

Intergovernmental Oceanographic Commission
Reports of Meetings of Experts and Equivalent Bodies



ICG/PTWS REGIONAL WORKING GROUP FOR THE SOUTHWEST PACIFIC

**Task Team on Seismic Data Exchange
in the South West Pacific**

First Meeting

Port Vila, Vanuatu,
19–20 October 2009

UNESCO

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- IV. LIST OF PARTICIPANTS
- V. TWO WAY DATA DISTRIBUTION SYSTEMS
- VI. LIST OF ACRONYMS AND ABBREVIATIONS

EXECUTIVE SUMMARY:

Attended by representatives from Fiji, Papua New Guinea, Samoa, Tonga, Vanuatu, Australia, China, New Zealand, CTBTO, IRIS, PTWC, SOPAC, IOC **the Task Team**, having met in Port Vila, Vanuatu on 19–20 October 2009, **agreed on the following Recommendations:**

Technical:

- 40 Hz, 3 channel, 20 second latency, Broadband.
- Countries are responsible for communications to national data centers and their data hub.
- All networks should consider joining the FDSN.
- Establish a data server in each country using SEEDLink for data ingestion and export.
 - Need multiple telecom solutions (VSAT, Internet, GPRS, radio modems, etc.)
- All broadband data to IRIS/FDSN (QC and data sharing, data curation).
 - Stress the need for collaboration with donor networks.
 - Inform networks of those that access network data.
 - References will be given to data sources.
- PTWC gets data from IRIS.
- Countries can run “virtual networks” by getting extra data from IRIS, CTBTO and other concentrating nodes.
 - Countries can pull any available data from SEEDLink servers from any of the concentrating nodes.
- Seiscomp3 or similar required (for data processing).
 - GFZ had made an offer to provide Seiscomp3.
- A variety of other display, analysis packages, is available and work with SEEDLink protocol (seisgram2K, etc).
- Training required (many potential providers).
 - Needs coordination on type of training and between CTBTO, GEOFON, IRIS, and others.
- Similar effort required for sea level monitoring.
- Continued coordination is necessary after initial data exchange is established.
- Find out status of Geoscope NOC station in New Caledonia.

The Task Team agreed on the following Actions:

- Summary of various analysis systems:
 - Seiscomp3, Antelope, Earthworm, Hydra,
- Summarize available data communication solutions and issues
 - Vsat, GPRS, Internet, radio modems.
- Summary of two way data distribution systems.
- Training recommendation needs to be scoped out.
- Complete development of turnkey system for SeedLink. Countries responsible for providing miniSEED.
- Each country will provide an inventory of existing and planned stations and their characteristics including sample rate, number of channels.
- Contact Pacific 21 program to see if real time data can be made available to SW Pacific Region.
- Get information about current status in Solomon Islands.

1. WELCOME AND OPENING OF THE MEETING

The Task Team meeting was convened at 9:15 a.m. on 19 October 2009 at the Hotel Chantilly's on the Bay, Port-Vila, Vanuatu. The Chair, Ken Gledhill welcomed the participants and asked Suzanne Paisley, UNESCO Office, Apia to detail the logistics. The Chair recalled that with Recommendation ICG/PTWS-XXIII.7 the Task Team on Seismic Data Exchange in the South West Pacific had been established (Annex III).

All participants introduced themselves. All presentations will be collected and shared with participants at the end of the meeting. They are also available at:

→ http://ioc-unesco.org/index.php?option=com_oe&task=viewEventDocs&eventID=495

Peter Koltermann, Head of the Tsunami Unit of the Intergovernmental Oceanographic Commission of UNESCO, welcomed all participants. He emphasized the vulnerability of coastal populations to natural hazards and the responsibility for all nations to be prepared for and to protect the most vulnerable communities from natural disasters. He reiterated the recognized need to enhance the regional seismic networks to better detect earthquakes, and to process these data adequately and timely, particular in regions like the Southwest Pacific with the high risk of strong local and regional potentially tsunamigenic earthquakes. This meeting was convened to address the underlying technical issues, which also cover the need to make all available seismic data accessible to all institutions in the region for their own monitoring and interpretation.

The meeting of the PTWS Regional Working Group V in Apia, Samoa, 16–18 February 2009 had concluded that enhancements of the observational networks, i.e. of sea level and to seismological observations in the SW Pacific Region were of paramount importance.

2. PTWC REPORT

Stuart Weinstein, Assistant Director of PTWC, reviewed the mandate and operations of the PTWC. The PTWC provides basin-wide alerts for Pacific countries, including the SW Pacific. For the SW Pacific, there are two unique challenges:

- (i) It is estimated that it takes 4-6 minutes longer to characterize the earthquake due to the sparse seismic network;
- (ii) The region is also an area where modest size earthquakes can cause destructive local tsunamis, suggesting that the warning thresholds should be lower than the threshold for basin-wide warnings.

He summarized the events served by PTWC over the last month. These included the Samoa tsunami (29 Sep), Padang earthquake (30 Sep.), Vanuatu (7 Oct., Mw7.7), and Santa Cruz (7 Oct., Mw7.8).

He reviewed the timeline for the 29 September 2009 event in Samoa, highlighting when data was received and actions taken. Sea level gauges provided immediate confirmation of tsunami arrival time and wave characteristics in Pago Pago and Apia harbours. The marigrams and tsunami measurements were posted to the Tsunami Bulletin Board on 29 and 30 September. The earthquake was a normal fault, causing in general a draw-down (receding wave) to be observed as the 1st wave.



Participants of the Task Team Meeting in Port Vila, Vanuatu

Suzanne Paisley reported that along the south coast of Upolu, Samoa, for those that already knew about tsunamis, the recession of the wave was recognized and heeded as a natural warning; when this was seen, people knew to immediately evacuate.

DISCUSSION

Highlights include the following:

- Continuing need for accurate magnitudes as soon as possible – more data are needed;
- Minimum latency for data, after which not useful – 20-30 sec. adequate (2-3 min not useful). Seismic characterization continues for 30-45 minutes after the event to incorporate later arriving phases;
- Issuance of local warnings; should be done within 3-6 minutes of event requiring more data; best done by a regional or local centre which can use lower thresholds.

3. COUNTRY PRESENTATIONS

3.1 FIJI REPORT – LASARUSA VUETIBAU, MINERAL RESOURCES DEPARTMENT

Current systems use Nanometrics systems. For data transmissions Fiji is currently using VSAT KU-Band, but in the future will upgrade to C-Band (701 C-Spot) used by Tonga in order to share data with Tonga. Both countries would receive data directly from field. To date three stations have been completed (civil works).

Fiji would like to share data with everyone.

DISCUSSION

Fiji questions are:

- How to transmit to PTWC?
- How to transmit to IRIS? – SEEDlink was decided and endorsed in Feb. 09 by SWP WG;
- CTBT station use;
- How many stations should be contributed (minimum number or all). Redundancy is essential. More is better. The Chair reminded everyone that the Task Team endorses international data sharing and collaboration;
- Data Sharing and Policy — Fiji would like to be involved if data is used to do research. New Zealand reported that it has an open data policy with caveats, e.g., conditions. The worst case (once) was that a 2nd party received data from a 1st party, and 1st party did not inform the 2nd party on the conditions. IRIS reported that for all data received (and shared), it asks for citation; emails quarterly reminding data receivers of the data source, and provides a report to the data source.

PTWC reported that it had investigated possible transmission methods:

- Add specific modems at each site;
- In Fiji and Tonga, each transmit on channel outwards – disadvantage is that it incurs additional transmit segments;
- Most viable – New Zealand as a data centre and then outward or distribution via IRIS.

Costs:

Depends on coverage wanted. Global is the most expensive (low power).
Regional bands would cost less and be able to transmit at higher power.

