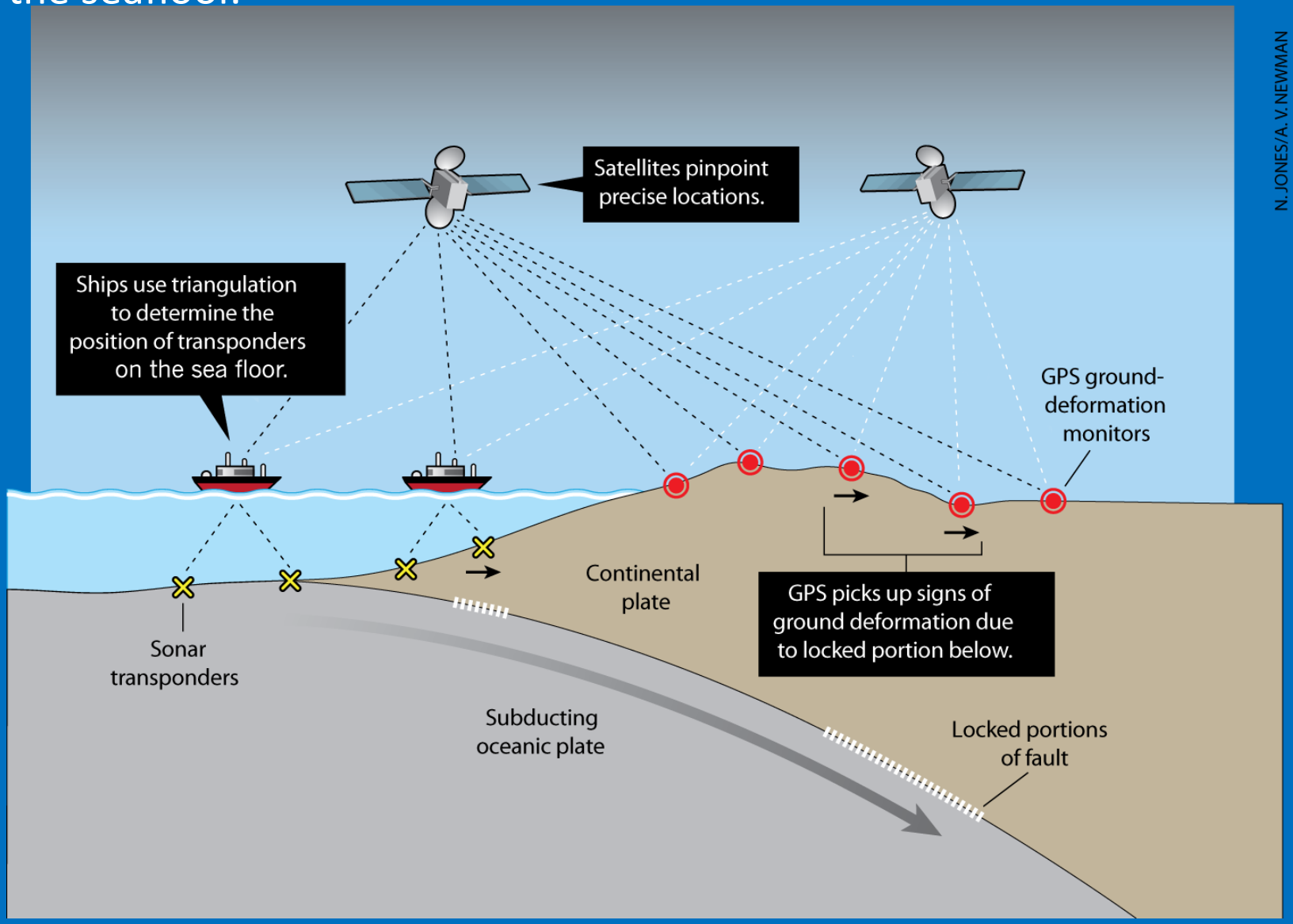
Offshore GPS
i.e.,
GPS-Acoustic Seafloor Geodesy

Dave Chadwell, SIO

Spahr Webb, Scott Nooner, Mike Tryon, Uwe Send

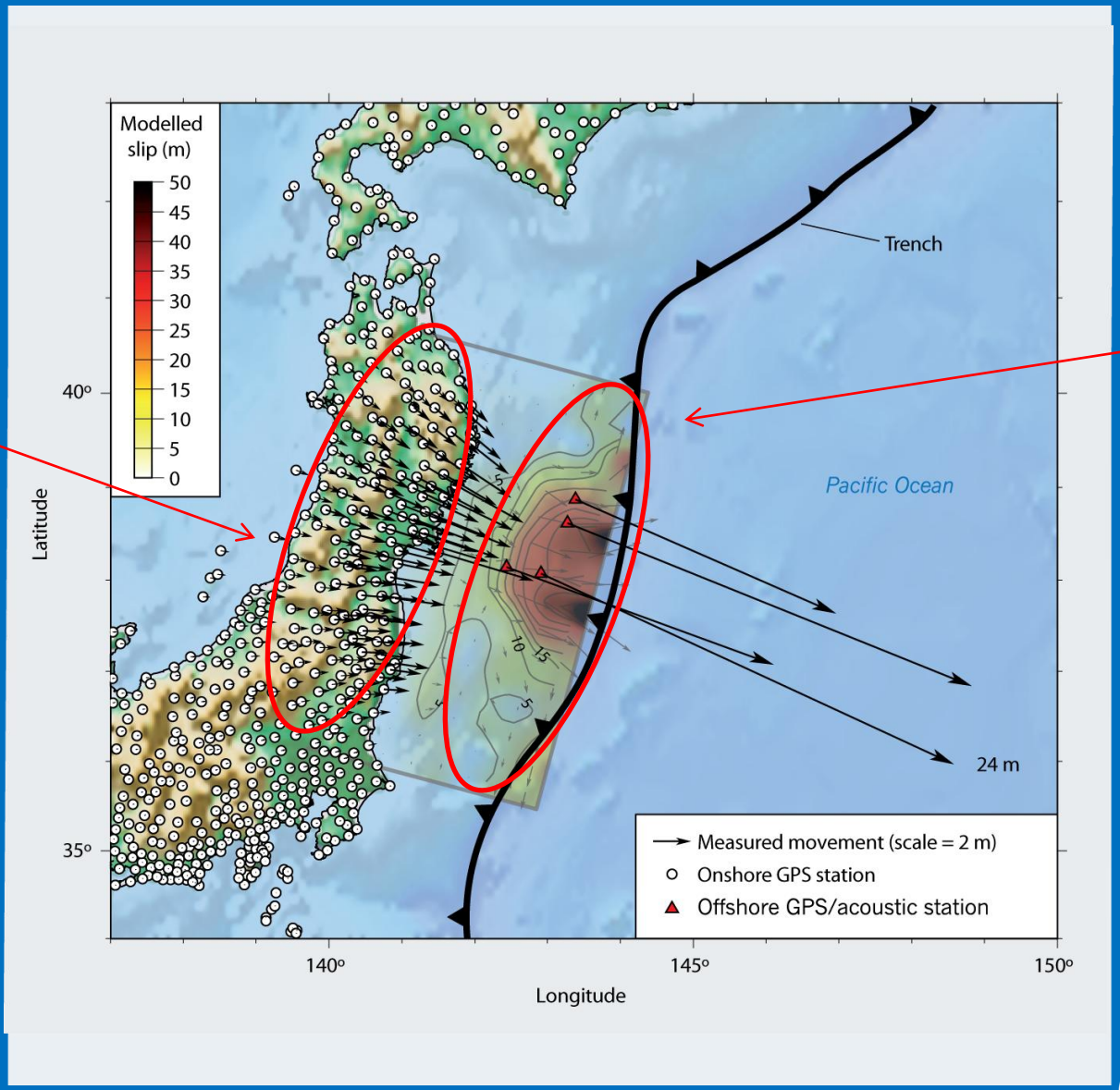
Offshore GPS or GPS-Acoustics combines kinematic GPS with precision acoustic ranging to seabed transponders to track the horizontal motion of the seafloor.



(Newman, 2011)

What offshore Geodetic observations contributed to determining the co-seismic slip of the Tohoku –Oki Earthquake ?

