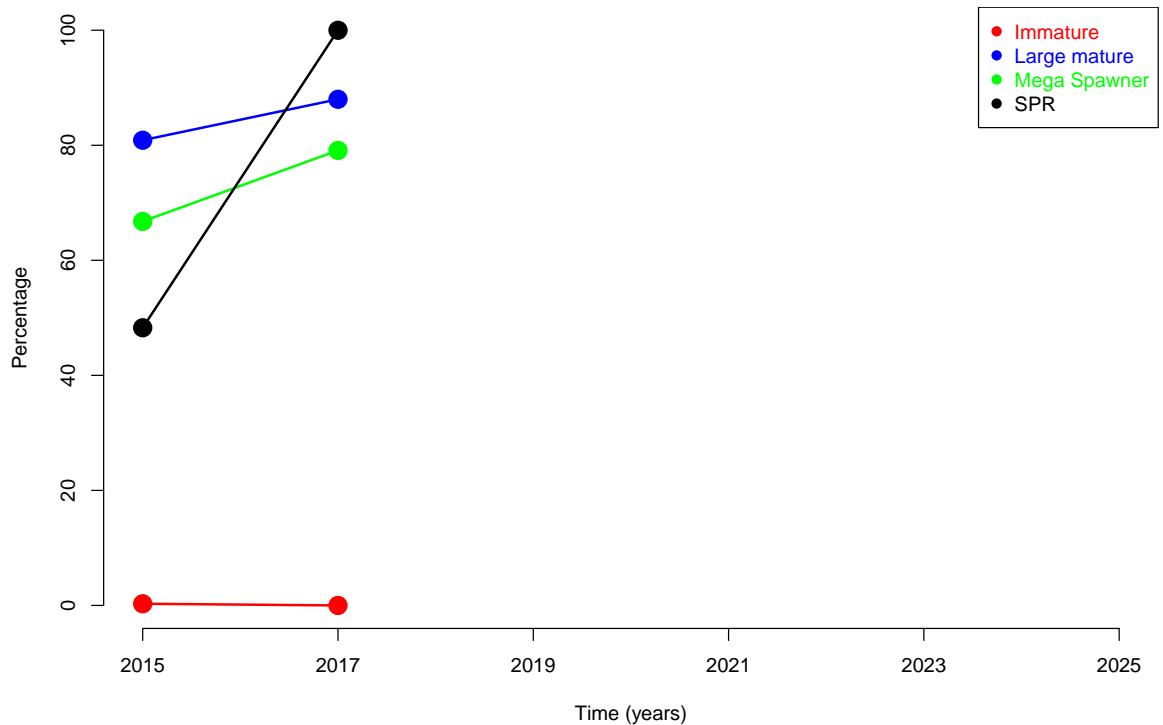
SPR is more than 40%. The stock is probably not over exploited, and the risk that the fishery will cause further stock decline is small. Risk level is low.

Trends in relative abundance by size group for *Epinephelus coioides* (ID #50, Epinephelidae), as calculated from linear regressions. The P value indicates the chance that this calculated trend is merely a result of stochastic variance.
% Immature falling over recent years, situation improving. P: not available
% Large Mature falling over recent years, situation deteriorating. P: not available
% Mega Spawner falling over recent years, situation deteriorating. P: not available
% SPR no trend over recent years, situation stable. P: not available

Catch length frequency for *Epinephelus chlorostigma* (ID #51, Epinephelidae), n = 1,307
 Most Recent 730 Days



Trends in relative abundance by size group for *Epinephelus chlorostigma* (ID #51, Epinephelidae)



The percentages of *Epinephelus chlorostigma* (ID #51, Epinephelidae) in most recent 730 days, n=1,307
Immature (< 27cm): 1%
Small mature (\geq 27cm, < 36cm): 13%
Large mature (\geq 36cm): 87%
Mega spawner (\geq 39.6cm): 78% (subset of large mature fish)
Spawning Potential Ratio: near 100

The trade limit is significantly higher than length at first maturity. This means that the trade puts a premium on fish that have spawned at least once. The trade does not cause any concern of recruitment overfishing for this species. Risk level is low.

At least 90% of the fish in the catch are mature specimens that have spawned at least once before they were caught. The fishery does not depend on immature size classes for this species and is considered safe for this indicator. This fishery will not be causing overfishing through over harvesting of juveniles for this species. Risk level is low.

The majority of the catch consists of size classes around or above the optimum harvest size. This means that the impact of the fishery is minimized for this species. Potentially higher yields of this species could be achieved by catching them at somewhat smaller size, although capture of smaller specimen may take place already in other fisheries. Risk level is low.

More than 30% of the catch consists of mega spawners which indicates that this fish population is in good health unless large amounts of much smaller fish from the same population are caught by other fisheries. Risk level is low.

SPR is more than 40%. The stock is probably not over exploited, and the risk that the fishery will cause further stock decline is small. Risk level is low.

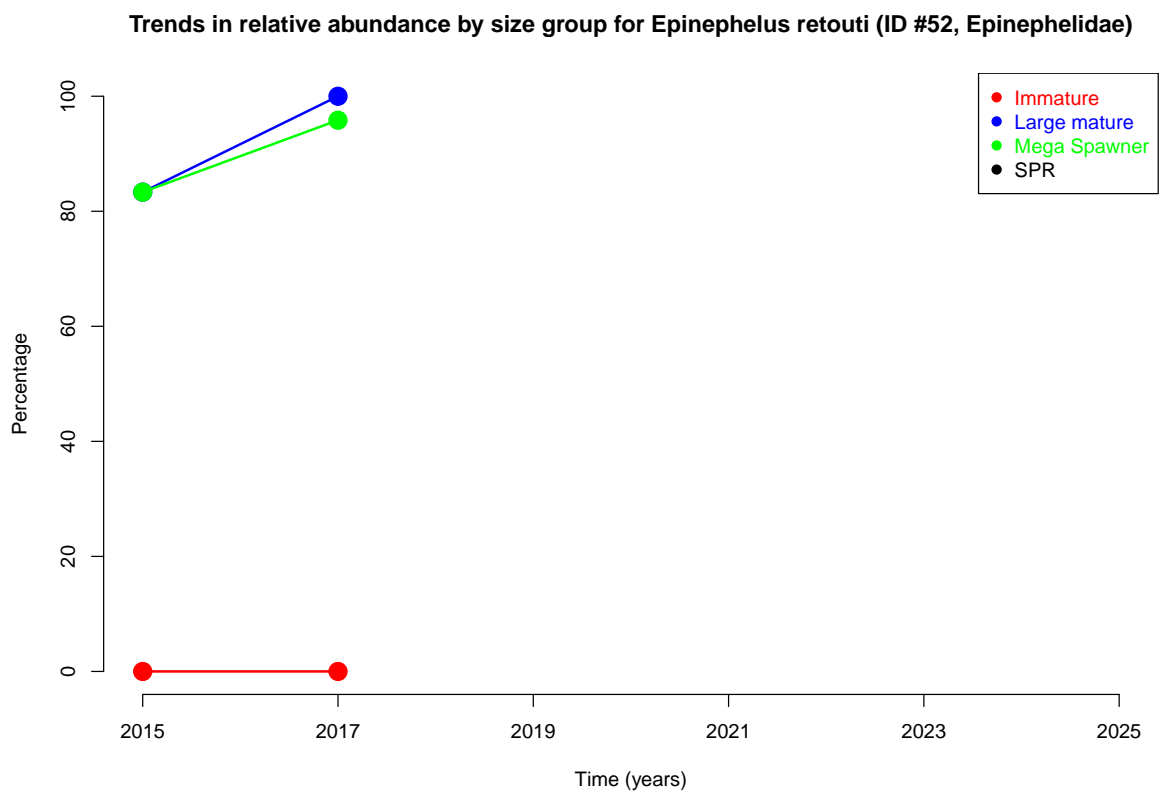
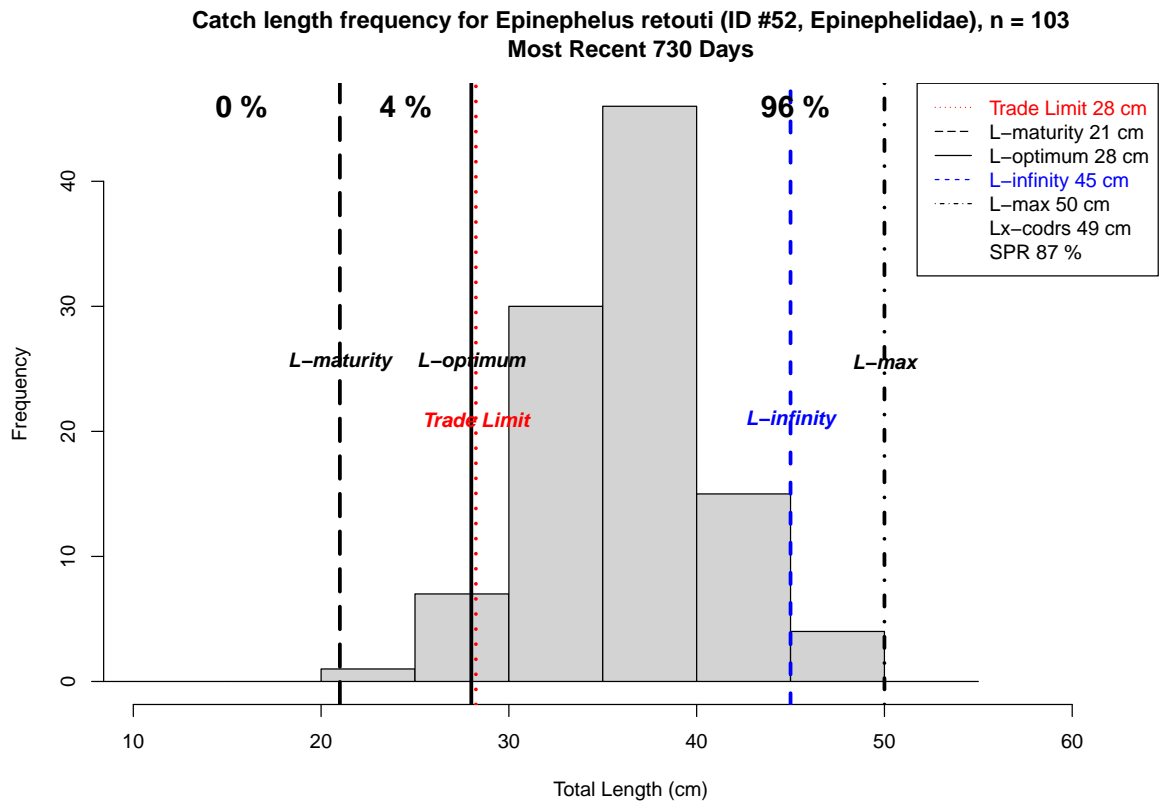
Trends in relative abundance by size group for *Epinephelus chlorostigma* (ID #51, Epinephelidae), as calculated from linear regressions. The P value indicates the chance that this calculated trend is merely a result of stochastic variance.

% Immature falling over recent years, situation improving. P: not available

% Large Mature rising over recent years, situation improving. P: not available

% Mega Spawner rising over recent years, situation improving. P: not available

% SPR rising over recent years, situation improving. P: not available



The percentages of *Epinephelus retouti* (ID #52, Epinephelidae) in most recent 730 days, n=103
Immature (< 21cm): 0%
Small mature (\geq 21cm, < 28cm): 4%
Large mature (\geq 28cm): 96%
Mega spawner (\geq 30.8cm): 92% (subset of large mature fish)
Spawning Potential Ratio: 87 %

The trade limit is significantly higher than length at first maturity. This means that the trade puts a premium on fish that have spawned at least once. The trade does not cause any concern of recruitment overfishing for this species. Risk level is low.

At least 90% of the fish in the catch are mature specimens that have spawned at least once before they were caught. The fishery does not depend on immature size classes for this species and is considered safe for this indicator. This fishery will not be causing overfishing through over harvesting of juveniles for this species. Risk level is low.

