UNIVERSITY *of* TASMANIA

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INSTITUTE FOR MARINE & ANTARCTIC STUDIES

Estimating Recreational Abalone Harvest Using Length-Weight Data from Commercial Catch Sampling

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1 Load most recent compilation of Commercial Abalone Catch Sampling data.

```
## Read in most recent commercial catch sampling compiled MM dataframe
compiledMM.df.final <- readRDS('C:/CloudStor/R_Stuff/MMLF/compiledMM.df.final.RDS')
```

2 Clean catch sampling data

```
## Quick plot checking for outliers
compiledMM.df.final %>%
  ggplot() +
  geom_point(aes(x = shell.length, y = whole.weight))+
 ggtitle('Length-Weight All Data')+
 xlab('Shell Length (mm)')+
 ylab('Whole Weight (g)')+
 theme_bw()
```

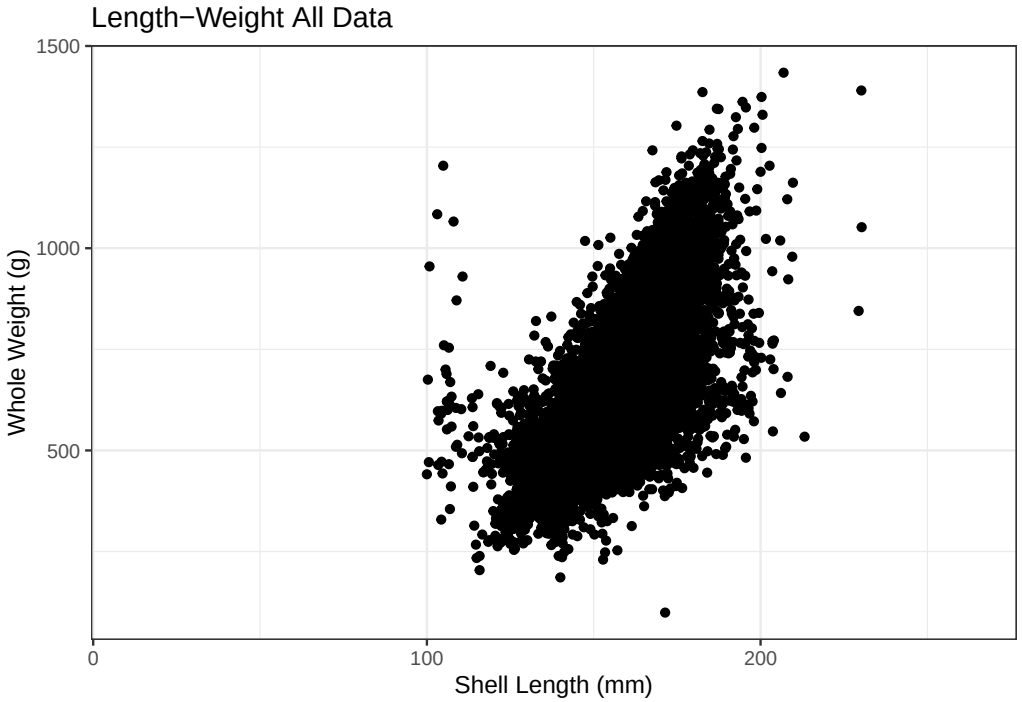

Figure 1: Length-weight relationship of commercial abalone catch sampling data for all zones collected between 2019-2021.

```
## remove erroneous data
  lw.dat <- compiledMM.df.final %>%
    filter(
      between(whole.weight, 200, 1500) & # abalone above or below these weights
        # unlikely
        between(shell.length, sizelimit - 5, 220) & # removes calibration measures
        # around 100 mm and accounts for minor measuring error for abalone near the LML
```

```
        !(shell.length > 175 & whole.weight < 600), # these appear to be erroneous weights
        !(shell.length > 180 & whole.weight < 1000))# these appear to be erroneous weights
```

```
## Quick plot re-checking for outliers for eastern zone
lw.dat %>%
  filter(newzone == 'E') %>%
  ggplot() +
  geom_point(aes(x = shell.length, y = whole.weight))+
 ggtitle('Length-Weight Cleaned Eatsern Zone Data')+
  xlim(130, 200)+
 xlab('Shell Length (mm)')+
 ylab('Whole Weight (g)')+
 theme_bw()
```

