Form: 6
Prepared By: Kasey Aderhold

Status: ☒ In progress ☐ Completed

Question from the Community

Name	Emily Morton		
Date of Contact	11/7/16		
Date of Response	11/7/16	Completion date	
Experiment	Cascadia		
IIC Affected & Contact	SIO – Jeff Babcock		
Stations Affected	J10B		
Contact Information	Emily Morton, New Mexico Tech, emily.morton@student.nmt.edu		

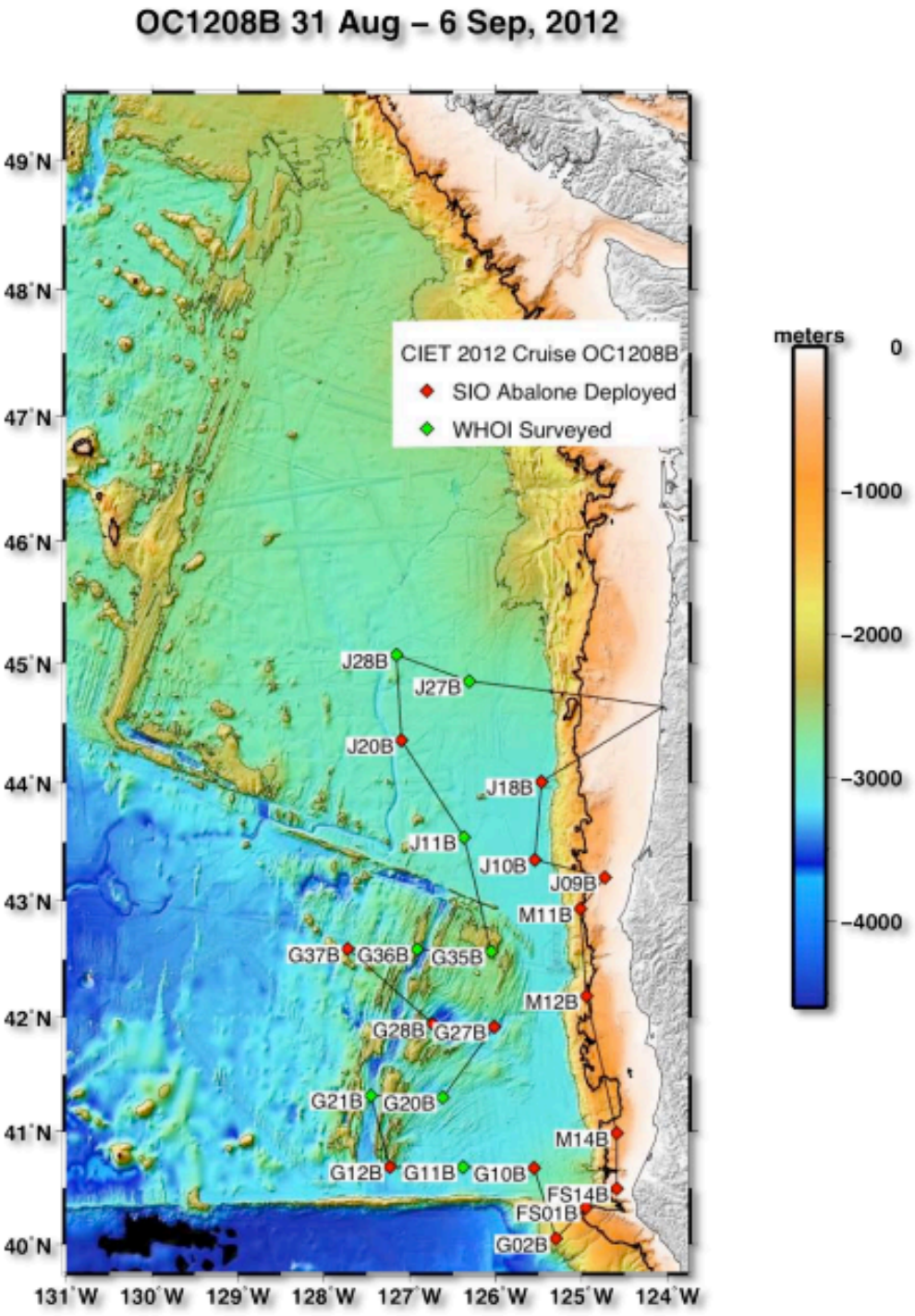
Summary:

Emily asked about the timing of station J10B on the BH* channels, saying initial waves from earthquakes had been coming in much too early given the proximity to other nearby stations. She gave an example of an earthquake on 9/8/2012 recorded on both OBS and land stations.

Steps Taken:

Date	Action
11/7	Responded to Emily Morton
11/14	Summarized investigation and additional evidence to confirm the timing error.
11/15	Jeff responded with more information about the station. A -62.53389230 second time correction was applied to J10B, which may indicate a real-time clock counter error and the correct correction would be -2.53389230 seconds. If the timing error is not consistent, it could be the oscillator/clock drifting more than a minute. Requested more evidence showing that the timing error is consistent throughout entire experiment.
11/16	Kasey e-mailed Emily for more evidence of the timing error being consistent, Emily quickly responded that J10B was consistently early for 47 events but that she could not confirm a consistent timing error. Additional teleseismic/regional events were used to estimate the timing error throughout the deployment and are summarized in figures below. Also added tables from recovery cruise report that indicate the large drift was identified as probable incorrect logging of the time at deployment during Day 2 of the recovery cruise.

From Deployment Cruise Report (2013/09/24):



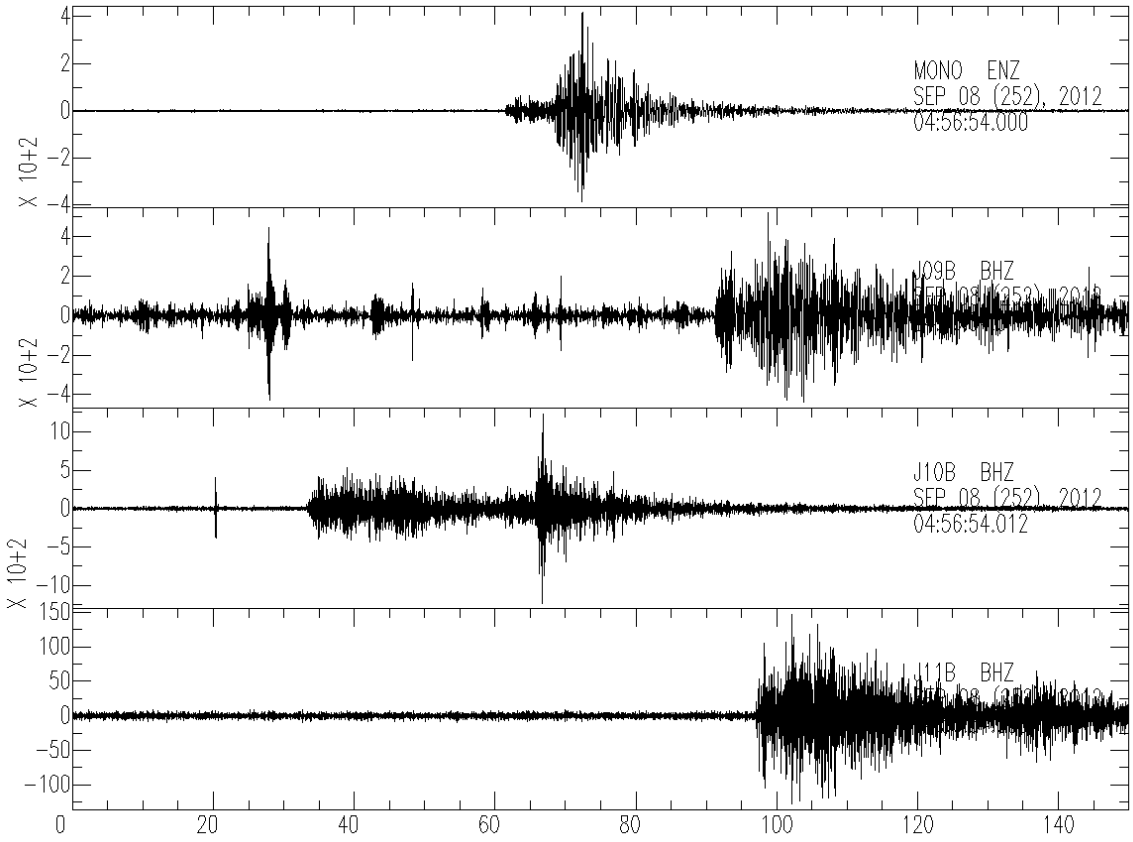


Figure 1. Plot from Emily Morton (sent 11/7/16) showing a presumably land earthquake detected on OBS (J09B, J10B, J11B) and a land station (MONO). Note that the earthquake comes in earlier on the J10B ocean station than all of the others, even though J10B is located in between J11B and J09B.

