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Assessment of lumpfish (*Cyclopterus lumpus*) in West Greenland based on commercial data 2010-2017

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Introduction

The lumpfish fishery in Greenland is conducted in the spring from April 1st to June 30th along the Greenland west coast. The fishery peaks in late May/early June. Prior to year 2000, reported roe landings were below 500 t, but in the last decade landings have steadily increased, reaching the highest level in 2013 with 2 124 t (Fig. 1). Before 2015 the fishery was unregulated, but in 2015 a management plan was implemented, that operates with TAC and restricted number of fishing days. The West Coast is divided into seven management areas, with the onset of the fishery being area dependent due to a timely displaced onset of spawning.

The fishery is conducted from small open boats (<6.5m) that operates with gill nets that typically fish for 24 hours. Due to the large mesh size (260mm) 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 landed at land based facilities. Hence, the number of fish landed is not reported, but only the total amount of roe. Due to the size of the fishing vessels, there is an upper limit to the number of nets each boat can carry. All calculations in this assessment rest on this vital assumption; that each fisherman is assumed to be incapable of increasing fishing effort (nets) as a response 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 prior to 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 2010-2017 on lumpfish and estimate the extent of the fishery.

Data

Since 2010 each landing has reliably been associated with 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 at least three years from 2008-2017.
- A fisherman must have landed a minimum of 500 kg roe from 2008-2017.

Additionally, a fisherman is considered as a different fisherman if he moves between NAFO areas between 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 where sorted based on the value of the catch, with roe having much higher weight specific value. Applying correct conversion factors allows for roe amount to be converted into whole fish weight, which in turn can be used to estimate the number of fish caught. At present the conversion factor from roe to whole fish is 6.7. Based on unpublished data we believe this is too high, and in the present document only roe landings are reported. Length data from commercial female catches are available from 2011. However, sampling has been sporadic and with insufficient coverage of the fishing area.

Analysis

In this document the procedure is shortly described in words only. All analyses were done in R (R core team, 2014) and the script for calculating LPUE is provided as an appendix to this document, including the data preparations steps. The calculations are derivatives of this script.

Initially, a year and NAFO division specific LPUE (kg pr. landing) for each individual fisherman is calculated. This LPUE is weighted by the share of the total catch in the respective NAFO division taken by the fisher-man. All LPUE's 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 LPUE's are weighted by the total west coast landings. This procedure ensures that the fishermen and areas with the highest landings are given the highest weight in the assessment of the stock status.

The field code information is used to get an overview of the extent of the fishery in general, but also to cal-culate the extent of the fishery in each NAFO division. This is done by simply calculating the number of field codes fished in each year in each NAFO division.

Results

The 2017 landings were 1102 t which is an increase of 55% compared to 2016 (Fig. 1).

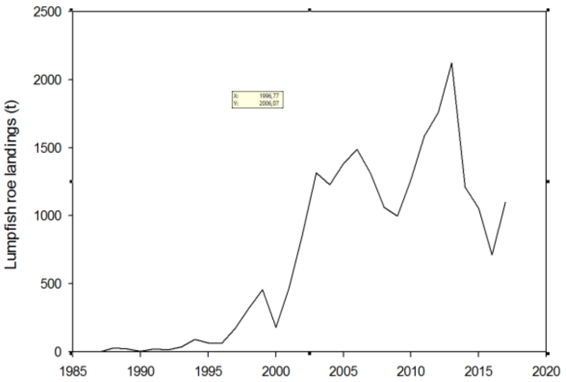

Figure 1: Total lumpfish roe landings (t) from 1987 to 2017.

The LPUE increased by 63% (Fig. 2, Table I). An increase was seen in all areas except 1B, where it decreased slightly. The most noticeable change was the high LPUE in NAFO 1D; 381 kg. pr. landing.

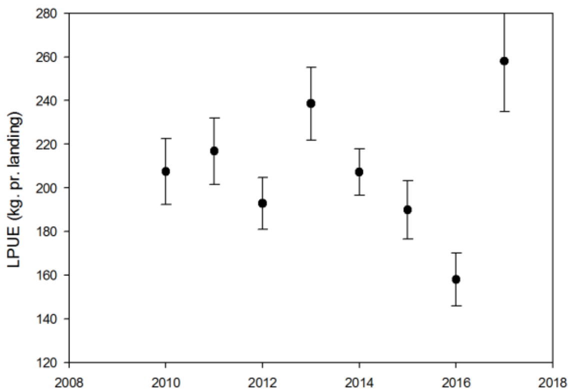

Figure 2: LPUE estimates for the West Greenland area Vertical bars are standard errors.

