Strål säkerhets myndigheten
Swedish Radiation Safety Authority

*Nationella strålsäkerhets- och forskningsdagarna 2019*

# Long-term variations of radioactive substances and metals in the marine environment of the Swedish west coast as studied by brown seaweed (*Fucus serratus* and *vesiculosus*)

***Project SSM2018-905***


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LUNDS UNIVERSITET

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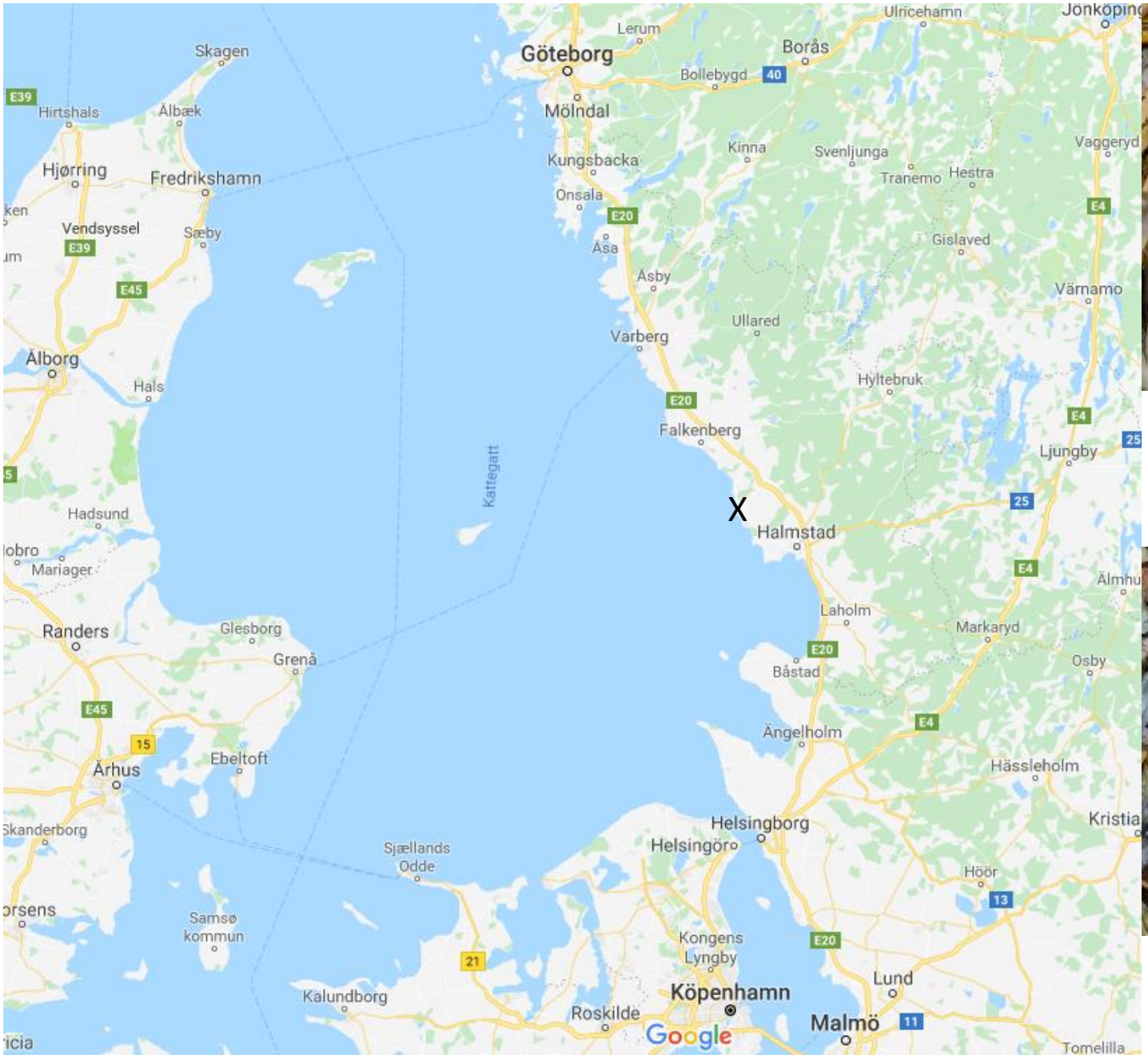
**First, I would like to acknowledge contributions from:**

**Rafael Garcia-Tenorio and José María López-Gutiérrez (analysis of $^{129}I$)**
**Guillaume Pédehontaa-Hiaa and Mynta Norberg (actinide radiochemistry)**




*Fucus serratus*
Eng:*Toothed wrack*
Sv: *Sågtång*

*Fucus vesiculosus*
Eng: *Bladder wrack*
Sv: *Blåstång*

## *Fucus serratus* (sågtång) and *Fucus vesiculosus* (blåstång) as bioindicators

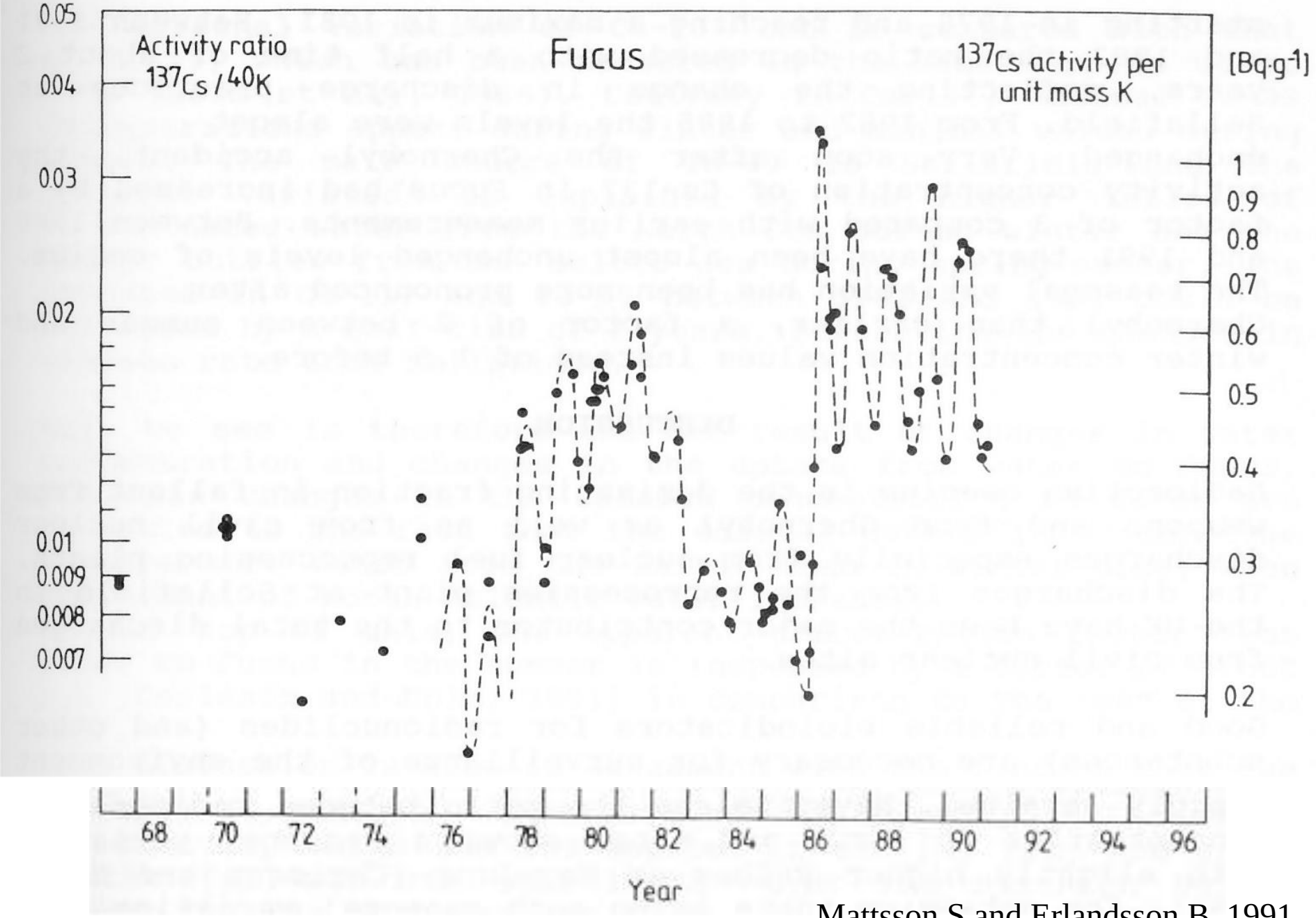
Sample collections were started in 1967, 52 years ago