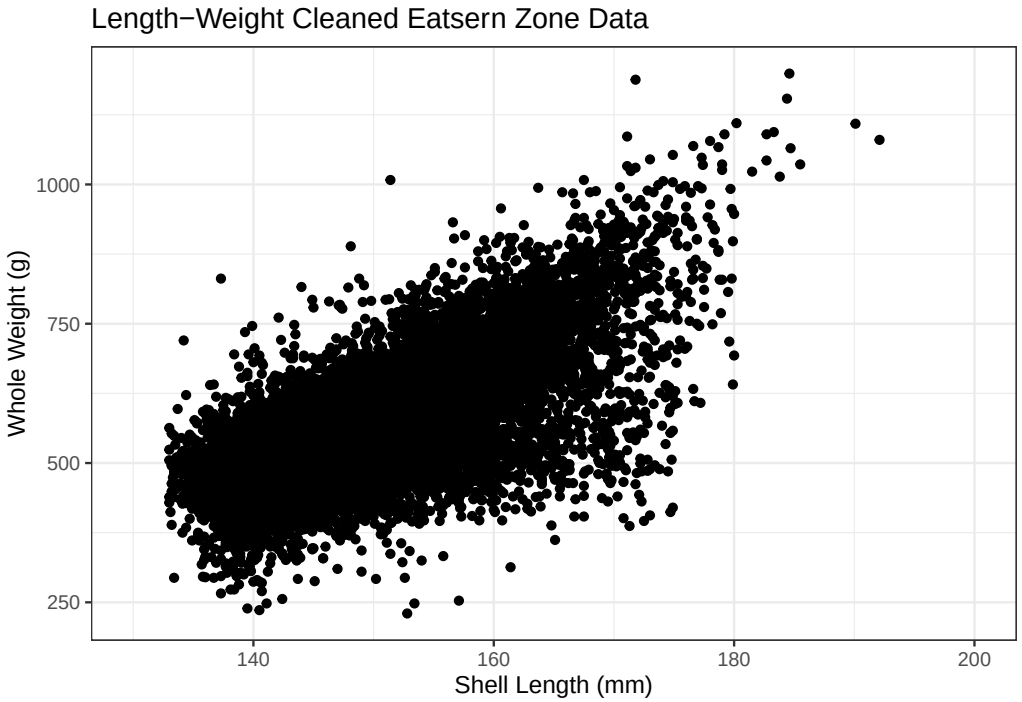

Figure 2: Length-weight relationship of cleaned commercial abalone catch sampling data for the eastern zone collected between 2019-2021.

3 Estimate Recreational harvest for by mean weight

The estimated combined east coast (areas 1-3) blacklip abalone recreational harvest number for 2020-21 was n = 22882 (95% CI 12774-34777) (area 1 = 11756, area 2 = 9919, area 3 = 1207) (Lyle et al. 2021). Estimated harvest weight (kg) is then traditionally estimated by multiplying the harvest number by the average weight of an individual abalone for each area based on commercial catch sampling data collected prior to 2018 (area 1 = 522 g, area 2 = 517 g, area 3 = 520 g). In 2020-21 this equates to 11916 kg (11.9 t) (see Table 6 in Lyle et al. 2021).

The following code have been developed to utilise the most recent data collected from the commercial abalone catch sampling program between 2019-2021.

3.1 Summarise mean weight by Zone

```
## Determine average weight by zone
zone.wt <- lw.dat %>%
  group_by(newzone) %>%
  summarise(Av.weight = mean(whole.weight),
            n = n(),
            catches = n_distinct(docket.number)) %>%
 as_tibble()

library(knitr)
kable(zone.wt, caption = "Average weight of individual abalone from commerical abalone catch sa
```

Table 1: Average weight of individual abalone from commerical abalone catch sampling data for all zones collected between 2019-2021.

