PINNGORTITALERIFFIK
GREENLAND INSTITUTE OF NATURAL RESOURCES
GRØNLANDS NATURINSTITUT

Nuuk, December 2025

Assessment of lumpfish (*Cyclopterus lumpus*) in West Greenland based on commercial data 2010-2025

Eqikkaaneq (summary in Greenlandic)

Kalaallit Nunaanni Pinngortitaleriffiup nipisanniarnermik nalilersuinini kiisalu nunatta kitaani 2026-mi arnarlunniarnissamut biologit siunnersuinerat matumuuna saqqummiuppai.

Biologit 2026-mi pisassiissutigineqartussatut siunnersuutigisaat 1.021 tonsiupput, taamaalilluni pisassiissutissatut siunnersuutit 2025-mut sanilliukkaanni 31%-imik annikilleriaateqarlutik. 2025-mi nipisaat suanniarnermi 1.098 tonsit qaqinneqarsimapput, tassa qaqinneqartut pisassiissutigineqartussatut siunnersuutigineqarsimasunit aammalu pisarineqarsinnaasut annertunerpaaffiannit (TAC-mit) 25%-inik annikinnerusimallutik.

Pisarineqartartut (LPUE) 2024-mut naleqqiullutik 2025-mi 15%-imik ikileriaateqarsimapput, taamalillutillu ukiuni marlunni kingullerni ikileriaateqarsimallutik.

Peqassutsimik nalilersuinermi toqqammavigineqarput aalisarneq pillugu paasissutissaatit pigineqartut, tamatumani qaqinneqartartut tamakkerlugit qaqinneqartartullu amerlassutsimikkut ineriartorneri.

Siunnersuineq ICES-ip najoqqutassiai - *Advice rules for category 2 and 3 stocks* - naapertorlugit suliarineqarpoq, tassani 1-over 2-regel (Method 3.3)-tut taaneqartartut atorneqarlutik.

2025-mi piffissaq aalisartitsiviusoq pillugu APNIPN-mi nalilersuilluni ataatsimiinnermi aalisartut piniartullu kattuffiinit, KNAPK-mit aamma QAK-mit piffissap aalisarfiusup ilungersunartorsiorfiusimanera nalunaarutigineqarpoq. Sikoqarnera silarloqattaarneralu peqqutigalugit aalisarneq ingerlanerliorsimavoq, sikullu peqqutigalugit aalisartut arlallit qassutiminnik annaasaqarsimapput.

Kattuffinnit oqaatigineqarpoq tamanna siornagut taama ingasatsigisumik misigineqarsimanngitsoq, piffissamilu aalisarfiusumi silap nillernerujussua aalisarnerup aallartinniaasaarneranik kinguneqarlunilu tulaassaqassutsimut sunniuteqarsimasoq.

Paasissutissaatigineqartut suli nalorninangaatsiartumiimmata ukiunilu marlunni kingullerni pisarineqartartut annikilleriaateqarsimammata, Pinngortitaleriffimmiut naliliipput pisassiissutigineqartussat ikinnerusariaqartut, ukiuni kingullerni siunnersuutigineqartartunut naleqqiussigaanni taamanerniit peqassutsit suli ikinnerulersimammata. 2026-mut siunnersuineq 2025-mi pisarineqarsimasunut sanilliukkaanni annertoqqatigiingajapput.

Resumé (summary in Danish)

Grønlands Naturinstitut (GN) fremlægger hermed vurderingen af stenbiderfiskeriet og præsenterer den biologiske rådgivning for fangst af stenbiderhunner i Vestgrønland 2026. Den biologiske **rådgivning for 2026 er på 1.021 tons**, hvilket svarer til en reduktion på 31 % i forhold til rådgivningen for 2025. Fangsterne i 2025 udgjorde 1.098 t rogn, hvilket var 25 % under den givne rådgivning og TAC. Fangstraterne (LPUE) faldt i 2025 med 15 % i forhold til 2024, og er dermed faldet to år i træk.

Vurderingen af bestanden bygger på tilgængelige fiskeridata, herunder totale fangster og udviklingen i fangstrater. Rådgivningen er udarbejdet efter *ICES guidelines - Advice rules for category 2 and 3 stocks* ved anvendelse af den såkaldte 1-over-2-regel (Method 3.3).

Under evalueringsmødet for fiskesæsonen 2025 hos APNIPN rapporterede fisker- og fangerorganisationerne, herunder KNAPK og QAK, at sæsonen var præget af vanskelige forhold. Is og vejr havde stor negativ indvirkning på fiskeriet, og flere fiskere mistede garn på grund af is. Organisationerne vurderede, at sådanne forhold ikke tidligere er set i samme omfang, og sæsonen var generelt kold med en forsinket start, hvilket påvirkede de samlede landinger.

Da datagrundlaget fortsat er forbundet med væsentlig usikkerhed, og fangstraterne har udvist et fald gennem de seneste to år, vurderer GN, at fangsterne bør sænkes i forhold til seneste års rådgivning for at begrænse risikoen for yderligere tilbagegang. Rådgivningen for 2026 ligger dog på niveau med fangsterne i 2025.

Abstract

The Greenland Institute of Natural Resources (GINR) hereby presents the assessment of the lumpfish fishery and provides the biological advice for the harvest of female lumpfish in West Greenland for 2026. The biological advice for 2026 is 1,021 tons, representing a 31% reduction compared to the advice for 2025. Landings in 2025 amounted to 1,098 t of roe, which was 25% below the given advice and TAC. Catch rates (LPUE) declined by 15% in 2025 compared to 2024, marking a decrease for two consecutive years.

The stock assessment is based on available fishery data, including total landings and trends in catch rates. The advice has been prepared following *ICES guidelines – Advice rules for category 2 and 3 stocks*, using the so-called "1-over-2" rule (Method 3.3).

During the evaluation meeting for the 2025 fishing season at APNIPN, fishing and harvester organizations, including KNAPK and QAK, reported that the season was characterized by difficult conditions. Ice and weather had a strong negative impact on the fishery, and several fishers lost nets due to ice. The organizations noted that such conditions had not previously been observed to the same extent, and the season was generally cold with a delayed start, which affected total landings.

As the underlying data remains associated with significant uncertainty, and catch rates have declined over the past two years, GINR assesses that landings should be reduced relative to last year's advice to limit the risk of further decline. The advice for 2026, however, remains at the same level as the landings in 2025.

