Following the Trail of Fukushima Tracers: Cross-basin Footprints Embedded in North Pacific Waters

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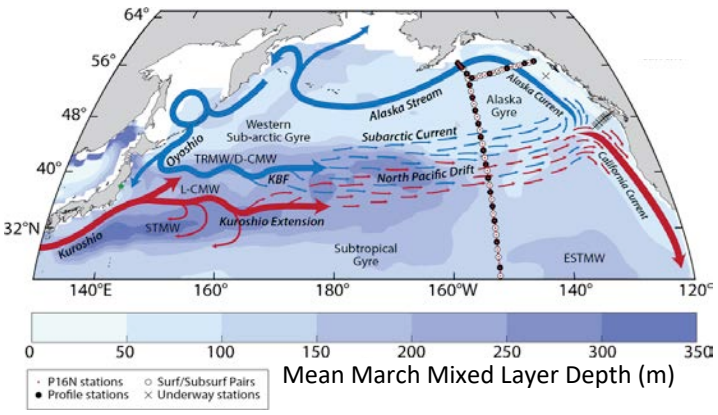

Figure 1: North Pacific circulation schematic. Water mass formation regions: Subtropical Mode Water (STMW), Light Central Mode Water (L-CMW), Dense Central Mode Water (D-CMW), Transition Region Mode Water (TRMW) and Eastern Subtropical Mode Water (ESTMW). Symbols P16N - 152°W sampling locations.

Introduction

In the Northwest Pacific, warm waters from the south meet cold subpolar waters from the north in an energetic "confluence zone" east of Japan (**Figure 1**). Mode waters (see definition below) formed here are known to sink and flow eastward. This study uses radiocesium (^{137}Cs, ^{134}Cs) observations obtained in 2015 in the Northeast Pacific (red an black circles) to identify mode waters that were in the confluence zone in 2011 when the Fukushima-Daichi power plant (FDPP) accident occurred. The goal is to elucidate the fate of these waters that traversed the basin over the 4-year period carrying FDPP-derived signal.

A mode water is a layer of nearly vertically homogeneous water found over a large geographical area at certain depth. It is formed by intense wintertime cooling at surface that cause the waters to become dense and sink. These waters have characteristics (temperature, salinity, density) set by local conditions at the time of formation and the NW Pacific has many flavors of mode water. In this presentation, we will be focusing on formation and evolution in time and space of the subtropical and central mode waters (STMW, L- and D-CMW).

^{137}Cs and ^{134}Cs at 152°W

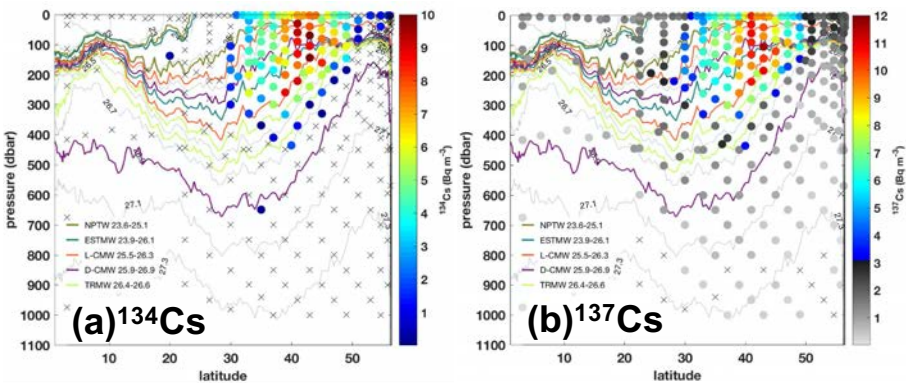

Figure 2: 2015 152°W ^{134}Cs (a) and ^{137}Cs (b) concentration in Bqm^{-3} (colored dots), water mass boundaries (color contours), values below 0.1 Bqm^{-3} (symbol x).