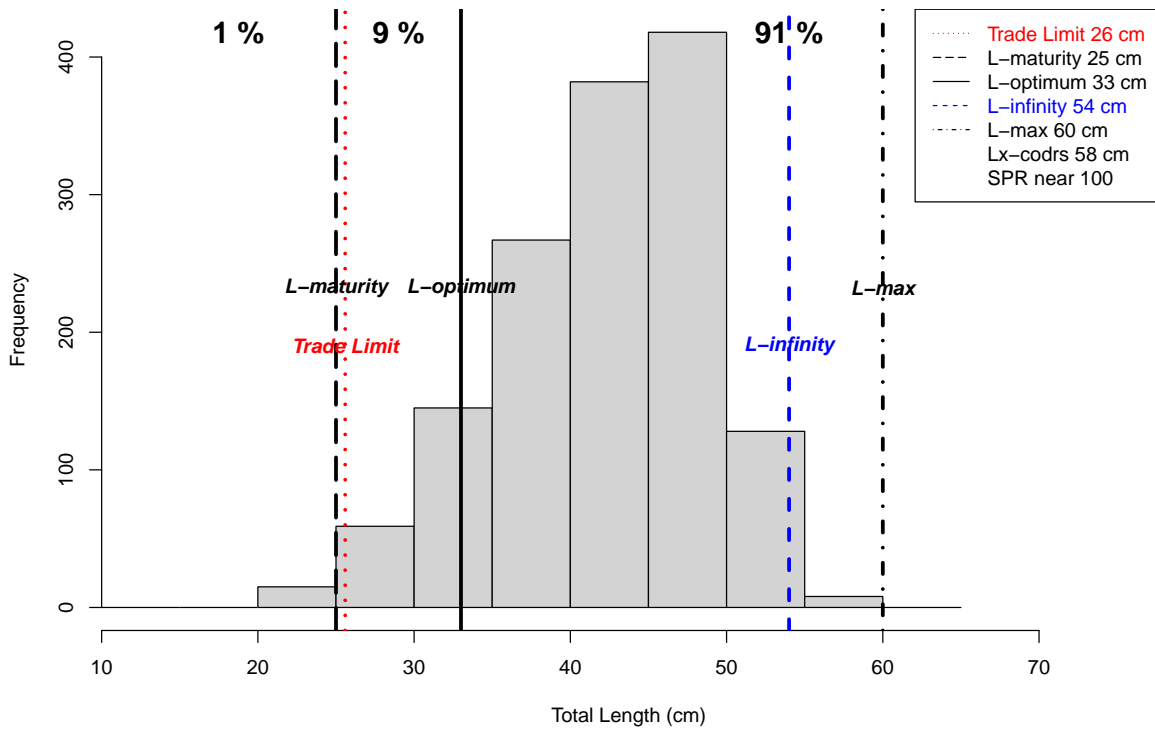
The majority of the catch consists of size classes around or above the optimum harvest size. This means that the impact of the fishery is minimized for this species. Potentially higher yields of this species could be achieved by catching them at somewhat smaller size, although capture of smaller specimen may take place already in other fisheries. Risk level is low.

More than 30% of the catch consists of mega spawners which indicates that this fish population is in good health unless large amounts of much smaller fish from the same population are caught by other fisheries. Risk level is low.

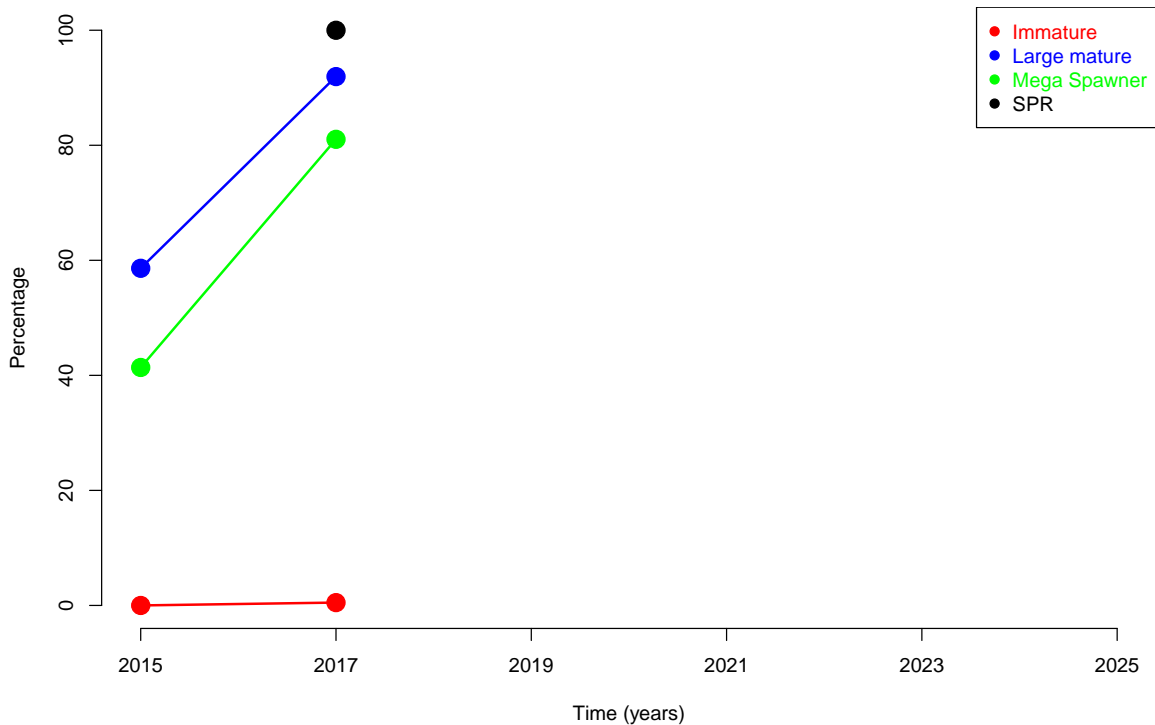
SPR is more than 40%. The stock is probably not over exploited, and the risk that the fishery will cause further stock decline is small. Risk level is low.

Trends in relative abundance by size group for *Epinephelus retouti* (ID #52, Epinephelidae), as calculated from linear regressions. The P value indicates the chance that this calculated trend is merely a result of stochastic variance.
% Immature no trend over recent years, situation stable. P: not available
% Large Mature rising over recent years, situation improving. P: not available
% Mega Spawner rising over recent years, situation improving. P: not available

Catch length frequency for *Epinephelus heniochus* (ID #53, Epinephelidae), n = 1,422
 Most Recent 730 Days



Trends in relative abundance by size group for *Epinephelus heniochus* (ID #53, Epinephelidae)



The percentages of *Epinephelus heniochus* (ID #53, Epinephelidae) in most recent 730 days, n=1,422
Immature (< 25cm): 1%
Small mature (\geq 25cm, < 33cm): 9%
Large mature (\geq 33cm): 91%
Mega spawner (\geq 36.3cm): 81% (subset of large mature fish)
Spawning Potential Ratio: near 100

The trade limit is about the same as the length at first maturity. This means that the trade puts a premium on fish that have spawned at least once, which improves sustainability of the fishery. Risk level is medium.

At least 90% of the fish in the catch are mature specimens that have spawned at least once before they were caught. The fishery does not depend on immature size classes for this species and is considered safe for this indicator. This fishery will not be causing overfishing through over harvesting of juveniles for this species. Risk level is low.

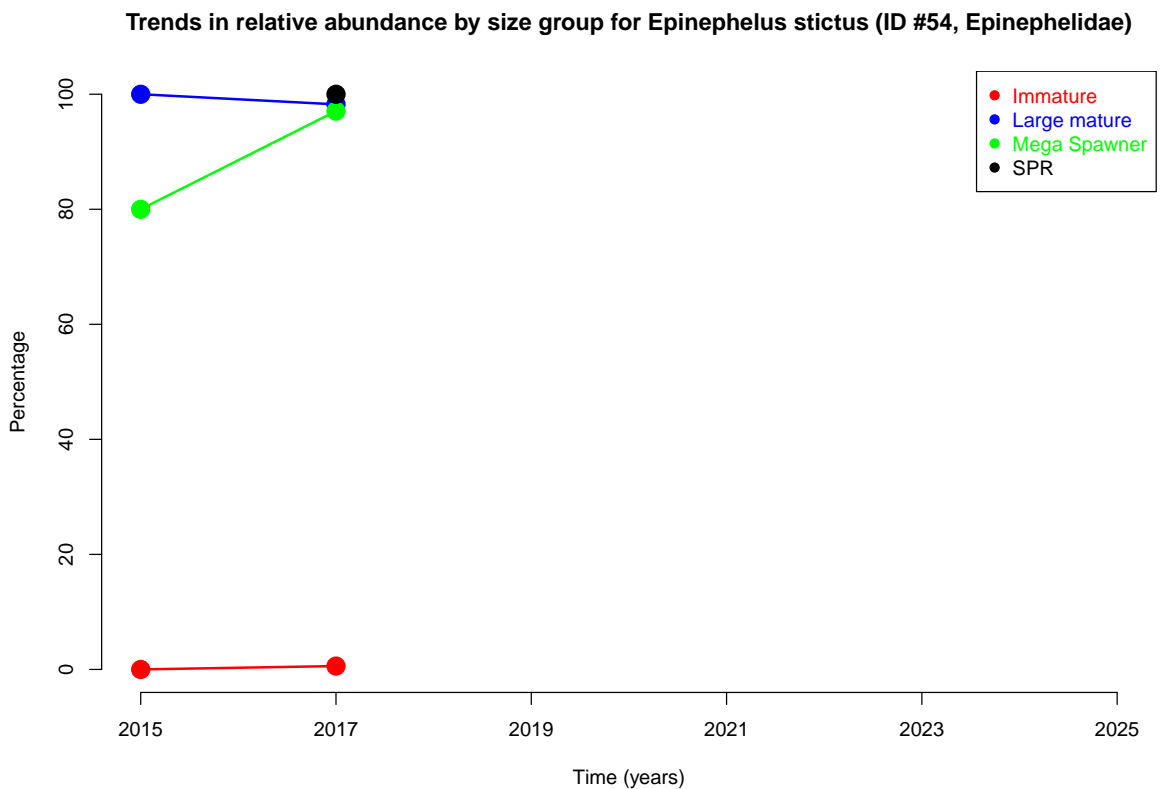
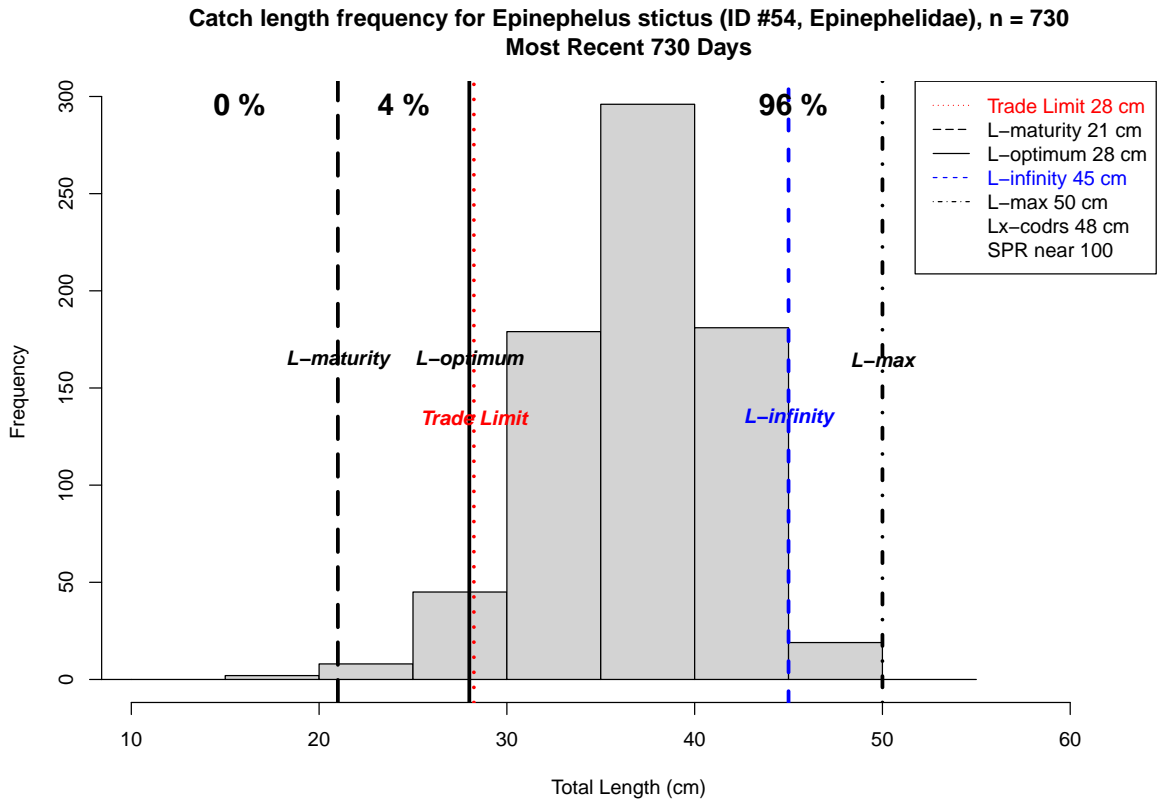
The majority of the catch consists of size classes around or above the optimum harvest size. This means that the impact of the fishery is minimized for this species. Potentially higher yields of this species could be achieved by catching them at somewhat smaller size, although capture of smaller specimen may take place already in other fisheries. Risk level is low.

More than 30% of the catch consists of mega spawners which indicates that this fish population is in good health unless large amounts of much smaller fish from the same population are caught by other fisheries. Risk level is low.

SPR is more than 40%. The stock is probably not over exploited, and the risk that the fishery will cause further stock decline is small. Risk level is low.