Introduction

The lumpfish fishery in Greenland takes place in the spring along the west coast, peaking around mid-May. Before 2000, reported roe landings were below 500 t, but in the last two decades, landings steadily increased, reaching a peak of 2,124 t in 2013 (Fig. 1). Since then, catches have generally decreased, currently being slightly above 1,000 t. Prior to 2015, the fishery was largely unregulated, but in 2015 a management plan was implemented that established a TAC and restricted fishing days. This plan has been updated over time. In 2021, a new management plan covering 2021–2025 was introduced, operating primarily with a TAC and a limit of 60 fishing days in total. Furthermore, the West Coast is divided into seven management areas (NAFO), each with an area-specific TAC and an area-dependent start of the fishery, reflecting the staggered timing of spawning. During the preparation of this document, a new management plan for 2026–2030 is currently under adoption, which will guide future regulation of the fishery.

Most of the fishery is conducted from small open boats (<6.5 m) that operate with gill nets that typically fish for 1-3 days. Due to the large mesh size (260 mm), the nets are highly selective and catch predominantly female lumpfish, which are much larger than males (Hedeholm *et al*. 2013). Upon capture, the roe is removed from the fish and stored in large barrels before being landed at land-based facilities. Hence, the number of fish landed is not reported, but the total amount of roe. Due to the size of the fishing vessels, there is an upper limit to the number of nets and barrels each boat can carry. All calculations in this assessment rest on this vital assumption; that the fishermen are assumed to be incapable of increasing fishing effort (nets) due to a decline in lumpfish abundance to maintain the same landings. Hence, kg. roe pr. landing is a proxy of landing per unit effort (LPUE) and can be used as a stock status indicator. If the extent of the fishing area is monitored simultaneously, we believe a reasonable indication of stock status can be provided, although no survey is available. The commercial data available have been of varying quality, and data before 2010 have not been evaluated valid for assessment purposes as those landings often lack supporting information such as fisherman ID and location.

In this document, we describe the assessment procedure, present an LPUE time series from 2010-2025 on lumpfish and estimate the extent of the fishery.

Data

Since 2010 each landing has reliably been associated with the amount of roe (kg.), date, fisherman ID, NAFO division and catch location (field code). Each field code is defined as 1/8-degree latitude * 1/4-degree longitude, which is roughly 14 km*8-14 km depending on latitude.

The data has been filtered to avoid bad data and “unserious” fishermen. Hence:

- A fisherman must have been active for at least three years from 2008-present.
- A fisherman must have landed a minimum of 500 kg roe from 2008-present.

- Single landing records above 500 kg are removed to exclude observations where the catches have been collected at larger vessels prior to landings (thereby not representing the typical fishery).
- Only landings from Marts-May (incl.) are included.

Additionally, a fisherman is considered different if moving between NAFO areas over years.

Each landing is categorized as "roe", "whole fish", or "gutted fish". The roe from the two latter categories is also landed, and the calculations are therefore only based on the "roe" category. Uncategorized landings were sorted based on the value of the catch; using roe has a much higher weight-specific value. Applying correct conversion factors allows for the roe amount to be converted into whole fish weight and estimates the number of fish caught. The conversion factor from roe to whole fish is 4 but it was 6.7 before 2021. Because of uncertainties with this conversion factor, only roe landings are reported in the present document. Length data of adult female catches are available from 2011. However, sampling has been sporadic and with insufficient coverage of the fishing area.

Analysis

For achieving an index of abundance for making catch advice, we calculate landings per unit effort (LPUE) from the commercial fishery. The procedure is shortly described here in words only. All analyses were done in R (R core team, 2021), and the script for calculating LPUE is provided as an appendix to this document, including the data preparation steps. The calculations are derivatives of this script.

Initially, a year and NAFO division-specific LPUE (kg pr. landing) for each fisher is calculated. This LPUE is weighted by the share of the total catch in the respective NAFO division taken by a fisher. All LPUEs from a NAFO area are summarized given a year and NAFO division-specific LPUE. To get the LPUE estimate for the entire Greenland west coast, the NAFO division-specific LPUEs are weighted by the total west coast landings. This procedure ensures that the fishers and areas with the highest landings are given the highest weight when assessing the stock status.

The field code information is used to explore the fishery extent in general and to calculate the extent in each NAFO division and between years. This is done by simply calculating the number of field codes fished each year in each NAFO division.

Results

The 2025 landings were 1098 t which is a decrease of 28 % compared to 2024 (Fig. 1). The TAC of 1475,3 t was therefore not reached. In the northern areas (NAFO 1A-1Ba, 1Bb), 32 % of the subarea-specific TAC was caught, while 33 % and 22 % were caught in 1C and 1D, respectively (Table I) (information about the management areas is provided in the management plan).

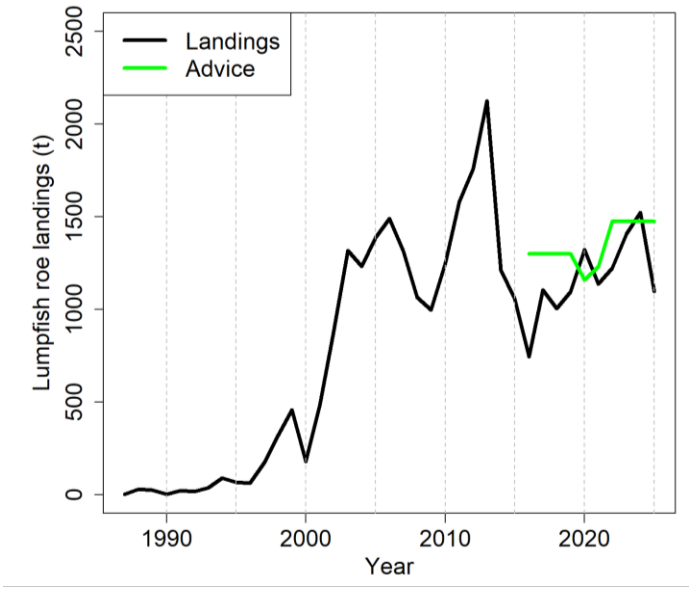

Figure 1: Total lumpfish roe landings (t) from 1987 to 2025 and TAC advice from 2016.

Table I: Landings (roe) by NAFO area in 2025 (from north to south).

NAFO	TAC (t)	Landing (t)	% of total landings
1A	211	164	14.9
1Ba	198	117	10.7
1Bb	103	74	6.7
1C	345	367	33.4
1D	302	238	21.7
1E	181	69	6.3
1F	136	69	6.3
Total	**1475.3**	**1098**	

The overall LPUE decreased by 15 % from 2024 (Fig. 2, Table II). This was driven by a decrease in all NAFO areas (Fig. 3).