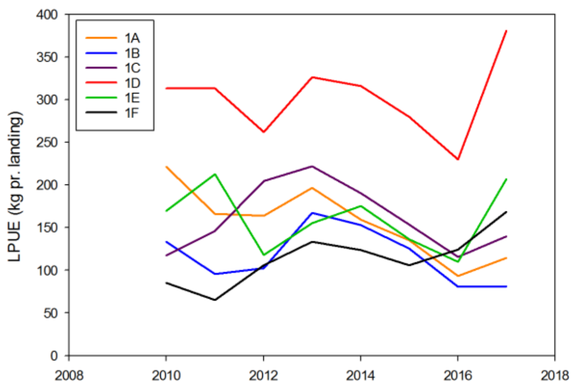

Figure 3: NAFO area specific LPUE estimates.

Table I: LPUE by year.

year	cpue
2010	207.5
2011	216.8
2012	192.8
2013	238.6
2014	207.2
2015	189.9
2016	158.0
2017	258.0

The number of fished field codes has declined from 265 in 2012 to 217 in 2017 (Table II) but is still distributed from 60°N to 71.5°N (Fig. 4). The decline is primarily driven by a decline in NAFO 1B, while all other areas have remained constant. The decline is coincident with a decline in fishermen in this area. On the other hand, in other areas number of filed codes and fishermen increased, especially in SW Greenland. The average fish length has been surprisingly stable between years, considering the low sample size, with 2011 (N=109), 2012 (N=561) and 2013 (N=69) length means being within 1.1% of each other (2011-2013 average=37.62 cm) whereas the 2014 (N=273) and 2015 fish (N=244) were slightly larger (39.18 cm and 38.3, respectively). There was no sampling from the commercial fishery in 2016 or 2017.

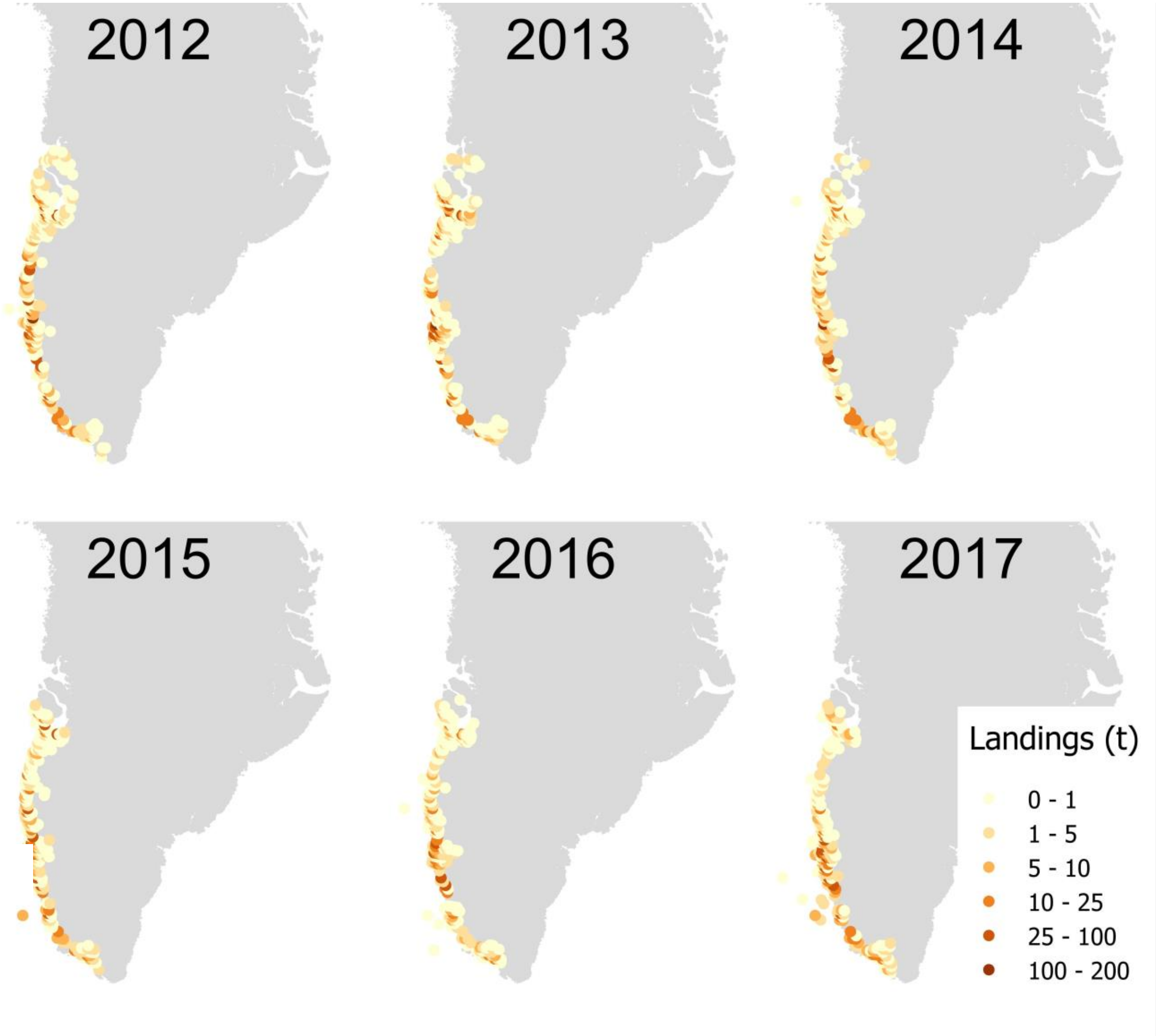

Figure 4: Distribution of lumpfish roe catches (t) summarized by field code.

