# Methods:

## Biomass weighting:

For each survey year we first calculated the average CPUE biomass (and frequency) of each predator (Kg Km-2 ) for a given length bin , in strata , as a function of survey biomass (frequency) at each station within each strata such that:

Eq. 1

The annual strata and bin specific proportion of biomass for a given length in a given year was calculated as the mean of the biomass (Kg), i.e., the product of the CPUE biomass and strata area :

Eq. 2

Similarly, the annual strata specific proportion of biomass in a given year was calculated as the mean of the product of the CPUE biomass (frequency) and strata area :

Eq. 3

and the annual bin specific proportion of biomass in a given year was calculated as the mean of the product of the CPUE biomass (frequency) and strata area :

Eq. 4

We then calculated the station-specific average () prey consumption (g) for each sampled predator for each length bin , of each prey species as:

Eq. 5

We then determined the regional annual mean of prey consumption across all predator size bins and strata as:

Eq. 6

And the annual strata-specific biomass weighted mean of prey consumption across predator size bins as:

Eq. 7

And the annual bin-specific biomass weighted annual mean of prey consumption across strata as:

Eq. 8

In the case where bin or strata specific CPUE was missing, mean values across years were used for , , .

## Energetic indices:

In addition to prey consumption we also calculated we calculated a set of bioenergetic indices for each predator stomach sample and biomass weighted them using the above methods. This included the following steps:

1. Convert synoptic individual diet observations () to daily rations ( per per ) following Holsman and Aydin 2015:

Eq. 9

Eq. 10

Eq. 11

Where is the digestion condition code (table 1) of each prey item in the diet of predator , is the proportion of each prey item digested corresponding to each category i.e., = 1 represents fully digested =0.99. is the time to complete digestion (h) given , is the time until complete digestion, is the gear temperature (bottom temperature) at the sampling station in in strata in given year , and and are the slope and the intercept of the exponential temperature digestion relationship and are equal to -0.0143 and 0.115, respectfully (Holsman and Aydin, 2015; Durbin et al. 1983; Dwyer et al. 1987).

1. Estimate theoretical maximum daily consumption rates from allometric and temperature specific algorithms for consumption (table 1).
2. Calculate relative foraging rate of each predator as:
3. Calculate the gravimetrically weighted mean energy density of each stomach i as :

where is the energy density (k) of each prey item j based on published values (table 2).

1. Convert gravimetric specific daily ration and to energetic specific ingestion rates () using the energy density of the stomach sample i:
2. Estimate potential growth as a function of energy allocated to metabolism and waste and the energy density of the predator :

Table 1: Bioenergetics model equations

|  |  |  |
| --- | --- | --- |
| Definition | Equation | Eq. |
| Modeled growth |  | T1.1 |
| Consumption |  | T1.2 |
| Modeled weight |  | T1.3 |
| Maximum consumption |  | T1.4 |
| Temperature scaling function |  | T1.5.1 |
|  |  | T1.5.2 |
|  |  | T1.5.3 |
|  |  | T1.5.4 |
|  |  | T1.5.5 |
| Respiration |  | T1.6 |
|  |  |  |
| Activity multiplier |  | T1.7.1 |
|  |  | T1.7.2 |
| Specific dynamic action |  | T1.8 |
| Egestion |  | T1.9 |
| Excretion |  | T1.10 |

Table 2. Pacific halibut bioenergetics parameters (Parm.), value, definition, and type (E: estimated parameter; M: model parameter; I: input parameter; D: data).

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Parm. | Value | Definition | Type |  |
|  | 0.0625 | Intercept of the allometric consumption function | E | a |
|  | -0.1076 | Slope of the allometric consumption function | E | a |
|  | 12.97 | Consumption optimum temperature | E | a |
|  | 18 | Consumption maximum temperature | E | a |
|  | 3.084 | Consumption temperature coefficient | E | a |
|  | 3.034e-4 | Consumption error term | E | a |
|  | 0.0016 | Intercept of the allometric respiration function | E | a |
|  | -0.1848 | Slope of the allometric respiration function | E | a |
|  | 0.0644 | Respiration temperature coefficient | E | a |
|  | 0.1560 | Respiration error term | E | a |
|  | 0.008 | Intercept of the temperature-specific activity function | E | a |
|  | 0.3729 | Slope of the temperature-specific activity function | E | a |
|  | 0.2215 | Activity parameter | E | a |
|  | 12 | Temperature limit of velocity function | E | a |
|  | 0.25 | Activity scalar | E | a |
|  | 8.171e-5 | Velocity error term | E | a |
|  | 0.1181 | SDA coefficient | E | a |
|  | 0.2574 | SDA error term | E | a |
|  | 0.0332 | 0.0332 Excretion coefficient | E | a |
|  | 0.0820 | Excretion error term | E | a |
|  | 0.2 | Egestion coefficient | I | b |
|  | 13560 | Oxygen energy equivalent (J ) | I | c |
|  | 4812 | Fish energy density (J ) | I | e |
|  | 365 | Number of simulation days for fish , year | I |  |
|  |  | Prey energy density (J ) | I |  |
|  |  | Relative Foraging Rate consumption scalar for fish , year | E or I | a |
|  |  | Temperature (oC) | D | f |
|  |  | Observed annual growth increment for fish | D | a |
|  |  | Starting weight for fish , year | I |  |
|  |  | Simulation day | M |  |
|  |  | Year (simulation interval) | M |  |
|  |  | Individual fish | M |  |