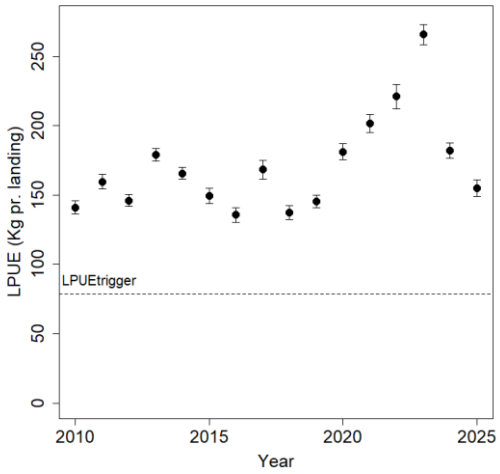

Figure 2: LPUE estimates for the West Greenland area. Vertical bars are standard errors. LPUEtrigger used for advice method is displayed as dashed line.

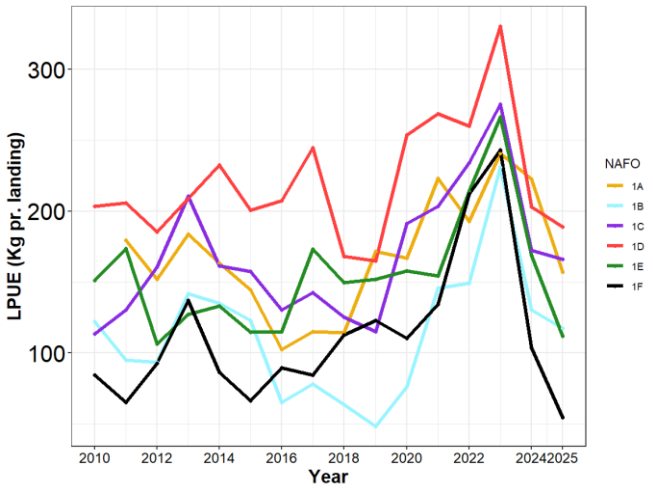

Figure 3: NAFO area specific Landings Per Unit Effort (LPUE) estimates.

Table II: LPUE index by year with standard deviations.

Year	LPUE	Standard error
2010	141.0	4.8
2011	159.7	5.1
2012	146.0	4.3
2013	178.9	4.6
2014	165.5	4.3
2015	149.2	5.6
2016	135.6	5.1
2017	168.4	6.7
2018	137.4	5.1
2019	145.4	4.4
2020	181.2	5.7
2021	201.5	6.4
2022	221.1	8.7
2023	265.7	7.4
2024	182.0	5.6
2025	154.9	6.1

The cumulative catches indicate that a large share in 2025 was taken later in the season compared to most recent years (Fig 4). This accords with oral reports from fishers stating that the fish appeared later at the spawning grounds compared to previous years. This delay was speculated to have been caused by a cold spring with an extraordinary amount of sea ice.

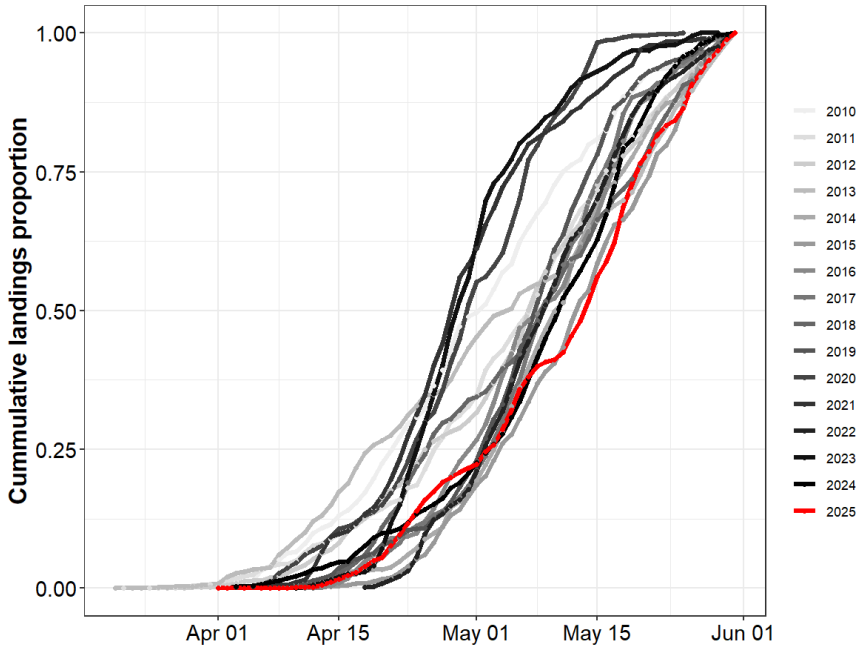

Figure 4: Cumulative landings over the year in proportions by year.

Active fishers declined slightly overall (by about 4%), although patterns varied across the different NAFO areas (Table III). The number of fished field codes remained generally constant, but some areas experienced notable changes (Table III). In area 1A, the number of fished field codes has increased slightly over the past three years; however, it remains within the range of values previously observed in this area.

Table III: Number of active fishers (by license) and field codes fished in each NAFO division and year. Numbers are for all landings for the months Marts-May (incl. landings filtered out for calculating the final LPUE).

Year	Number of fishers						Total	Number of field codes fished						Total
	1A	1B	1C	1D	1E	1F		1A	1B	1C	1D	1E	1F	
2012	218	151	185	152	104	26	836							
2013	180	126	145	181	93	24	749							
2014	123	106	148	95	105	14	591							
2015	114	73	192	93	108	11	591	36	44	56	29	41	3	209
2016	114	74	180	83	87	2	540	53	35	55	28	53	2	226
2017	84	44	194	97	100	15	534	25	28	53	39	47	9	201
2018	138	62	235	116	96	13	660	45	29	62	43	49	9	237
2019	184	71	219	104	102	22	702	60	41	64	35	52	9	261
2020	192	72	224	100	113	20	721	73	48	61	35	49	2	268
2021	146	44	185	72	96	19	562	53	32	57	30	44	4	220
2022	110	47	177	59	76	2	471	40	27	48	33	32	2	182
2023	150	63	177	55	77	16	538	55	35	46	29	31	4	200
2024	168	105	235	79	94	16	699	56	51	53	39	42	3	244
2025	188	85	217	84	84	15	673	65	44	58	31	39	4	241

The average fish length has been relative stable between years (considering the low sample size) with 2011 (N=109), 2012 (N=561), and 2013 (N=69) length mean being within 1.1% of each other (2011-2013 average=37.62 cm), whereas 2014 (N=273) and 2015 fish (N=244) were slightly larger (39.18 and 38.3 cm, respectively). There was no sampling from the commercial fishery in 2016-2018.
Dedicated studies on bycatch from the lumpfish fishery were conducted from 2019 to 2024. These projects involved the collection and measurement of female lumpfish caught close to Nuuk throughout most of the fishing season (Table IV). A particular trend in the development of the size composition has not been inferred.

Table IV: Lumpfish mean length and numbered measured as part of different bycatch projects*.