Trends in relative abundance by size group for *Epinephelus heniochus* (ID #53, Epinephelidae), as calculated from linear regressions. The P value indicates the chance that this calculated trend is merely a result of stochastic variance.

% Immature rising over recent years, situation deteriorating. P: not available
% Large Mature rising over recent years, situation improving. P: not available
% Mega Spawner rising over recent years, situation improving. P: not available
% SPR no trend over recent years, situation stable. P: not available



The percentages of *Epinephelus stictus* (ID #54, Epinephelidae) in most recent 730 days, n=730
Immature (< 21cm): 0%
Small mature (\geq 21cm, < 28cm): 4%
Large mature (\geq 28cm): 96%
Mega spawner (\geq 30.8cm): 92% (subset of large mature fish)
Spawning Potential Ratio: near 100

The trade limit is significantly higher than length at first maturity. This means that the trade puts a premium on fish that have spawned at least once. The trade does not cause any concern of recruitment overfishing for this species. Risk level is low.

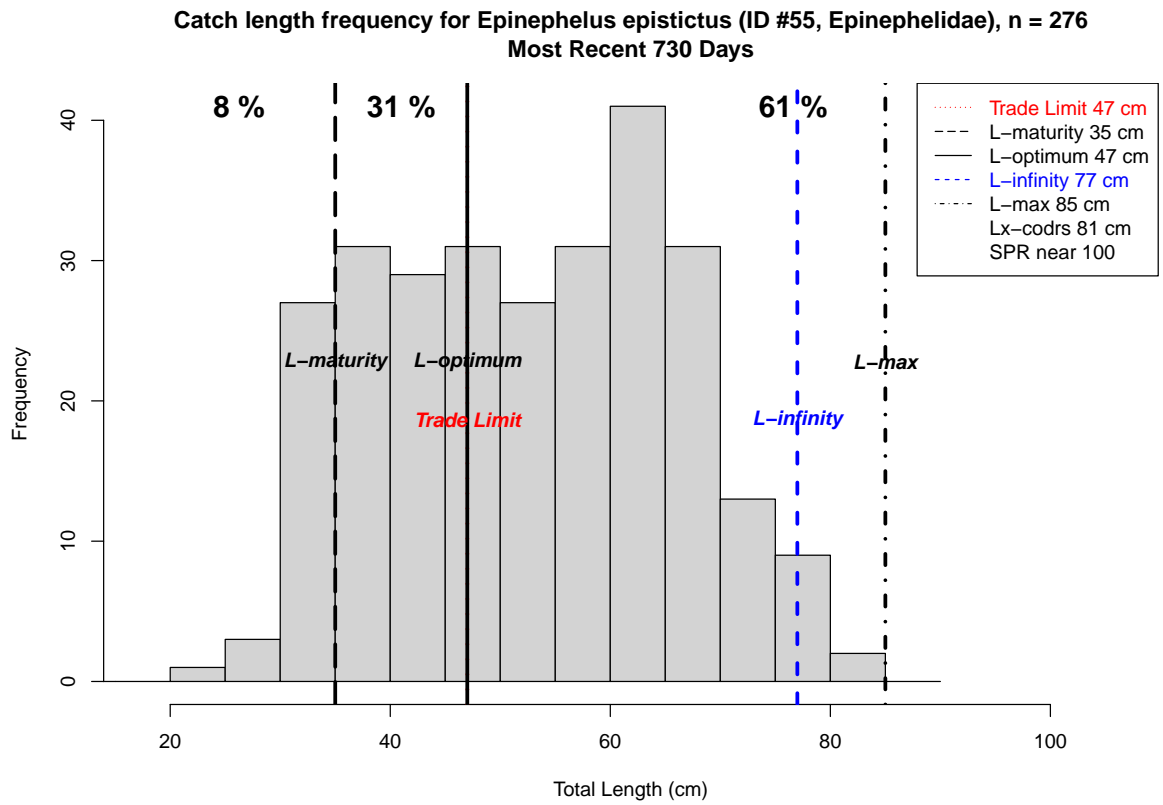
At least 90% of the fish in the catch are mature specimens that have spawned at least once before they were caught. The fishery does not depend on immature size classes for this species and is considered safe for this indicator. This fishery will not be causing overfishing through over harvesting of juveniles for this species. Risk level is low.

The majority of the catch consists of size classes around or above the optimum harvest size. This means that the impact of the fishery is minimized for this species. Potentially higher yields of this species could be achieved by catching them at somewhat smaller size, although capture of smaller specimen may take place already in other fisheries. Risk level is low.

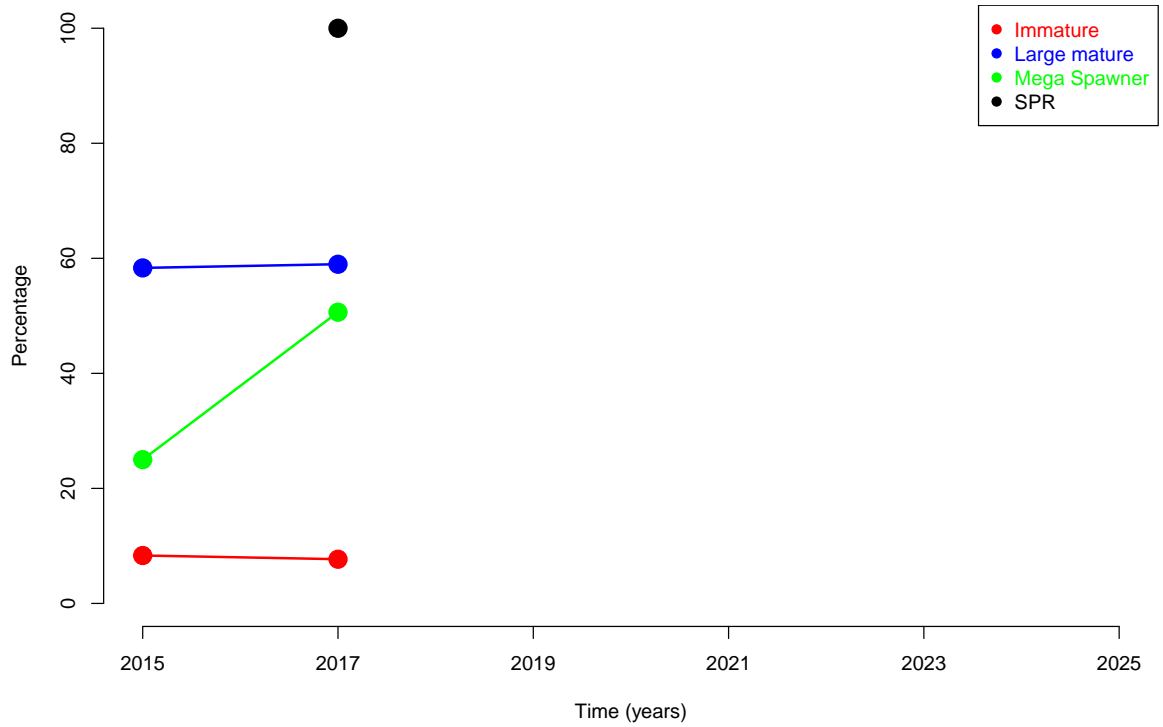
More than 30% of the catch consists of mega spawners which indicates that this fish population is in good health unless large amounts of much smaller fish from the same population are caught by other fisheries. Risk level is low.

SPR is more than 40%. The stock is probably not over exploited, and the risk that the fishery will cause further stock decline is small. Risk level is low.

Trends in relative abundance by size group for *Epinephelus stictus* (ID #54, Epinephelidae), as calculated from linear regressions. The P value indicates the chance that this calculated trend is merely a result of stochastic variance.
% Immature rising over recent years, situation deteriorating. P: not available
% Large Mature falling over recent years, situation deteriorating. P: not available
% Mega Spawner rising over recent years, situation improving. P: not available
% SPR no trend over recent years, situation stable. P: not available



Trends in relative abundance by size group for *Epinephelus epistictus* (ID #55, Epinephelidae)



The percentages of *Epinephelus epistictus* (ID #55, Epinephelidae) in most recent 730 days, n=276
Immature (< 35cm): 8%
Small mature ($\geq 35\text{cm}$, < 47cm): 31%
Large mature ($\geq 47\text{cm}$): 61%
Mega spawner ($\geq 51.7\text{cm}$): 55% (subset of large mature fish)
Spawning Potential Ratio: near 100

The trade limit is significantly higher than length at first maturity. This means that the trade puts a premium on fish that have spawned at least once. The trade does not cause any concern of recruitment overfishing for this species. Risk level is low.

At least 90% of the fish in the catch are mature specimens that have spawned at least once before they were caught. The fishery does not depend on immature size classes for this species and is considered safe for this indicator. This fishery will not be causing overfishing through over harvesting of juveniles for this species. Risk level is low.

The majority of the catch consists of size classes around or above the optimum harvest size. This means that the impact of the fishery is minimized for this species. Potentially higher yields of this species could be achieved by catching them at somewhat smaller size, although capture of smaller specimen may take place already in other fisheries. Risk level is low.

More than 30% of the catch consists of mega spawners which indicates that this fish population is in good health unless large amounts of much smaller fish from the same population are caught by other fisheries. Risk level is low.

SPR is more than 40%. The stock is probably not over exploited, and the risk that the fishery will cause further stock decline is small. Risk level is low.

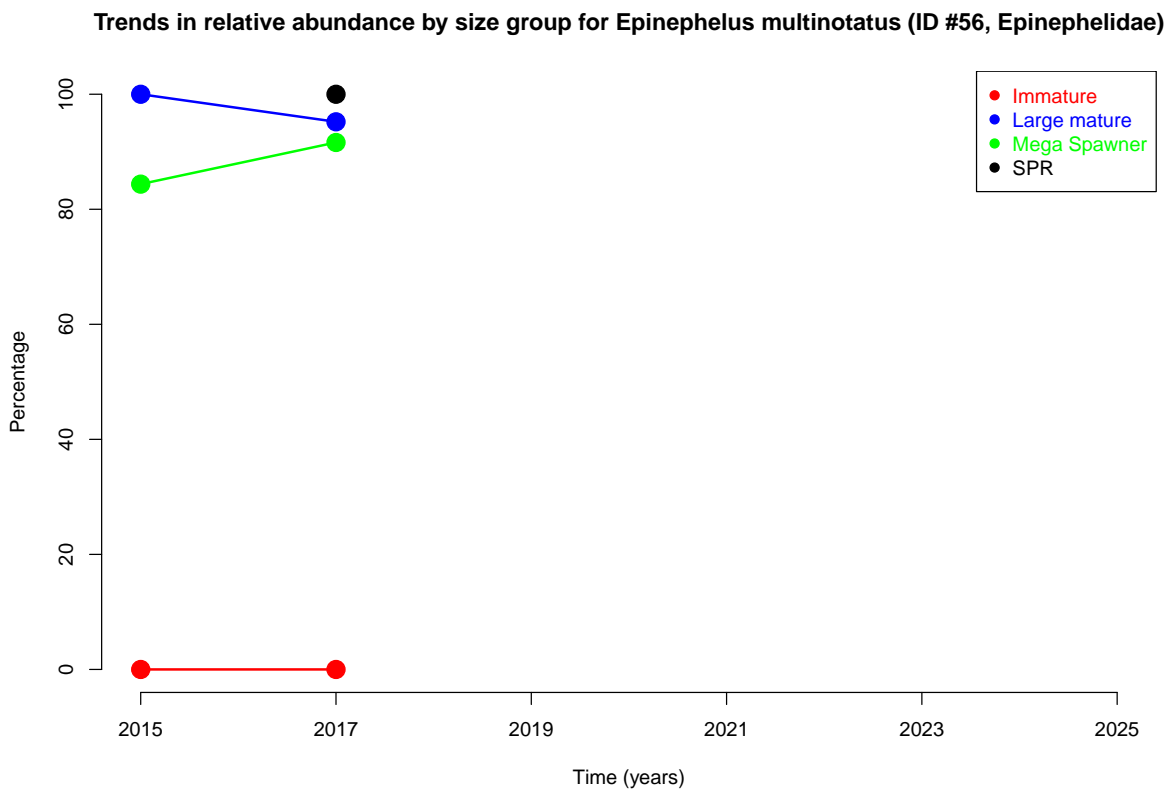
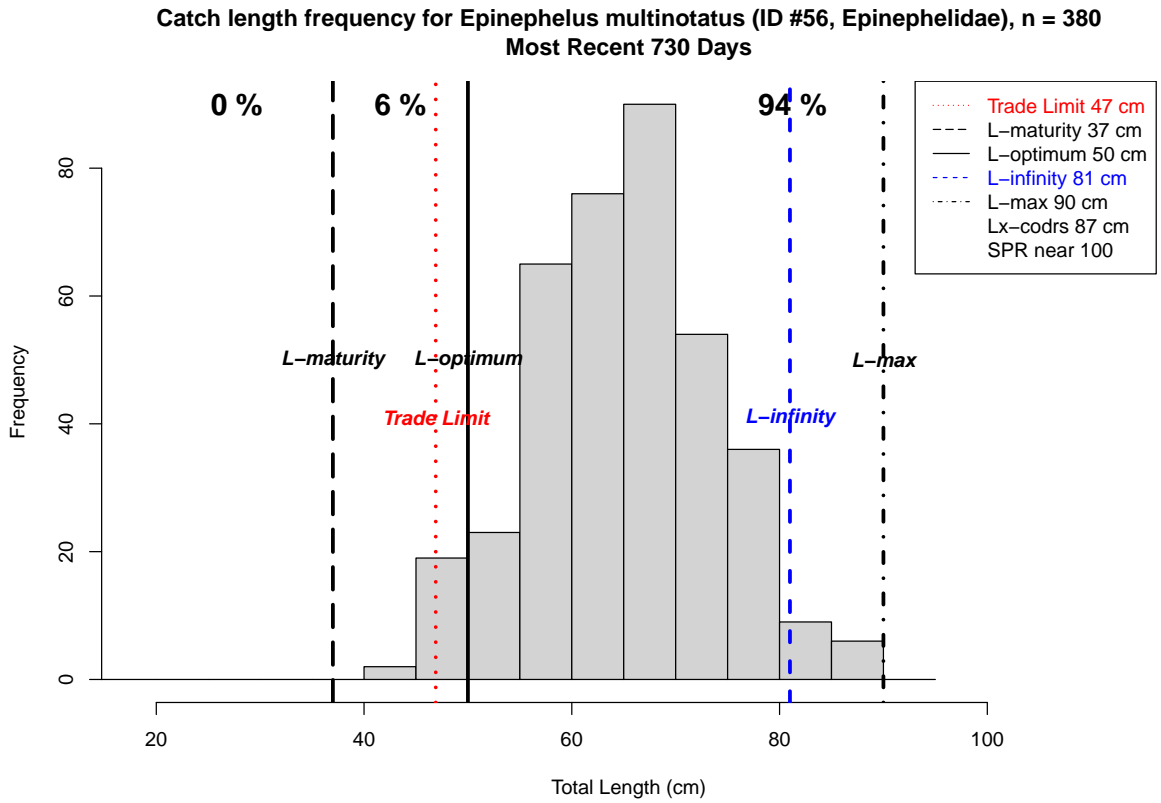
Trends in relative abundance by size group for *Epinephelus epistictus* (ID #55, Epinephelidae), as calculated from linear regressions. The P value indicates the chance that this calculated trend is merely a result of stochastic variance.

