Appendix E

Blank Questionnaire and Tabular Compilation of Responses

Name: ___________________________

Input on Topic of Final Plenary (to be collected at end of session)

What is the path forward to achieve an offshore sensor network for the subduction zone?

Is there a sensible phased approach (such as intermediate experiments or deployments)?

What assessment, development, or studies are required before implementation?

Who are the stakeholders, particularly those groups not represented at the workshop?

How do we build a coalition who can advocate for a plan?

Other thoughts, impressions, or suggestions…

What is the path forward to achieve an offshore sensor network for the subduction zone?

Comment	Number (if >1)
Engagement	
Get input from / engage emergency managers	3
Additional meetings with expanded science and stakeholder participation	3
Engage/inform as many stakeholders and science communities as possible	2
Involve agencies responsible for issuing warning	2
Engage high tech companies (Bezos)	2
Develop and implement a plan for public dissemination and engagement	2
Develop collaboration between academia, industry and emergency management agencies	2
Engage communities / public in areas that will benefit	2
Engage funding agencies early	
Brief potential funders early	
Authoritative advisory panel	
Engage industry	
Identify stakeholders	
Priorities	
Prioritize EW and response (civil protection); science is important but not the driver	4
Decide on goals EW versus science and EW versus science (priorities)	3
Simplify to EEW and TEW - no mission creep	2
Prioritize according to life safety - TEW before EEW	2
Choose a focus - TEW	2
Focus on hazards and hazards reduction	
Balance between science and ops	
EEW and TEW wrong initial goals	
Make sure system is dual purpose	
Is EW for tsunamis or earthquakes or both?	
Clearly define the problem we are trying to solve and the outcomes (sell it this way)	
Form a razor sharp vision of what the network will provide in tangible terms	
System should balance science and EEW	
Link priorities to funding sources	
Approach	
Instrument existing nodes with extension cables and use this to show the benefit and evaluate new technologies	5
Develop a plan and get input from stakeholders	3
Phased approach to increase understanding	2
Step-wise progress	
Flexible reliable expandable infrastructure - incremental	
Build it in stages	
Build EW system gradually	
Improve tsunami warnings for 1 locality to demonstrate progress	
Path is complex	
Develop a consensus plan within the science community	
Design	
Study other networks (especially Japanese systems)	3
Get funding for further developing designs - multiple options	2
What is the minimal system needed?	2
Finalize requirements for system	2
Develop a design and use community critique to motivate campaign style experiments to fill in gaps	
Use Japanese systems as blueprints	
Quantify the costs of the system including O&M	
Determine what you want to measure and design system to do that.	
Anticipate that technologies will evolve	
Plan for a multi-decadal activity	
Sensors	

Not all sensors need to cabled	2
Development of sensors with bandwidth and dynamic range for pressure, strain, ground motion, gravimetry	2
Evaluation and Demonstration	
Detailed simulations and optimization to show improvements in EW metrics	3
Do a thorough cost/benefit analysis	2
Quantify risk reduction potential	2
Funds to develop and test cheaper technology	2
Focus on making the measurements we can now to inform stakeholders of capabilities	
Show it is needed for public safety - TEW	
Show it is cost effective - offshore EEW is not with cabled system	
Early Offshore Observations	
Autonomous GPS-acoustic	2
Start with uncabled deployments to optimize cabled design for warning	
Incorporate core science like offshore imaging	
Mapping and seismic imaging	
Science community to push for instrumenting existing cables	
Autonomous seismic observations (100 OBS)	
GPS-A and other geodesy along profiles	
Funding the System	
Convince legislators and public that it is worthwhile	4
Identify funding sources including non-standard ones (private companies, insurers, World bank etc.)	3
Politics	
Convince public/FEMA that system will save lives	
Convince politicians of economic consequences	
Convince stakeholders it is worth it - sales	
Lobby government agencies for broad scale EEW and TEW	
Figure out how to market it.	
Get advice from lobbyists	
Develop succinct briefing of benefits	

Is there a sensible phased approach (such as intermediate experimets or deployments)?