Year	Length (cm)	Number measured
2019	36.1	823
2021	38.0	452
2022	37.5	168
2023	38.3	2167
2024	37.7	324

* (Merkel et al. 2022; Post et al. 2023;2024, Olesen et 2025)

Discussion and advice following the ICES guidelines - Advice rules for category 2 and 3 stocks (Method 3.3)

The data used in this assessment appears consistent and provides a useful basis for evaluating the state of the lumpfish stock, acknowledging the uncertainties inherent in the assumptions Landings in 2025 were 25 % below the advice and TAC of 1,475.3 t and compared with 2024 catches it was 28 % lower. The LPUE decreased for the second consecutive year, and this decline was observed across all management areas. The LPUE in 2025, together with the overall catch pattern throughout the season, indicates that the fishery was less effective than in recent years - consistent with several verbal reports from fishers. Although both the number of active fishers and fished field codes declined slightly in 2025, they remain above the long-term average.

The advice for 2026 has been calculated using *the ICES guidelines – Advice rules for category 2 and 3 stocks*, Method 3.3 (ICES, 2025). This method has been developed by ICES to provide precautionary advice for relatively short-lived stocks and in situations where there is not sufficient data to complete more analytical assessments, but where there are data on stock trends and the length composition of the catch. At the same time, the method incorporates the variability of the stock indicator and provides a regulating mechanism that considers the state of the stock such that advice is reduced/increased in a way that adjusts the harvest rate in a precautionary way. This method has been reviewed extensively by ICES (ICES 2025) and with the LPUE time series now being long enough (2010-2025) GINR considers it an appropriate way to provide advice.

The method has three scenarios with different approaches to generating advice, all based on the development of the LPUE indicator:

1) $LPUE_y$ / Average ($LPUE_{y-1}$:$LPUE_{y-2}$) > 0.2
2) $LPUE_y$ / Average ($LPUE_{y-1}$:$LPUE_{y-2}$) ≥ 0.2 or <1.8
3) $LPUE_y$ / Average ($LPUE_{y-1}$:$LPUE_{y-2}$) ≥1.8

Based on table II:

- $LPUE_y$ / Average ($LPUE_{y-1}$:$LPUE_{y-2}$) = (154.9 / (265.7+182)/2) = 0.692

Therefore 2) is used to calculate the advice.

To calculate the advice from this method, a $LPUE_{trigger}$ value is needed which takes LPUE variability into consideration:

- $LPUE_{trigger} = mean(LPUE_{all\ years}) * e^{-1.645 * std.dev\ (ln\ LPUE_{all\ years})}$
- $LPUE_{trigger} = 171 * e^{-1.645 * std.dev\ (0.1853)}$
- $LPUE_{trigger} = 171 * 0.737 = 125$

This $LPUE_{trigger}$ value is used as a way of reducing the advice more rapidly should the LPUE in the latest year be a large reduction – i.e. an early indication of a very rapid stock decline.
Therefore, this is calculated:

- $LPUE_y$ / $LPUE_{trigger}$ = 154.9 / 125 = 1.24

Because this value is above 1, the advice is not further regulated beyond the general trend in the LPUE.

The final advice is then calculated as:

- $Advice_{2026} = Advice_{2025} * (LPUE_y$ / Average ($LPUE_{y-1}$:$LPUE_{y-2}$))
- **$Advice_{2026}$ = 1475.3 t * 0.69 = 1021 t**

This is a 31% reduction in advice from the previous year.

Large year-to-year fluctuations in the number of spawners are expected in lumpfish, as few year classes comprising the vast majority of the spawning component (Hedeholm *et al*. 2014, 2017). Recruitment anomalies in a single year will therefore influence the fishery 3–4 years later. This makes assessments based on historical landings alone sub-optimal; however, in the absence of any measure of the juvenile component, these data currently form the only basis for evaluating stock development.

Male lumpfish landings are not estimated in this assessment because they are not systematically reported (commercial landings began on a small scale around 2019). Given the mesh size used in the roe fishery (260 mm) and the pronounced sexual size dimorphism (Hedeholm et al. 2014), male catches are assumed to be relatively low. Davenport (1985) noted, based on Icelandic data, that males are predominantly taken in 170–190 mm gillnets. Although small quantities of males are occasionally landed for the domestic market, these amounts are minor, likely only a few tonnes. A recreational fishery targeting females also exists but is unquantified; this fishery likewise uses 260–270 mm gillnets, and no estimates of recreational removals are available.

The LPUE-based biomass index used here relies on several important assumptions. One is that the fishing effort per vessel (i.e. number of nets) remains stable across years. At present, available data do not allow formal evaluation of this assumption. Nonetheless, seminars and discussions with fishers indicate that most vessels operate at their net capacity ("net-saturated"), suggesting limited flexibility to increase or decrease effort in response to catch rates. This assumption also implies that fishers do not substantially change vessel or gear type between years, although isolated cases cannot be excluded.

Another key assumption is that catch is landed shortly after capture. This appears well justified: roe quality deteriorates rapidly over a few days, and the small vessels used in this fishery lack facilities for onboard storage. Fishers consistently confirm this practice, and some buyers impose formal limits on the maximum time between capture and landing.

Although the LPUE time series is based on high-quality landing data, uncertainties remain due to these underlying assumptions, the relatively short time series, and limited biological knowledge of the stock. Consequently, LPUE-derived trends should be interpreted cautiously, and a precautionary approach to management remains warranted until additional data and monitoring become available.