% Immature falling over recent years, situation improving. P: not available

% Large Mature rising over recent years, situation improving. P: not available

% Mega Spawner rising over recent years, situation improving. P: not available

% SPR no trend over recent years, situation stable. P: not available



The percentages of *Epinephelus multinotatus* (ID #56, Epinephelidae) in most recent 730 days, n=380
Immature (< 37cm): 0%
Small mature (\geq 37cm, < 50cm): 6%
Large mature (\geq 50cm): 94%
Mega spawner (\geq 55cm): 88% (subset of large mature fish)
Spawning Potential Ratio: near 100

The trade limit is significantly higher than length at first maturity. This means that the trade puts a premium on fish that have spawned at least once. The trade does not cause any concern of recruitment overfishing for this species. Risk level is low.

At least 90% of the fish in the catch are mature specimens that have spawned at least once before they were caught. The fishery does not depend on immature size classes for this species and is considered safe for this indicator. This fishery will not be causing overfishing through over harvesting of juveniles for this species. Risk level is low.

The majority of the catch consists of size classes around or above the optimum harvest size. This means that the impact of the fishery is minimized for this species. Potentially higher yields of this species could be achieved by catching them at somewhat smaller size, although capture of smaller specimen may take place already in other fisheries. Risk level is low.

More than 30% of the catch consists of mega spawners which indicates that this fish population is in good health unless large amounts of much smaller fish from the same population are caught by other fisheries. Risk level is low.

SPR is more than 40%. The stock is probably not over exploited, and the risk that the fishery will cause further stock decline is small. Risk level is low.

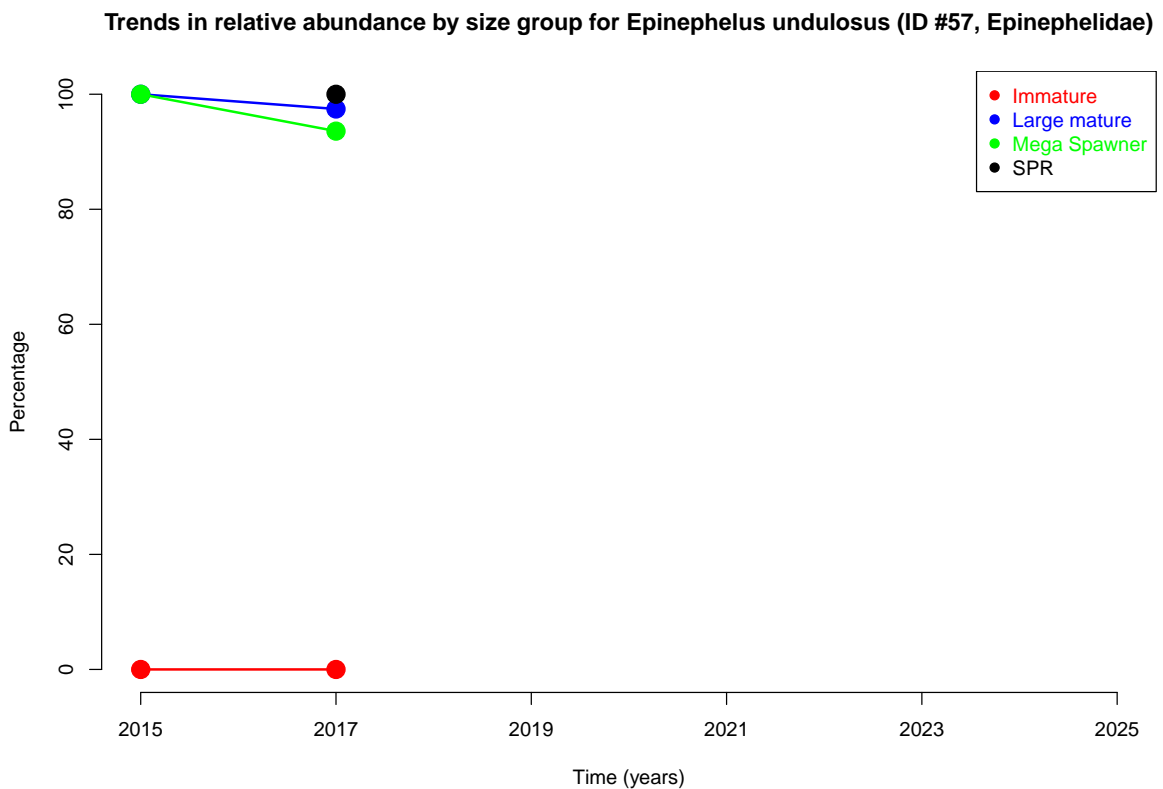
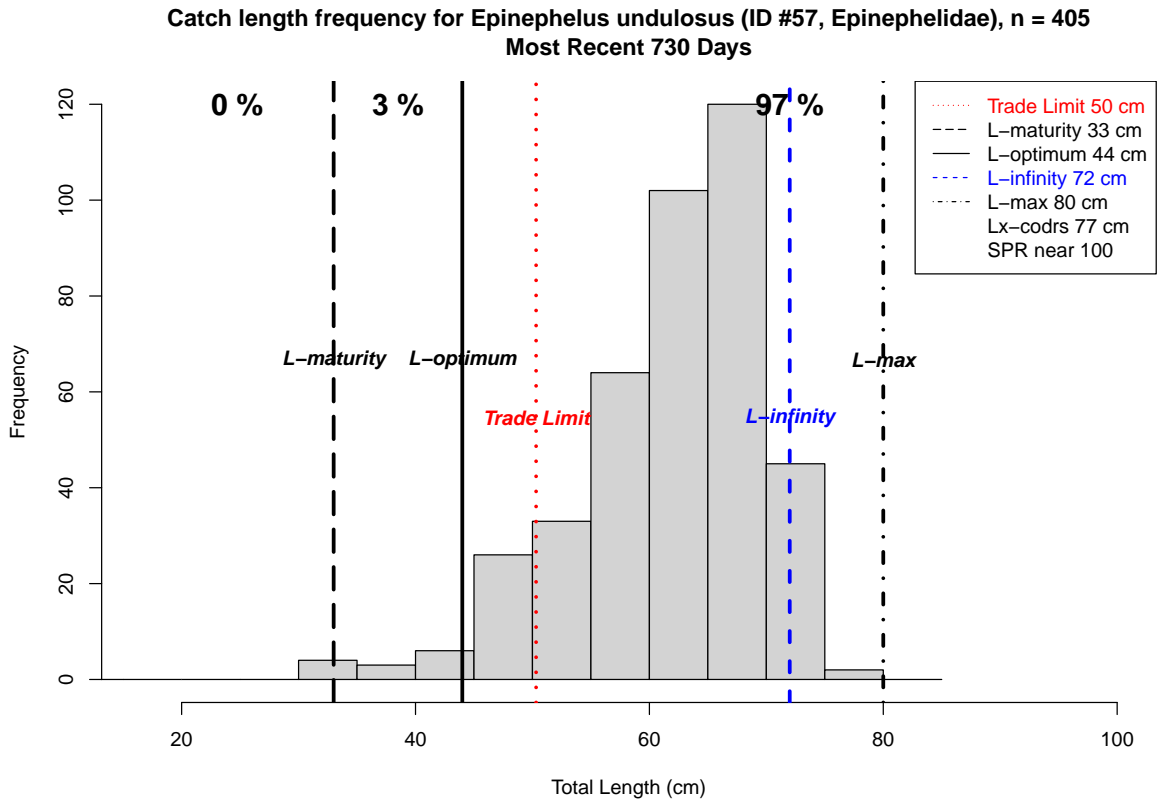
Trends in relative abundance by size group for *Epinephelus multinotatus* (ID #56, Epinephelidae), as calculated from linear regressions. The P value indicates the chance that this calculated trend is merely a result of stochastic variance.

% Immature no trend over recent years, situation stable. P: not available

% Large Mature falling over recent years, situation deteriorating. P: not available

% Mega Spawner rising over recent years, situation improving. P: not available

% SPR no trend over recent years, situation stable. P: not available



The percentages of *Epinephelus undulosus* (ID #57, Epinephelidae) in most recent 730 days, n=405
Immature (< 33cm): 0%
Small mature (\geq 33cm, < 44cm): 3%
Large mature (\geq 44cm): 97%
Mega spawner (\geq 48.4cm): 93% (subset of large mature fish)
Spawning Potential Ratio: near 100

The trade limit is significantly higher than length at first maturity. This means that the trade puts a premium on fish that have spawned at least once. The trade does not cause any concern of recruitment overfishing for this species. Risk level is low.