Table II: Number of field codes fished and active fishermen in each NAFO division and year.

Year	Field codes fished						Total	Number of fishermen						Total
	1A	1B	1C	1D	1E	1F		1A	1B	1C	1D	1E	1F	
2012	22	113	38	43	17	32	265	109	164	158	141	33	61	666
2013	11	106	23	57	19	33	249	100	154	85	171	33	69	612
2014	5	109	37	33	13	36	233	57	131	115	88	36	68	495
2015	21	79	34	59	15	31	239	43	126	105	102	34	60	470
2016	18	69	38	44	25	32	226	41	103	101	96	32	47	420
2017	17	51	40	62	14	44	217	43	97	118	119	30	71	456

Discussion

The data used in this assessment seem consistent, and provides a useful tool in assessing the state of the lumpfish stock (given correct assumptions). Overall, landings decreased drastically from 2013 to 2016 but increased again in 2017 (Fig 1). In 2014 and 2015 the winter was longer than usual, meaning that the season was shortened and in 2014 landing facilities and fishermen had a dispute on prices, again shortening the season, resulting in a fishery that started 14 days later than in 2013 and with fewer active fishermen (table II, Fig. 5). In 2015 a management plan with a restriction on the number fishing days was implemented, resulting in a shorter season, and as a consequence the fishery started later in the season. This implementation was coincident with a 2015 LPUE decline, even though the opposite could have been expected as the fishery upon restrictions would likely concentrate in the best part of the season. It is especially noteworthy that the LPUE decline was consistent across all areas. This trend continued in 2016, and the LPUE (158 kg/landing) was well below time series mean of 209 kg/ landing. The observed increase in LPUE in 2017 to the highest level in the time series does not seem to be related to the number of fishermen or number of fished field codes. It therefore suggests that lumpfish were indeed abundant in 2017. The previous LPUE decrease could be related to high catches in 2011-2013, and similarly the current increase could be a response to reduced landings in 2014-2016; especially when considering that the average age of first time spawning lumpfish is believed to be 3-4 years. However, many environmental factors not accounted for here affect recruitment, and the recent decline could also reflect natural stock dynamics. Monitoring the stock should continue, and be extended to include improved data on effort (i.e. number of nets and soaking time) and length measurements of the catch. However, as long as the sole unit of landings is kg of roe, the two factors are inseparable.

The advice for number of fishing days and quantity for catches (TAC) is generated by applying the decision tree in figure 6. An elaboration of this procedure is given in the current management plan. The data for 2017 results in an advice for 2018 and 2019 that is maintained at the current level, which is 1300 t of roe and 41 days. The advice is based on the two LPUE equations in the decision tree:

$$LPUE\ advice\ index\ 1 = \frac{\text{lpue2016} + \text{lpue2017}}{\text{lpue2014} + \text{lpue2015}} = \frac{158 + 258}{207.2 + 189.9} = \ 0.972\ (below\ 1)$$

$$LPUE\ advice\ index\ 2 = \frac{\text{lpue2016+lpue2017}}{\text{lpue2010}-\text{2013}} = \frac{158+258}{207.5+216.8+192.8+238.6} = \ 1.048\ (above\ 1)$$

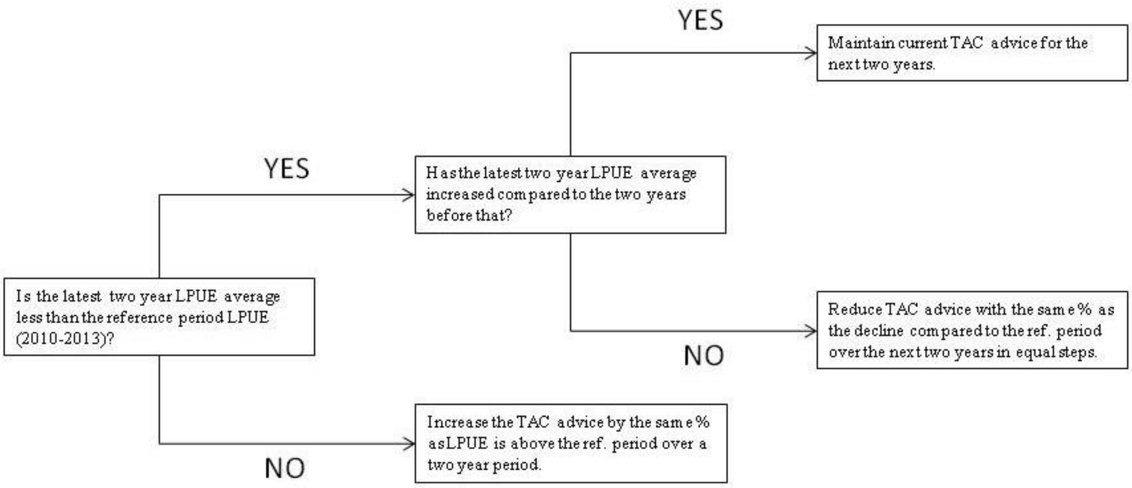

Figure 6: Advisory decision tree.