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Appendix I

R script used in LPUE calculations.

```
intCurrentYear <- 2025 #Current year

#Packages and functions ----
library(car)
library(plyr)
library(dplyr)
library(readxl)
library(lubridate) #yday()

#Function to calculate field code ----
Funktion <- function(x) {
  if(x == "A") y <- 1
  if(x == "B") y <- 2
  if(x == "D") y <- 3
  if(x == "E") y <- 4
  if(x == "F") y <- 5
  if(x == "G") y <- 6
  if(x == "H") y <- 7
  if(x == "J") y <- 8
  if(x == "K") y <- 9
  if(x == "L") y <- 10
  if(x == "M") y <- 11
  if(x == "N") y <- 12
  if(x == "P") y <- 13
  if(x == "R") y <- 14
  if(x == "S") y <- 15
  if(x == "T") y <- 16
  if(x == "V") y <- 17
  if(x == "X") y <- 18
  if(x == "Z") y <- 19
  if(x == "+") y <- NA
  if(x == "0") y <- NA
  if(x == "1") y <- NA
  if(x == "2") y <- NA
  if(x == "3") y <- NA
  if(x == "4") y <- NA
  if(x == "5") y <- NA
  if(x == "6") y <- NA
  if(x == "7") y <- NA
  if(x == "8") y <- NA
  if(x == "9") y <- NA
  if(x == "y") y <- NA
  if(x == "") y <- NA
  return(y)}

y<-NULL

#Working directory ----
cUser = 'sopo' #Set your own initials.
#setwd(paste('C:/Users/',cUser,'/Grønlands Naturinstitut/FiSk (TEAMS) - Dokumenter/General/37 Andre arter, inv., bl. forsøgsfiskeri/00 Rådgivning og sagsbehandling/02 Stenbider/00 Data/Oparbejdning/Output/', sep = ''))
setwd(paste('C:/Users/',cUser,'/Grønlands Naturinstitut/FiSk (TEAMS) - Dokumenter/General/37 Andre arter, inv, bl forsoegsfiskeri/00 Rådgivning og sagsbehandling/02 Stenbider/00 Data/Oparbejdning/Output/', sep = ''))

#data prep ----
data2025 = read.table('Z:/Luli/Logbook_Indhandling_All_species/Indhandling_Data/INDH_2025.txt', header = T, sep = ";", quote = "", fileEncoding = "latin1")
data2025 = data2025[data2025$ART_KODE=='LUM',]
data2024 = read.table('Z:/Luli/Logbook & Indhandling All species/INDH_ALL_2024.txt', header = T, sep = ";", quote = "", fileEncoding = "latin1")
data2024 = data2024[data2024$ART_KODE=='LUM',]
data2023 <- readxl::read_xlsx('Z:/Luli/37 Stenbider/Indhandlingsdata/2023/Stenbiderindhandlinger 2020-2023 06.06.2023.xlsx')
data2022 <- read.csv('Z:/Luli/37 Stenbider/Indhandlingsdata/2022/Indhandlinger LUM 2020-2022 20220916.csv', sep=';',dec=".", header=T, fileEncoding = "Latin1", check.names = F)
data2021 <- read.csv('Z:/Luli/37 Stenbider/Indhandlingsdata/2022/Stenbider2021 v1 08072021.csv', sep=';',dec=".", header=T, fileEncoding = "Latin1", check.names = F)
data2020 <- read.csv('Z:/Luli/37 Stenbider/Indhandlingsdata/2021 - med nyt script/LUM_10_20_1.csv', sep=';', header=T, fileEncoding = "Latin1", check.names = F)
```

```
data2023 <- as.data.frame(data2023[data2023$AAR==2023,])
names(data2022) <- toupper(names(data2022)) #
data2022 <- data2022[data2022$AAR==2022,]
data2021 <- data2021[data2021$AAR==2021,]

data2020 <- data2020[,c('INDHANDLINGSDATO','INDHANDLINGSSTED_GFLKNR','LANDINGSSTED_GFLKNR','FI-
SKER_GFLKNR','BEHGRD_KODE',"MAENGDE","VAERDI",'FANGSTFELT')]

data2020$day <- as.numeric(as.character(substring(data2020$INDHANDLINGSDATO, 1,2)))
data2020$month <- as.numeric(as.character(substring(data2020$INDHANDLINGSDATO, 4,5)))
data2020$year <- as.numeric(as.character(substring(data2020$INDHANDLINGSDATO, 7,10)))

data2021 <- plyr::rename(data2021 ,c('GFLK_NR'='FISKER_GFLKNR'))
data2022 <- plyr::rename(data2022 ,c('GFLK_NR'='FISKER_GFLKNR'))

#Different format between years. Syncronyzing these
#For 2021 it is MM-DD-YYYY, while earlier DD-MM-YYYY
data2021$INDHANDLINGSDATO <- substr(data2021$INDHANDLINGSDATO, 1,10)
common_names <- intersect(names(data2020), names(data2021))
data2021 <- data2021[,common_names]
data2021$day   <- as.numeric(as.character(substring(data2021$INDHANDLINGSDATO, 4,5)))
data2021$month <- as.numeric(as.character(substring(data2021$INDHANDLINGSDATO, 1,2)))
data2021$year  <- as.numeric(as.character(substring(data2021$INDHANDLINGSDATO, 7,10)))

data2022$INDHANDLINGSDATO <- substr(data2022$INDHANDLINGSDATO, 1,10)
common_names <- intersect(names(data2020), names(data2022))
data2022 <- data2022[,common_names]
data2022$day <- as.numeric(as.character(substring(data2022$INDHANDLINGSDATO, 1,2)))
data2022$month <- as.numeric(as.character(substring(data2022$INDHANDLINGSDATO, 4,5)))
data2022$year <- as.numeric(as.character(substring(data2022$INDHANDLINGSDATO, 7,10)))

data2023 <- dplyr::rename(data2023, "year"="AAR", "FISKER_GFLKNR"="GFLK_NR")
data2023$day   <- as.numeric(as.character(substring(data2023$INDHANDLINGSDATO, 9,10)))
data2023$month <- as.numeric(as.character(substring(data2023$INDHANDLINGSDATO, 6,7)))
data2023 <- data2023[,names(data2022),]
data2023 <- data2023[!is.na(data2023$FANGSTFELT),] #Three obs in 2023 have missing info on FANGSTFELT. Remove these

data2024$year <- data2024$INDHANDLINGSDATO_YYYY
data2024$month <- as.numeric(as.character(substring(data2024$INDHANDLINGSDATO, 4,5)))
data2024$day   <- as.numeric(as.character(substring(data2024$INDHANDLINGSDATO, 1,2)))
data2024 <- data2024[,names(data2022),]
#data2024 <- data2024[!is.na(data2024$FANGSTFELT),]

data2025$year <- data2025$INDHANDLINGSDATO_YYYY
data2025$month <- as.numeric(as.character(substring(data2025$INDHANDLINGSDATO, 4,5)))
data2025$day   <- as.numeric(as.character(substring(data2025$INDHANDLINGSDATO, 1,2)))
data2025 <- data2025[,names(data2022),]


#Bind years together
data1 <- rbind(data2020, data2021, data2022, data2023, data2024, data2025)
data1 <- data1[!is.na(data1$FISKER_GFLKNR),] #Remove obs when no info on fisher

data1$Fk_character1<-substring(data1$FANGSTFELT,1,1)
data1$Fk_character2<-substring(data1$FANGSTFELT,2,2)

