Consumption of forage fishes by marine birds in the Gulf of the Farallones, California

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Purpose

Provide succinct overview of data sets collected by Point Blue and Oikonos

Present a bioenergetics model to estimate forage fish consumption by marine birds in GF region

Review modeling techniques and limitations

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Background

Seabirds are top predators in marine systems and consume large proportion of forage fish biomass

Can impact forage fish populations and compete with other top-predators and commercial fisheries

Harvest rules based, in part, on preserving a portion of stock biomass for predators

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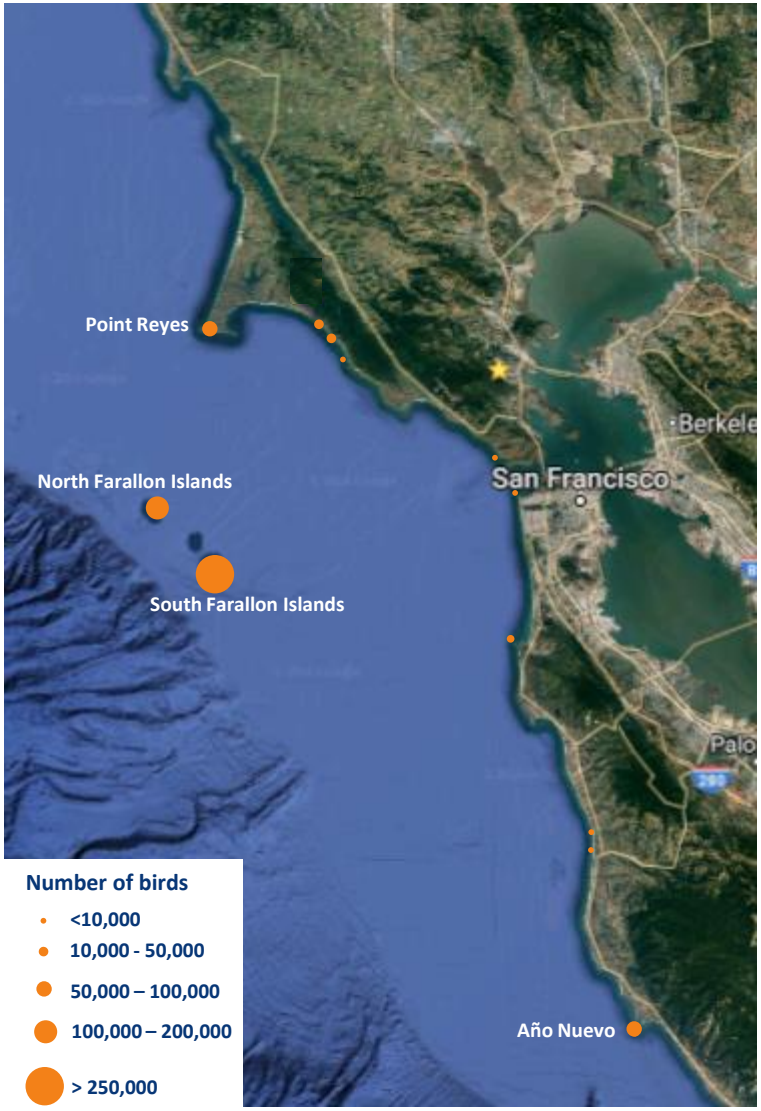
Study area

Greater Farallones region from Bodega head to Año Nuevo

Main seabird colonies at Farallon Islands, Point Reyes, Año Nuevo and scattered nearshore rocks and headlands