3.2 PAPUA NEW GUINEA REPORT – LAWRENCE ANTON PORT MORESBY OBSERVATORY

Most PNG tsunamis have been generated by earthquakes, either co-seismically or by submarine slumps caused by earthquake shaking. The 1998 Aitape Tsunami was caused by slumping due to shaking associated with a magnitude 7.1 earthquake. Some tsunamis have been generated by volcanic activity. The 1888 Ritter Island volcanic cone collapse caused a tsunami which devastated the northern New Guinea coastlines, and killed thousands of inhabitants. The tsunami was devastating locally on Umboi (Siassi) Island and neighbouring islands, and on New Britain Island.

For the Warning System a SOP has been developed that for ideally would cover:

Immediate 24/7 operation:

Activate shift operations, for example two watch-standers nightly, have the means to incorporate allowance or remuneration system, include in Duty Statements where possible, complete recruitment into available positions, fast track seismic network project, assist NDC enhance linkage to PMGO and provinces. It would have PC and software for TW tools to assist

24/7 operation, ensure an automated system including dedicated internet connection and dedicated PCs for seismic and tide gauge data retrieval and analysis. Issues are budgetary assistance, improve on existing facilities and sustained funding source.

There is currently a skeleton network of seismic stations which forms a system to monitor local earthquakes, although the system does not meet the requirements for early warning of tsunamis. A small number of tide gauges are in use but they are not configured for tsunami monitoring. Tide Tools by ITIC and PTWC are welcomed here but, state government commitments for better hardware and internet are a must.

Inadequate monitoring equipment has resulted in poor monitoring of earthquakes and inadequate response to tsunami events. We currently rely on the Pacific Tsunami Warning Centre (PTWC), for earthquake information and tsunami bulletins (advisory, watch and warnings) for events that occur anywhere in the Pacific basin. For such events, we in PNG will have time to issue warnings to coastal communities, authorities and news media. For example, the tsunami generated by the 1960 Chilean Magnitude 9.5 (Mw 8.2) Earthquake which took almost 24 hours to reach PNG, and the Samoan tsunami of 29 September 2009 which was to take 5 hours to arrive in PNG.

PNG is also a beneficiary of the West Coast/Alaska and Northwest Pacific Tsunami Information Centre (Japanese Meteorological Agency) tsunami warning systems, and hopefully soon the ATWC.

For locally generated tsunamis, we advise local coastal communities through continuing awareness that the best warning of a tsunami may be the earthquake shaking itself. Tsunamis resulting from local earthquakes do not take long to strike coastlines, thus making it almost impossible to issue an effective warning. For example, the Aitape Tsunami of 1998 occurred about 20 minutes after the magnitude 7.1 earthquake nearby. It is also known from our historical records that much smaller earthquakes have generated tsunamis in PNG. In 1930, a 10.5 meters tsunami was generated by a magnitude 5.8 earthquake which occurred in the Bismarck Sea.

Needs were identified as the replacement of the Seismic Network:

- Twelve seismic stations, of both broadband and short period, including ATWS stations, and possibly others in the region;
- Near real-time data acquisition, having an appropriate communication system;
- Possibly VSAT, &/or ADSL;
- Appropriate data analysis software;
- Proper communication system for secure and safe information dissemination.

DISCUSSION

The definition and use of the term 'real-time' was discussed. For seismologists, all data has some latency (delay), which might be greater for teleseismic data (such as 20 seconds for IRIS distributions) or less for local data (such as 100 sps data continuously fed). Thus, the preference of 'near real-time'.

However, for politicians, the term 'near real time' would have negative consequences since it would lower the priority of action. It is preferred to use the term 'real-time' as a requirement.

3.3 SAMOA REPORT – SIOSINA LUI, GEOPHYSICS, SAMOA METEOROLOGICAL DIVISION

She provided a summary of the activities, including AFI and Samoa Lithospheric Integrated Seismic Experiment (SLISE), (3 stations in Samoa, 1 in American Samoa). The SLISE project has data downloaded every 6 months, and is currently in the 2nd year of 5 year project.

Samoa policies are:

- Samoa wants to develop national capacities, acknowledging contributions from China, and to contribute to the international community through data sharing. Site Surveys continuing this week with CEA;
- Samoa supports establishment of SWP Tsunami Warning Centre.

Challenges:

- Communications infrastructure (hardware and software);
- Long-terms sustainability – need technical and other support.

DISCUSSION

Data Sharing – NIED suggested using the same satellite. CEA responded that it will provide data to Samoa, and then afterward, Samoa can share and do as it would like.

CEA suggests that within a country it goes to central centre and then out.

Sustainability — SOPAC emphasized sustainability, especially as some are small islands with limited resources and skills development may take some time. ITIC highlighted the consideration of ‘cheap’ means of data sharing, such as through the internet and using hubs for distribution (such as IRIS DMS or a SEEDlink server run by a country in the region). IRIS indicated that cell modems have been used for in-country data transmissions successfully and at modest costs.

For the US Transportable Array, IRIS is using GPRS for all data transmission; other examples are available. Initially, such continuous use was blocked (i.e., data transfer limitations), but eventually removed since it was found not to be a problem.

3.4 SOLOMONS REPORT — BOBBY KELLY, SENIOR SEISMOLOGICAL OFFICER, MINISTRY OF MINES, ENERGY AND RURAL ELECTRIFICATION, SOLOMON ISLANDS

Bobby Kelly, representing the Solomon Islands, was finally unable to attend. No report available.

3.5 TONGA REPORT – KELEPI SEULI MAFI, MINISTRY OF LANDS, SURVEY AND NATURAL RESOURCES, TONGA

Kelepi Seuli Mafi stressed the importance of inter-island seismic data-sharing, and concurred with the presentation jointly prepared with Fiji.

3.6 VANUATU REPORT — ESLINE GARAEBITI, DEPT OF GEOLOGY, MINES AND WATER RESOURCES

She reviewed the existing systems and the plans for the future. The needs are to monitor active volcanoes, earthquakes, and tsunami warning. She summarized the actions taken for the 7 Oct. 2009 earthquake and small tsunami.

The plan for Vanuatu includes 9 stations on different islands for earthquake and volcano monitoring, 5 BB and 5 SP. Transmission by VSAT and GPRS (mobile) where possible since it is lower cost. The mobile service is provided by Digicel which has good national coverage. GPRS may not be able to support full transmission of waveform data.

Port Vila station — accelerator installed and to be placed in the basement of new Met bldg. planned for August 2010. STS-1 was damaged (being reviewed now to see if possible to fix), so probably STS-2 to be installed.

MMT (Geoscope) is being upgraded to real-time using landline.

VSAT (6 stations) — Initial capital costs high (depends on dish size), as well as maintenance – KU band were cheaper, C band much more expensive.

Vanuatu quote from Nanometrics — \$ 6,000/year for 10 stations with costs mostly from VSAT space segment transmission. Nanometrics systems are as cheap as can be since you are just paying them for segment – if you go to provider directly, much more expensive.

4 SEISMIC NETWORK PRESENTATIONS

4.1 IRIS REPORT – TIM AHERN, DATA MANAGEMENT SYSTEM HEAD

An introduction to IRIS was given, specifically its mission, scope and partners, and services, including data serving (receiving, transmitting, archiving). In August 2009, there was data from 1926 stations being received by IRIS, dominated by US Transportable Array programme. From the IRIS GSN perspective, the coverage is acceptable since coverage is specified at 2,000 km spacing.

The DMS provides extensive data serving through user-driven, automated, and customizable scripts through its BUD data serving tool. Data quality assurance tools and reports (standard and customizable, and can be subscribed to) is provided through QUACK. Probability Density Plots are useful summaries of each station over time. All basic tools and script-making are automated to enable efficiency, and to maximize information and reporting to enable the network operators to take action to solve any problems.