100+
Onshore
GPS stations



~ 6
Offshore
GPS-Acoustic
stations

(Newman, 2011)

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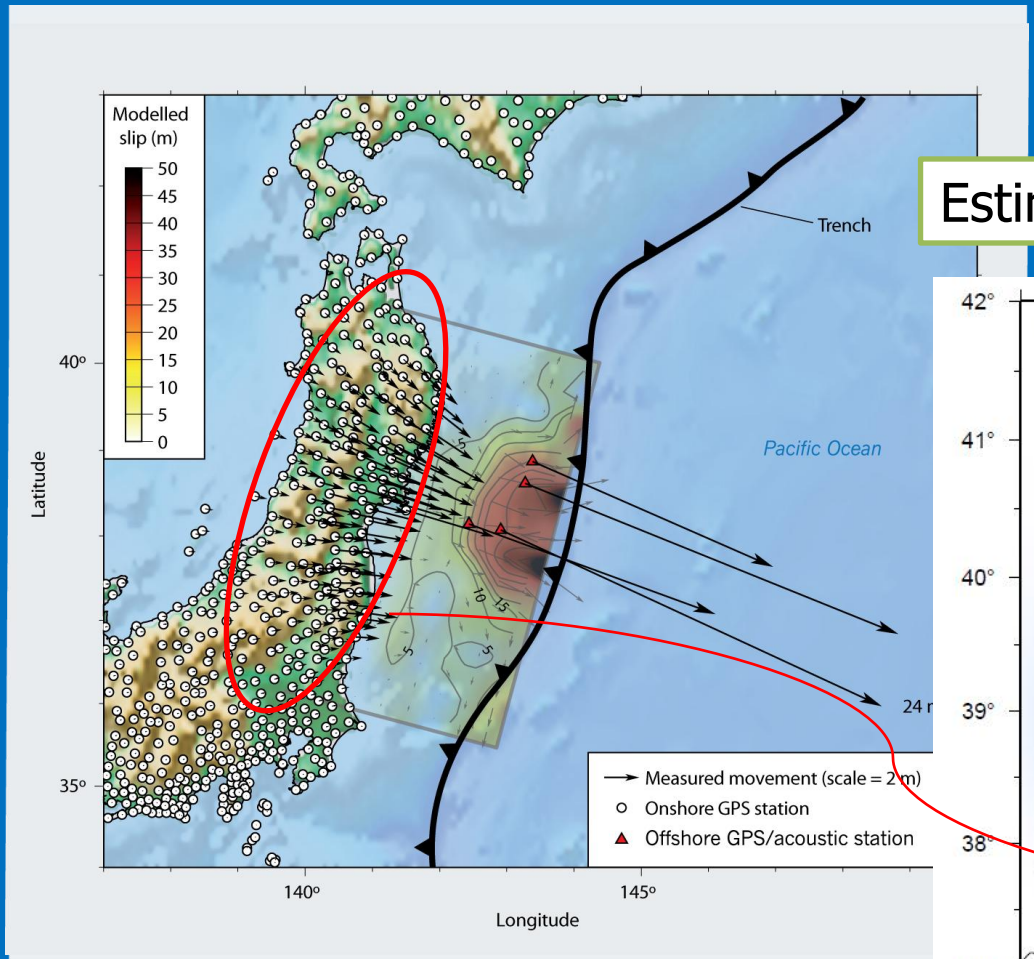
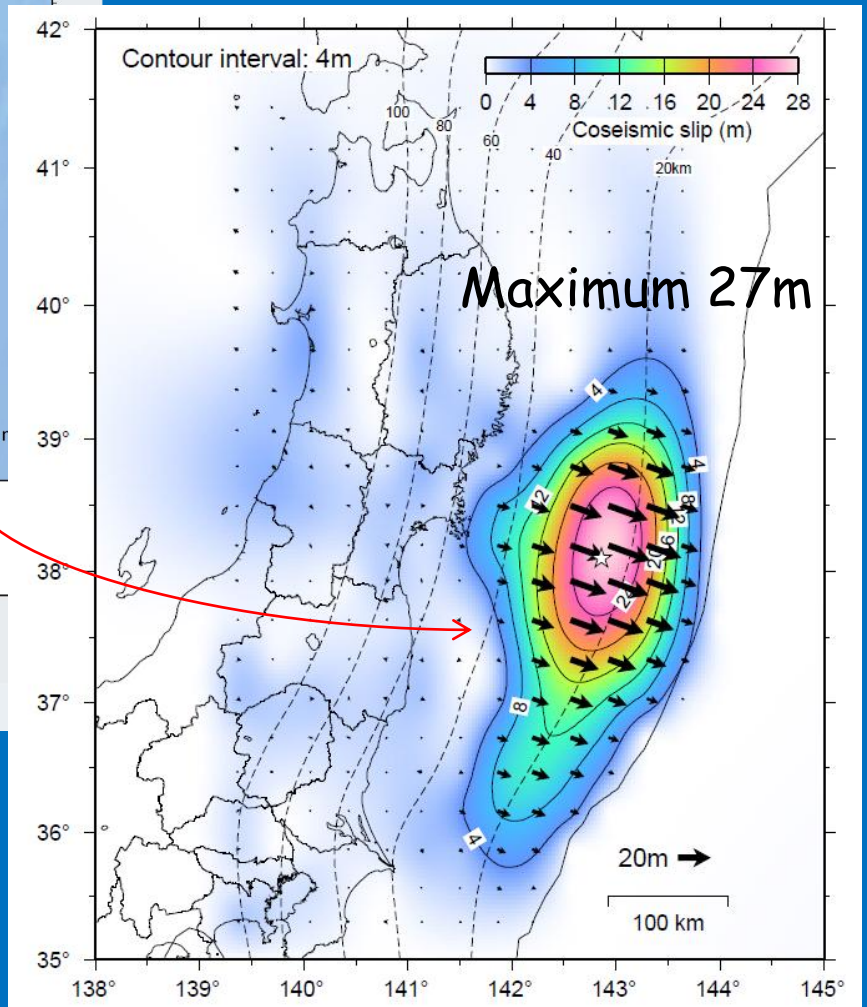


(Newman, 2011)

