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ミナミマグロ 1 歳魚の曳縄指数：
グリッドタイプ曳縄指数の更新 2026 年

Trolling indices for age-1 southern bluefin tuna: update of the grid type trolling index in 2026

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要約

オーストラリア南西岸において実施したミナミマグロ 1 歳魚の科学加入量調査の曳縄漁獲データから、1996 年から現在までの 20 年以上に及ぶ加入量指数を求めた。本文書では、2026 年調査データを追加して計算した結果を示す。ピストンライン曳縄指数（TRP）は、既定の調査定線（ピストンライン）上における探索距離 100km 当たりの漁獲をモデルベースの標準化はせずに求めた。グリッドタイプ曳縄指数（TRG）は、より広範な海域のデータを使用してデルタログノーマルアプローチで一般化線形モデルで標準化して計算した。2026 年の TRG は 2025 年よりも減少し、29 年間の平均値の 90%であった。

Summary

From the trolling catch data of the scientific recruitment monitoring surveys for the age-1 southern bluefin tuna (SBT) on the southwestern coast of Australia, the recruitment index for more than 20 years since 1996 to the present was calculated. This document shows updated indices by adding the 2026 survey data. The piston-line trolling index (TRP) was derived from catch per 100 km search distance on a predetermined transect line (called piston-line) without model-based standardization. The grid-type trolling index (TRG) was calculated based on data from a wider area and standardized by the generalized linear model with a delta lognormal approach. TRG in 2026 decreased from 2025 and was 82% of the 29-year average.

Introduction

Trolling survey for southern bluefin tuna (*Thunnus maccoyii* SBT) is a scientific research survey which aims to provide recruitment indices of the stock at age-1. The survey has been carried out on the southern coast of Western Australia since 2006, except in 2015. It has provided an index named the piston-line trolling index (TRP) which have been reported to CCSBT since 2006 (Itoh and Kurota 2006, Itoh 2007, Itoh and Sakai 2007, 2008, 2009, 2010, Itoh et al. 2011, 2012, 2013, Itoh and Tokuda 2014, Itoh and Tsuda 2016, Tsuda and Itoh 2017, 2018, 2019, Itoh and Tsuda 2020, Itoh 2021, 2022, 2023, 2024, 2025). TRP is derived from catch per 100 km search distance on a pre-determined transect line (called piston-line) without model-based standardization. In addition, another recruitment index, the grid-type trolling index (TRG), which uses data from a wider area and is standardized by the generalized linear model (GLM), has been developed and has been reported to CCSBT since 2014 (Itoh and Takahashi 2014).

In 2021, while the trolling survey was conducted, the survey area was limited to off Esperance only due to the influence of COVID-19, which resulted in no surveys on the piston-line. We presented the updated TRG and provided a variation of TRG (TRG_esp) limited to the area off Esperance. In 2022, the trolling survey was carried out in full range scale including piston-line, though still under the influence of COVID-19 to some extent. Since 2023, the trolling survey has been able to be carried out in the same specification as before 2020. In this document, we provide updated TRP and TRG as of 2026.

Materials and methods

1. Piston-line Trolling Index　TRP

For TRP, the data used were the trolling catch data on the piston-line in the acoustic survey in 2005 and 2006 and that in the trolling survey from 2006 to 2014, 2016 to 2020, and 2022 to 2026. Details of the survey were described in other papers that were submitted every year (e.g., Itoh 2026). It contains data a total of 253 times on the piston-line (Table 1). Data from another 12 times were not included because the line was incomplete due mainly to rough sea conditions. Datasets were separated between the acoustic survey and trolling survey because there were differences in the two surveys, such as survey design, the vessel used especially in size, and the specification of trolling gears. Trolling operations on the piston-line were repeated from 7 to 20 times per year.

The piston-line was set off Bremer Bay, in the middle of the whole area for the acoustic and trolling surveys (Fig. 1). The exact locations and length of the line have been changed a few times since its first determination in 2005. The offshore part of the piston line, which had

caught a small number of fish over the past years, was cut and extended towards the coast, in which available to enter for the small vessels used in the trolling survey in 2007. The data in 2005 and 2006 where locate offshore than the 2007 end points were eliminated (no SBT were caught in the eliminated data). The locations of the piston-line have been almost the same from 2008 to the present. Figure 2 shows the piston-line in 2026. The vessel proceeded almost without deviation on the piston line for all seven times.

The summary of data is shown in Table 2. It reached a total of 676 hours in search time and 8,677 km in search distance. The number of age-1 SBT caught was 855 individuals.

TRP was calculated as a catch of age-1 SBT per 100 km search distance. There were five types of catch definition, and TRPs were calculated for each of them.

(1) School of age-1 SBT. A catch of age-1 SBT that apart from 2 km in distance from the last catch of age-1 SBT is defined as a different school. TRP from this definition is "TRI_2km."

(2) School of age-1 SBT. A catch of age-1 SBT that apart from 20 minutes in time from the last catch of age-1 SBT is defined as a different school. TRP from this definition is "TRI_20min."

(3) School of age-1 SBT. A catch of age-1 SBT that apart from 30 minutes in time from the last catch of age-1 SBT is defined as a different school. TRP from this definition is "TRI_30min."

(4) Number of times age-1 SBT caught. All the catches even it was likely to be from the same school were counted as different. TRP from this definition is "TRI_Times.

(5) Number of age-1 SBT individuals. TRP from this definition is "TRI_ind."

Confidence intervals of TRP were calculated from data sampled 1000 times by the bootstrap method, and the results were shown by median, 5% and 95% points.

2. Grid-type Trolling Index　TRG

For TRG, data used were the trolling catch in the acoustic survey between 1996 and 2003, 2005 and 2006, and in the trolling survey between 2006 and 2014, and between 2016 and 2026. While the surveys were carried out from December in some years, the year was referred to that included January in the survey (e.g., the survey extended from December 2008 to January 2009 was referred to as the 2009 survey) in this analysis.

Search distance of trolling, catch of age-1 SBT and CPUE (catch/100km searched) were aggregated by survey type (acoustic survey / trolling survey), year, month, day, hour, longitude (0.1 degree), latitude (0.1 degree) and four area types (described later). Data west of 117.5E were eliminated.

Time intervals of a recording of latitude and longitude during the surveys differed by year. Up to the 2005 acoustic survey, latitude and longitude were only recorded when any events occurred, including hourly environmental observation, catch, detection of anything in sonar, the arrival of the transect reflection point, CTD observation, etc. Then, locations at every one minute were calculated by interpolating two points of records available. Since the 2006 surveys, locations were recorded in a short interval, such as 10 or 15 seconds, by GPS logger devises and mean locations by one minute were used for analysis.

In the acoustic survey, it was planned that trolling was operated in the daytime from 6 AM to 6 PM. Actual times of start and end of trolling were not recorded. Some records of catches before 6 AM and after 6 PM were eliminated. In the trolling survey, all the times of the start and end of trolling operations were recorded.

Catch was limited to age-1 SBT (estimated from fork length of 40-63 cmFL) in the analysis. Catch was defined as a fish school and schools were defined as those successive catches more than 30 minutes apart were from different schools. Other definitions of a school (e.g. 20 minutes apart, 2 km apart) can be possible, however, it has already been confirmed that it caused little difference in the previous analysis.

In the research area, SBT distribution was distinctly different by area type which was categorized as follows (Fig. 1).

lump: Small seamounts or small islands. Its center position was measured on nautical charts.

shelfedge: A range near 200 m isobath. The range was determined from observing SBT catch records that 3.0 km toward inshore and 0.5 km toward offshore.

onshore: the northern area of the shelfedge.

offshore: the southern area of the shelfedge.

The area for each grid was classified as follows. When a part of the shelfedge zone is included in the grid, it is classified as shelfedge, the coastal side is classified as on-shore (or described as on-shelf), and the offshore side is classified as offshore. After that, those whose center position of any lump is included in the grid are classified as lumps. Furthermore, in the case of four lumps (Figure of eight Island, Investigator Island, etc.), where the lump is large or the center of the lump is near the edge of the grid, the adjacent grid that is likely to be affected by the lump is also classified as lump. In the 2021 analysis, the number of lumps to be referred to was increased (170), so the data classification was different from the previous data.

Delta log-normal GLM was applied for CPUE standardization because of a high percentage of zero catch observations (Lo et al. 1992, Li and Jiao 2013). The delta model handles zero

catch data and positive catch data in two separate sub-models, i.e., one sub-model to estimate the probability of catching SBT age-1 with an assumption of a binomial distribution and logit link function (binomial sub-model), and the other to fit the positive catch data with an assumption of a lognormal distribution (CPUE sub-model).

Binomial sub-model:

log(p/(1-p)) ~ year + month + hour + area + survey + offset(log(distance)) + error

error ~ binomial

CPUE sub-model:

log(catch) ~ year + month + hour + area + survey + offset(log(distance)) + error

error ~ gaussian

where p is the probability of positive catch, survey is either acoustic or trolling surveys, explanatory variables of year, month, hour, area and survey are treated as factors.

In this GLM standardization, the explanatory variables for the optimum model were selected based on the AIC using MuMIn package in R software v4.5.2 (R-core team 2012). The MuMIn package calculates the AIC for models of all combinations of the explanatory variables. The lowest AIC model containing the year explanatory variable was selected as the best model. The product of estimates from these two sub-models gives the final estimate of the TRG. Furthermore, the bootstrap method was applied to obtain a range of the estimate. 1000 datasets were made through stratified sampling by year.

Because the survey area in 2021 was limited to the offshore of Esperance due to the survey design temporarily revised in response to the situation of COVID-19, another TRG that was limited to the area off Esperance (TRG_esp) was calculated. Eliminated data before 2012 when there is little data for this calculation, the area east of longitude 121.4E was used. There are two types of areas, onshore and lump. As with TRG, we used a delta model consisting of a binomial sub-model and a CPUE sub-model. The model structure used was similar except for the survey.

Binomial sub-model for TRG_esp:

log(p/(1-p)) ~ year + month + hour + area + offset(log(distance)) + error

error ~ binomial

where p is the probability of positive catch.

CPUE sub-model for TRG_esp:

log(catch) ~ year + month + hour + area + offset(log(distance)) + error

error ~ gaussian

Results

1. Piston-line Trolling Index: TRP

Summary of data on piston-line is shown in Table 2. Figure 3 and Table 3 show the five types of estimated TRP by different school/catch definitions. Figure 4 shows the median of the five types of indices that were adjusted to the mean of each. Small differences were observed among the five type indices except in 2013, where there was a large difference between school indices (TRI_20min, 30min, and 2km) and catch indices (TRI_times and ind.). The relative index of TRI_30min was consistent with the index from the acoustic survey in 2006. The fluctuation in TRI_30min overtime was smaller among the five types of indices. Therefore, the TRI_30min index, which was submitted to the CCSBT data exchange, is used as TRP. SBT age-1 of 10 individuals were caught in the seven piston lines in 2026. The TRP in 2026 decreased from 2025.