IRIS is also involved in:

- Metadata management;
- SeisComp3 — consider support to meet other gaps that DMS sees as important;
- Other software and products;
- Data serving and metadata workshops

Summary:

- Large capacity — free and open, no charge, archives;

- Active Archive — high availability; GSN – 85% nominally for global network, web tools available that users can use to find out about data availability;
- Real Time data re-distribution that is quality controlled — latency related to packet-building through SEEDlink.

DISCUSSION

- Capacity building is needed. IRIS often runs training on data formats and management;
- Latency — 20 sec. (20 sps) OK for global, but 5 sec. better for local/regional. Depends on packet size (for each there is a technical solution, though it may be cost-prohibitive) Antelope – 1 sec. packets, but it is expensive; SEEDlink results in 20 sec. latency.

4.2 CTBT REPORT – LASSINA ZERBO, INTERNATIONAL DATA CENTRE, HEAD

He informed the Group about CTBT activities and how data can be accessed by national data centres (state signatory) or as the national tsunami warning centre for the country. Data, including the auxiliary stations, are available. For WG B, Siosina Lui/Samoa is the contact from this region and can help to inform others in the region. Next year, perhaps another person from the region can be invited to participate.

Another contribution from CTBT would be for capacity building, for tsunami and other disasters. It is committed to working with partners, such as IRIS and UNESCO/IOC when conducting training.

Requests to service@ctbt.org should be made officially to Provisional Technical Secretariat (PTS), who can then address the request and take action. They do not work 7x24 but the data is available. Spiro Spiliopoulos/CTBTO will be point of contact for data access, availability and other needs from the SW Pacific. Users are also requested to provide feedback on the value of the data (how is it used, how timely, how reliable).

CTBT is willing to commit resources to improve the data availability (compatibility). CTBT is also planning to set up a PTWS virtual data centre for non-NDCs (and others); for instance for IRIS DMC, it is for QA/QC of data streams, or for others involved, such as UC/Berkeley (Livermore, Los Alamos, China), for research purposes. At some time in the future, full access to data is a goal, but it will take a long time.

DISCUSSION

- Continuous, real-time data streams from auxiliary stations are available for National Tsunami Warning Centres (but not NDC) stations.

4.3 AUSTRALIA REPORT — TIM BARTON, GEOSCIENCE AUSTRALIA (GA)

He described the requirements of the ATWS for tsunami warning, specifically on data networks required (many international contributors, azimuthal coverage important), and communications systems. For communications, it is both old and modern technology, including mobiles and ADSL (requires fixed IP), VPN from satellite providers (limitation is lack of power), radio, internet (bulk, 200+ stations). GA (200 stations by direct send, Canberra) has mirror sites in BOM (180 stations by direct send, 40 by conventional methods). GA is collaboratively helping the community to do any maintenance if needed, especially since travel to sites is expensive.

In the Pacific, GA has installed Niue, upgraded Norfolk, Lord Howe, Kiribati, and is doing two new stations in PNG, and still planning for Timor Leste.

Issues to consider:

Communications (examples):

- \$834/site (\$10K/year/site) for VSAT up and downlink, and return to Australia by internet, 40 sps, 3 channels BB data, 1.8 m dish => .8 to 1 Gb data/month – amount possible is usually related to limitations on regulatory issues in countries. The advantage is in reliability, but it costs money;
- \$ 60/month, 20 sps, by mobile for data transmission, which is usually affordable.

Data Quality essential:

IRIS tools are very useful (QUACK).

Network Installation Requirements:

- Communications (suggested that IRIS has been critical for data ingestion and re-transmission);
- Power (independent power, such as solar);
- Security.

Australia can offer:

- Capacity Building;
- Support for IRIS stations or other maintenance if passing through the area;
- Money is not really available anymore.

DISCUSSION:

- Suggestion: grab whatever data are available, and in different ways to minimize capability;
- For local or regional location, 40+ sps needed – 20 sps not adequate. (OK for global studies);
- Additionally, the quality of the station affects whether good data can be made available;
- Capacity Building at various levels and with different contents is being offered by a number organizations (IRIS, CTBT, Australia, others). Understanding who should be attending is essential, so knowledgeable vetting is needed.

Internet by satellite is more cost-effective than direct bi-lateral data sharing linkages for specific stations. Fundamental limitation is bandwidth non-availability.

4.4 NEW ZEALAND REPORT – KEN GLEDHILL, GNS SCIENCE, GEONET PROJECT DIRECTOR

New Zealand has a network of almost 56 channel (broadband and strong motion) stations sampled at 100 sps. All this data is available via a seed link server. Additionally, we have more than 120 short period (3D) stations in areas of higher risk and more than 200 strong motion stations.

50 VSAT links – \$ 350 to \$ 400 Australian/month.

Currently digitizing at 100 sps, but could down-sample to lower sampling rate for distribution.

DISCUSSION:

- Technical performance and details: Required data rates are a few kbps for 3-component broad band data (say 2 – 3 kbps for 3-component, 40 sps);
- Latency – definition needed – review PTWS WG Recommendations (suggest 20 seconds maximum);
- Seismic monitoring minimum standard suggestions:
 - Sampling rate: For regional earthquakes 40 sps is minimum; 3-component.
 - Maximum latency 20 seconds; for local earthquakes 100 sps is recommended.

5 SEISMIC SOFTWARE SOLUTIONS

5.1 SEISCOMP3 REPORT – WINFRIED HANKE, GFZ, AS PRESENTED BY KEN GLEDHILL

The Chair presented a presentation provided by GFZ offering SeisComP3 installation and training. Training includes support for trainers, but not for computers. Funding is limited to the first half next year. *[Note: this training workshop entitled “International Workshop on Seismology, Seismic Hazard and Tsunami Early Warning” was held from 12 July to 23 July 2010 in Suva/Fiji and was sponsored by Foreign Ministry of the Federal Republic of Germany.]*

DISCUSSION

NZ indicated from experience, 1 week of training is sufficient for installing SeisComP3, but not for understanding and using it on a day-to-day basis.

A collaborative effort at the IRIS Metadata workshop with SeisComP3 is an option. NZ may be able to help.

5.2 DISCUSSION

A lengthy discussion evolved on general and specific issues of software – what to use and how to train. This is summarized in the conclusions of the meeting.

6 COUNTRY-SPECIFIC OBJECTIVES MERGED WITH SEVEN PRACTICAL ARRANGEMENTS FOR SEISMIC DATA EXCHANGE

The questions for each country are similar:

- What they are trying to do?
- What are impediments?

Needs: Can countries supply data in SEEDlink format?

Fiji / Tonga: Need assistance:

- To transmit data to PTWC in real time and for SEEDlink implementation (software).

Vanuatu: Need help to guide technical requirements and implementation:

- Will build a network that enables data sharing – same solution as in Samoa;
- Run a data centre in Port Vila, then make available to others (Fiji, Tonga, PTWC, etc.) include data use policy, such as mentioned by Fiji and an example given from IRIS.

Papua New Guinea: Happy to share and SEEDlink server is part of planning, need assistance.

China: Suggested a data centre located in the region.

IRIS: Can provide two-way generic software so there is commonality, could do so within a few weeks.

SEEDlink is acceptable protocol – SeisComP3, Earthworm, HYDRA (1.47) can use it. SEEDlink server is used at the IRIS DMC, suggest national data centres use it, and then distribute by internet. VSAT should be still encouraged since it provides redundancy.

CTBT / IRIS coordinate to conduct training on data formatting /metadata and extend training to all regions globally.