Zone	Av.weight (g)	n	Catches
BS	402.0413	339	4
E	557.8497	15838	165
G	662.9899	296	3
N	486.2810	630	6
W	692.6604	15145	158

3.2 Estimate recreational harvest weight for east coast based on mean weight of individual abalone from commerical catch sampling for the eastern zone

```
# The estimated recreational harvest number for the eastern zone in 2020-21 was:
rec.harvest.no <- 22882

east.wt <- lw.dat %>%
  filter(newzone == 'E') %>%
  summarise(Av.weight = mean(whole.weight)) %>%
  mutate(Harvest = (rec.harvest.no * Av.weight) / 1000) %>%
 rename("Av.weight (g)" = Av.weight,
        "Harvest (kg)" = Harvest) %>%
 as_tibble()

library(knitr)
kable(east.wt, caption = "Estimated Recreational harvest based on average weight of individual
```

Table 2: Estimated Recreational harvest based on average weight of individual abalone from commerical catch sampling for the eastern zone collected between 2019-2021.

Av.weight (g)	Harvest (kg)
557.8497	12764.72

4 Estimate Recreational harvest based on length-weight relationship

```
## Calculate log of length and weight
lw.dat.log <- lw.dat %>%
  mutate(log.sl = log(shell.length),
         log.wt = log(whole.weight))

## Calculate length-weight regression coefficient for each zone
lw.dat.coeff.zone <- lw.dat.log %>%
  nest(data = -newzone) %>%
  mutate(fit = map(data, ~ lm(log.wt ~ log.sl, data = .x)),
         tidied = map(fit, broom::tidy)) %>%
  unnest(tidied) %>%
  filter(term %in% c('(Intercept)', 'log.sl')) %>%
  select(c(newzone, estimate, term)) %>%
  as.data.frame() %>%
  spread(., term, estimate) %>%
  dplyr::rename(b = 'log.sl',
                intercept = "(Intercept)") %>%
  mutate(a = exp(intercept)) %>%
  select(c(newzone, a, b))

library(knitr)
kable(lw.dat.coeff.zone, caption = "Estimated length-weight model parameters from commerical ab
```

Table 3: Estimated length-weight model parameters from commerical abalone catch sampling data for all zones collected between 2019-2021.

Zone	a	b
BS	0.0021595	2.474915
E	0.0099341	2.182369
G	0.0000692	3.162481
N	0.0013457	2.585293
W	0.0028179	2.448732

```
## Select length-weight regression parameters for eastern zone to use for estimating weight
lw.coeff.zone <- lw.dat.coeff.zone %>%
  filter(newzone == 'E') %>%
  select(a, b) %>%
  mutate(join.id = 1)

## Create dataframe of proposed legal minimum lengths (LMLs) for eastern zone
lml.df <- data.frame('LML' = c(138, 140, 145, 150, 155, 160))

## Join chosen regression parameters to proposed LMLs
lml.wt.df <- lml.df %>%
  mutate(join.id = 1) %>%
```

```
  left_join(., lw.coeff.zone)

## Determine weight for proposed LMLs

rec.harvest.no <- 22882

lml.wt.est.df <- lml.wt.df %>%
  mutate(est.weight = ((a * (LML ^ b))),
         harvest = (est.weight * rec.harvest.no) / 1000,
         harvest5 = harvest * 0.95,
         harvest10 = harvest * 0.90)

lml.wt.est.tab <- lml.wt.est.df %>%
  select(c(LML, est.weight, harvest, harvest5, harvest10))

library(knitr)
kable(lml.wt.est.tab, caption = "Estimated Recreational harvest for each LML based on abalone l
```

Table 4: Estimated Recreational harvest for each LML based on abalone length-weight relationship from commerical catch sampling for the eastern zone collected between 2019-2021.