2. Grid-type Trolling Index: TRG

Summary of data aggregated by grid is shown in Table 4. It consists of 13,100 records in total that reach about 64,427 km search distance, and 1,099 age-1 schools. One record with anomalously high CPUE (>2000) with a short distance was removed for analysis. Quite a large part of the data was zero catch (91.6%).

Distributions of effort, catch, and CPUE in 2026 are shown in Fig. 5. Those in previous years are available in the previous document (e.g., Itoh 2025). It covers the area from Esperance to Albany through Bremer Bay as usual years. The probability of catch is different by area type, with the largest in lump (12%), followed by onshelf and shelfedge, and lowest in offshore (2.3%) (Table 5). In the positive catch, CPUE by area was higher in lump (53) than other area types (27-28).

Nominal CPUE is shown in Fig. 6. Note that a substantial part of the effort was made up offshore, where few SBT were caught from 1996 to 2005, which is expected to underestimate compared to the latter half period. In 2026, the nominal CPUE decreased from 2025 and was higher than the range in the past nine years.

The selected GLM models for TRG based on the AIC were as follows (Table 6):

Binomial sub-model:

log(p/(1-p)) ~ year + month + area + offset(log(distance)) + error

CPUE sub-model:

log(catch) ~ year + month + area + survey + offset(log(distance)) + error

Relationships between the probability of catch and various variables and between CPUE and various variables in terms of least squares mean are shown in Fig.7 and Fig. 8, respectively. The estimated values of each variable are shown in Table 7 and Table 8. QQ plot of CPUE sub-model is shown in Fig. 9, which shows a good fit in the lower and middle parts, though lack of fit in the high values. LS-means of year trend in each sub-model are shown in Table 9 and Table 10. Indices of both sub-models and point estimation of TRG are shown in Table 11 and Fig. 10.

Table 12 and Fig. 11 show TRG with confidence intervals calculated through 1000-times bootstrap. TRG showed considerably low levels in 2000-2002, then increased in 2005-2008 and reached a relatively high level in 2006-2016 with fluctuations from year to year. TRG values in the recent ten years (2017-2026) have returned to relatively low levels, similar to those in 2000-2002. TRG value for 2026 increased from 2025, while the median is 82 % of the mean over 29 years.

3. Comparison among indices

We compared TRG, TRP, and TRG_esp. The trolling index from grid data limited to off Esperance (TRG_esp) was calculated between 2013 and 2026 (Fig. 12). From the full models, the following models were selected by AIC.

Binomial sub-model:

log(p/(1-p)) ~ year + offset(log(distance)) + error

CPUE sub-model:

log(catch) ~ year + offset(log(distance)) + error

The TRG_esp in 2026 was higher than the average of TRG_esp in 13 years. Figure 13 shows a comparison between TRG and TRG_esp. The two indices are significantly correlated (Pearson's correlation coefficient, $r=0.739$, $p < 0.05$), and general trends are similar to each other, while the increase in 2023 was distinct in TRG_esp. It is suggested that the index derived from the survey area, reduced temporarily in 2021 only off Esperance, represents that from all survey areas.

Figure 14 shows a comparison between TRG and TRP. Two indices are significantly correlated to each other (Pearson's correlation coefficient, $r=0.922$, $p < 0.001$).

Discussion

The present paper provided updated Piston line trolling index (TRP) and Grid-type trolling index (TRG) of age-1 SBT recruitment indices. Both trolling indices are based on catch that is the number of schools. When we encountered SBT school in the survey, the number of fish individuals caught and the catch times could have increased if we handled the trolling line well and/or the vessel moved well to catch up or attract the fish school. The number of fish individuals caught and catch times were decreased when a suspended fishing operation such as several trolling lines was tangled at one catch, and we needed several minutes to solve the tangling. The number of fish individuals or catch time can depend on crew skills in trolling. The number of schools was selected as a catch to avoid the influence of crew skill. However, the definition of catch as a school for the index means to set an assumption that the probability distribution of the size of school (the number of individuals per school) is consistent over years.

TRG is a comprehensive index that includes not only the piston-line but also the whole area surveyed. TRG was enabled to extend the years to as long as 29 years, by adding the trolling data in the acoustic survey from 1996 to 2003. The acoustic survey and the trolling survey were not originally designed to obtain TRG. However, because the acoustic survey was well designed to cruise randomly in the research area for sonar detection, the trolling catch operated simultaneously during the daytime is expected to be a random sampling in the area. While the survey area was concentrated on the piston-line in 2006 and 2007, the trolling survey was also operated in the larger area since 2008, intending to develop TRG. When trolling was operated on a lump, we tried to operate trolling also in the area outside the lump so that collect data to evaluate the SBT distribution difference in area types.

In GLM standardization, the delta method, which is frequently used for data with a high percentage of zero observations, was used. Area type was highly significant in the binomial sub-model. It is well known that the effect of sea bottom topography, such as lumps, on SBT distribution (Hobday and Campbell 2009). It should fully consider the effect of lumps and islands on SBT distribution for survey design. On the other hand, as Tsuda and Itoh (2017) showed, weather conditions have a negligible effect on the standardization of TRG.

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Table 1. Number of times piston-line surveyed

Year	Total	Used for index	Incomplete and not used for index
Acoustic Survey			
2005	21	20	1
2006	22	18	4
Trolling Survey			
2006	16	12	4
2007	14	14	
2008	10	10	
2009	11	10	1
2010	11	11	
2011	12	12	
2012	14	14	
2013	13	13	
2014	14	14	
2016	14	14	
2017	10	10	
2018	9	9	
2019	8	8	
2020	10	10	
2022	15	13	2
2023	12	12	
2024	12	12	
2025	10	10	
2026	7	7	
Total	265	253	12

Table 2. Summary data of the piston-line survey

Acoustic survey

Year	Value	Search hours	Search distance (km)	Date	Start time	End time	sch20min	sch30min	sch2km	hit.times	number SBT	Index sch20min	Index sch30min	Index sch2km	Index hit.times	Index numbser SBT
2005	min	1:57	30.3	2005/1/15	5:45	8:10	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
	max	2:26	30.3	2005/2/15	12:23	14:23	2	2	3	5	11	6.61	6.61	9.92	6.53	6.36
	mean	2:09	30.3	2005/1/30	8:38	10:47	0.70	0.60	0.80	1.00	2.00	2.31	1.98	2.64	3.31	6.61
	total	43:17	605.0				14	12	16	20	40					
2006	min	1:52	29.7	2006/1/15	6:11	8:14	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
	max	2:50	29.7	2006/2/13	14:54	16:50	3	2	6	12	27	10.11	6.74	20.22	40.43	90.97
	mean	2:07	29.7	2006/1/27	10:13	12:21	1.61	1.39	2.50	4.33	7.89	5.43	4.68	8.42	4.60	6.58
	total	38:16	534.2				29	25	45	78	142					