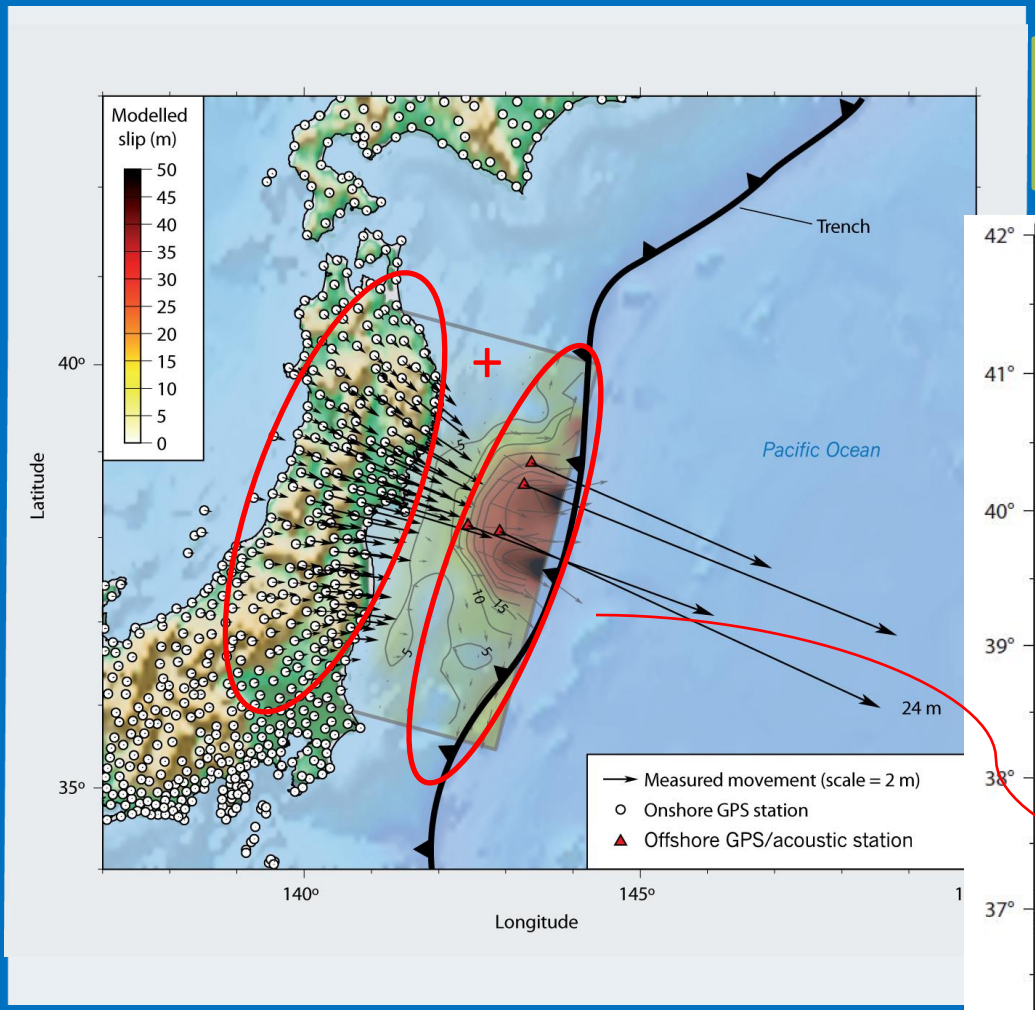
Estimated by terrestrial GPS data only



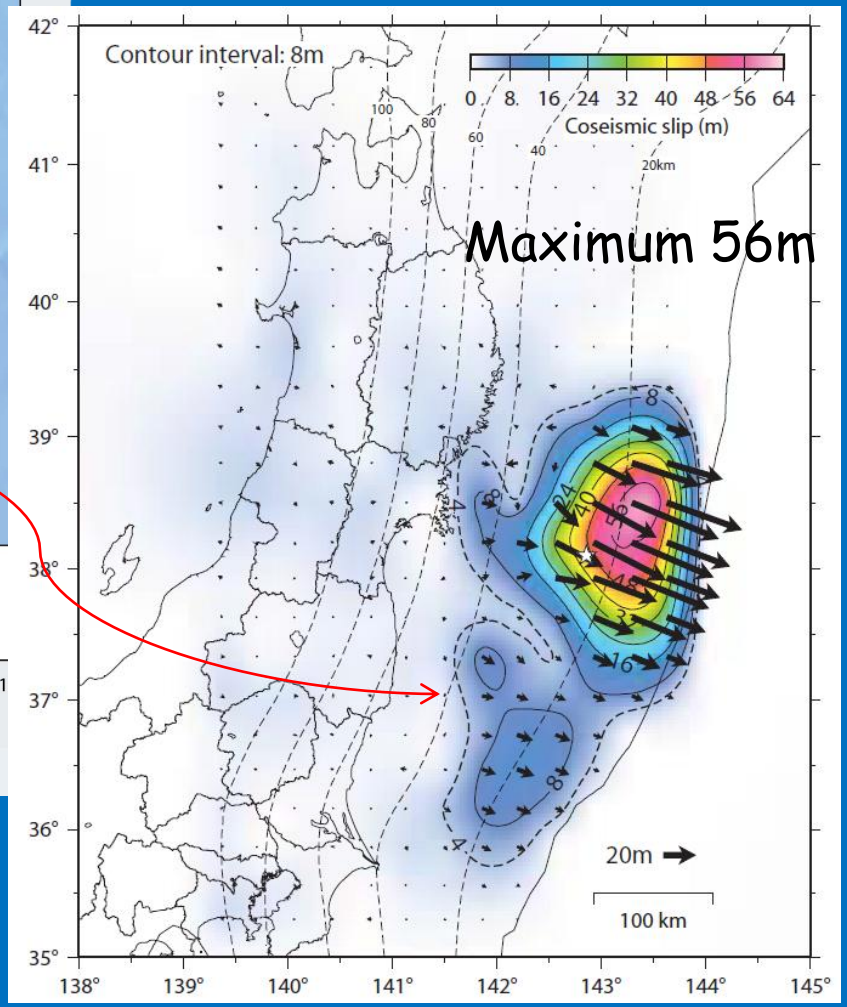
(Ozawa et al., Nature 2011)

What offshore Geodetic observations contributed to determining the co-seismic slip of the Tohoku –Oki Earthquake ?

Estimated by terrestrial GPS data and seafloor GPS/Acoustic data



(Newman, 2011)



(from GSI web site)

What offshore Geodetic observations contributed to determining the co-seismic slip of the Tohoku –Oki Earthquake ?

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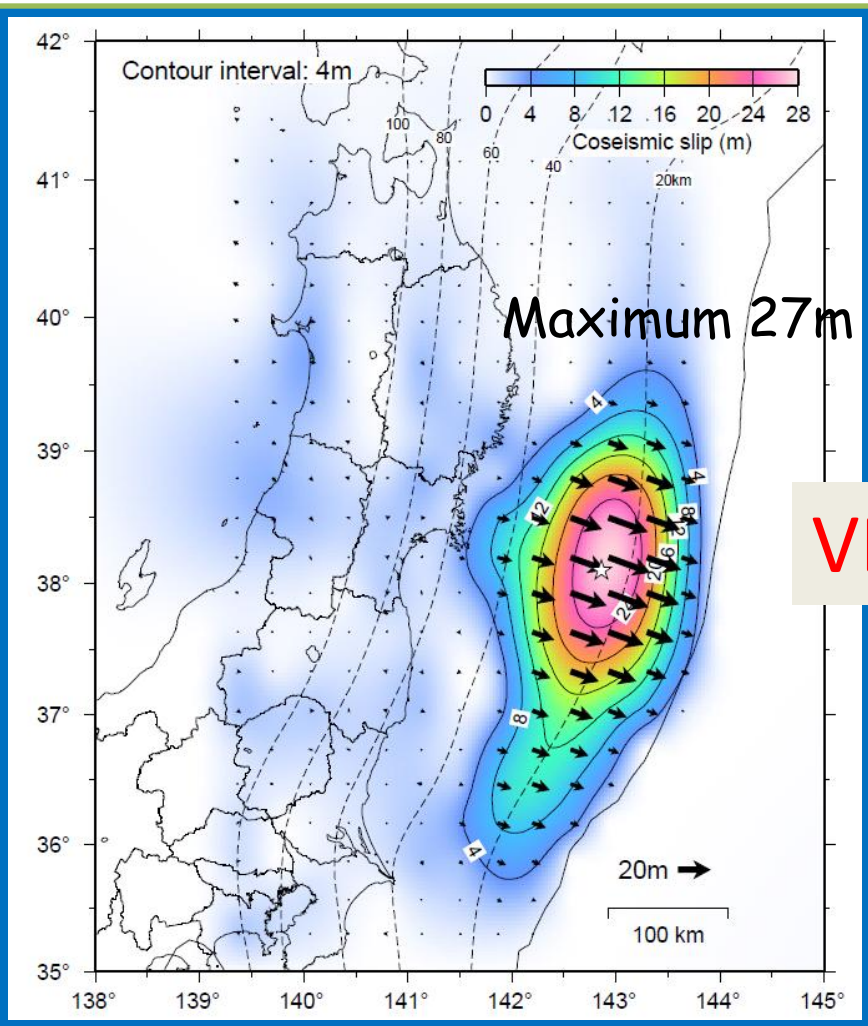
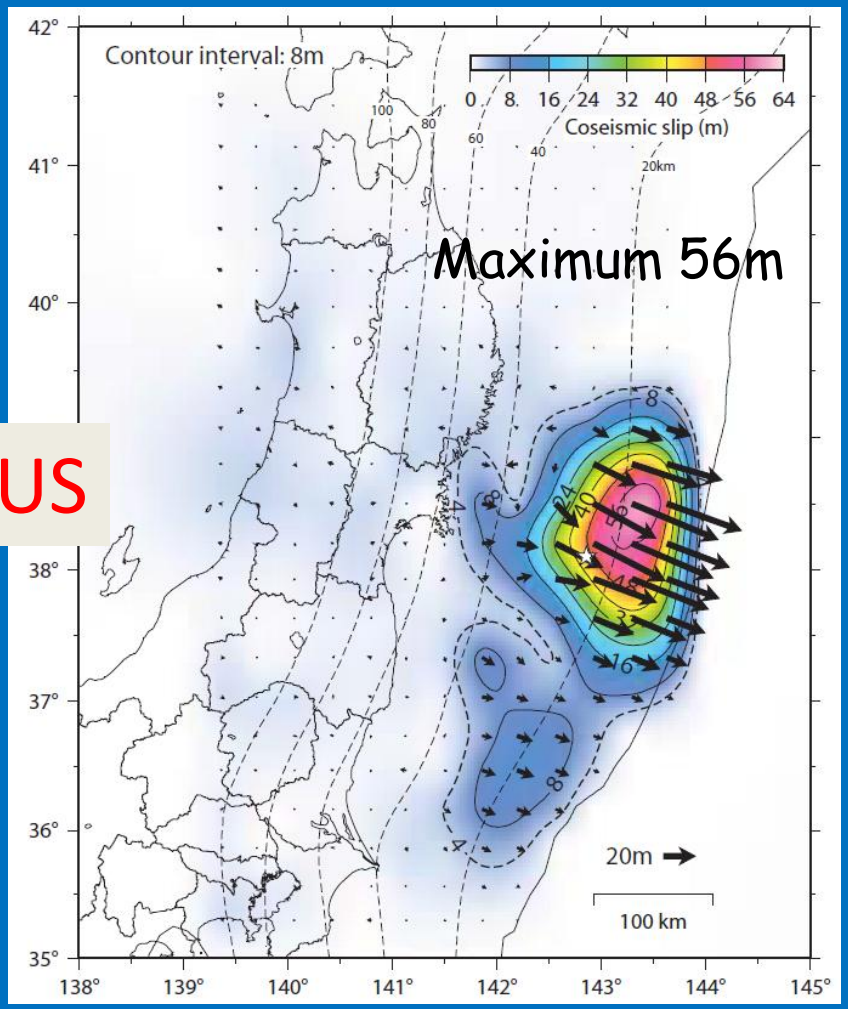


(Ozawa et al., Nature 2011)