Comment	Number (if >1)
Yes or No	
Phased approach only path forward	4
Aim for comprehensive system in a decade	2
Planning	
Evaluate Japanese experience	3
Solidify objective and requirements	2
Identify a few key observations that can benefit the public	
Plan for a funded program	
Prioritize science questions - which can be addressed with a few focused measurements?	
2-3 decade implementation plan	
Explore governance	
Standalone Deployments	
GPS-Acoustic	11
Temporary deployments to test instrument placement/value	5
BPR observations	5
Mapping & seismic imaging	4
OBS deployments	3
Start with non-cabled approaches	2
Drilling proposal	
OOI & ONC cabled networks	
Add sensors and test concepts with existing cable sites	20
Expand existing cables	6
Pilot project for EW on existing cable	3
Testing New Technologies	
Sensor development and evaluation	4
Deploy a modest glider/acoustic optical system	2
Look at HF radar	2
Test bed in-line cable system	
Test GPS buoy system for tsunamis	
Test distributed fiber optic sensing	
Existing Data and Modeling	
Numerical simulations to determine optimal configuration and identify highest priority sites	3
Evaluate existing data (e.g., Cascadia Initiative)	2
OBS network sensitivity tests	
Modeling studies to determine optimal design	
Phased Approach to Construction	
Phased approach - Focused on highest risk first	4
One cable loop at a time. Modular system. Highest risk first	3
Phased - start in N&S where initiation more likely	2
Phased approach to real time sensors based on sensitivity studies	2
Start with a sparse cabled network and then density	2
Start with a small dense network to demonstrate utility of a large dense network	2
Add one or more cabled transects	
Phases - start in S where there is more seismicity	
Phased approach to improving EEW	
Consider short simple cables offshore largest population centers	
Focus first on public safety with existing technology	
A few targeted nodes that benefit EEW and scientific understanding	
Start with a few sensors and make heavy use of models for TEW	
General Advice	
Build in flexibility to respond to technology	4

Need to coordinate experiments (between agencies)	2
Expandable hybrid cable	2
Validate technology	
Build on small successes to demonstrate path forward	
Operational deployment as the 1st milestone	
Activities should be based on demonstrating quantifiable successes	

What assessment, development, or studies are required before implementation

Comment	Number (if >1)
Seafloor Deployments	
Understand geologic architecture much better, at a scale where faults are images - mapping & seismics (+ magnetotellurics)	14
Develop and test cheaper more efficient sensors (e.g., distributed fiber optic sensing)	5
Geotechnical surveys at instrument sites	3
Define locked zones GPS-A	3
Testing of wave gliders and GPS buoys	2
Focused offshore experiments	
Test new technologies & concepts as quickly as possible	
Test in areas with biggest signals	
Alternative lower cost communication links	
Pilot cable with new design	
Pre-noise surveys at seismometer sites	
Testing of new technology	
Modeling and Data Analysis	
Optimization modeling/sensitivity studies (instrument density and locations)	17
Tsunami modeling studies	3
Studies to improve BPR (and other sensor) processing for tsunami, coseismic and seismic signals	3
Improve slip inversion methodologies	2
Investigate tsunami / earthquake assimilation schemes	2
Viability, utility and sensitivity tests of proposed network	
Analyze existing data more	
Implement/test the A. Newman tsunami earthquake discriminator algorithm	
Determine the methods that will be used to process data	
Cross-cutting model development risk versus time	
Requirements	
Methodology for delivering early warning needs to be defined	4
Goals/Assessment for EEW and TEW in terms of lives saved	3
Define system requirements	2
NAS style study	
Quantify science value	
Societal goals - public safety versus science	
Agreement on instrument priorities	
Engineering and Evaluation	
Cost/benefit analysis	6
Understand probabilities that seafloor equipment will survive earthquake - ground failure	3
Analysis of failure modes to improve reliability/robustness (number of shore landings)	3
SMART cable (cooperate with telecommunication companies)	2
Network design - best technological approach	2
Evaluation of sensor performance	2
Independent study of economic impact of EEW and TEW	2
Careful evaluation of sensors and platforms before integration	
Quantify latency of cabled and non cabled systems	
Concept designs of system that are transparent to new technology	
Engineering challenge	
Better understanding of hazards from submarine landslides	
Determine operational costs	
A good risk assessment	
Cost trade off studies	
Assessment of new network technologies	
General	

Broad education and idea socialization, selling system	4
Synergies with other observing goals (e.g., meteorology)	
Maintaining data consistency throughout project	
Develop equipment that is universally compatible	
See Jessie Saunders GPS poster	