The LPUE in NAFO 1D is considerably and consistently higher than in all other areas. The exact reason for this is unknown but is believed to be a result of the largest boats being located in the largest city, Nuuk. Furthermore, 1D is in the central part of the west coast, suggesting that it could be the primary habitat.

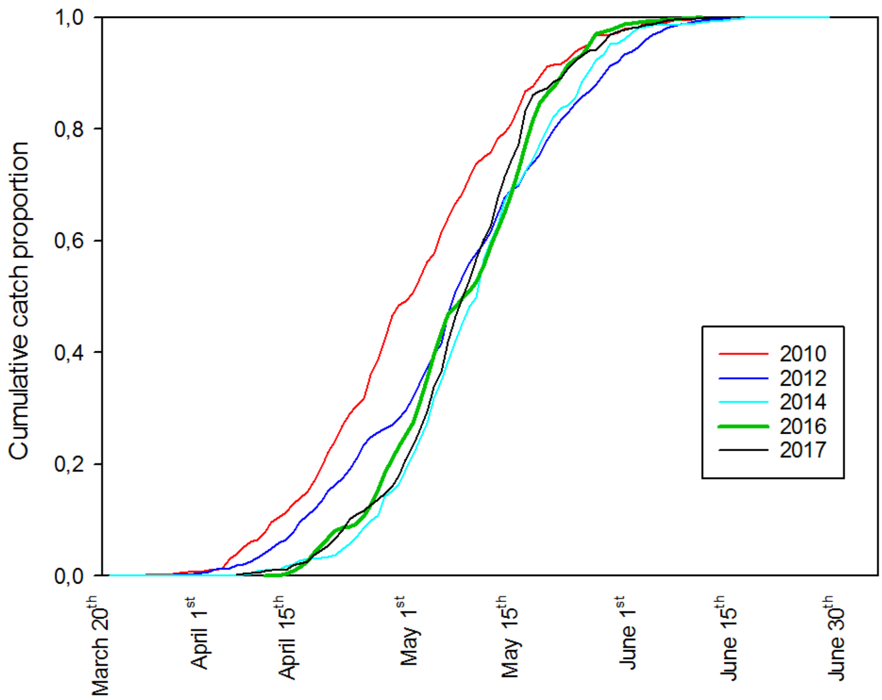

Figure 5: Cumulative catches in proportions

At present, no lumpfish survey exists, but this would be a valuable tool to assess if field codes fished actually do reflect changes in distribution, especially as fisheries have often been able to maintain high catch rates in spite of reduced fish abundance. We do not provide any estimate of male lumpfish landings as these are unreported. However, given the mesh size of the gill nets (260mm) and the significant sexual size dimorphism (Hedeholm et al. 2013) we believe that male catches are very low. Davenport J. (1985) states, that based on Icelandic data males are predominantly caught in 170-190 mm gill nets. However, small amounts of males are landed and sold on the domestic market, but catches are surely small and amounts to only a few tones. There is also a recreational fishery for females that is not accounted for in this study. The recreational landings are also from 260mm gill nets, but there is no estimate of the amount. Based on personal communication it is however estimated, that total recreational roe landings are less than 25 t pr. year, and therefore negligible.

The LPUE estimates presented here rests on vital assumptions. If the fleet change effort (i.e. number of nets pr. boat) the LPUE time series will not only reflect population changes. Currently, data does not allow us to evaluate the validity of this assumption, but based on seminars and personal communication the fishermen appear to carry the same number of nets regardless of catch rates – the small boats are simply saturated.

A vital assumption for this assessment is that the fishermen land their catch just after capture, even if this means having only some fraction of the maximum capacity in the boat. We believe this is justified, as lumpfish roe will not stay at premium quality for days after capture, and the fishermen have no storage facility in their small boats. This has also been confirmed in seminars. This “net saturation assumption” also implies that a fisherman does not change “set up” between years, meaning that the effort in regards to nets is fixed. We cannot, however, rule out that certain fishermen changes boat/gear type in the period.

The LPUE times series is based on high quality data, but given the assumptions, the relatively short time series and the lack of biological knowledge on lumpfish means that LPUE estimates are associated with some uncertainty, and hence the fishery should be managed based on precautionary approach until more data is available. Also, the field codes fished is not currently implemented in a formal way in the management plan, which ideally should be considered.

References

Davenport J. 1985. Synopsis of the biological data on lumpsucker *Cyclopterus lumpus* (Linnaeus, 1758). FAO Fisheries synopsis No. 147. Rome 1985.