>80% of seabirds on SFI



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Introduction to data series

Farallon National Wildlife Refuge

Offshore colony near shelf break

Largest seabird colony

13 breeding seabird species

Continuous study since 1968

Año Nuevo Island

Nearshore colony

6 breeding seabird species

Continuous study by Pt. Blue and Oikonos since 1993

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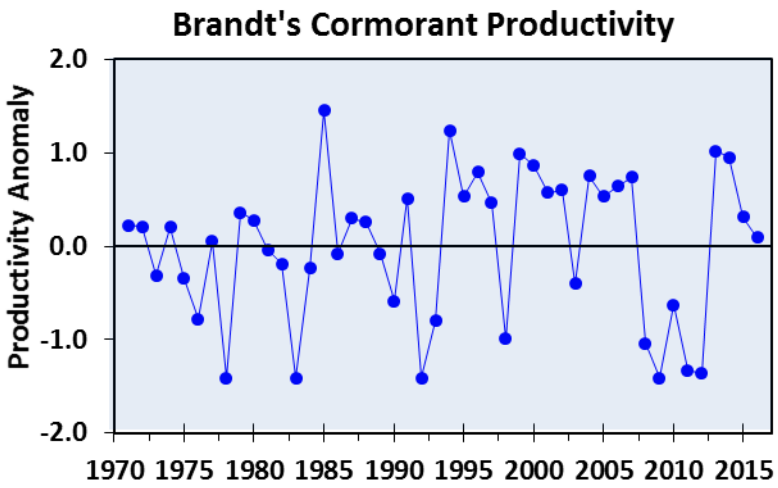
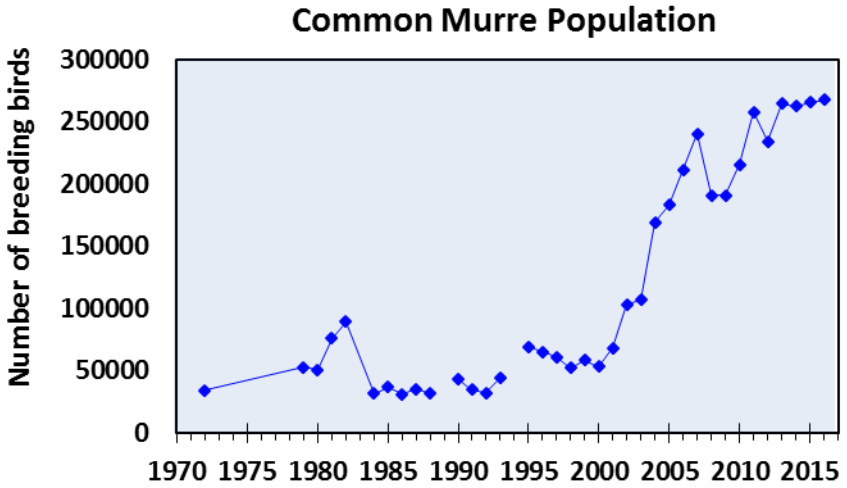
Long-term continuous data sets
Farallon Island seabirds

Dataset	Year started	General description
Productivity	1971	Breeding success - 9 species
Breeding Populations	1971	From annual censuses – 12 species





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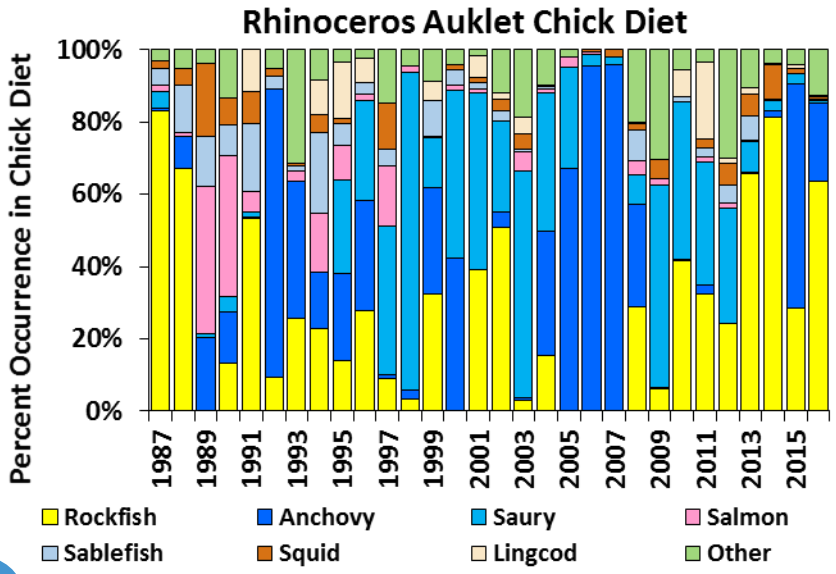
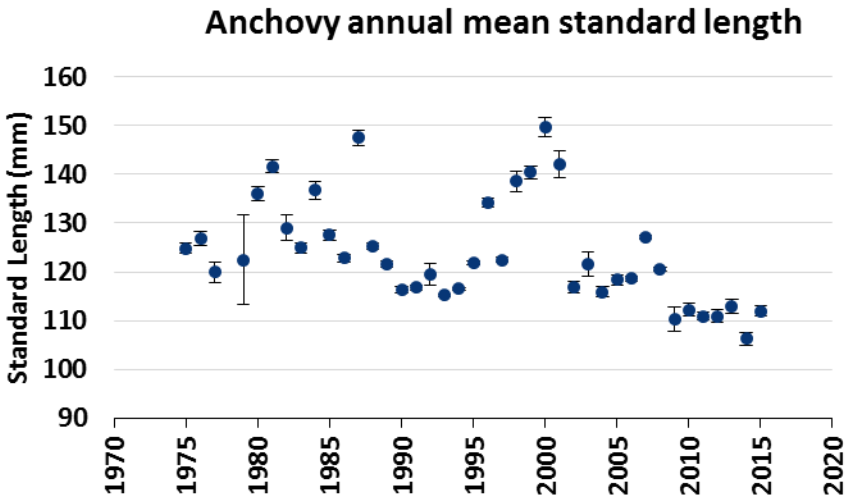
Long-term continuous data sets
Farallon Island seabirds