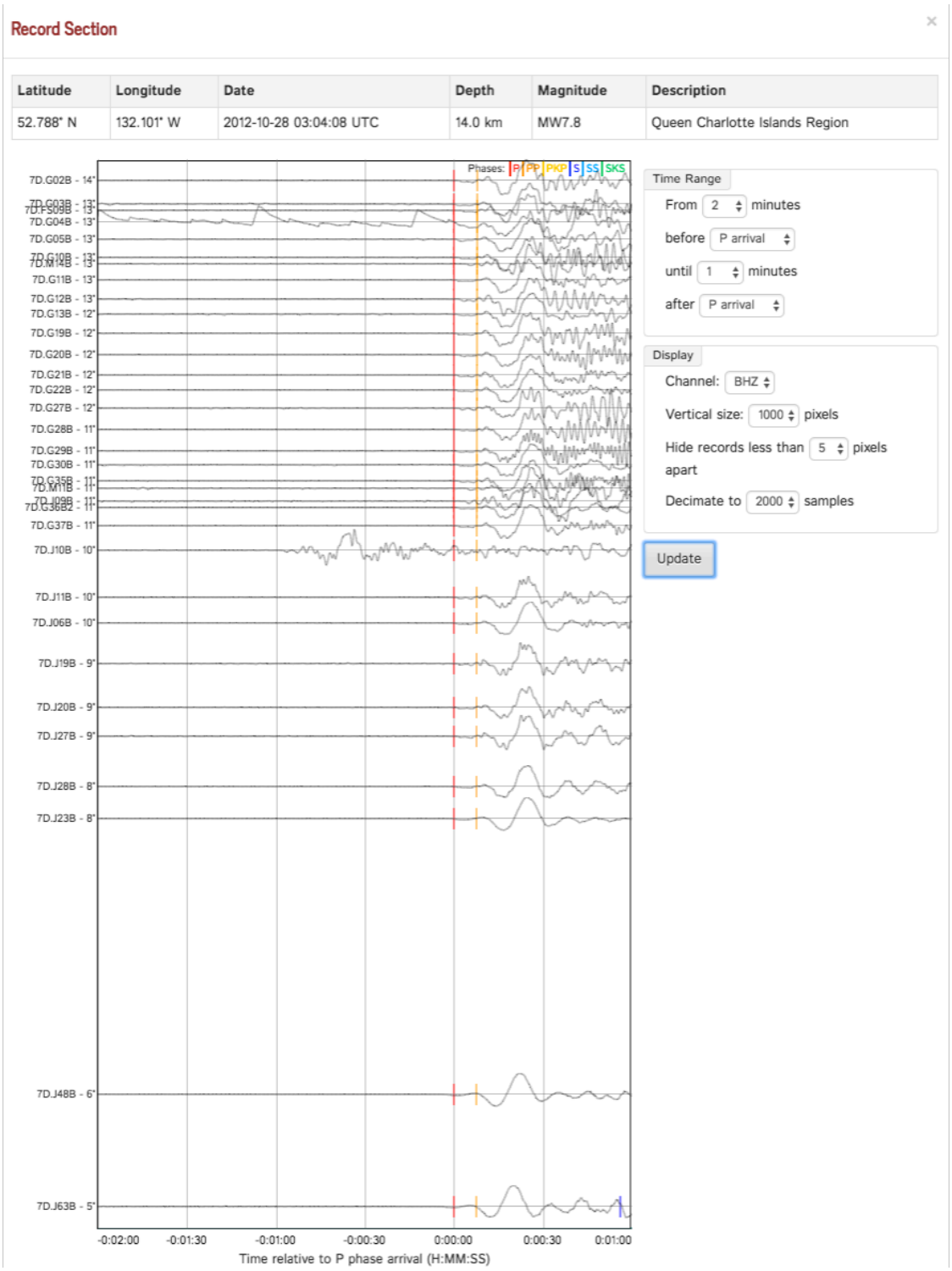


Figure 2. 2012 M7.8 Queen Charlotte earthquake recorded on the Cascadia Initiative OBS stations. Note that J10B has a P wave arrival approximately 1 minute earlier than the other stations. Automatic P wave picks are in red.