Trolling survey

Year	Value	Search hours (hour)	Search distance (km)	Date	Start time	End time	sch20min	sch30min	sch2km	hit.times	number SBT	Index sch20min	Index sch30min	Index sch2km	Index hit.times	Index numbser SBT
2006	min	2.78	28.3	2006/1/23	5:15	8:19	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
	max	3.43	37.8	2006/1/29	10:16	17:45	3	2	5	7	14	10.33	6.88	16.85	23.58	48.19
	mean	3.03	31.5	2006/1/25	8:02	12:36	1.33	1.25	1.75	2.83	5.58	4.25	3.96	5.61	8.87	17.68
	total	36.30	377.5				16	15	21	34	67					
2007	min	2.23	17.9	2007/1/22	6:46	9:46	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
	max	3.25	35.9	2007/1/28	11:31	18:18	5	5	6	7	21	16.63	16.63	18.11	23.49	69.83
	mean	2.72	31.1	2007/1/25	8:53	13:41	2.00	1.79	2.36	3.07	7.00	6.39	5.72	7.52	9.86	22.59
	total	38.10	435.7				28	25	33	43	98					
2008	min	2.58	34.3	2008/1/21	6:55	9:53	1	1	1	1	1	2.81	2.81	2.81	2.81	2.83
	max	4.42	39.6	2008/1/31	14:26	18:05	3	3	4	4	8	8.59	8.59	10.10	11.30	22.60
	mean	3.15	35.8	2008/1/25	9:23	13:39	1.80	1.80	2.00	2.30	5.00	4.99	4.99	5.53	6.37	13.85
	total	31.48	358.1				18	18	20	23	50					
2009	min	2.03	30.2	2009/1/18	6:23	8:46	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
	max	3.92	35.8	2009/1/28	14:26	17:04	3	3	3	5	11	9.75	9.75	9.75	14.59	32.11
	mean	2.59	33.6	2009/1/21	8:55	12:50	1.18	1.09	1.18	1.55	3.36	3.53	3.26	3.53	4.58	9.92
	total	28.52	369.7				13	12	13	17	37					
2010	min	2.45	34.3	2010/1/20	5:18	7:57	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
	max	3.92	36.2	2010/1/31	13:31	16:06	2	2	3	8	11	5.63	5.53	8.29	22.13	30.40
	mean	2.88	35.7	2010/1/26	8:13	11:57	1.00	0.91	1.18	2.09	3.36	2.79	2.54	3.30	5.86	9.39
	total	31.70	392.6				11	10	13	23	37					
2011	min	2.33	27.6	2011/1/26	5:28	8:28	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
	max	3.33	35.3	2011/2/8	10:32	17:46	4	4	6	10	18	14.47	14.47	18.00	30.01	65.12
	mean	2.77	33.6	2011/1/31	7:41	12:23	2.08	1.67	2.33	3.08	5.92	6.33	5.11	7.07	9.37	18.52
	total	33.28	402.8				25	20	28	37	71					
2012	min	2.52	33.8	2012/1/25	5:21	8:06	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
	max	3.45	36.2	2012/2/7	13:27	16:02	2	2	2	2	5	5.77	5.77	5.77	5.77	14.42
	mean	2.87	35.3	2012/1/31	7:51	11:36	0.57	0.57	0.64	0.64	0.93	1.63	1.63	1.83	1.83	2.66
	total	40.13	493.6				8	8	9	9	13					
2013	min	2.63	33.8	2013/1/19	5:25	8:20	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
	max	3.35	36.0	2013/1/31	13:38	16:21	2	2	3	13	18	5.80	5.80	8.42	37.72	52.23
	mean	2.82	35.2	2013/1/24	8:34	12:25	1.54	1.38	1.77	3.69	7.62	4.35	3.92	5.00	10.48	21.61
	total	36.72	458.0				20	18	23	48	99					
2014	min	2.50	34.3	2014/1/26	5:32	8:15	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
	max	3.07	35.7	2014/2/7	14:45	17:26	3	2	4	7	7	8.41	5.83	11.21	19.62	20.23
	mean	2.77	35.0	2014/1/30	8:45	12:15	1.14	1.00	1.36	1.71	2.36	3.26	2.86	3.88	4.88	6.74
	total	38.77	490.0				16	14	19	24	33					
2016	min	2.37	33.1	2016/1/27	5:40	8:09	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
	max	2.88	35.2	2016/2/8	12:30	16:54	3	3	3	3	9	8.74	8.74	8.74	8.74	25.60
	mean	2.62	34.6	2016/2/2	8:14	11:40	1.50	1.36	1.57	1.71	3.57	4.33	3.92	4.54	4.95	10.26
	total	36.70	484.5				21	19	22	24	50					
2017	min	2.20	33.4	2017/1/31	5:54	8:14	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
	max	2.58	37.0	2017/2/7	13:05	17:03	2	2	2	2	5	5.76	5.76	5.76	5.76	14.96
	mean	2.41	34.9	2017/2/2	8:36	11:57	0.60	0.60	0.60	0.60	1.90	1.71	1.71	1.71	1.71	5.44
	total	24.12	349.2				6	6	6	6	19					
2018	min	2.27	33.2	2018/2/4	6:15	9:16	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
	max	2.58	35.4	2018/2/12	14:53	17:12	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
	mean	2.38	34.6	2018/2/7	11:00	13:33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	total	21.45	311.1				0	0	0	0	0					
2019	min	2.62	34.8	2019/2/3	5:55	8:40	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
	max	2.90	36.2	2019/2/11	14:14	17:21	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
	mean	2.75	35.5	2019/2/5	8:37	11:30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	total	21.98	284.2				0	0	0	0	0					
2020	min	2.38	33.6	2020/2/1	6:17	9:15	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
	max	2.87	36.1	2020/2/11	13:41	16:22	2	2	2	2	8	5.86	5.86	5.86	5.86	22.76
	mean	2.56	34.8	2020/2/6	9:06	12:30	0.60	0.60	0.60	0.70	2.00	1.72	1.72	1.72	2.01	5.75
	total	25.63	348.2				6	6	6	7	20					
2022	min	1.80	30.5	2022/2/13	6:30	8:34	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
	max	2.83	36.1	2022/2/20	16:14	18:08	1	1	1	2	5	3.11	3.11	3.11	5.54	13.85
	mean	2.33	33.9	2022/2/16	10:38	13:08	0.31	0.31	0.31	0.38	1.00	0.90	0.90	0.90	1.11	2.89
	total	30.27	441.2				4	4	4	5	13					
2023	min	2.75	38.5	2023/2/2	5:55	9:25	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
	max	5.15	45.2	2023/2/10	11:40	16:02	1	1	1	1	1	2.26	2.26	2.26	2.26	2.26
	mean	3.31	43.7	2023/2/5	8:16	12:47	0.08	0.08	0.08	0.08	0.08	0.19	0.19	0.19	0.19	0.19
	total	39.68	524.3				1	1	1	1	1					
2024	min	2.55	34.4	2024/2/2	6:10	9:00	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
	max	3.88	36.4	2024/2/12	13:31	17:02	2	2	3	3	5	5.50	5.50	8.25	8.25	14.25
	mean	2.89	35.3	2024/2/6	8:46	12:31	0.33	0.33	0.42	0.42	1.00	0.93	0.93	1.16	1.16	2.82
	total	34.67	423.5				4	4	5	5	12					
2025	min	2.38	34.5	2025/2/7	6:32	8:58	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
	max	2.80	35.4	2025/2/16	11:53	15:47	3	3	3	4	17	8.55	8.55	8.55	11.40	48.01
	mean	2.56	35.1	2025/2/11	8:51	12:06	0.8	0.7	1.2	1	4	2.28	1.99	3.41	3.98	12.21
	total	25.62	350.8				8	7	12	14	43					
2026	min	2.38	33.0	2026/2/7	6:29	8:52	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
	max	3.02	35.5	2026/2/19	15:00	17:45	1	1	2	4	8	2.89	2.89	5.73	11.46	22.92
	mean	2.69	34.6	2026/2/14	8:58	11:56	0.29	0.29	0.43	0.71	1.43	0.82	0.82	1.23	2.05	4.10
	total	18.85	242.4				2	2	3	5	10					

A part of the data not used for TRP has already been excluded.

Table 3. Piston-line Trolling Index value

index	Survey	Year	Minimum	5%	Median	95%	Maximum
sch20min	Acoustic	2005	0.496	1.322	2.314	3.471	4.297
	Acoustic	2006	3.369	4.493	5.429	6.364	7.113
	Trolling	2006	2.277	3.018	4.254	5.692	6.830
	Trolling	2007	2.826	4.474	6.385	8.431	10.487
	Trolling	2008	3.113	3.955	4.995	6.092	6.927
	Trolling	2009	1.031	2.080	3.536	5.060	6.624
	Trolling	2010	1.011	1.782	2.795	3.817	4.794
	Trolling	2011	1.699	4.598	6.333	8.346	9.972
	Trolling	2012	0.414	0.811	1.622	2.440	3.275
	Trolling	2013	2.580	3.482	4.359	5.034	5.692
	Trolling	2014	1.226	2.247	3.257	4.294	5.271
		2015					
	Trolling	2016	1.450	2.845	4.349	5.796	6.984
	Trolling	2017	0.000	0.836	1.702	2.826	3.470
	Trolling	2018	0.000	0.000	0.000	0.000	0.000
	Trolling	2019	0.000	0.000	0.000	0.000	0.000
	Trolling	2020	0.000	0.849	1.723	2.850	4.059
	Trolling	2021					
	Trolling	2022	0.000	0.239	0.896	1.547	2.067
	Trolling	2023	0.000	0.000	0.188	0.565	0.941
	Trolling	2024	0.000	0.236	0.932	1.849	3.267
	Trolling	2025	0.000	0.855	2.276	3.700	5.702
	Trolling	2026	0.000	0.000	0.822	1.643	2.462
sch30min	Acoustic	2005	0.331	1.157	1.983	2.975	3.801
	Acoustic	2006	3.182	3.931	4.680	5.429	5.990
	Trolling	2006	1.836	2.970	3.971	4.940	5.577
	Trolling	2007	1.945	3.917	5.732	7.803	9.959
	Trolling	2008	3.110	3.943	4.993	6.018	6.906
	Trolling	2009	0.761	1.852	3.188	4.734	6.591
	Trolling	2010	0.517	1.541	2.538	3.535	4.539
	Trolling	2011	1.957	3.416	5.085	6.791	9.192
	Trolling	2012	0.397	0.811	1.618	2.432	3.269
	Trolling	2013	2.379	3.046	3.918	4.802	5.278
	Trolling	2014	1.225	2.030	2.859	3.690	4.335
		2015					
	Trolling	2016	1.440	2.679	4.046	5.333	7.091
	Trolling	2017	0.279	0.839	1.711	2.848	4.017
	Trolling	2018	0.000	0.000	0.000	0.000	0.000
	Trolling	2019	0.000	0.000	0.000	0.000	0.000
	Trolling	2020	0.000	0.842	1.718	2.623	4.066
	Trolling	2021					
	Trolling	2022	0.000	0.239	0.887	1.559	2.036
	Trolling	2023	0.000	0.000	0.188	0.565	1.129
	Trolling	2024	0.000	0.236	0.932	1.862	2.764
	Trolling	2025	0.000	0.848	1.991	3.422	5.416
	Trolling	2026	0.000	0.000	0.822	1.643	2.459
sch2km	Acoustic	2005	0.331	1.322	2.644	3.967	5.289
	Acoustic	2006	5.054	6.364	8.236	10.670	13.478
	Trolling	2006	2.404	3.497	5.589	8.115	12.275
	Trolling	2007	2.840	4.992	7.600	10.133	12.226
	Trolling	2008	3.386	4.490	5.510	6.673	7.850
	Trolling	2009	0.551	2.082	3.518	5.216	6.625
	Trolling	2010	0.771	2.035	3.304	4.574	6.546
	Trolling	2011	3.127	4.662	6.936	9.621	11.888
	Trolling	2012	0.596	1.007	1.835	2.828	3.873
	Trolling	2013	2.842	3.923	5.000	6.052	6.707
	Trolling	2014	1.627	2.643	3.862	5.298	7.278
		2015					
	Trolling	2016	1.640	3.130	4.561	5.832	6.821
	Trolling	2017	0.000	0.849	1.709	2.819	4.036
	Trolling	2018	0.000	0.000	0.000	0.000	0.000
	Trolling	2019	0.000	0.000	0.000	0.000	0.000
	Trolling	2020	0.000	0.586	1.723	2.620	3.763
	Trolling	2021					
	Trolling	2022	0.000	0.239	0.899	1.562	2.243
	Trolling	2023	0.000	0.000	0.188	0.565	0.941
	Trolling	2024	0.000	0.236	0.949	2.320	3.909
	Trolling	2025	0.000	1.431	3.411	5.144	7.383
	Trolling	2026	0.000	0.000	1.231	2.462	4.506
hit.times	Acoustic	2005	0.331	1.653	3.306	5.124	7.107
	Acoustic	2006	7.488	9.921	14.414	19.468	25.083
	Trolling	2006	3.082	5.081	8.757	12.538	15.902
	Trolling	2007	2.983	6.462	9.747	13.432	15.768
	Trolling	2008	3.706	4.802	6.343	7.927	9.235
	Trolling	2009	0.521	2.400	4.534	6.786	8.877
	Trolling	2010	1.017	3.039	5.853	9.460	14.285
	Trolling	2011	2.903	5.700	9.007	13.378	16.874
	Trolling	2012	0.397	1.005	1.824	2.837	3.669
	Trolling	2013	4.762	6.518	10.215	15.174	18.969
	Trolling	2014	1.846	3.031	4.697	7.126	9.059
		2015					
	Trolling	2016	2.073	3.493	4.956	6.589	8.206
	Trolling	2017	0.270	0.836	1.709	2.835	3.460
	Trolling	2018	0.000	0.000	0.000	0.000	0.000
	Trolling	2019	0.000	0.000	0.000	0.000	0.000
	Trolling	2020	0.277	0.863	1.997	3.185	4.927
	Trolling	2021					
	Trolling	2022	0.000	0.426	1.110	1.976	3.032
	Trolling	2023	0.000	0.000	0.188	0.565	0.941
	Trolling	2024	0.000	0.236	1.159	2.535	3.909
	Trolling	2025	0.000	1.709	3.988	6.511	8.511
	Trolling	2026	0.000	0.000	2.050	4.912	8.187
number SBT	Acoustic	2005	0.661	3.140	6.446	10.578	15.371
	Acoustic	2006	12.355	18.157	26.394	35.753	52.039
	Trolling	2006	5.252	9.928	17.214	25.477	34.511
	Trolling	2007	9.036	14.091	22.339	31.975	41.992
	Trolling	2008	7.942	10.712	13.847	16.826	19.820
	Trolling	2009	1.806	5.204	9.677	15.056	20.433
	Trolling	2010	2.531	4.911	9.191	14.246	18.051
	Trolling	2011	5.347	9.269	18.249	28.709	42.850
	Trolling	2012	0.404	1.206	2.622	4.513	5.788
	Trolling	2013	9.448	15.352	21.585	28.254	35.290
	Trolling	2014	2.421	4.138	6.661	9.600	12.271
		2015					
	Trolling	2016	3.515	6.612	10.276	14.342	18.443
	Trolling	2017	0.000	2.471	5.353	8.595	11.456
	Trolling	2018	0.000	0.000	0.000	0.000	0.000
	Trolling	2019	0.000	0.000	0.000	0.000	0.000
	Trolling	2020	0.277	2.003	5.521	9.489	13.765
	Trolling	2021					
	Trolling	2022	0.000	0.922	2.892	5.180	7.660
	Trolling	2023	0.000	0.000	0.188	0.565	1.129
	Trolling	2024	0.000	0.687	2.575	5.194	8.026
	Trolling	2025	0.859	4.791	11.901	21.267	27.478
	Trolling	2026	0.000	0.000	4.099	9.824	13.923

