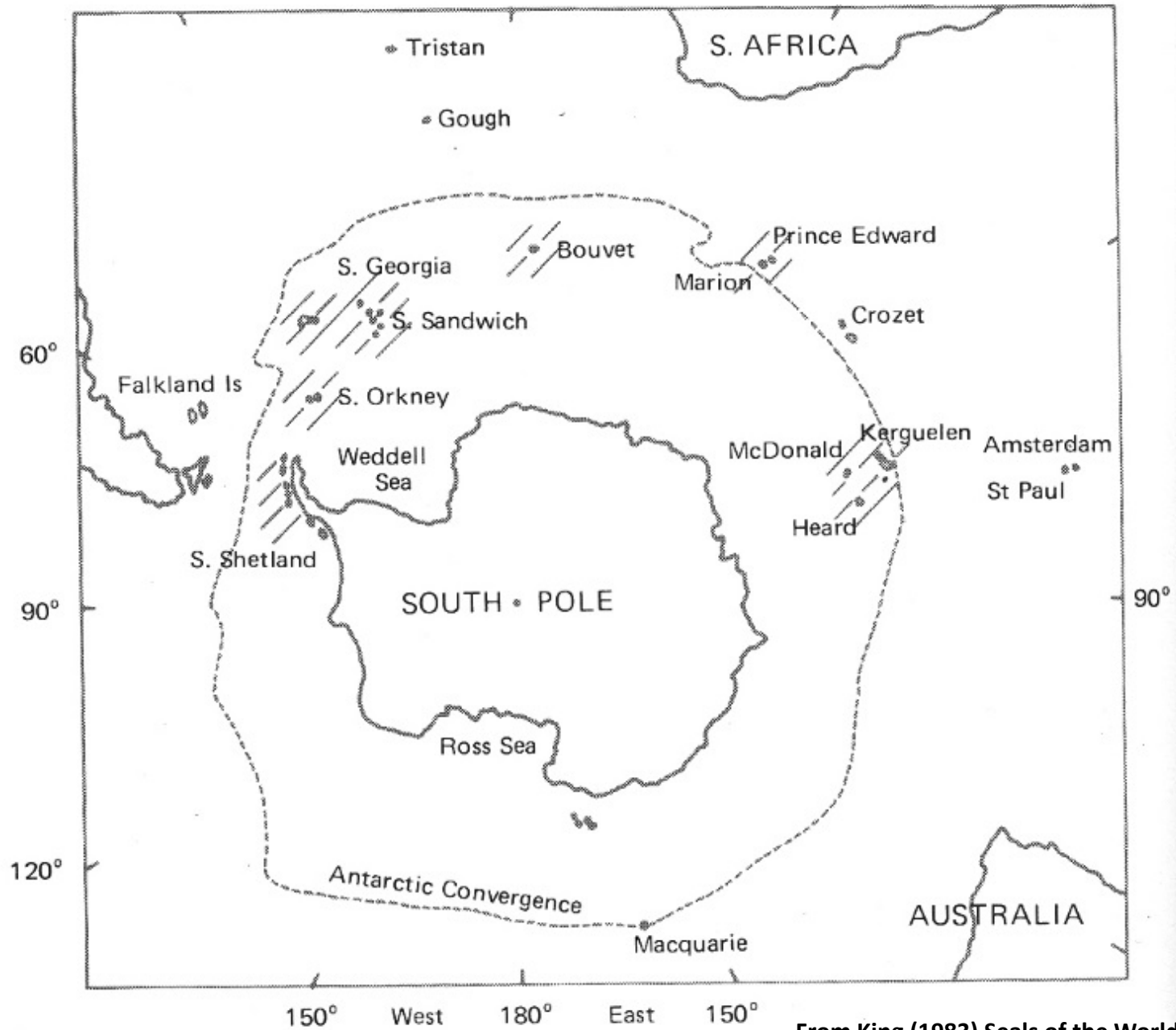


# Whaling and sealing in the Southern Ocean and the krill surplus hypothesis



# Distribution of Antarctic Fur Seal



From King (1983) Seals of the World

**Soon after the subantarctic islands were discovered sealers began exploiting them for profit**

**Fur seals provided luxuriant pelts with the thick soft coats  
Elephant seals and even King penguins had enough blubber  
to produce oils**

**Large populations of these species on the Falklands, South Georgia,  
Kerguelen, and Macquarie Islands**



## **Subantarctic Islands suffered first:**

**Falkland Islands discovered in 1765**

**South Georgia in 1775 by James Cook**

**Macquarie in 1810**

## **Antarctic Peninsula was next:**

**South Shetland Islands first sighted in 1819**

**All were heavily exploited soon after discovery**



## Campbell Island Sealers, 1913



# History of Exploitation

Ellis (1991)

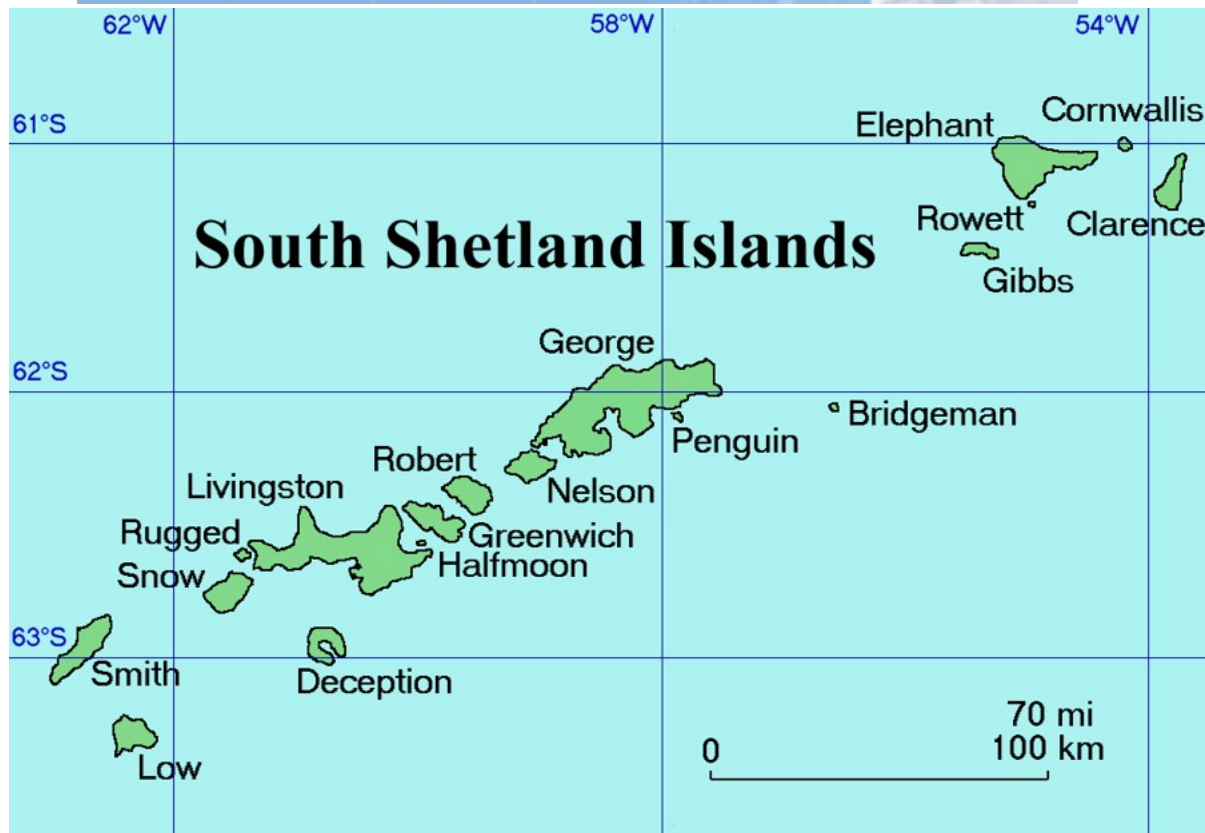
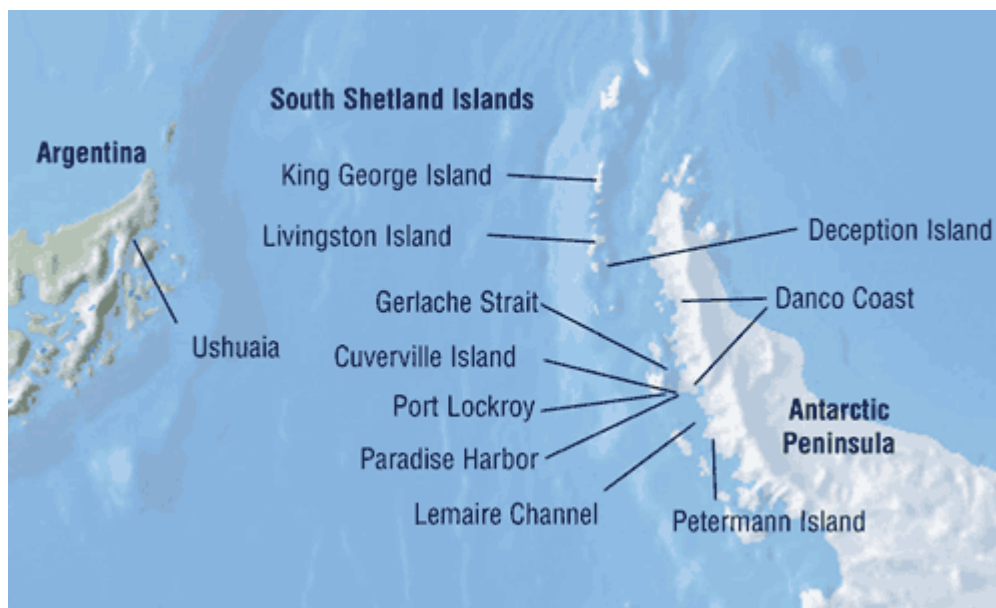
- Sealing began on Falklands in 1766 and on South Georgia Island in 1786
- In 1775, 13,000 fur seal skins were taken from Falklands by one ship
- 1793-1807, est. 3.2 million fur seal skins taken; by 1819 operations moved into Antarctic Peninsula
- 300,000 skins taken from AP in four years, industry ended by 1822 and elephant seals were exploited
- Whaling began in earnest by late 1800s