Installation of stations:

Fiji-Tonga
Fiji converts to C-Band (June/July 2010)

7 FUTURE DEVELOPMENTS

The Chair reviewed the comments, expressed needs and commonalities aired at the meeting. He identified as basic issues:

- Financial and technical sustainability;
- Joint training at the regional level to ensure common standards to solicit effective technical assistance;
- Investigate the feasibility of a regional seismic data centre or hub in the region;
- Common data sharing for the benefit of all participants.

The Chair recognized the success of this 1st meeting of the Task Team that will have to follow through in detail recommendations and actions. He was confident that as a first step the ground has been laid to enable tsunami warning services in the region to improve their monitoring and assessment activities. In view of the very short lead time in the region this was important to build on for effective warning systems and warning dissemination.

8 DISCUSSION AND ADOPTION OF THE REPORT

The Chair presented the recommendations that had been jointly developed and finally agreed (Annex II). The need for considerable and sustained support from outside the region was confirmed, recognizing the support already available. He also noted the need for consolidating the seismic data streams in the region, and potentially to develop a concept for a regional seismic centre in the region. A common approach will help to optimize nationally available and other incoming resources and to harmonize technical capabilities in the region.

9 CLOSURE

The Chair thanked all participants for their valuable and active participation. He acknowledged the interest, presence and support of several organizations. He finally asked Esline Garaebiti to convey the thanks of the Task Team to the Vanuatu authorities for giving all the opportunity to meet in Port Vila and enjoy the hospitality and scenery of Vanuatu.

ANNEX I

TIMETABLE/AGENDA

First Meeting of the PTWS Task Team on Seismic Data Exchange in the South West Pacific

Port Vila, Vanuatu
19–20 October 2009

PROVISIONAL TIMETABLE

Hour	Monday 19 October	Hour	Tuesday 20 October
8.00 – 9.00	Registration, logistics		
9.00– 13.00	1.WELCOME AND OPENING Ken Gledhill, Chair Peter Koltermann, IOC/TSU 2.PTWC Report 3.Country Presentations 3.1 Fiji 3.2 Papua New Guinea 3.3 Samoa	9.00 – 13.00	6.Country Specific Objectives 7.Practical Arrangements for Seismic Data 8.Future Developments
13.00 – 14.00	LUNCH BREAK	13.00 – 14.00	Lunch break
14.00 – 17.30	Country reports cont. 3.4 Solomon Islands 3.5 Tonga 3.6 Vanuatu 4. Seismic Network Presentations: IRIS CTBTO Geosciences Australia 5. Seismic Software Solutions		9.Discussion and Adoption of the Report 10.Closure

ANNEX II

RECOMMENDATIONS

PTWS/SWP Seismic Data Sharing Task Team, 19-20 Oct 2009, Port Vila, Vanuatu

Attended by representatives from Fiji, Papua New Guinea, Samoa, Tonga, Vanuatu, Australia, China, New Zealand, CTBTO, IRIS, PTWC, SOPAC, IOC the Task team agreed on the following Recommendations:

- 40 hz, 3 channel, 20 second latency, Broadband.
- Countries are responsible for communications to national data centres and their data hub.
- All networks should consider joining the FDSN.
- Establish a data server in each country using SeedLink for data ingestion and export.
 - Need multiple telecom solutions (VSAT, Internet, GRSM, radio modems, etc).
- All broadband data to IRIS/FDSN (QC and data sharing, data curation).
 - Stress the need for collaboration with donor networks.
 - Inform networks of those that access network data.
 - References will be given to data sources.
- PTWC gets data from IRIS.
- Countries can run “virtual networks” by getting extra data from IRIS, CTBTO and other concentrating nodes.
 - Countries can pull any available data from SeedLink servers from any of the concentrating nodes.
- Seiscomp3 or similar required (for data processing).
 - GFZ had made an offer to provide Seiscom3.
- A variety of other display, analysis packages, is available and work with SeedLink protocol (seisgram2K, etc).
- Training required (many potential providers).
 - Needs coordination on type of training and between CTBTO, GEOFON, IRIS, and others.
- Similar effort required for sea level monitoring.
- Continued coordination is necessary after initial data exchange is established.
- Find out status of Geoscope NOC station in New Caledonia (P. Koltermann).

The Task Team agreed on the following Actions:

- Summary of various analysis systems (Peter K.).
 - Seiscomp3, Antelope, Earthworm, Hydra.
- Summarize available data communication solutions and issues (Tim Barton).
 - Vsat, GPRS, Internet, radio modems.
- Summary of two way data distribution systems (T. Ahern).
- Training recommendation needs to be scoped out. (L. Zerbo, W. Hanka, T. Ahern, S. Weinstein, L. Kong, M. Yamamoto).
- Complete development of turnkey system for SeedLink. Countries responsible for providing miniSEED. (T. Ahern).
- Each country will provides an Inventory of existing and planned stations and their characteristics including sample rate, number of channels (K. Gledhill).
- Contact Pacific 21 program to see if real time data can be made available to SW Pacific Region (T. Ahern).
- Get information about current status in Solomon Islands (L. Kong).

ANNEX III

Recommendation ICG/PTWS-XXIII.7

SEISMIC DATA EXCHANGE IN THE SOUTH WEST PACIFIC

The Intergovernmental Coordination Group for the Pacific Tsunami Warning and Mitigation System,

Acknowledging that a sessional meeting held during ICG/PTWS-XXIII discussed the matter of sharing of seismic data in the South West Pacific, and

Noting reports from China, Japan and Australia on plans to establish seismograph stations in the South West Pacific region over the period 2009-2010, where as some Pacific Island countries have already applied for such support and others are in the process of requesting support, and

Noting that concerned members expressed their willingness to share seismic data, and that data from stations installed by Australia is available directly from Geoscience Australia or from IRIS via the Seedlink protocol,

Recognising that technical issues (such as data exchange protocols and data bandwidth) will need to be addressed in order to achieve data sharing,

Noting that data from seismograph stations is useful for research and earthquake catalogue creation and not just tsunami warning,

Recognising Recommendation ICG/PTWS-XXII.1 on Sea-Level Measurement, Data Collection and Exchange,

Agrees that South West Pacific countries with existing or planned broadband seismograph stations share the data in real-time with their neighbours and internationally, including making the data available to Tsunami Warning Centres,

Encourages South West Pacific countries with existing or planned broadband seismograph stations to join FDSN, use the standards developed by FDSN for data exchange and take advantage of the data archiving provided by FDSN,

Decides that a Task Team be formed under inter-sessional Working Group 2: Detection, warning and Dissemination to assist South West Pacific countries achieve data sharing,

Agrees that the Terms of Reference for the Task Team are:

1. To advocate seismic data sharing in the region;
2. To advise South West Pacific countries on data sharing protocols, techniques and technologies;
3. To work with SWP countries and donors to ensure a common data sharing policy;
4. To ensure the recommendations of the ICG/PTWS-XXIII Sessional Working Group on Data Exchange in the South West Pacific are achieved.

Requests that donors are encouraged to help South West Pacific countries achieve data sharing in coordination with the proposed Task Team.

ANNEX IV

LIST OF PARTICIPANTS

PTWS Task Team on Seismic Data Exchange in the South West Pacific

First Meeting of the Task Team
(Port Vila, Vanuatu, 19–20 October, 2010)

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ANNEX V

TWO WAY DATA DISTRIBUTION SYSTEMS SOUTHWEST PACIFIC SEISMIC DATA EXCHANGE TASK TEAM

Introduction: Seismic data used in monitoring tsunamigenic events are normally distributed in one of two formats. The requirements identified at the Task Team meeting in Vanuatu were: 1) data distribution in miniSEED format, 2) data streams sampled at 40 samples per second, and 3) with latencies on the order of 20 seconds. The International Federation of Digital Seismograph Networks (FDSN) developed and supports the Standard for Exchange of Earthquake Data (SEED) format. This format clearly specifies the metadata and waveform data requirements and is documented in the SEED manual (Ref: http://www.iris.edu/manuals/SEEDManual_V2.4.pdf). The Comprehensive Test Ban Treaty (CTBT) Organization utilizes a format based on the CSS 3.x data format. Both of these communities provide support and real time distribution of data within seismic networks and these systems are in a mature state.