num_character1<-sapply(data1$Fk_character1,Funktion)
num_character1<-array(num_character1)
data2<-cbind(data1,num_character1)
num_character2<-sapply(data1$Fk_character2,Funktion)
num_character2<-array(num_character2)
data3<-cbind(data2,num_character2)

#Lat and lon from mid pos of field code. Gives an error warning, as the first years have missing values.
data3$Latitude<- 60 + (1/16) + (1/8)*((19*(as.numeric(as.character(data3$num_character1))-6)+as.numeric(as.character(data3$num_character2))-
9))
data3$Longitude<- (58 + (1/8) - (1/4)*as.numeric(as.character(substring(data3$FANGSTFELT,3,5)))) * (-1)

data4 <- data3[,c('year','month','day','BEHGRD_KODE','MAENGDE','FISKER_GFLKNR','VAERDI','FANGSTFELT','Latitude','Longi-
tude','INDHANDLINGSSTED_GFLKNR')]
data4 <- plyr::rename(data4 ,c('BEHGRD_KODE'='BEHGRD','FISKER_GFLKNR'='SAELGER','FANGSTFELT'='FELTKODE')) #Old name =
New name.
```

```
#NAFO from pos of field code
NAFO<-ifelse(data4$Latitude>=68.50,"1A",
  ifelse(data4$Latitude<68.50&data4$Latitude>=66.15,"1B",
  ifelse(data4$Latitude<66.15&data4$Latitude>=64.15,"1C",
  ifelse(data4$Latitude<64.15&data4$Latitude>=62.30,"1D",
  ifelse(data4$Latitude<62.30&data4$Latitude>=60.45,"1E",
  ifelse(data4$Latitude<60.45&data4$Latitude>=55.20,"1F",""))))))

data5<-cbind(data4,NAFO)

#Remove data when it is not roe
#data13a <- subset(data5, !BEHGRD %in% c('MHUI', 'HEL', 'HEL-M', 'HEL-F', 'HELRSW'))
data6 <- subset(data5, !BEHGRD %in% c('MHUI', 'HEL', 'HEL-M', 'HEL-F', 'HELRSW'))

#Get day of year
data6$day_of_year <- yday(ymd(paste(data6$year, data6$month, data6$day, sep = "-")))
#There will be a warning which is due to NA values.

#Choosing landings/indhandlinger from March, April and May for the LPUE calculations
data7 <- data6[data6$month %in% c(3,4,5),]
#For a sensitivity test using data only in the same time period
#data7 <- data13a[data13a$day_of_year >= min(data13a[data13a$year==2023, 'day_of_year']) & data13a$day_of_year <=
max(data13a[data13a$year==2023, 'day_of_year']) ,]
#data7 <- data13a[data13a$day_of_year >= 108 & data13a$day_of_year <= 132 ,] # 104 approx april 18. and may 12, which was the fishing period
for a large part of the fishery in 2023
#data7 <- data13a[data13a$month %in% c(5),] #To see if the late start in 2022 and other years affects the results
#TEST of removing observations later than may 15 (140). This is done because 2021 was a year heavily influenced by management (buying places
closed)
# data7$Date <- as.Date(paste(data7$day, data7$month, data7$year, sep = '-'))
# data7$DayOfYear <- yday(data7$Date)
# data7 <- data7[data7$DayOfYear<141,]

#Some landings lag info about field code. For these, bying place (indhandlingssted) is used to assign to area. ----
data7$INDHANDLINGSSTED_GFLKNR <-  as.factor(data7$INDHANDLINGSSTED_GFLKNR)
#In 2023 there where some new Indhandlingssteder.
recode_INDHANDLINGSSTED_BY <- c("1010" = "Nanortalik", "1040" = "Narsaq", "1050" = "Paamiut", "1060" = "Nuuk", "1070" = "Maniit-
soq",
                "1080" = "Sisimiut", "1100" = "Aasiaat", "1110" = "Qasigiannguit", "1120" = "Ilulissat", "1121" = "Ilulissat",
                "1122" = "Ilulissat", "1123" = "Ilulissat", "1124" = "Ilulissat", "1140" = "Qeqertarsuaq", "1150" = "Uummannaq",
                "1151" = "Uummannaq", "1152" = "Uummannaq", "1153" = "Uummannaq", "1154" = "Uummannaq", "1155" = "Uummannaq",
                "1156" = "Uummannaq", "1157" = "Uummannaq", "1210" = "Arsuk", "1211" = "Nuuk", "1212" = "Nuuk",
                "1213" = "Maniitsoq", "1214" = "Maniitsoq", "1217" = "Kangaatsiaq", "1218" = "Aasiaat", "1219" = "Aasiaat",
                "22111" = "Nanortalik", "22167" = "Upernavik", "22532" = "Qaqortoq", "22597" = "Innaarsuit", "22619" = "Ship",
                "22761" = "Ilulissat", "22810" = "Kangersuatsiaq", "22815" = "Attu", "22818" = "Upernavik", "22835" = "Qaanaaq",
                "22857" = "Sisimiut", "22874" = "Sisimiut", "22876" = "Kuumiut", "22928" = "Sisimiut", "22930" = "Maniitsoq",
                "23011" = "Maniitsoq", "23039" = "Ilimanaq", "23049" = "Maniitsoq", "23137" = "Qeqertarsuaq", "23139" = "Aasiaat",
                "1616" = "Ship", "1651" = "Ship", "1653" = "Ship", "22111" = "Nanortalik", "22162" = "Uummannaq",
                "22167" = "Upernavik", "22479" = "Ilulissat", "22532" = "Qaqortoq", "22597" = "Upernavik", "22619" = "Ship",
                "22761" = "Ilulissat", "22810" = "Upernavik", "22815" = "Aasiaat", "22818" = "Upernavik", "22835" = "Qaanaaq",
                "22857" = "Sisimiut", "22874" = "Sisimiut", "22876" = "Tasiilaq", "22928" = "Sisimiut", "22930" = "Qaqortoq",
                "23103" = "Upernavik", "23104" = "Upernavik", "23105" = "Upernavik", "23106" = "Upernavik", "23108" = "Uummannaq",
                "23011" = "Maniitsoq", "23039" = "Ilulissat", "23049" = "Nanortalik", "23137" = "Qeqertarsuaq", "23139" = "Aasiaat",
                "23275" = "Sisimiut", "23338" = "Sisimiut", "23286" = "Upernavik", "23395" = "Upernavik", "22821" = "Nuuk",
                "22992" = "Maniitsoq", "22993" = "Aasiaat", "23114" = "Nanortalik", "23325" = "Qeqertarsuaq", "23691" = "Upernavik",
                "23733" = "Ilulissat", "29500" = "Narsaq", "68" = "Nuuk", "23374" = "Narsaq", "24052" = "Maniitsoq",
                "27557" = "Narsaq", "23502" = "Maniitsoq", "23514" = "Sisimiut", "23505" = "Attu", "23581" = "Aasiaat",
                "29501" = "Nuuk", "23692" = "Uummannaq", "23978" = "Maniitsoq", "23503" = "Ikamiut", "24483" = "Qasigiannguit",
                "25419" = "Narsaq", "24429" = "Ilulissat", "62132" = "Sisimiut", "38417" = "Nuuk", "27501" = "Nuuk",