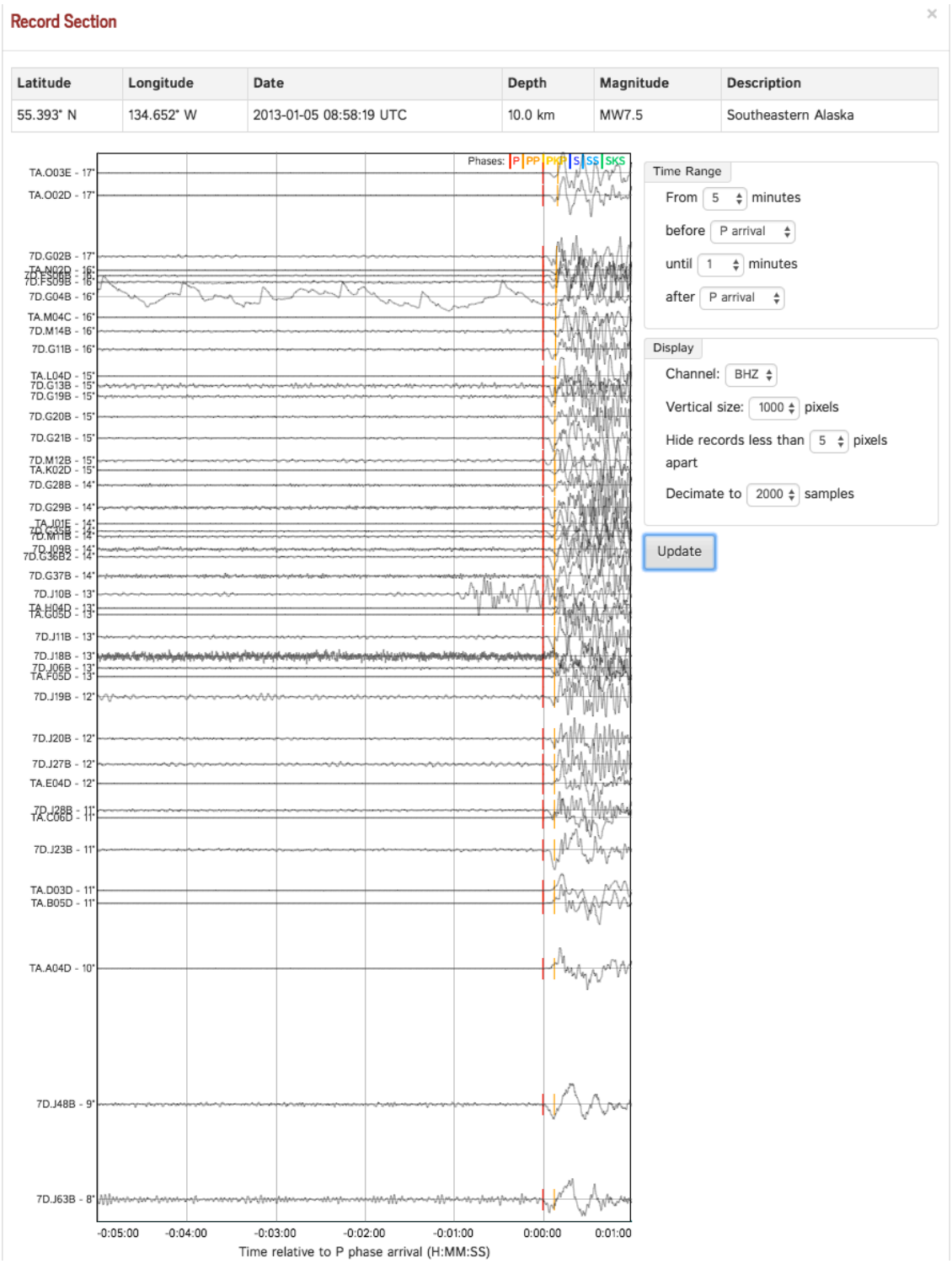


Figure 3. 2013 M7.5 Craig earthquake recorded on the Cascadia Initiative OBS stations and the TA land stations. Note that J10B has a P wave arrival approximately 1 minute earlier than the other stations. Automatic P wave picks are in red.

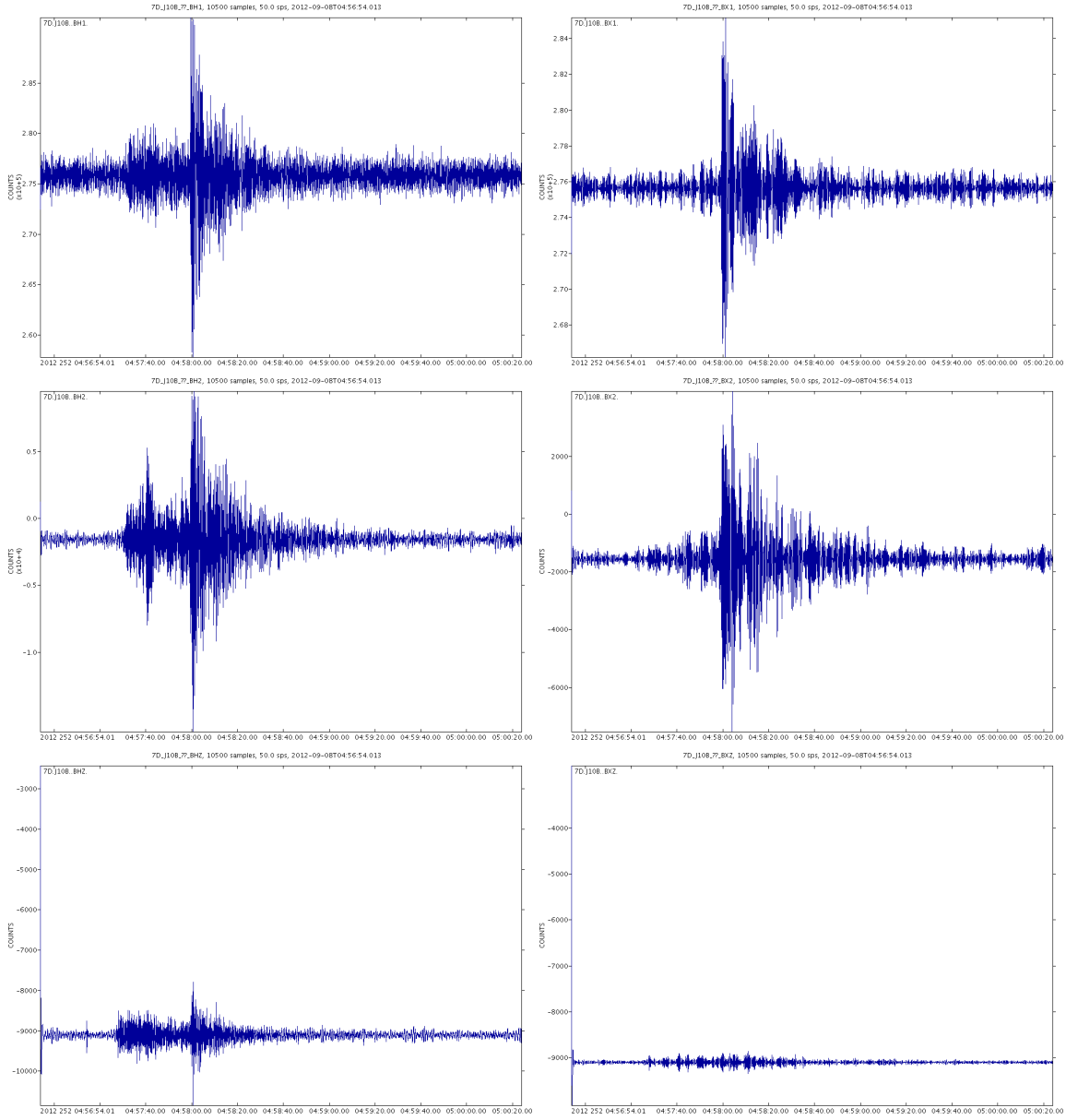
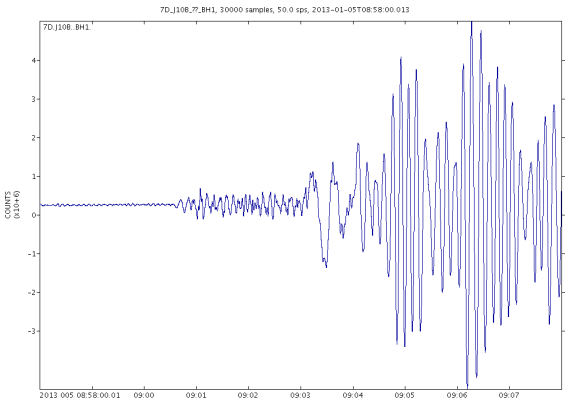


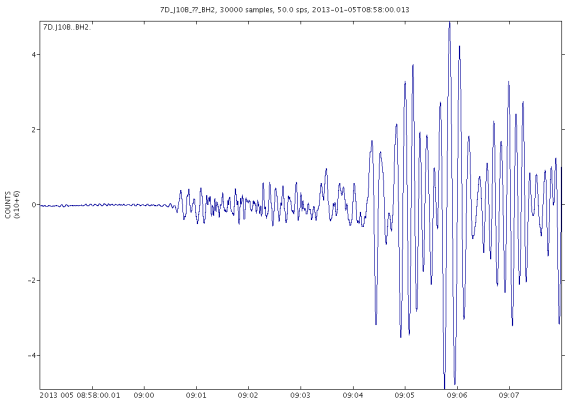
Figure 4. Left column is BH1 (top), BH2 (middle), and BHZ (bottom). Right column is BX1 (top), BX2 (middle), and BXZ (bottom). Recording is 9/8/2012 4:56 earthquake to show consistency across all channels, although the filtered data (?X? channels) does alter the wave forms significantly for this local event.

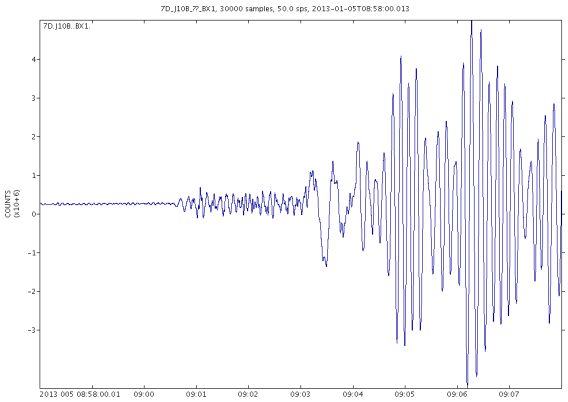
Figure 5. a) Recordings of the 2013 M7.5 Craig earthquake on J10B to show consistency in timing across all channels. This is clearer for a regional event as the waveforms are not affected by the filter in the ?X? channels. Horizontal seismic channels.