SeedLink: The most widely used exchange mechanism in use by multiple organizations is built upon the SeedLink protocol pioneered by the GFZ group in Potsdam. This protocol is straightforward to implement. It is limited to time series data in miniSEED format. It is a First-In-First-Out (FIFO) format but would meet latency requirements in the SW Pacific. SeedLink obviously will meet the data exchange needs in the SW Pacific. It is possible to produce a turnkey system to install SeedLink servers at any of the seismic networks in the SW Pacific region.

CD1.1: The CTBTO utilizes the Continuous Data 1.1 (CD1.1) protocol for real time data distribution. This system is a Last-In-First-Out (LIFO) protocol. It requires access to software contained in the CTBTO's Data Centre in a Box package but is easily released to states parties. It is an inherently different format from SeedLink and SEED and will require conversion into the SEED format. These conversion utilities exist and would not be a significant impediment. The protocol would support data rates and latencies identified by the task team. While either approach can meet the needs of the SW Pacific Data Exchange team, it appears that the SeedLink protocol is most closely aligned with the team's needs.

The Proposed Model: The model that evolved at the SW Pacific Data Exchange Meeting acknowledged the limited bandwidth available in the region. For this reason it was proposed that each network would send their data one time to a data concentration centre and specifically to the IRIS DMC. Each of the networks would then draw desired data from other networks in the region or other seismic networks from the concentration centre. The protocol would be SeedLink. Concentrating the data at the IRIS DMC will provide value added services such as quality assurance of data, redistribution of the data to the global seismological research community, and complete data curation and data backup services.

ANNEX VI

LIST OF ACRONYMS AND ABBREVIATIONS

FDSN	Federation of Digital Broad-Band Seismograph Networks
GPS	Global Positioning System
GTS	Global Telecommunication System
ICG	Intergovernmental Coordination Group (UNESCO/IOC)
IRIS	Incorporated Research Institutions for Seismology
IOC	Intergovernmental Oceanographic Commission (of UNESCO)
ISDR	International Strategy for Disaster Reduction (UN)
ITIC	International Tsunami Information Centre
JCOMM	Joint WMO/IOC Technical Commission for Oceanography and Marine Meteorology
NGO	Non-Governmental Organizations
NMHS	National Meteorological and Hydrological Services
NOAA	National Oceanographic Atmospheric Administration (USA)
NWS	National Weather Service
PTWC	Pacific Tsunami Warning Center
SeisComP	Seismological Communication Processor
SLISE	Samoa Lithospheric Integrated Seismic Experiment
SOP	Standard Operating Procedures, or SOP Workshops
TNC	Tsunami National Contact
TWS	Tsunami Warning System
TWFP	Tsunami Warning Focal Point
UN	United Nations
UNDP	United Nations Development Programme
UNESCO	United Nations Educational, Scientific & Cultural Organization
UNGA	United Nations General Assembly

USGS	United States Geological Survey
WCDR	World Conference on Disaster Reduction
WMO	World Meteorological Organization

In this Series, entitled

Reports of Meetings of Experts and Equivalent Bodies, which was initiated in 1984 and which is published in English only, unless otherwise specified, the reports of the following meetings have already been issued:

1. Third Meeting of the Central Editorial Board for the Geological/Geophysical Atlases of the Atlantic and Pacific Oceans
2. Fourth Meeting of the Central Editorial Board for the Geological/Geophysical Atlases of the Atlantic and Pacific Oceans S. Fourth Session of the Joint IOC-WMO-CPPS Working Group on the Investigations of 'El Niño' (**Also printed in Spanish**)
4. First Session of the IOC-FAO Guiding Group of Experts on the Programme of Ocean Science in Relation to Living Resources
5. First Session of the IOC-UN(OETB) Guiding Group of Experts on the Programme of Ocean Science in Relation to Non-Living Resources
6. First Session of the Editorial Board for the International Bathymetric Chart of the Mediterranean and Overlay Sheets
7. First Session of the Joint CCOP(SOPAC)-IOC Working Group on South Pacific Tectonics and Resources
8. First Session of the IODE Group of Experts on Marine Information Management
9. Tenth Session of the Joint CCOP-IOC Working Group on Post-IDOE Studies in East Asian Tectonics and Resources
10. Sixth Session of the IOC-UNEP Group of Experts on Methods, Standards and Intercalibration
11. First Session of the IOC Consultative Group on Ocean Mapping (**Also printed in French and Spanish**)
12. Joint 100-WMO Meeting for Implementation of IGOSS XBT Ships-of-Opportunity Programmes
13. Second Session of the Joint CCOP/SOPAC-IOC Working Group on South Pacific Tectonics and Resources
14. Third Session of the Group of Experts on Format Development
15. Eleventh Session of the Joint CCOP-IOC Working Group on Post-IDOE Studies of South-East Asian Tectonics and Resources
16. Second Session of the IOC Editorial Board for the International Bathymetric Chart of the Mediterranean and Overlay Sheets
17. Seventh Session of the IOC-UNEP Group of Experts on Methods, Standards and Intercalibration
18. Second Session of the IOC Group of Experts on Effects of Pollutants
19. Primera Reunión del Comité Editorial de la COI para la Carta Batimétrica Internacional del Mar Caribe y Parte del Océano Pacífico frente a Centroamérica (**Spanish only**)
20. Third Session of the Joint CCOP/SOPAC-IOC Working Group on South Pacific Tectonics and Resources
21. Twelfth Session of the Joint CCOP-IOC Working Group on Post-IDOE Studies of South-East Asian Tectonics and Resources
22. Second Session of the IODE Group of Experts on Marine Information Management
23. First Session of the IOC Group of Experts on Marine Geology and Geophysics in the Western Pacific
24. Second Session of the IOC-UN(OETB) Guiding Group of Experts on the Programme of Ocean Science in Relation to Non-Living Resources (**Also printed in French and Spanish**)
25. Third Session of the IOC Group of Experts on Effects of Pollutants
26. Eighth Session of the IOC-UNEP Group of Experts on Methods, Standards and Intercalibration
27. Eleventh Session of the Joint IOC-IHO Guiding Committee for the General Bathymetric Chart of the Oceans (**Also printed in French**)
28. Second Session of the IOC-FAO Guiding Group of Experts on the Programme of Ocean Science in Relation to Living Resources
29. First Session of the IOC-IAEA-UNEP Group of Experts on Standards and Reference Materials
30. First Session of the IOCARIBE Group of Experts on Recruitment in Tropical Coastal Demersal Communities (**Also printed in Spanish**)
31. Second IOC-WMO Meeting for Implementation of IGOSS XBT Ship-of-Opportunity Programmes
32. Thirteenth Session of the Joint CCOP-IOC Working Group on Post-IDOE Studies of East Asia Tectonics and Resources
33. Second Session of the IOC Task Team on the Global Sea-Level Observing System
34. Third Session of the IOC Editorial Board for the International Bathymetric Chart of the Mediterranean and Overlay Sheets
35. Fourth Session of the IOC-UNEP-IMO Group of Experts on Effects of Pollutants
36. First Consultative Meeting on RNODCs and Climate Data Services
37. Second Joint IOC-WMO Meeting of Experts on IGOSS-IODE Data Flow
38. Fourth Session of the Joint CCOP/SOPAC-IOC Working Group on South Pacific Tectonics and Resources
39. Fourth Session of the IODE Group of Experts on Technical Aspects of Data Exchange
40. Fourteenth Session of the Joint CCOP-IOC Working Group on Post-IDOE Studies of East Asian Tectonics and Resources
41. Third Session of the IOC Consultative Group on Ocean Mapping
42. Sixth Session of the Joint IOC-WMO-CCPS Working Group on the Investigations of 'El Niño' (**Also printed in Spanish**)
43. First Session of the IOC Editorial Board for the International Bathymetric Chart of the Western Indian Ocean
44. Third Session of the IOC-UN(OALOS) Guiding Group of Experts on the Programme of Ocean Science in Relation to Non-Living Resources
45. Ninth Session of the IOC-UNEP Group of Experts on Methods, Standards and Intercalibration
46. Second Session of the IOC Editorial Board for the International Bathymetric Chart of the Caribbean Sea and the Gulf of Mexico
47. Cancelled
48. Twelfth Session of the Joint IOC-IHO Guiding Committee for the General Bathymetric Chart of the Oceans
49. Fifteenth Session of the Joint CCOP-IOC Working Group on Post-IDOE Studies of East Asian Tectonics and Resources
50. Third Joint IOC-WMO Meeting for Implementation of IGOSS XBT Ship-of-Opportunity Programmes
51. First Session of the IOC Group of Experts on the Global Sea-Level Observing System
52. Fourth Session of the IOC Editorial Board for the International Bathymetric Chart of the Mediterranean
53. First Session of the IOC Editorial Board for the International Chart of the Central Eastern Atlantic (**Also printed in French**)
54. Third Session of the IOC Editorial Board for the International Bathymetric Chart of the Caribbean Sea and the Gulf of Mexico (**Also printed in Spanish**)
55. Fifth Session of the IOC-UNEP-IMO Group of Experts on Effects of Pollutants
56. Second Session of the IOC Editorial Board for the International Bathymetric Chart of the Western Indian Ocean
57. First Meeting of the IOC *ad hoc* Group of Experts on Ocean Mapping in the WESTPAC Area
58. Fourth Session of the IOC Consultative Group on Ocean Mapping
59. Second Session of the IOC-WMO/IGOSS Group of Experts on Operations and Technical Applications

