**Introduction**

Food web structure is regulated by availability of resources (bottom-up control) and the presence of top predators (top-down control) (**citation**). Anthropogenic and environmental drivers alter the structure and composition of marine ecosystems by changing predation pressure and competition for resources (Kordas et al. 2011). Physical ocean conditions alter nutrient distribution, light penetration, and community composition at the base of the food web (citation), which can impact primary productivity and ultimately constrain energy availability and thus abundance at higher trophic levels (citation). Similarly, the removal of top predators from an ecosystem as a result of human activities such as fishing can decrease predation pressure and increase abundance on adjacent trophic, an effect that can cascade through the food web and impact abundance at non=adjacent trophic levels (cite trophic cascades). Legislative action aimed at promoting top predator abundance by reducing fishing pressure or by-catch can have inverse effect; top predator abundance increases, increasing predation pressure on adjacent trophic levels. Top-down and bottom-up control are often studied as independent mechanisms, however large scale changes in nutrient availability (citations) and top predator abundance over the past century (citation) means many food webs are experiencing shifts in both mechanisms of regulation in tandem, making it challenging to identify dominant mechanisms structuring abundance.

Ecosystems in coastal Washington and the Salish Sea have experienced dramatic restructuring over the past century due to declines and subsequent recoveries of marine predators (citation) and changes in environmental conditions (citation). Decades of hunting resulted marine mammal populations reaching a historic low in the 1970's, with harbor seal abundance estimated to be XXX (citation). Following the Marine Mammal Protection Act in 1972 top-predator abundance increased dramatically. Benefitting from a relatively short life history, generalist diet, and legislation, harbor seal populations increased 10-fold from 1970-2010 (citation Jeffries). This increase in abundance While increases in marine mammal abundance has been a primary change in the ecosystem, dramatic changes in physical oceanic conditions have occurred isimultaneously, which have an equal potential for altering the food web.

Paragraph about tradeoffs and decision making...what is important for informed decisions? comprehensive understanding of how harbor seals interact with the eccosystem

Top-down pressures exerted by marine predators’ function in tandem with bottom-up forces, physical and oceanographic conditions have the potential to alter abundance and availability of lower trophic level species, thus altering predation pressure. Predation pressure exerted by generalist predators, which feed opportunistically on a variety of available prey sources, are particularly susceptible to shifting predation pressure in response to prey availability.

Understanding historical context of ecosystem function is necessary to predict future ecosystem responses to human disturbance and environmental change. Historic datasets are important for understanding ecosystem dynamics in the absence of anthropogenic pressure and ecological responses to climatic shifts. However, historic data and methods for analyzing these data are limited, which presents a challenge for robust ecosystem-based management.

CSIA provides the necessary means for reconstructing historical ecological data.

Here we examine a century of harbor seal trophic position data...The objectives of this work are to identify how physical ocean drivers, productivity, and prey availability

**Methods**

Prey and isotope data was standardized around a mean of 0 and divided by the standard deviation.

*Trophic Position Calculation*

Bone collagen was decalcified, acid hydrolyzed, derivatized and analyzed for compound-specific stable isotope (δ15N) analysis (CSIA) of 12 individual amino acids (*SI Appendix 1*). δ15N was measured as:

Collagen samples were measured in triplicate with a laboratory standard containing a 12 amino acid mixture of known isotopic composition (mean reproducibility = ). Previous controlled feeding studies have determined the trophic discrimination factor (TDF) for harbor seals is substantially lower than the conventional literature value of 7.6‰ (Germain et al. 2013) and thus applying a harbor seal specific trophic discrimination factor is more ecologically realistic (McMahon et al. 2015). Therefore, trophic position was calculated using a harbor seal specific TDF, described by McMahon et al. (2015) as a "multi-TDF" approach, using the following equation:

where TDF(Tr-Phe) plankton is the difference between given trophic amino acid - phenylalanine pair of typical phytoplankton and lower food web species, specific for cyanobacteria and algae (Table 1, Chikaraishi et al 2010). TDF(Tr-Phe) harbor seal represents the harbor seal specific TDF for a given trophic amino acid - phenylalanine pair calculated from Germain et al (2003) controlled feeding study data (Table 1) and βTr is the δ15N difference between a specific trophic amino acid and phenylalanine of primary producers estimated by Nielsen et al. (2015).

Table 1:

|  |  |  |  |
| --- | --- | --- | --- |
| Trophic Amino Acid | β | TDF harbor seal | TDF plankton |
| Glutamic acid (Glu) | 2.9 | 3.4 | 3.4 |
| Alanine (Ala) | 2.8 | 2.5 | 3.2 |
| Proline (Pro) | 2.7 | 5.5 | 3.1 |
| Aspartic Acid (Asp) | 1.8 | 3.5 | 5.4 |
| Valine (Val) | 3.4 | 7.5 | 4.6 |

**-** No change through time indicates harbor seal foraging strategies able to compensate for dramatic changes in resources without altering foraging niche

-Dynamics that operate on more trophic level/community wide scales that may alter multiple species at the same time are a better predictor of harbor seal foraging abundance than individual prey species

-forward selection is bias towards type II error, but for the sake of this exercise we believe it is justified.

-Food web results represent a prey species that is both abundant in harbor seal diet and has experienced large scale changes in the system

-Sex does not appear to influence trophic position. While coastal harbor seals may exhibit different foraging strategies based on sex. This is contradictory to previous studies. Weight may be a better predictor than length but given the nature of this data was not possible to analyze. Or previous studies may have identified a more local phenomenon.

-Location is important, and variability may be the most important component of

**Figure :** Trophic position calculated by glutamic acid-phenylalanine.

