

Falkland
Islands
Fisheries
Department



Vessel Units

Allowable Effort

Allowable Catch

2022

Summary and Recommendations

© Crown Copyright 2021

No part of this publication may be reproduced without prior permission from the Falkland Islands Government Fisheries Department.

For citation purposes this publication should be referenced as follows:

FIFD. 2021. Vessel Units, Allowable Effort, and Allowable Catch 2022. Summary and Recommendations. Fisheries Department, Directorate of Natural Resources, Falkland Islands Government.

Contents

1. FOREWORD	3
2. <i>DORYTEUTHIS GAHI (LOLIGO)</i> – FALKLAND CALAMARI.....	5
<i>Andreas Winter</i>	
2.1. MANAGEMENT AND STOCK TRENDS.....	5
2.2. VESSEL UNITS AND Q-VALUES.	5
2.3. REFERENCES.....	7
3. FINFISH.....	8
<i>Andreas Winter</i>	
3.1. INTRODUCTION	8
3.2. VESSEL UNITS AND FISHING TIME.....	8
3.3. REFERENCES	10
4. <i>DISSOSTICHUS ELEGINOIDES</i> – PATAGONIAN TOOTHFISH	12
<i>Frane Škeljo</i>	
4.1. INTRODUCTION	12
4.2. STOCK ASSESSMENT ESTIMATES.....	13
4.3. RECOMMENDATION	13
4.4. REFERENCES	14
5. RAJIFORMES – SKATES	15
<i>Andreas Winter</i>	
5.1. MANAGEMENT AND STOCK TRENDS.....	15
5.2. ALLOWABLE EFFORT AND VESSEL UNITS	16
5.3. REFERENCES	17
6. QUICK REFERENCE GUIDE TO VUM/GT CATEGORY	18
6.1. FALKLAND CALAMARI FISHERY (C).....	18
6.2. FINFISH FISHERY (A, G, W)	18
6.3. SKATE FISHERY (F).....	19
6.4. TOOTHFISH LONGLINE FISHERY (L).....	19
6.5. RESTRICTED FINFISH PELAGIC FISHERY (S).....	19

1. Foreword

The 2022 Licensing Advice document (Vessel Units, Allowable Effort, and Allowable Catch) summarizes licensing advice for all regulated fisheries in Falkland Islands Conservation Zones for 2022 apart from the B-licensed *Illex* fishery. Current licencing advices are based on data through the end of 2020 for finfish, toothfish and skates, and through the end of first season 2021 for calamari. Summary tables of the licencing advice are presented at the end of the report.

Stock assessments and survey data that inform the licencing advice standards are published as separate reports and available on the Falkland Islands Fisheries Department website: <https://www.fig.gov.fk/fisheries/> (publications).

Falkland calamari *Doryteuthis (Loligo) gahi* obtained the highest catch total in 1st season 2021 since 1995, but was shut by emergency order for a perceived excess of small squid being caught by mid-April. Three of the past four 1st seasons have totalled over 40,000 tonnes *D. gahi* catch, and three of the past four 2nd seasons have totalled over 29,000 tonnes *D. gahi* catch. With stock levels continuing to show a robust status overall, allowable effort is set with the expectation of full seasons in 2022, and vessel units were calculated as the average of the past three years: 27.01.

Finfish license allocations have been changed significantly with the retirement of the effort index based on rock cod (*Patagonotothen ramsayi*) and shift towards a Total Allowable Catch system along the guidelines of the 2020 external review for finfish. Total Allowable Efforts from last year were set as a baseline for continuity, but adjusted by target proportion and TAC proportion factors calculated from the current stock assessments of individual species. Finfish license allocations for 2022 also represent the directive to revert finfish licenses to their Ordinance statuses with A license as unrestricted finfish, G license as *Illex* squid plus restricted finfish, and W license as restricted finfish. Accordingly, A license is the only license allocated to target-fish hake (*Merluccius*). Hake comprised by far the greatest percentage of finfish catches in 2020 for the fourth consecutive year, resulting in a large increase to A license allocation, and decreases to G and W license allocations.

Patagonian toothfish (*Dissostichus eleginoides*) catch in the target longline fishery obtained 1043.5 tonnes in 2020; the full quota plus a small amount of overage from the year before, while bycatches in finfish and calamari trawls continued lower than their peaks in 2017 and 2016. The current stock assessment estimates a spawning stock biomass (SSB) of 11,056 t toothfish and a ratio of 2020 SSB to unfished SSB of 0.477 – both slightly higher than the last year's estimate. At a level >0.45 the SSB ratio is in the *expansion range* of the harvest control rules; however, since the previous year's ratio was below 0.45, and at least three consecutive years within the expansion range are required before considering TAC alterations, TAC for toothfish is maintained at 1040 tonnes.

Total skate (Rajiformes) catch in 2020 (1413 tonnes) was the lowest since 1998. Skate-license effort in 2020 (59 days) was the second-lowest since 1998, ahead of 2019. Just 2.25% of total skate catch in 2020 was taken under skate (F) licence, a proportion again ahead of only 2019, which are the only two years on record with less than 20%. Given the low commercial activity in skate fishing, stock assessment for skates was not updated and the same biomass as the 2018 estimate was used as the basis for licencing allocation. As in previous years, allocations were equalized among GT categories.

Southern blue whiting (*Micromesistius australis*) commercial catches in Falkland waters were in 2020 the lowest annual total on record for the third straight year, at 58 tonnes. Of this total 95.5% were taken by W license, 4.1% by calamari C and X licenses, and 0.3% by A license. Additionally, 10.8 tonnes were taken under experimental trawl licenses for finfish and calamari. S (surimi) license was not fished in 2020, having most recently had four days of exploratory use in 2018, during which no southern blue whiting was caught. With last year's stock assessment showing a low but slowly recovering biomass estimate, the statutory TAC of 2,000 metric tonnes under S licence was maintained for southern blue whiting.