Dataset	Year	General description
Breeding Phenology	1971	Timing of breeding – 10 species
Survival	1971	From banding studies – 7 species
Diet & Prey size	1971	Observational and collected - 5 species





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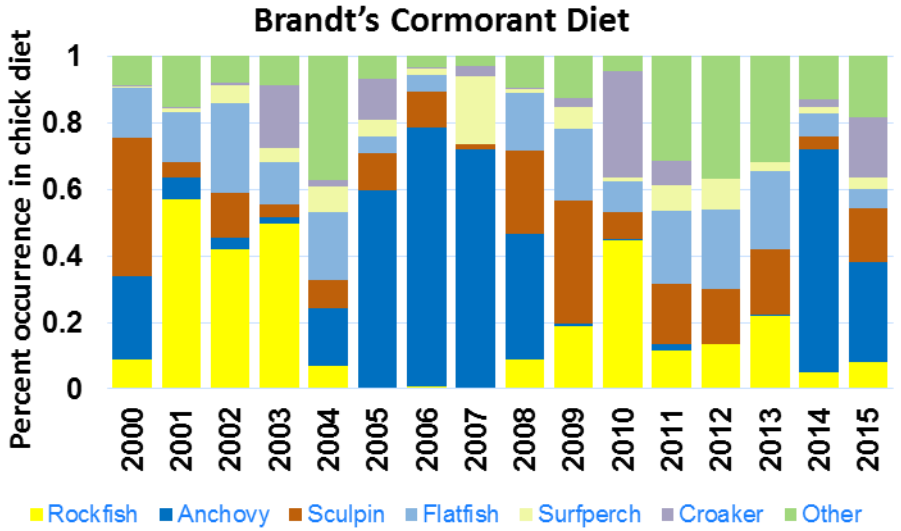
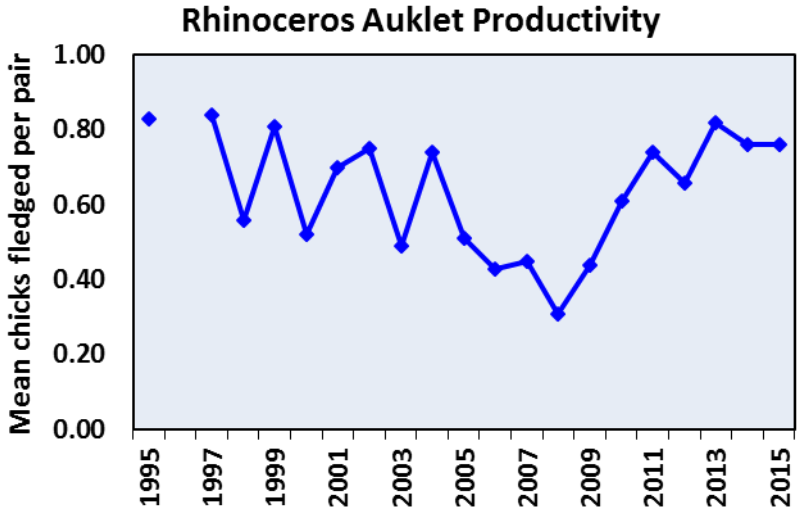
Long-term continuous data sets
Año Nuevo seabirds

Dataset	Year	General description
Productivity	1995	Breeding success - 5 species
Breeding Populations	1993	From annual censuses – 6 species
Diet & Prey size	1993	Collected - 3 species





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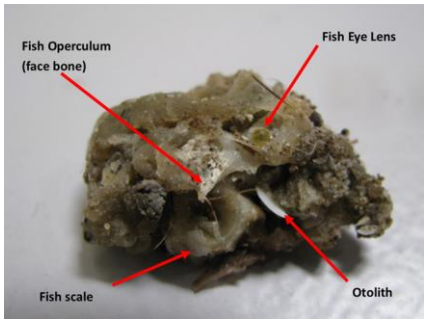
Prey consumption

Created species specific bioenergetics models

Estimated amount of prey required to balance daily energy expenditure (i.e. energy intake = energy burned)

Modeled consumption for common murre, Brandt's cormorant, rhinoceros auklet and western gull



Most abundant breeders in GF region and together account for more than 90% of breeders

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Bioenergetics Model Parameters

- Daily FMR and AE for each species derived from literature
  - COMU – 1530 kJ/day – Roth et al. 2008 (based on Cairns et al. 1990)
  - BRAC – 1883 kJ/day – Ancel et al. 2000
  - RHAU – 1021 kJ/day – Ellis and Gabrielson 2002 (allometric equation)
  - WEGU – 1142 kJ/day – Spear et al. 1993
- Population segments based on rough energy requirements
  - Breeding adults – Mar-Aug (184 days)
  - Non-breeding adults – Mar-Aug (184 days)
  - Dependent chicks – Jun-July (30 - 50 days)
  - All birds non-breeding season – Sept-Feb (181 days)
- Assigned seasonal daily energy requirements to each population segment (see Roth et al. 2008)