BH1

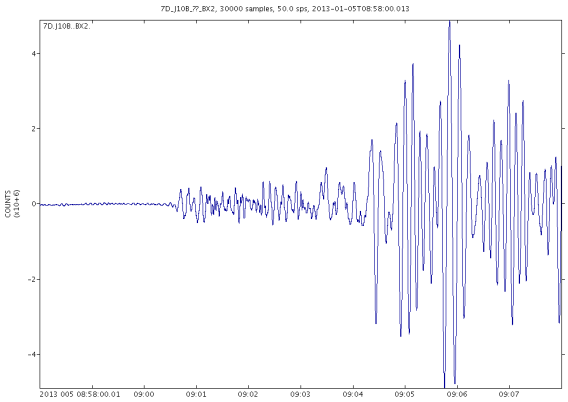


BH2





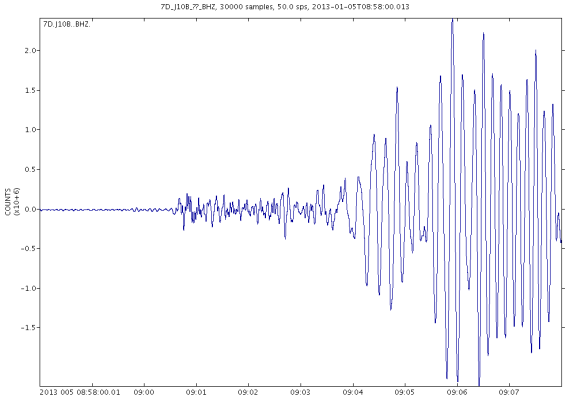
BX1



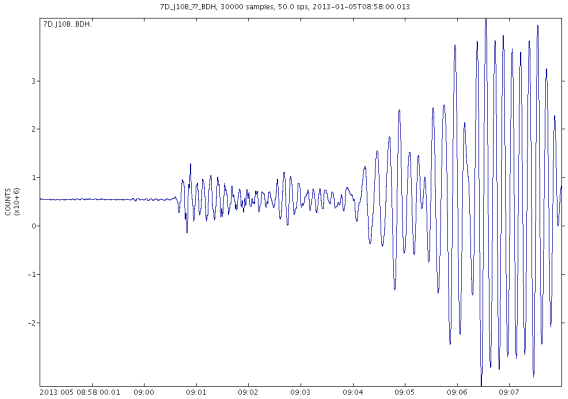
BX2

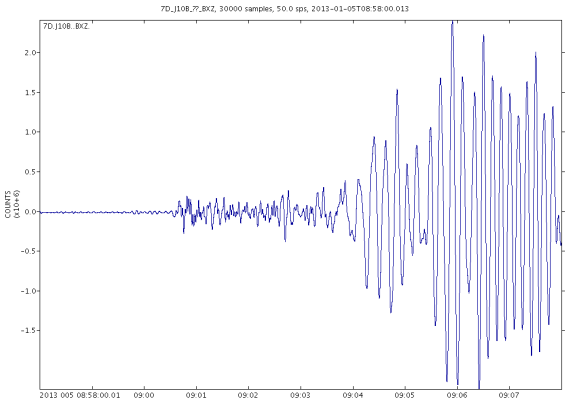
Figure 5. b) Recordings of the 2013 M7.5 Craig earthquake on J10B to show consistency in timing across all channels. Vertical seismic and DPG channels.

BHZ

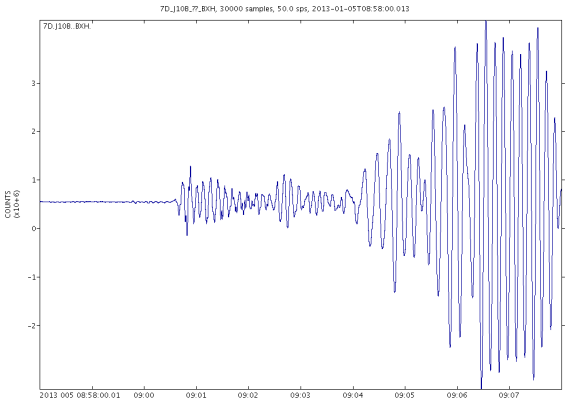


BDH





BXZ



BXH

Figure 6. Station metadata at the DMC as of 11/16/16.

Network	7D :: Cascadia Initiative Community Experiment-OBS component :: 7D Network Map :: DOI
Station	J10B :: SIO OBS ID J10B :: 2013-CASCADIA_YR2 :: J10B Station Map :: RESP :: SAC PZs :: XML
Latitude	43.349400
Longitude	-125.543500
Elevation	-3093
Start	2012/09/01 (245) 00:00:00
End	2013/06/18 (169) 23:59:59
Epoch	**2012/09/01 (245) 20:00:00 - 2013/06/18 (169) 08:09:00**
Instrument	T-compact OBS-SIO/ABALONES-4x4
Channels (Hz)	Location --: BH1 (50)A, BH2 (50)A, BHZ (50)A
Instrument	T-compact OBS-SIO/ABALONES-4x4-CASC2-FIL
Channels (Hz)	Location --: BX1 (50)A, BX2 (50)A, BXZ (50)A
Instrument	DPG OBSIP-SIO/ABALONES-4x4
Channels (Hz)	Location --: BDH (50)A
Instrument	DPG OBSIP-SIO/ABALONES-4x4-CASC2-FIL
Channels (Hz)	Location --: BXH (50)A
MetaData Load	2016/08/09 (222) 16:16:08

Figure 7. Summary of timing offsets from predicted versus picked P wave arrival times for events throughout the deployment time. Picks are estimated, particularly in the case of the catalogued "Local Event" and can be referenced to figures within this document for further review.

Date	Event	Clear P wave?	Timing Difference (estimate)
09/01/2012	J10B OBS Deployed		
09/05/2012	M7.6 Costa Rica	Yes	60 seconds
09/08/2012	Local Event	Yes	55 seconds
10/28/2012	M7.8 Queen Charlotte	Yes	60 seconds
11/08/2012	M6.1 Vancouver Island	No	60 seconds
12/14/2012	M6.4 Baja California	Yes	60 seconds
01/05/2013	M7.5 Craig	Yes	60 seconds
02/06/2013	M8.0 Santa Cruz	No	60 seconds
04/19/2013	M7.2 Kuril Islands	Yes	60 seconds
05/24/2013	M8.3 Sea of Okhotsk	Yes	60 seconds
06/15/2013	M6.5 Nicaragua	No	60 seconds
06/18/2013	J10B OBS Recovered		

Figure 8. 2013 M7.6 Costa Rica earthquake recorded on select Cascadia Initiative OBS. Automatic P wave picks are in red.