We are grateful to the scientific observers of the FIFD for data collection and to data management staff for processing catch reports from fishing vessels. We also thank our local and foreign-partner fishing companies for their cooperation in providing timely and reliable fisheries data.

2. *Doryteuthis gahi* (*Loligo*) – Falkland calamari

2.1. Management and stock trends.

The targeted fishery for Falkland calamari (*Doryteuthis gahi* – colloquially *Loligo*) is managed through two levels of control: 1) season schedule and 2) total biomass to a minimum escapement threshold per season. Season schedules are currently set as: 1st season (C licence), 64/65 days opening from late February; 2nd season (X licence), 64 days from late July. In 2021 1st season opened on February 26th; by agreement a two-day delay because of bad weather (Winter 2021). Since 2013 a flexible option also allows vessels to start and end either season as much as 6 days later. In either 1st or 2nd season the minimum escapement threshold is set at 10,000 tonnes biomass (Barton 2002, Arkhipkin et al. 2008). If in-season depletion models project that calamari biomass will fall below 10,000 tonnes, the fishery may be suspended or stopped before the scheduled end date of the season.

With the use of these controls, actual vessel units (VU) play a nominal role in determining the effort allocation to the Falkland calamari fishery. As long as no significant decline in stock biomass is anticipated, all licensed vessels can expect to fish for the duration of the season (except vessels restricted to fixed proportions of the season based on their replacement categories; see below). Vessel allocations are calculated from 1st seasons, given the schedule for publishing licencing advice. Three of the last five 1st seasons were among the five highest for CPUE since at least 2004, when catch management was assumed by the FIFD (Winter 2021). Concurrently abundant biomasses are reflected in nil to low risks of season-end escapement failure (Table 2.1).

Table 2.1. Catches, estimated biomass, escapement risks, and VU allocations of Falkland calamari 1st seasons 2017-2021.

Year	1 st season calamari catch (t)	1 st season calamari biomass (t) ^a	Risk of <10,000 t escapement	Total VU allocation
2017	39,433	113,939	0.000	27.02
2018	43,085	106,237	0.000	27.01
2019	55,586	189,577	0.000	27.01
2020	29,116	52,941	0.001	27.01
2021	59,587	145,482	0.000	27.01

a: Biomass estimate at the end of the pre-season survey, plus in-season immigration.

2.2. Vessel units and q-values.

As in previous years (e.g., Section 2 in FIFD 2020), the total VU allocation for 2022 was set as the average of the preceding three years (Table 2.1). As this procedure has been followed for a number of years, the total VU allocation at this point is essentially a fixed value of 27.01.

Total VU allocation was partitioned among licensed vessels in proportion to the GT category-averaged catchability coefficients (q values). Catchability coefficients represent the efficiency of a vessel at fishing (Arreguin-Sanchez 1996), and are calculated as catch per unit effort per available biomass. To smooth variations within seasons, catchability coefficients were averaged over the most recent three years 2019 to 2021 (Table 2.2). Since 2016

catchability coefficients have been calculated only on unsubstituted vessels, i.e. excluding vessels that had been entered as short-term substitutes for logistic or mechanical reasons. Substitute vessels are often less experienced in the fishery and are therefore likely to have lower catch efficiency independently of their GT category. Two short-term substitute vessels were employed in calamari 1st season 2021; for 1 and 7 days respectively.

Table 2.2. Parameters for average q-value calculations. Trends were visualized for the five years 2017 - 2021; q averages were calculated for the most recent three years 2019 – 2021.

Parameter	GT cat	Year					3-year average
		2017	2018	2019	2020	2021	
Biomass		113,939	106,237	189,577	52,941	145,482	
Catch (t)	3	241.5	0.0	0.0	0.0	0.0	
	4	6603.1	8812.7	11275.0	6674.6	15946.3	
	5	12203.7	12805.9	16712.5	8988.6	15570.2	
	6	13950.9	13121.6	18320.0	9307.3	19196.3	
	7	3389.4	7449.0	9225.3	4145.6	8450.5	
Fishing days	3	7	0	0	0	0	
	4	185	239	232	251	283	
	5	314	297	294	322	217	
	6	311	292	303	318	273	
	7	62	123	124	121	110	
CPUE (t day ⁻¹)	3	34.5					
	4	35.7	36.9	48.6	26.6	56.3	
	5	38.9	43.1	56.8	27.9	71.8	
	6	44.9	44.9	60.5	29.3	70.3	
	7	54.7	60.6	74.4	34.3	76.8	
Catchability (q)	3	3.03e-4					
	4	3.13e-4	3.47e-4	2.56e-4	5.02e-4	3.87e-4	3.82e-4
	5	3.41e-4	4.06e-4	3.00e-4	5.27e-4	4.93e-4	4.40e-4
	6	3.94e-4	4.23e-4	3.19e-4	5.53e-4	4.83e-4	4.52e-4
	7	4.80e-4	5.70e-4	3.92e-4	6.47e-4	5.28e-4	5.23e-4

One category 4 vessel has been licensed to replace a category 3 vessel, since 2019 (FIFD 2019). The standard procedure for long-term replacement vessels has been to adjust their VU allocation to the category they are replacing based on the current calculation of averaged catchability. However, there has been no category 3 vessel in the fishery since 2017, so the allocation proportion has been fixed at its previous value of 92%. One category 7 vessel had part of its allocation transferred to a newer category 5 vessel. The allocation reduction was calculated to 86% (Table 2.3), and is subject to review next year.