At that time, I did not know of anyone who used algae as bioindicators for radioactive substances in the environment

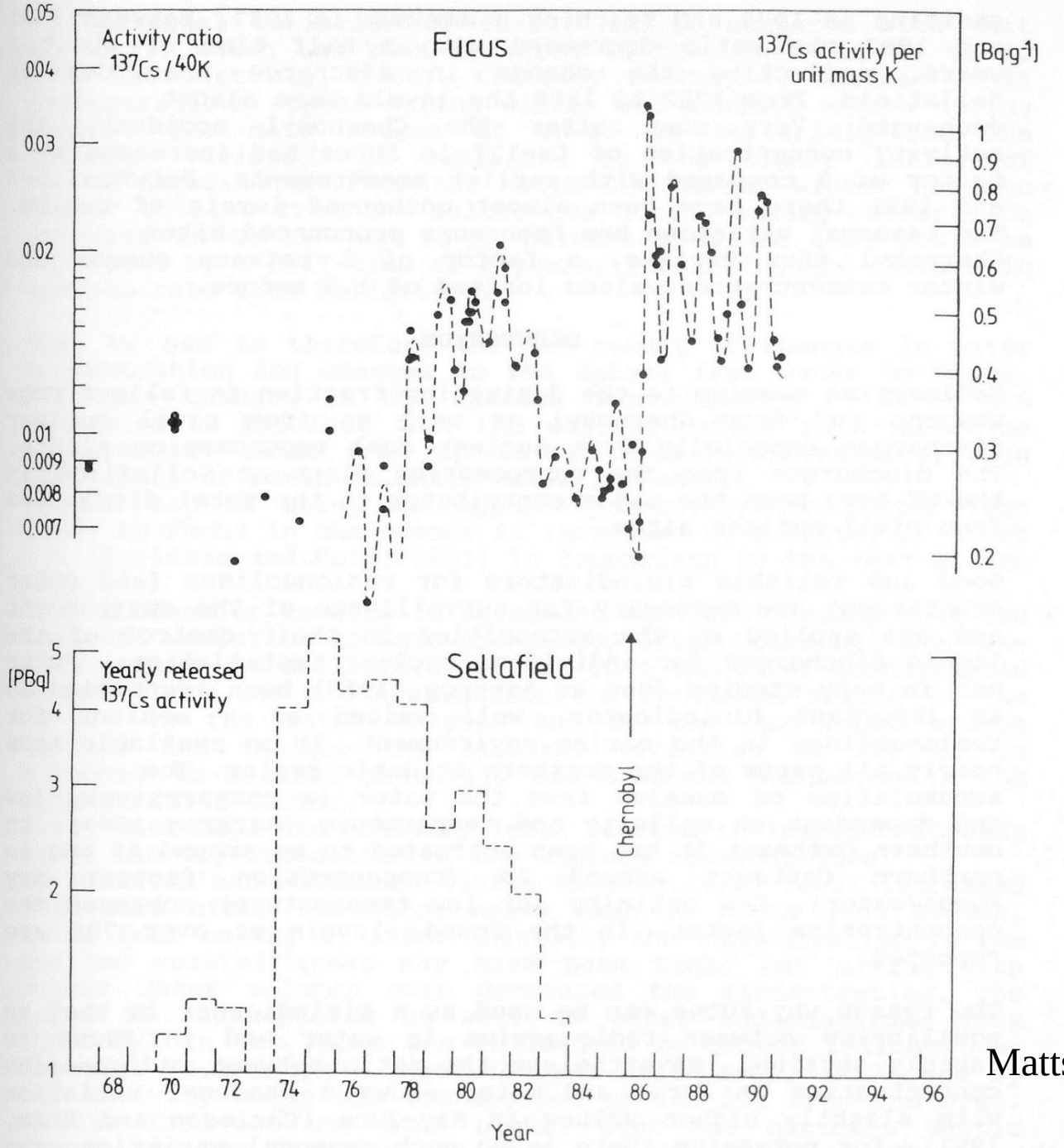
In addition to natural $^{40}K$, there was $^{137}Cs$, which could be explained by the 1956-58 and 1961-62 nuclear weapons tests in the atmosphere

During the summer of 1976, $^{60}Co$ was registered for the first time!

In 1978, the $^{137}Cs$ levels began to increase! Then Chernobyl in 1986, ….