Latitude	Longitude	Date	Depth	Magnitude	Description
10.085° N	85.315° W	2012-09-05 14:42:07 UTC	35.0 km	MW7.6	Costa Rica

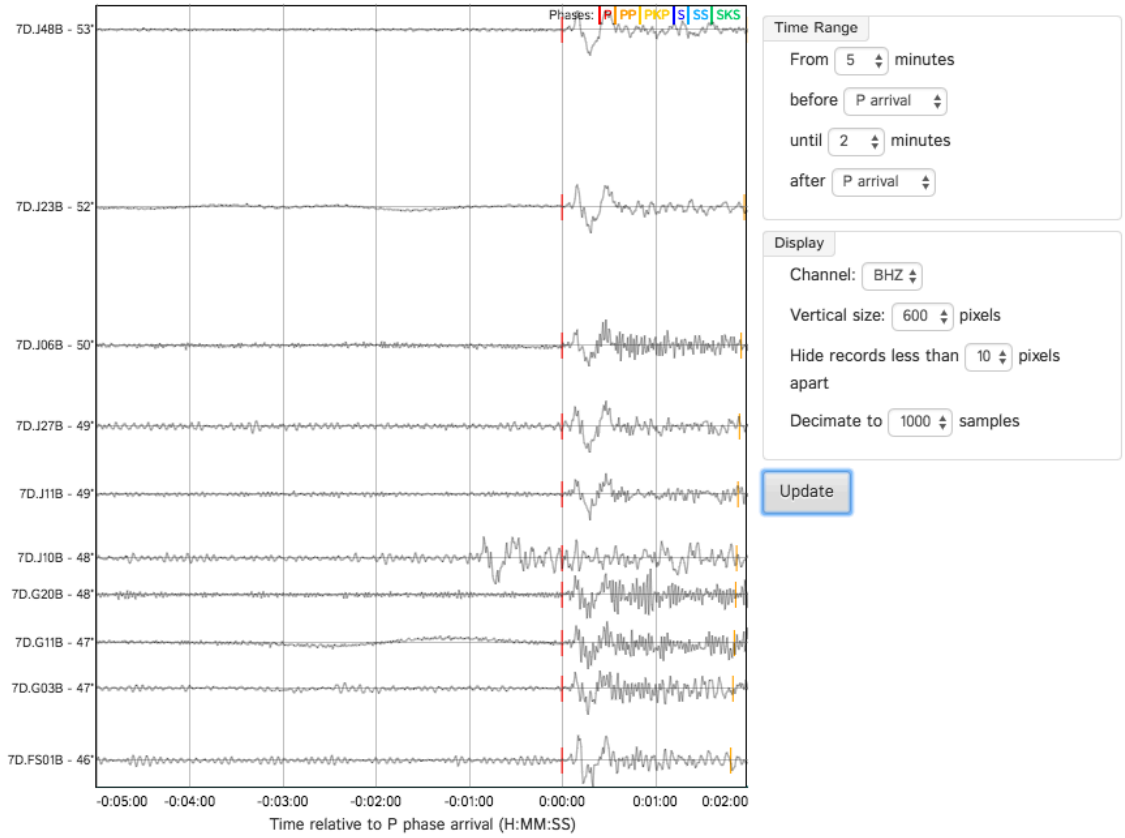


Figure 9. 2012 M6.1 Vancouver Island earthquake recorded on select Cascadia Initiative OBS. Automatic P wave picks are in red. This event was very nearby the stations and it looks like the P wave picks are a few seconds off on the other stations too, though J10B is still coming in much earlier which is apparent for the S wave.

Latitude	Longitude	Date	Depth	Magnitude	Description
49.231° N	128.477° W	2012-11-08 02:01:50 UTC	13.7 km	MW6.1	Vancouver Island Region

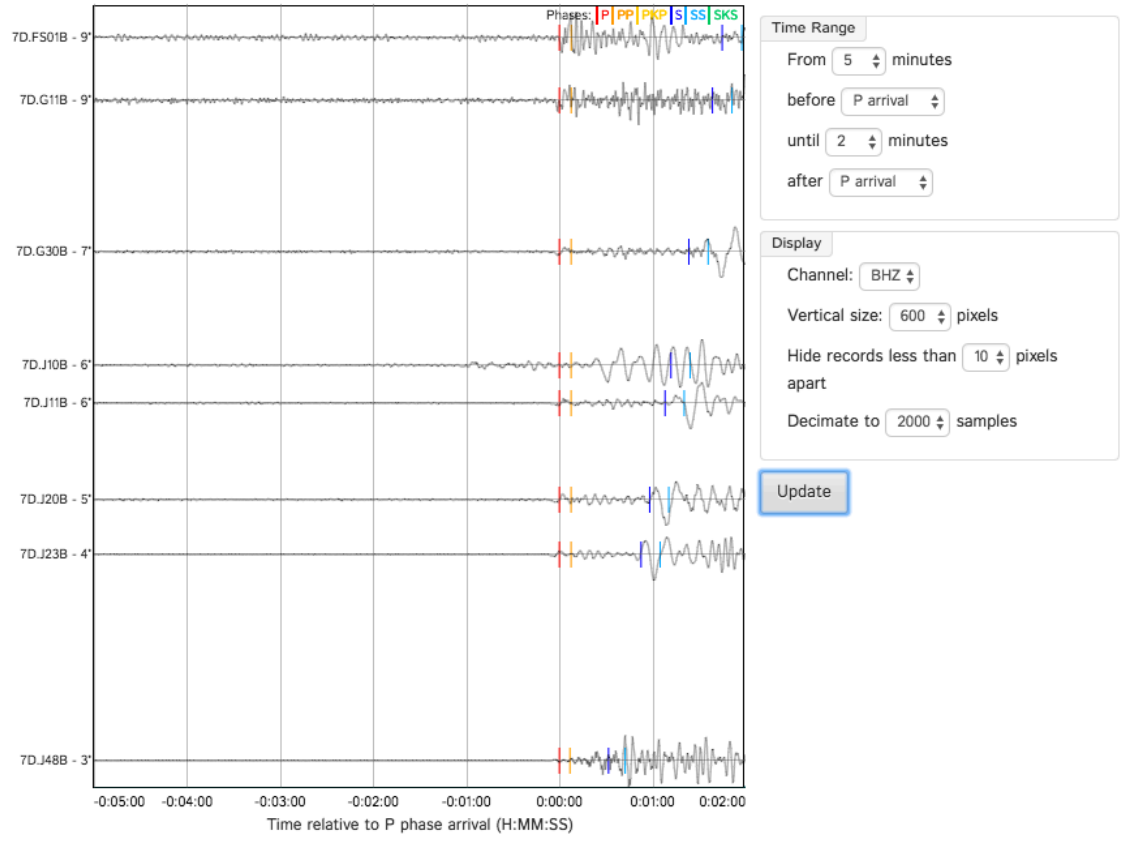


Figure 10. 2012 M6.4 Baja California earthquake recorded on select Cascadia Initiative OBS. Automatic P wave picks are in red.

Latitude	Longitude	Date	Depth	Magnitude	Description
31.095° N	119.66° W	2012-12-14 10:36:01 UTC	13.0 km	MW6.4	Off W. Coast Of Baja California