VERSUS

Estimated by terrestrial GPS data and seafloor GPS/Acoustic data

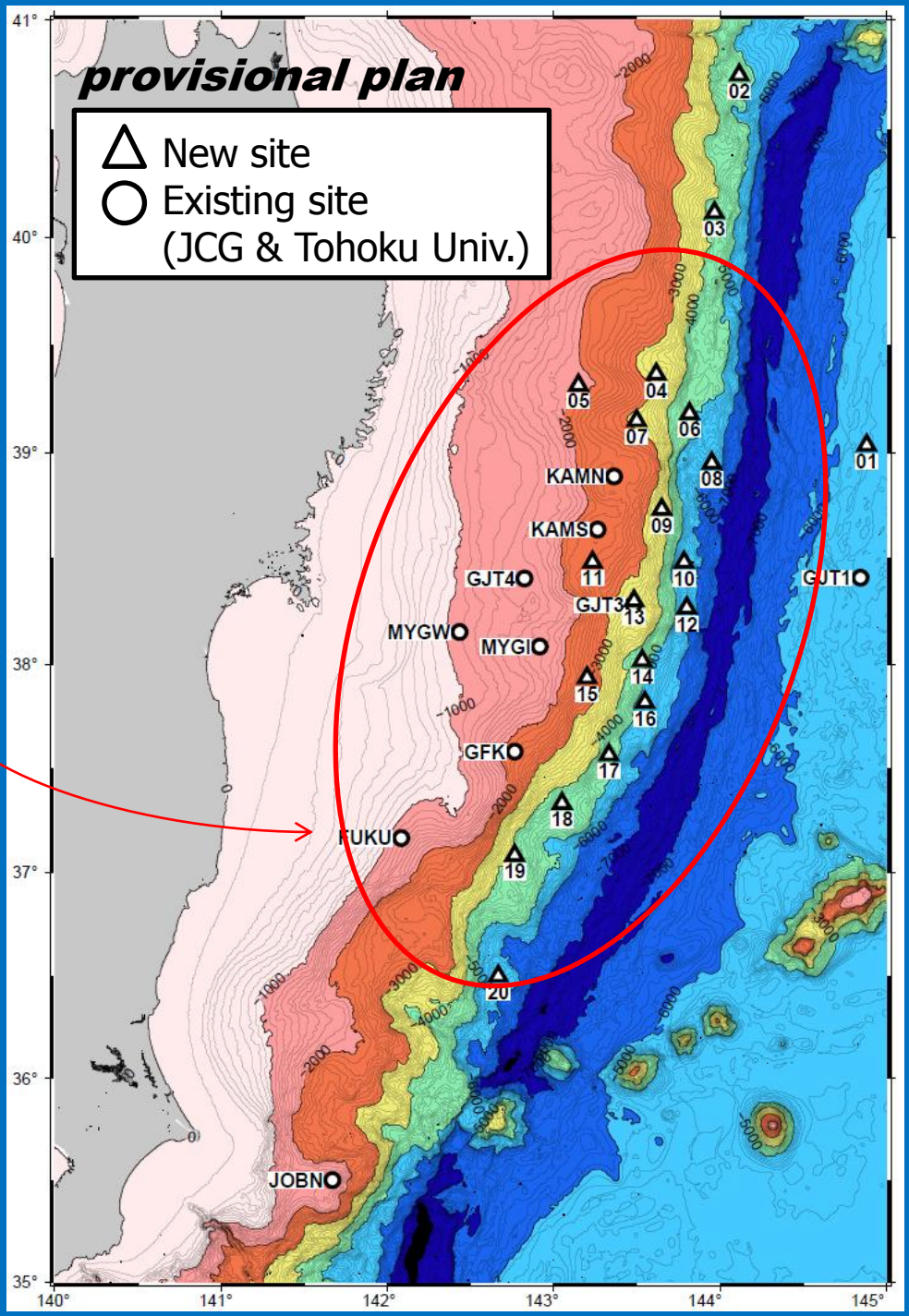


(from GSI web site)

(slide from Ishikawa et al. 2012)

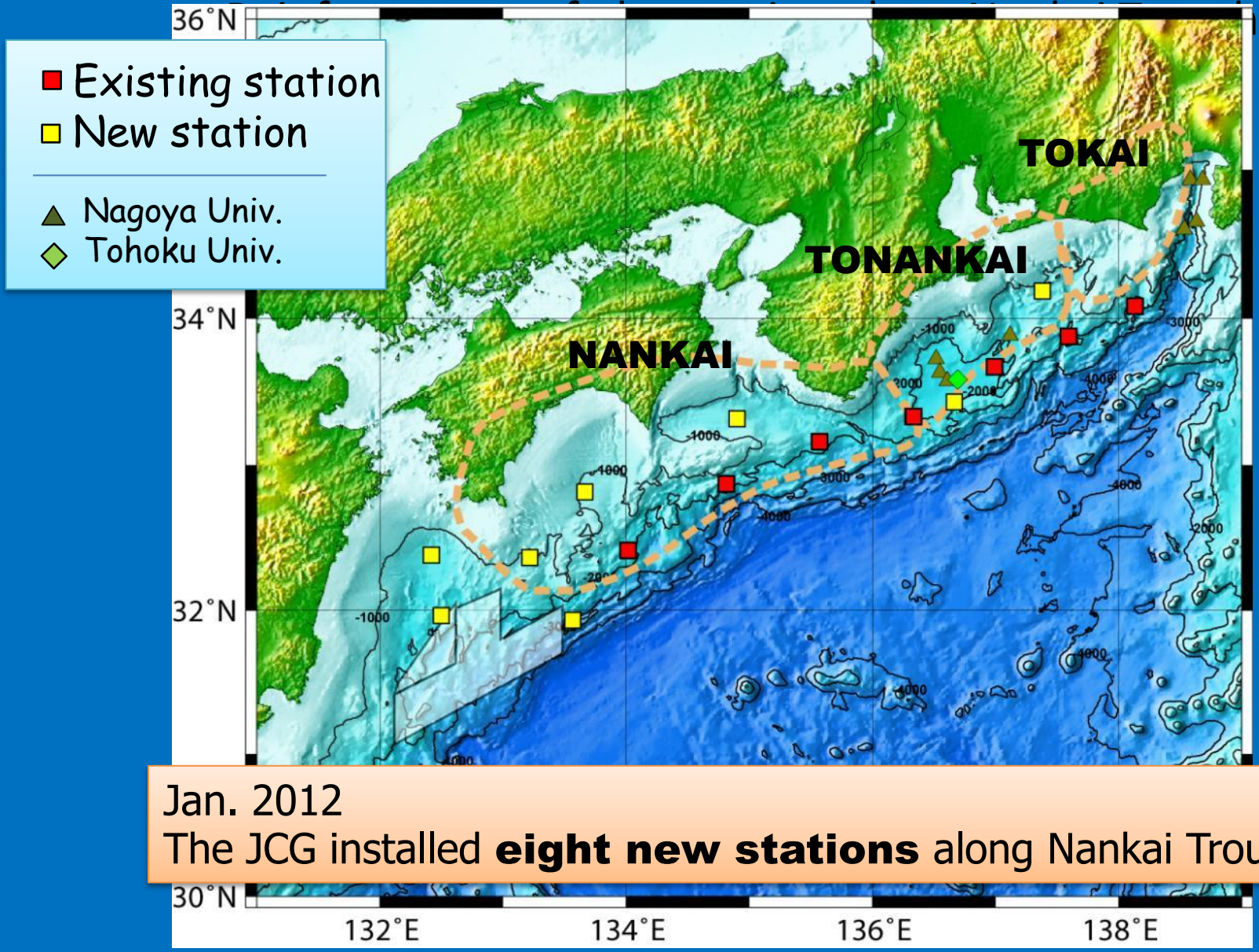
More GPS-A sites in Japan …

An additional ~20 sites (for a total of ~ 30) to be deployed in the offshore region of the Tohoku EQ.



(slide from Ishikawa et al. 2012)