Mattsson S and Erlandsson B, 1991

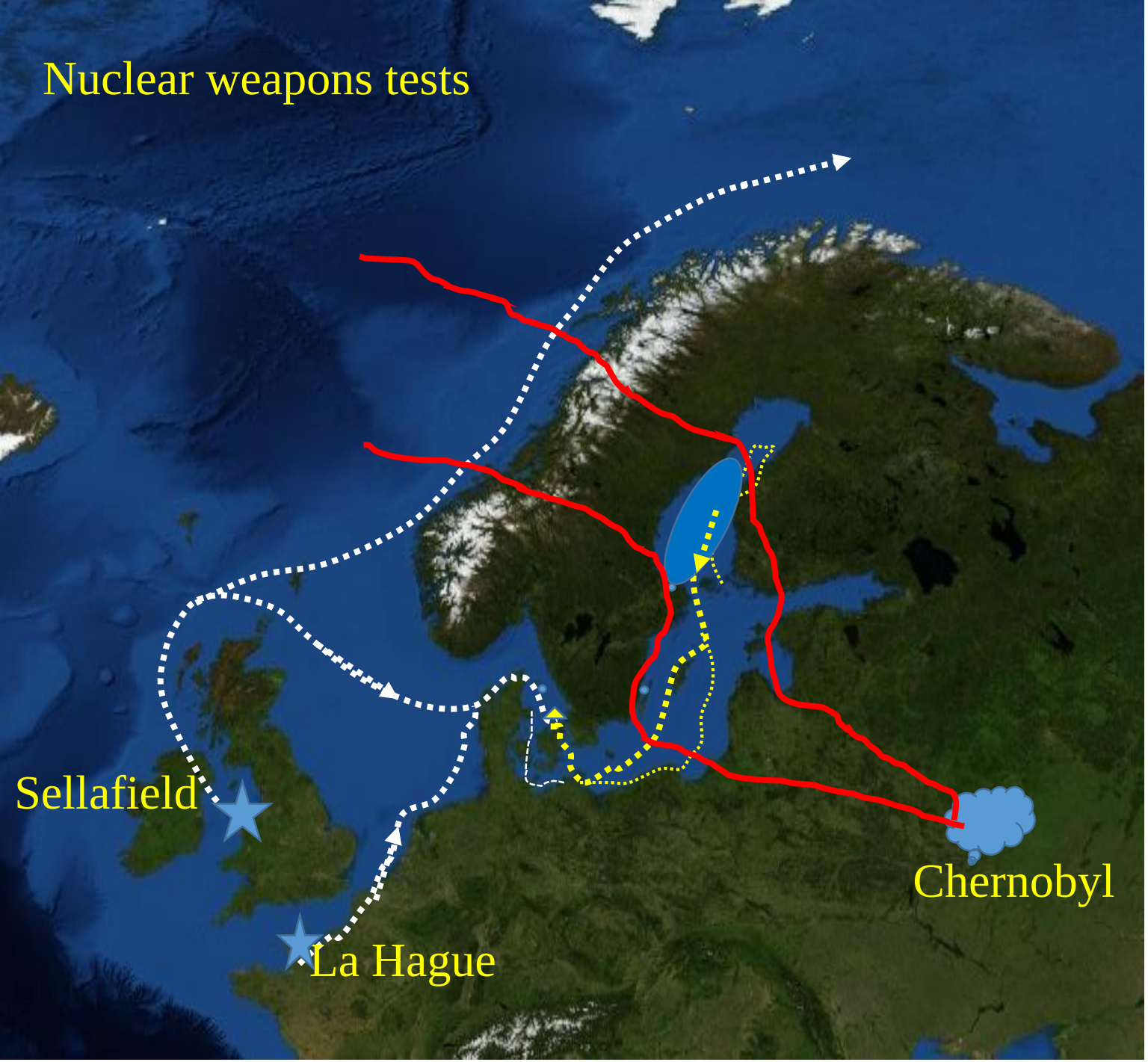



Mattsson S and Erlandsson B, 1991

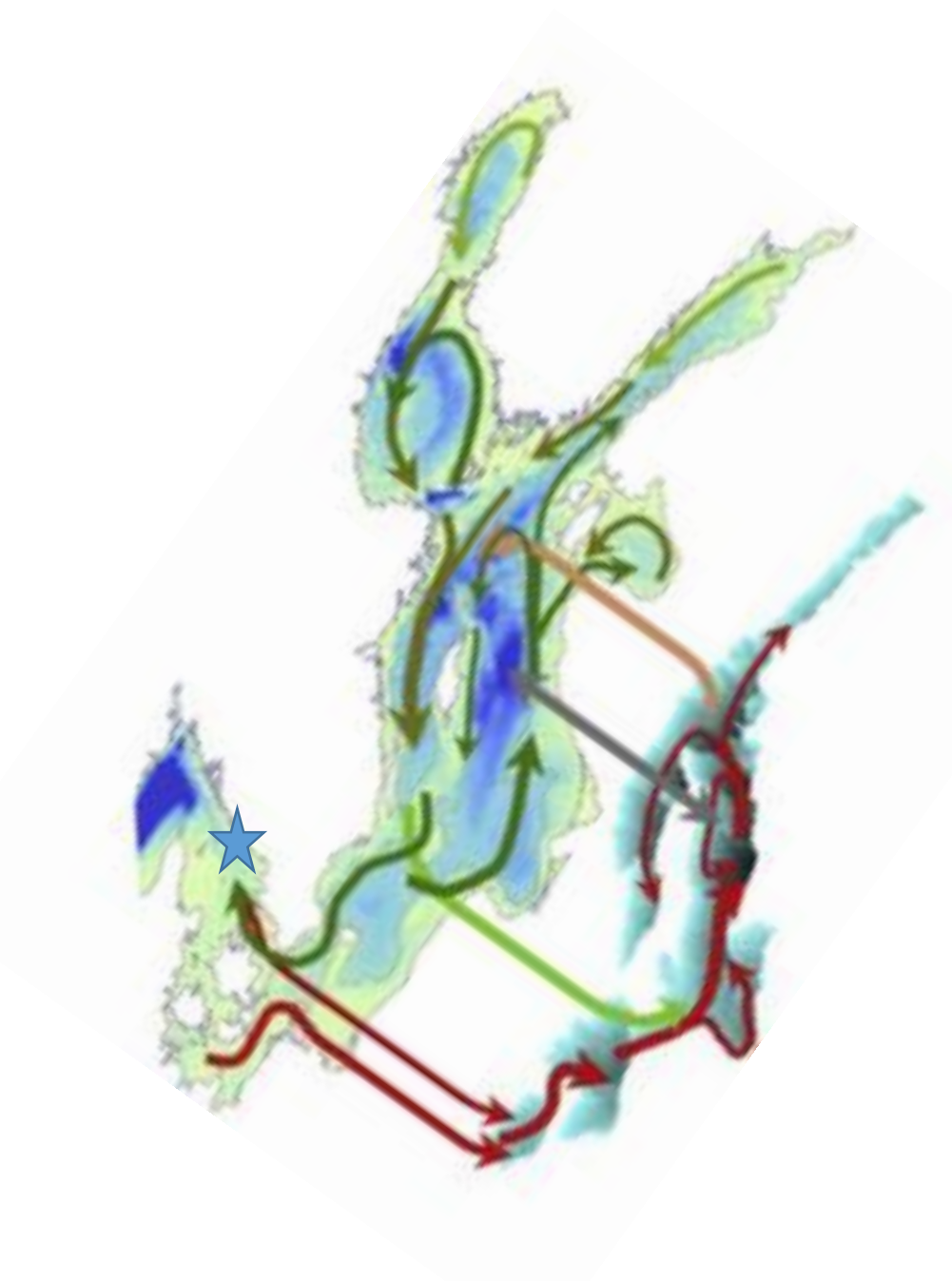
**Why such studies of seaweed ?**

- High-sensitivity detection of changes in radionuclide concentrations in water.
- Indicator of activity concentrations in other parts of the marine environment.
- The development over time is important when assessing and making decisions. Back-ground values will be in great demand in an emergency.
- Of value for information to the public.
- Swedish contribution to international activities (e, g, in OSPAR and HELCOM) and the guidance they produce.

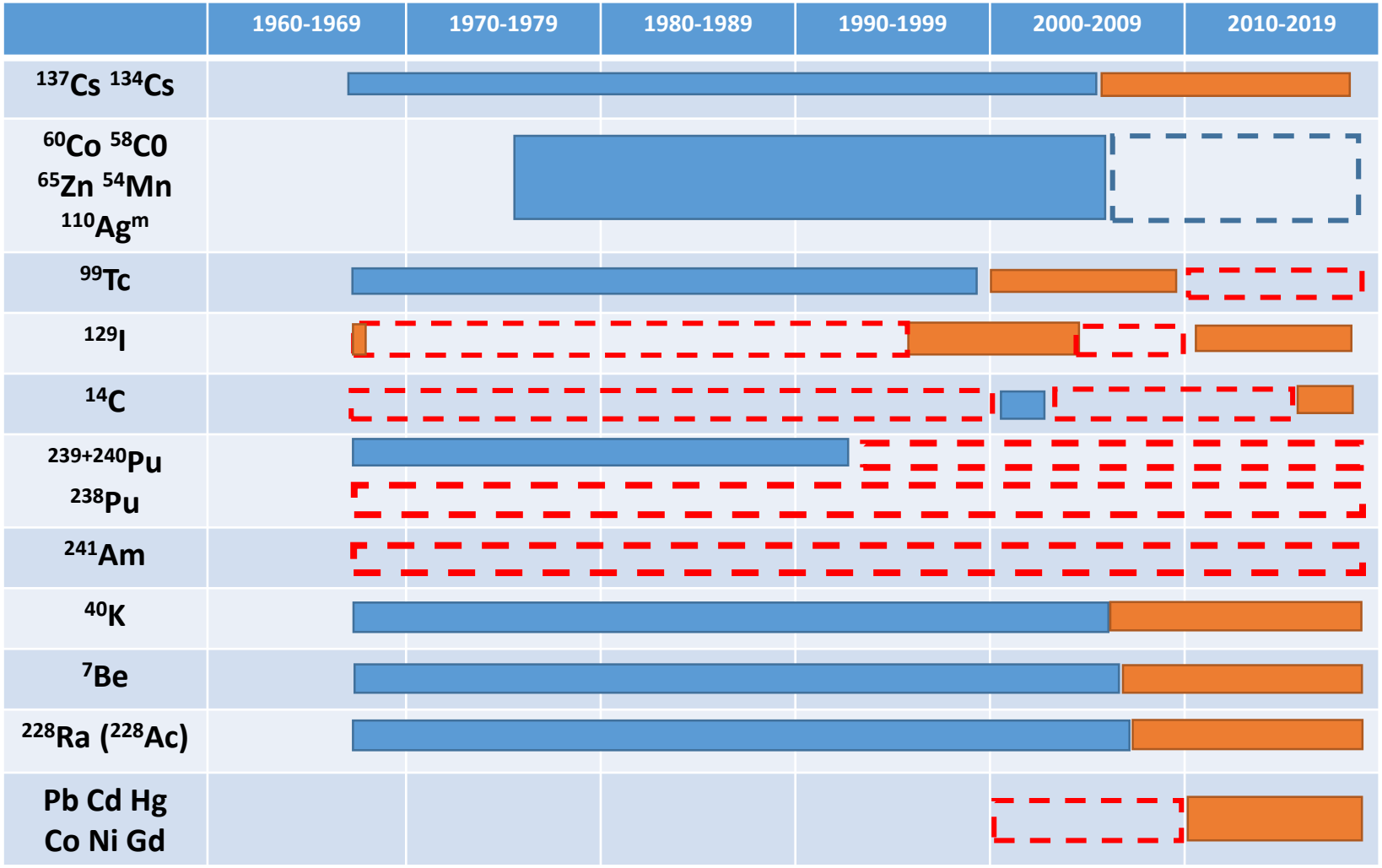
- To get the most out of a bio-indicator you need to know its behavior (normal values, seasonal variations, ...) in relation to the radionuclides of interest.