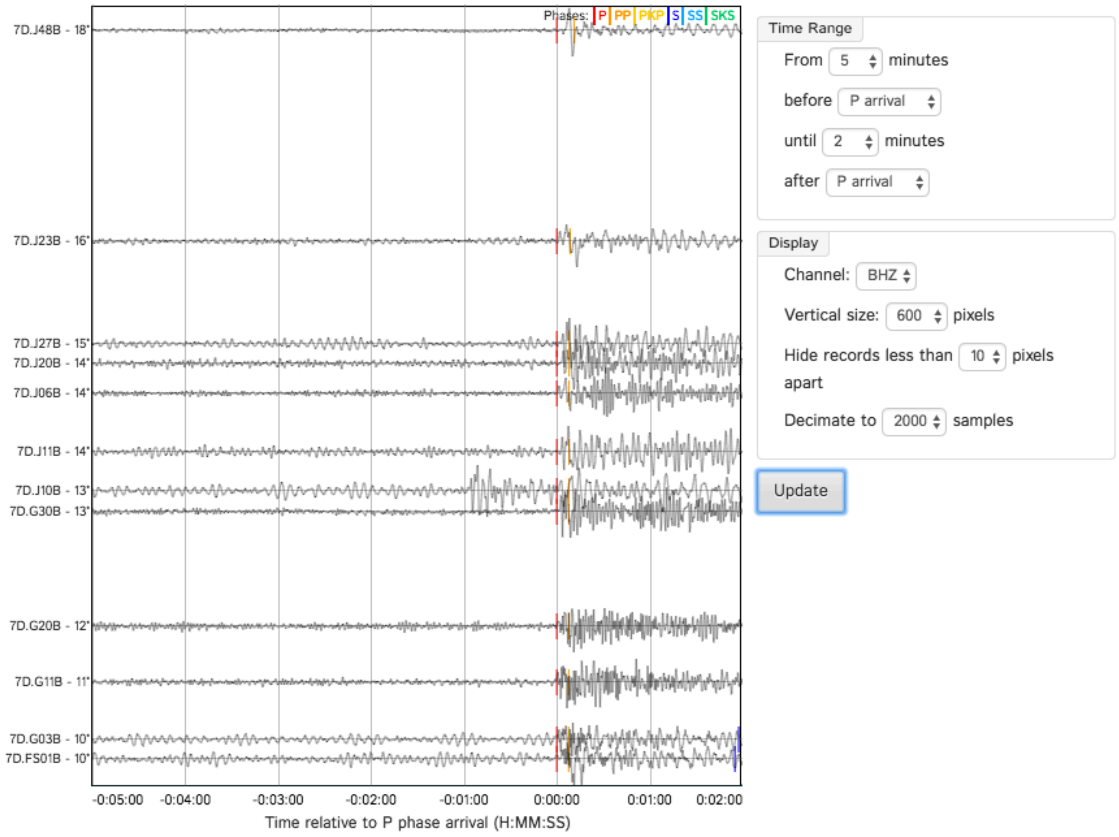


Figure 11. 2013 M8.0 Santa Cruz Islands earthquake recorded on select Cascadia Initiative OBS. Automatic P wave picks are in red. There was a lot of noise during this event (I think it was part of a couplet or multiplet) so surface waves are shown to better identify the timing shift.

Latitude	Longitude	Date	Depth	Magnitude	Description
10.738° S	165.138° E	2013-02-06 01:12:27 UTC	28.7 km	MW8.0	Santa Cruz Islands

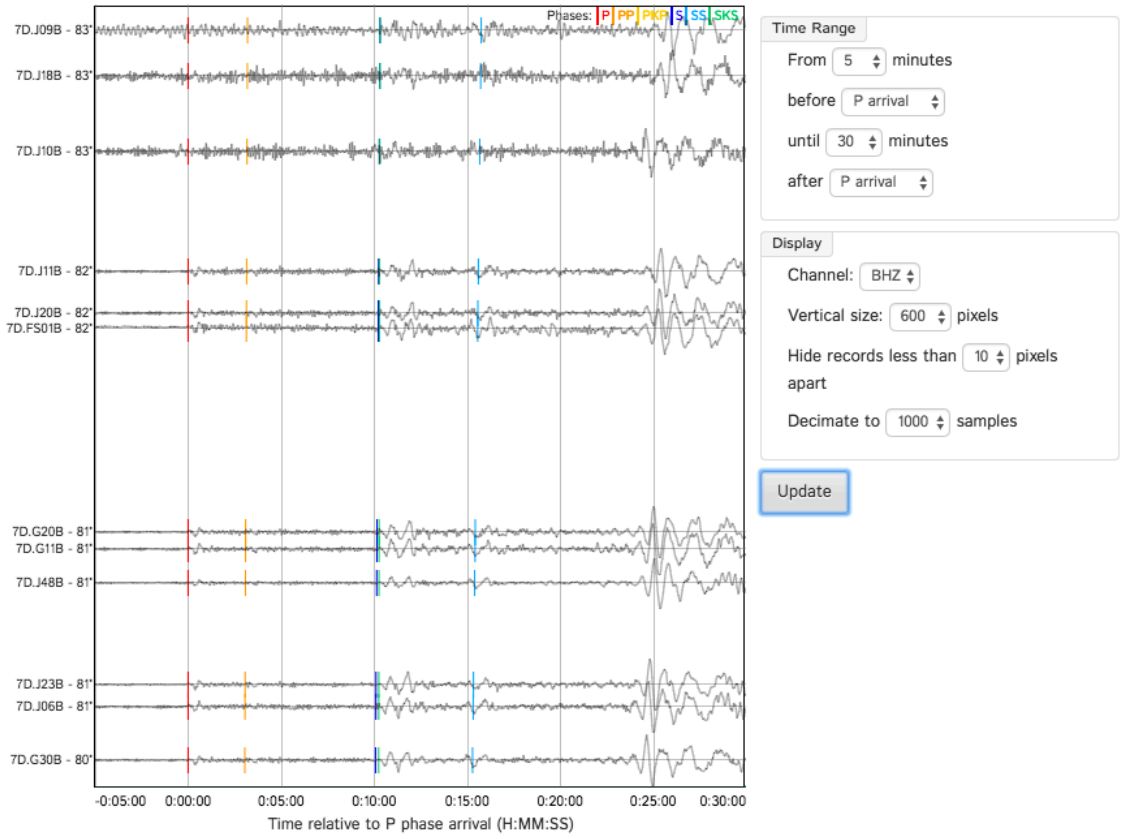


Figure 12. 2013 M7.2 Kuril Islands earthquake recorded on select Cascadia Initiative OBS. Automatic P wave picks are in red. This event was very clear so we are able to zoom in on this four-minute segment.

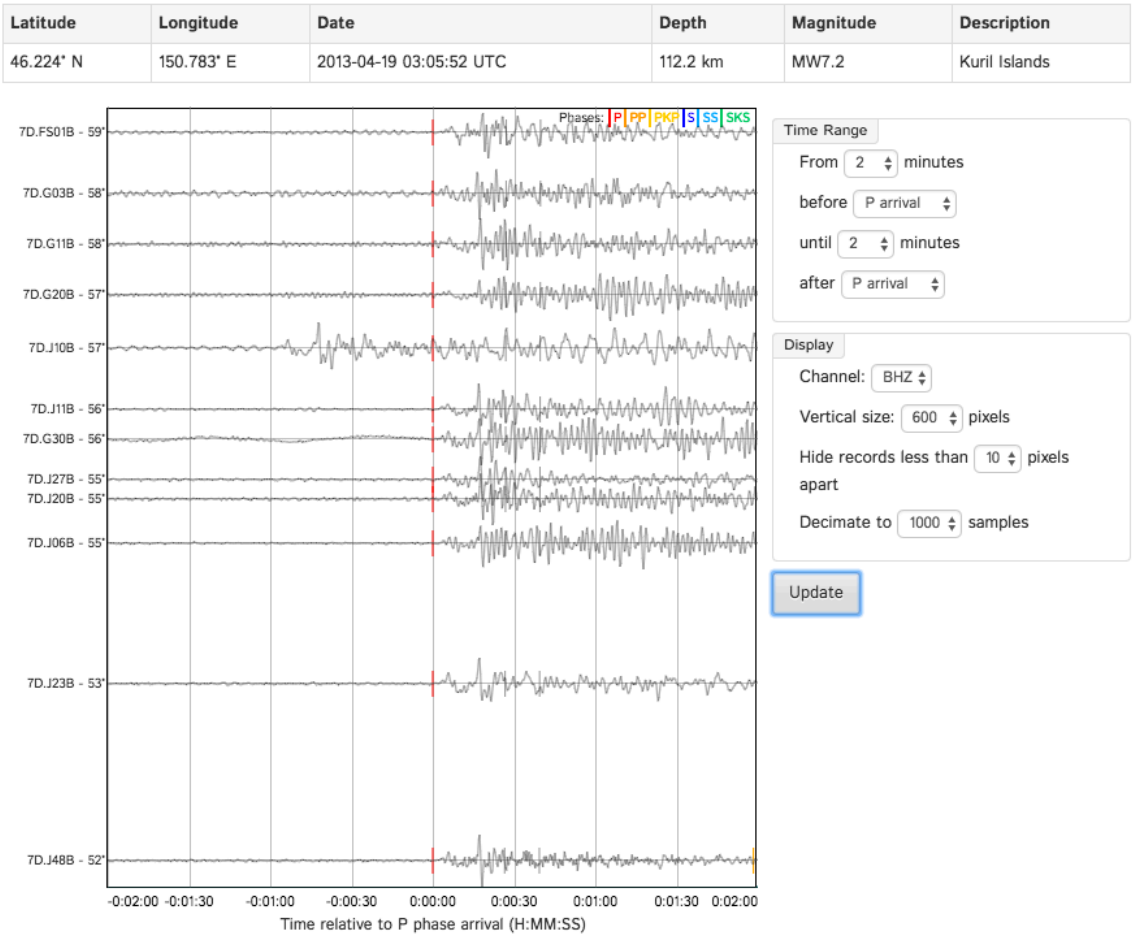


Figure 13. 2013 M8.3 Sea of Okhotsk earthquake recorded on select Cascadia Initiative OBS. Automatic P wave picks are in red. This event was very clear so we are able to zoom in on this four-minute segment.