Hedeholm, R., et al. 2013. First estimates of age and production of lumpsucker (*Cyclopterus lumpus*) in Greenland. Fish. Res. (2013), http://dx.doi.org/10.1016/j.fishres.2013.08.016

Hedeholm, R., et al. 2017. Life history trait variation of Greenland lumpfish (*Cyclopterus lumpus*) along a 1600 km latitudinal gradient. Polar Biology. Doi 10.1007/s00300-017-2160-x.

Hutchings J. 1996. Spatial and temporal variation in the density of northern cod and a review of hypotheses for the stock's collapse. Can J Fish Aquat Sci 53:943–962

R Core Team (2014). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL http://www.R-project.org/.

Appendix I

R script used in LPUE calculations.

```
#
#  HUSK AT ÆNDRE "," TIL "." I DATAARKET FØR GROGRAMMET KØRES!
####################################################################################################################
########
# - Beregner LPUE for stenbider og laver tre Excel filer - Første til brug i SAS til at beregne gps pos,
#   der senere benyttes til at lave et fangstkort.Anden og tredje fil giver vægtet LPUE pr område og år henholdsvis.
# - HEL og MHUI kattegorierne frasorteres.
# - Se dokumentet "LPUE procedure brugt i rådgivningen for den vestgrønlandske stenbider.doc" for nærmere beskrivelse af proceduren.
# - Script lavet af RaHe og SoPo 2014. R version 3.1.1
####################################################################################################################
########

#Oprydning af idligere arbejder i R.
rm(list = ls(all.names=TRUE))
#Arbejdssti
setwd('F:/20-39 FiSk/37 Andre fiskarter, invertebrater, blan. forsøgsfiskeri/00 Rådgivning og sagsbehandling/02 Stenbider/00 Data/Oparbejd-ning/2017')
#data1 <- read.csv('Z:/31 Andre fisk/2015 data/LUM2010_2015.csv', sep=',', header=T)
#data1 <- read.table('Z:/31 Andre fisk/2015 data/LUM2010_2015.txt', sep=';', header=T)
data1 <- read.csv('F:/20-39 FiSk/37 Andre fiskarter, invertebrater, blan. forsøgsfiskeri/00 Rådgivning og sagsbehandling/02 Stenbider/00 Data/Opar-bejdning/2017/LUM2010_2017.csv', sep=';', header=T)
#data1 <- read.table('C:/Users/rahe/Desktop/LUM2010_2016.txt', sep='\t', header=T)
#data1 <- read.csv('C:/Users/rahe/Desktop/LUM2010_2016_2.csv', sep=';', header=T)

data1$day <- as.numeric(as.character(substring(data1$INDHANDLINGSDATO, 1,2)))
data1$month <- as.numeric(as.character(substring(data1$INDHANDLINGSDATO, 4,5)))
data1$year <- as.numeric(as.character(substring(data1$INDHANDLINGSDATO, 7,10)))

data2a <- data1[,c('year','month','day','BEHGRD_KODE','MAENGDE','INDHANDLINGSSTED_GFLKNR','FISKER_GFLKNR','VAERDI','FANGSTFELT')]
names(data2a)[1:9] <- c('year','month','day','BEHGRD','MAENGDE','Location','SAELGER','VAERDI','FELTKODE')
data2a$MAENGDE <- as.numeric(as.character( sub(",", ".", data2a$MAENGDE)))
data2a$VAERDI <- as.numeric(as.character( sub(",", ".", data2a$VAERDI)))

data1<-data2a #work-around for at få resten af programmet til at køre

#install.packages('car')
library("car")
data2<-subset(data1, month=='3')
data3<-subset(data1, month=='4')
data4<-subset(data1, month=='5')
data5<-subset(data1, month=='6')
data6<-rbind(data2,data3)
data7<-rbind(data6,data4)
```

```
data8<-rbind(data7,data5)

data9<-subset(data8,BEHGRD!='MHUI')
data9b<-subset(data9,BEHGRD!='HEL')

write.table(data9b, file = "tilsas2.csv", sep = ";", na = "NA", row.names = F)

#der er linjer uden angivelse af behgrd. For at tjekke om det rogn eller MHUI/HEL regnes en kg pris ud.
#Herefter smides de linjer ud, hvor kg.prisen er under 5 kr.
data9b$value <- data9b$VAERDI / data9b$MAENGDE #kg.prisen udregnes
data9b <- subset(data9b, value>5)

#der er enkelte fejl i data, blandt andet negative mængder, som smides ud her.
data10<-subset(data9b, MAENGDE>0)

