Abalone Catch Sampling Length-Weight Relationship

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Load most recent compilation of Commercial Abalone Catch Sampling data.

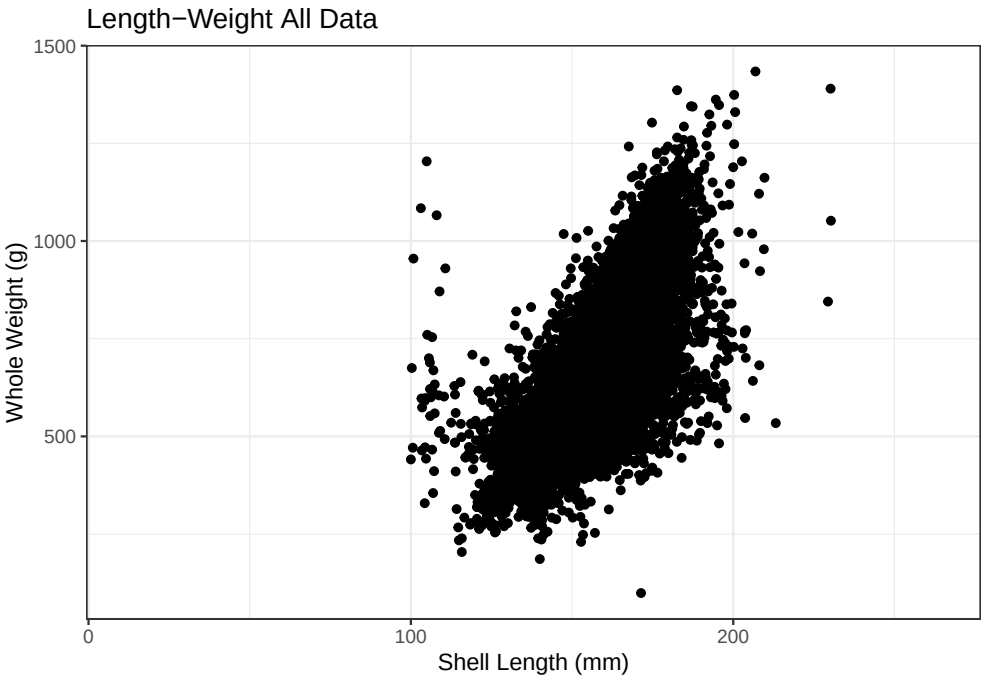
```
## Read in most recent commercial catch sampling compiled MM dataframe
compiledMM.df.final <- readRDS('C:/CloudStor/R_Stuff/MMLF/compiledMM.df.final.RDS')
```

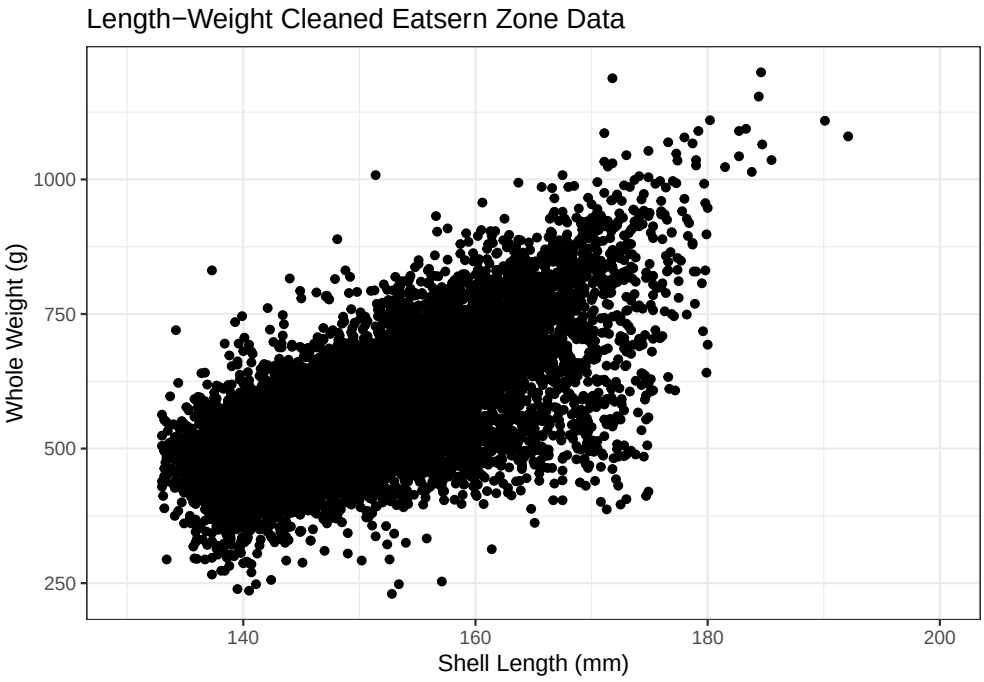
Clean catch sampling data

```
## 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()

## 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()
```





Summarise mean weight by Zone

```
## Determine average weight by zone
lw.dat %>%
  group_by(newzone) %>%
  summarise(Av.weight = mean(whole.weight),
            n = n(),
```

```
            catches = n_distinct(docket.number)) %>%
 as_tibble()
```

```
# A tibble: 5 x 4
  newzone Av.weight     n catches
  <chr>       <dbl> <int>   <int>
1 BS           402.   339       4
2 E            558. 15838     165
3 G            663.   296       3
4 N            486.   630       6
5 W            693. 15145     158
```

Estimate Recreational harvest for eastern zone by mean weight

The estimated combined east coast (areas 1-3) blacklip abalone recreational harvest noumber for 2020-21 was 22882 (12774-34777) (Lyle et al. 2021).