Table 4. Data summary for Grid-type Trolling Index (TRG)

Survey	Year	N_Record	Time_Min	Time_Max	Range			
					South	North	West	East
Acoustic	1996	385	21 Jan. 1996 06:00	13 Feb. 1996 17:00	-35.2	-34.4	118.2	121.7
	1997	459	26 Jan. 1997 09:00	26 Feb. 1997 12:00	-35.3	-34.0	117.5	121.8
	1998	469	19 Jan. 1998 06:00	24 Feb. 1998 17:00	-35.4	-34.4	117.7	121.7
	1999	596	21 Jan. 1999 06:00	14 Mar. 1999 17:00	-35.4	-34.0	118.0	121.8
	2000	626	19 Jan. 2000 06:00	14 Mar. 2000 14:00	-35.4	-34.0	117.5	122.5
	2001	686	22 Jan. 2001 06:00	14 Mar. 2001 16:00	-35.4	-33.9	117.5	121.9
	2002	578	22 Jan. 2002 06:00	14 Mar. 2002 15:00	-35.4	-33.9	117.5	121.9
	2003	463	25 Dec. 2002 08:00	28 Jan. 2003 15:00	-35.3	-33.9	117.9	121.9
	2005	806	14 Jan. 2005 06:00	04 Mar. 2005 16:00	-35.3	-33.9	117.5	121.9
	2006	756	12 Jan. 2006 06:00	18 Feb. 2006 13:00	-35.4	-34.0	117.5	121.9
Trolling	2006	198	22 Jan. 2006 08:00	31 Jan. 2006 15:00	-34.8	-34.1	119.3	121.3
	2007	181	21 Jan. 2007 10:00	29 Jan. 2007 07:00	-34.8	-34.1	119.3	121.3
	2008	334	20 Jan. 2008 09:00	01 Feb. 2008 08:00	-35.5	-34.1	117.6	121.3
	2009	359	03 Dec. 2008 10:00	29 Jan. 2009 07:00	-35.5	-34.1	117.5	121.3
	2010	381	19 Jan. 2010 08:00	04 Feb. 2010 17:00	-35.5	-34.1	117.7	123.4
	2011	375	25 Jan. 2011 08:00	11 Feb. 2011 10:00	-35.5	-34.1	117.8	121.8
	2012	372	24 Jan. 2012 08:00	10 Feb. 2012 11:00	-35.5	-34.0	117.9	121.9
	2013	402	19 Jan. 2013 06:00	04 Feb. 2013 12:00	-35.5	-33.9	117.9	122.1
	2014	413	25 Jan. 2014 08:00	11 Feb. 2014 10:00	-35.4	-34.0	117.6	123.2
	2016	399	26 Jan. 2016 08:00	12 Feb. 2016 12:00	-35.5	-34.0	117.7	122.3
	2017	384	27 Jan. 2017 06:00	13 Feb. 2017 11:00	-34.9	-33.9	118.8	122.4
	2018	453	31 Jan. 2018 06:00	17 Feb. 2018 13:00	-34.9	-33.9	118.8	122.3
	2019	415	31 Jan. 2019 07:00	18 Feb. 2019 12:00	-35.5	-34.0	117.7	122.5
	2020	369	30 Jan. 2020 07:00	15 Feb. 2020 10:00	-35.3	-34.0	117.8	122.2
	2021	235	03 Feb. 2021 06:00	20 Feb. 2021 14:00	-34.4	-33.9	121.5	122.2
	2022	354	31 Jan. 2022 06:00	26 Feb. 2022 15:00	-34.9	-33.9	119.3	122.2
	2023	404	31 Jan. 2023 07:00	14 Feb. 2023 10:00	-35.3	-33.9	117.8	122.2
	2024	473	30 Jan. 2024 07:00	16 Feb. 2024 10:00	-35.5	-33.9	117.8	122.2
	2025	357	04 Feb. 2025 07:00	21 Feb. 2025 12:00	-35.3	-33.9	117.8	122.2
	2026	418	04 Feb. 2026 07:00	24 Feb. 2026 10:00	-35.3	-33.9	117.8	122.2

Survey	Year	Distance searched (km)					SBT Catch
		Total	Offshore	Shelfedge	On Shore	Lump	
Acoustic	1996	2,765	1,498	1,192	75		21
	1997	3,134	1,589	1,019	438	88	38
	1998	3,214	1,657	1,184	324	49	34
	1999	3,961	2,080	1,317	493	71	56
	2000	4,049	1,906	1,375	685	82	17
	2001	4,388	1,809	1,125	954	501	20
	2002	3,783	1,699	1,055	815	214	9
	2003	2,865	854	1,220	649	143	29
	2005	5,054	1,418	1,624	1,348	665	62
	2006	3,884	1,380	1,584	817	103	84
Trolling	2006	910	222	378	281	29	27
	2007	904	163	423	309	9	33
	2008	1,149	213	407	440	90	44
	2009	1,402	257	467	550	127	41
	2010	1,499	294	432	566	207	56
	2011	1,392	265	447	571	108	58
	2012	1,394	221	385	566	221	38
	2013	1,516	234	392	716	174	50
	2014	1,597	176	427	811	184	50
	2016	1,508	268	354	745	140	68
	2017	1,471	131	194	1,009	137	27
	2018	1,734	318	270	943	203	26
	2019	1,445	154	156	819	316	16
	2020	1,342	221	255	563	303	34
	2021	916			730	186	19
	2022	1,352	295	263	649	145	16
	2023	1,449	309	277	551	313	28
	2024	1,641	298	232	783	328	27
	2025	1,235	137	165	668	264	37
	2026	1,472	165	171	787	349	34
Total		64,427	20,231	18,789	19,655	5,752	1,099

SBT Catch is the number of schools with the definition that 30 minutes is necessary to be a different school from the last catch.

Table 5. Summary data by area type

Area	N_records	Catch	CPUE		
	All	positive catch	% positive	Mean	SD
Lump	2,037	247	12.1%	52.5	232.7
Offshore	4,009	94	2.3%	26.7	31.1
OnShelf	4,294	431	10.0%	27.8	77.1
Shelfedge	3,523	327	9.3%	26.5	38.4
Total	13,863	1,099	7.9%		

Table 6. AIC and selected models for two sub-models in TRG

	model	AIC	Model
Binomial sub-model	full	6561.6	pn~fyear + fmonth + fhour + farea + survey + offset(log(dist))
	AIC selected	6544.6	pn~fyear + fmonth + farea + offset(log(dist))
CPUE sub-model	full	2369.9	catch~fyear + fmonth + fhour + farea + survey + offset(log(dist))
	AIC selected	2356.1	catch~fyear + fmonth + farea + survey + offset(log(dist))

Table 7. Estimated values by GLM for binomial sub-model of TRG

	Estimate	Std. Error	z value	Pr (>| z |)	Significance
(Intercept)	-3.34897	0.25977	-12.89219	4.98.E-38	***
fyear1997	0.39034	0.29477	1.32422	1.85.E-01	
fyear1998	0.31437	0.29689	1.05889	2.90.E-01	
fyear1999	0.85298	0.28021	3.04405	2.33.E-03	**
fyear2000	-0.61097	0.33737	-1.81099	7.01.E-02	
fyear2001	-0.69423	0.33516	-2.07134	3.83.E-02	*
fyear2002	-1.15918	0.40166	-2.88598	3.90.E-03	**
fyear2003	-0.17107	0.32330	-0.52913	5.97.E-01	
fyear2005	-0.02549	0.27522	-0.09263	9.26.E-01	
fyear2006	0.93181	0.25950	3.59073	3.30.E-04	***
fyear2007	1.32209	0.32121	4.11594	3.86.E-05	***
fyear2008	1.19692	0.30079	3.97921	6.91.E-05	***
fyear2009	0.87344	0.30565	2.85763	4.27.E-03	**
fyear2010	1.11745	0.28864	3.87138	1.08.E-04	***
fyear2011	1.36744	0.28224	4.84502	1.27.E-06	***
fyear2012	0.74595	0.29911	2.49394	1.26.E-02	*
fyear2013	0.96714	0.29074	3.32651	8.79.E-04	***
fyear2014	0.90932	0.28660	3.17279	1.51.E-03	**
fyear2016	1.44433	0.27836	5.18881	2.12.E-07	***
fyear2017	0.20901	0.31920	0.65478	5.13.E-01	
fyear2018	0.05609	0.32051	0.17500	8.61.E-01	
fyear2019	-0.42475	0.35501	-1.19644	2.32.E-01	
fyear2020	0.58765	0.30623	1.91899	5.50.E-02	
fyear2021	0.20540	0.34745	0.59116	5.54.E-01	
fyear2022	-0.11366	0.35494	-0.32022	7.49.E-01	
fyear2023	0.33119	0.31622	1.04733	2.95.E-01	
fyear2024	0.05884	0.31850	0.18475	8.53.E-01	
fyear2025	0.63472	0.30737	2.06501	3.89.E-02	*
fyear2026	0.29329	0.31075	0.94384	3.45.E-01	
fmonth2	-0.04125	0.08634	-0.47777	6.33.E-01	
fmonth3	-0.80203	0.25175	-3.18590	1.44.E-03	**
fmonth12	0.28052	0.32386	0.86617	3.86.E-01	
fareaOffshore	-2.28794	0.13727	-16.66768	2.25.E-62	***
fareaOnShore	-0.75120	0.09234	-8.13477	4.13.E-16	***
fareaShelfedge	-0.97330	0.10249	-9.49667	2.17.E-21	***

Significances are *** < 0.001, ** < 0.01 and * < 0.05.