**Elephant seals also were hunted for their blubber which produced an oil similar to whale oil**

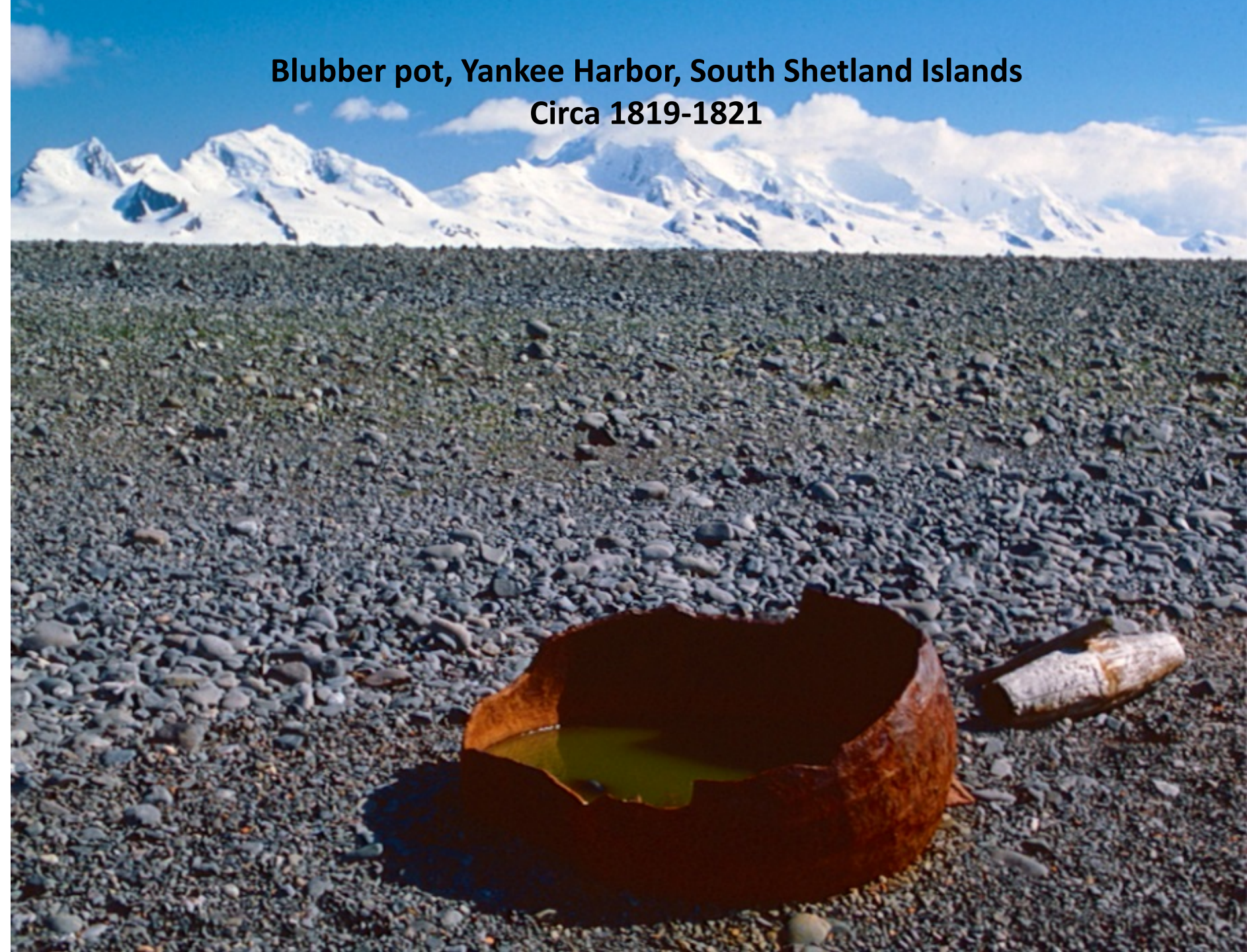
**Hunted more as fur seals declined**







**Blubber pot, Yankee Harbor, South Shetland Islands  
Circa 1819-1821**



# Campbell Island Tripot



# Sealer's cave on Livingston Island



**Whaling also taking place by mid 1800s in the AP  
Whales had to be taken one by one, flensed next to ship or on land**



# Humpback whale skeleton reassembled by Jacques Cousteau in 1972



# Progression of whaling methods

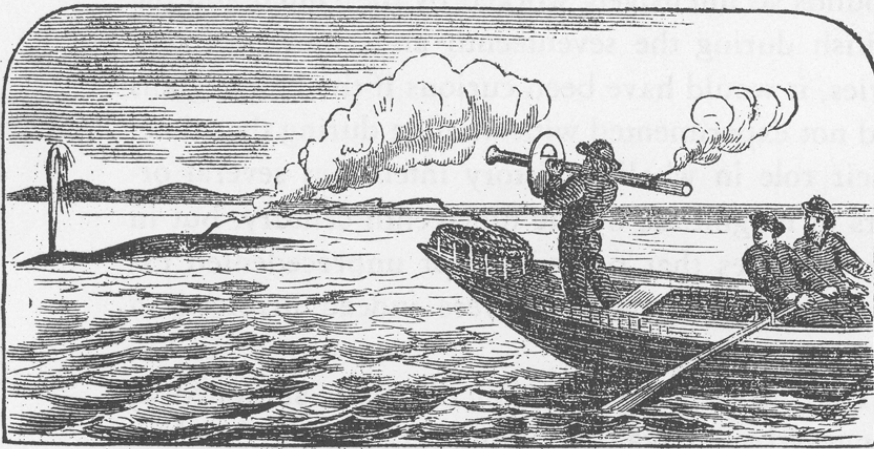
## 1. Handheld harpoons from small boats—Nantucket 'sleigh ride'