Nuclear weapons tests
Sellafield
La Hague
Chernobyl


OSPAR, 2000 (after Turrell et al., 1992)

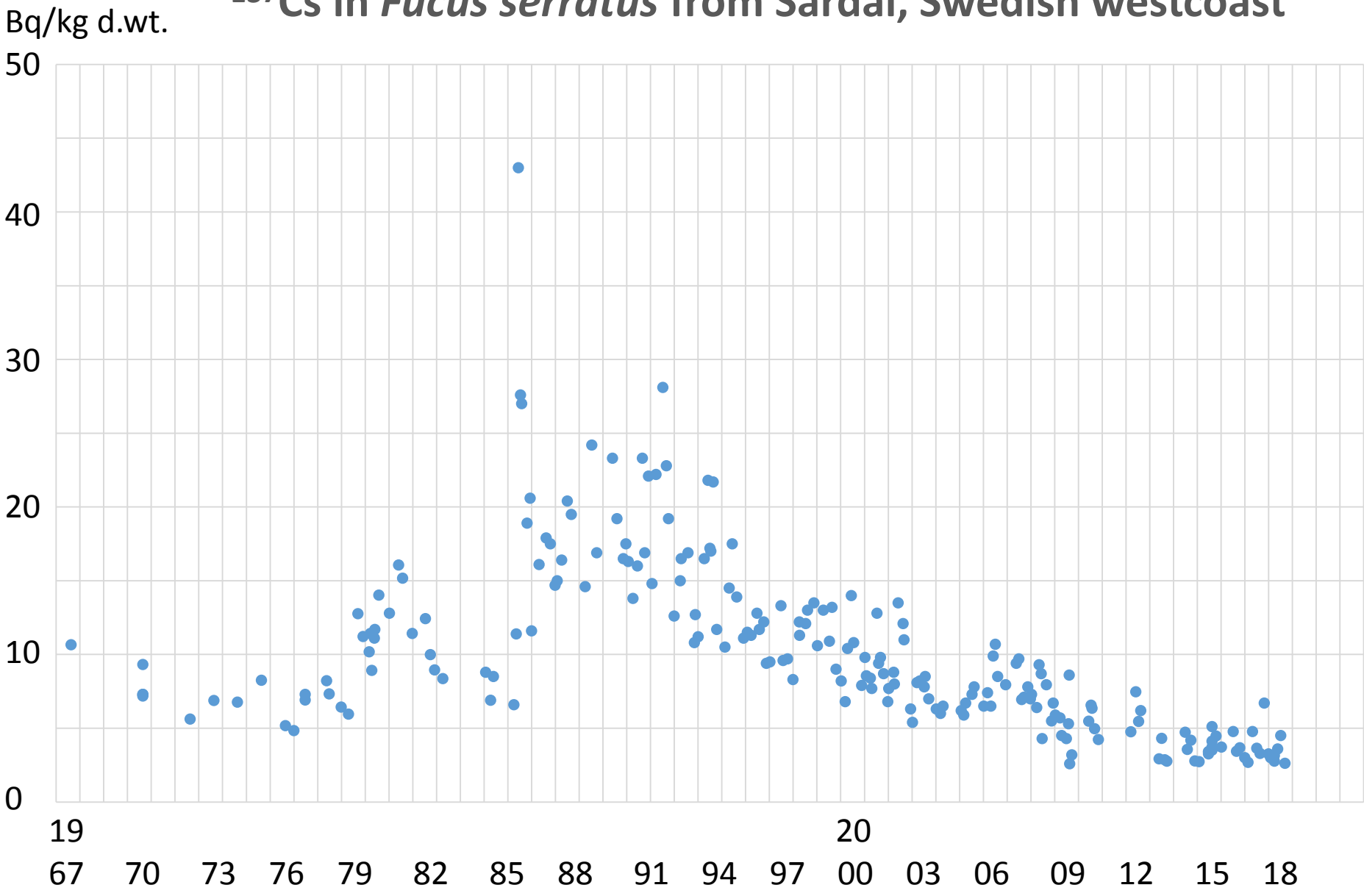


From Elken and Matthäus, 2008


1960-1969
1970-1979
1980-1989
1990-1999
2000-2009
2010-2019
$^{137}Cs$ $^{134}Cs$
$^{60}Co$ $^{58}C0$
$^{65}Zn$ $^{54}Mn$
$^{110}Ag^{m}$
$^{99}Tc$
$^{129}I$
$^{14}C$
$^{239+240}Pu$
$^{238}Pu$
$^{241}Am$
$^{40}K$
$^{7}Be$
$^{228}Ra$ ($^{228}Ac$)
Pb Cd Hg
Co Ni Gd