Table 2.3. VU allocations per vessel.

Vessel Callsign	GT category	GT avg. q	VU allocation
ZDLC1	4	3.82e-4	1.50
ZDLC4	4	3.82e-4	1.50
Z added LD4	5	4.40e-4	1.73
ZDLE1	6	4.52e-4	1.78
ZDLF2	5	4.40e-4	1.73
ZDLM3 ^a	4	3.51e-4	^a 1.38
ZDLO1	6	4.52e-4	1.78
ZDLP1	5	4.40e-4	1.73
ZDLR1	6	4.52e-4	1.78
ZDLS3	5	4.40e-4	1.73
ZDLT1	4	3.82e-4	1.50
ZDLU1	6	4.52e-4	1.78
ZDLW3	4	3.82e-4	1.50
ZDLY ^b	7	4.49e-4	^b 1.77
ZDLZ	7	5.23e-4	2.05
ZDLZ1	6	4.52e-4	1.78
			27.01

^a ZDLM3 replaced a category 3 vessel, and is restricted to 92% of the season to offset its higher fishing capacity.

^b ZDLY was part of a 3-way replacement between category 5 and category 7 vessels, and was allocated 55 days; equivalent to 86% of the season.

2.3. References.

Arkhipkin, A.I., Middleton, D.A.J., Barton, J. 2008. Management and conservation of a short-lived fishery resource: *Loligo gahi* around the Falkland Islands. American Fisheries Society Symposium 49:1243-1252.

Arreguin-Sanchez, F. 1996. Catchability: a key parameter for fish stock assessment. Reviews in Fish Biology and Fisheries 6:221-242.

Barton, J. 2002. Fisheries and fisheries management in Falkland Islands Conservation Zones. Aquatic Conservation: Marine and Freshwater Ecosystems 12:127-135.

FIFD. 2019. Vessel Units, Allowable Effort, and Allowable Catch 2020. Part I. Summary and recommendations. Fisheries Dept., Directorate of Natural Resources, Falkland Islands Government, 21 p.

FIFD. 2020. Vessel Units, Allowable Effort, and Allowable Catch 2021. Summary and Recommendations. Fisheries Dept., Directorate of Natural Resources, Falkland Islands Government, 20 p.

Winter, A. 2021. Stock assessment –Falkland calamari *Doryteuthis gahi* 1st season 2021. Technical Document, Falkland Islands Fisheries Department. 34 p.

3. Finfish

3.1. Introduction

Finfish trawl catch in the Falkland Islands is allocated by three licences: A (unrestricted finfish), G (*Illex* squid and restricted finfish), and W (restricted finfish). Specialized fisheries for toothfish, skates and surimi are separately allocated by L, F and S licences. In 2020, catch of major commercial species by A, G and W licences totalled 55,579 tonnes (Table 3.1).

Table 3.1. Catches in 2020 of commercial species targeted by finfish licences.

Species	Catch by Licence (tonnes)			
	A	G	W	
Common hake	20863.1	8254.1	13236.0	42353.3
Southern hake	0.0	0.7	47.3	48.1
<i>Illex</i> squid	4.5	2341.9	116.6	2463.0
Blue whiting	0.2	0.0	55.4	55.6
Hoki	128.4	1447.2	5943.2	7518.9
Red cod	298.0	258.7	733.8	1290.6
Kingclip	635.2	327.1	571.2	1533.5
Rock cod	18.8	42.2	254.7	315.7
	21948.2	12671.9	20958.3	55578.5

Finfish licence allocations are set by Total Allowable Effort (TAE). Effort allocations have previously been calculated as the catchability function of an index species. However, catches of the most recent index species rock cod (*Patagonotothen ramsayi*) have declined (FIG 2021) to the point that this approach can scarcely be considered relevant to the fisheries any longer. Instead, the external review of Falkland Islands fisheries management (MEP 2020) has recommended transferring finfish allocation to a system of Total Allowable Catch (TAC), and this approach is in development.

Pending completion and approval of a suitable TAC plan, a transitional protocol was adopted this year to start with the TAE per licences from last year, as a baseline for continuity, but then adjust these TAE by target proportion and TAC proportion factors calculated as described in the September 2021 Fisheries Committee paper (Winter et al. 2021). A particular issue informing proportionality has been the predominant catch of hake (*Merluccius*) over the past few years by all three finfish licences (Table 3.1; FIG 2021), even though hake is allocated as a target species only to A licence under the Fisheries (Management and Conservation) Ordinance (FIG 2011). For the past two years, A licence had been set by agreement as a *de facto* hake (only) licence rather than unrestricted finfish licence, in return for exemption of a decrease in effort allocation that was linked to the index species rock cod (FIFD 2019, FIFD 2020). With the retirement of the index species approach, and pending focus on TAC, A licence has been reverted to the status of unrestricted finfish licence as originally established in the Ordinance (FIG 2011). All finfish effort allocations following in this document reference A licence as the unrestricted finfish licence.

3.2. Vessel units and fishing time.

TAE is expressed by Vessel Units (VU), a metric of the fishing effort expected to yield a standard level of catch of the target species. VUs are then used to apportion the total VU allocation into fishing time.

The VUs from 2021 per finfish licence were multiplied by each of the proportion factors calculated by Winter et al. (2021) to give the 2022 VUs:

Table 3.2. 2022 VU allocation calculated from 2021 VU allocations.