# Progression of whaling methods

1. Handheld harpoons from small boats—Nantucket 'sleigh ride'
2. Bomb guns by mid 19<sup>th</sup> century to kill easier

## PATENT ROCKET HARPOONS AND GUNS.



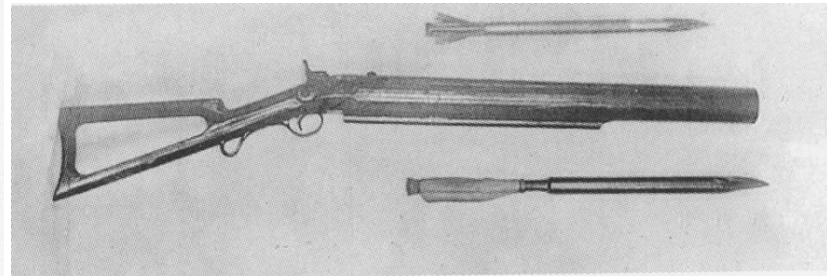
**FASTEN TO AND KILL INSTANTLY WHALES OF EVERY SPECIES.**

**WITH PROPER LINES AND BOATS,  
SUCH AS WERE USED BY THE OFFICERS OF BARK REINDEER IN 1864,  
ALL WHALES ARE SAVED.**

N. B.—Two Months' notice required to fill an Order for the Season of 1865.

—FOR SALE BY—

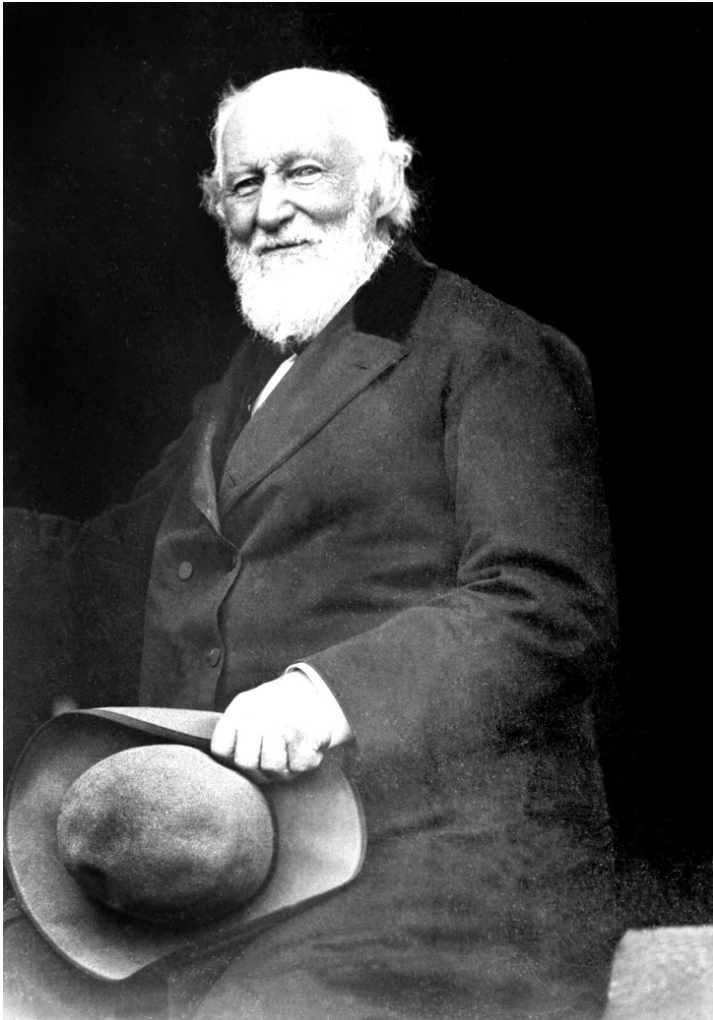
**G. A. LILLIENDAHL, - - - - - NEW YORK**



The heavy gun used to fire bomb lances

## Progression of whaling methods

1. Handheld harpoons from small boats—Nantucket 'sleigh ride'
2. Bomb guns by mid 19<sup>th</sup> century to kill easier
3. Harpoon canons mounted in the bow of ships



**Svend Foyn  
(1809-1894)  
Norwegian whaler**



**The harpoon had an explosive head that would kill the whale on impact**



**King George Island whale skull with harpoon**





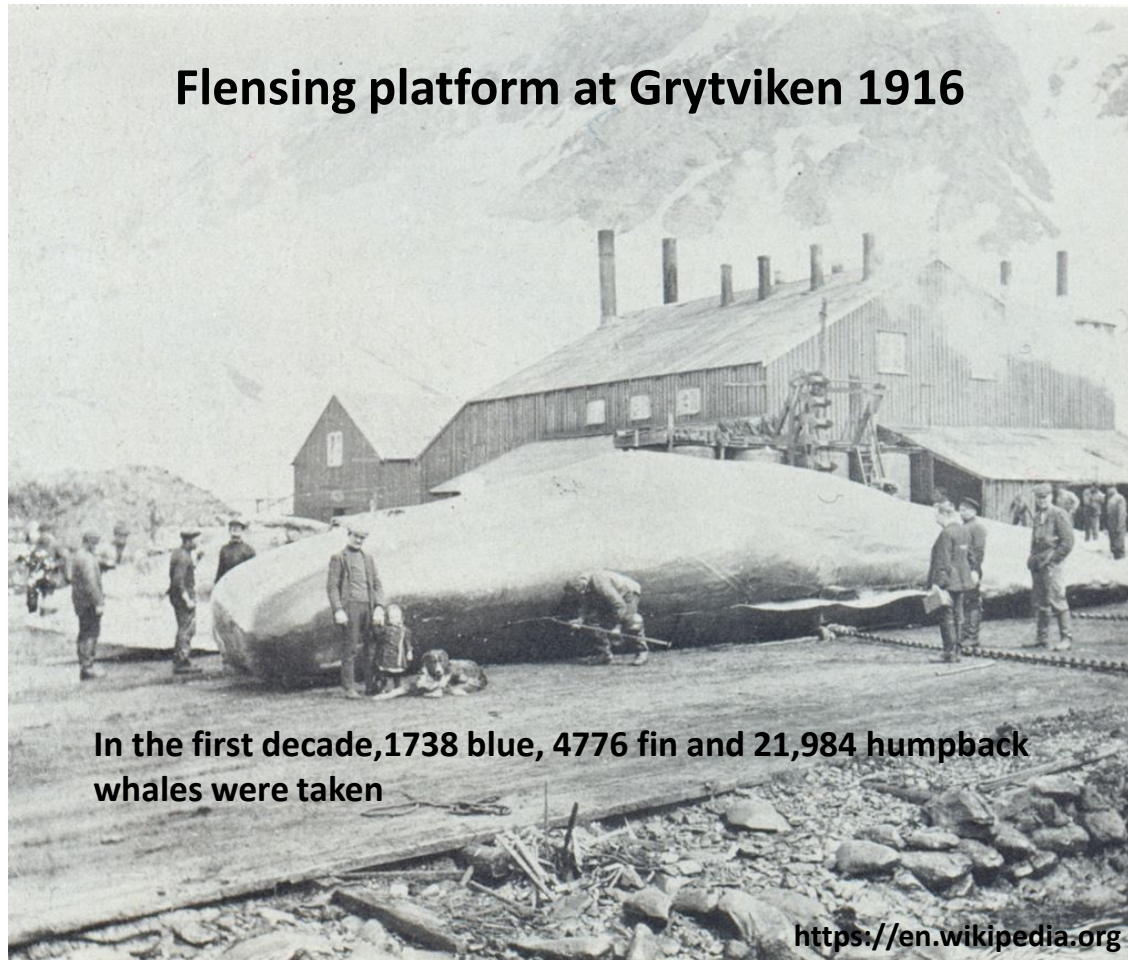
Spears  
from the  
17th century



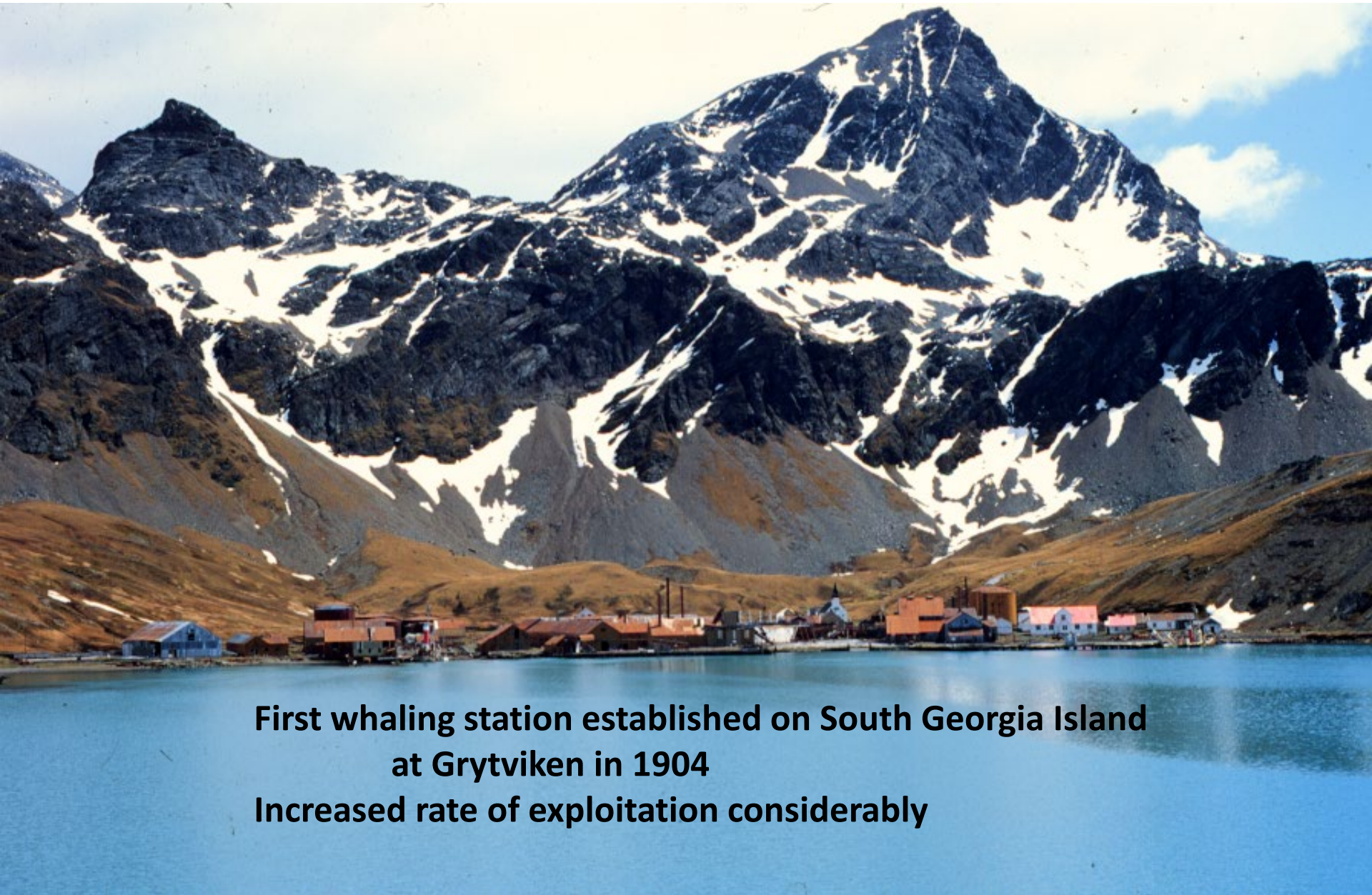
# Progression of whaling methods

1. Handheld harpoons from small boats—Nantucket 'sleigh ride'
2. Bomb guns by mid 19<sup>th</sup> century to kill easier
3. Harpoon canons mounted in the bow of ships
4. Land-based whaling stations by early 20<sup>th</sup> century