60. Second Session of the IOC Group of Experts on the Global Sea-Level Observing System
61. UNEP-IOC-WMO Meeting of Experts on Long-Term Global Monitoring System of Coastal and Near-Shore Phenomena Related to Climate Change
62. Third Session of the IOC-FAO Group of Experts on the Programme of Ocean Science in Relation to Living Resources
63. Second Session of the IOC-IAEA-UNEP Group of Experts on Standards and Reference Materials
64. Joint Meeting of the Group of Experts on Pollutants and the Group of Experts on Methods, Standards and Inter-calibration
65. First Meeting of the Working Group on Oceanographic Co-operation in the ROPME Sea Area
66. Fifth Session of the Editorial Board for the International Bathymetric and its Geological/Geophysical Series
67. Thirteenth Session of the IOC-IHO Joint Guiding Committee for the General Bathymetric Chart of the Oceans **(Also printed in French)**
68. International Meeting of Scientific and Technical Experts on Climate Change and Oceans
69. UNEP-IOC-WMO-IUCN Meeting of Experts on a Long-Term Global Monitoring System
70. Fourth Joint IOC-WMO Meeting for Implementation of IGOSS XBT Ship-of-Opportunity Programmes
71. ROPME-IOC Meeting of the Steering Committee on Oceanographic Co-operation in the ROPME Sea Area
72. Seventh Session of the Joint IOC-WMO-CPPS Working Group on the Investigations of 'El Niño' **(Spanish only)**
73. Fourth Session of the IOC Editorial Board for the International Bathymetric Chart of the Caribbean Sea and the Gulf of Mexico **(Also printed in Spanish)**
74. UNEP-IOC-ASPEI Global Task Team on the Implications of Climate Change on Coral Reefs
75. Third Session of the IODE Group of Experts on Marine Information Management
76. Fifth Session of the IODE Group of Experts on Technical Aspects of Data Exchange
77. ROPME-IOC Meeting of the Steering Committee for the Integrated Project Plan for the Coastal and Marine Environment of the ROPME Sea Area
78. Third Session of the IOC Group of Experts on the Global Sea-level Observing System
79. Third Session of the IOC-IAEA-UNEP Group of Experts on Standards and Reference Materials
80. Fourteenth Session of the Joint IOC-IHO Guiding Committee for the General Bathymetric Chart of the Oceans
81. Fifth Joint IOG-WMO Meeting for Implementation of IGOSS XBT Ship-of-Opportunity Programmes
82. Second Meeting of the UNEP-IOC-ASPEI Global Task Team on the Implications of climate Change on Coral Reefs
83. Seventh Session of the JSC Ocean Observing System Development Panel
84. Fourth Session of the IODE Group of Experts on Marine Information Management
85. Sixth Session of the IOC Editorial Board for the International Bathymetric chart of the Mediterranean and its Geological/Geophysical Series
86. Fourth Session of the Joint IOC-JGOFS Panel on Carbon Dioxide
87. First Session of the IOC Editorial Board for the International Bathymetric Chart of the Western Pacific
88. Eighth Session of the JSC Ocean Observing System Development Panel
89. Ninth Session of the JSC Ocean Observing System Development Panel
90. Sixth Session of the IODE Group of Experts on Technical Aspects of Data Exchange
91. First Session of the IOC-FAO Group of Experts on OSLR for the IOCINCWIO Region
92. Fifth Session of the Joint IOC-JGOFS CO₂ Advisory Panel Meeting
93. Tenth Session of the JSC Ocean Observing System Development Panel
94. First Session of the Joint CMM-IGOSS-IODE Sub-group on Ocean Satellites and Remote Sensing
95. Third Session of the IOC Editorial Board for the International Chart of the Western Indian Ocean
96. Fourth Session of the IOC Group of Experts on the Global Sea Level Observing System
97. Joint Meeting of GEMSI and GEEP Core Groups
98. First Session of the Joint Scientific and Technical Committee for Global Ocean Observing System
99. Second International Meeting of Scientific and Technical Experts on Climate Change and the Oceans
100. First Meeting of the Officers of the Editorial Board for the International Bathymetric Chart of the Western Pacific
101. Fifth Session of the IOC Editorial Board for the International Bathymetric Chart of the Caribbean Sea and the Gulf of Mexico
102. Second Session of the Joint Scientific and Technical Committee for Global Ocean Observing System
103. Fifteenth Session of the Joint IOC-IHO Committee for the General Bathymetric Chart of the Oceans
104. Fifth Session of the IOC Consultative Group on Ocean Mapping
105. Fifth Session of the IODE Group of Experts on Marine Information Management
106. IOC-NOAA *Ad hoc* Consultation on Marine Biodiversity
107. Sixth Joint IOC-WMO Meeting for Implementation of IGOSS XBT Ship-of-Opportunity Programmes
108. Third Session of the Health of the Oceans (HOTO) Panel of the Joint Scientific and Technical Committee for GLOSS
109. Second Session of the Strategy Subcommittee (SSC) of the IOC-WMO-UNEP Intergovernmental Committee for the Global Ocean Observing System
110. Third Session of the Joint Scientific and Technical Committee for Global Ocean Observing System
111. First Session of the Joint GCOS-GOOS-WCRP Ocean Observations Panel for Climate
112. Sixth Session of the Joint IOC-JGOFS CO₂ Advisory Panel Meeting
113. First Meeting of the IOC/WESTPAC Co-ordinating Committee for the North-East Asian Regional - Global Ocean Observing System (NEAR-GOOS)
114. Eighth Session of the Joint IOC-WMO-CPPS Working Group on the Investigations of "El Niño" **(Spanish only)**
115. Second Session of the IOC Editorial Board of the International Bathymetric Chart of the Central Eastern Atlantic **(Also printed in French)**
116. Tenth Session of the Officers Committee for the Joint IOC-IHO General Bathymetric Chart of the Oceans (GEBCO), USA, 1996
117. IOC Group of Experts on the Global Sea Level Observing System (GLOSS), Fifth Session, USA, 1997
118. Joint Scientific Technical Committee for Global Ocean Observing System (J-GOOS), Fourth Session, USA, 1997
119. First Session of the Joint 100-WMO IGOSS Ship-of-Opportunity Programme Implementation Panel, South Africa, 1997
120. Report of Ocean Climate Time-Series Workshop, Joint GCOS-GOOS-WCRP Ocean Observations Panel for Climate, USA, 1997
121. IOC/WESTPAC Co-ordinating Committee for the North-East Asian Regional Global Ocean Observing System (NEAR-GOOS), Second Session, Thailand, 1997