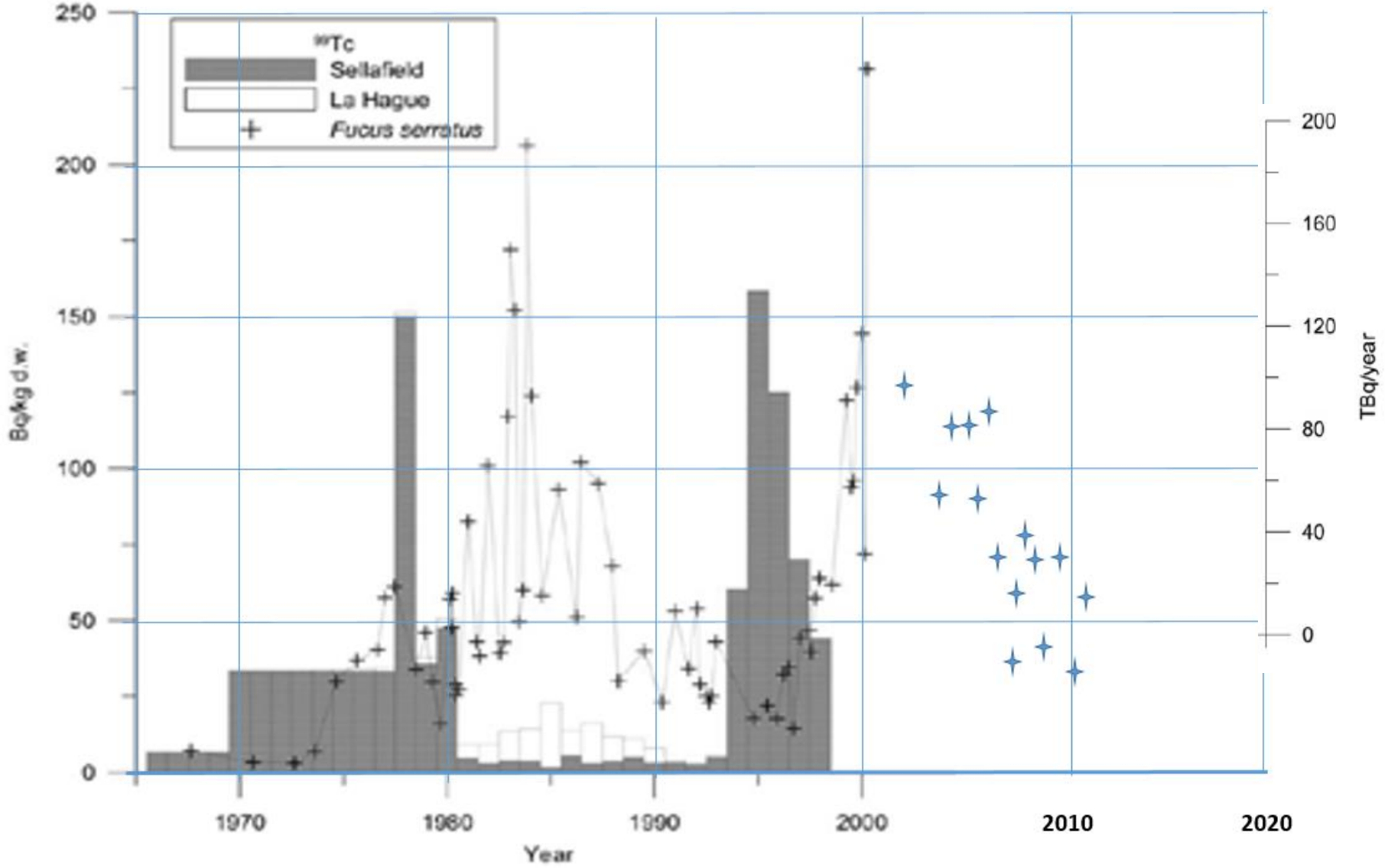
$^{137}Cs$

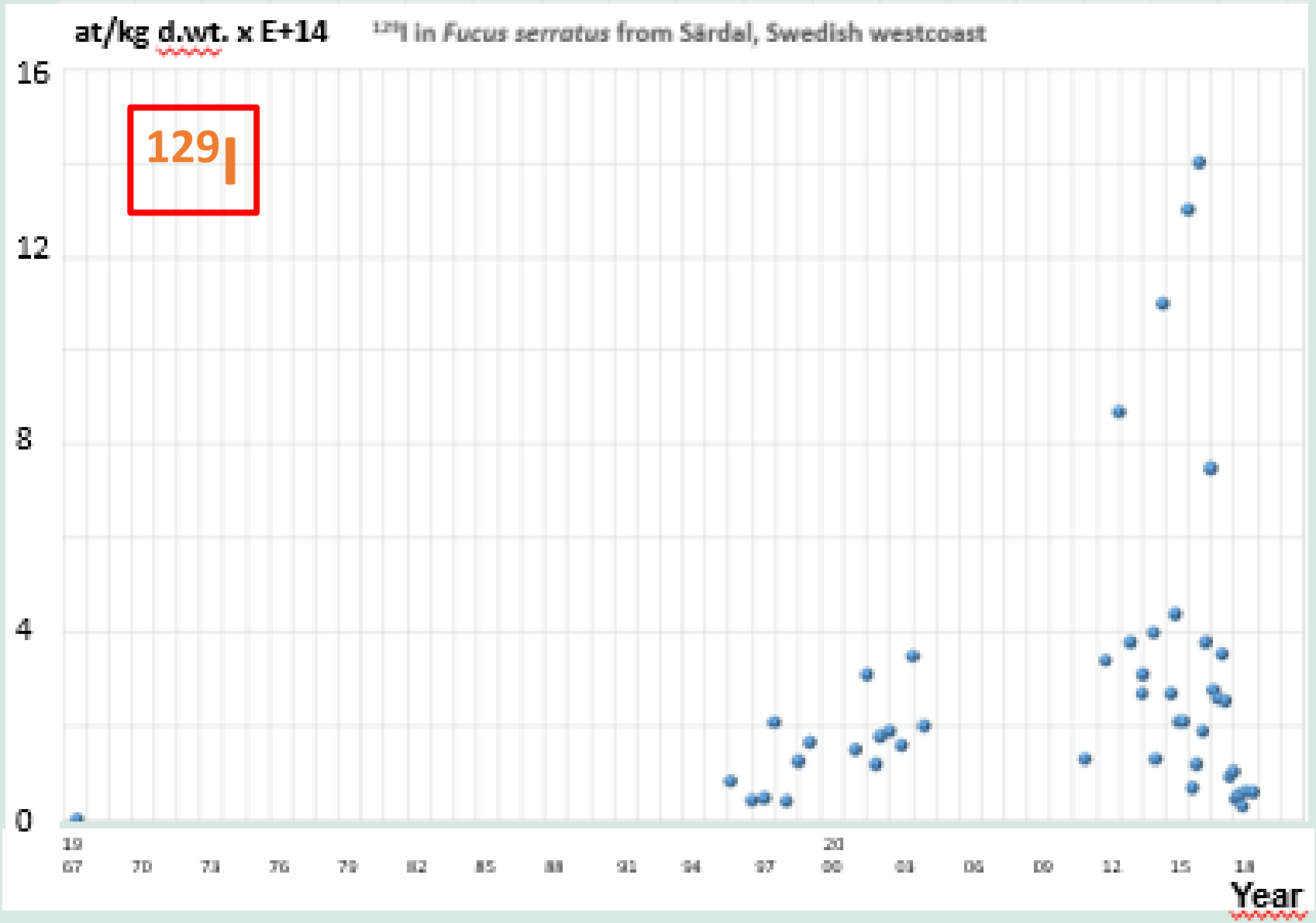
# $^{137}Cs$ in *Fucus serratus* from Särdal, Swedish westcoast



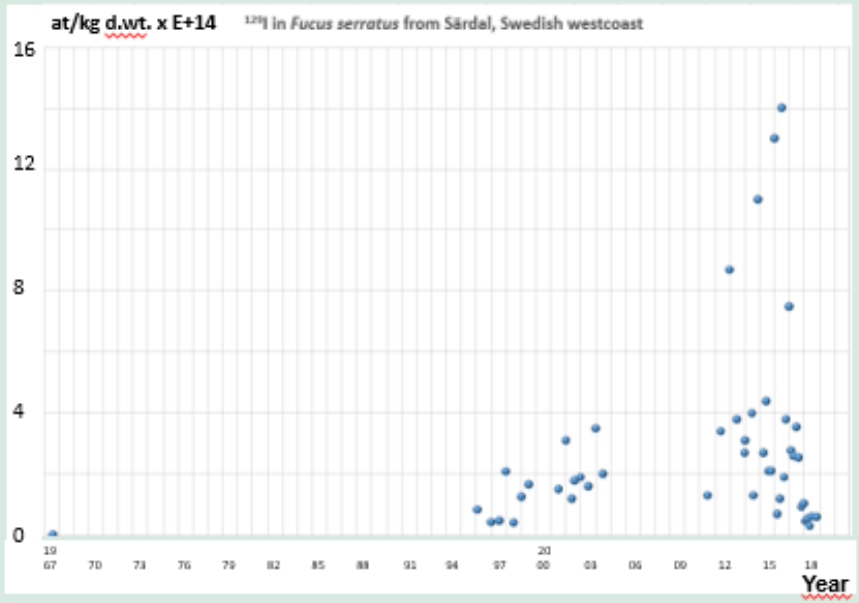
# $^{99}Tc$

**Lindahl et al. J Env Radioact 67, 145–156, 2003** **New**






$^{129}$I concentration (atoms/kg d.wt.) in *Fucus serratus*, 1967-2018.

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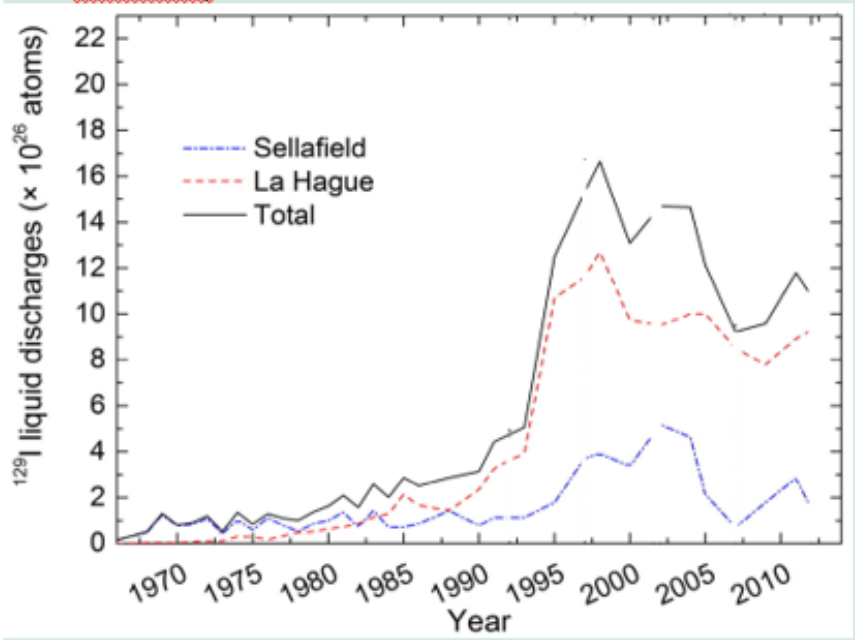



Reported annual liquid discharges of $^{129}$I from La Hague and Sellafield (Modified from Vivo-Vilches et al., 2018)