Licence	2021 VU		target proportion		TAC proportion		2022 VU
A	12.20	×	0.973	×	1.886	=	22.39
G	12.77	×	0.522	×	1.101	=	7.34
W	14.27	×	0.392	×	0.717	=	4.01

VUs are translated to fishing time (vessel-days or vessel-months) by the vessel-units per month (VUMs), which are a function of catchability and available fish biomass. For 2022 VUMs are considered constant since the year before, as catchability may be assumed to have not fundamentally changed, and available fish biomass is accounted for by the TAC proportion. Differences in fishing time allocated for 2022 are therefore directly proportional to differences in VU, from 2021:

Table 3.3. Fishing effort VUM and allocated fishing time in vessel-months by GT category, for A licence, 2013 to 2022.

GT category	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Fishing effort VUM										
3	0.46	0.46	0.46	0.45	0.46	0.46	0.46	0.46	0.46	0.46
4	0.46	0.46	0.46	0.45	0.46	0.46	0.46	0.46	0.46	0.46
5	0.46	0.46	0.46	0.45	0.46	0.46	0.46	0.46	0.46	0.46
6	0.46	0.46	0.46	0.45	0.46	0.46	0.46	0.46	0.46	0.46
7							0.46	0.46	0.46	0.46
Fishing time vessel-months										
3	28.3	29.3	29.3	26.5	26.6	26.6	26.6	26.6	26.6	48.7
4	28.3	29.3	29.3	26.5	26.6	26.6	26.6	26.6	26.6	48.7
5	28.3	29.3	29.3	26.5	26.6	26.6	26.6	26.6	26.6	48.7
6	28.3	29.3	29.3	26.5	26.6	26.6	26.6	26.6	26.6	48.7
7							26.6	26.6	26.6	48.7

Table 3.4. Fishing effort VUM and allocated fishing time in vessel-months by GT category, for G licence, 2013 to 2022.

GT category	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Fishing effort VUM										
3	0.42	0.49	0.37	0.40	0.40	0.40	0.38	0.38	0.38	0.38
4	0.79	0.75	0.72	0.68	0.68	0.68	0.73	0.73	0.73	0.73
5	1.17	1.01	1.06	0.96	0.96	0.96	1.07	1.07	1.07	1.07
6	1.54	1.27	1.40	1.25	1.25	1.25	1.42	1.42	1.42	1.42
7							1.76	1.76	1.76	1.76

Fishing time vessel-months										
3	52.6	40.7	53.8	49.7	44.8	38.1	40.0	35.2	33.4	19.3
4	28.0	26.6	27.9	29.3	26.3	22.4	21.0	18.5	17.5	10.1
5	18.9	18.9	18.9	20.7	18.7	15.9	14.3	12.6	11.9	6.9
6	14.4	14.4	14.2	16.1	14.5	12.3	10.8	9.5	9.0	5.2
7							8.7	7.7	7.3	4.2

Table 3.5. Fishing effort VUM and allocated fishing time in vessel-months by GT category, for W licence, 2013 to 2022.

GT category	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Fishing effort VUM										
3	0.24	0.23	0.27	0.31	0.31	0.31	0.40	0.40	0.40	0.40
4	0.51	0.48	0.47	0.49	0.49	0.49	0.56	0.56	0.56	0.56
5	0.78	0.74	0.67	0.66	0.66	0.66	0.72	0.72	0.72	0.72
6	1.04	1.00	0.87	0.84	0.84	0.84	0.88	0.88	0.88	0.88
7							1.03	1.03	1.03	1.03
Fishing time vessel-months										
3	102.9	97.1	81.2	71.0	64.0	54.4	42.5	37.4	35.5	10.0
4	48.4	46.5	47.0	45.7	41.2	35.0	30.5	26.9	25.4	7.2
5	31.7	30.2	33.1	33.7	30.3	25.8	23.8	21.0	19.9	5.6
6	23.8	22.3	25.5	26.7	24.0	20.4	19.5	17.2	16.3	4.6
7							16.5	14.5	13.8	3.9

Note that GT categories are equalized for A licence only, as previous analyses (FIFD 2018) showed no statistically significant correlation between GT and VU of individual vessels under A licence. Also note that VUM and vessel-months per category are alternate (not additive) total outcomes, for example, the W-licence fishery could be taken by Cat 3 vessels fishing a total of 10.0 vessel-months or by Cat 4 vessels fishing a total of 7.2 vessel-months or by Cat 5 vessels fishing a total of 5.6 vessel-months, etc.; or any fractional combination of these categories.

3.3. References.

FIFD. 2018. Vessel Units, Allowable Effort, and Allowable Catch 2019. Part I. Summary and recommendations. Fisheries Dept., Directorate of Natural Resources, Falkland Islands Government, 21 p.

FIFD. 2019. Vessel Units, Allowable Effort, and Allowable Catch 2020. Part I. Summary and recommendations. Fisheries Dept., Directorate of Natural Resources, Falkland Islands Government, 21 p.

FIFD. 2020. Vessel Units, Allowable Effort, and Allowable Catch 2021. Summary and recommendations. Fisheries Dept., Directorate of Natural Resources, Falkland Islands Government, 20 p.

Falkland Islands Government (FIG). 2011. Notices No. 84, 85, 87. Falkland Islands Gazette, Vol.20, No. 19, 30 September 2011.

Falkland Islands Government (FIG). 2021. Fisheries Department Fisheries Statistics, Volume 25, 2020. Stanley, FIG Fisheries Department, 68 p.

MEP (MacAlister Elliot & Partners Ltd.). 2020. Review of Falkland Islands Finfish Fisheries – Executive Summary. Report for Directorate of Natural Resources – Fisheries, Falkland Islands Government, 15 p.