Bioenergetics Model Parameters

- Prey species consumed
  - % occurrence of prey items fed to chicks at SEFI and ANI
  - Assumed same for adults and chicks and constant within year
- Energy density of prey items from literature (kJ/g)
  - Species specific values from literature when available
  - Otherwise used average value of all prey for which ED known
- Population
  - Breeders determined from colony counts at SEFI and ANI
  - Aerial surveys from McChesney and Capitolo (Capitolo et al. 2014 & unpublished)
  - Non-breeders and winter from population modeling

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Final Model

$$\frac{\text{FMR} * \text{Diet Composition}}{\text{Energy Density} * \text{A.E.}} * \text{Population Size} * \text{Days}$$

$$\frac{\cancel{kJ}}{\cancel{day}} * \frac{g}{\cancel{kJ}} * \cancel{days}$$

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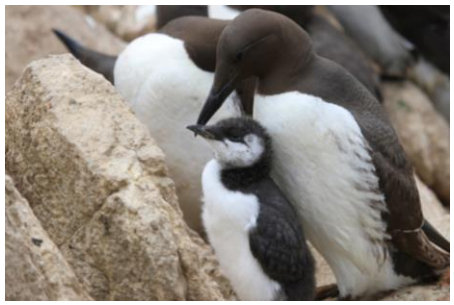
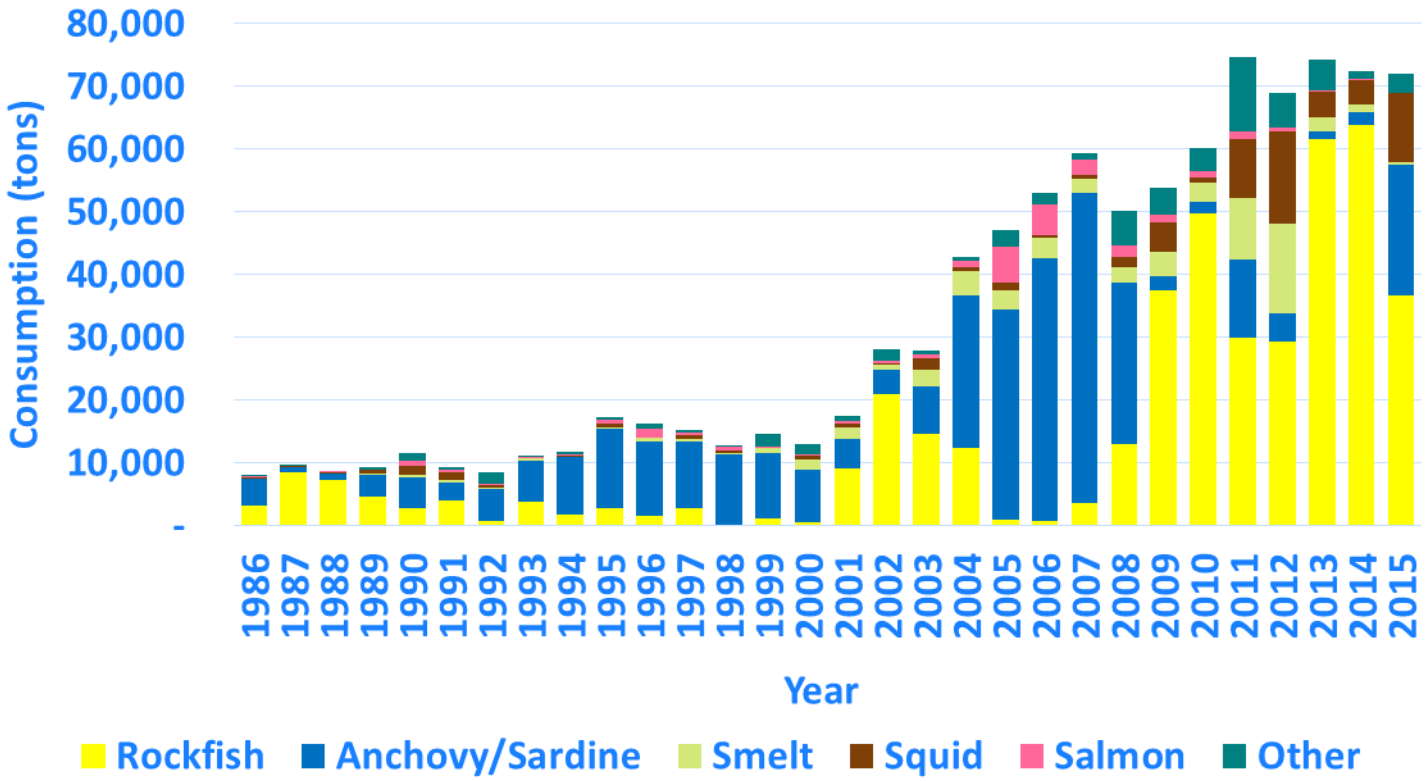
Results – SEFI murres