Flensing platform at Grytviken 1916



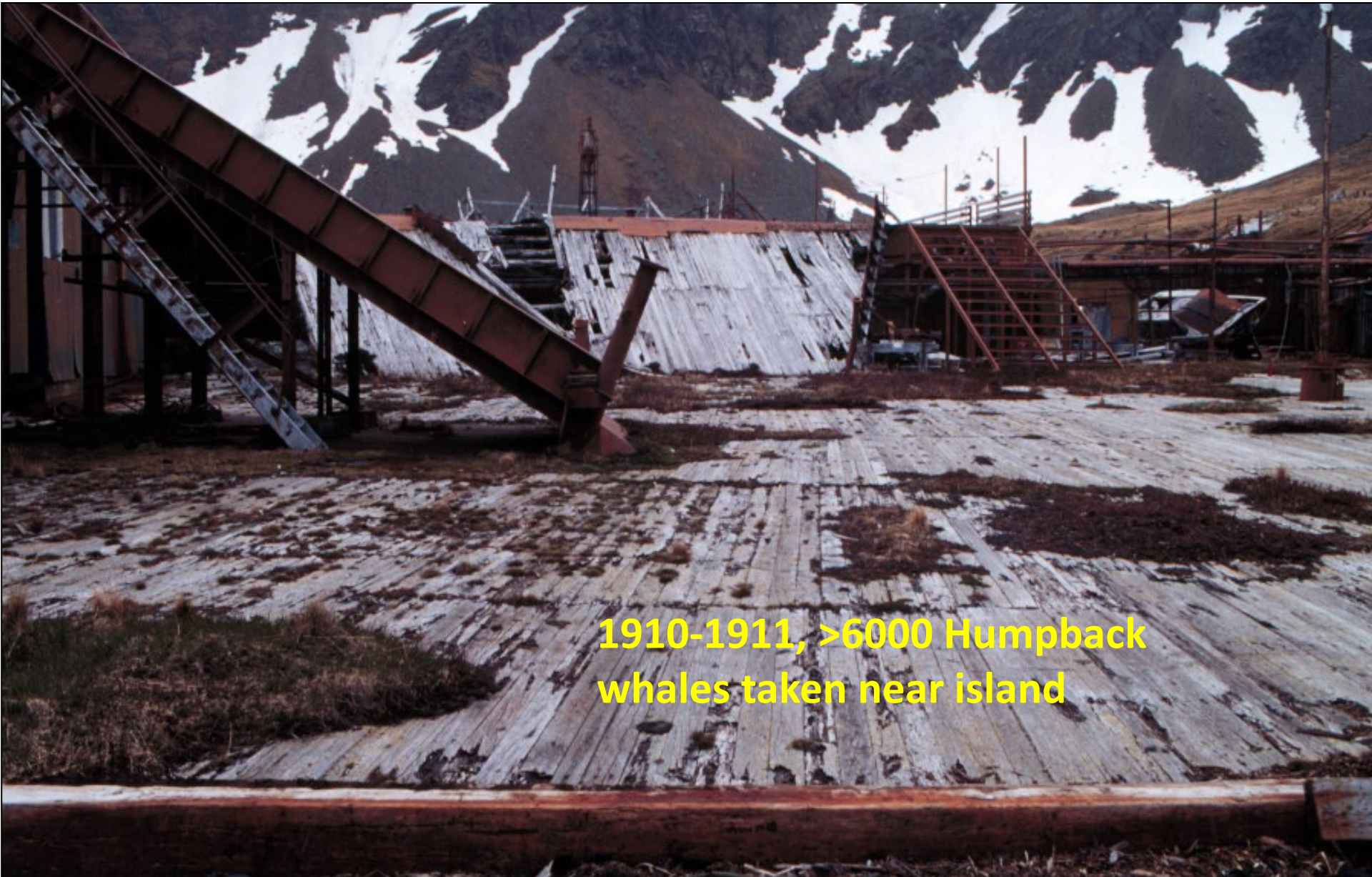
In the first decade, 1738 blue, 4776 fin and 21,984 humpback whales were taken



**First whaling station established on South Georgia Island  
at Grytviken in 1904**

**Increased rate of exploitation considerably**

## Flensing platform at Grytviken



1910-1911, >6000 Humpback  
whales taken near island

## Abandoned whaling ship at Grytviken



**Harpoon cannon invented by Svend Foyn in 1865**



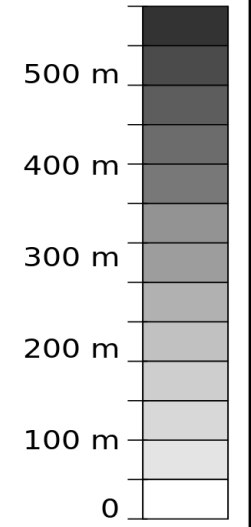


# BRANSFIELD STRAIT

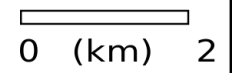
## Deception Island



### Legend:



- Ice-free
- Summer Station
- ASPA
- Peak
- Ruins



# Boilers on Deception Island Norwegian Whaling Station 1906-1931





*Hananui* at her Whangamumu base with a Humpback whale on the slipway. COURTESY OF LEONIE TOIA



Some of the whalers from Cook's station on Campbell Island with harpoons from the *Hananui*



*Left:* Sid Toms, Dick Norton and Harry Norton, three of the Marlborough whalers, with seals they have killed at the Rocky Bay colony, Campbell Island, in about 1913.  
*Right:* *Hananui* off the Northland coast. COURTESY OF LEONIE TOIA

## Foyn Harbor abandoned whaling ship, 1915





**With the discovery of oil in Pennsylvania in 1861, and refinement of kerosene that burned cleaner and brighter, the whale oil market began to collapse**

The New Bedford waterfront, circa 1870, awash in casks of whale oil.

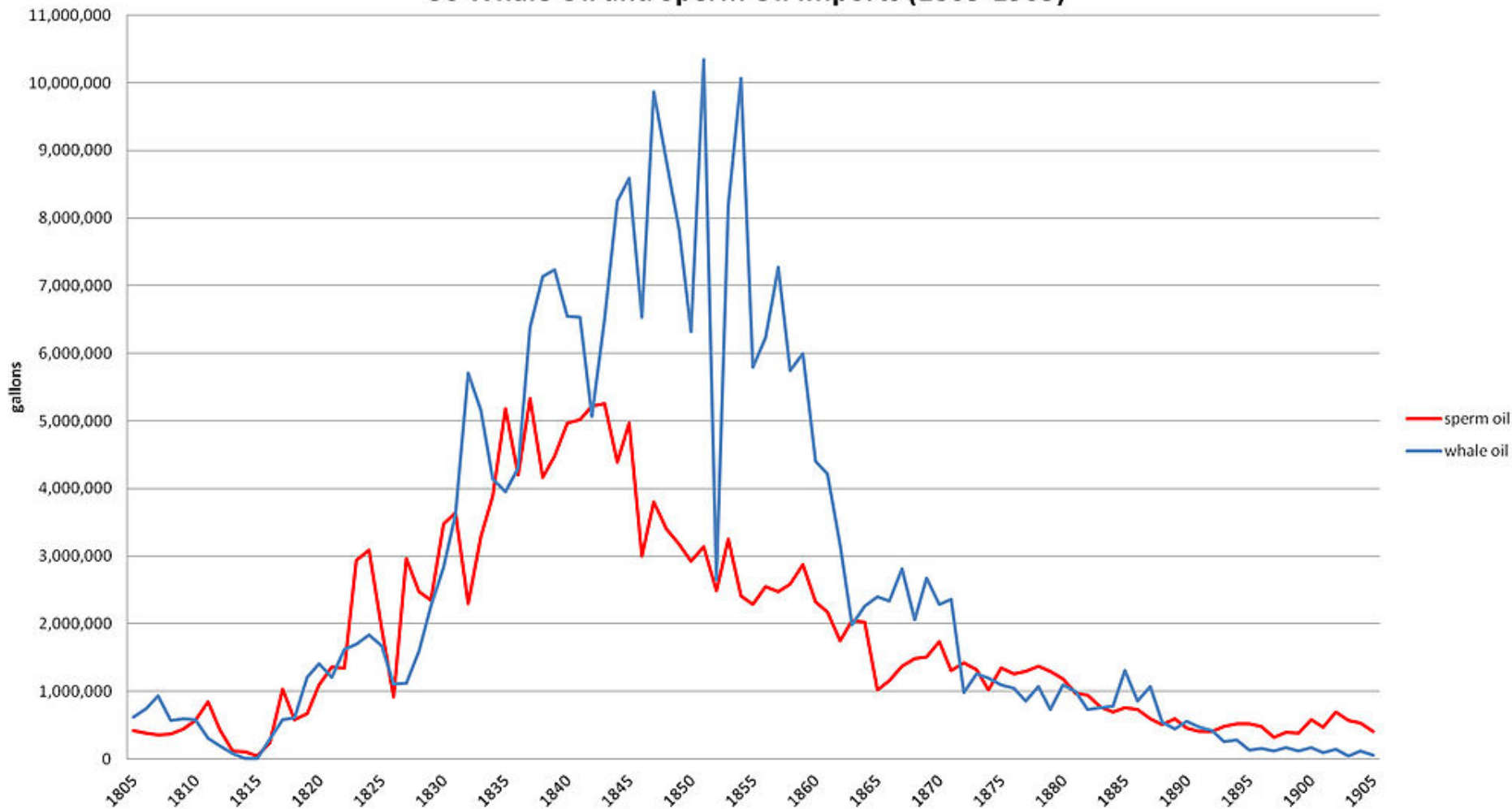
COURTESY OF NEW BEDFORD WHALING MUSEUM



DETAIL OF A *VANITY FAIR* CARTOON (APRIL 1861)—  
GRAND BALL GIVEN BY THE *WHALES* IN HONOR OF THE  
*DISCOVERY OF THE OIL WELLS IN PENNSYLVANIA.*