Table 8. Estimate values by GLM for CPUE sub-model of TRG

	Estimate	Std. Error	t value	Pr (>| t |)	Significance
(Intercept)	-0.07947	0.17284	-0.45981	6.46.E-01	
fyear1997	-0.53191	0.20030	-2.65552	8.04.E-03	**
fyear1998	-0.51657	0.20121	-2.56737	1.04.E-02	*
fyear1999	-0.20918	0.18654	-1.12137	2.62.E-01	
fyear2000	-0.16047	0.23348	-0.68728	4.92.E-01	
fyear2001	-0.54771	0.23105	-2.37051	1.79.E-02	*
fyear2002	-0.09877	0.27940	-0.35352	7.24.E-01	
fyear2003	0.04945	0.20830	0.23741	8.12.E-01	
fyear2005	-0.20834	0.18532	-1.12419	2.61.E-01	
fyear2006	-0.29641	0.17756	-1.66930	9.54.E-02	
fyear2007	-0.61014	0.25861	-2.35936	1.85.E-02	*
fyear2008	-0.34907	0.25104	-1.39050	1.65.E-01	
fyear2009	-0.75932	0.25177	-3.01597	2.62.E-03	**
fyear2010	-0.60961	0.24673	-2.47076	1.36.E-02	*
fyear2011	-0.38085	0.24481	-1.55569	1.20.E-01	
fyear2012	-0.78611	0.25534	-3.07874	2.13.E-03	**
fyear2013	-0.48995	0.24990	-1.96055	5.02.E-02	
fyear2014	-0.77510	0.24899	-3.11299	1.90.E-03	**
fyear2016	-0.52916	0.24308	-2.17688	2.97.E-02	*
fyear2017	-0.64381	0.26860	-2.39689	1.67.E-02	*
fyear2018	-0.35143	0.26958	-1.30362	1.93.E-01	
fyear2019	-0.64693	0.29208	-2.21489	2.70.E-02	*
fyear2020	-0.83251	0.25903	-3.21391	1.35.E-03	**
fyear2021	-0.81083	0.28173	-2.87806	4.08.E-03	**
fyear2022	-0.42008	0.28921	-1.45250	1.47.E-01	
fyear2023	-0.76229	0.26542	-2.87205	4.16.E-03	**
fyear2024	-0.61309	0.26741	-2.29267	2.21.E-02	*
fyear2025	-0.79205	0.25845	-3.06462	2.24.E-03	**
fyear2026	-0.58049	0.26221	-2.21384	2.71.E-02	*
fareaOffshore	-0.29071	0.09493	-3.06234	2.25.E-03	**
fareaOnShore	-0.36907	0.05978	-6.17369	9.54.E-10	***
fareaShelfedge	-0.40077	0.07050	-5.68454	1.70.E-08	***
surveyTR	0.36350	0.15737	2.30981	2.11.E-02	*

Significances are *** < 0.001, ** < 0.01 and * < 0.05

Table 9. Year trends of binomial sub-model of TRG

Year	Mean	Mean-SE	Mean+SE
1996	0.1286	0.0956	0.1617
1997	0.1748	0.1387	0.2108
1998	0.1649	0.1301	0.1997
1999	0.2434	0.2030	0.2838
2000	0.0764	0.0548	0.0980
2001	0.0710	0.0513	0.0907
2002	0.0465	0.0298	0.0631
2003	0.1117	0.0861	0.1373
2005	0.1260	0.1012	0.1507
2006	0.2565	0.2191	0.2940
2007	0.3271	0.2707	0.3835
2008	0.3036	0.2540	0.3532
2009	0.2468	0.2037	0.2898
2010	0.2890	0.2432	0.3349
2011	0.3358	0.2874	0.3843
2012	0.2262	0.1838	0.2686
2013	0.2626	0.2186	0.3065
2014	0.2527	0.2099	0.2956
2016	0.3508	0.3027	0.3990
2017	0.1520	0.1170	0.1870
2018	0.1346	0.1023	0.1669
2019	0.0900	0.0638	0.1161
2020	0.2022	0.1614	0.2430
2021	0.1516	0.1127	0.1904
2022	0.1171	0.0844	0.1499
2023	0.1671	0.1298	0.2044
2024	0.1349	0.1029	0.1668
2025	0.2091	0.1671	0.2512
2026	0.1623	0.1266	0.1980

Table 10. Year trends of CPUE sub-model of TRG

Year	Mean	Mean-SE	Mean+SE
1996	2.1397	1.9391	2.3403
1997	1.6078	1.4419	1.7737
1998	1.6232	1.4542	1.7921
1999	1.9305	1.7813	2.0798
2000	1.9793	1.7735	2.1850
2001	1.5920	1.3924	1.7916
2002	2.0410	1.7851	2.2968
2003	2.1892	2.0128	2.3655
2005	1.9314	1.7850	2.0778
2006	1.8433	1.7235	1.9631
2007	1.5296	1.3564	1.7027
2008	1.7907	1.6318	1.9495
2009	1.3804	1.2206	1.5402
2010	1.5301	1.3800	1.6802
2011	1.7589	1.6108	1.9070
2012	1.3536	1.1898	1.5175
2013	1.6498	1.4954	1.8042
2014	1.3646	1.2111	1.5181
2016	1.6106	1.4673	1.7538
2017	1.4959	1.3124	1.6794
2018	1.7883	1.6039	1.9727
2019	1.4928	1.2766	1.7090
2020	1.3072	1.1379	1.4766
2021	1.3289	1.1263	1.5315
2022	1.7196	1.5050	1.9343
2023	1.3774	1.1984	1.5565
2024	1.5266	1.3441	1.7092
2025	1.3477	1.1789	1.5164
2026	1.5592	1.3855	1.7329

Table 11. Point estimates of TRG

Year	Prob*Pos	Standardized
1996	0.2752	0.8946
1997	0.2810	0.9134
1998	0.2677	0.8703
1999	0.4699	1.5275
2000	0.1513	0.4919
2001	0.1130	0.3674
2002	0.0948	0.3083
2003	0.2445	0.7948
2005	0.2433	0.7909
2006	0.4729	1.5372
2007	0.5004	1.6266
2008	0.5436	1.7671
2009	0.3406	1.1073
2010	0.4423	1.4377
2011	0.5907	1.9203
2012	0.3062	0.9953
2013	0.4332	1.4081
2014	0.3449	1.1212
2016	0.5651	1.8369
2017	0.2274	0.7391
2018	0.2407	0.7824
2019	0.1343	0.4367
2020	0.2643	0.8592
2021	0.2014	0.6547
2022	0.2014	0.6549
2023	0.2301	0.7481
2024	0.2059	0.6694
2025	0.2819	0.9163
2026	0.2530	0.8226

Table 12. TRG with confidence intervals calculated by 1000-times bootstrap

Year	5 percentile	25 percentile	Median	75 percentile	95 pecentile
1996	0.702	0.811	0.900	0.955	1.072
1997	0.772	0.871	0.915	0.991	1.061
1998	0.722	0.814	0.869	0.939	1.035
1999	1.352	1.464	1.537	1.629	1.735
2000	0.426	0.462	0.494	0.533	0.576
2001	0.298	0.339	0.361	0.389	0.461
2002	0.233	0.284	0.310	0.342	0.373
2003	0.655	0.747	0.796	0.848	0.916
2004					
2005	0.693	0.753	0.805	0.848	0.900
2006	1.398	1.490	1.538	1.607	1.669
2007	1.459	1.553	1.622	1.684	1.803
2008	1.605	1.673	1.754	1.854	1.960
2009	0.992	1.054	1.093	1.143	1.250
2010	1.293	1.385	1.449	1.504	1.553
2011	1.785	1.839	1.908	1.980	2.098
2012	0.886	0.953	0.989	1.036	1.111
2013	1.238	1.353	1.414	1.471	1.574
2014	1.012	1.078	1.119	1.165	1.220
2015					
2016	1.634	1.732	1.831	1.898	2.002
2017	0.645	0.701	0.743	0.777	0.837
2018	0.658	0.729	0.772	0.817	0.901
2019	0.371	0.399	0.430	0.464	0.493
2020	0.758	0.827	0.865	0.901	0.995
2021	0.505	0.598	0.665	0.712	0.789
2022	0.531	0.606	0.644	0.687	0.773
2023	0.645	0.704	0.758	0.806	0.873
2024	0.566	0.614	0.648	0.695	0.773
2025	0.787	0.862	0.905	0.944	1.014
2026	0.723	0.778	0.821	0.871	0.930

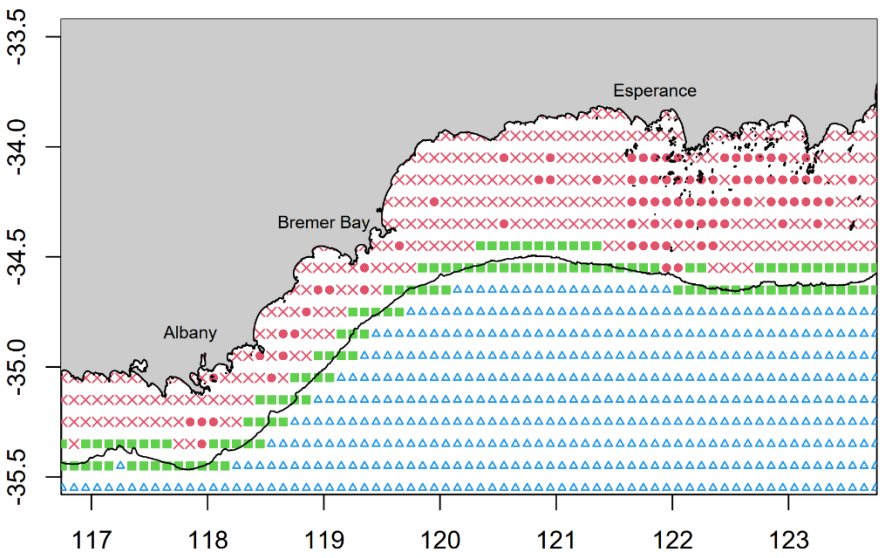


Fig. 1. Map and area classified.

Red cross denotes on-shore, red solid circle denotes lump, green solid square denotes shelf-edge, and open blue triangle denotes offshore.