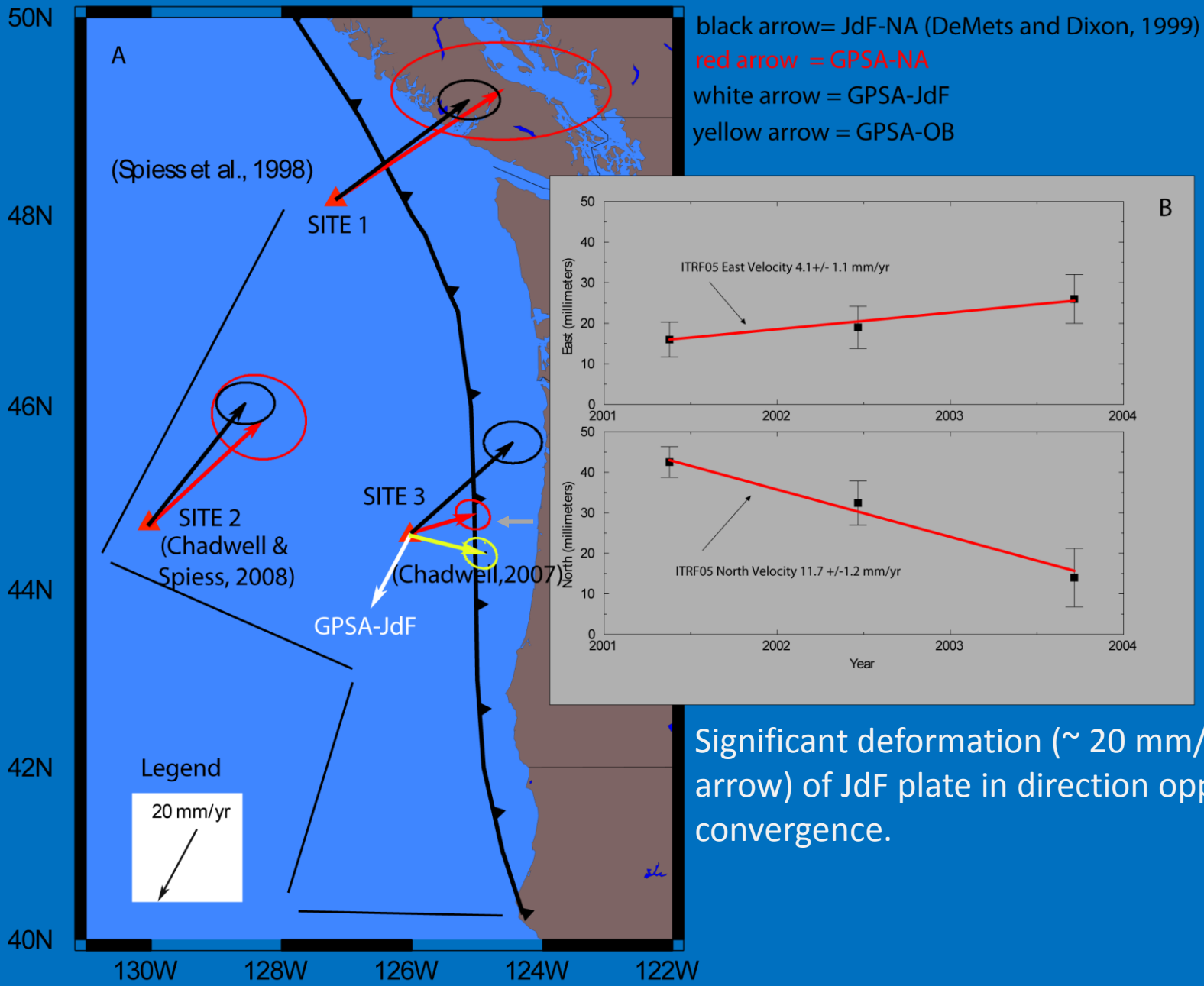
More GPS-A sites in Japan …



Jan. 2012
The JCG installed **eight new stations** along Nankai Trough

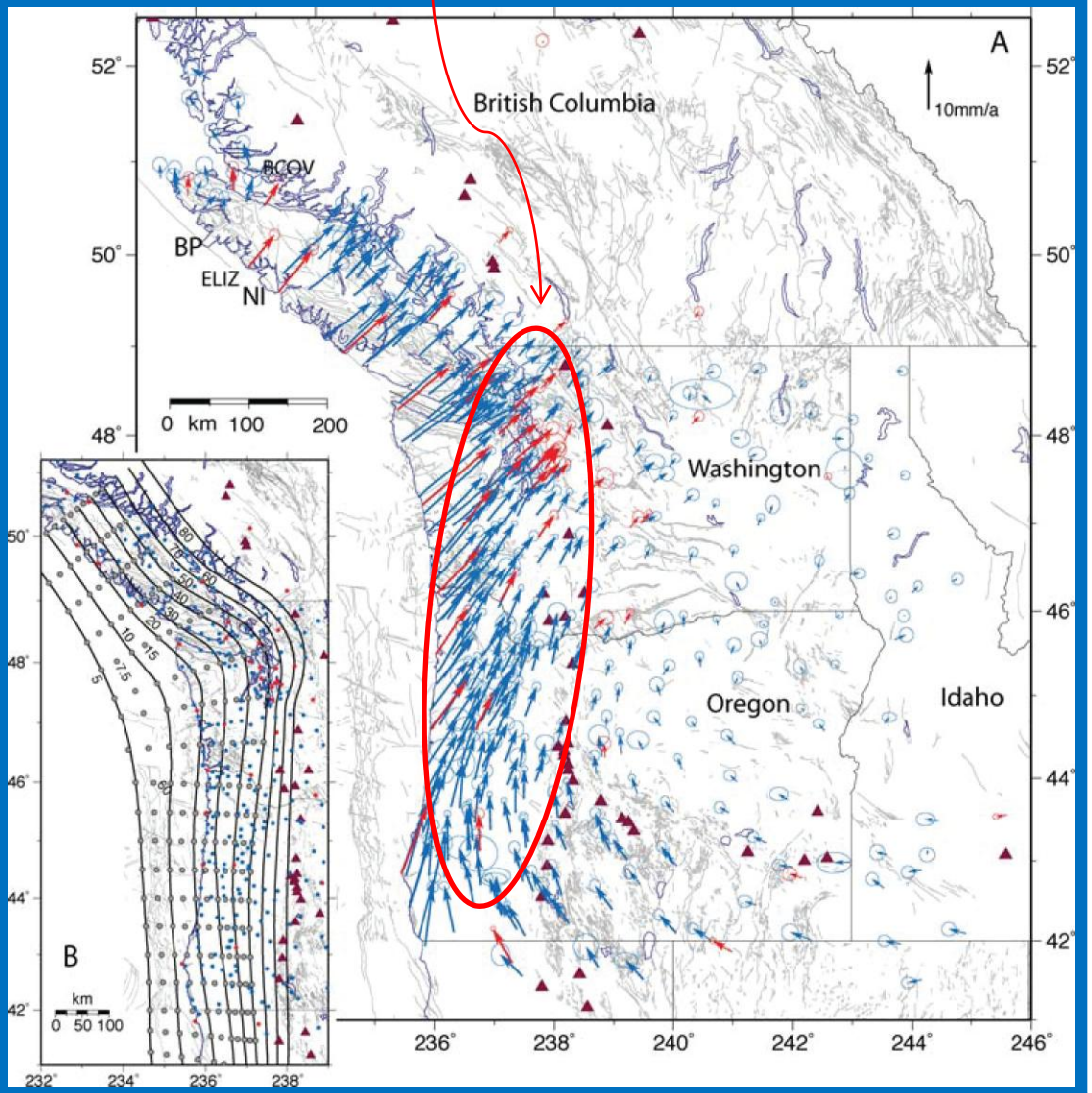
(slide from Ishikawa et al. 2012)

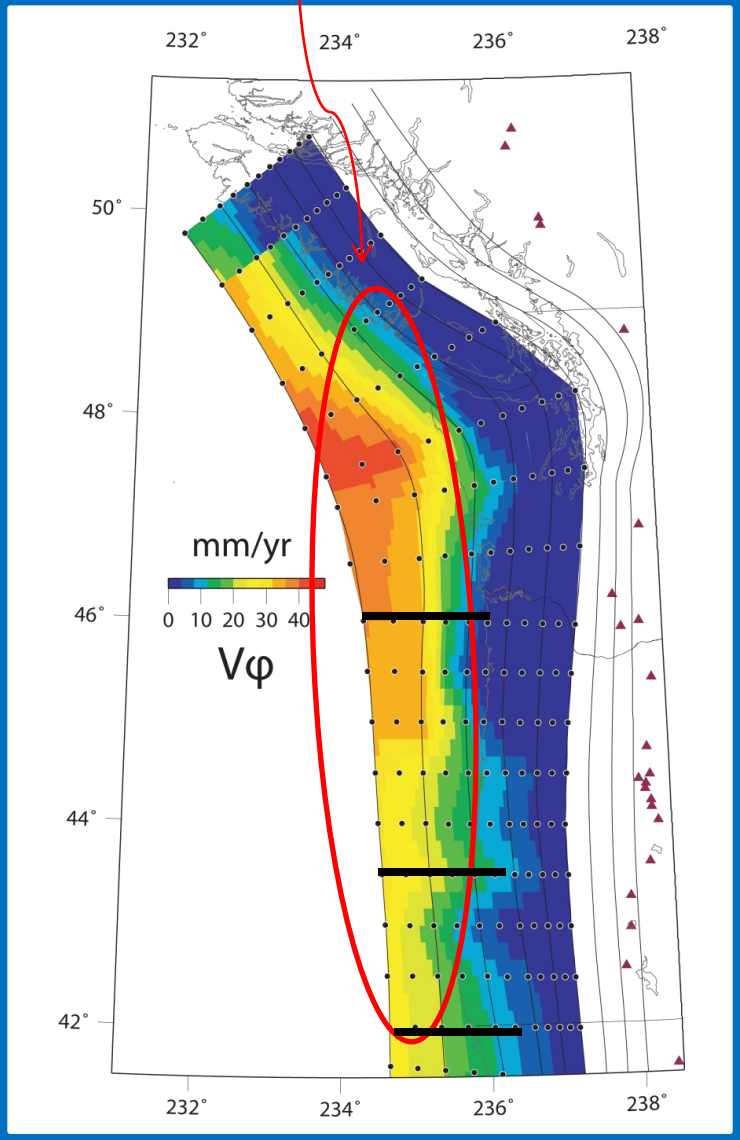
GPS-A sites in Cascadia



Significant deformation (~ 20 mm/yr : white arrow) of JdF plate in direction opposite to convergence.

While all (almost) geodetic data onshore the majority of slip-rate deficit occurs offshore.