# Oil and kerosene began to replace whale oil usage

US Whale Oil and Sperm Oil Imports (1805-1905)<sup>1</sup>



<sup>1</sup>Walter S. Tower (1907). *A History of the American Whale Fishery*. Table III, pg 126



A sea of whalebone (baleen) drying in the sun in the yard of the Pacific Steam Whaling Company in San Francisco.

COURTESY OF NEW BEDFORD WHALING MUSEUM





**Baleen was used in women's corsets**

<https://en.wikipedia.org/>



## Progression of whaling methods

1. Handheld harpoons from small boats—Nantucket 'sleigh ride'
2. Bomb guns by mid 19<sup>th</sup> century to kill easier
3. Harpoon canons mounted in the bow of ships
4. Land-based whaling stations by early 20<sup>th</sup> century
5. Factory ships to catch, kill and process whales at sea



Norwegian factory ship *Sir James Clark Ross* in the Antarctic in 1924 with several whale carcasses alongside.

# Now whales could be processed at sea, more taken without going ashore



The giant Russian ship *Slava*, one of the *Slava's* chasers and a Blue whale being hauled through the *Slava's* stern slipway. FROM MARINE FISHERIES REVIEW 73

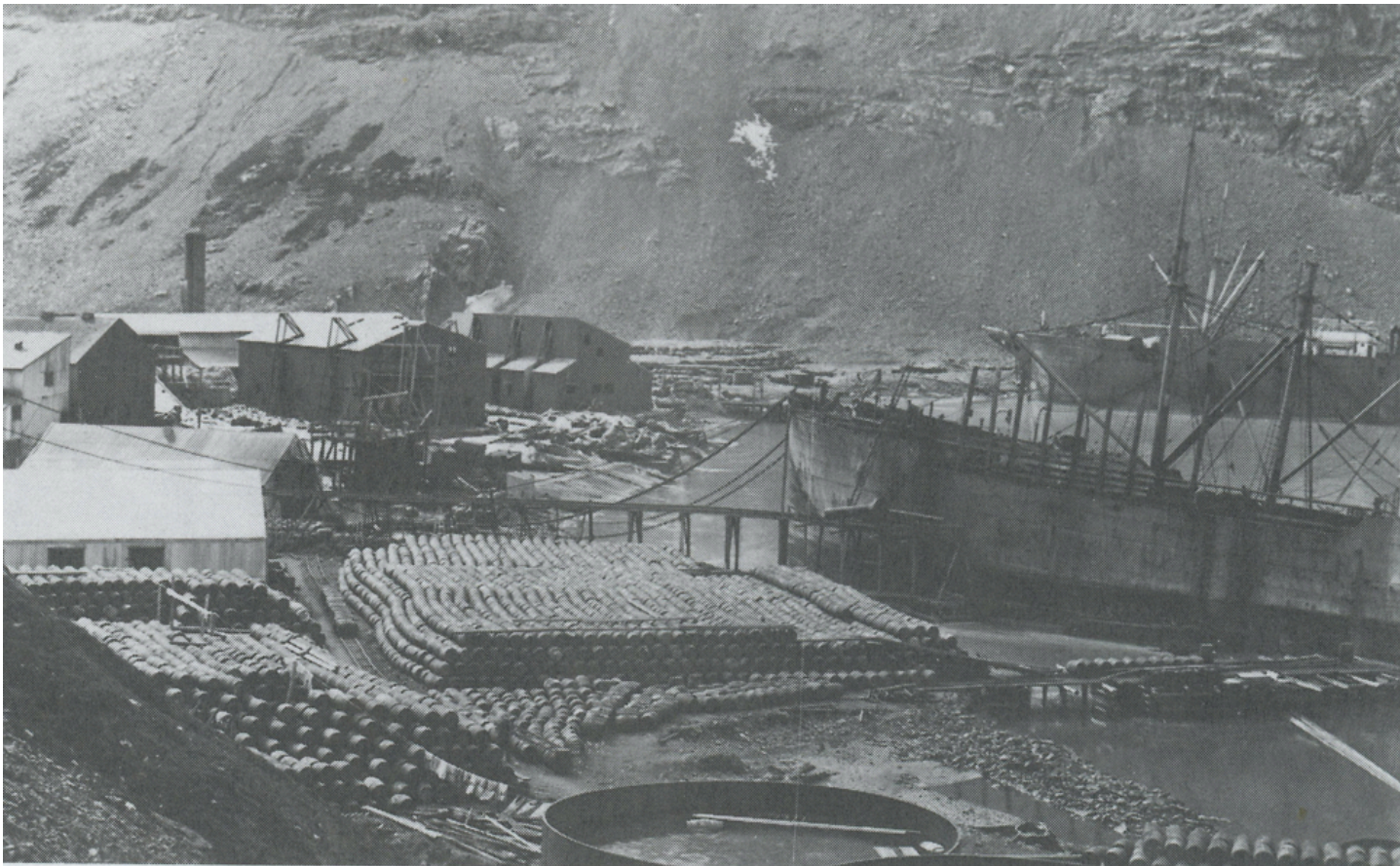
**First factory ships were in 1925**

**By 1930 there were 41 of these ships**

**Whale takes went from 14,219 in 1925 to 40,207 in 1931**

**Land-based factories began to close down**

**By 1925, whaling nations realized that whale stocks were way down and controls were needed to sustain the industry**



# **Whale Conservation**

**Convention for the Regulation of Whaling in 1931 led to agreement among 22 nations, but Japan and Germany refused to join**

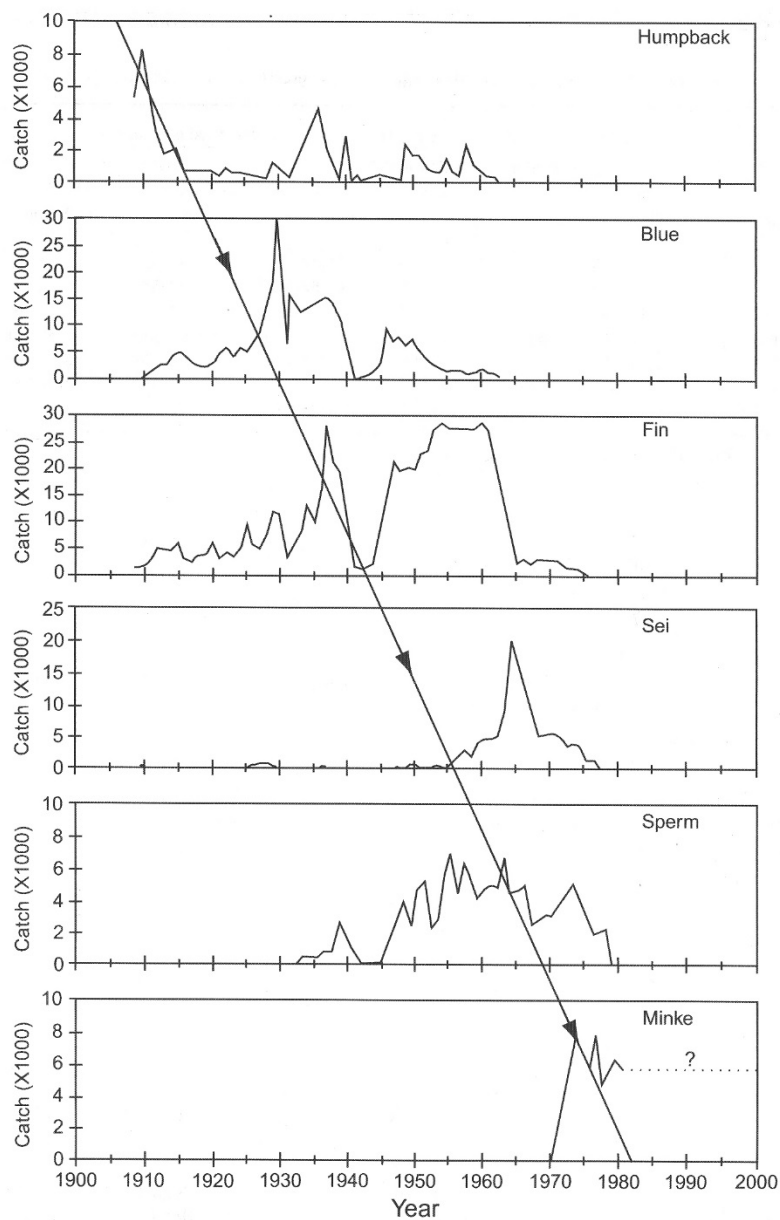
**--applied only to baleen whales**

**--no right whales could be taken**

**--no whales with calves could be taken**

**--no immature or nursing young could be taken**

**--ships must have permits, report takes**



**FIGURE 10.3** Annual catches of the great whales in the Antarctic marine ecosystem, showing the progressive depletion (diagonal line) of the different species during the 20th century. The whaling hiatus between 1940 and 1945 was due to World War II. These whaling activities have reduced the overall biomass among all whale species by more than 80% and among the humpback (*Megaptera novaeangliae*) and blue (*Balaenoptera musculus*) whales by more than 95% (Tables 10.1 and 10.2). The dashed line from the minke whale (*Balaenoptera acutorostrata*), among the smallest baleen whales, represents ongoing discussions about its future exploitation since the larger species no longer are commercially viable. Modified from Gambell (1985) and Berkman (1992).