Consume 8-75k tons of forage fish per year

Up to 64k tons of rockfish and 49k tons anchovy



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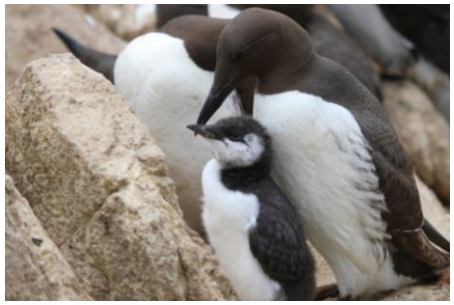
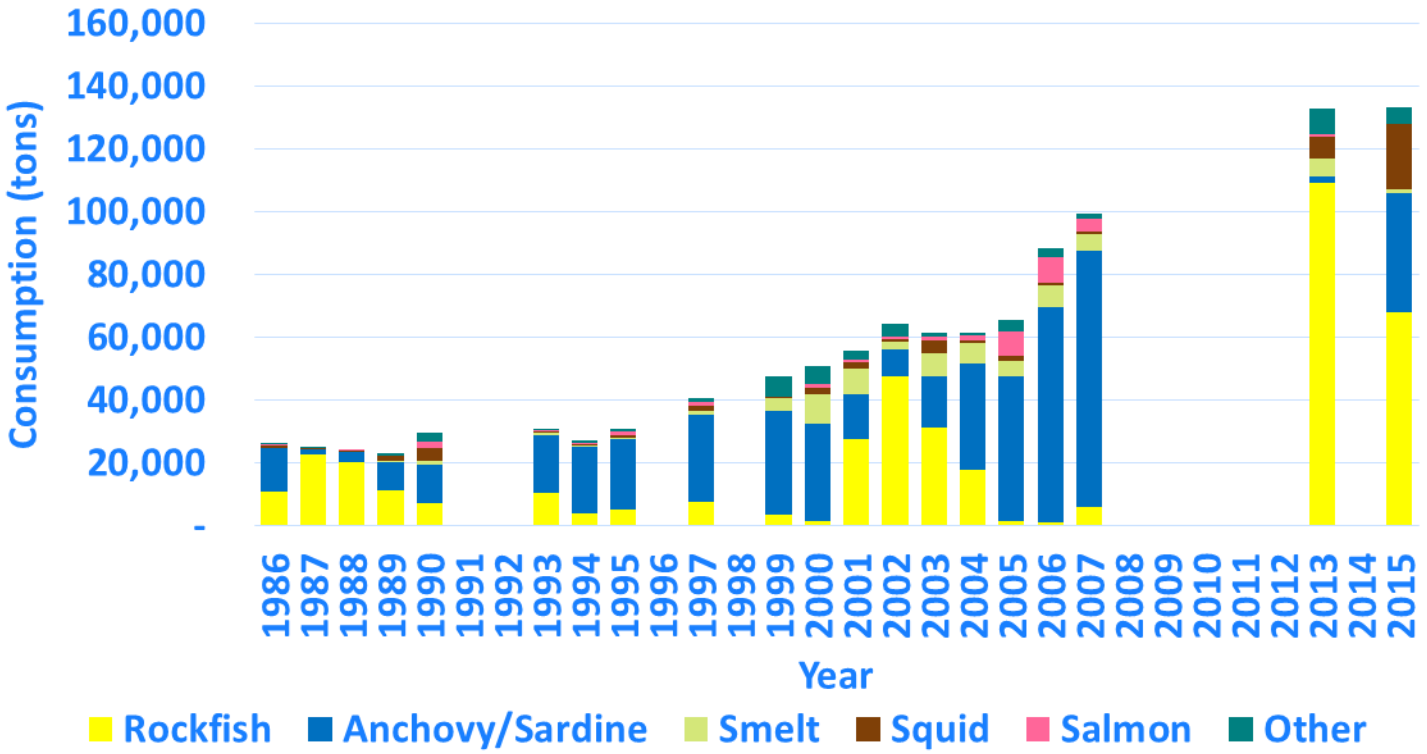
Results – All murres

Up to 134k tons of forage fish per year

Missing population counts for some years





Includes NFI and coastal colony populations from McChesney and Capitolo (USFWS and UCSC unpublished data)