Who are the stakeholders, particularly those groups not represented at this meeting?	
Comment	**Number (if >1)**
Public	
Public	13
Coastal communities and populations	10
Education and Outreach	2
Tourists	
Regional Media	
Schools	
Government	
Government	10
State/Provincial	8
Politicians	5
Coastal tribes / first nations	5
City managers / engineers	4
Federal Government	3
Local	3
County	2
Coastal jurisdiction (city/county)	2
Municipal	2
Coastal legislators	
Governor	
Civil Authorities	
Federal Agencies	
US Navy / Military	11
Tsunami Warning centers (Pacific & National)	7
FEMA	5
USCG	4
NSF	3
Authorities who issue warnings	3
National Weather Service	2
DoD	
Homeland Security	
NOAA	
USGS	
NASA	
Emergency Services	
Emergency planners/managers/responders	11
Civil Defense	2
Building code developers	
National Tsunami Hazard Mitigation Program (NTHMP) members	
West Coast Emergency Management	
Canadian provincial and federal emergency managers	
First responders	
State emergency services	
Non-governmental	
Non-scientific policy groups (NGOs, Academic)	3
Philanthropic Organizations (Moore, Schmidt)	3
Consortium for for Ocean Leadership	
Companies	
Insurance (reinsurance) industry	15
Power companies (e.g, PG&E), the grid	13
Tech companies (Microsoft, Amazon, Intel, Google)	11

Local companies (Microsoft, Boeing, Amazon)	8
Utility companies	6
Industry	5
Telecom	3
Chemical plants	
Finance and investment	
Maritime	
Port Authorities	5
Shippers	2
Maritime industry	2
Fisheries groups	
Infrastructure	
Transportation systems	4
Highway Agencies	2
Large automated systems	
Experts	
Science Community / Academia	6
Oceanographers	
Experts in communications, sensor interfaces, in situ repair	
Statistical data analysts	
Tsunami researchers	
International	
International Scientists	
United Nations	
Global community	
International tsunami warning centers	

How do we build a coalition who can advocate for the plan?

Comment	Number (if >1)
As we are doing now	
Leadership	
Find a leader to articulate the vision relentlessly for 10 years - politically savvy and technically knowledgeable	2
Need an interface person/people to bring academic, government and civil groups together	2
Need to develop a single voice (baseline agreement)	2
Small working groups for targeted efforts	2
Agree on a common goal	
Coastal groups benefit the most so they need to be part of the leadership	
Committee to adopt decisions based on science and stakeholder input	
Effective leadership and common vision	
Form an advisory committee with broad expertise and background	
Need a congressional united voice (CA, OR, WA, AK?)	
UW needs to take leadership role - oceanography/seismology	
Who is in the coalition?	
Cross-border collaboration - may disagree on technical issues or implementation models but not on principles	2
Approach as many stakeholders as possible	
Approach other organizations (e.g., NASA)	
Buy-in from emergency response agencies	
Clearly identify stakeholders	
Develop international collaboration	
Engage Industry	
Enlist influential people (B & M Gates, Allen, Elon Musk)	
Entrain scientists nationally so it is not just a regional science effort	
Get ear of higher ups in government agencies	
Identify key people and groups - multi-institution and multi-agency	
Industry representatives and input	
Involve scientists, emergency responders, engineers, and city planners	
Involve foundation	
Involve industry	
Involve members of selected communities	
Involve scientists from other fields who can benefit from infrastructure (oceanography)	
Multi-angle group	
Representatives from US + Canadian universities, government agencies, interested contractors to get realistic goals	
Representatives in USG, NOAA, NASA	
Collaborate with Oceanography community - vessels	
More collaboration (coercion) with OOI and ONC	
Who and How to Convince	
Develop and push public message about what is at stake	3
Outreach to public, show system will help them	2
Capture attention of legislators and media	
Convince congress of economic shock if unprepared	
Convince local people that lives will be saved and damage to infrastructure reduced	
Convince stakeholders who will benefit financially (e.g., insurance companies and infrastructure companies)	
Engage stakeholders to buy into cost/benefit argument	
Engage STEM teachers and schools	
Get science results that have societal relevance into public eye	
Leverage FEMA EEW bill	
Model effect on US if PNW goes down	
Tools to Convince	