#her droppes ligegyldige variable.
data10$ART <- data10$KVALITET <- data10$BEHGRD <- data10$KVOTE <- data10$VAERDI <- data10$value <- NULL

#her laves location om til en kategorisk variabel.
data10$Location = as.factor(data10$Location)

data10$Location_2<-recode(data10$Location,"c(1010)='Nanortalik';c(1040)='Narsaq';c(1050)='Paamiut';c(1060)='Nuuk';c(1070)='Maniitsoq';
c(1080)='Sisimiut';c(1100)='Aasiaat';c(1110)='Qasigiannguit';c(1120)='Ilulissat';c(1121)='Ilulissat';c(1122)='Ilulissat';
c(1123)='Ilulissat';c(1124)='Ilulissat';c(1140)='Qeqertarsuaq';c(1150)='Uummannaq';c(1151)='Uummannaq';c(1152)='Uummannaq';
c(1153)='Uummannaq';c(1154)='Uummannaq';c(1155)='Uummannaq';c(1156)='Uummannaq';c(1157)='Uummannaq';c(1210)='Arsuk';
c(1211)='Nuuk';c(1212)='Nuuk';c(1213)='Maniitsoq';c(1214)='Maniitsoq';c(1217)='Kangaatsiaq';c(1218)='Aasiaat';c(1219)='Aasiaat';
c(22111)='Nanortalik';c(22167)='Upernavik';c(22532)='Qaqortoq';c(22597)='Innaarsuit';c(22619)='Ship';c(22761)='Ilulissat';
c(22810)='Kangersuatsiaq';c(22815)='Attu';c(22818)='Upernavik';c(22835)='Qaanaaq';c(22857)='Sisimiut';c(22874)='Sisimiut';c(22876)='Kuumi-
ut';c(22928)='Sisimiut';
c(22930)='Maniitsoq';c(23011)='Maniitsoq';c(23039)='Ilimanaq';c(23049)='Maniitsoq';
c(23137)='Qeqertarsuaq';c(23139)='Aasiaat';c(1616)='Ship';c(1651)='Ship';c(1653)='Ship';c(22111)='Nanortalik';c(22162)='Uummannaq';
c(22167)='Upernavik';c(22479)='Ilulissat';c(22532)='Qaqortoq';c(22597)='Upernavik';c(22619)='Ship';c(22761)='Ilulissat';
c(22810)='Upernavik';c(22815)='Aasiaat';c(22818)='Upernavik';c(22835)='Qaanaaq';c(22857)='Sisimiut';c(22874)='Sisimiut';c(22876)='Tasiilaq';
c(22928)='Sisimiut';c(22930)='Qaqortoq';c(23103)='Upernavik';c(23104)='Upernavik';c(23105)='Upernavik';c(23106)='Upernavik';
c(23108)='Uummannaq';c(23011)='Maniitsoq';c(23039)='Ilulissat';c(23049)='Nanortalik';c(23137)='Qeqertarsuaq';c(23139)='Aasiaat';
c(23275)='Sisimiut';c(23338)='Sisimiut';c(23286)='Upernavik';c(23395)='Upernavik';c(22821)='Nuuk';c(22992)='Maniitsoq';c(22993)='Aasi-
aat';c(23114)='Nanortalik';
c(23325)='Qeqertarsuaq';c(23691)='Upernavik';c(23733)='Ilulis-
sat';c(29500)='Narsaq';c(68)='Nuuk';c(23374)='Narsaq';c(24052)='Maniitsoq';c(27557)='Narsaq';c(23502)='Maniitsoq';
c(23514)='Sisimiut';c(23505)='Attu';c(23581)='Aasiaat';c('29501')='Nuuk';c('23692')='Uummannaq';c('23978')='Maniitsoq';c(23503)='Ikamiut'")
unique(data10$Location_2) #Tjekker om der er nogle feltkoder som ikke omskrives til område
#efter snak med GFLK er der lavet ændringer i område allokeringen 8-12-2016, RaHe.

data10$Location_2 <- as.factor(data10$Location_2)
#data10<-subset(data10, Location!='27501') #Fjerner bifangst fra loddefiskeriet i Island
```

```
data10$NAFO<-recode(data10$Location_2,"c('Nanortalik')='1F';c('Narsaq')='1F';c('Paamiut')='1E';c('Nuuk')='1D';c('Maniitsoq')='1C';
c('Sisimiut')='1B'; c('Aasiaat')='1B'; c('Qasigiannguit')='1B';c('Ilulissat')='1A';c('Qeqertarsuaq')='1A';c('Uummannaq')='1A';c('Arsuk')='1E';
c('Kangaatsiaq')='1B';c('Upernavik')='1A';c('Qaqortoq')='1F';c('Innaarsuit')='1A';c('Kangersuatsiaq')='1A'; c('Attu')='1B';
c('Qaanaaq')='1A';c('Sisimiut')='1B';c('Kuumiut')='XIVb';c('Ilimanaq')='1A';c('Tasiilaq')='XIVb'; c('Ikamiut')='1B'")
summary(data10)

summary_table1 <- aggregate(data10[,c('MAENGDE')],list(Location_2=data10$Location_2, year=data10$year),sum,na.rm=T)
summary_table1$tons <- summary_table1$x/1000
summary_table2 <- aggregate(data10[,c('MAENGDE')],list(year=data10$year, NAFO=data10$NAFO),sum,na.rm=T)
summary_table2$tons <- summary_table2$x/1000

#herunder skal de fiskere som skal indgå i beregningerne udvælges. Det sker efter flere kriterier:
#først regnes antallet af år en fisk har været aktiv
data10$dummy <-1