LML	Est. weight (g)	Harvest (kg)	Harvest 95% (kg)	Harvest 90% (kg)
138	464.6605	10632.36	10100.74	9569.126
140	479.4831	10971.53	10422.96	9874.379
145	517.6456	11844.77	11252.53	10660.290
150	557.3963	12754.34	12116.63	11478.908
155	598.7451	13700.49	13015.46	12330.437
160	641.7016	14683.42	13949.24	13215.074

4.1 Determine relative change in Recreational harvest from initial LML

```
## Select harvest for initial eastern zone LML
harvest.wt <- lml.wt.est.df[1, 'harvest']

## Calculate relative change in harvest from initial LML
lml.wt.est.df.rel <- lml.wt.est.df %>%
  mutate(rel.change = harvest / harvest.wt) %>%
  select(-join.id)
```

```
## Quick plot demostrating change in harvest with LML increase
lml.wt.est.df.rel %>%
 ggplot()+
 geom_line(aes(x = LML, y = harvest))+
 geom_point(aes(x = LML, y = harvest))+
 xlab('Legal Minimum Length (mm)')+
 ylab('Harvest (kg)')+
 theme_bw()
```

```r
## Rename columns of final dataframe
  lml.wt.est.df.final <- lml.wt.est.df.rel %>%
 rename('Est. weight (g)' = est.weight,
        'Harvest (kg)' = harvest,
        'Harvest Change' = rel.change) %>%
 select(-c(a, b, harvest5, harvest10)) %>%
  as_tibble()

library(knitr)
kable(lml.wt.est.df.final, caption = "Relative change in estimated Recreational harvest for an
```

Table 5: Relative change in estimated Recreational harvest for an increase in LML based on abalone length-weight relationship from commerical catch sampling for the eastern zone collected between 2019-2021.

LML	Est. weight (g)	Harvest (kg)	Harvest Change
138	464.6605	10632.36	1.000000
140	479.4831	10971.53	1.031900
145	517.6456	11844.77	1.114030
150	557.3963	12754.34	1.199577
155	598.7451	13700.49	1.288565
160	641.7016	14683.42	1.381012