Latitude	Longitude	Date	Depth	Magnitude	Description
54.874° N	153.281° E	2013-05-24 05:44:49 UTC	608.9 km	MW8.3	Sea Of Okhotsk

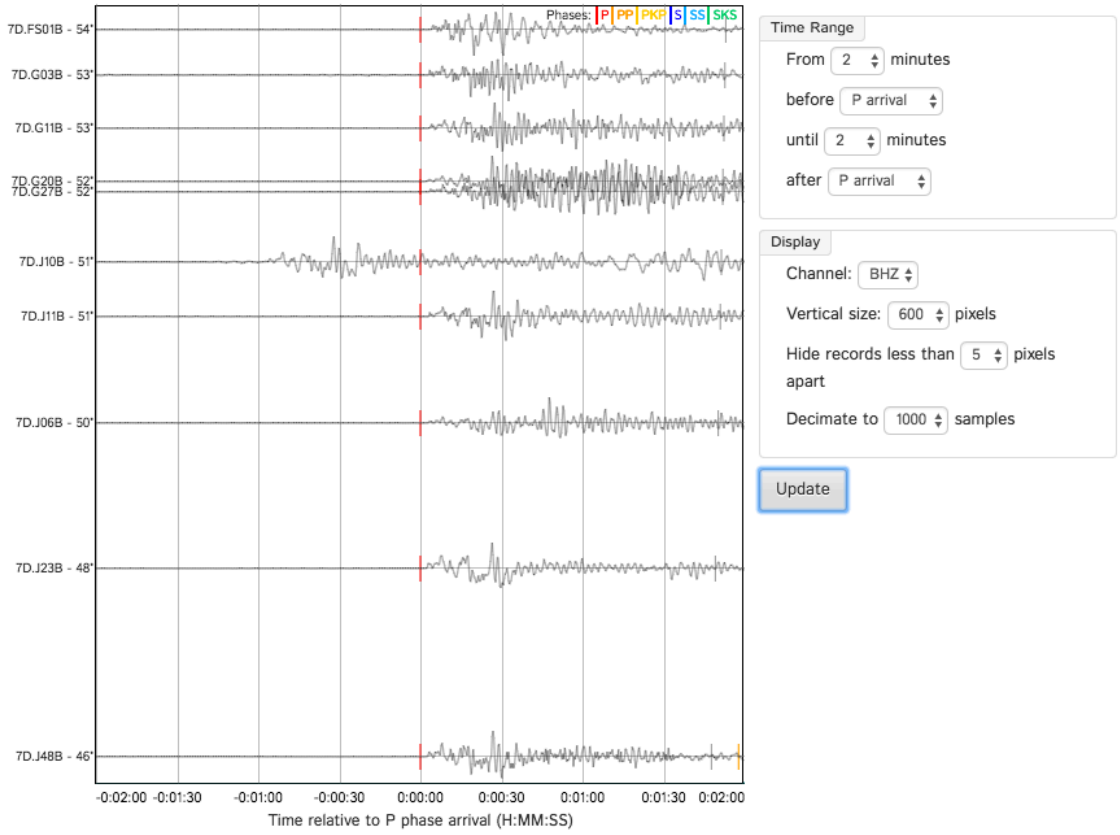


Figure 14. 2013 M6.5 Nicaragua earthquake recorded on select Cascadia Initiative OBS. Automatic P wave picks are in red. It was difficult to see this smaller event and there were no large teleseismic earthquakes during June, so the surface waves are shown as well to help the P wave and timing shift pop out above the noise.

Latitude	Longitude	Date	Depth	Magnitude	Description
11.7246° N	86.9754° W	2013-06-15 17:34:29 UTC	35.8 km	MWB6.5	Near Coast Of Nicaragua

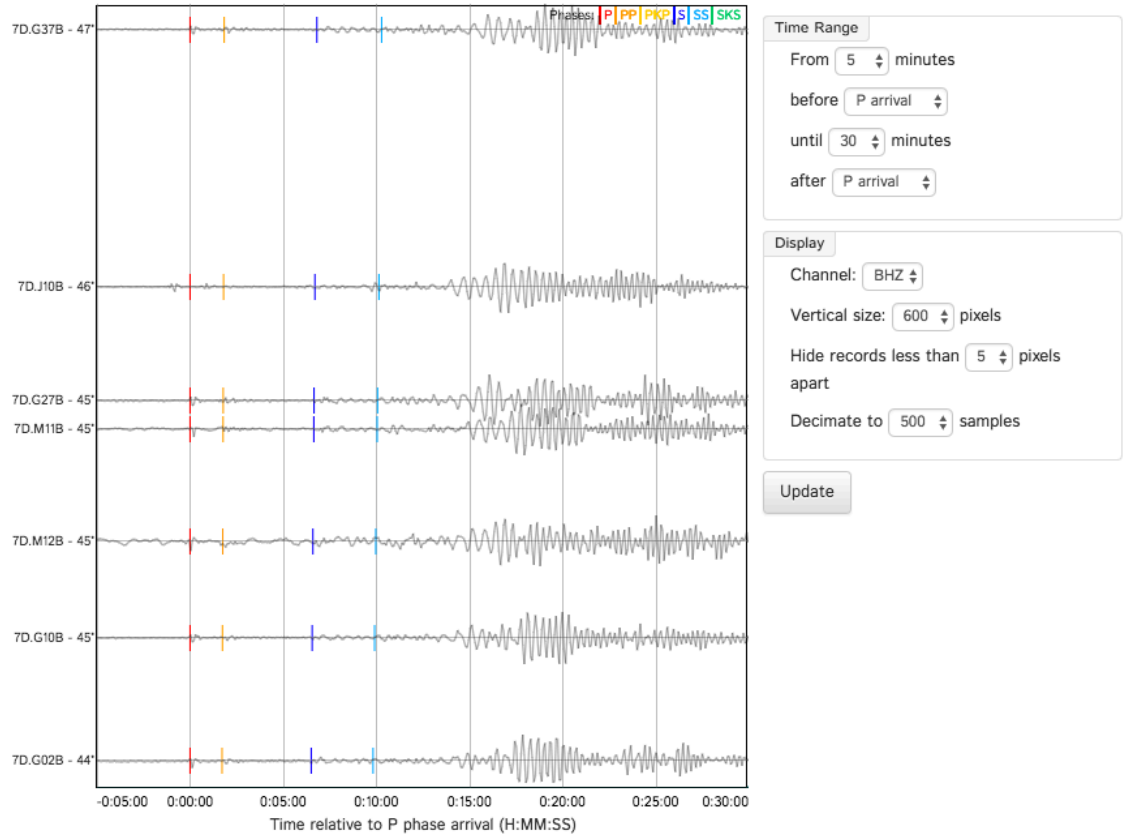


Figure 15. Log entry from Day 2 of recovery cruise report. (http://ds.iris.edu/data/reports/7D_2011_2017/Cascadia2013_Toomey_CruiseReport_7D_rec_SIO_10_07_2103.pdf)

Day 2: Tuesday June 18, 2012 (Recovered J10;M11; M12; M14; FS10)

OBS onboard at 01:00 PDT. SIO OBS number 5.