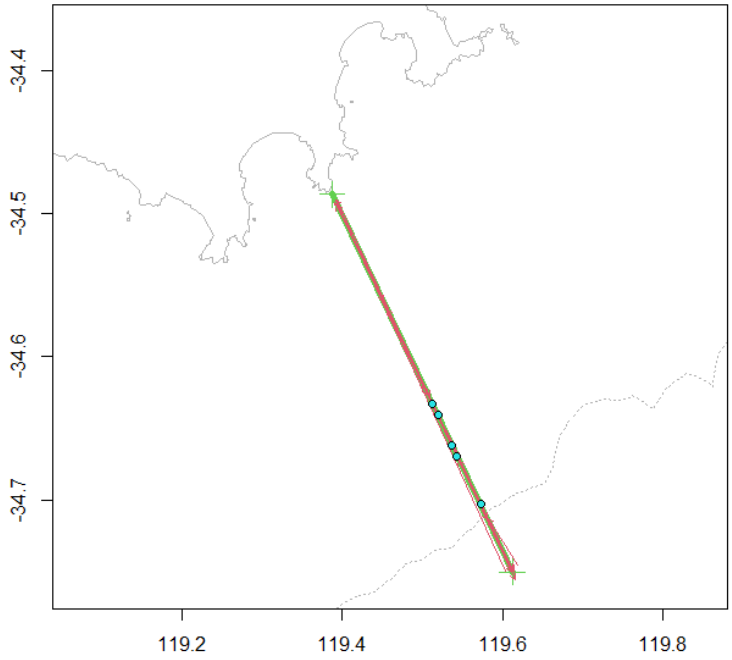


Fig. 2. Locations of the piston-line off Bremer Bay in the 2026 survey.

Green cross marks are defined end points of the piston line. Red arrow denotes each of the piston lines and direction. Circles denote locations where age-1 SBT were caught. Dotted line is the 200 m isobath.

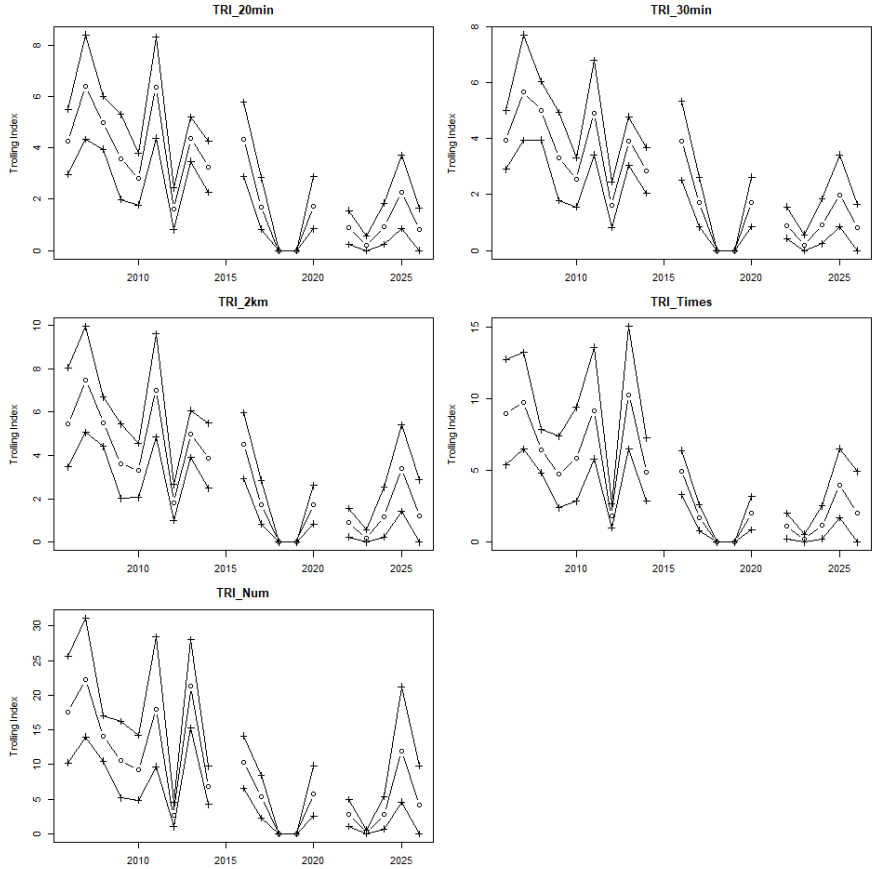


Fig. 3. Five types of the piston-line trolling index (TRP) by different school/catch definitions.
Showing median, 5 and 95 percentiles.

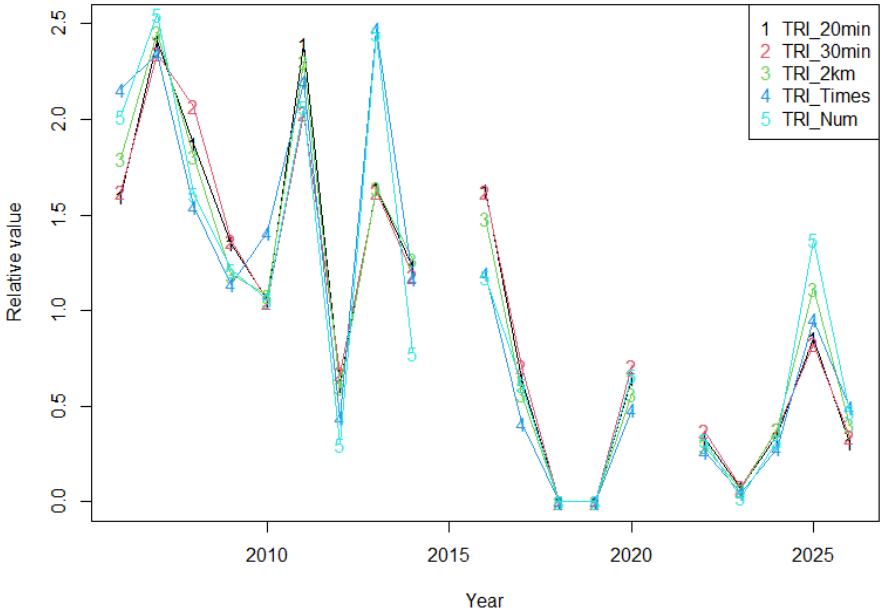


Fig. 4. Comparison of the median from five types of piston-line trolling index (TRP) by different school/catch definitions.
Standardized with the mean of each index.

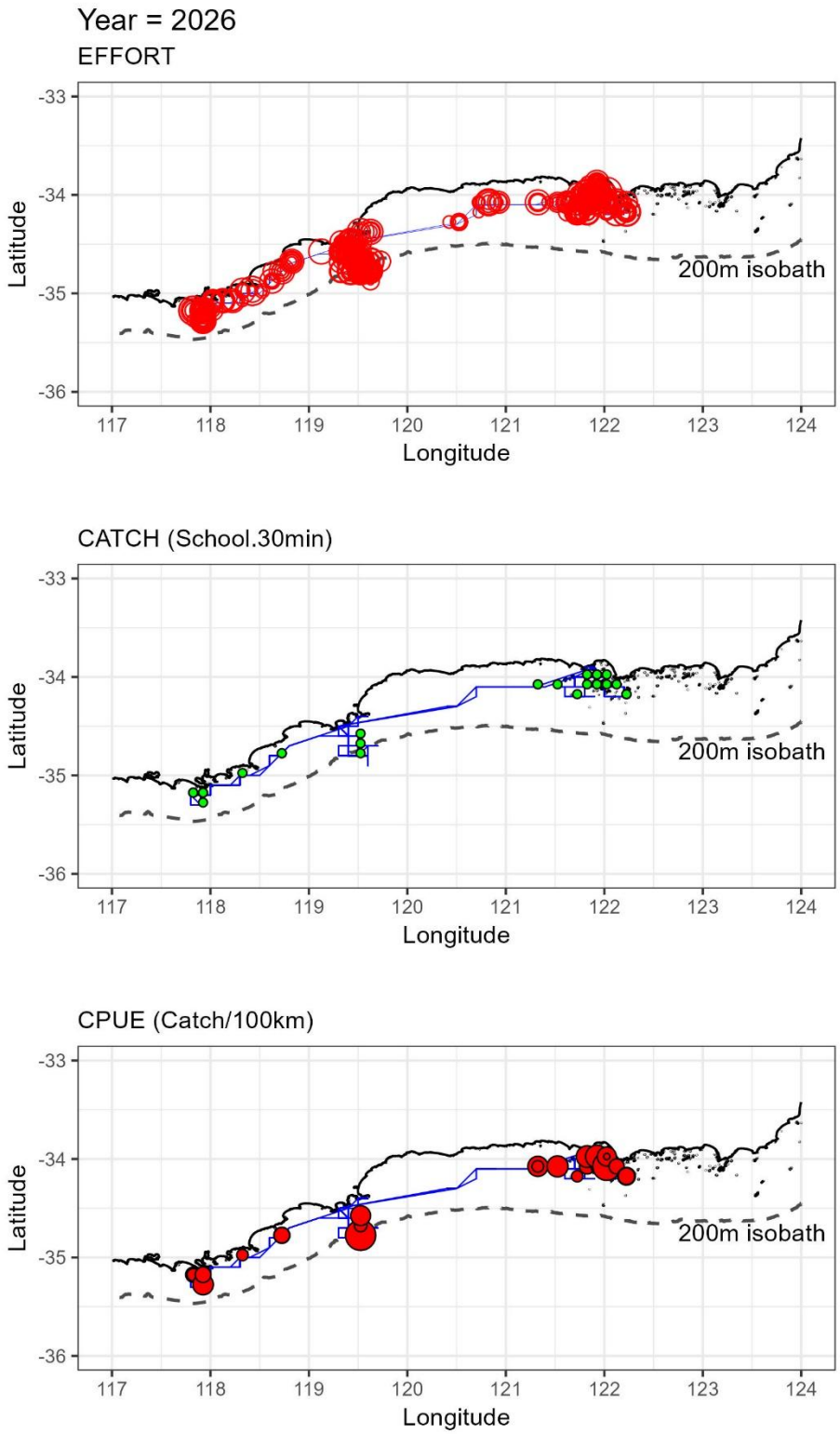


Fig. 5. Distributions of effort, age-1 SBT catch and CPUE in the 2026 survey

Blue line is the trajectory of the vessel while trolling.

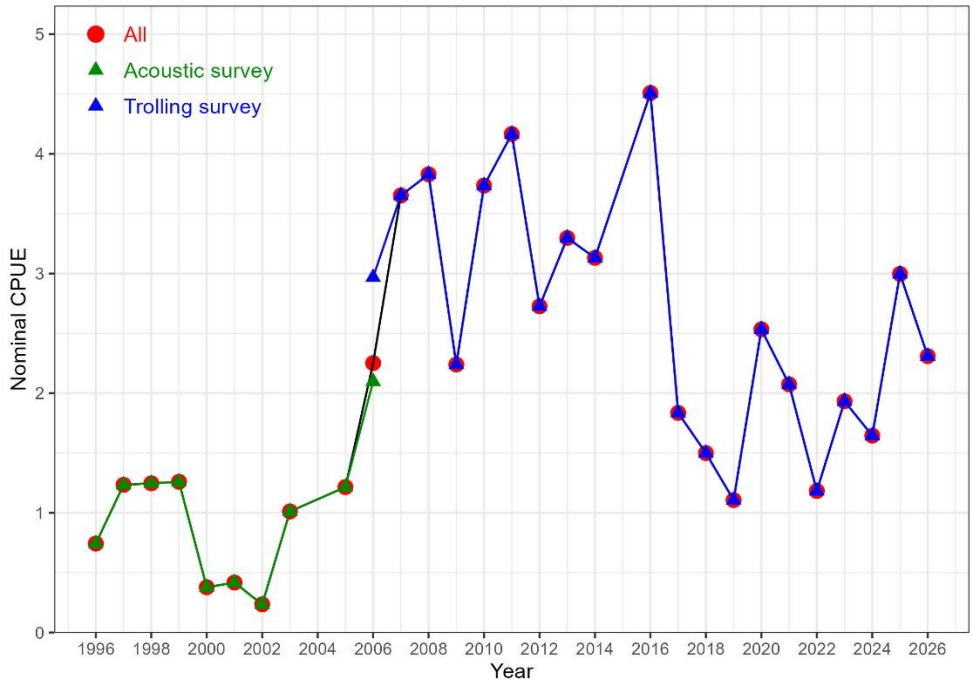


Fig. 6. Nominal CPUE of TRG.