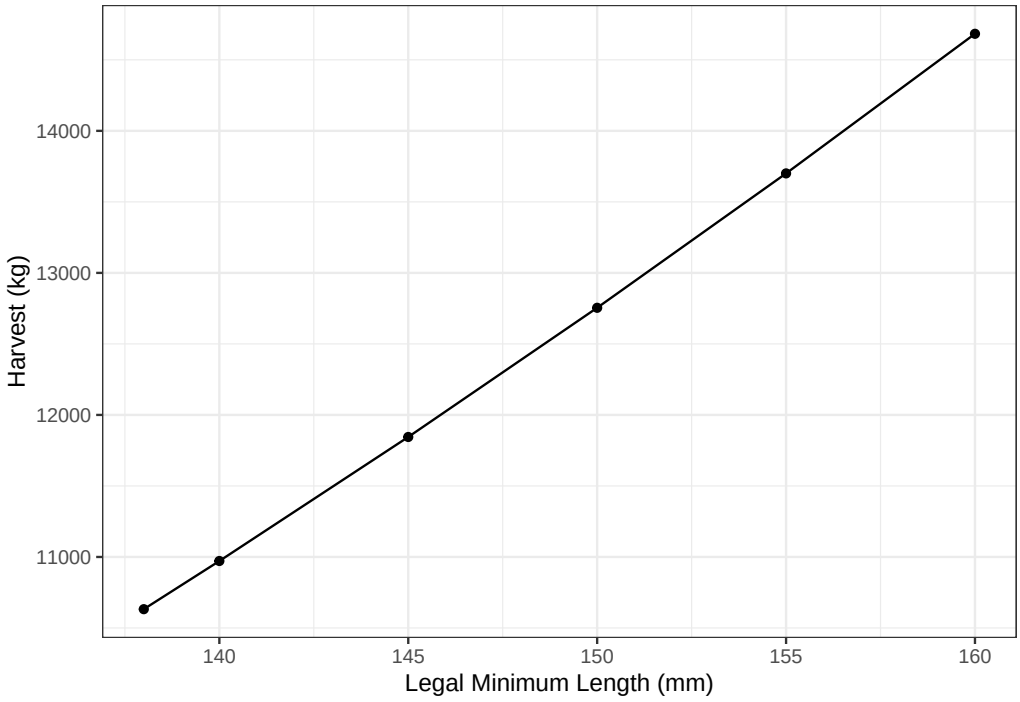

Figure 3: Estimated Recreational harvest for each LML based on abalone length-weight relationship from commerical catch sampling for the eastern zone collected between 2019-2021.

5 Estimate Recreational harvest based on commercial catch sampling size frequencies

```
## Add size class bin to catch sampling data
lw.dat.size <- lw.dat %>%
  mutate(size.class = cut(shell.length, breaks = seq(0, 220, 1))) %>%
  separate(size.class, into = c('minsize', 'maxsize'), sep = ',', convert = TRUE, remove = F) %
  mutate(minsize = as.numeric(gsub("[^0-9.-]", "", minsize)),
         maxsize = as.numeric(gsub("[^0-9.-]", "", maxsize)),
         midsize = (minsize + maxsize) / 2)

## Create vector of proposed legal minimum lengths (LMLs) for eastern zone
lml <- c(138, 140, 145, 150, 155, 160)

## Create blank dataframe to populate LML harvest
lml.harvest <- data.frame(LML  = lml,
                          est.harvest = NA)

## Determine number of iterations for loop
n.lml <- length(lml)

## Estimate harvest for each change in LML
for (i in 1:n.lml) {
  ##get value in row i of the "i" column
  i.current <- lml.harvest[i, "LML"]

  ## Summarise size frequency composition of catch for eastern zone
  lw.dat.freq <- lw.dat.size %>%
    filter(newzone == 'E',
           shell.length >= i.current) %>%
    group_by(size.class, midsize) %>%
    summarise(n.size = n()) %>%
    ungroup() %>%
    mutate(percent.size = (n.size / sum(n.size)))

  ## Select length-weight regression parameters for eastern zone to use for estimating weight
  lw.coeff.zone <- lw.dat.coeff.zone %>%
    filter(newzone == 'E') %>%
    select(a, b) %>%
    mutate(join.id = 1)

  ## Join chosen regression parameters to proposed LMLs
  lw.dat.freq.wt <- lw.dat.freq %>%
    mutate(join.id = 1) %>%
    left_join(., lw.coeff.zone)

  ## Determine weight for proposed LMLs
  rec.harvest.no <- 22882
```

```
  lw.dat.freq.wt.har <- lw.dat.freq.wt %>%
    mutate(
      est.weight = ((a * (midsize ^ b))),
      harvest = (est.weight * rec.harvest.no * percent.size) / 1000
    )

  tot.harvest <- sum(lw.dat.freq.wt.har$harvest)

  #save it to dataframe
  lml.harvest[i, "est.harvest"] <- tot.harvest
}

lml.harvest.final <- lml.harvest %>%
  mutate(harvest5 = est.harvest * 0.95,
         harvest10 = est.harvest * 0.90)

library(knitr)
kable(lml.harvest.final, caption = "Estimated Recreational harvest for each LML based on abalor
```

Table 6: Estimated Recreational harvest for each LML based on abalone length-weight relationship and size frequencies from commerical catch sampling for the eastern zone collected between 2019-2021.