a. This study

b. (Deslauriers et al., 2017)

c. (Elliott & Davison, 1975)

d. (Auchterlonie, 1998)

e. (Vollenweider et al., 2011)

f. NOAA National Data Buoy Center [www.ndbc.noaa.gov](http://www.ndbc.noaa.gov)

agg.preyED$TempC[i] <- bb$gPred\_per\_gPred\_d$TempC

agg.preyED$fTc[i] <- bb$gPred\_per\_gPred\_d$fTc

agg.preyED$fTr[i] <- bb$gPred\_per\_gPred\_d$fTr

agg.preyED$Cmax\_jgd[i] <- bb$J\_per\_gd$Cmax\_jgd # max C J

agg.preyED$Cmax\_ggd[i] <- bb$gPrey\_per\_gPred\_d$Cmax\_ggd # max C gprey/gpred/d

agg.preyED$Cobs\_ggd[i] <- (agg.preyED$Obs\_TWT[i]/agg.preyED$W\_use[i])

# ration.data$propDig <- dig.table2$propDig[match(ration.data$DIG,dig.table2$DIG)]

# ration.data$S0 <- ration.data$TWT/(1-ration.data$propDig)

# ration.data$digR <- (1-exp(24\*-0.0143\*exp(0.115\*ration.data$GEAR\_TEMP)))

# ration.data$maxT <- log(.01)/(-0.0143\*exp(0.115\*ration.data$GEAR\_TEMP))

# ration.data$C1 <- (ration.data$S0/ration.data$maxT)\*24 # Beaudreau & Essington 2009 g/d

# ration.data$C1 <- (ration.data$S0/ration.data$maxT)\*24 # Beaudreau & Essington 2009 g/d

agg.preyED$C1\_ggd[i] <- (agg.preyED$C1\_TWT[i]/agg.preyED$W\_use[i])

agg.preyED$RFR\_J[i] <- agg.preyED$tot\_C\_J\_gpred[i]/bb$J\_per\_gd$Cmax\_jgd

agg.preyED$RFR\_ObsTWT[i] <- (agg.preyED$Obs\_TWT[i]/agg.preyED$W\_use[i])/bb$gPrey\_per\_gPred\_d$Cmax\_ggd

agg.preyED$RFR\_C1[i] <- (agg.preyED$C1\_TWT[i]/agg.preyED$W\_use[i])/bb$gPrey\_per\_gPred\_d$Cmax\_ggd

agg.preyED$R\_RFR1\_ggd[i] <- bb$gPrey\_per\_gPred\_d$R\_ggd

agg.preyED$MAXG\_ggd[i] <- bb$gPred\_per\_gPred\_d$G\_ggd

# now with observed RFR:

# pp$RFR <- agg.preyED$RFR

agg.preyED$RFR[i] <- agg.preyED$RFR\_C1[i]

pp$RFR <- agg.preyED$RFR[i]

aa <- bioE(par=pp,

data=list(W=agg.preyED$W\_use[i],

TempC=tt,

Eprey=agg.preyED$mnEDJ\_g[i],

Epred=agg.preyED$predE[i],indgst=0,diet=0))

agg.preyED$R\_ggd[i] <- aa$gPrey\_per\_gPred\_d$R\_ggd

agg.preyED$C\_ggd[i] <- aa$gPred\_per\_gPred\_d$C\_ggd

agg.preyED$G\_ggd[i] <- aa$gPred\_per\_gPred\_d$G\_ggd

agg.preyED$F\_ggd[i] <- aa$gPred\_per\_gPred\_d$F\_ggd

agg.preyED$U\_ggd[i] <- aa$gPred\_per\_gPred\_d$U\_ggd

agg.preyED$SDA\_ggd[i] <- aa$gPred\_per\_gPred\_d$SDA\_ggd

agg.preyED$ACT[i] <- aa$gPred\_per\_gPred\_d$Act

agg.preyED$R\_Act\_ggd[i] <- aa$gPred\_per\_gPred\_d$R\_Act\_ggd