122. First Session of the IOC-IUCN-NOAA *Ad hoc* Consultative Meeting on Large Marine Ecosystems (LME), France, 1997
123. Second Session of the Joint GCOS-GOOS-WCRP Ocean Observations Panel for Climate (OOPC), South Africa, 1997
124. Sixth Session of the IOC Editorial Board for the International Bathymetric Chart of the Caribbean Sea and the Gulf of Mexico, Colombia, 1996
(also printed in Spanish)
125. Seventh Session of the IODE Group of Experts on Technical Aspects of Data Exchange, Ireland, 1997
126. IOC-WMO-UNEP-ICSU Coastal Panel of the Global Ocean Observing System (GOOS), First Session, France, 1997
127. Second Session of the IOC-IUCN-NOAA Consultative Meeting on Large Marine Ecosystems (LME), France, 1998
128. Sixth Session of the IOC Consultative Group on Ocean Mapping (CGOM), Monaco, 1997
129. Sixth Session of the Tropical Atmosphere - Ocean Array (TAO) Implementation Panel, United Kingdom, 1997
130. First Session of the IOC-WMO-UNEP-ICSU Steering Committee of the Global Ocean Observing System (GOOS), France, 1998
131. Fourth Session of the Health of the Oceans (HOTO) Panel of the Global Ocean Observing System (GOOS), Singapore, 1997
132. Sixteenth Session of the Joint IOC-IHO Guiding Committee for the General Bathymetric Chart of the Oceans (GEBCO), United Kingdom, 1997
133. First Session of the IOC-WMO-UNEP-ICSU-FAO Living Marine Resources Panel of the Global Ocean Observing System (GOOS), France, 1998
134. Fourth Session of the IOC Editorial Board for the International Bathymetric Chart of the Western Indian Ocean (IOC/EB-IBCWIO-IW3), South Africa, 1997
135. Third Session of the Joint GCOS-GOOS-WCRP Ocean Observations Panel for Climate (OOPC), France, 1998
136. Seventh Session of the Joint IOC-JGOFS CO2 Advisory Panel Meeting, Germany, 1997
137. Implementation of Global Ocean Observations for GOOS/GCOS, First Session, Australia, 1998
138. Implementation of Global Ocean Observations for GOOS/GCOS, Second Session, France, 1998
139. Second Session of the IOC-WMO-UNEP-ICSU Coastal Panel of the Global Ocean Observing System (GOOS), Brazil, 1998
140. Third Session of IOC/WESTPAC Co-ordinating Committee for the North-East Asian Regional - Global Ocean Observing System (NEAR-GOOS), China, 1998
141. Ninth Session of the Joint IOC-WMO-CPPS Working Group on the Investigations of 'El Niño', Ecuador, 1998 **(Spanish only)**
142. Seventh Session of the IOC Editorial Board for the International Bathymetric Chart of the Mediterranean and its Geological/Geophysical Series, Croatia, 1998
143. Seventh Session of the Tropical Atmosphere-Ocean Array (TAO) Implementation Panel, Abidjan, Côte d'Ivoire, 1998
144. Sixth Session of the IODE Group of Experts on Marine Information Management (GEMIM), USA, 1999
145. Second Session of the IOC-WMO-UNEP-ICSU Steering Committee of the Global Ocean Observing System (GOOS), China, 1999
146. Third Session of the IOC-WMO-UNEP-ICSU Coastal Panel of the Global Ocean Observing System (GOOS), Ghana, 1999
147. Fourth Session of the GCOS-GOOS-WCRP Ocean Observations Panel for Climate (OOPC); Fourth Session of the WCRP CLIVAR Upper Ocean Panel (UOP); Special Joint Session of OOPC and UOP, USA, 1999
148. Second Session of the IOC-WMO-UNEP-ICSU-FAO Living Marine Resources Panel of the Global Ocean Observing System (GOOS), France, 1999
149. Eighth Session of the Joint IOC-JGOFS CO2 Advisory Panel Meeting, Japan, 1999
150. Fourth Session of the IOC/WESTPAC Co-ordinating Committee for the North-East Asian Regional – Global Ocean Observing System (NEAR-GOOS), Japan, 1999
151. Seventh Session of the IOC Consultative Group on Ocean Mapping (CGOM), Monaco, 1999
152. Sixth Session of the IOC Group of Experts on the Global Sea level Observing System (GLOSS), France, 1999
153. Seventeenth Session of the Joint IOC-IHO Guiding Committee for the General Bathymetric Chart of the Oceans (GEBCO), Canada, 1999
154. Comité Editorial de la COI para la Carta Batimétrica Internacional del Mar Caribe y el Golfo de Mexico (IBCCA), Septima Reunión, Mexico, 1998
IOC Editorial Board for the International Bathymetric Chart of the Caribbean Sea and the Gulf of Mexico (IBCCA), Seventh Session, Mexico, 1998
155. Initial Global Ocean Observing System (GOOS) Commitments Meeting, IOC-WMO-UNEP-ICSU/Impl-III/3, France, 1999
156. First Session of the *ad hoc* Advisory Group for IOCARIBE-GOOS, Venezuela, 1999 **(also printed in Spanish and French)**
157. Fourth Session of the IOC-WMO-UNEP-ICSU Coastal Panel of the Global Ocean Observing System (GOOS), China, 1999
158. Eighth Session of the IOC Editorial Board for the International Bathymetric Chart of the Mediterranean and its Geological/Geophysical Series, Russian Federation, 1999
159. Third Session of the IOC-WMO-UNEP-ICSU-FAO Living Marine Resources Panel of the Global Ocean Observing System (GOOS), Chile, 1999
160. Fourth Session of the IOC-WMO-UNEP-ICSU-FAO Living Marine Resources Panel of the Global Ocean Observing System (GOOS). Hawaii, 2000
161. Eighth Session of the IODE Group of Experts on Technical Aspects of Data Exchange, USA, 2000
162. Third Session of the IOC-IUCN-NOAA Consultative Meeting on Large Marine Ecosystems (LME), France, 2000
163. Fifth Session of the IOC-WMO-UNEP-ICSU Coastal Panel of the Global Ocean Observing System (GOOS), Poland, 2000
164. Third Session of the IOC-WMO-UNEP-ICSU Steering Committee of the Global Ocean Observing System (GOOS), France, 2000
165. Second Session of the *ad hoc* Advisory Group for IOCARIBE-GOOS, Cuba, 2000 **(also printed in Spanish and French)**
166. First Session of the Coastal Ocean Observations Panel, Costa Rica, 2000
167. First GOOS Users' Forum, 2000
168. Seventh Session of the Group of Experts on the Global Sea Level Observing System, Honolulu, 2001
169. First Session of the Advisory Body of Experts on the Law of the Sea (ABE-LOS), France, 2001 **(also printed in French)**
170. Fourth Session of the IOC-WMO-UNEP-ICSU Steering Committee of the Global Ocean Observing System, Chile, 2001
171. First Session of the IOC-SCOR Ocean CO₂ Advisory Panel, France, 2000
172. Fifth Session of the GCOS-GOOS-WCRP Ocean Observations Panel for Climate (OOPC), Norway, 2000 **(electronic copy only)**
173. Third Session of the *ad hoc* Advisory Group for IOCARIBE-GOOS, USA, 2001 **(also printed in Spanish and French)**
174. Second Session of the Coastal Ocean Observations Panel and GOOS Users' Forum, Italy, 2001
175. Second Session of the Black Sea GOOS Workshop, Georgia, 2001
176. Fifth Session of the IOC/WESTPAC Co-ordinating Committee for the North-East Asian Regional – Global Ocean Observing System (NEAR-GOOS), Republic of Korea, 2000
177. Second Session of the Advisory Body of Experts on the Law of the Sea (IOC/ABE-LOS), Morocco, 2002 **(also printed in French)**
178. Sixth Session of the Joint GCOS-GOOS-WCRP Ocean Observations Panel for Climate (OOPC), Australia, 2001 **(electronic copy only)**
179. *Cancelled*