# $^{129}$I

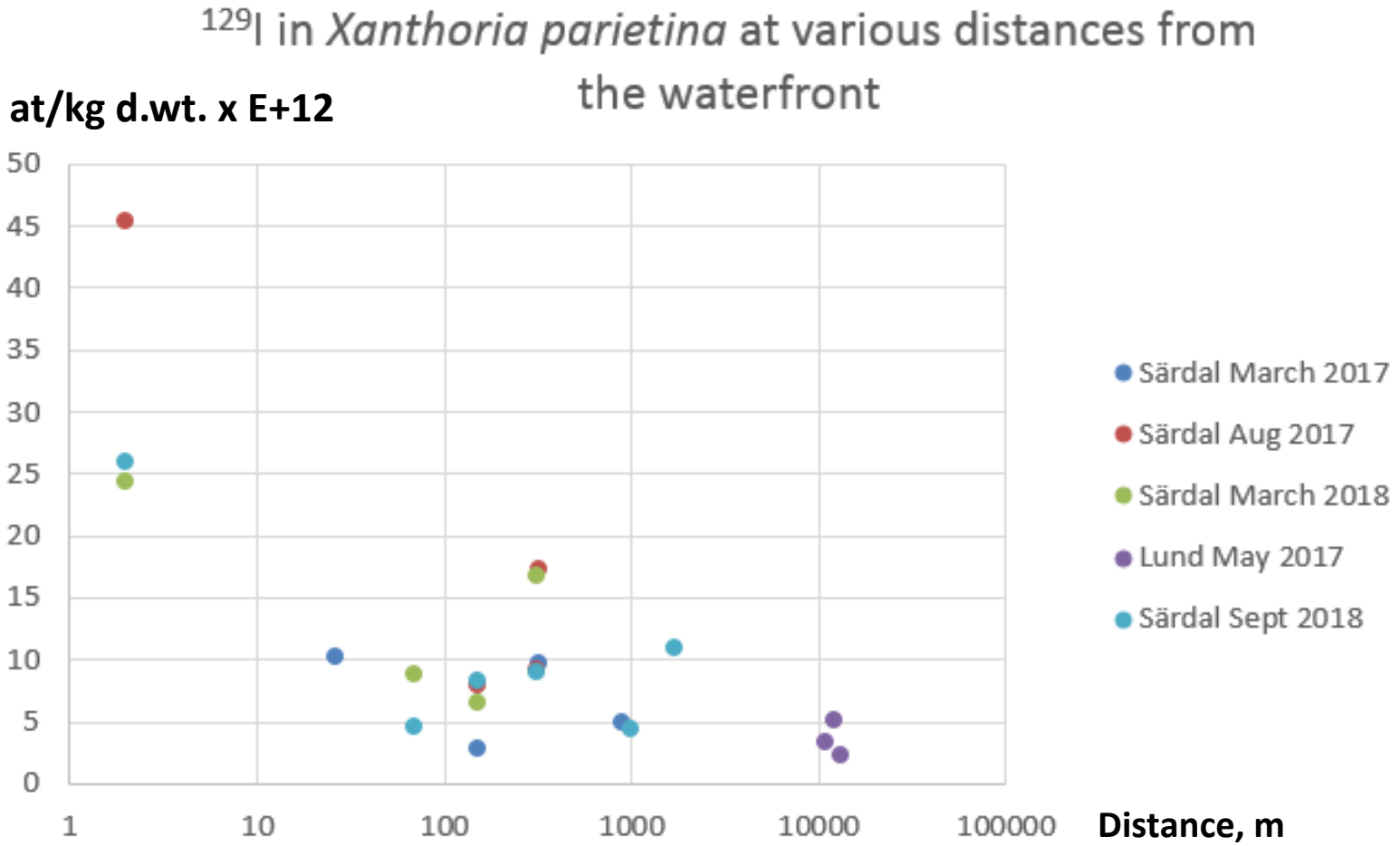
Ratio between $^{129}$I concentration in *Fucus serratus* from Särdal during summer and winter

| Year | 0.43 |
|---|---|
| 1997 | 0.38 |
| 1998 | 0.24 |
| | |
| 2001 | 0.48 |
| 2002 | 0.60 |
| 2003 | 0.59 |
| | |
| 2012 | 0.39 |
| 2013 | 0.67 |
| 2014 | 0.39 |
| 2015 | 0.51 |
| 2016 | 0.60 |

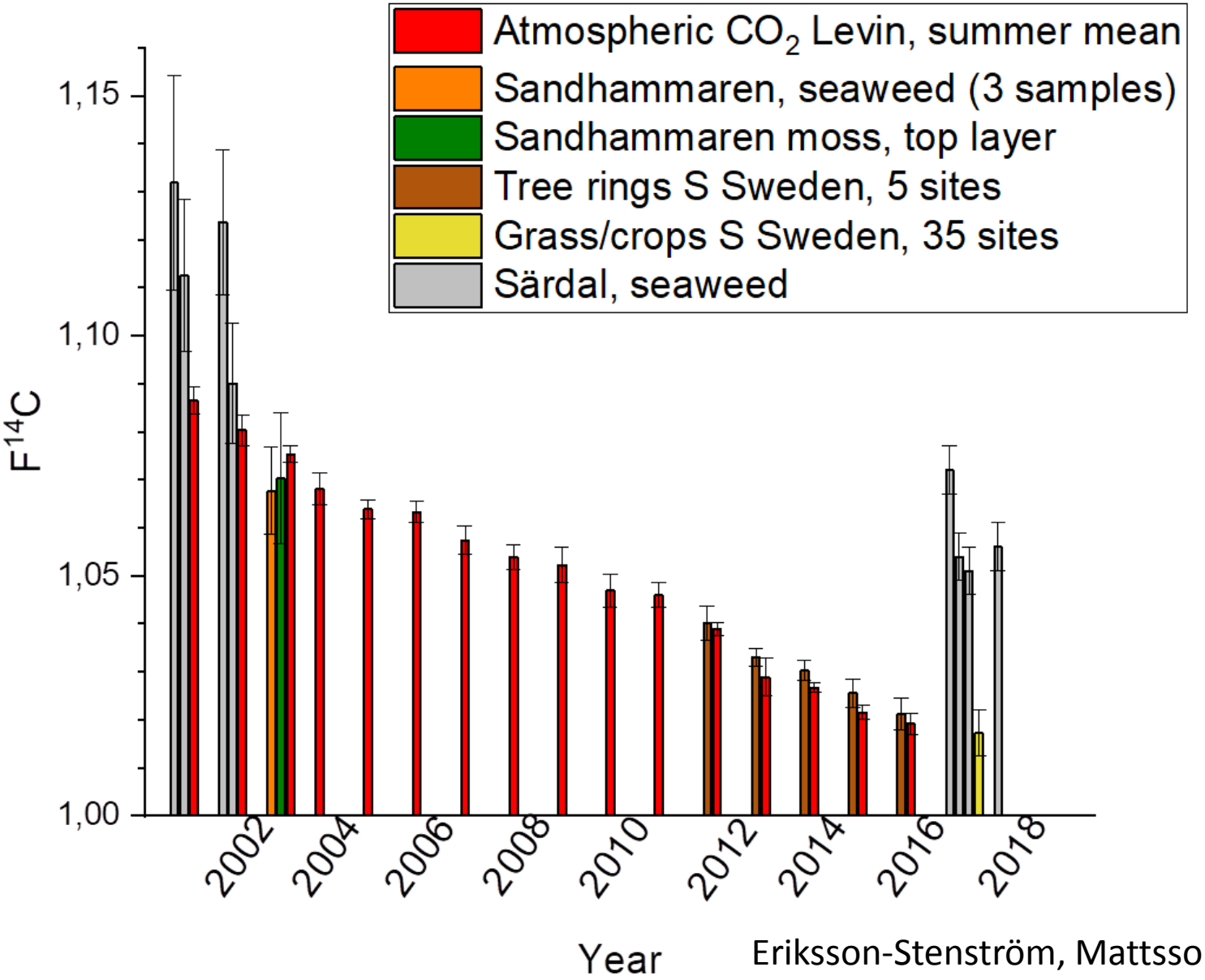
**Mean value= 0.43**

$^{129}$I

*Xanthoria parietina*
Eng: *Common orange lichen,*
*yellow scale,*
*maritime sunburst lichen,*
*shore lichen*
Sv: *Gul vägglav*