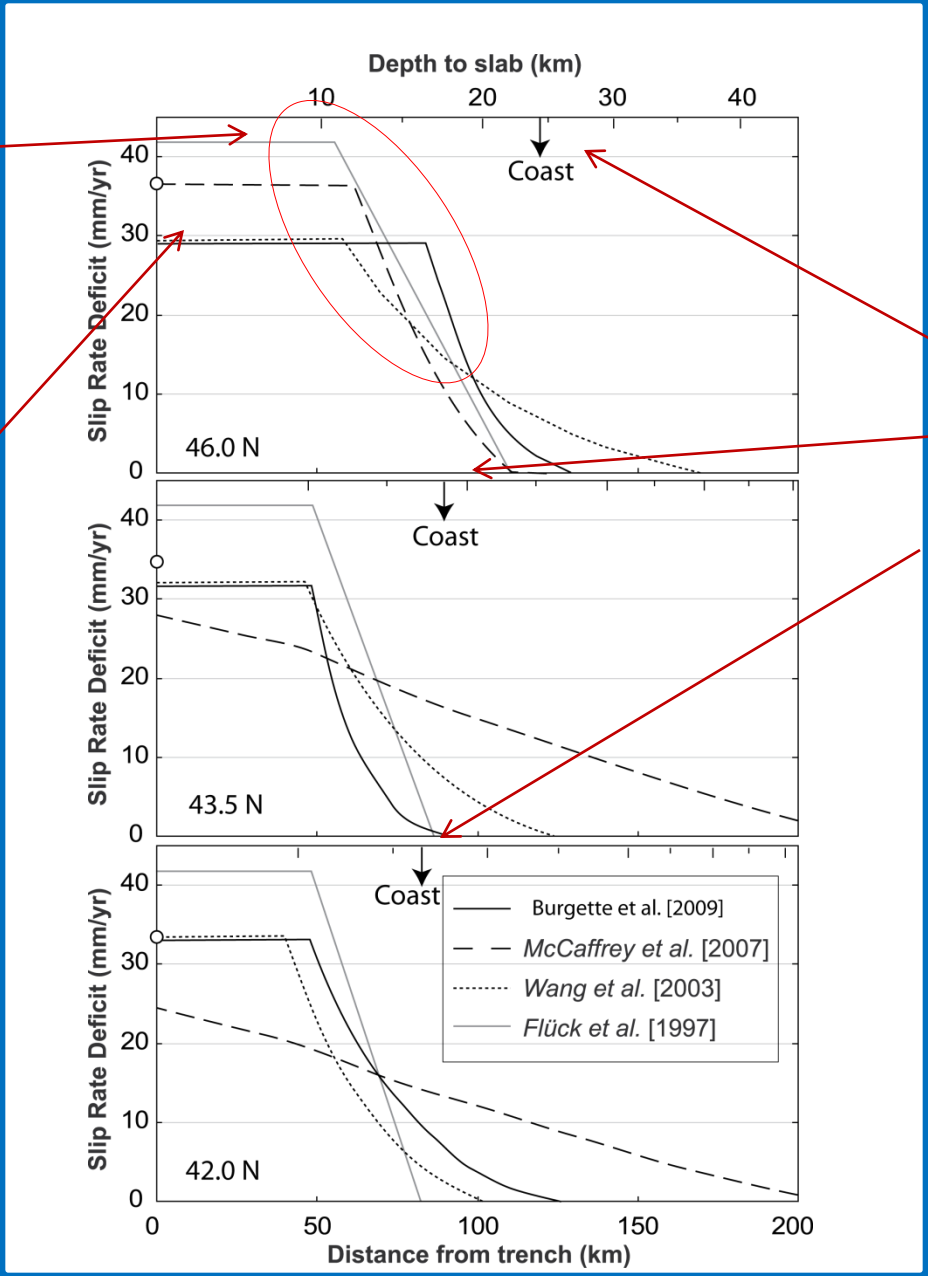


(McCaffrey et al., GJI, 2007)

Seafloor geodesy needed to refine understanding of fault behavior

1. Boundary between “locked” and transition zone.

2. What is the fault behavior in the up-dip region ?



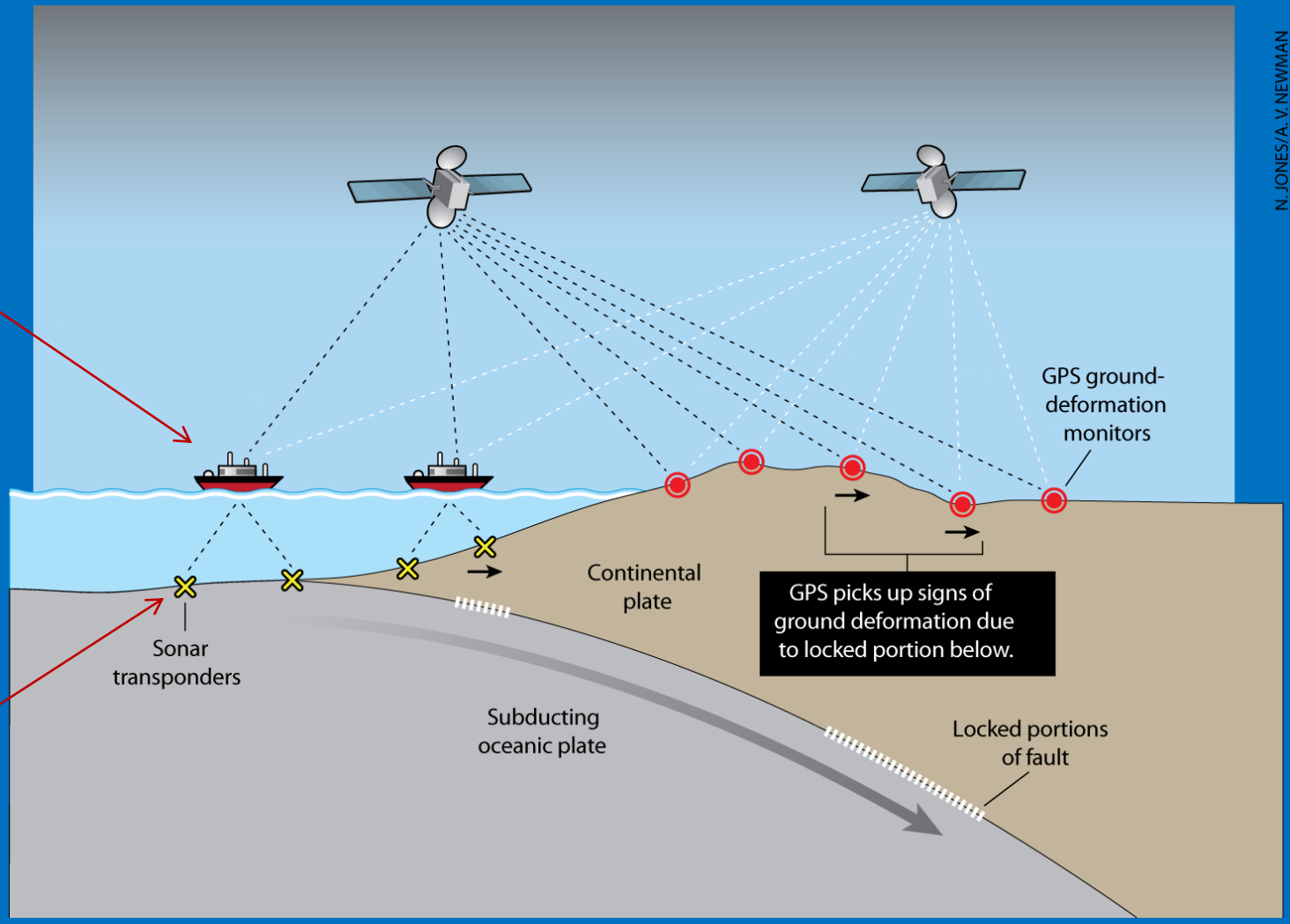
Extent of onshore GPS coverage

(Burgette et al., 2009)

Operational barriers to more GPS-Acoustics

Need less expensive alternatives to large ships for the surface platform.