J10 had full data record (19 Gbytes).
Data from J10 was embargoed by the Navy.
J10 recovered position: 43 20.964; 125 32.612'W, depth= 3093
J10 also had a 60 second time drift. SIO believes this was caused by an incorrect logging of the time at deployment.

Figure 16. SIO OBS Year 2 station table from recovery cruise report. J10B is station number 2.

Table 1: SIO OBS Abalone Location and Instrument Identification

* = FILTERED DATA ONLY (Navy Approved). We are not allowed any type of unfiltered data.

Number	Site Name	Data Logger	Frame	Trillium	Lat			Lon			Water Depth
1	J18 (*)	8	10	10	44	0.498	44.0083	-125	27.9588	-125.46598	3047
2	J10 (*)	12	5	11	43	20.9637	43.349395	-125	32.6119	-125.5435317	3093
3	M11	7	14	9	42	55.9222	42.93203667	-125	1.0273	-125.0171217	1109
4	M12	2	7	2	42	11.0396	42.18399333	-124	56.7662	-124.9461033	1045
5	M14	9	11	4 (Dup?)	40	59.1026	40.98504333	-124	35.3849	-124.5897483	638
6	FS14	4	4	8	40	29.7303	40.495505	-124	35.5049	-124.5917483	107
7	FS01	10	3	7	40	19.6063	40.32677167	-124	56.9501	-124.9491683	940
8	G02	1	8	14	40	2.9164	40.04860667	-125	17.8155	-125.296925	1920
9	G10	3	15	12	40	40.6723	40.67787167	-125	33.2004	-125.55334	2936
10	G12B (*)	1001	2	4	40	41.2162	40.68693667	-127	13.7315	-127.2288583	3080
11	G27 (*)	1000	9	5	41	54.9946	41.91657667	-126	1.0016	-126.0166933	3480
12	G28 (*)	6	6	3	41	56.5654	41.94275667	-126	44.0311	-126.7338517	3327
13	G37 (*)	11	13	1	42	35.4778	42.59129667	-127	43.2803	-127.7213383	3004
14	J20 (*)	13	1	15	44	21.2511	44.354185	-127	5.71	-127.0951667	2934
15	J09	5	5	13	43	09.067	43.15.1117	-124	43.644	-124.7270183	252

Figure 17. SIO OBS Year 2 clock table from recovery cruise report. Station number 2 is J10B.

Table 2: SIO OBS Abalone Clock and CPU Synchronism Information

	CPU Clock Sync (only active if batteries do not fail)					
Number	CPU Sync	CPU Recovery Time	Difference between CPU Recovery Time and CPU Sync Time	Difference between CPU Recovery Time and CPU Sync Time (s)	CPU Time Tag (s)	Drift Correction (Hex Count - CPU Diff) (seconds)
1	2012:244:19:03:00	2013:169:03:13:00	290d:08h:10m:00s	25085400	25085400.05662650	0.05662647
2	2012:244:20:00:00	2013:169:08:09:00	290d:12h:09m:00s	25099740	25099677.46610770	-62.53389230
3	2012:245:07:06:00	2013:169:12:20:00	290d:05h:14m:00s	25074840	25074841.77229280	1.77229279
4	2012:245:12:31:00	2013:169:17:12:00	290d:04h:41m:00s	25072860	25072856.73578030	-3.26421973
5	2012:245:22:56:00	2013:170:00:28:00	290d:01h:32m:00s	25061520	25061522.89938340	2.89938339
6	2012:245:23:24:00	2013:170:03:54:00	290d:04h:30m:00s	25072200	N/A	N/A
7	2012:245:23:59:00	2013:170:08:00:00	290d:08h:01m:00s	25084860	25084860.07532280	0.07532281
8	2012:246:01:23:00	2013:170:11:27:00	290d:10h:04m:00s	25092240	25092239.26744860	-0.73255142
9	2012:246:15:08:00	2013:170:16:44:00	290d:01h:36m:00s	25061760	25061760.03478520	0.03478522
10	2012:246:22:22:00	2013:171:01:11:00	290d:02h:49m:00s	25066140	N/A	N/A
11	2012:246:23:38:00	2013:171:11:43:00	290d:12h:05m:00s	25099500	25099500.24978720	0.24978717
12	2012:248:01:44:00	2013:171:16:35:00	289d:14h:51m:00s	25023060	25023059.22973150	-0.77026846
13	2012:248:07:02:00	2013:171:23:23:00	289d:16h:21m:00s	25028460	25028460.50508480	0.50508478
14	2012:249:17:30:00	2013:172:10:34:00	288d:17h:04m:00s	24944640	24944640.79321890	0.79321893
15	2012:245:02:19:00	2013:172:22:07:00	293d:19h:48m:00s	25386480	25386480.91804100	0.918040983

Figure 18. SIO OBS Year 2 instrument status table from recovery cruise report. Station number 2 is J10B.

Table 3: SIO OBS Abalone Clock Drift, Gain Settings, and Instrument Status When Recovered

	Hardware Clock Sync NOT USED - Hardware Backup		(Low Power Battery Backup for Clock)					
Rec. #	CLOCK Recovery/Tag	Drift	Num Chan	SPS	Gain 1,2,3 (X, Y, Z)	Gain 4 (DPG)	File Sizes (GB)	Status
1	2013:169:03:19:59.9434096	-0.0565904	4	50	1	64	19.91	OK.
2	2013:169:08:14:02.5339444	2.5339444	4	50	1	64	19.92	Large drift of 62+ seconds - typo? Clock backup and CPU are 60 seconds off - using -2.53389230 second drift correction in database files. This matches clock board correction.
3	2013:169:12:25:58.2276907	-1.7723093	4	50	1	64	19.90	OK. Z channel looks noisy.
4	2013:169:17:17:03.2643304	3.2643304	4	50	1	64	19.90	OK. Z channel looks noisy.
5	2013:170:00:29:57.1005857	-2.8994143	4	50	1	64	19.89	OK. Z channel looks noisy.
6	2013:170:03:57:00.7526043	0.7526043	4	50	1	64	6.69	FPGA had been cycled - could not get system time. Using clock backup (matches with generated pulse from system time clock). Data only exists up to 2012:343. Battery Bottle not connected? Data Looks OK.
7	2013:170:08:02:59.9246883	-0.0753117	4	50	1	64	19.90	DPG channel bad. Other channels appear good.
8	2013:170:11:30:00.7325638	0.7325638	4	50	1	64	19.91	DPG looks fine. Tril-X,Y, and Z have lots of noise.
9	2013:170:16:47:59.9652285	-0.0347715	4	50	1	64	19.89	OK. Check channel 1 (Tril-Y) - weird noise.
10	2013:171:01:20:58.0108636	-1.9891364	4	50	1	64	4.62	FPGA has been cycled - could not get system time. Using clock backup. Data only exists up to 2012:314. Data looks OK.
11	2013:171:11:44:59.7502314	-0.2497686	4	50	1	64	19.91	Bad DPG.
12	2013:171:16:37:00.7703058	0.7703058	4	50	1	64	19.86	OK.
13	2013:171:23:23:59.4949400	-0.50506	4	50	1	64	19.86	OK.
14	2013:172:10:38:59.2067851	-0.7932149	4	50	1	64	16.66	Power fluctuations - data collection stopped early. Check wiring of packs/cables. Bad DPG. Noisy, low amplitude, signal on X,Y,Z.
15	2013:172:22:09:59.0819484	-0.9180516	4	50	1	64	20.15	OK.