indhandlinger_pr_fisherman_pr_aar <- aggregate(data10[,c('dummy')],list(SAELGER=data10$SAELGER, year=data10$year),sum,na.rm=T) #giver
antal indhandlinger pr år pr. fisker
indhandlinger_pr_fisherman_pr_aar$dummy2 <-1 #en ny dummy variable som vi summerer herunder
antal_aktive_fiskeaar <- aggregate(indhandlinger_pr_fisherman_pr_aar[,c('dummy2')],list(SAELGER=indhandlinger_pr_fisherman_pr_aar$SAEL-
GER),sum,na.rm=T) #giver antal år med indhandlinger pr. fisker

data11 <- merge(data10, antal_aktive_fiskeaar,by='SAELGER') #de to datark kombineres

#nu smides der linjer ud efter følgende kriterier:
#1) en fisker skal have været aktiv i mindst 3 år i perioden 2008-20XX for at indgå i beregningerne
data12 <- subset(data11, x >2)

#2) en fisker skal have fanget minimum 500 kg er perioden 2008-20xx for at indgå
#først regnes den totale fangstmængde for hver fisker
total_indhandling_pr_fisker <- aggregate(data11[,c('MAENGDE')],list(SAELGER=data11$SAELGER), sum,na.rm=T)
data13 <- merge(data12,  total_indhandling_pr_fisker, by='SAELGER')
#og fiskerne slettes
data14 <- subset(data13, x.y>500)

#3) Vi har vurderet at data før 2010 er af for dårlig kvalitet og derfor udelades de.
data15<-subset(data14, year>2009)
head(data15)

#her gøres hver sælger unik - dvs, at hvis en sælger flytter område er han betragtet som en anden sælger
data15$SAELGER_unik <- paste(data15$SAELGER, data15$NAFO, sep='_')


#nu udskrives en fil osm skal bruges til at lave et kort med fiskeintensitet. Dette er gjort 2014
write.table(data15, file = "tilsas2.csv", sep = ";", na = "NA", row.names = F)
```

```
#herunder begynder selve analysen
data16 <- aggregate(data15$MAENGDE,list(SAELGER_unik=data15$SAELGER_unik, year=data15$year, NAFO=data15$NAFO), sum,na.rm=T) #her summeres mængden for hver sælger i hvert område i hvert år.
data17 <- aggregate(data15$dummy,list(SAELGER_unik=data15$SAELGER_unik, year=data15$year, NAFO=data15$NAFO), sum,na.rm=T) #her tælles hvor mange indhandlinger hver sælger har i hvert område i hvert år.
data18 <- cbind(data16,data17$x) #de to datasæt sættes sammen, og herunder omdøbes de nye varialble.
#install.packages('plyr')
library(plyr)
names(data18)[names(data18)=='x']<-'rogn_saelger_pr_år_pr_område'
names(data18)[names(data18)=='data17$x']<-'antal_indhandlinger_pr_år_pr_område_pr_fanger'

#der regnes nu et CPUE for hver unik sælger i hver område i hvert år.
data18$CPUE_kg_pr_indhandling <- data18$rogn_saelger_pr_år_pr_område/data18$antal_indhandlinger_pr_år_pr_område_pr_fanger

#der laves en tabel som viser antallet af indhandlinger for hver sælger i hvert område, og den sættes sammen med tabellen med CPUE'en
data19 <- aggregate(data18$antal_indhandlinger_pr_år_pr_område_pr_fanger,list(year=data18$year, NAFO=data18$NAFO), sum,na.rm=T)
data20 <- merge(data18,data19, by=c('year','NAFO'))
#de nye variable omdøbes.
names(data20)[names(data20)=='x']<-'antal_indhandlinger_pr_år_pr_område'

#der laves en vægtning idet sælgere med flest indhandlinger skal vægte tungest.
#vægten defineres som en sælgers antal indhandlinger pr. år pr område / antal indhandlinger i det område i det år (altså andelen).
data20$weight_til_CPUE <- data20$antal_indhandlinger_pr_år_pr_område_pr_fanger/data20$antal_indhandlinger_pr_år_pr_område
#herunder ganges vægten sammen med det rå CPUE
data20$vægtet_CPUE <- data20$CPUE_kg_pr_indhandling * data20$weight_til_CPUE

#disse linjer regner område- og årsspecifikke CPUE'er og tilhørende standard deviation
data21 <- aggregate(data20$vægtet_CPUE,list(year=data20$year, NAFO=data20$NAFO), sum,na.rm=T)
data21b <- aggregate(data20$vægtet_CPUE,list(year=data20$year, NAFO=data20$NAFO), FUN=sd)
names(data21)[names(data21)=='x']<-'CPUE_pr_område_pr_år'
names(data21b)[names(data21b)=='x']<-'SD'