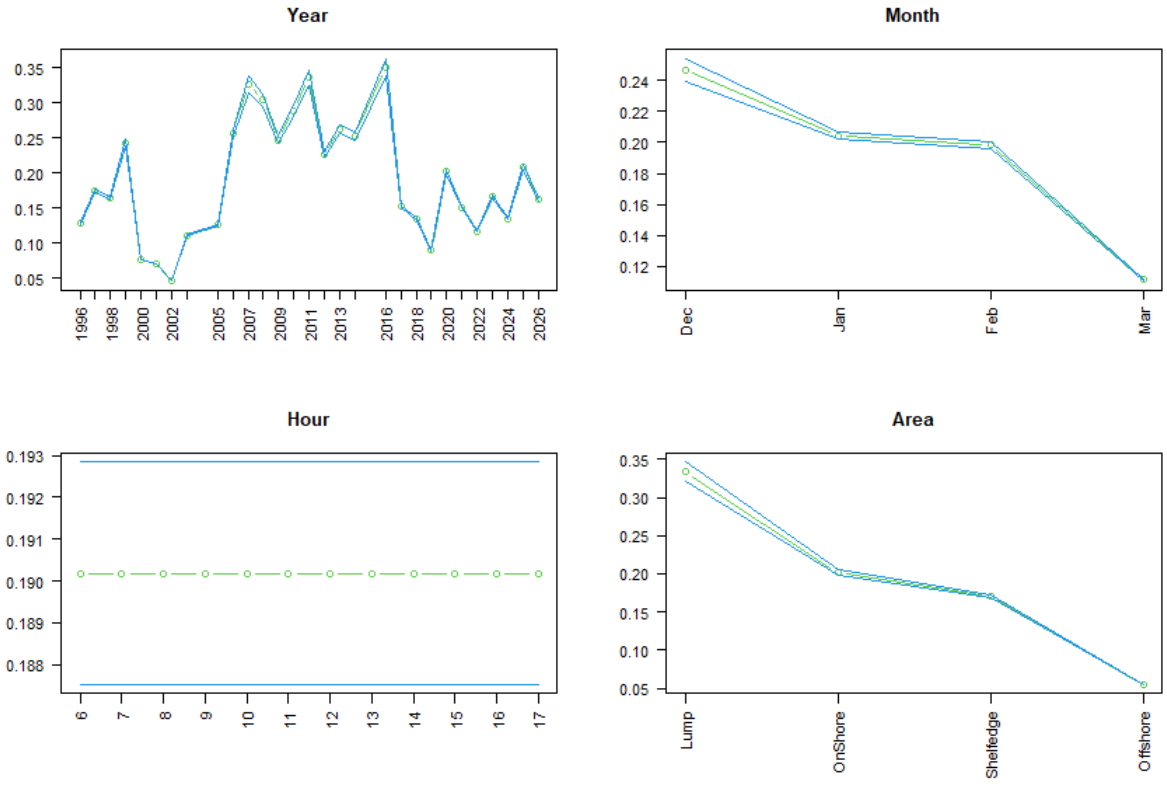


Fig. 7. Least squares means of variables in binomial sub-model for TRG.

Green is the mean, and blue is mean±SD. Catch was defined as schools with a definition of 30 minutes is necessary for a different school. Note that the hour term was not selected in the optimal model formula.

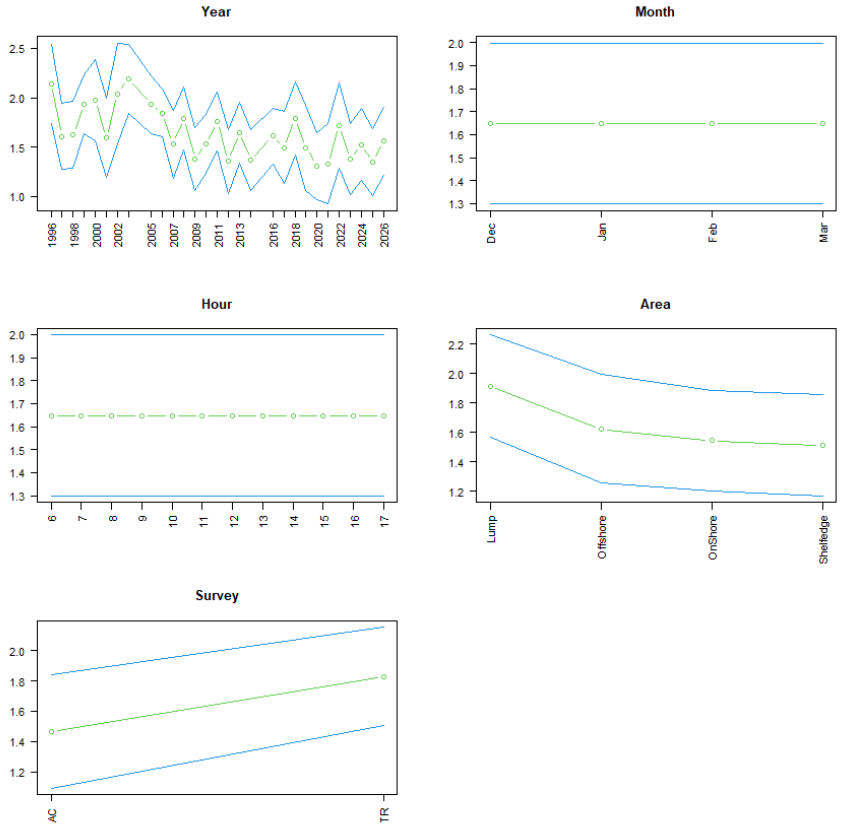


Fig. 8. Least squares means of variables in catch in the CPUE sub-model for TRG.

Green is the mean, and blue is mean±+SD. Catch was defined as schools with a definition of 30 minutes is necessary for a different school. Note that month and hour terms were not selected in the optimal model formula.

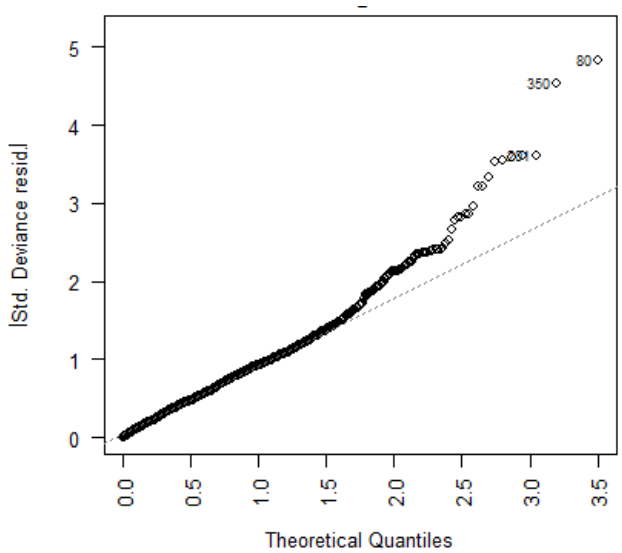


Fig. 9. QQ plot of GLM for CPUE sub-model for TRG.

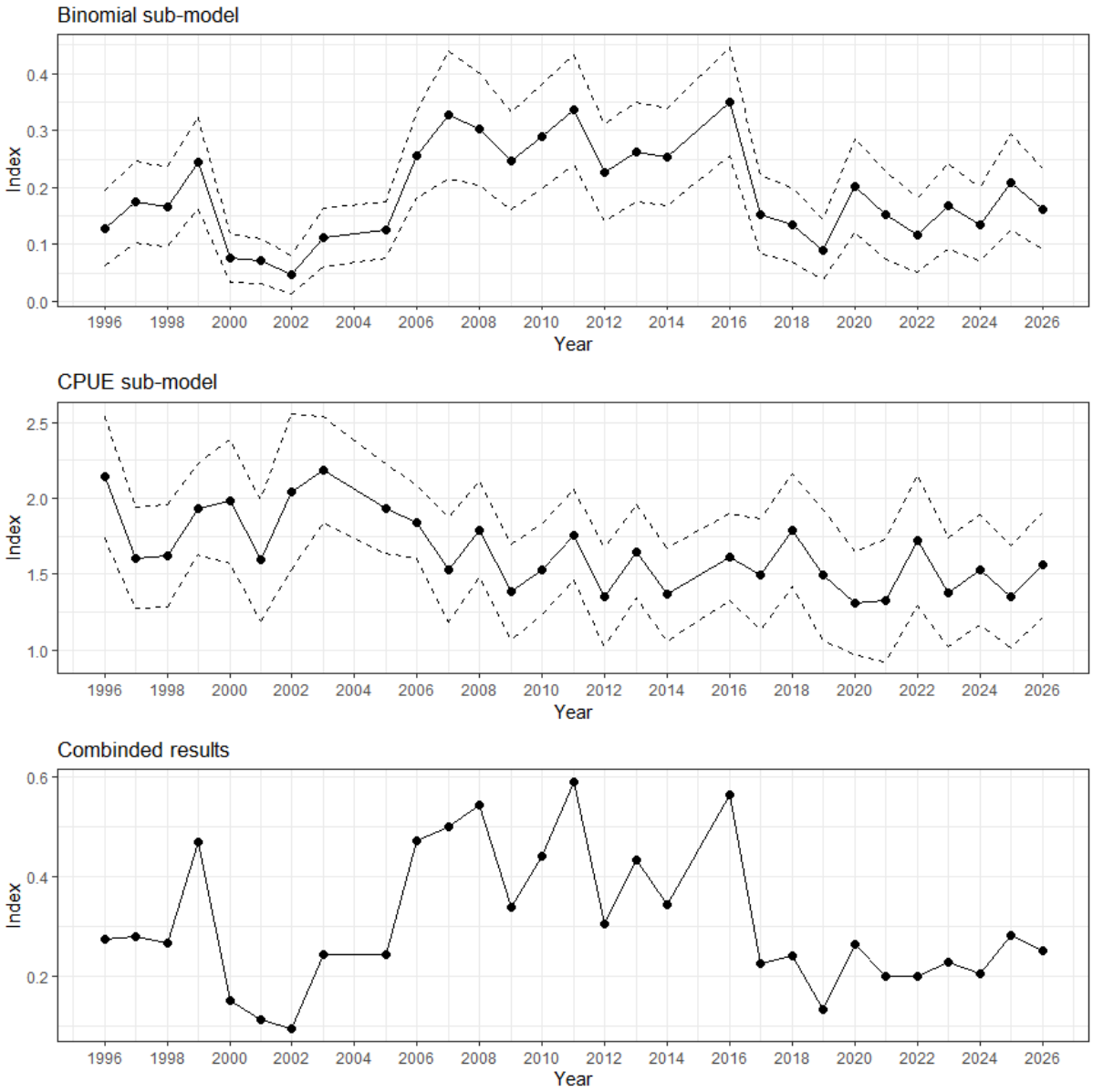


Fig. 10. Binomial sub-model, CPUE sub-model, and combined index from two sub-models (point estimation standardized TRG).