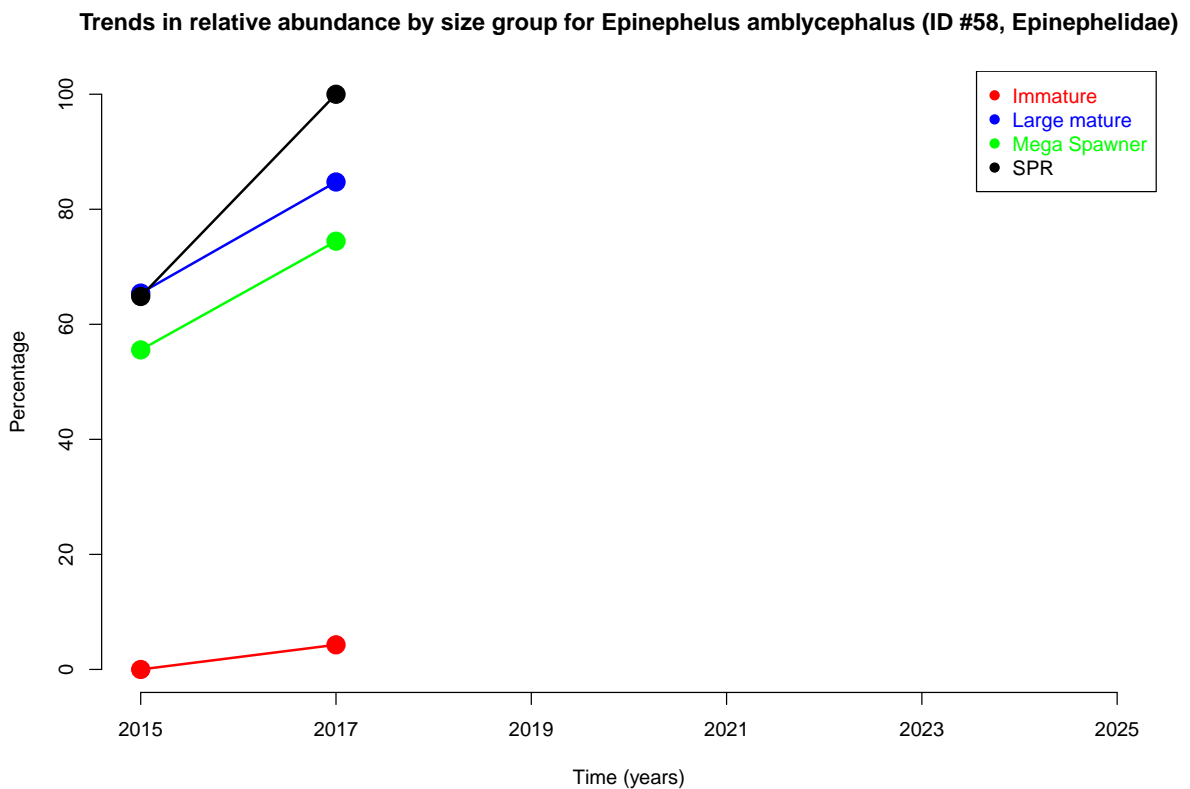
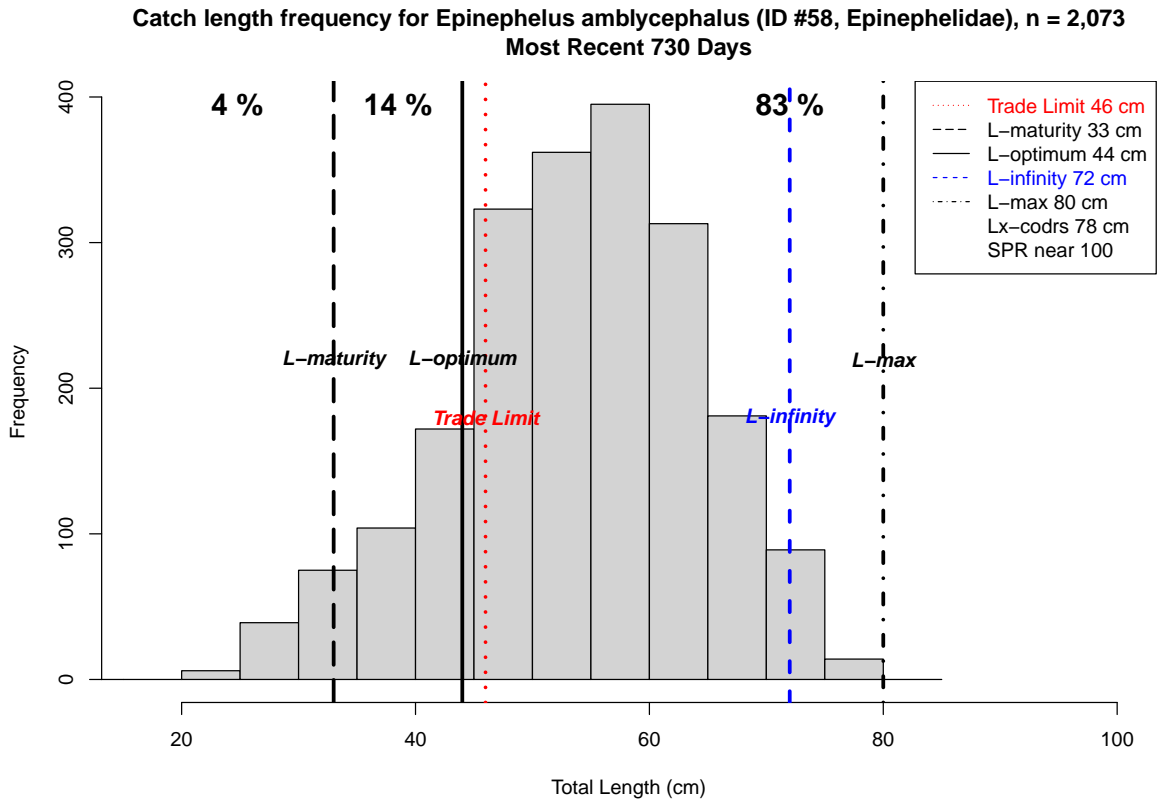
At least 90% of the fish in the catch are mature specimens that have spawned at least once before they were caught. The fishery does not depend on immature size classes for this species and is considered safe for this indicator. This fishery will not be causing overfishing through over harvesting of juveniles for this species. Risk level is low.

The majority of the catch consists of size classes around or above the optimum harvest size. This means that the impact of the fishery is minimized for this species. Potentially higher yields of this species could be achieved by catching them at somewhat smaller size, although capture of smaller specimen may take place already in other fisheries. Risk level is low.

More than 30% of the catch consists of mega spawners which indicates that this fish population is in good health unless large amounts of much smaller fish from the same population are caught by other fisheries. Risk level is low.

SPR is more than 40%. The stock is probably not over exploited, and the risk that the fishery will cause further stock decline is small. Risk level is low.

Trends in relative abundance by size group for *Epinephelus undulosus* (ID #57, Epinephelidae), as calculated from linear regressions. The P value indicates the chance that this calculated trend is merely a result of stochastic variance.
% Immature no trend over recent years, situation stable. P: not available
% Large Mature falling over recent years, situation deteriorating. P: not available
% Mega Spawner falling over recent years, situation deteriorating. P: not available
% SPR no trend over recent years, situation stable. P: not available



The percentages of *Epinephelus amblycephalus* (ID #58, Epinephelidae) in most recent 730 days, n=2,073

Immature (< 33cm): 4%

Small mature (>= 33cm, < 44cm): 14%

Large mature (>= 44cm): 83%

Mega spawner (>= 48.4cm): 73% (subset of large mature fish)

Spawning Potential Ratio: near 100

The trade limit is significantly higher than length at first maturity. This means that the trade puts a premium on fish that have spawned at least once. The trade does not cause any concern of recruitment overfishing for this species. Risk level is low.

At least 90% of the fish in the catch are mature specimens that have spawned at least once before they were caught. The fishery does not depend on immature size classes for this species and is considered safe for this indicator. This fishery will not be causing overfishing through over harvesting of juveniles for this species. Risk level is low.

The majority of the catch consists of size classes around or above the optimum harvest size. This means that the impact of the fishery is minimized for this species. Potentially higher yields of this species could be achieved by catching them at somewhat smaller size, although capture of smaller specimen may take place already in other fisheries. Risk level is low.

More than 30% of the catch consists of mega spawners which indicates that this fish population is in good health unless large amounts of much smaller fish from the same population are caught by other fisheries. Risk level is low.

SPR is more than 40%. The stock is probably not over exploited, and the risk that the fishery will cause further stock decline is small. Risk level is low.

Trends in relative abundance by size group for *Epinephelus amblycephalus* (ID #58, Epinephelidae), as calculated from linear regressions. The P value indicates the chance that this calculated trend is merely a result of stochastic variance.

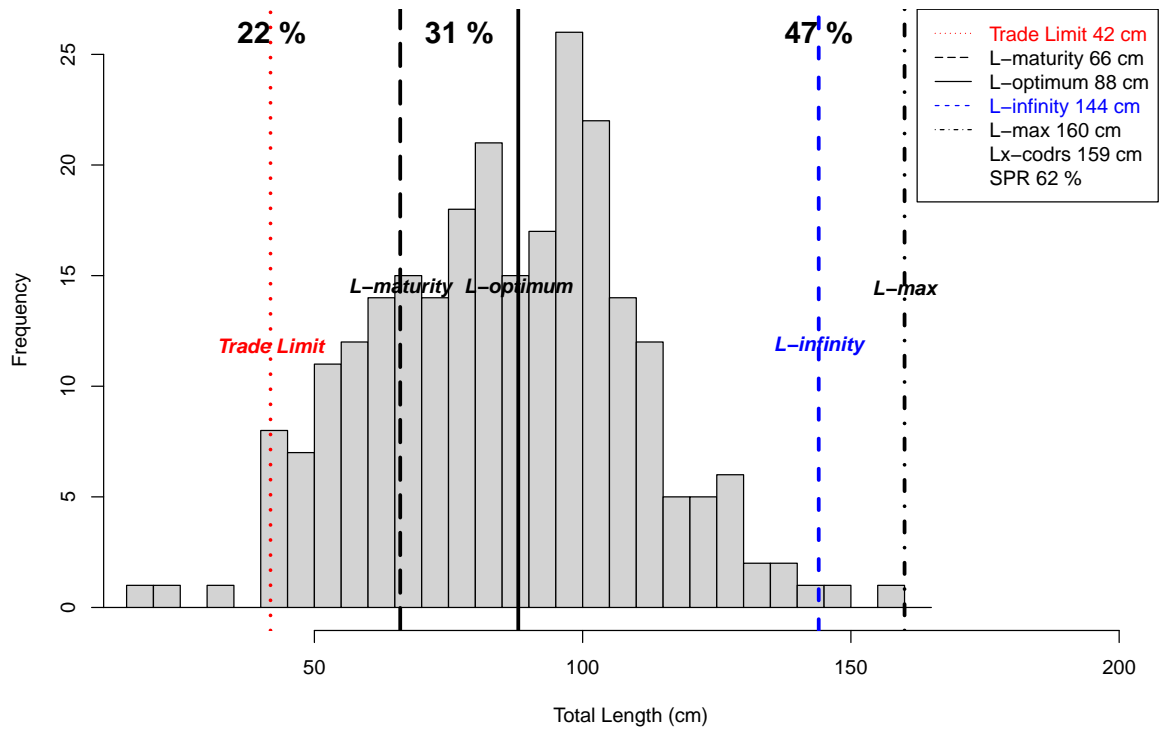
% Immature rising over recent years, situation deteriorating. P: not available

% Large Mature rising over recent years, situation improving. P: not available

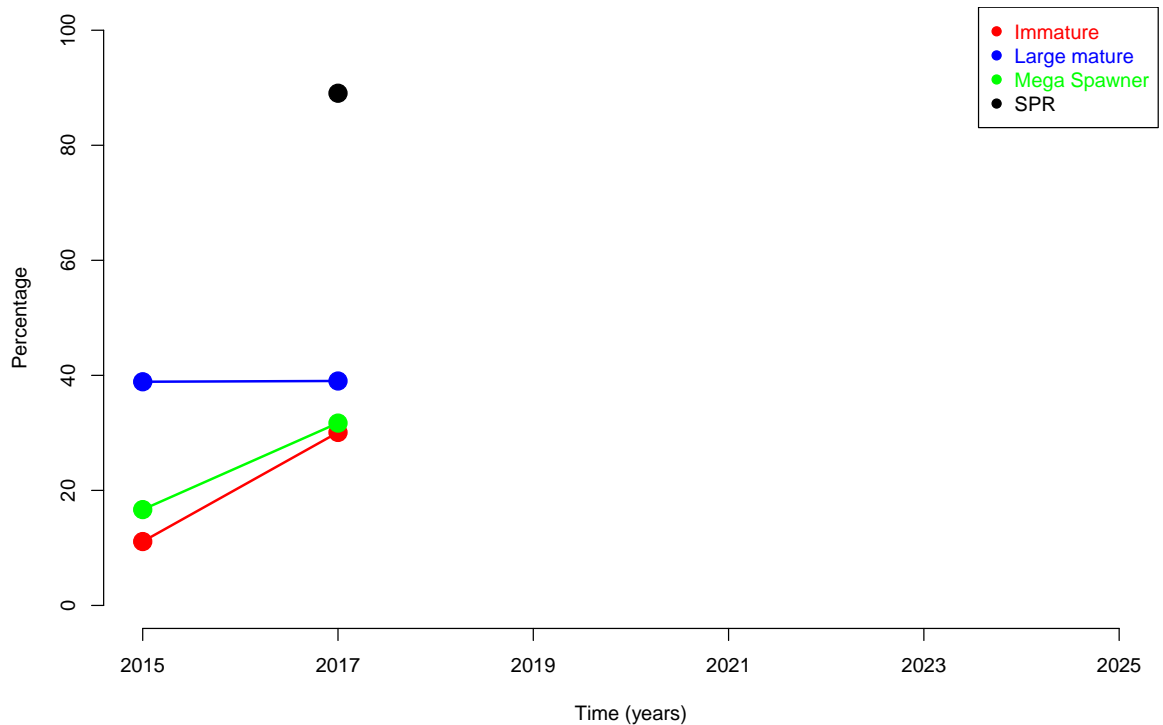
% Mega Spawner rising over recent years, situation improving. P: not available

% SPR rising over recent years, situation improving. P: not available

Catch length frequency for *Hyporthodus octofasciatus* (ID #59, Epinephelidae), n = 252
 Most Recent 730 Days



Trends in relative abundance by size group for *Hyporthodus octofasciatus* (ID #59, Epinephelidae)



The percentages of *Hyporthodus octofasciatus* (ID #59, Epinephelidae) in most recent 730 days, n=252

Immature (< 66cm): 22%

Small mature (>= 66cm, < 88cm): 31%

Large mature (>= 88cm): 47%

Mega spawner (>= 96.8cm): 36% (subset of large mature fish)

Spawning Potential Ratio: 62 %

The trade limit is significantly lower than the length at first maturity. This means that the trade encourages capture of immature fish, which impairs sustainability. Risk level is high.