# $^{14}C$




Eriksson-Stenström, Mattsson et al., 2018

239+240Pu

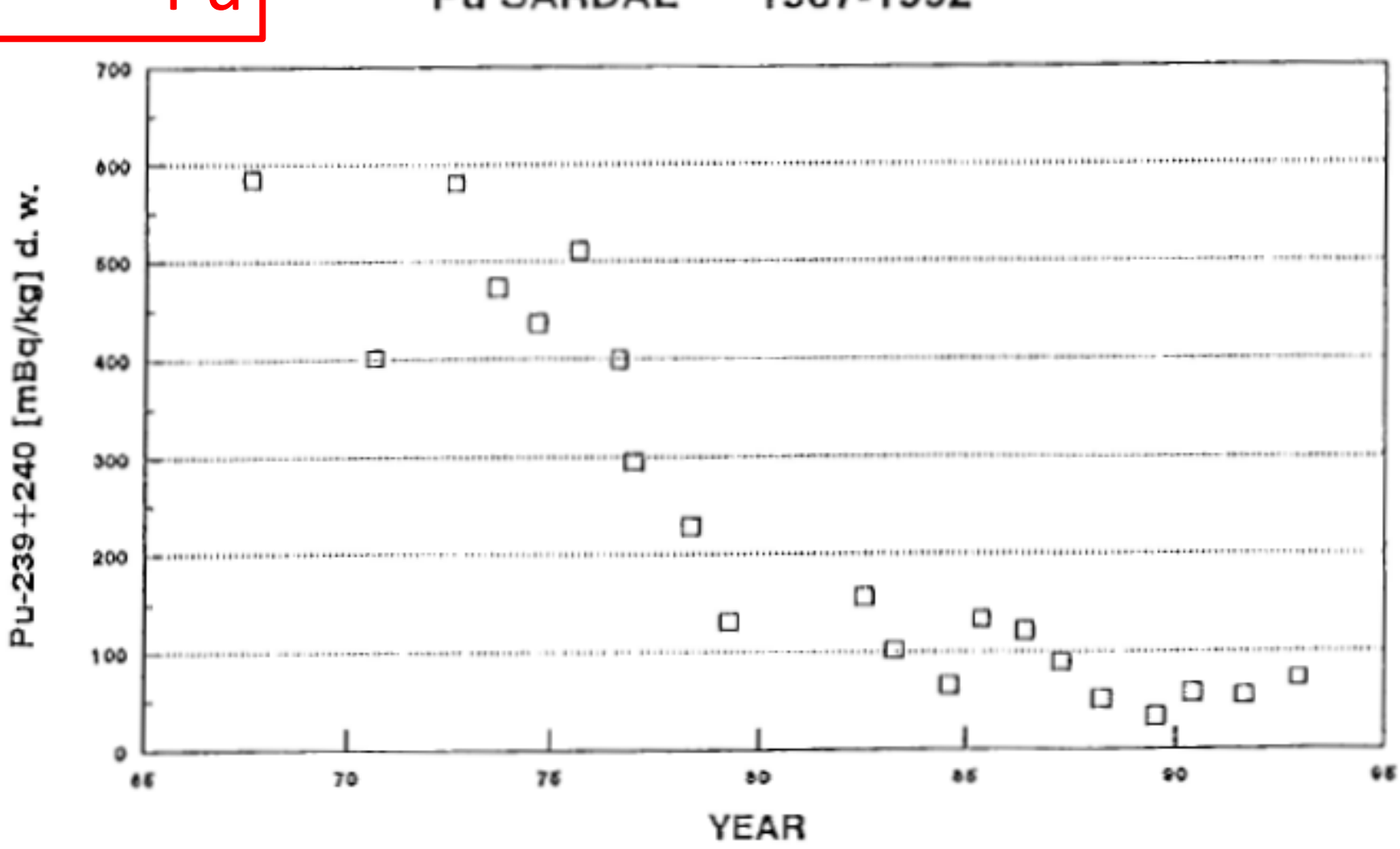



*Figure 2.* $^{239+240}$Pu *in Fucus Serratus collected at Särdal on the Swedish west coast (56.76 °N, 12.63 °E) between 1967 and 1992.*

Roos, Holm, Thornberg and Mattsson, 1993

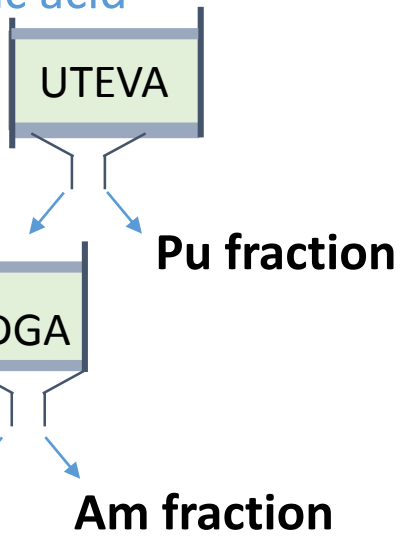
# Restart of radiochemistry

## Analytes of interest: $^{238}Pu$, $^{239/240}Pu$ and $^{241}Am$

## 4 main steps from collection of the sample to measurement of actinide content:

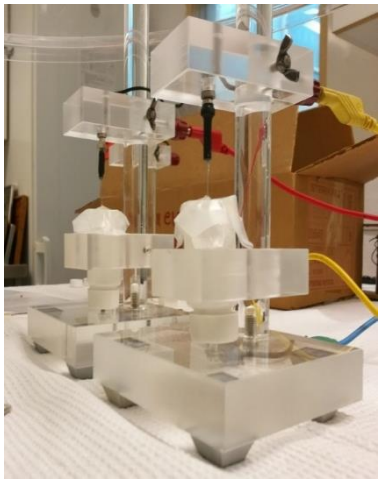
1. Sample collection and pretreatment
2. Chemical separation
3. Preparation of the alpha planchette
4. Alpha measurement

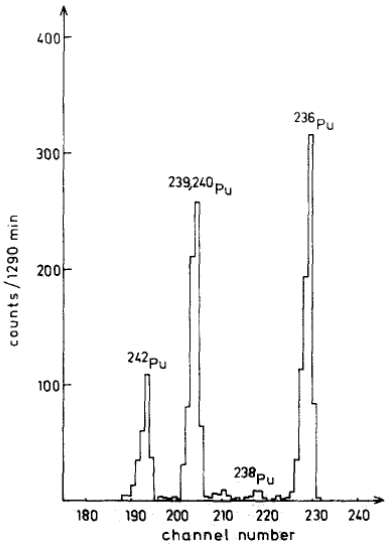
Sample dissolved in nitric acid



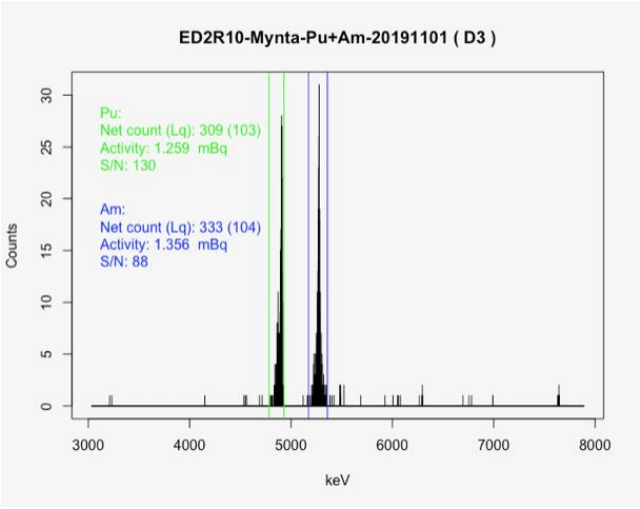

Pretreatment:

- Ashing of dried seaweed
- Addition of tracers ($^{242}Pu$ and $^{243}Am$)





| Method | Recovery Pu ± SD | Recovery Am ± SD | n |
|---|---|---|---|
| 1 Saéz Munoz: stainless steel cathode in sodiumsulphate electrolyte | 62.2% ± 15.2% | 29.2% ± 8.0% | 6 |
| 2 Krmpotic et al.: stainless steel cathode in ammonium oxalate electrolyte (0.6 A, 120 min) | 41.0% ± 5.7% | 26.4% ± 12.8% | 3 |
| 2 (0.8 A, 90 min) | 73.1% ± 20.4% | 31.6% ± 8.5% | 4 |
| 2 (1.0A, 75 min) | 101.3% ± 13.4% | 63.8% ± 1.1% | 3 |
| 3 Krmpotic et al.: Copper cathode in sodiumsulphate electrolyte | $< L_D$ | $< L_D$ | 3 |