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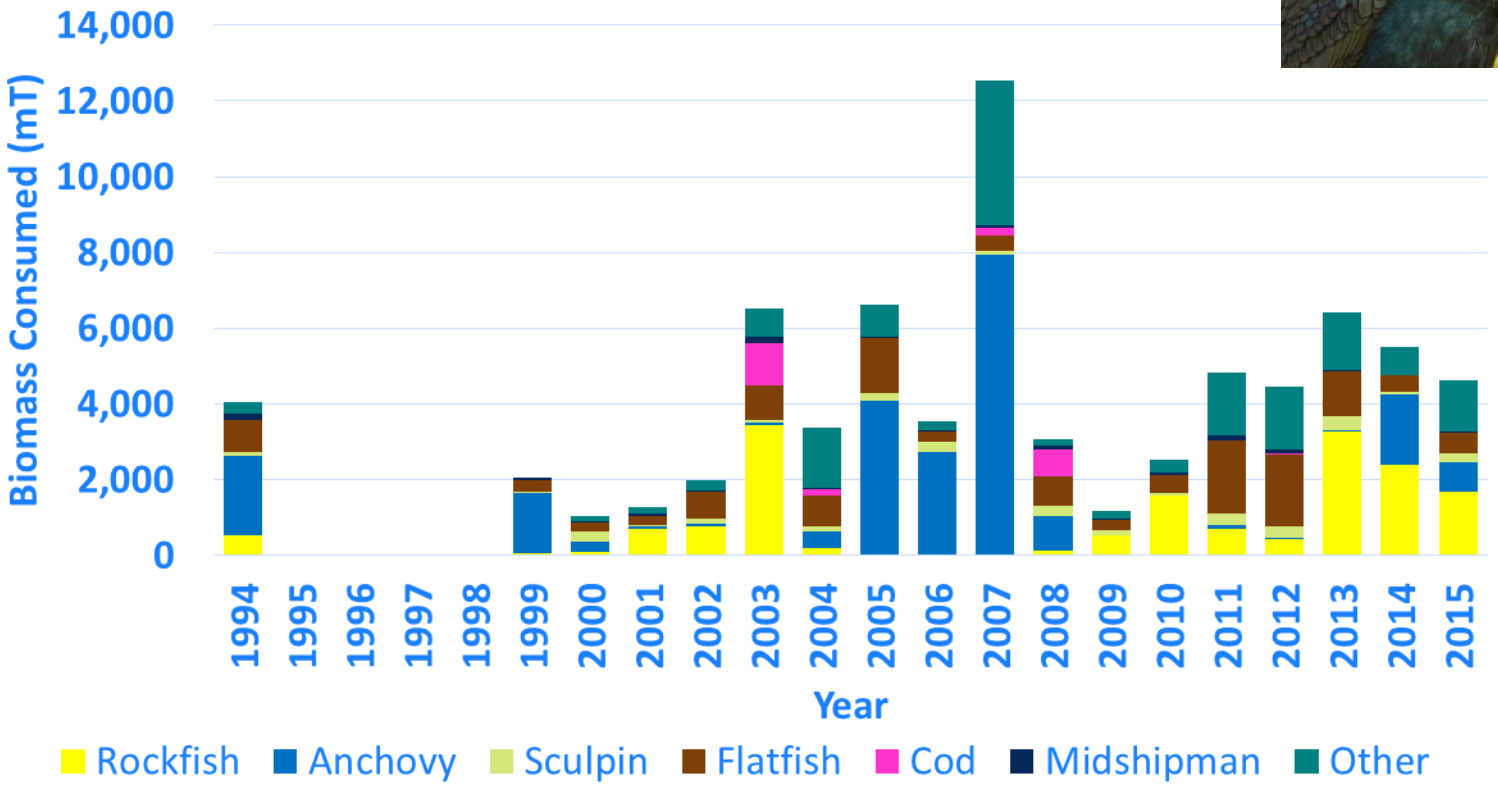
Results – Brandt's cormorant

Consume 2-12k tons of forage fish per year

Up to 3.5k tons of rockfish and 8k tons anchovy



Includes NFI and coastal colony populations from McChesney and Capitolo (USFWS and UCSC unpublished data)