                "29446" = "Nuuk", "73085"="Kitsissuarsuit","77442" = "Nuuk","82684" = "Nuuk")

data7$INDHANDLINGSSTED_BY <- recode(data7$INDHANDLINGSSTED_GFLKNR, !!!recode_INDHANDLINGSSTED_BY)

unique(data7$INDHANDLINGSSTED_BY) #Check an see if records miss area info. If one is missing, look in file "Åbne landingssteder.pdf"
#After talk with GFLK, changes are made in the area allocation 8-12-2016, RaHe.

data7$INDHANDLINGSSTED_BY <- as.factor(data7$INDHANDLINGSSTED_BY)
data7<-subset(data7, INDHANDLINGSSTED_BY!='27501') #Remove bycatches from the capelin fishery in Iceland
data7<-subset(data7, INDHANDLINGSSTED_BY!='35117') #Remove some catches in Norway

data7$NAFO_fra_Indhandlingssted <- recode(data7$INDHANDLINGSSTED_BY,
                                "Nanortalik" = "1F",
                                "Narsaq" = "1F",
```

```
                                "Paamiut" = "1E",
                                "Nuuk" = "1D",
                                "Maniitsoq" = "1C",
                                "Sisimiut" = "1B",
                                "Aasiaat" = "1B",
                                "Qasigiannguit" = "1B",
                                "Ilulissat" = "1A",
                                "Qeqertarsuaq" = "1A",
                                "Uummannaq" = "1A",
                                "Arsuk" = "1E",
                                "Kangaatsiaq" = "1B",
                                "Upernavik" = "1A",
                                "Qaqortoq" = "1F",
                                "Innaarsuit" = "1A",
                                "Kangersuatsiaq" = "1A",
                                "Attu" = "1B",
                                "Qaanaaq" = "1A",
                                "Sisimiut" = "1B",
                                "Kuumiut" = "XIVb",
                                "Ilimanaq" = "1A",
                                "Tasiilaq" = "XIVb",
                                "Ikamiut" = "1B",
                                "Kitsissuarsuit"="1A")

    data7<-subset(data7, NAFO_fra_Indhandlingssted!='XIVb') #Remove the few obs from East Greenland

    data7$NAFO <- ifelse(is.na(data7$NAFO), as.character(data7$NAFO_fra_Indhandlingssted), as.character(data7$NAFO))
    data7$NAFO <- ifelse(data7$NAFO=='', as.character(data7$NAFO_fra_Indhandlingssted), as.character(data7$NAFO))
    data7$NAFO <- as.factor(data7$NAFO)
    #Filter on data----
    #Check if landings are roe or whole fish (MHUI/HEL). Do this by looking at the kg price.
    #Hereafter exclude lines where kg price is below 5 kr. There are some uncertainty around this procedure
    data7$value <- data7$VAERDI / data7$MAENGDE #kg price
    #data13c <- subset(data7, value>5&value<=50) #NY: both upper and lower limit. Generally it is few obs that are removed.
    data8 <- subset(data7, value>5&value<=50) #NY: both upper and lower limit. Generally it is few obs that are removed.

    #Few data errors with negative values. These are excluded. Also exlcude values above 500 kg. As these are not seen as representative for the general fishers
    data9<-subset(data8, MAENGDE>0&MAENGDE<500)

    #Dropping variables that are not used.
    data9$BEHGRD <- data9$VAERDI <- data9$value <- NULL

    #data9 <- data13b #If not selecting from indhandling data
    data9$feltkode = as.factor(data9$FELTKODE)

    summary_table1 <- aggregate(data9[,c('MAENGDE')],list(FELTKODE=data9$FELTKODE, year=data9$year),sum,na.rm=T)
    summary_table1$tons <- summary_table1$x/1000
    summary_table2 <- aggregate(data9[,c('MAENGDE')],list(year=data9$year, NAFO=data9$NAFO),sum,na.rm=T)
    summary_table2$tons <- summary_table2$x/1000

    #Selecting fishers that are used in the LPUE calculations. Using selveral criteria:
    #First calculate number of years individual fishers have been active
    data9$dummy <-1
    indhandlinger_pr_fisherman_pr_aar <- aggregate(data9[,c('dummy')],list(SAELGER=data9$SAELGER, year=data9$year),sum,na.rm=T) #giver antal indhandlinger pr år pr. fisker
    indhandlinger_pr_fisherman_pr_aar$dummy2 <-1 #A dummy variable used for summarizing
    antal_aktive_fiskeaar <- aggregate(indhandlinger_pr_fisherman_pr_aar[,c('dummy2')],list(SAELGER=indhandlinger_pr_fisherman_pr_aar$SAELGER),sum,na.rm=T) #giver antal ?r med indhandlinger pr. fisker

    data9 <- merge(data9, antal_aktive_fiskeaar,by='SAELGER') #Combining data

    #Exlude lines using some criteria:
    #1) A fisher has to be active in at least three years in the  period 2008-current year
    data9 <- subset(data9, x >2)

    #2) A fisher need to have caugth minimum 500 kg in the perioden 2008-current year
    #First total catch for every fisher
    total_indhandling_pr_fisker <- aggregate(data9[,c('MAENGDE')],list(SAELGER=data9$SAELGER), sum,na.rm=T)
    data9 <- merge(data9,  total_indhandling_pr_fisker, by='SAELGER')

    #Delete some fishers.
    data9 <- subset(data9, x.y>500)
```

```
#3) We have evaluated that data prior 2010 had to poor quality to be used
data9<-subset(data9, year>2009)

#Create unique fisher ID, e.g. if fisher(seller) move area, he/she is reagarded as a new fisher.
#data9 <- data6 #If not selecting from indhandling i data
data9$SAELGER_unik <- paste(data9$SAELGER, data9$NAFO, sep='_')

#Start analysis
data10 <- aggregate(data9$MAENGDE,list(SAELGER_unik=data9$SAELGER_unik, year=data9$year, NAFO=data9$NAFO), sum,na.rm=T)
#sum the catch for every fisher in every area and year.
data11 <- aggregate(data9$dummy,list(SAELGER_unik=data9$SAELGER_unik, year=data9$year, NAFO=data9$NAFO), sum,na.rm=T) #Num-