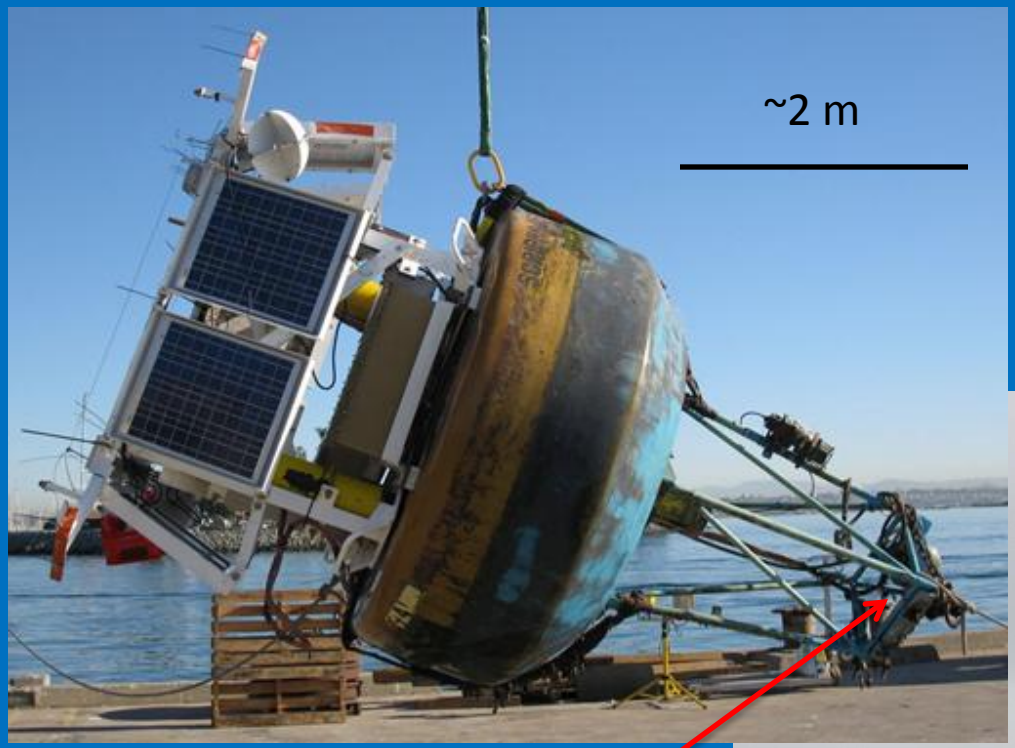
Need longer lasting, less expensive markers on the seafloor.

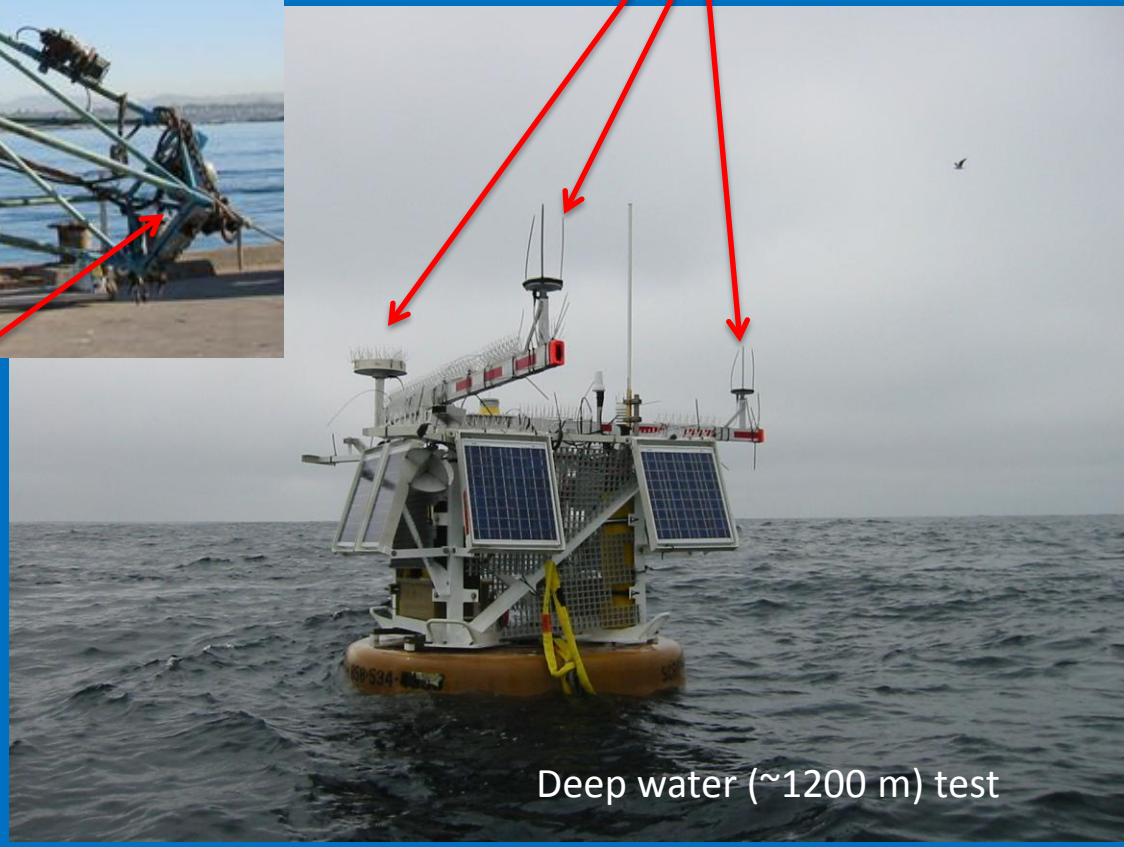


Projects addressing these issues ….

PLATFORM 1: An autonomous, moored buoy for CONTINUOUS GPS-A

GOAL: To increase the temporal resolution from months, years to days.



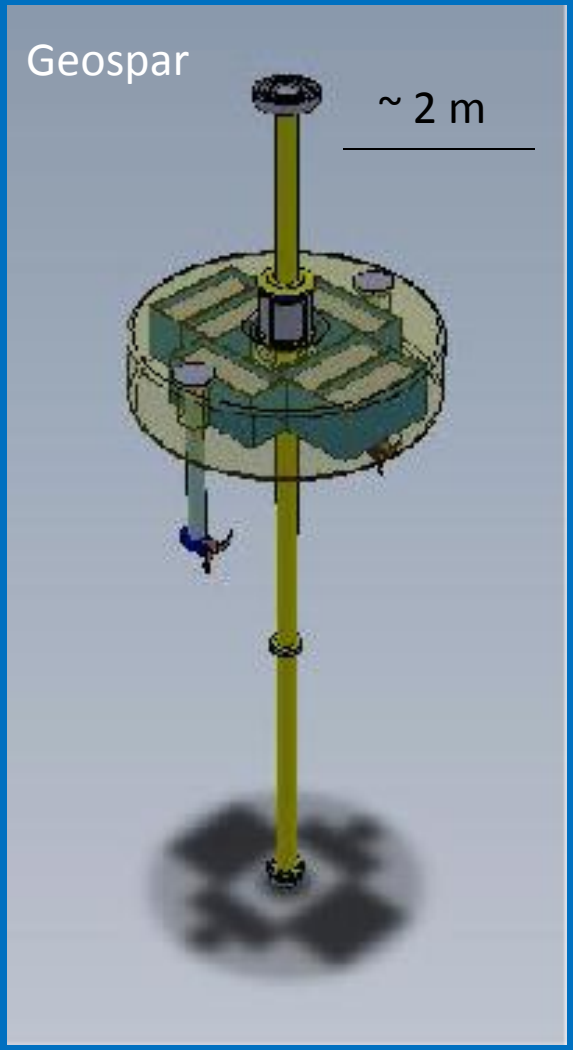


(NSF-OCE-0551363 from OTIC)

(Chadwell, Send, Tryon)

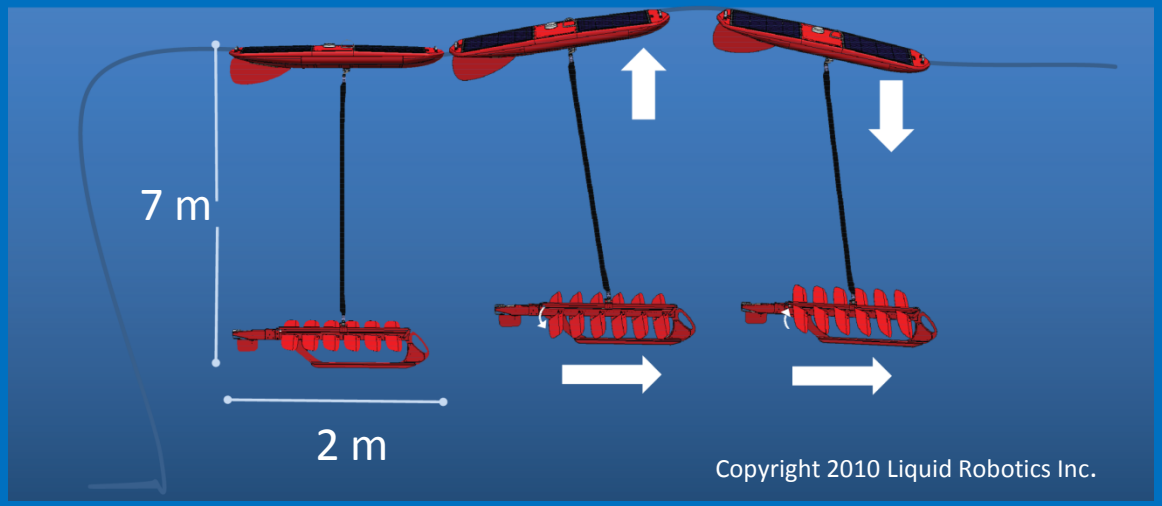
PLATFORMS 2: Small vehicles for GPS-Acoustics

GOAL: To remove the requirement for a specialized ship or any ship.



Portable, self-powered GPS-Acoustic float, deployable from small vessels.