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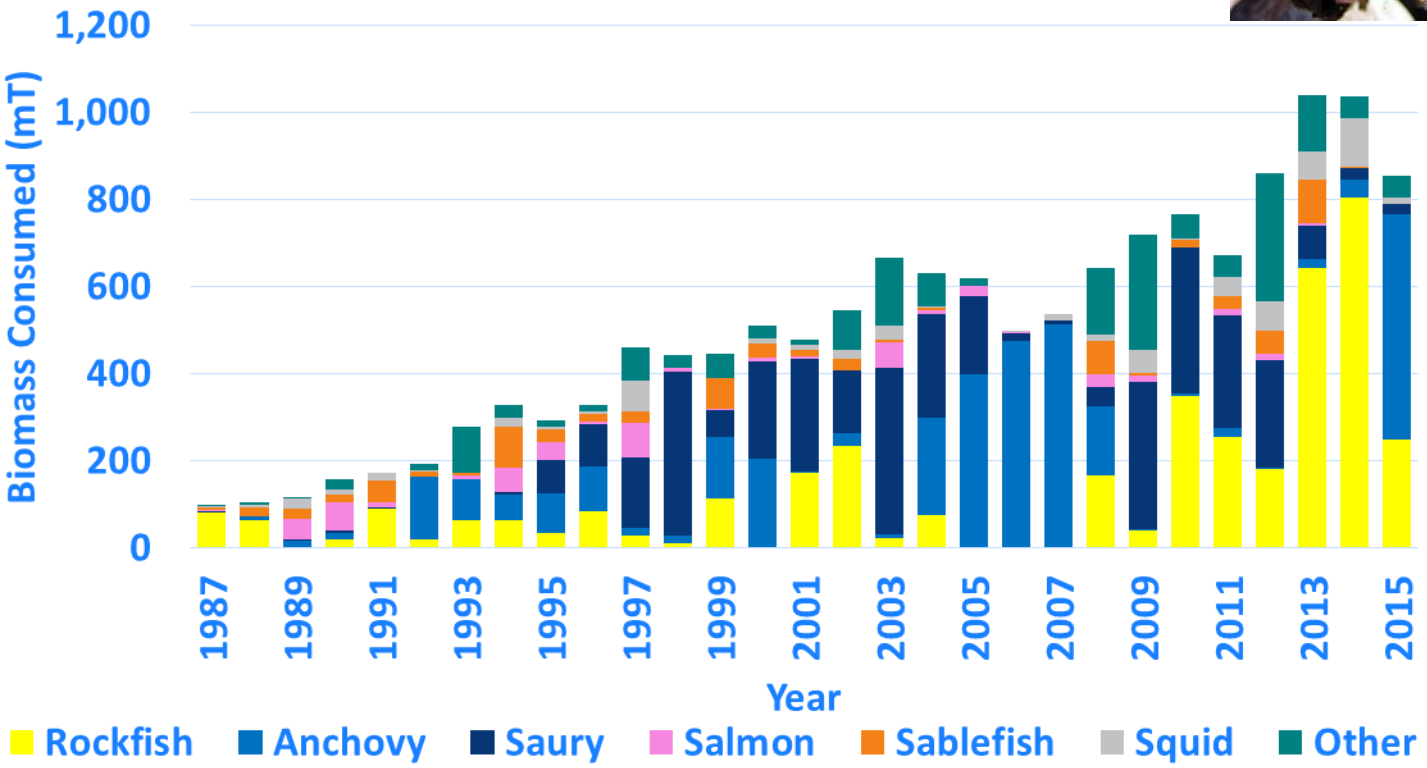
Results – Rhinoceros auklet

Consume 100-1000 tons of forage fish per year

Up to 800 tons of rockfish and 500 tons anchovy



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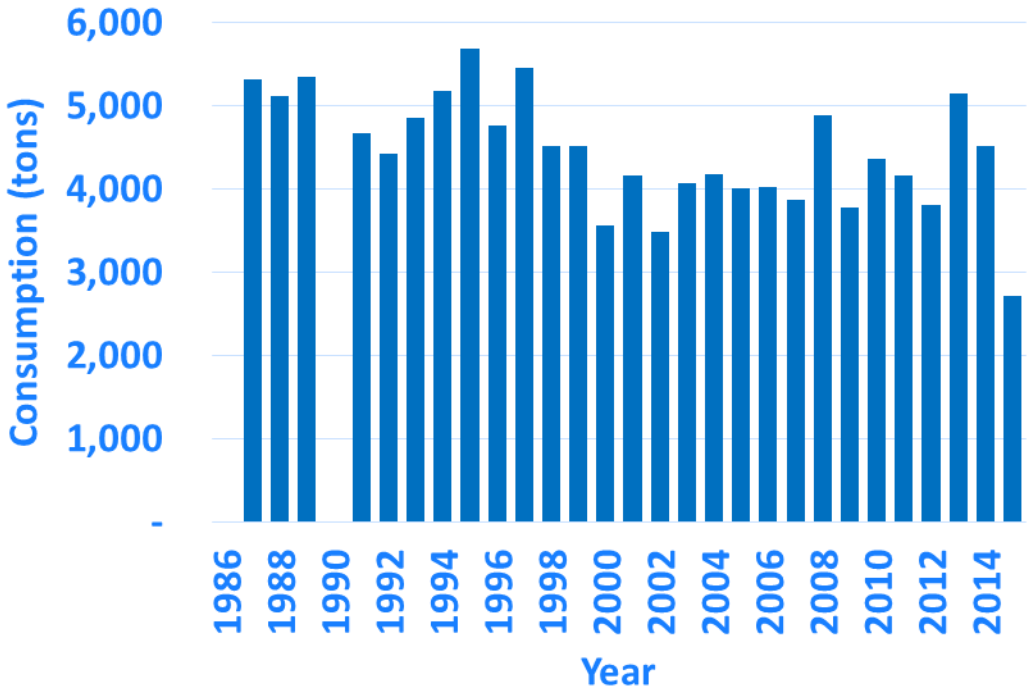
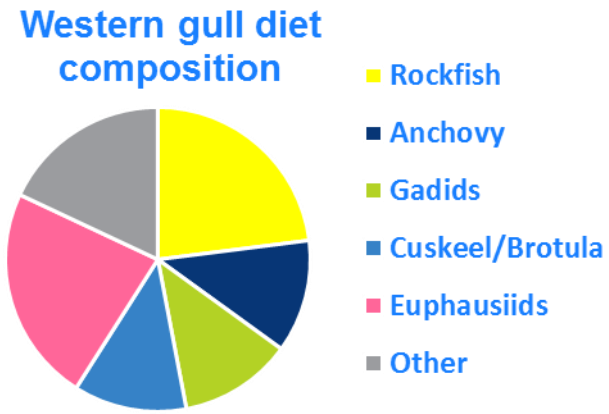
Results – Western gull