bers of indhandlinger by seller, area and year.
data12 <- cbind(data10,data11$x) #Combine data

names(data12)[names(data12)=='x']<-'rogn_saelger_pr_aar_pr_omraade'
names(data12)[names(data12)=='data11$x']<-'antal_indhandlinger_pr_aar_pr_omraade_pr_fanger'

#LPUE for every unique seller/fisher in every area and year.
data12$CPUE_kg_pr_indhandling <- data12$rogn_saelger_pr_aar_pr_omraade/data12$antal_indhandlinger_pr_aar_pr_omraade_pr_fanger

#Table showing number of indhandlinger for every fisher from every area. Combining with LPUE table
data13 <- aggregate(data12$antal_indhandlinger_pr_aar_pr_omraade_pr_fanger,list(year=data12$year, NAFO=data12$NAFO), sum,na.rm=T)
data14 <- merge(data12,data13, by=c('year','NAFO'))

names(data14)[names(data14)=='x']<-'antal_indhandlinger_pr_aar_pr_omraade'

#Weigthing of LPUE by number of indhandlinger.
#Weighting defined by a sellers number of sales/indhandlinger per year and area / number of indhandlinger in the area in the year (e.g. ratio).
data14$weight_til_CPUE <- data14$antal_indhandlinger_pr_aar_pr_omraade_pr_fanger/data14$antal_indhandlinger_pr_aar_pr_omraade

#Multiply weight with cpue (lpue)
data14$vaegtet_CPUE <- data14$CPUE_kg_pr_indhandling * data14$weight_til_CPUE

#Area and year specific lpue with standard deviation
data15 <- aggregate(data14$vaegtet_CPUE,list(year=data14$year, NAFO=data14$NAFO), sum,na.rm=T)
data15b <- aggregate(data14$vaegtet_CPUE,list(year=data14$year, NAFO=data14$NAFO), FUN=sd)
names(data15)[names(data15)=='x']<-'CPUE_pr_omraade_pr_aar'
names(data15b)[names(data15b)=='x']<-'SD'

#SE for estimates
data15b$nrow <- nrow(data12)
data15b$SE <- data15b$SD/sqrt(data15b$nrow)
data16 <- merge (data15,data15b, by=c('year','NAFO'))
#Weighted LPUE/CPUE for every area and year with SE.
#write.table(data12, file = "CPUE_pr_area.xls", sep = "\t", row.names = F)

#CPUE by year.
#Catch by area and year
data17 <- aggregate(data14$rogn_saelger_pr_aar_pr_omraade,list(year=data14$year, NAFO=data14$NAFO),sum,na.rm=T)
#Catch by year
data17b <- aggregate(data14$rogn_saelger_pr_aar_pr_omraade,list(year=data14$year),sum,na.rm=T)
#Rename
names(data17)[names(data17)=='x']<-'kg_pr_omraade_pr_aar'
names(data17b)[names(data17b)=='x']<-'kg_pr_aar'

#Merging tables. Contains sold amount by area and year, and total catch by year
data18 <-merge (data17, data17b, by='year')

#Weighing lpue from different areas by sold amount.
#Calculated by amount per area / amount of the year
data18$weight_til_CPUE <- data18$kg_pr_omraade_pr_aar/data18$kg_pr_aar

#Number of sales(indhandlinger) per year per area, used for CPUE calculations.
data19 <- aggregate (data14$antal_indhandlinger_pr_aar_pr_omraade_pr_fanger,list(year=data14$year,NAFO=data14$NAFO), sum,na.rm=T)
names(data19)[names(data19)=='x']<-'indhandlinger_pr_omraade_pr_aar'

#Table with weighing (data18) and number of sales (data19) are merged.
data20 <- merge (data18,data19, by=c('year','NAFO'))

#CPUE for every area and year: kg per area per year / number of sales per area per year which are weighted.
data20$CPUE_pr_omraade_pr_aar <- data20$kg_pr_omraade_pr_aar / data20$indhandlinger_pr_omraade_pr_aar
data20$vaegtet_CPUE <- data20$CPUE_pr_omraade_pr_aar * data20$weight_til_CPUE
```

```
data20<-data20[-1,]    # First line without NAFO due to missing field codes

#Weighted CPUE added for every year, with SD
data21 <- aggregate(data20$vaegtet_CPUE,list(year=data20$year), sum,na.rm=T)
data21b <- aggregate(data20$vaegtet_CPUE,list(year=data20$year), FUN=sd)
names(data21)[names(data21)=='x']<-'CPUE_pr_aar'
names(data21b)[names(data21b)=='x']<-'SD'

data21b$nrow <- nrow(data21) #SE
data21b$SE <- data21b$SD/sqrt(data21b$nrow)
data22 <- merge (data21,data21b, by=c('year'))
print(data22[, c("year","CPUE_pr_aar","SD","SE")], row.names = F)

#1-over-2 rule (ICES 2025)-----
df_1over2 <- data22[,c('year','CPUE_pr_aar')]
df_1over2 <- df_1over2 |>
  dplyr::rename(lpue = CPUE_pr_aar)

#Get a new column with 1 over 2 values
df_1over2 <- df_1over2 |>
  dplyr::arrange(year) |>
  dplyr::mutate(
    avg_prev2 = (dplyr::lag(lpue, 1) + dplyr::lag(lpue, 2)) / 2,
    ratio = lpue / avg_prev2 )

# To select which approach to use we need to select on of these
# Method 1: Ratio of LPUEy/LPUEy-2,y-1 < 0.2
# Method 2: Ratio of LPUEy/LPUEy-2,y-1 > 0.2 but also <1.8
# Method 3: Ratio of LPUEy/LPUEy-2,y-1 > 1.8

df_1over2 <- df_1over2 |>
  mutate(method = case_when(
      ratio < 0.2 ~ "method 1",
      ratio >= 0.2 & ratio <= 1.8 ~ "method 2",
      ratio > 1.8 ~ "method 3",
      TRUE ~ NA_character_) )
df_1over2 #In all years the method (so far) is method 2

df_1over2 <- df_1over2 |>
  dplyr::arrange(year) |>
  dplyr::mutate(
    sd = log(df_1over2$lpue) )

lpue_geom_mean <-  exp(mean(df_1over2$sd))      # Geometric mean of LPUE using natural log (i.e. ln)
lpue_log_sd <- sd(df_1over2$sd) * sqrt((length(df_1over2$lpue)-1)/length(df_1over2$lpue)) # Standard deviation of LPUE (a bit complicated to
match excel output)
LPUEtrigger <- lpue_geom_mean * exp(-1.645 * lpue_log_sd)
LPUEtrigger

#the method looks at the current state of LPUE compared to the LPUEtrigger.
latest_LPUE <- df_1over2 %>%
  filter(year == max(year)) %>%
  pull(lpue)
lpue_lpuetrigger <- latest_LPUE / LPUEtrigger
lpue_lpuetrigger

latest_ratio <- df_1over2 %>%
  slice_tail() %>%
  pull(ratio)

#based on this value (above/below 1) the advice is calculated.
advice <- if (lpue_lpuetrigger > 1) {
  # High LPUE case
  intLastYearAdvice * latest_ratio * 1
} else {
  # Low LPUE case
  intLastYearAdvice * latest_ratio * lpue_lpuetrigger
}
advice
```