Between 20% and 30% of the fish in the catch are specimens that have not yet reproduced. This is reason for concern in terms of potential overfishing through overharvesting of juveniles, if fishing pressure is high and percentages immature fish would further rise. Targeting larger fish and avoiding small fish in the catch will promote a sustainable fishery. Risk level is medium.

The bulk of the catch includes age groups that have just matured and are about to achieve their full growth potential. This indicates that the fishery is probably at least being fully exploited. Risk level is medium.

More than 30% of the catch consists of mega spawners which indicates that this fish population is in good health unless large amounts of much smaller fish from the same population are caught by other fisheries. Risk level is low.

SPR is more than 40%. The stock is probably not over exploited, and the risk that the fishery will cause further stock decline is small. Risk level is low.

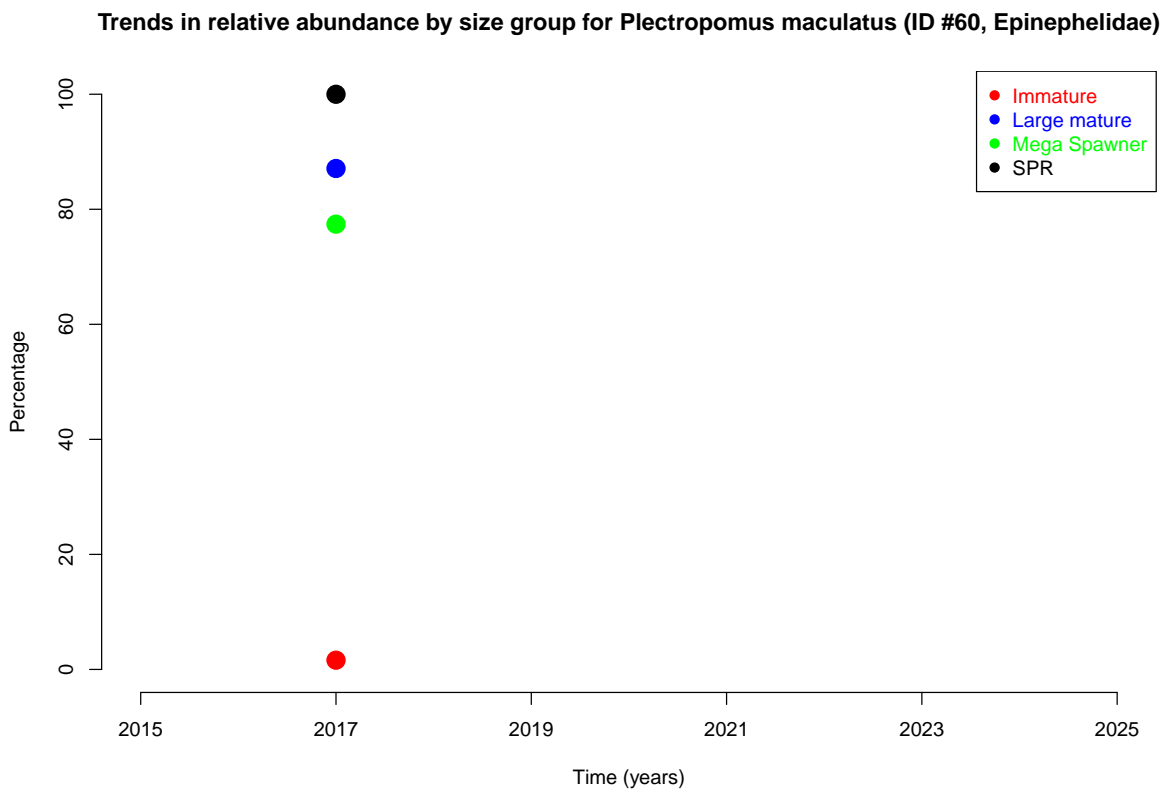
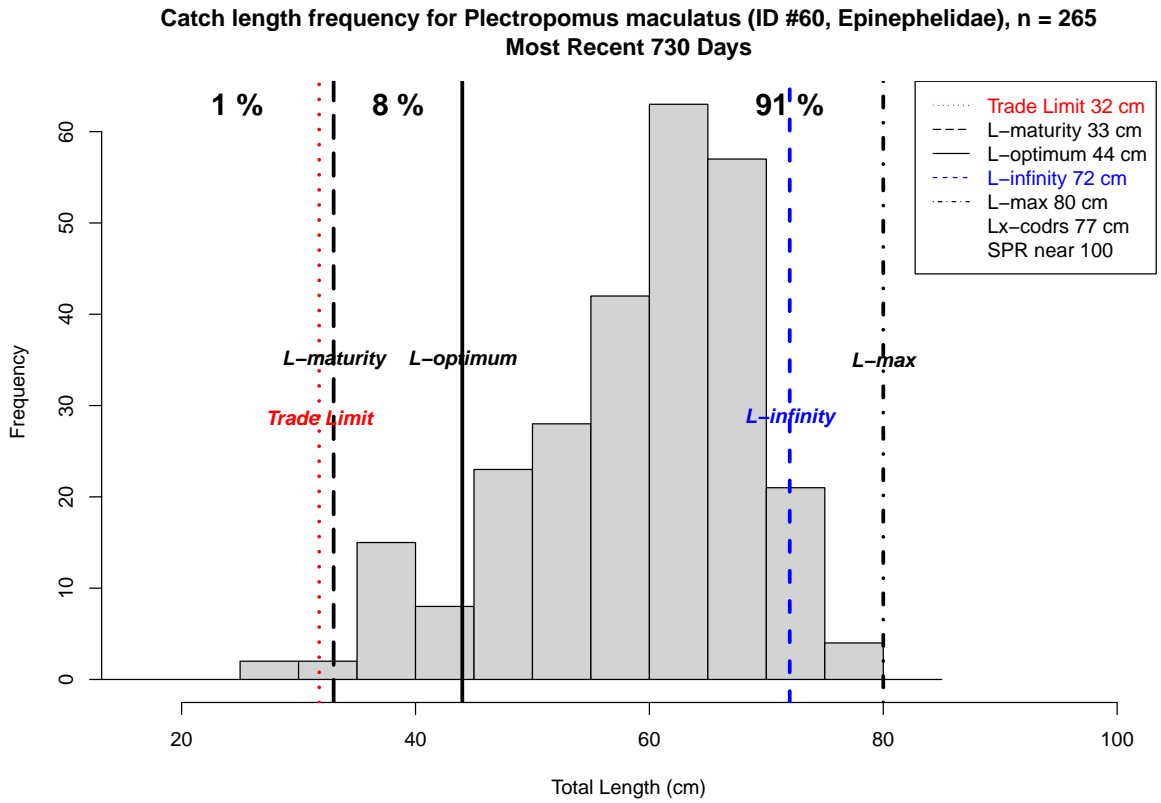
Trends in relative abundance by size group for *Hyporthodus octofasciatus* (ID #59, Epinephelidae), as calculated from linear regressions. The P value indicates the chance that this calculated trend is merely a result of stochastic variance.

% Immature rising over recent years, situation deteriorating. P: not available

% Large Mature no trend over recent years, situation stable. P: not available

% Mega Spawner rising over recent years, situation improving. P: not available

% SPR no trend over recent years, situation stable. P: not available



The percentages of *Plectropomus maculatus* (ID #60, Epinephelidae) in most recent 730 days, n=265
Immature (< 33cm): 1%
Small mature ($\geq 33\text{cm}$, < 44cm): 8%
Large mature ($\geq 44\text{cm}$): 91%
Mega spawner ($\geq 48.4\text{cm}$): 84% (subset of large mature fish)
Spawning Potential Ratio: near 100

The trade limit is about the same as the length at first maturity. This means that the trade puts a premium on fish that have spawned at least once, which improves sustainability of the fishery. Risk level is medium.

At least 90% of the fish in the catch are mature specimens that have spawned at least once before they were caught. The fishery does not depend on immature size classes for this species and is considered safe for this indicator. This fishery will not be causing overfishing through over harvesting of juveniles for this species. Risk level is low.

The majority of the catch consists of size classes around or above the optimum harvest size. This means that the impact of the fishery is minimized for this species. Potentially higher yields of this species could be achieved by catching them at somewhat smaller size, although capture of smaller specimen may take place already in other fisheries. Risk level is low.

More than 30% of the catch consists of mega spawners which indicates that this fish population is in good health unless large amounts of much smaller fish from the same population are caught by other fisheries. Risk level is low.

SPR is more than 40%. The stock is probably not over exploited, and the risk that the fishery will cause further stock decline is small. Risk level is low.

Trends in relative abundance by size group for *Plectropomus maculatus* (ID #60, Epinephelidae), as calculated from linear regressions. The P value indicates the chance that this calculated trend is merely a result of stochastic variance.

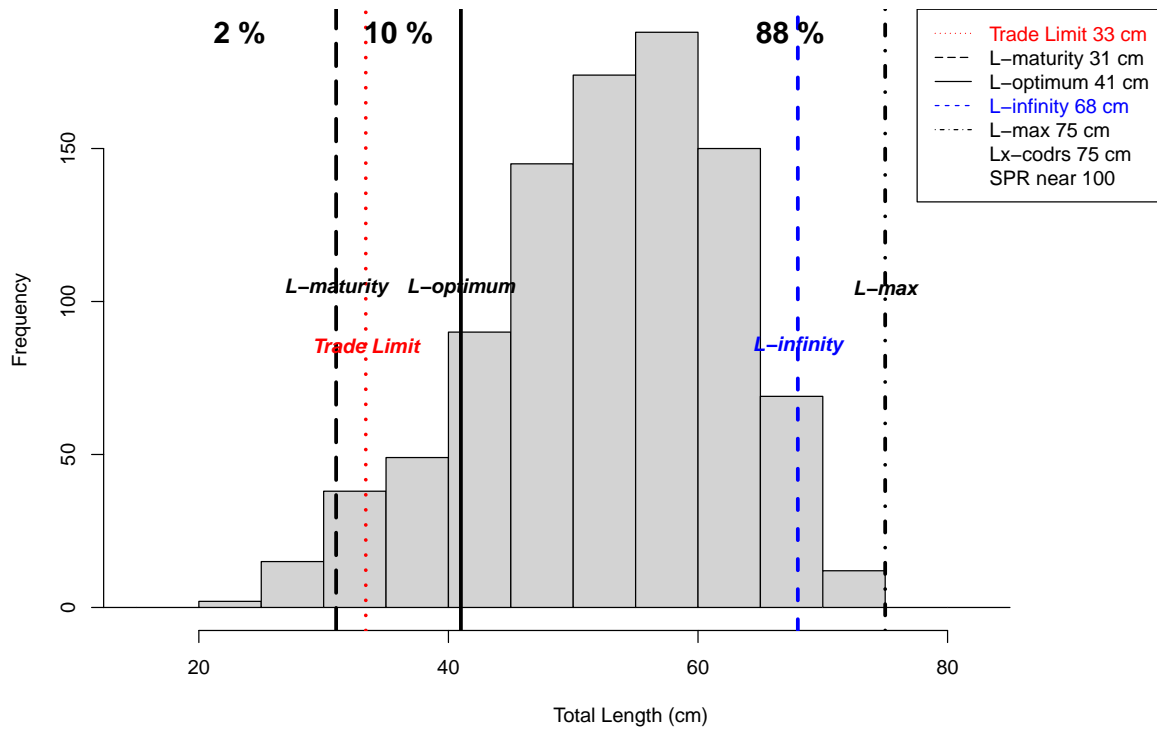
% Immature no trend over recent years, situation stable. P: not available