Winter, A., Clausen, A.P., Blake, A., Arkhipkin, A., Costelloe, T., Ross, S. 2021. Licencing advice and management proposals for Falkland Islands finfish for 2022. Part II. Fisheries Advisory Committee paper, September 2021, 19 p.

4. *Dissostichus eleginoides* – Patagonian toothfish

4.1. Introduction

The targeted longline fishery for Patagonian toothfish (*Dissostichus eleginoides*) is listed under the L-licence, and managed through total allowable catch (TAC). In addition to longline, notable quantities of toothfish are taken as bycatch in finfish and calamari trawl fisheries. In the finfish fishery toothfish is a commercially valuable bycatch, while in the calamari fishery it is usually discarded, due to the small size of the specimens.

Toothfish stock assessment is calculated as an age-structured production model in CASAL software (Bull et al. 2012), and integrates the catch and effort data reported by fisheries with toothfish age, length and maturity data collected by observers during the commercial trips and research surveys. The main observations used to inform the model are: catch-at-age data for Spanish-system longline, umbrella-system longline, finfish trawl and calamari trawl fisheries, catch-at-age data for groundfish and Loligo pre-season surveys, and CPUE data for Spanish- and umbrella-system longline. CPUE is estimated in kg-per-umbrella, and standardized across a wide set of covariates (individual vessel, month, soak-time, depth, fishing region and number of hooks-per-umbrella).

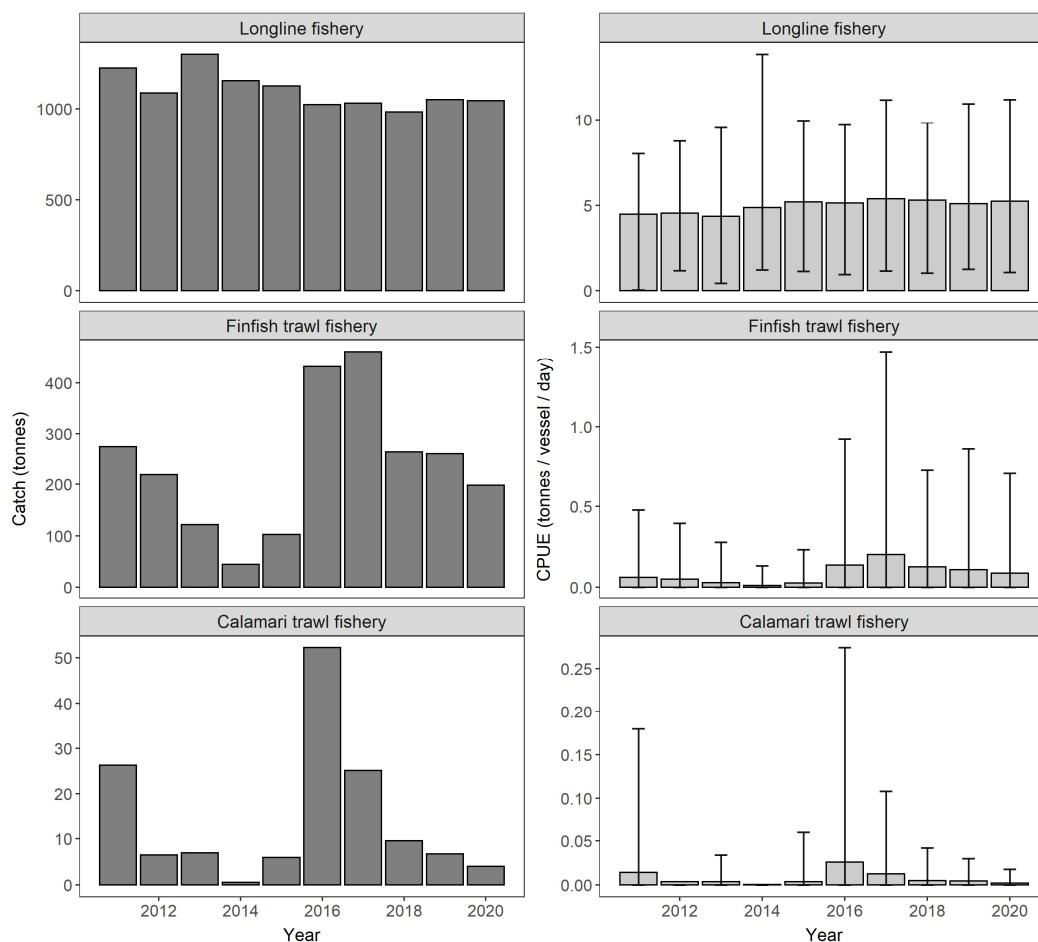


Figure 4.1. Time series of toothfish catches (left) and observed CPUE (right) for longline, finfish trawl and calamari trawl fisheries. Error bars are 95% quantiles of observed CPUE.

Reported toothfish catch in 2020 totalled 1246.3 tonnes, of which 83.7% was caught by longline (1043.5 t in 198 vessel-days), 15.8% by finfish trawl (197.5 t in 2048 vessel-days), 0.3% by calamari trawl (4.0 t in 2005 vessel-days) (Figure 4.1). The remaining 0.1% (1.4 t) was caught under the experimental licence. Toothfish bycatch in finfish and calamari trawl fisheries decreased compared to the previous year.

4.2. Stock assessment estimates

The key output parameters estimated in 2020 toothfish stock assessment are summarised in Table 4.1.