Consume 2,500-6,000 tons of forage fish per year

Up to 800 tons of rockfish and 500 tons anchovy





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Results – Total biomass consumed

Total biomass ranged from 26k to 145k tons of forage fish per year

On average 70% of consumption was of anchovy and juvenile rockfishes (multiple species)

Murres account for ~85% of total consumption by breeding seabirds

Species	Maximum Population	Maximum Consumption (tons)
Common murre	490,000	134,000
Brandt's cormorant	36,000	12,500
Rhinoceros auklet	5,500	1,000
Western gull	48,000	5,700
Total	579,500	153,200

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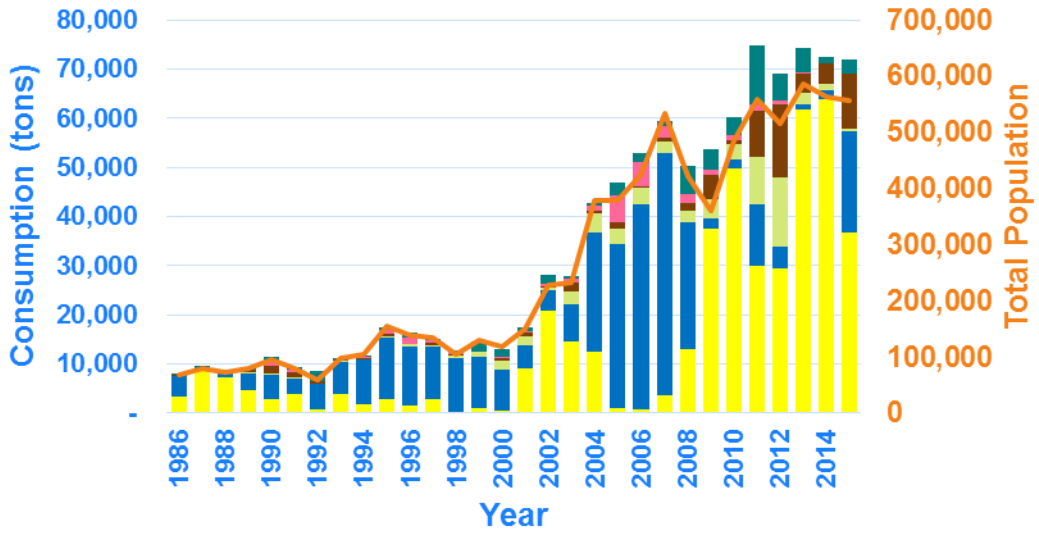
Results – Drivers of consumption

- Population size had the greatest influence on overall forage fish consumption



- Reproductive success, dominant forage species eaten, and environmental variability were also important
- Prey consumption was reduced in 1998, 2003, 2005 and 2006 and was contrary to population trends

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Assumptions/Limitations

Assumes diet composition same for adults and chicks

- probably not true in at least some years

Assumes diet is constant throughout the year

- likely varies in time and space (see Ainley et al. 1995)

Assumes FMR exists in two states - breeding and non-breeding – and does not vary

- likely varies with individuals, SST, weather, prey distribution and molt etc.

Assumes constant assimilation efficiency

- Likely varies among individuals, age-classes, years and prey types

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Assumptions/Limitations

Assumes chick energy requirements are constant and 10% of adult

- Likely varies with age, species and conditions

Assumes that predators take only what is needed to meet FMR requirements (i.e. don't take extra large portions)

Does not account for non-breeding species that consume high forage fish biomass

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Conclusions

- Seabirds consume a very large amount of forage fish
- High inter-annual variability in total consumption
- Forage species consumed varies with environmental conditions
- Growing populations putting greater pressure on forage fish stocks
- Environment influences total amount and prey species consumed
- Climate change may exacerbate predation pressure on forage fish

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Thank you!

United States Fish and Wildlife Service
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Boring Family Foundation
Hellman Family Foundation
Marisla Foundation
Firedoll Foundation
Marisla Foundation
McCaw Family Foundation
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