LML	Est. Harvest (kg)	Harvest 95% (kg)	Harvest 90% (kg)
138	12731.47	12094.90	11458.33
140	12891.67	12247.09	11602.51
145	13507.29	12831.92	12156.56
150	14238.07	13526.16	12814.26
155	15018.10	14267.20	13516.29
160	15893.95	15099.25	14304.55

```
## Select harvest for initial eastern zone LML
harvest.wt <- lml.harvest[1, 'est.harvest']

## Calculate relative change in harvest from initial LML
lml.wt.est.df.rel <- lml.harvest %>%
  mutate(rel.change = est.harvest / harvest.wt)
```

```
## Quick plot demonstrating change in harvest with LML increase
lml.wt.est.df.rel %>%
 ggplot()+
 geom_line(aes(x = LML, y = est.harvest))+
 geom_point(aes(x = LML, y = est.harvest))+
 xlab('Legal Minimum Length (mm)')+
 ylab('Harvest (kg)')+
 theme_bw()

## Rename columns of final dataframe
```

```
lml.harvest.final <- lml.wt.est.df.rel %>%
 rename('Harvest (kg)' = est.harvest,
        'Harvest Change' = rel.change) %>%
  as_tibble()

library(knitr)
kable(lml.harvest.final, caption = "Relative change in estimated Recreational harvest for an in
```

Table 7: Relative change in estimated Recreational harvest for an increase in LML based on abalone length-weight relationship and size frequencies from commerical catch sampling for the eastern zone collected between 2019-2021.

LML	Harvest (kg)	Harvest Change
138	12731.47	1.000000
140	12891.67	1.012583
145	13507.29	1.060936
150	14238.07	1.118336
155	15018.10	1.179604
160	15893.95	1.248398

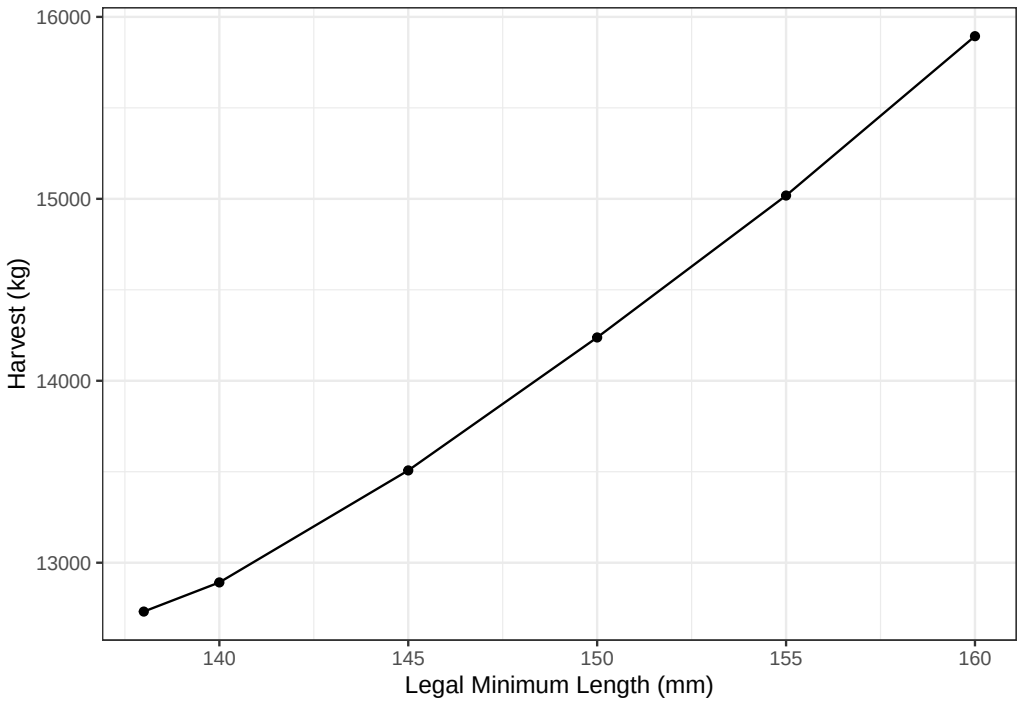

Figure 4: Estimated Recreational harvest for each LML abalone length-weight relationship and size frequencies from commerical catch sampling for the eastern zone collected between 2019-2021.