Show what mitigation can do. What can you do with warning? How can this program assist with day to day activities and lives>	3
Movies like San Andreas	2
Start with demonstrations	2
Avoid sensational headlines	
Clone John Delaney	
Condense message into handful of 20-30 minute presentations	
Demonstrate benefits to science, education and public safety	
Demonstrate multi-use benefits, warning, science, telecom	
Demonstrate utility of land based system and show improvements from offshore component	
Develop emotional hook	
Full court press emphasizing destructive capabilities and infrastructural vulnerabilities	
National Academy of Sciences	
Outreach, communicate, campaign	
Emphasize that we do not understand hazard	
Know existing limitations - getting message out to coastal residents Is hard	
Communication	
Lots of communication	2
Communication	
Highlight successful science	
Need to build excitement	
Openness and more meeting to keep groups engaged	
Workshops	
Funding	
Major NSF/USGS/NOAA initiative	
Push NSF/NOAA/USGS to request $1M NAS/NRC study	
Will need a new body to develop plans and seek resources (quite common in Oceanography)	
Get buy in from stakeholders	
Some Steps to Take	
Choose a focus (e.g. tsunami warning) then identify stakeholders	
Clear mission that can be owned by stakeholders	
Imaging process from end to end	
Investigate previous earthquakes	
Quantify the risk, costs, values	
Build upon consensus around tsunamis	

Other thoughts, impressions or suggestions

Comment	Number (if >1)
Encouragement	
Great workshop or thanks for organizing	8
Hurry up!	
We need to do this	
Missing from this Workshop	
A lessons learned discussion was missing from workshop. Analyze existing networks (land and ocean)	
More bounded scenario planning (you have $50M, $100M, $500M, here are costs, optimize and compare cost/benefit)	
Not much emphasis on structure of incoming plate - need wide-angle seismic refraction studies	
Why wasn't Oregon State present?	
Bold or Cautious	
Be bold - understand inner space, entrance into oceans to prepare for search for life on other planets	2
Be more aggressive with opportunities (e.g., SMART cable)	
Develop implementation as staggered plan	
Grandiose S-Net / DONET plan is unlikely to gain traction. Plan for smaller cables focused on tsunamis that lead to the greatest loss of life	
Phased approach may be best	
What is the Goal	
Decide if goal EW or EW & science	
Focus on EW (science is secondary and complementary)	
Hard to balance science and warning	
Remember 2 primary goals EEW & TEW	
Real Time Data	
Don't overreach on science - much of it does not need to be real time	
Don't underestimate the power of real time data	
Design	
A hybrid or scaled approach that leverages existing capabilities may be more complementary to funders	
Cable is needed for EEW but not TEW	
Consider balance of uniform coverage with targeted monitoring	
Environmental sustainability of the offshore network installation	
EW system is not a science research infrastructure so needs to be implemented from an engineering point of view	
For EEW, keep it simple	
In-line cable system may be noisy due to rotation of cable	
Multidisciplinary systems (geodetic, pressure etc.) already exist so much R&D required	
Need optimization studies to balance cable length with science and monitoring goals	
Plan the best network possible but consider a multi-stage construction	
Shelf can be monitored from land so offshore system should focus on the near-trench region	
Think outside the S-net	
Future Technology	
Artificial Intelligence for deployment and repair of ocean networks - its coming	2
May need to rethink need for cables in 5-10 years time given advances in low power instrumentation and satellite bandwidth	
Plan for the future and not for current technology	
Engagement	
Build on interdisciplinary approach of this workshop	2
Public/community engagement and education	2
Any role for social media companies	
Be prepared to focus on the ports	
Engage foundations and telecom companies	
Go NASA route - emotional hooks and outreach	

More meetings (engage graduate students)	
Once we have a design (instrument locations) engage other science communities who can add their sensors	
Things to Remember	
Do not forget the difficult events (did M7.5 generate tsunami)	2
Need science plan for activities with system while waiting for big event (e.g., noise cross correlation monitoring, teleseismic events)	2
Emphasize efforts in other countries	
Need to develop data management plan	
Remember to consider what stakeholders are expecting	
What about edge cases / tsunami earthquakes	
Funding	
$300-400M is not a lot of money for the US. Industry might get on board	
Identify likely funder early on and plan for a long slog	
To build a strong case more data, more analysis and more modeling is needed	
International	
Are there formal opportunities for multinational research collaboration to understand SZ processes?	
NZ tsunami warning plan has 3 stages: Y or N, refining and confirmation (minutes); detailed analysis (10s minutes)	