#disse linjer regner SE for estimaterne
data21b$nrow <- nrow(data20)
data21b$SE <- data21b$SD/sqrt(data21b$nrow)
data22 <- merge (data21,data21b, by=c('year','NAFO'))



#denne linje giver en excel fil med et vægtet CPUE for hvert område i hvert år med SE.
#write.table(data22, file = "CPUE_pr_område.xls", sep = "\t", row.names = F)



#herunder regens nu CPUE for de enkelte år.
#denne linje regner hvor meget der er indhandlet i hvert område i hvert år
```

```
data23 <- aggregate(data20$rogn_saelger_pr_år_pr_område,list(year=data20$year, NAFO=data20$NAFO),sum,na.rm=T)
#denne linje regner hvor meget der er indhandlet i hvert år
data23b <- aggregate(data20$rogn_saelger_pr_år_pr_område,list(year=data20$year),sum,na.rm=T)
#de nye variable omdøbes
names(data23)[names(data23)=='x']<-'kg_pr_område_pr_år'
names(data23b)[names(data23b)=='x']<-'kg_pr_år'

#de to tabeller sættes sammen, og den viser hvor meget der er indhandlet i hvert område i hvert år, og den samlede mængde i hvert år
data24 <-merge (data23, data23b, by='year')

#idet der ikke fanges lige meget i hvert område i hvert år vægtes de enkelte områder.
#vægten regnes som mængden pr område pr år / mængden det pågælgende år
data24$weight_til_CPUE <- data24$kg_pr_område_pr_år/data24$kg_pr_år

#denne tabel indeholder antal indhandlinger pr år pr område, som bruges til CPUE beregning.
data25 <- aggregate (data20$antal_indhandlinger_pr_år_pr_område_pr_fanger,list(year=data20$year,NAFO=data20$NAFO), sum,na.rm=T)
names(data25)[names(data25)=='x']<-'indhandlinger_pr_område_pr_år'

#tabellerne med vægten (data22) og antal indhandlinger (data23) sættes sammen.
data26 <- merge (data24,data25, by=c('year','NAFO'))
#der regnes et CPUE for hvert område i hvert år: kg pr område pr år / antal indhandlinger pr område pr år og disse vægtes
data26$CPUE_pr_område_pr_år <- data26$kg_pr_område_pr_år / data26$indhandlinger_pr_område_pr_år
data26$vægtet_CPUE <- data26$CPUE_pr_område_pr_år * data26$weight_til_CPUE

#de vægtede CPUE lægges sammen for hvert år, og der regnes en SD
data27 <- aggregate(data26$vægtet_CPUE,list(year=data26$year), sum,na.rm=T)
data27b <- aggregate(data26$vægtet_CPUE,list(year=data26$year), FUN=sd)
names(data27)[names(data27)=='x']<-'CPUE_pr_år'
names(data27b)[names(data27b)=='x']<-'SD'

#der regnes SE for estimaterne
data27b$nrow <- nrow(data27)
data27b$SE <- data27b$SD/sqrt(data27b$nrow)
data28 <- merge (data27,data27b, by=c('year'))



#denne tabel giver et vægtet CPUE for hvert år med tilhørende SE:
#write.table(data26, file = "CPUE_pr_år.csv", sep = "\t", row.names = F)


#data2015 <- subset(data10, year=="2015") # Bruges til at chekke om 2015 tallene er korrekte
#summary
#write.table(data2015, file = "datacheck.csv", sep = "\t", row.names = F)

# Positioner på indhandlingssteder
```

```
#df_Indhandlingssteder <- unique(data10$Location_2)
#df_Indhandlingssteder <- sort(df_Indhandlingssteder)
df_Indhandlingssteder <- c("Arsuk","Attu","Ikamiut","Ilulissat","Kangaatsiaq","Maniitsoq","Narsaq","Nuuk","Paamiut","Qaqortoq","Qasigiann-
guit","Qeqertarsuaq","Sisimiut","Upernavik","Uummannaq","Aasiaat")
df_Indhandlingssteder <- as.data.frame(df_Indhandlingssteder)
names(df_Indhandlingssteder)[1] <- 'Indhandlingssted'
df_Indhandlingssteder$lat <- 0
df_Indhandlingssteder$lon <- 0
#df_Indhandlingssteder <- df_Indhandlingssteder[order(df_Indhandlingssteder$Indhandlingssted),]
df_Indhandlingssteder$lat <- c(61.17, 67.94, 68.63, 69.22, 68.30, 65.41, 60.91, 64.18, 61.99, 60.72, 68.82, 69.24, 66.94, 72.79, 70.68, 68.70)
df_Indhandlingssteder$lon <- c(-48.48,-53.62, -52.16, -51.1, -53.45, -52.90, -46.05, -51.70, -49.67, -46.03, -51.18, -53.54, -53.68, -56.14, -52.13, -
52.86)
names(df_Indhandlingssteder)[1] <- 'Landing_Place'
```