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

rec.harvest.no <- 22882

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()
```

```
# A tibble: 1 x 2
  `Av.weight (g)` `Harvest (kg)`
            <dbl>          <dbl>
1            558.         12765.
```

Estimate Recreational harvest for eastern zone 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(-intercept)

lw.dat.coeff.zone
```

```
  newzone        b            a
1      BS 2.474915 2.159471e-03
2       E 2.182369 9.934138e-03
3       G 3.162481 6.922677e-05
4       N 2.585293 1.345728e-03
5       W 2.448732 2.817899e-03
```

```
## 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)
lml.wt.est.df
```

```
  LML join.id           a        b est.weight  harvest
1 138       1 0.009934138 2.182369   464.6605 10632.36
2 140       1 0.009934138 2.182369   479.4831 10971.53
3 145       1 0.009934138 2.182369   517.6456 11844.77
4 150       1 0.009934138 2.182369   557.3963 12754.34
5 155       1 0.009934138 2.182369   598.7451 13700.49
6 160       1 0.009934138 2.182369   641.7016 14683.42
```

Determine relative change in Recreational harvest from initial LML

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

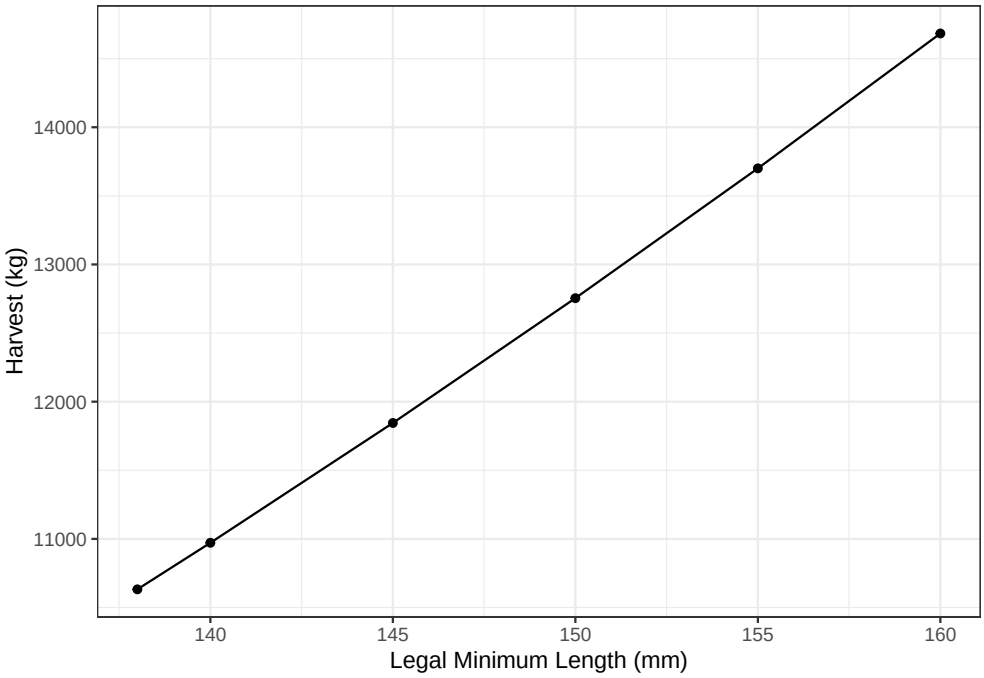
```r
## Calculate relative change in harvest from initial LML
lml.wt.est.df.rel <- lml.wt.est.df %>%
  mutate(rel.change = harvest / harvest.wt) %>%
  select(-join.id)

## 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()

## 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)) %>%
  as_tibble()

  lml.wt.est.df.final
```

```
# A tibble: 6 x 4
    LML `Est. weight (g)` `Harvest (kg)` `Harvest Change`
  <dbl>             <dbl>          <dbl>            <dbl>
1   138              465.          10632.             1
2   140              479.          10972.             1.03
3   145              518.          11845.             1.11
4   150              557.          12754.             1.20
5   155              599.          13700.             1.29
6   160              642.          14683.             1.38
```



Estimate Recreational harvest for eastern zone based on commercial catch sampling proportions

```
## 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
```

```
  LML est.harvest
1 138    12731.47
2 140    12891.67
3 145    13507.29
4 150    14238.07
5 155    15018.10
6 160    15893.95
```

```
## 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 demostrating 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()

lml.harvest.final
```

```
# A tibble: 6 x 3
    LML `Harvest (kg)` `Harvest Change`
  <dbl>          <dbl>            <dbl>
1   138         12731.             1
2   140         12892.             1.01
3   145         13507.             1.06
4   150         14238.             1.12
5   155         15018.             1.18
6   160         15894.             1.25
```