% Large Mature no trend over recent years, situation stable. P: not available

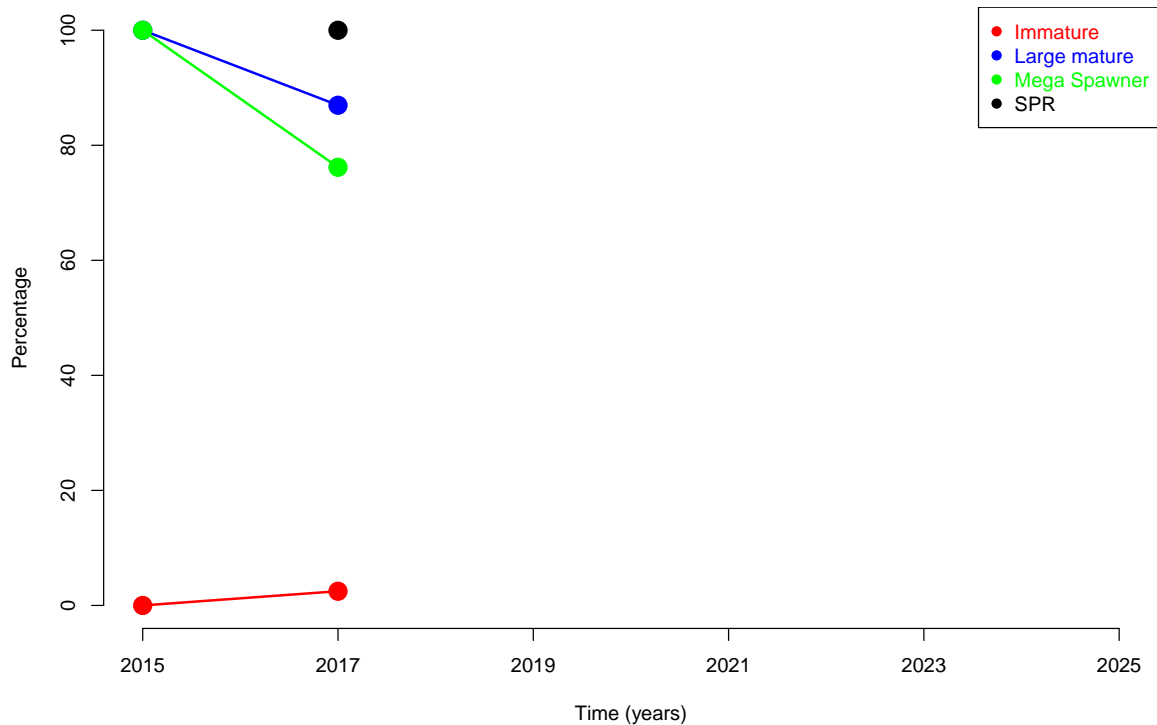
% Mega Spawner no trend over recent years, situation stable. P: not available

% SPR no trend over recent years, situation stable. P: not available

Catch length frequency for *Plectropomus leopardus* (ID #61, Epinephelidae), n = 932
 Most Recent 730 Days



Trends in relative abundance by size group for *Plectropomus leopardus* (ID #61, Epinephelidae)



The percentages of *Plectropomus leopardus* (ID #61, Epinephelidae) in most recent 730 days, n=932
Immature (< 31cm): 2%
Small mature (\geq 31cm, < 41cm): 10%
Large mature (\geq 41cm): 88%
Mega spawner (\geq 45.1cm): 79% (subset of large mature fish)
Spawning Potential Ratio: near 100

The trade limit is about the same as the length at first maturity. This means that the trade puts a premium on fish that have spawned at least once, which improves sustainability of the fishery. Risk level is medium.

At least 90% of the fish in the catch are mature specimens that have spawned at least once before they were caught. The fishery does not depend on immature size classes for this species and is considered safe for this indicator. This fishery will not be causing overfishing through over harvesting of juveniles for this species. Risk level is low.

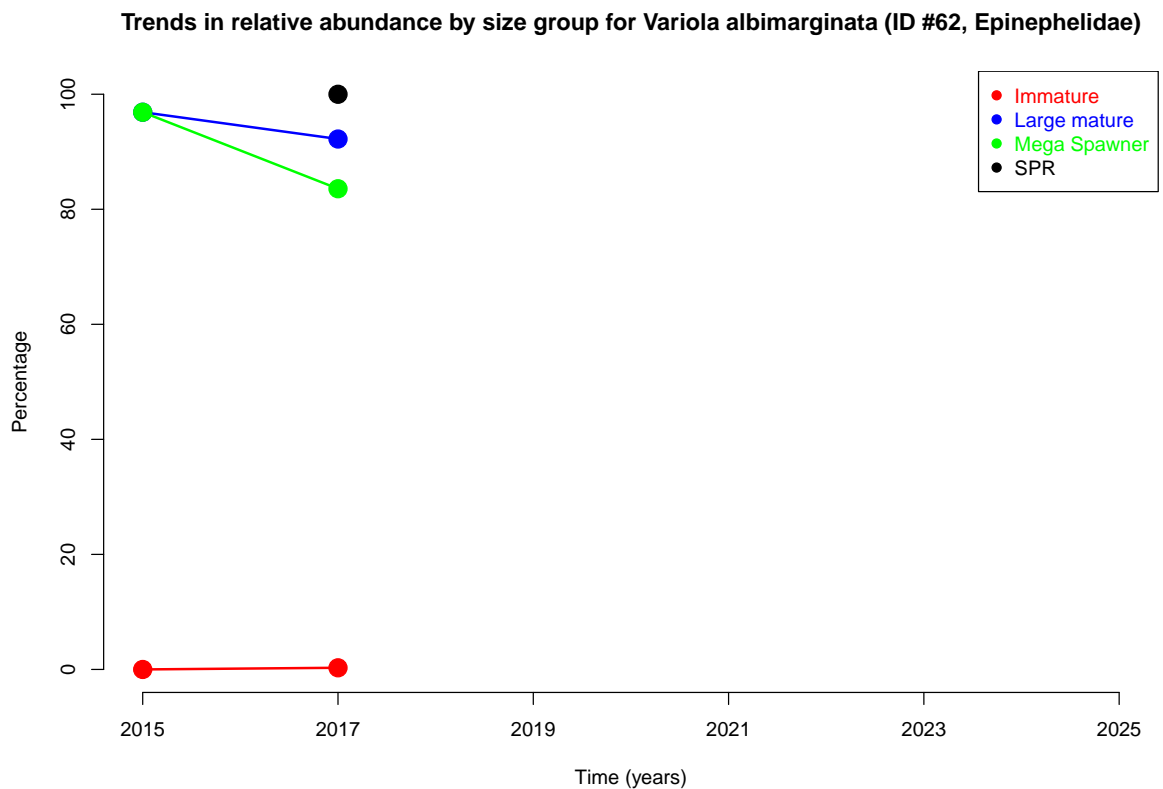
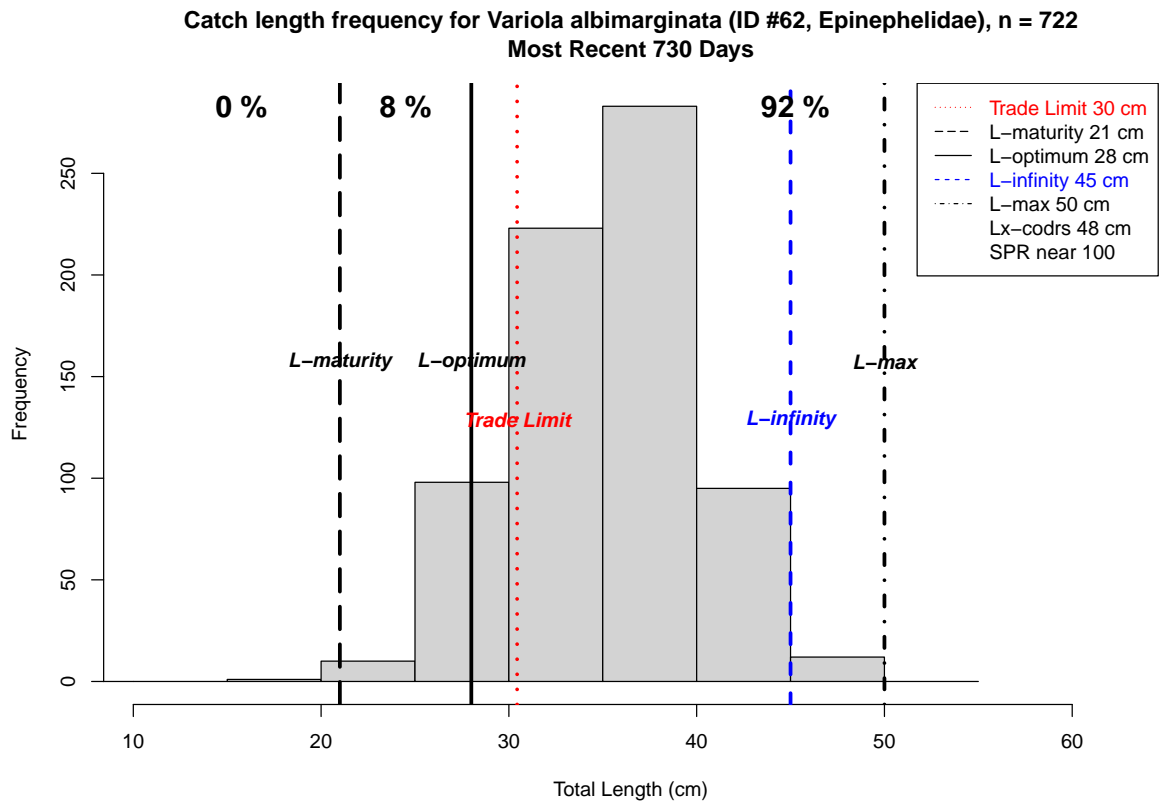
The majority of the catch consists of size classes around or above the optimum harvest size. This means that the impact of the fishery is minimized for this species. Potentially higher yields of this species could be achieved by catching them at somewhat smaller size, although capture of smaller specimen may take place already in other fisheries. Risk level is low.

More than 30% of the catch consists of mega spawners which indicates that this fish population is in good health unless large amounts of much smaller fish from the same population are caught by other fisheries. Risk level is low.

SPR is more than 40%. The stock is probably not over exploited, and the risk that the fishery will cause further stock decline is small. Risk level is low.

Trends in relative abundance by size group for *Plectropomus leopardus* (ID #61, Epinephelidae), as calculated from linear regressions. The P value indicates the chance that this calculated trend is merely a result of stochastic variance.

% Immature rising over recent years, situation deteriorating. P: not available
% Large Mature falling over recent years, situation deteriorating. P: not available
% Mega Spawner falling over recent years, situation deteriorating. P: not available
% SPR no trend over recent years, situation stable. P: not available



The percentages of *Variola albimarginata* (ID #62, Epinephelidae) in most recent 730 days, n=722
Immature (< 21cm): 0%
Small mature (\geq 21cm, < 28cm): 8%
Large mature (\geq 28cm): 92%
Mega spawner (\geq 30.8cm): 85% (subset of large mature fish)
Spawning Potential Ratio: near 100

The trade limit is significantly higher than length at first maturity. This means that the trade puts a premium on fish that have spawned at least once. The trade does not cause any concern of recruitment overfishing for this species. Risk level is low.

At least 90% of the fish in the catch are mature specimens that have spawned at least once before they were caught. The fishery does not depend on immature size classes for this species and is considered safe for this indicator. This fishery will not be causing overfishing through over harvesting of juveniles for this species. Risk level is low.

The majority of the catch consists of size classes around or above the optimum harvest size. This means that the impact of the fishery is minimized for this species. Potentially higher yields of this species could be achieved by catching them at somewhat smaller size, although capture of smaller specimen may take place already in other fisheries. Risk level is low.

More than 30% of the catch consists of mega spawners which indicates that this fish population is in good health unless large amounts of much smaller fish from the same population are caught by other fisheries. Risk level is low.

SPR is more than 40%. The stock is probably not over exploited, and the risk that the fishery will cause further stock decline is small. Risk level is low.

Trends in relative abundance by size group for *Variola albimarginata* (ID #62, Epinephelidae), as calculated from linear regressions. The P value indicates the chance that this calculated trend is merely a result of stochastic variance.
% Immature rising over recent years, situation deteriorating. P: not available
% Large Mature falling over recent years, situation deteriorating. P: not available
% Mega Spawner falling over recent years, situation deteriorating. P: not available
% SPR no trend over recent years, situation stable. P: not available

Table 3.1: Values of Indicator in the most recent 730 Days Length-Based Assessment

#ID	Species	Trade Limit Prop. Lmat	Immature %	Exploitation %imm+%smat	Mega Spawn %	SPR %
36	Saloptia powelli	1.19	1.28	7.69	89.74	83 %
37	Cephalopholis miniata	1.39	0.00	16.28	72.09	63 %
38	Cephalopholis sexmaculata	1.49	0.00	7.82	83.95	near 100
39	Cephalopholis sonnerati	1.12	1.77	16.59	76.84	90 %
40	Cephalopholis igarashiensis	1.40	0.00	3.11	88.20	near 100
41	Epinephelus latifasciatus	1.04	3.71	31.16	46.47	61 %
42	Epinephelus radiatus	0.83	3.07	25.57	55.18	73 %
43	Epinephelus morrhua	0.83	12.50	64.51	19.48	36 %
44	Epinephelus poecilnotus	0.94	1.30	17.92	68.05	near 100
45	Epinephelus areolatus	1.37	0.43	19.18	66.23	49 %
46	Epinephelus bleekeri	0.85	1.22	14.39	74.37	near 100
47	Epinephelus miliaris	1.27	0.00	4.43	93.67	near 100
48	Epinephelus bilobatus	1.21	0.00	1.83	96.58	near 100
49	Epinephelus malabaricus	0.81	13.88	46.12	41.63	near 100
50	Epinephelus coioides	0.94	3.49	34.91	47.06	72 %
51	Epinephelus chlorostigma	1.28	0.84	13.39	78.27	near 100
52	Epinephelus retouti	1.34	0.00	3.88	92.23	87 %
53	Epinephelus heniochus	1.02	0.63	9.28	81.43	near 100
54	Epinephelus stictus	1.34	0.27	3.84	92.47	near 100
55	Epinephelus epistictus	1.34	7.97	38.77	55.07	near 100
56	Epinephelus multinotatus	1.27	0.00	5.53	88.42	near 100
57	Epinephelus undulosus	1.52	0.00	2.72	93.33	near 100
58	Epinephelus amblycephalus	1.39	3.62	17.32	73.03	near 100
59	Hyporhamphus octofasciatus	0.63	21.83	52.78	36.11	62 %
60	Plectropomus maculatus	0.96	1.13	9.06	83.77	near 100
61	Plectropomus leopardus	1.08	1.82	12.23	79.18	near 100
62	Variola albimarginata	1.45	0.14	7.76	84.90	near 100