Upper panel shows the year trend from the binomial sub-model. Mean±1SD. The middle panel shows the year trend from the CPUE sub-model. Mean±1SD. The lower panel shows TRG, which is a product of two sub-models.

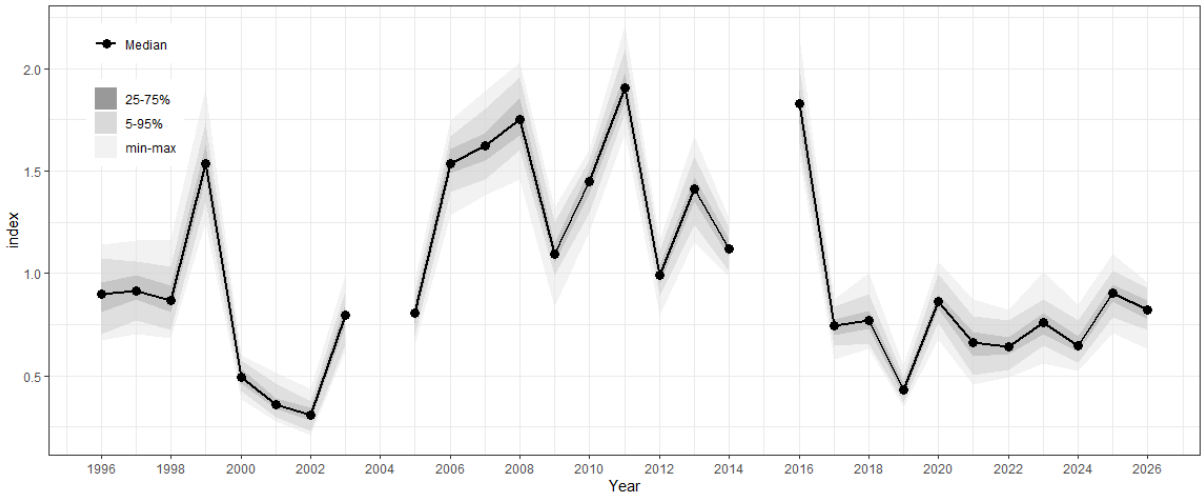


Fig. 11. TRG with confidence intervals.

The estimate was simulated with 1000-times bootstrapping.

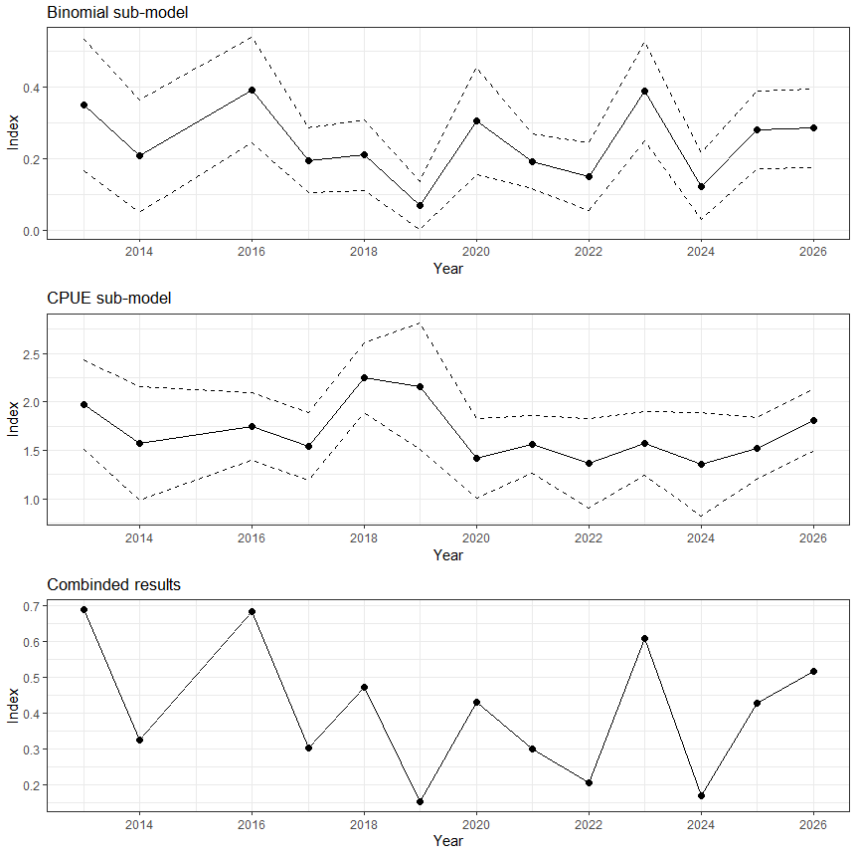


Fig. 12. TRG off Esperance only (TRG_esp) with confidence intervals.

Upper panel shows the year trend from the binomial sub-model. Mean±1SD. The middle panel shows the year trend from the CPUE sub-model. Mean±1SD. The lower panel shows TRG_esp, which is a product of two sub-models.

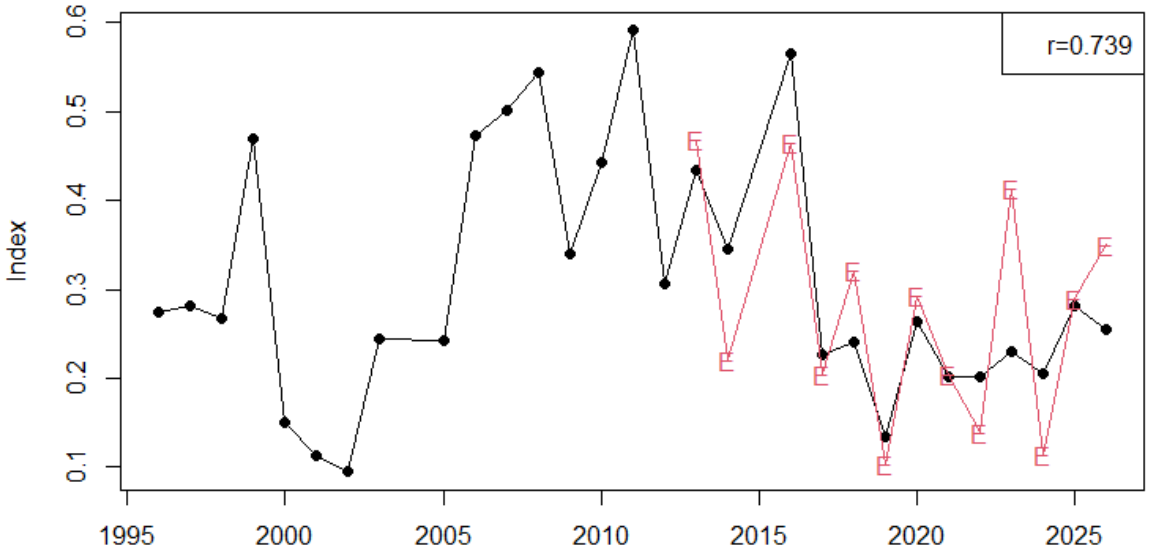


Fig. 13. Comparison between TRG and TRG_esp where data are limited off Esperance only.

Values of TRG_esp are standardized to the mean of TRG between 2013 and 2026. r is Pearson's correlation.

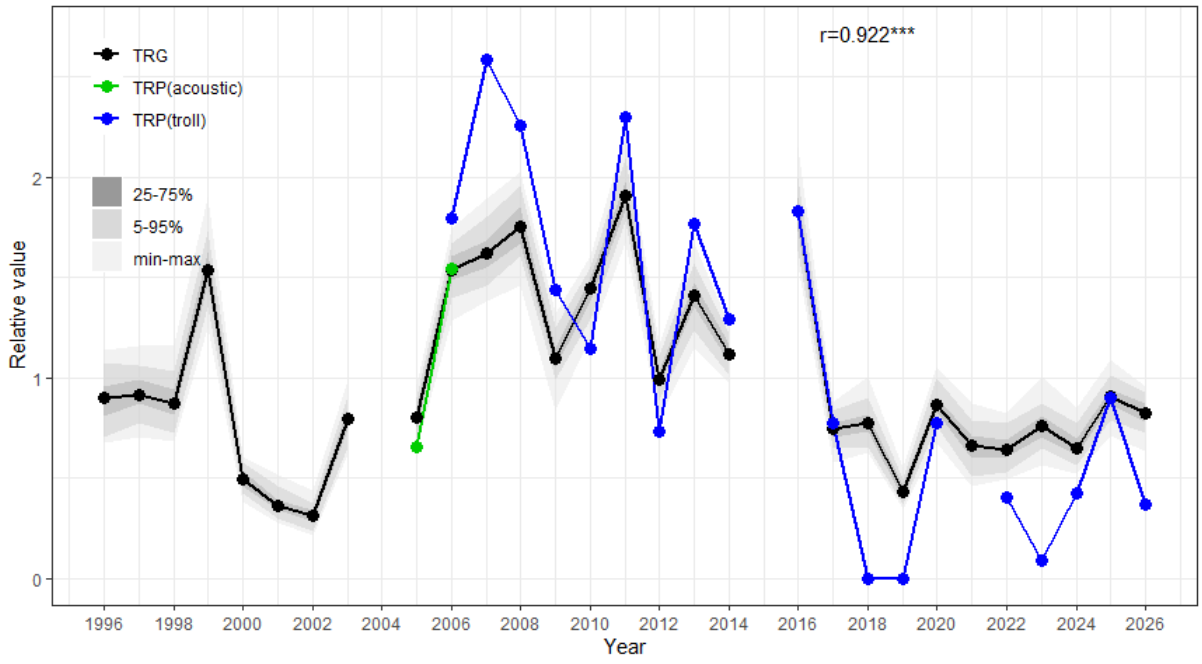


Fig. 14. Comparison between TRG and TRP.

r is Pearson's correlation.