The estimates of the current spawning stock biomass (SSB_{2020}) and the ratio of current spawning stock biomass to initial spawning stock biomass (SSB_{2020}/SSB_0) were slightly higher than the last year's ($SSB_{2019} = 10,637$ t, SSB_{2019}/SSB_0 in 2019 = 0.440). According to the existing harvest control rules (HCR) (Farrugia and Winter 2018, 2019), the current SSB_{2020}/SSB_0 of 0.477 places the stock in the *expansion range*. The future trend of SSB/SSB_0 ratio was projected based on the constant future annual catches (longline 1,040 t, finfish trawl 300 t, calamari trawl 30 t), and indicated that the ratio will remain in the HCR *expansion range*, on a slightly increasing trend, expected to level out by the end of the projection period.

Maximum sustainable yield (MSY) is the maximum constant annual catch that can be sustained under deterministic recruitment and the assumed constant catch partition. MSY was determined to be 1,850 t. Deducting from the MSY 300 t for finfish trawl and 30 t for calamari trawl fishery leaves 1,520 t available for the longline toothfish fishery. As a precautionary measure, TAC should be set below the MSY to provide a buffer to account for undetected whale depredation, uncertainties in the model, and variability in the toothfish stock and the environmental conditions.

Table 4.1. Key output parameters estimated by the 2020 toothfish stock assessment model, with corresponding MCMC credible intervals.

Parameter	MPD value	MCMC 95% CI
SSB_0	23,169 t	20,516 - 94,602 t
SSB_{2020}	11,056 t	8,895 - 85,530 t
SSB_{2020}/SSB_0	0.477	0.425 - 0.944
MSY	1,850 t	1,637 - 7,550 t

4.3. Recommendation

Management advice is based on harvest control rules (HCR) established for the Falkland Islands toothfish longline fishery (Farrugia and Winter 2018, 2019). The estimated SSB_{2020}/SSB_0 ratio of 0.477 is above the *upper target reference point* (0.45), i.e. in the *expansion range*, and the projection suggests it will remain above 0.45 in the future. Since the previous year's ratio was below 0.45 (Skeljo and Winter 2020), and at least three consecutive years within the expansion range are required before considering TAC alterations, no action is anticipated by HCR at this point. Therefore, the recommendation for the toothfish longline fishery is to maintain the annual total allowable catch (TAC) at its current level of 1,040 tonnes.

A second recommendation is to maintain the existing '1.5% toothfish bycatch limit', as toothfish bycatch in both finfish and calamari trawls progressively decreased since 2017, coinciding with the introduction of this regulation. A longer time period is needed to ascertain the effectiveness of the bycatch limit, as recent bycatch decline could be a consequence of natural variability in toothfish recruitment (i.e., weak recruitment in the last three years). Therefore, close monitoring of toothfish bycatch, especially in the finfish trawl fishery where larger quantities are taken, needs to be continued.

4.4. References

- Bull, B., Francis, R.I.C.C., Dunn, A., McKenzie, A., Gilbert, D.J., Smith, M.H., Bian, R., Fu, D. 2012. CASAL (C++ algorithmic stock assessment laboratory): CASAL User Manual v2.30-2012/03/21. NIWA Technical Report 135, 275 p.
- Farrugia, T.J., Winter, A. 2018. 2017 Stock Assessment Report for Patagonian toothfish, Fisheries Report SA-2017-TOO. Fisheries Department, Directorate of Natural Resources, Falkland Islands Government, 35 p.
- Farrugia, T.J., Winter, A. 2019. 2018 Stock Assessment Report for Patagonian toothfish, Fisheries Report SA-2018-TOO. Fisheries Department, Directorate of Natural Resources, Falkland Islands Government, 37 p.
- Skeljo, F., Winter, A. 2020. 2019 Stock Assessment Report, Patagonian toothfish (*Dissostichus eleginoides*), Fisheries Report SA-2019-TOO. Fisheries Department, Directorate of Natural Resources, Falkland Islands Government, 37 p.

5. Rajiformes – Skates

5.1. Management and stock trends

Skate (Rajiformes) are since 1994 licensed separately from other groundfish trawl fisheries in the Falkland Islands (F license). The skate fishery is regulated by total allowable effort (TAE) of licensed vessels. However, a large proportion of skate catch is routinely taken in finfish trawls, while skate-licensed vessels may take large amounts of groundfish other than skate. In 2020, 31.8 tonnes of skate were caught under skate target F license, together with 493.6 t hake (*Merluccius hubbsi*), 2.8 t rock cod, 76.7 t kingclip, and 29.4 t red cod, but zero hoki or blue whiting. Conversely, 1381.2 t skate were caught in 2020 under licenses other than skate target license.

Total catch of skate in 2020 was the lowest since 1998 and has been decreasing continually since 2015 (Figure 5.1). Target catch of skate has been decreasing continually since 2014, concurrently with a strong decrease in effort, and in 2020 was the lowest on record (Figure 5.1). Recent stock assessments (e.g., Winter 2018) have shown stable trends of the skate stock, and reviews of the skate assemblage (Arkhipkin et al. 2012, Winter et al. 2015) have noted high population abundance, species diversity, and habitat structure. Therefore, a new stock assessment was not calculated in 2021. The same biomass as the last two years is used as a baseline: 43,342.6 metric tonnes (Winter 2018).