## **1946 International Whaling Convention established to:**

**“provide for the proper conservation of whale stocks and thus make possible the orderly development of the whaling industry“**

**--14 nations at first**

**--some whaling nations did not join, including Peru, Chile, and Argentina**

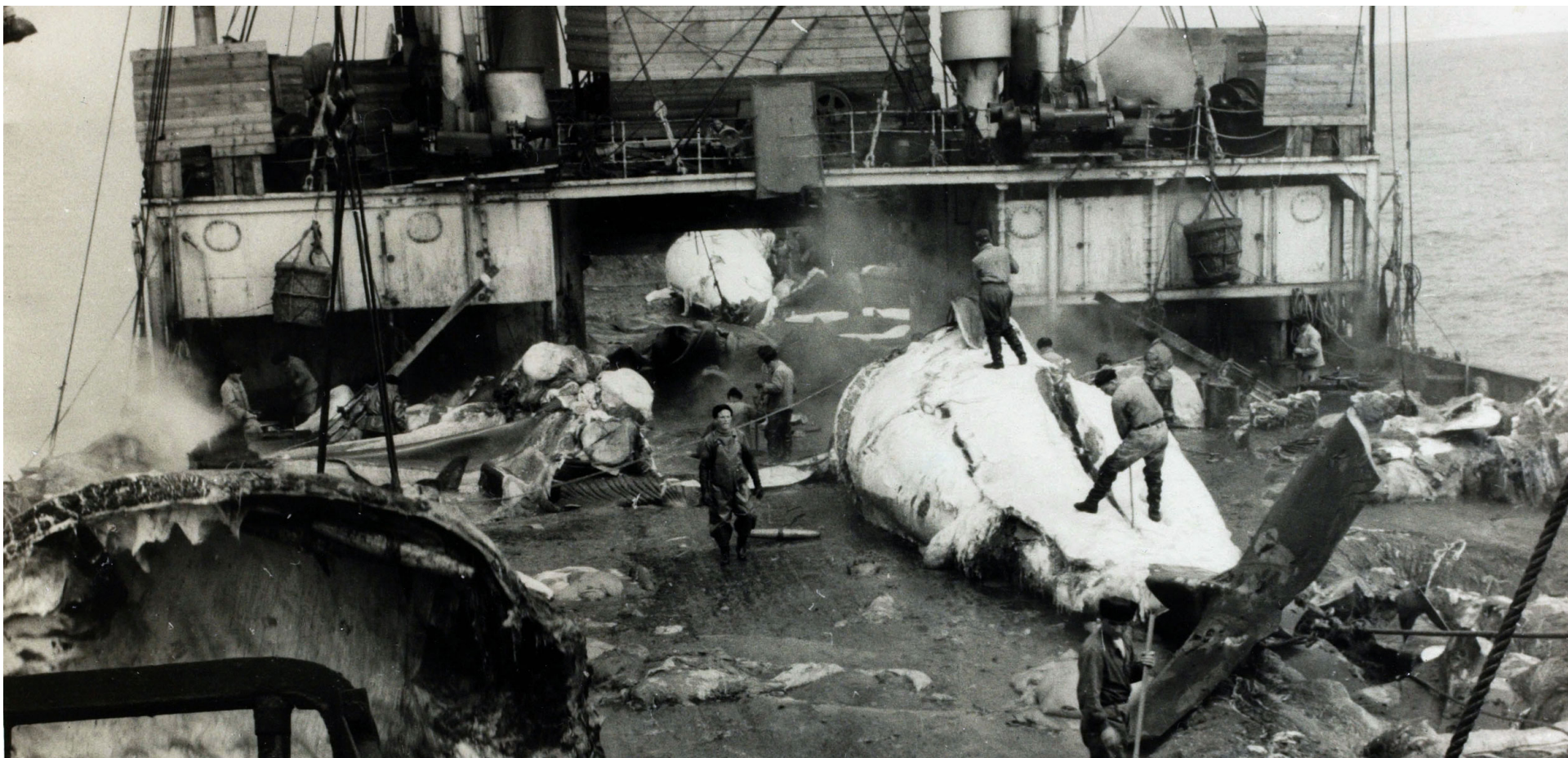
**--by late 1940s, 70% of whale takes were from the Southern Ocean and Antarctica**



**By 1982, the IWC established a moratorium on commercial whaling**

**--Japan, Canada and others did not agree**

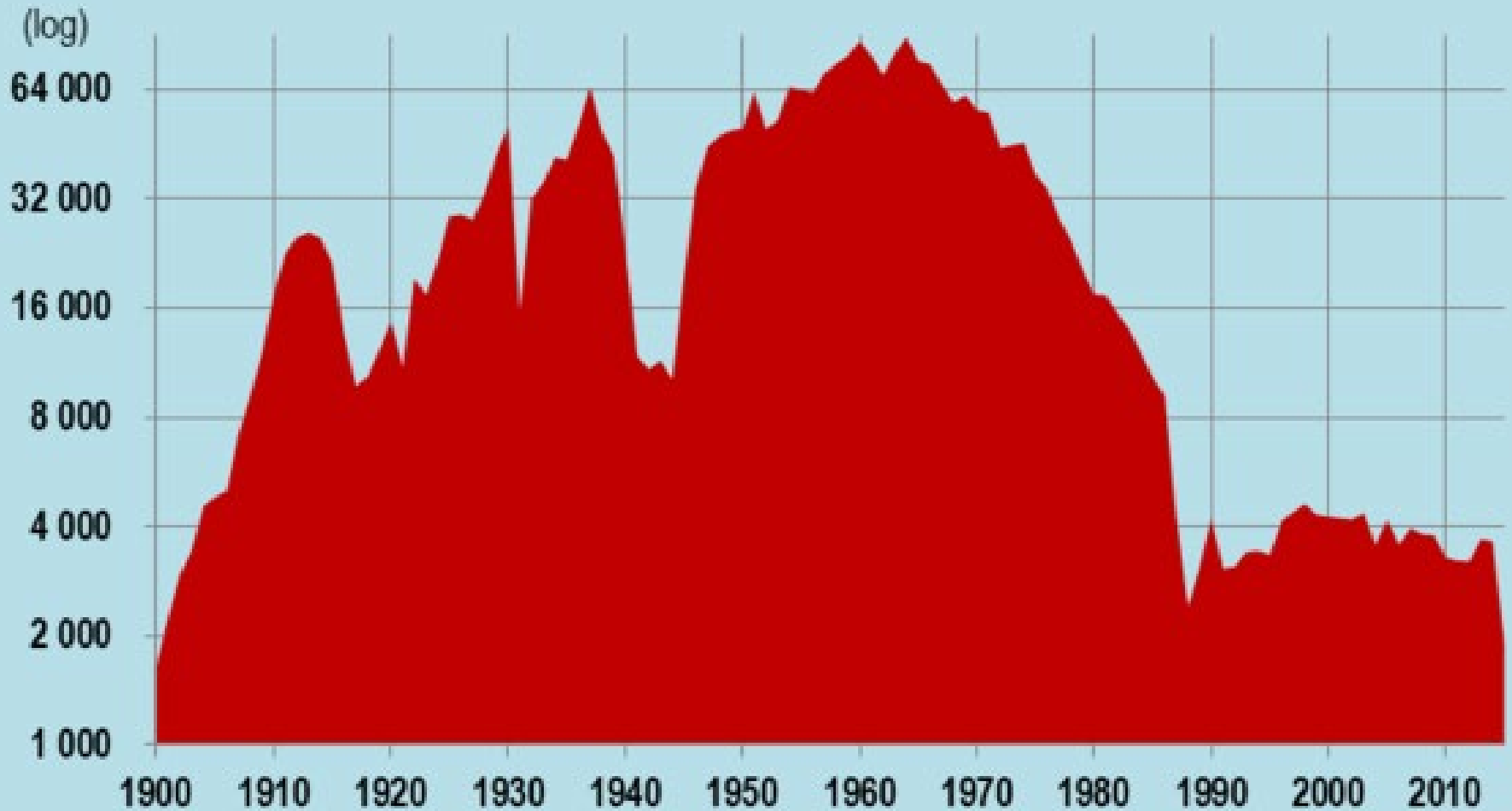
**--Russia was also taking thousands of whales by that time, most illegal**