- The core of the 2015 152°W (**Figure 1**) radionuclide samples (**Figure 2**) lies at 41-43°N at 30-220m cuts off at ~30°N.
- The signal penetrates to ~300m at 30°N and 400m at 40°N and shoal with the density surface that rise toward the north.
- In density, most of the signal lies between 25.2 and 26.5σ_θ, all associated with mode waters, and the strongest signal lies in the D-CMW density range.
- The largest ^{134}Cs is 10.8±0.8 Bq m^{-3} lies between 50-100 m·
- The estimated cross-basin speed of the signal is ~4.8 cm s^{-1}.
- We estimate a total ^{134}Cs inventory of 11-16 PBq.

Summary

- In 2015, Fukushima-derived radiocesium was found in upper 400m water at 152°W.
- The core signal was observed at 41-43°N, 30-220m.
- Float data supports the 152°W finding that this signal is associated with advection and outcropping Dense-Central Mode Waters (D-CMW) formed off the coast of Japan four years earlier.

Mode Waters and Circulation

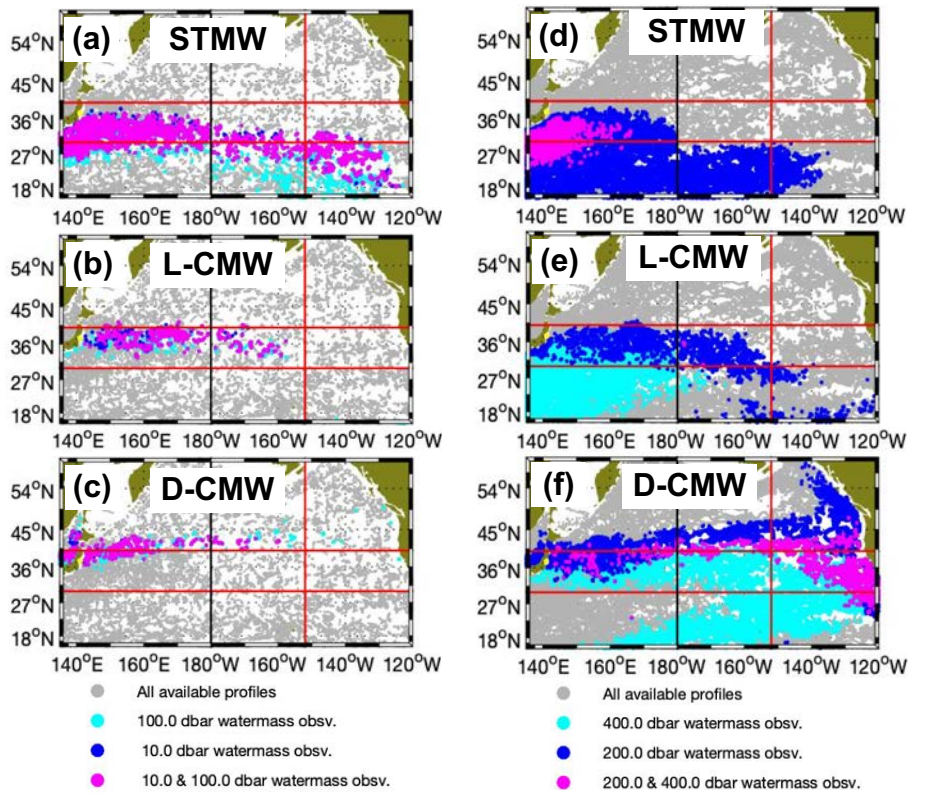

Figure 3: 2011-2015 Argo profile Locations for the months of January-March (a-c) and all months (d-f). Profiles with the temperature, salinity and density characteristics of STMW (a,d) L-CMW (b,e) and D-CMW (c,f) at various depths (see legend). For reference: black line at 180° longitude, red lines at 30°N, 40°N and 152°W. Yellow circle on Japan coast indicates FDNPP.

Temperature and salinity Argo floats tell us about formation regions and the spread of each mode water (**Figure 3**).

- LHS Pink dots: D-CMW and L-CMW formation regions (b-c) are concentrated in western Pacific, and while STMW has broader footprint (a).
- RHS Pink dots: looking deeper, the distribution suggests that only D-CMW properties reach at 152°W between about 39°N and 43°N, the span of our core Cs signal (f).