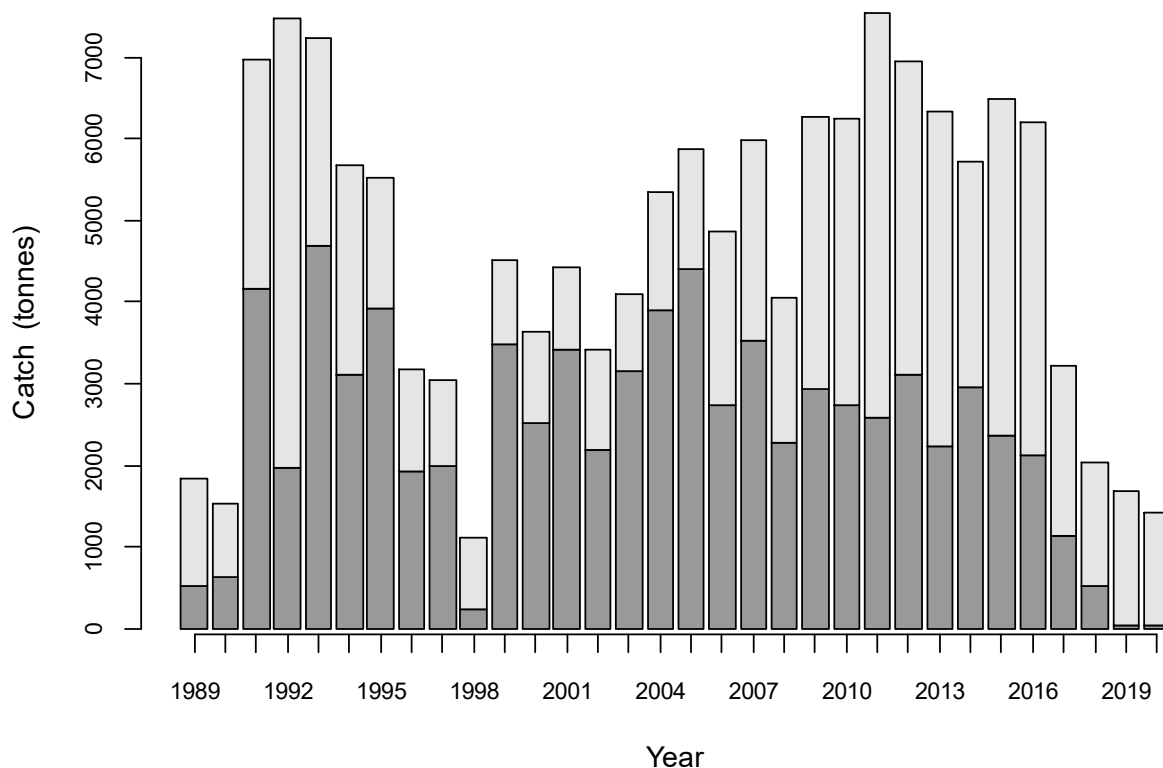


Figure 5.1. Target-licence catches (dark) and all catches (light grey) of skates, 1989 to 2020.

5.2. Allowable effort and vessel units

The recommendation for 2022 is to aim for maintaining F license skate target catch nominally at the current level. F license was minimally used in 2019 and 2020 (Figure 5.1), and so far not at all in 2021. Whenever substantial commercial fishing effort in this license is resumed, assessment and allocation will need to be re-evaluated. For current purposes, effort allocations were calculated by Vessel Units based on catchability per GT category, averaged over the preceding three years. Catchability coefficients (q-values) per GT category were calculated as:

$$Q_i = \frac{\overline{\text{catch}_i(t)}}{\text{effort}_i(\text{hrs}) \times \text{biomass}(t)} \Bigg|_{2018}^{2020}$$

where catch and effort of the i th GT category are obtained from vessel reports, and biomass in each year 2018 to 2020 is the biomass estimate north of 51°S (Table 5.1). As a conservation measure, directed fishing for skates was prohibited south of 51°S in 1996 (Agnew et al. 1999).

Table 5.1. Skate-licence fishery parameters 2018 – 2020, used for calculating the 3-year averaged Vessel Unit allocations.

Parameter	GT category	Year		
		2018	2019	2020
Biomass		43,343	43,343	43,343
Catch	3	462	15	3
	4	0	7	2
	5	54	13	26
	7	0	0	0
Effort Hours	3	798	182	94
	4	0	40	105
	5	311	113	543
	7	0	0	0
Licensed Days	3	174	50	94
	4	0	14	12
	5	84	50	51
	7	0	0	0
Fishing Days	3	45	14	9
	4	0	3	7
	5	19	10	43
	7	0	0	0

Vessel units per month (VUM) per GT category were calculated as:

$$\text{VUM}_i = Q_i \times \text{biomass}_{2018} \times \frac{\overline{\frac{\text{fish hrs}_i}{\text{fish days}_i}}}{30.5} \Bigg|_{2018}^{2020} / 100$$

where fishing hours and fishing days of the i th GT category are obtained from vessel reports, 30.5 converts month/day, and 100 is a scaling factor of the vessel units. VU allocations per GT category were calculated as:

$$VU_i = \frac{VUM_i \times \text{licensed days}_{i,2020}}{30.5}$$

Fishery parameters for the past three years are summarized in Table 5.1, and the recommended VU allocations are summarized in Table 5.2. As in previous years (since FIFD 2014) the VUM were equalized between GT categories. Equalization was implemented because the small scale of this fishery (4 vessels in 2020; one each in GT categories 3 and 4; two in 5) would confound any independent differences between GT categories.

The total allocation is 3.94 VU (Table 5.2), corresponding to a nominally expected skate catch of 394 tonnes, which is nevertheless more than 12× higher than 2020's actual F-licensed skate catch. The VUs are again reduced from the year before (FIFD 2020), on account of lower total skate catch despite an increase in total fishing days (Table 5.1). All three GT categories showed lower catchability coefficients Q than the year before, reflecting that the skate license effort was mostly employed in 2020 for exploratory purposes.