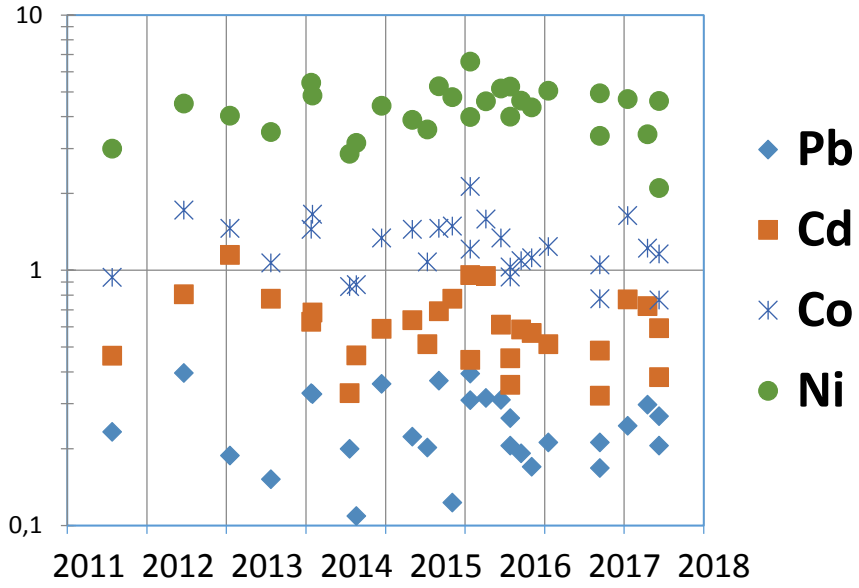

$^{242}$Pu and $^{243}$Am

*Marina Saéz Munoz*, Report - Fast and sequential procedure for plutonium, uranium and americium determination in soil samples, 2016

*Krmpotić et al.,* Applied Radiation and Isotopes 128 (2017) 158–164

*Krmpotić et al.,* Applied Radiation and Isotopes 136 (2018) 37–44

**Metal concentration in *Fucus serratus*, mg/kg d.wt.**




# Stable elements - Metals

Inductively Coupled Plasma-Optical Emission Spectrometer (ICP-OES)
Perkin Elmer Optima 8300 at the Department of Biology, Lund University

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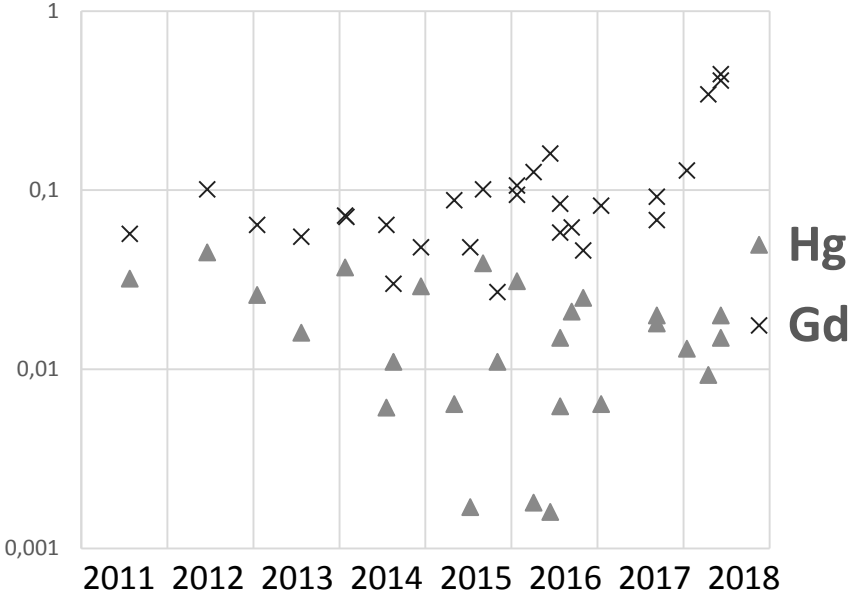

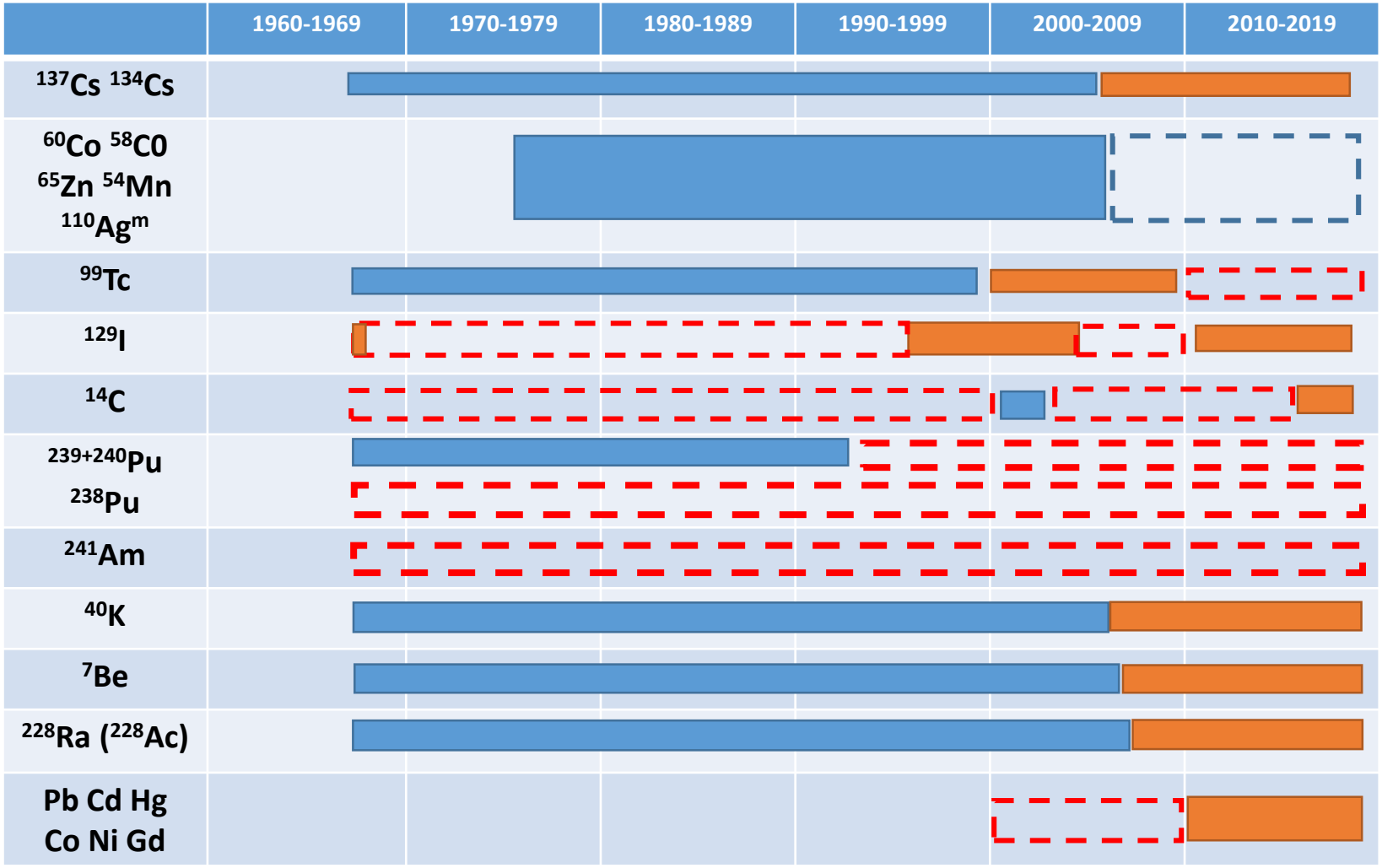
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***Thank you for listening!***

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