# An estimated 3 million whales were taken in the 20<sup>th</sup> century Japan refused moratorium, still taking whales for 'scientific' purposes

Whales Caught per Year *Baleines Capturées par An* *Ballenas Capturadas por Año*





**Chinstrap penguins at Bailey Head, Deception Island**

**Krill Surplus Hypothesis first proposed by Sladen (1964) to account for large increases in penguins and fur seals in the AP from the 1940s to 1970s**

## Krill Surplus Hypothesis

- Extensive slaughter of whales and seals in 19<sup>th</sup> and 20<sup>th</sup> centuries in Southern Ocean
- Reduced whale populations by 90-95 %, still in recovery
- Caused near extinction of Antarctic and sub-Antarctic Fur Seals (*Arctocephalus gazella* and *A. tropicalis*)
- Resulted in excess krill estimated at ~150 million tons

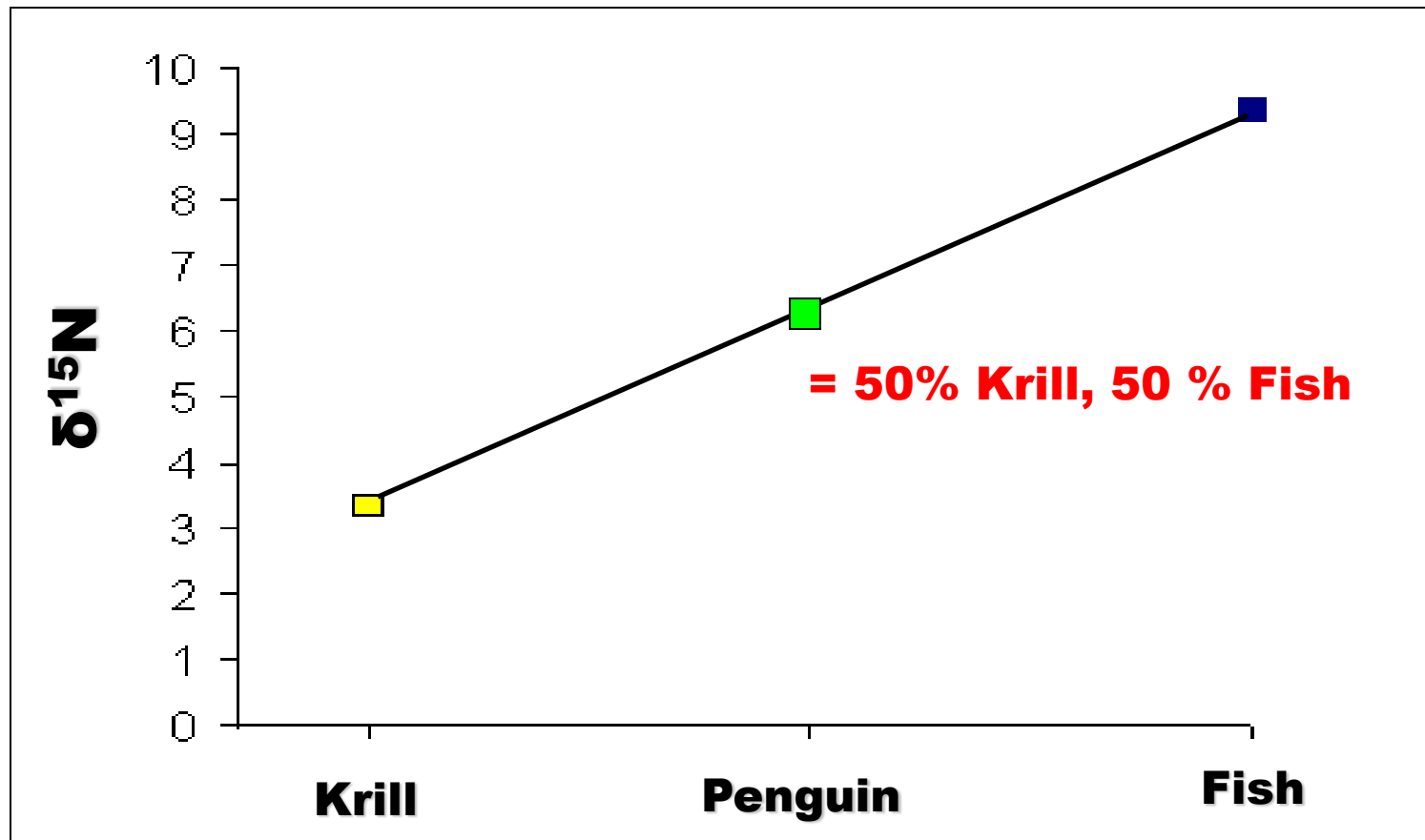
**Hypothesis suggests that penguins switched their diet more to krill with this surplus increasing since the early 1800s**





**Stable isotope analyses  
reveal more on krill vs.  
fish consumption by  
penguins**

# Inferring Diets Using $^{15}\text{N}$

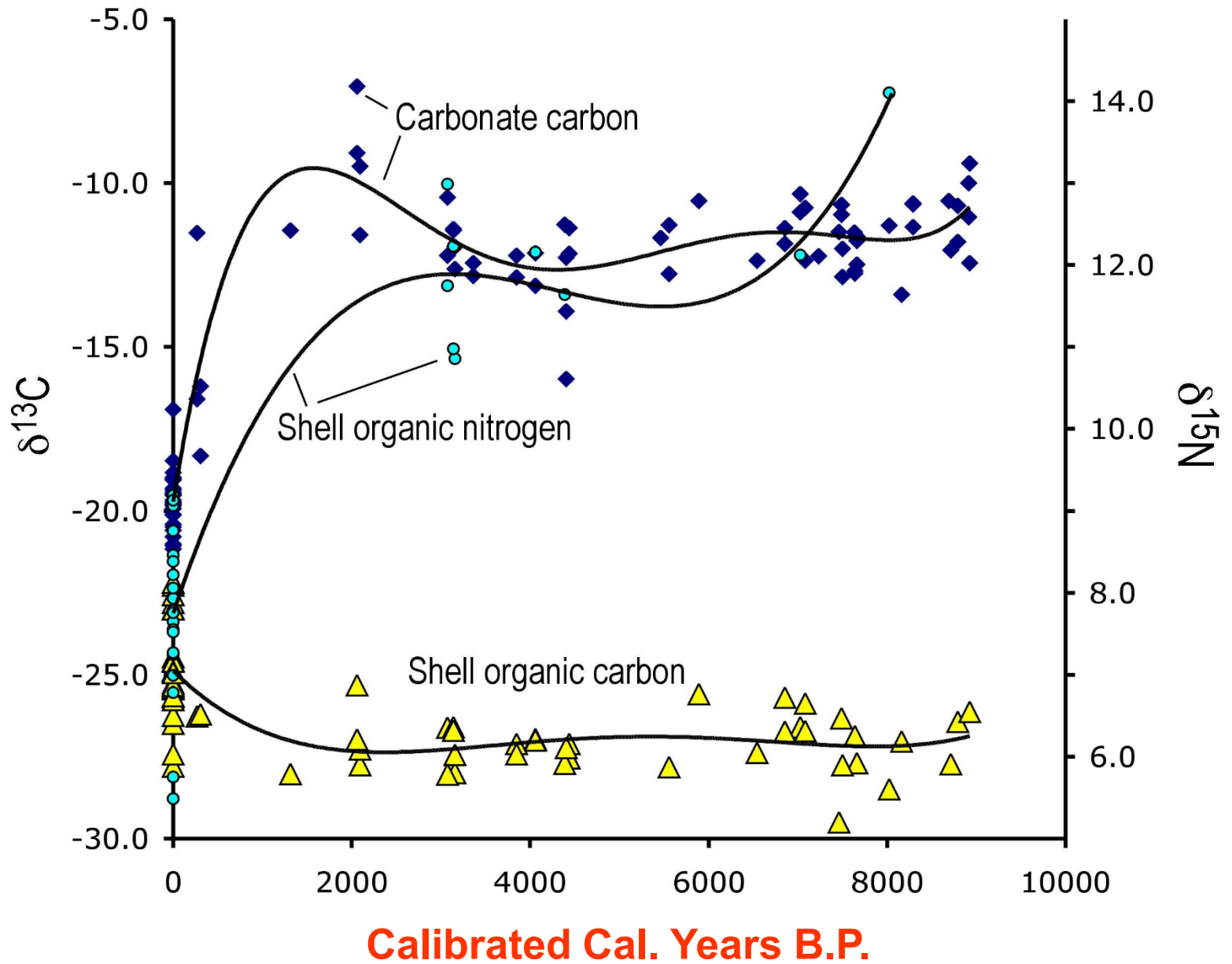


**Two end member linear mixing model**

(Phillips & Gregg 2001)