Wave Glider



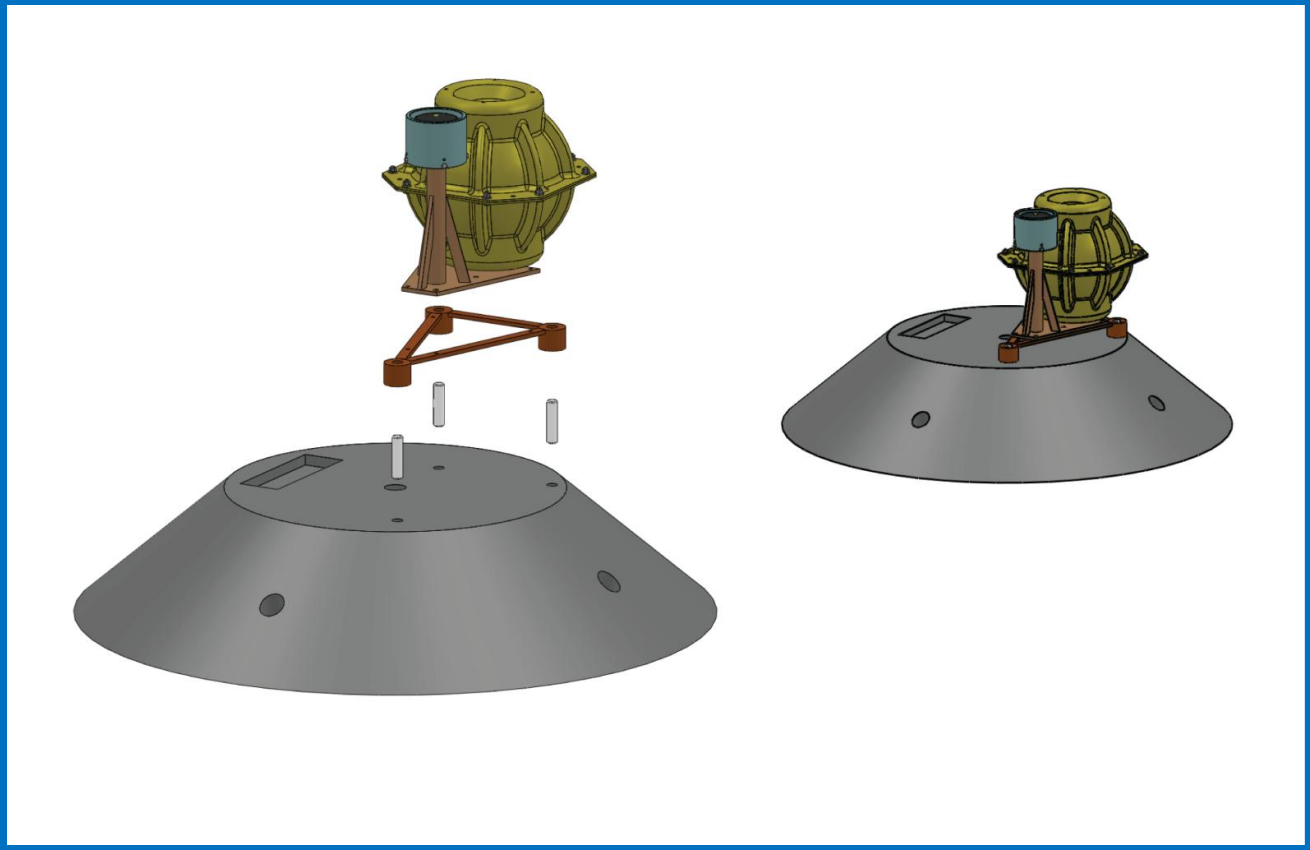
- A rudder at the tail steers the glider in any direction
- Both upward and downward motions produce forward thrust

Presently both systems under evaluation for GPS-A. The Wave Glider requires no ship and is potentially transformative for GPS-A.

(NSF OCE-1130003 from OTIC)

Permanent seafloor Benchmarks

GOAL: To provide horizontal and vertical reference marks on the seafloor for the long-term.

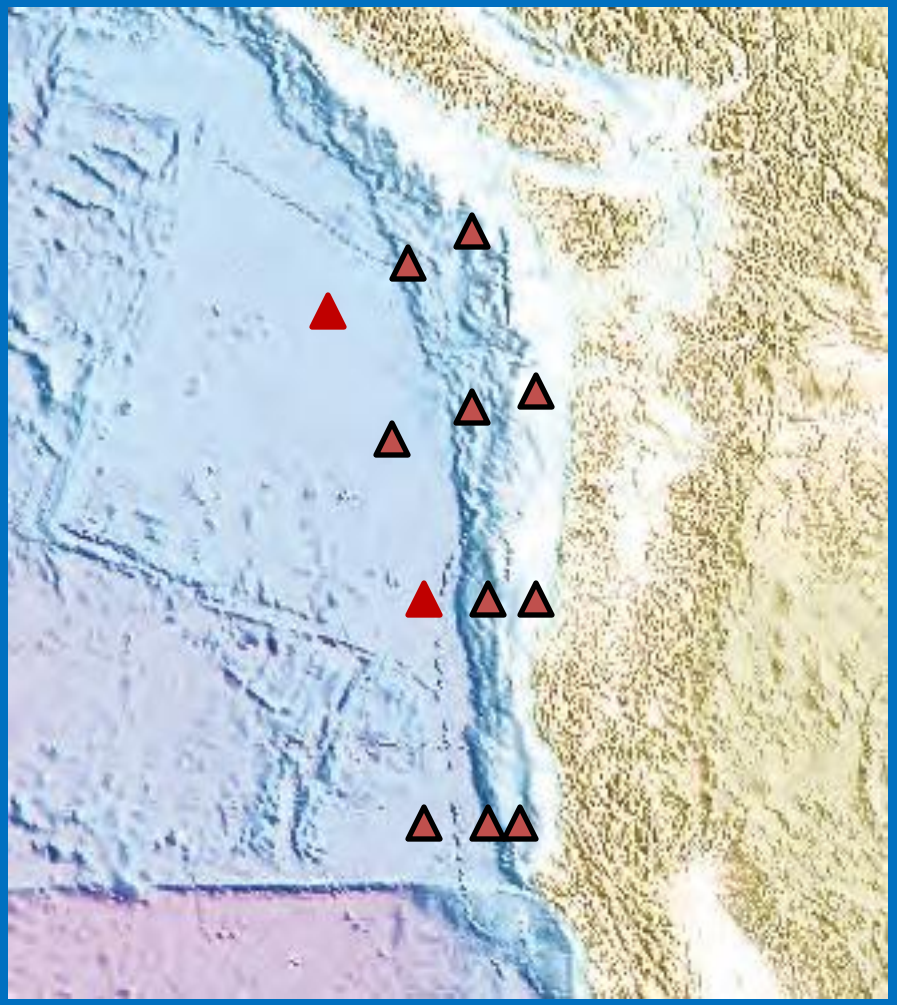


In-expensive, permanent seafloor benchmarks allow seafloor transponders to be placed and removed with mm registration.

(Chadwell, Webb, Nooner)

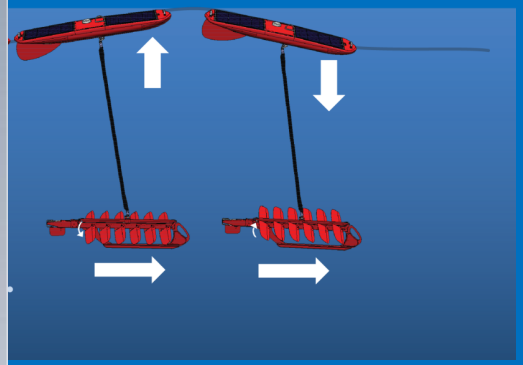
(NSF-OCE-1155305 recommended by OTIC)

Offshore PBO ?

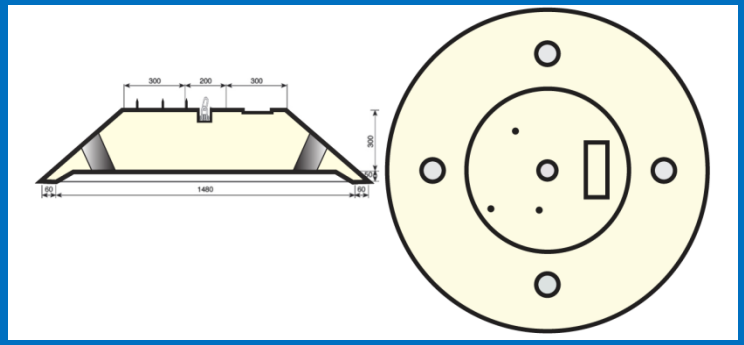


Geospar

Wave Glider



Benchmarks



Combine Geospar, Wave Glider and Benchmarks for a five year campaign in Cascadia. Then can move transponders to Alaska, benchmarks remain for future re-measurement.

Tasks for seafloor geodesy:

1. Refine location of boundary between "locked" and transition zone. *Occurs offshore, seafloor sensors see larger signal.*
2. Fault behavior in the up-dip region. *Locked or Frictionless, etc.?*
3. Deformations of the incoming plate. *Always at same long-term geologic rate?*
4. Capture eventual co-seismic motion. *Example from Japan.*
5. Transient motions. *Continuous seafloor geodetics.*