Table 5.2. Mean catchability coefficients Q and recommended equalized vessel unit allocations by GT category.

GT category	Q ($\times 10^{-6}$)	Vessel Units per month	Vessel Unit allocation
3	5.35	0.76	
4	2.31	0.76	
5	2.60	0.76	3.94
7			

5.3. References

- Agnew, D.J., Nolan, C.P., Pompert, J. 1999. Management of the Falkland Islands skate and ray fishery. In: Case studies of the Management of Elasmobranch Fisheries (R. Shotton, ed.), FAO, Rome, pp. 268-284.
- Arkhipkin, A., Brickle, P., Laptikhovsky, V., Pompert, J., Winter, A. 2012. Skate assemblage on the eastern Patagonian Shelf and Slope: structure, diversity and abundance. *Journal of Fish Biology* 80:1704-1726.
- FIFD. 2014. Vessel Units, Allowable Effort, and Allowable Catch 2015. Fisheries Dept., Directorate of Natural Resources, Falkland Islands Government. 54 p.
- FIFD. 2020. Vessel Units, Allowable Effort, and Allowable Catch 2021. Summary and recommendations. Fisheries Dept., Directorate of Natural Resources, Falkland Islands Government, 20 p.
- Winter, A. 2018. Stock assessment – skates (Rajidae). Technical Report, Falkland Islands Fisheries Department. 14 p.
- Winter, A., Pompert, J., Arkhipkin, A., Brewin, P. 2015. Interannual variability in the skate assemblage on the South Patagonian shelf and slope. *Journal of Fish Biology* 87: 1449-1468.

6. Quick reference guide to VUM/GT Categories

6.1. Falkland calamari fishery (C)

VU = 27.01 – allows for a standard fleet of 16 vessels.

6.2. Finfish fishery (A, G, W)

VU allocations for 2021 and 2022.

Licence	2021 VU	2022 VU
A	12.20	22.39
G	12.77	7.34
W	14.27	4.01

A licence. Fishing effort VUM and fishing time vessel-months.

GT category	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Fishing effort VUM										
3	0.46	0.46	0.46	0.45	0.46	0.46	0.46	0.46	0.46	0.46
4	0.46	0.46	0.46	0.45	0.46	0.46	0.46	0.46	0.46	0.46
5	0.46	0.46	0.46	0.45	0.46	0.46	0.46	0.46	0.46	0.46
6	0.46	0.46	0.46	0.45	0.46	0.46	0.46	0.46	0.46	0.46
7							0.46	0.46	0.46	0.46
Fishing time vessel-months										
3	28.3	29.3	29.3	26.5	26.6	26.6	26.6	26.6	26.6	48.7
4	28.3	29.3	29.3	26.5	26.6	26.6	26.6	26.6	26.6	48.7
5	28.3	29.3	29.3	26.5	26.6	26.6	26.6	26.6	26.6	48.7
6	28.3	29.3	29.3	26.5	26.6	26.6	26.6	26.6	26.6	48.7
7							26.6	26.6	26.6	48.7

G licence. Fishing effort VUM and fishing time vessel-months.

GT category	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Fishing effort VUM										
3	0.42	0.49	0.37	0.40	0.40	0.40	0.38	0.38	0.38	0.38
4	0.79	0.75	0.72	0.68	0.68	0.68	0.73	0.73	0.73	0.73
5	1.17	1.01	1.06	0.96	0.96	0.96	1.07	1.07	1.07	1.07
6	1.54	1.27	1.40	1.25	1.25	1.25	1.42	1.42	1.42	1.42
7							1.76	1.76	1.76	1.76
Fishing time vessel-months										
3	52.6	40.7	53.8	49.7	44.8	38.1	40.0	35.2	33.4	19.3
4	28.0	26.6	27.9	29.3	26.3	22.4	21.0	18.5	17.5	10.1
5	18.9	18.9	18.9	20.7	18.7	15.9	14.3	12.6	11.9	6.9
6	14.4	14.4	14.2	16.1	14.5	12.3	10.8	9.5	9.0	5.2
7							8.7	7.7	7.3	4.2

W licence. Fishing effort VUM and fishing time vessel-months.

GT category	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Fishing effort VUM										
3	0.24	0.23	0.27	0.31	0.31	0.31	0.40	0.40	0.40	0.40
4	0.51	0.48	0.47	0.49	0.49	0.49	0.56	0.56	0.56	0.56
5	0.78	0.74	0.67	0.66	0.66	0.66	0.72	0.72	0.72	0.72
6	1.04	1.00	0.87	0.84	0.84	0.84	0.88	0.88	0.88	0.88
7							1.03	1.03	1.03	1.03
Fishing time vessel-months										
3	102.9	97.1	81.2	71.0	64.0	54.4	42.5	37.4	35.5	10.0
4	48.4	46.5	47.0	45.7	41.2	35.0	30.5	26.9	25.4	7.2
5	31.7	30.2	33.1	33.7	30.3	25.8	23.8	21.0	19.9	5.6
6	23.8	22.3	25.5	26.7	24.0	20.4	19.5	17.2	16.3	4.6
7							16.5	14.5	13.8	3.9

6.3. Skate fishery (F)

GT category	Q ($\times 10^{-6}$)	Vessel Units per month	Vessel Unit allocation
3	5.35	0.76	
4	2.31	0.76	
5	2.60	0.76	3.94
7			

6.4. Toothfish longline fishery (L)

TAC – 1,040 tonnes.

6.5. Restricted finfish – Pelagic fishery (S)

TAC for southern blue whiting – 2,000 tonnes.