Table 3.2: Risk Level in Fisheries by Species and by Indicator for the most recent 730 Days

#ID	Species	Trade Limit	Immature	Exploitation	Mega Spawn	SPR
36	Saloptia powelli	low	low	low	low	low
37	Cephalopholis miniata	low	low	low	low	low
38	Cephalopholis sexmaculata	low	low	low	low	low
39	Cephalopholis sonnerati	low	low	low	low	low
40	Cephalopholis igarashiensis	low	low	low	low	low
41	Epinephelus latifasciatus	medium	low	low	low	low
42	Epinephelus radiatus	high	low	low	low	low
43	Epinephelus morrhua	high	medium	medium	high	medium
44	Epinephelus poecilonotus	medium	low	low	low	low
45	Epinephelus areolatus	low	low	low	low	low
46	Epinephelus bleekeri	high	low	low	low	low
47	Epinephelus miliaris	low	low	low	low	low
48	Epinephelus bilobatus	low	low	low	low	low
49	Epinephelus malabaricus	high	medium	low	low	low
50	Epinephelus coioides	medium	low	low	low	low
51	Epinephelus chlorostigma	low	low	low	low	low
52	Epinephelus retouti	low	low	low	low	low
53	Epinephelus heniochus	medium	low	low	low	low
54	Epinephelus stictus	low	low	low	low	low
55	Epinephelus epistictus	low	low	low	low	low
56	Epinephelus multinotatus	low	low	low	low	low
57	Epinephelus undulosus	low	low	low	low	low
58	Epinephelus amblycephalus	low	low	low	low	low
59	Hyporthodus octofasciatus	high	medium	medium	low	low
60	Plectropomus maculatus	medium	low	low	low	low
61	Plectropomus leopardus	medium	low	low	low	low
62	Variola albimarginata	low	low	low	low	low

Table 3.3: Trends in Relative Abundance by Size Group and Species Over Recent Years

#ID	Species	% Immature	% Large Mature	% Mega Spawner	% SPR
36	Saloptia powelli	deteriorating	deteriorating	deteriorating	unknown
37	Cephalopholis miniata	stable	deteriorating	deteriorating	stable
38	Cephalopholis sexmaculata	improving	deteriorating	deteriorating	stable
39	Cephalopholis sonnerati	deteriorating	improving	improving	improving
40	Cephalopholis igarashiensis	stable	improving	improving	stable
41	Epinephelus latifasciatus	improving	improving	deteriorating	deteriorating
42	Epinephelus radiatus	deteriorating	improving	improving	improving
43	Epinephelus morrhua	improving	improving	improving	improving
44	Epinephelus poecilonotus	deteriorating	improving	deteriorating	stable
45	Epinephelus areolatus	deteriorating	deteriorating	deteriorating	improving
46	Epinephelus bleekeri	deteriorating	deteriorating	deteriorating	improving
47	Epinephelus miliaris	stable	deteriorating	deteriorating	stable
48	Epinephelus bilobatus	stable	deteriorating	deteriorating	stable
49	Epinephelus malabaricus	deteriorating	deteriorating	deteriorating	stable
50	Epinephelus coioides	improving	deteriorating	deteriorating	stable
51	Epinephelus chlorostigma	improving	improving	improving	improving
52	Epinephelus retouti	stable	improving	improving	unknown
53	Epinephelus heniochus	deteriorating	improving	improving	stable
54	Epinephelus stictus	deteriorating	deteriorating	improving	stable
55	Epinephelus epistictus	improving	improving	improving	stable
56	Epinephelus multinotatus	stable	deteriorating	improving	stable
57	Epinephelus undulosus	stable	deteriorating	deteriorating	stable
58	Epinephelus amblycephalus	deteriorating	improving	improving	improving
59	Hyporthodus octofasciatus	deteriorating	stable	improving	stable
60	Plectropomus maculatus	stable	stable	stable	stable
61	Plectropomus leopardus	deteriorating	deteriorating	deteriorating	stable
62	Variola albimarginata	deteriorating	deteriorating	deteriorating	stable

4 Discussion and conclusions

Whereas I-Fish generates daily updates of the graphs and conclusions on indicator values by species as presented in this report, it does not provide discussions on overall status and trends in the fisheries. In this chapter, we discuss broad conclusions based on the status on January 25, 2017. Versions of this report generated after January 25, 2017, are based on a mix of data collected before this date as well as data collected thereafter. It is therefore likely that some details presented in this chapter differ somewhat from the more up-to-date values presented in chapter 3.

Overall, the status of deepwater grouper drop line and bottom long line fisheries in central and eastern Indonesia is not as bleak as might be expected for an open-access fishery on valuable species. The impact of these fisheries on groupers in general seems much less than it is on snapper resources which are the main target of these fisheries. Without a doubt, several of the grouper species covered in this report are severely at risk from the impact of other fisheries, in different habitats in Eastern Indonesia, but the impact that can be contributed to the deep slope hook and line fisheries seems limited.

Several of the grouper species that occur in the deep slope fisheries are under severe pressure from shallow-water reef fisheries in our region, mostly by small-scale vessels (less than 5 GT), which are currently unregulated. Recruitment of species that start their life-history on shallow coral reefs to the deeper waters will be severely depressed by intensive shallow-water fisheries. Improvements in fisheries management in shallow water habitats and especially in small scale coastal fisheries, could potentially greatly improve outputs from deeper water fisheries that target groupers among other species.

The indicators for *Plectropomus leopardus*, for example, show a “low” to “medium” level of risk from our target fisheries, whereas it is common knowledge that this species has suffered severe depletion in our region. The relatively low risk level reported here, indicates the impact from deep slope fisheries only. The few *P. leopardus* who survive the extremely high fishing mortality in shallow waters, and who make it to deeper waters, are subject to only moderate exploitation pressure by the deepwater snapper and grouper fishery. A low risk level as indicated in this report refers to the effect of the deepwater dropline and longline fishery only, and a low risk level does not mean that the population as a whole is in good shape.

Some species covered in this report do indicate reasons for serious concern, including for especially *Epinephelus morrhua* and possibly also *Variola albimarginata*. The important species of *Epinephelus morrhua* (2nd most abundant species of grouper in our target fisheries) seems to be highly vulnerable to the deep slope hook and line fisheries and is being caught in relatively high numbers just around its size of female maturation, mostly before reaching the optimum harvesting length. Fishing mortality is very high from the moment this species enters the catch and very few specimen reach lengths anywhere near "mega spawner" size. As is the case for a number of other species, the current trading limit (the minimum size at which traders start paying premium price) is well below the size of female maturation and far below the optimum size for harvesting. The trading limit clearly needs to be increased to improve the status of this species. In general, low trading limits, below size of female maturation, pose a significant potential threat to the status of a large number of species in the deep slope drop line and long line fisheries.

Variola albimarginata shows an extremely low level of SPR, indicating that the potential for recovery of this species has been severely diminished. *Epinephelus morrhua* shows medium to high levels of threat for most indicators. A few other species like *Epinephelus areolatus* show medium to high levels of risk for some of the indicators. Most other species of grouper seem to be impacted only at acceptable levels by the deep slope hook and line fisheries.

The highly productive *E. areolatus* is the most abundant grouper species in the deep slope hook and line fisheries, and it is the number 3 most important species in these fisheries overall. However, for *E. areolatus* most indicators show only low levels of risk, while only F/M risk is high. Fishing mortality is very high once this species enters the catch, but it has already reached optimum harvest size at that time. This species is doing so well because it has a small maximum size and matures at 21 cm total length, spawning and even reaching optimum harvest size before it is seriously impacted by the fisheries.

For most groupers in our target fisheries, the percentage of immature fish in the catch appears to be low, even where risk levels for other indicators are medium to high, and even though juveniles are well within the commercial size range (as can be seen from the number of species showing medium to high risk level in respect to the Trade Limit). This may indicate that the deepwater grouper fishery is not targeting these species in areas where juveniles occur. This finding is consistent with the common tendency among many groupers to inhabit shallower water as juveniles, and move to deeper waters as they grow to a larger size. Note that in the same deep slope fishery, the percentage of immature specimen of Eteline snappers, which complete their life cycle in deeper waters, is much higher (see other I-Fish reports on these fisheries).

For most of the grouper species targeted by the deep slope hook and line fisheries all the above means that regulation of fishing effort in combination with industry agreements on a minimum size may suffice to guarantee sustainable harvesting by these fisheries. Other than that, in order to improve the status of the stocks of these species, fisheries management needs to start dealing with the immense problem of over-fishing by small scale fisheries in shallower coastal waters, where juveniles as well as adults of many species are being decimated.

This report on groupers pools all observations from the entire study area of the TNC Indonesia Fisheries Conservation Program, which means that it does not show differences between fishery management areas (WPPs). However, such differences do exist. For example, the I-Fish reports of WPPs 573, 714-715, and 718 show that the percentage of immature fish in the catch of *Epinephelus morrhua* is highest in WPP 573 (19%), and substantially lower in WPP 714, 715, and 718 (10-11%). The indicators for WPP 573 and WPP 718 suggest that a relatively high number of species are at higher risk in WPP 573 and WPP 718 compared to WPP 714-715. This may be a consequence of a relatively intense fishery in WPP 573, with many fishing vessels concentrating in Indonesian waters around the Sahul banks and the Arafura Sea.

A more detailed analysis is necessary to disentangle the effects of fishing gear and depth of fishing grounds. This report pools data from longliners and dropliners, where longliners tend to fish somewhat shallower waters. Hence, the size compositions in the catch are affected by the relative contribution of each of these two gears.

5 References

Australian Surveying & Land Information Group (AUSLIG), 1996. Commonwealth Department of Industry Science and Resources. MAP 96/523.21.1.

Ehrhardt, N.M. and Ault, J.S. 1992. Analysis of two length-based mortality models applied to bounded catch length frequencies. *Trans. Am. Fish. Soc.* 121:115-122.

Froese, R. 2004. Keep it simple: three indicators to deal with overfishing. *Fish and Fisheries* 5: 86-91.

Froese, R. and Binohlan C. 2000. Empirical relationships to estimate asymptotic length, length at first maturity and length at maximum yield per recruit in fishes, with a simple method to evaluate length frequency data. *J. Fish Biol.* 56:758-773.

Froese, R. and D. Pauly, (eds.) 2000. *FishBase 2000: concepts, design and data sources*. ICLARM, Los Baños, Laguna, Philippines. 344 p.

Froese, R., Winker, H., Gascuel, D., Sumaila, U.R. and Pauly, D. 2016. Minimizing the impact of fishing. *Fish and Fisheries* DOI: 10.1111/faf.12146.

Fujita, R., Karr, K., Apel, A. and Mateo, I. 2012. Guide to the use of Froese sustainability indicators to assess and manage data-limited fish stocks. Oceans Program, Environmental Defense Fund, Research and Development Team.

Martinez-Andrade F., 2003. A comparison of life histories and ecological aspects among snappers (Pisces: lutjanidae). Dissertation http://etd.lsu.edu/docs/available/etd-1113103-230518/unrestricted/Martinez-Andrade_dis.pdf

Meester G.A., Ault J.S., Smith S.G., Mehrotra A. 2001. An integrated simulation modeling and operations research approach to spatial management decision making. *Sarsia* 86:543-558.

Prescott, V., 2000. East Timor's Potential Maritime Boundaries. East Timor and its Maritime Dimensions: Legal and Policy Implications for Australia, Australian Institute of International Affairs, Canberra.

Quinn, T.J. and Deriso R.B. 1999. *Quantitative Fish Dynamics*. New York: Oxford University Press.

Vasilakopoulos, P., O'Neill, F. G. and Marshall, C. T. 2011. Misspent youth: does catching immature fish affect fisheries sustainability? - *ICES Journal of Marine Science*, 68: 1525-1534.

Wallace, R.K. and Fletcher, K.M. 2001. *Understanding Fisheries Management: A Manual for understanding the Federal Fisheries Management Process, Including Analysis of the 1996 Sustainable Fisheries Act*. Second Edition. Auburn University and the University of Mississippi. 62 pp.

Zhang, C.I., Kim, S., Gunderson, D., Marasco, R., Lee, J.B., Park, H.W. and Lee, J.H. 2009. An ecosystem-based fisheries assessment approach for Korean fisheries. *Fisheries Research* 100: 26-41.