## Adélie Penguin Eggshell

- Carbonate reflects isotopes from recently consumed food in late spring/early summer
- Modern and fossil eggshell from same and different localities can be compared
- Eggshell from abandoned colonies well preserved
- Record extends up to 9000 years ago in some areas
- 62 modern, 20 historic, and 166 fossil samples analyzed



**Calibrated Cal. Years B.P.**



## Exactly when did the dietary shift in penguins occur?

- Radiocarbon record has poor resolution
- Only know it occurred after ~200 years ago
- Historical samples are needed to calibrate the shift

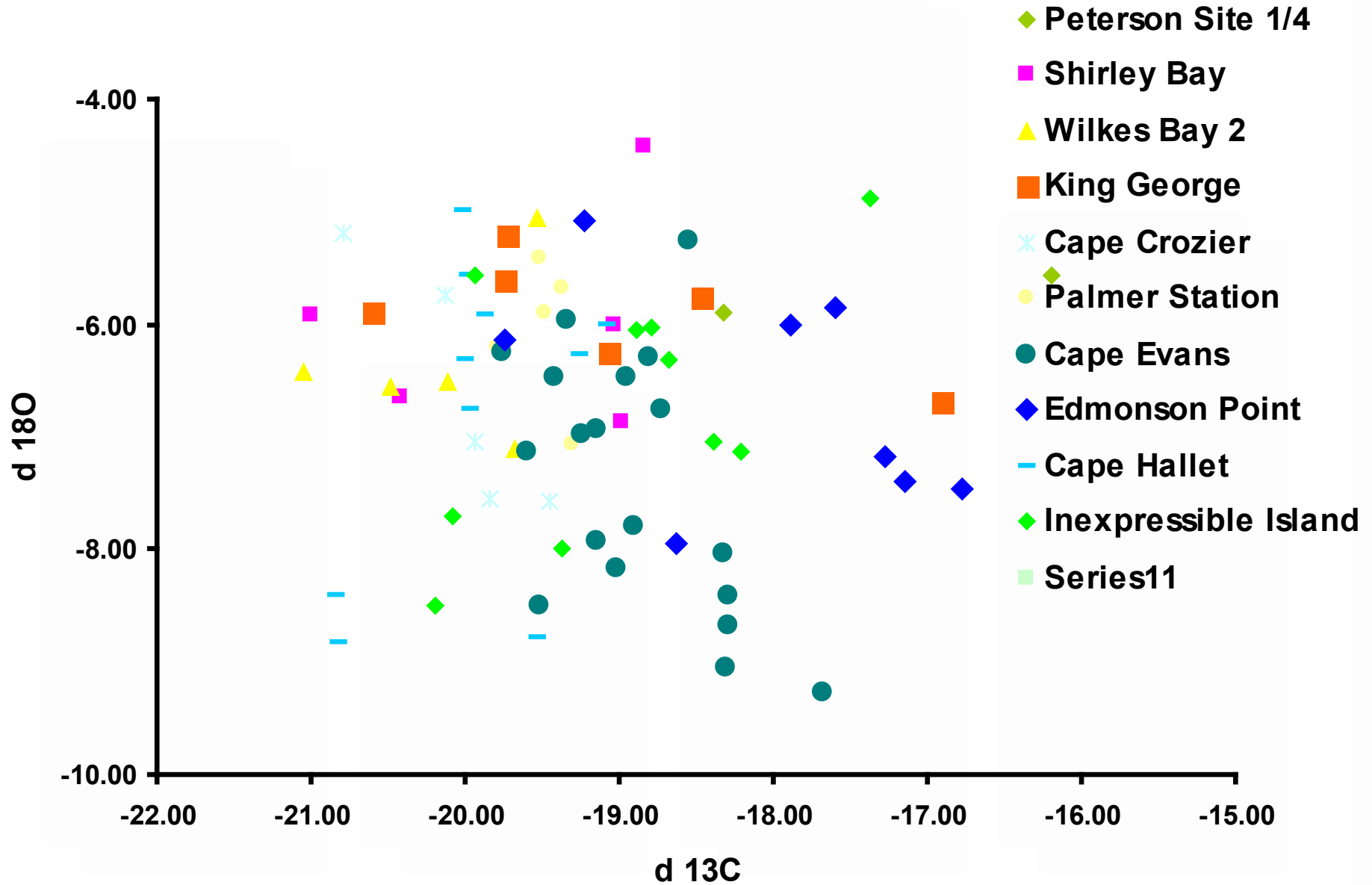


**Cape Evans Hut, 1911-1917**

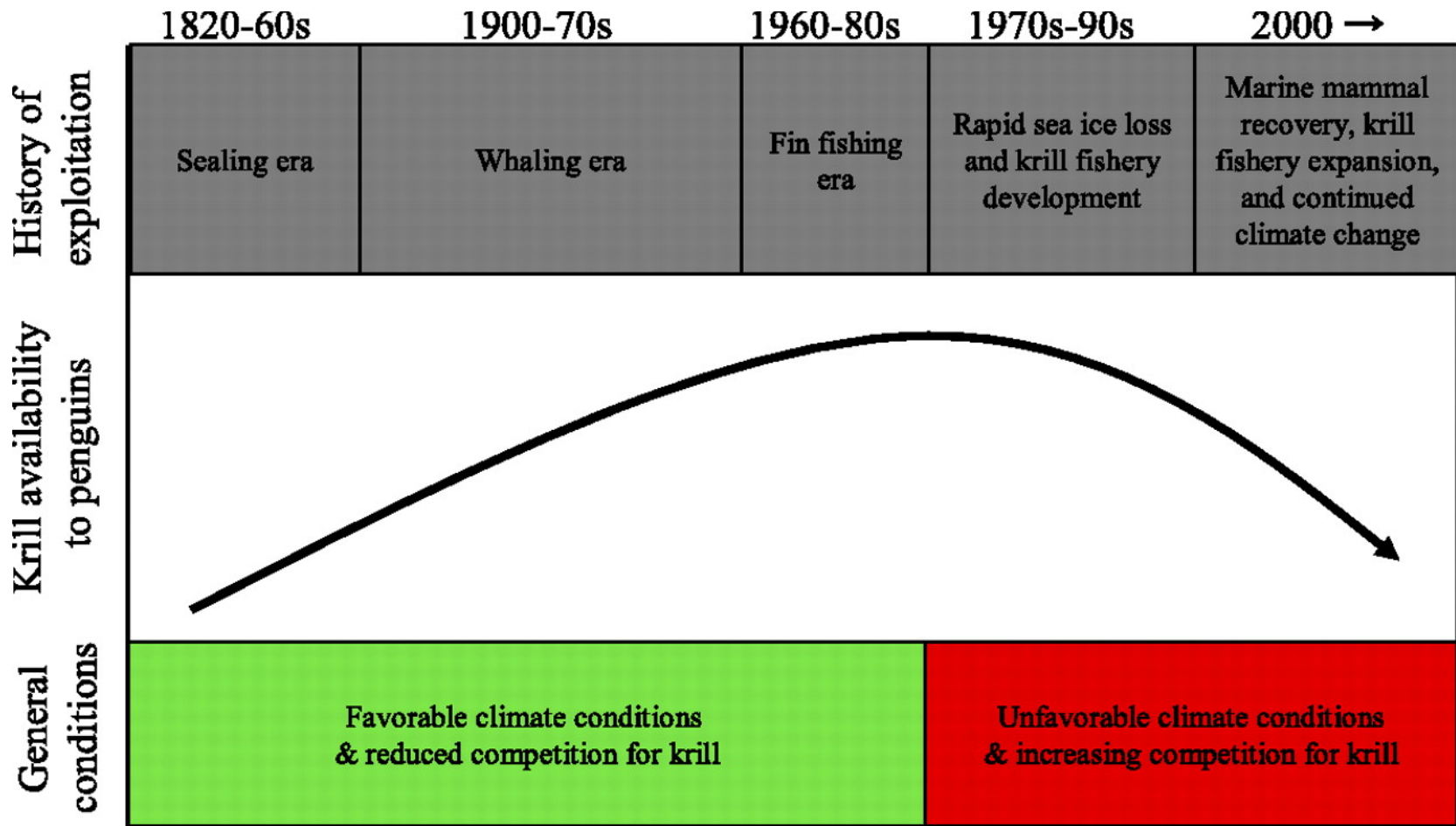




# Modern Adélie Eggshells



- **Ancient penguin eggshell isotope ratios show little variation from 9000 to ~200 yr ago**
- **Rapid loss in  $\delta^{15}\text{N}$  and  $\delta^{13}\text{C}$  enrichment thereafter**
- **Best explained by increased exploitation of krill by Adélie Penguins following historic decline of krill-eating seals and whales**
- **Modern penguin diet with dependency on krill is a recent phenomenon**



From Trivelpiece et al. 2011

**Evidence now indicates that the krill surplus is gone, future declines of Adélie and Chinstrap Penguins in the Antarctic Peninsula are expected**

# Quiz

1. When and where did sealing and whaling begin to have an impact in the Southern Ocean and Antarctica?
2. What was the progression of technological improvements in the 1800s that increased the rate of whale harvesting?
3. What are factory ships and how did they speed the exploitation of whales?
4. What is the krill surplus hypothesis and on what observations is it based?
5. What are future predictions for Antarctic penguins relying on krill for most of their diet?