180. Second Session of the IOC-SCOR Ocean CO₂ Advisory Panel, Honolulu, Hawaii, U.S.A, 2002 (*electronic copy only*)
181. IOC Workshop on the Establishment of SEAGOOS in the Wider Southeast Asian Region, Seoul, Republic of Korea, 2001 (SEAGOOS preparatory workshop) (*electronic copy only*)
182. First Session of the IODE Steering Group for the Resource Kit, USA, 19–21 March 2001
183. Fourth Session of the IOC-IUCN-NOAA Consultative Meeting on Large Marine Ecosystems (LMEs), France, 2002
184. Seventh Session of the IODE Group of Experts on Marine Information Management (GEMIM), France, 2002 (*electronic copy only*)
185. Sixth Session of IOC/WESTPAC Coordinating Committee for the North-East Asian Regional - Global Ocean Observing System (NEAR-GOOS), Republic of Korea, 2001 (*electronic copy only*)
186. First Session of the Global Ocean Observing System (GOOS) Capacity Building Panel, Switzerland, 2002 (*electronic copy only*)
187. Fourth Session of the ad hoc Advisory Group for IOCARIBE-GOOS, 2002, Mexico (*also printed in French and Spanish*)
188. Fifth Session of the IOC Editorial Board for the International Bathymetric Chart of the Western Indian Ocean (IBCWIO), Mauritius, 2000
189. Third session of the Editorial Board for the International Bathymetric Chart of the Western Pacific, China, 2000
190. Third Session of the Coastal Ocean Observations Panel and GOOS Users' Forum, Vietnam, 2002
191. Eighth Session of the IOC Consultative Group on Ocean Mapping, Russian Federation, 2001
192. Third Session of the Advisory Body of Experts on the Law of the Sea (IOC/ABE-LOS), Lisbon, 2003 (*also printed in French*)
193. Extraordinary Session of the Joint IOC-WMO-CPPS Working Group on the Investigations of 'El Niño', Chile, 1999 (*Spanish only; electronic copy only*)
194. Fifth Session of the IOC-WMO-UNEP-ICSU Steering Committee of the Global Ocean Observing System, France, 2002
195. Sixth Session of the IOC-WMO-UNEP-ICSU Steering Committee of the Global Ocean Observing System, South Africa, 2003
196. Fourth Session of the Coastal Ocean Observations Panel, South Africa, 2002 (*electronic copy only*)
197. First Session of the JCOMM/IODE Expert Team On Data Management Practices, Belgium, 2003 (*also JCOMM Meeting Report No. 25*)
198. Fifth Session of the IOC-IUCN-NOAA Consultative Meeting on Large Marine Ecosystems (LMEs), Paris, 2003
199. Ninth Session of the IOC Consultative Group on Ocean Mapping, Monaco, 2003 (*Recommendations in English, French, Russian and Spanish included*)
200. Eighth Session of the IOC Group of Experts on the Global Sea level Observing System (GLOSS), France, 2003 (*electronic copy only*)
201. Fourth Session of the Advisory Body of Experts on the Law of the Sea (IOC/ABE-LOS), Greece, 2004 (*also printed in French*)
202. Sixth Session of the IOC-IUCN-NOAA Consultative Meeting on Large Marine Ecosystems (LMEs), Paris, 2004 (*electronic copy only*)
203. Fifth Session of the Advisory Body of Experts on the Law of the Sea (IOC/ABE-LOS), Argentina, 2005 (*also printed in French*)
204. Ninth Session of the IOC Group of Experts on the Global Sea level Observing System (GLOSS), France, 2005 (*electronic copy only*)
205. Eighth Session of the IOC/WESTPAC Co-ordinating Committee for the North-East Asian Regional – Global Ocean Observing System (NEAR-GOOS), China, 2003 (*electronic copy only*)
206. Sixth Meeting of the Advisory Body of Experts on the Law of the Sea (IOC/ABE-LOS), Spain, 2006 (*also printed in French*)
207. Third Session of the Regional Forum of the Global Ocean Observing System, South Africa, 2006 (*electronic copy only*)
208. Seventh Session of the IOC-UNEP-IUCN-NOAA Consultative Meeting on Large Marine Ecosystems (LMEs), Paris, 2005 (*electronic copy only*)
209. Eighth Session of the IOC-UNEP-IUCN-NOAA Consultative Meeting on Large Marine Ecosystems (LMEs), Paris, 2006 (*electronic copy only*)
210. Seventh Meeting of the IOC Advisory Body of Experts on the Law of the Sea (IOC/ABE-LOS), Gabon, 2007 (*bilingual English/French*)
211. First Meeting of the IOC Working Group on the Future of IOC, Paris, 2008 (*Executive Summary in English, French, Russian and Spanish included*)
212. First meeting of the Working Group on Tsunamis and Other Hazards Related to Sea-Level Warning and Mitigation Systems (TOWS-WG), Paris, 3–4 April 2008 (*Executive Summary in English, French, Russian and Spanish included*)
213. First Session of the Panel for Integrated Coastal Observation (PICO-I), Paris, 10–11 April 2008 (*electronic copy only*)
214. Tenth Session of the IOC Group of Experts on the Global Sea level Observing System (GLOSS), Paris, 6–8 June 2007 (*electronic copy only*)
215. Eighth Meeting of the IOC Advisory Body of Experts on the Law of the Sea (IOC/ABE-LOS), Paris, 21–25 April 2008 (*bilingual English/French*)
216. Fourth Session of the Global Ocean Observing System (GOOS) Regional Alliances Forum (GRF), Guayaquil, Ecuador, 25–27 November 2008 (*electronic copy only*)
217. Second Session of the Working Group on Tsunamis and Other Hazards Related to Sea-Level Warning and Mitigation Systems (TOWS-WG), Paris, 27 March 2009 (*Executive Summary in English, French, Russian and Spanish included*)
218. Ninth Meeting of the IOC Advisory Body of Experts on the Law of the Sea (IOC/ABE-LOS), Paris, 30 March–3 April 2009 (*bilingual English/French*)
219. First Session of the IOC-SCOR International Ocean Carbon Coordination Project (IOCCP) Scientific Steering Group (also IOCCP Reports, 3), Broomfield, Colorado, U.S.A., 1 October 2005 (*electronic copy only*)
220. Second Session of the IOC-SCOR International Ocean Carbon Coordination Project (IOCCP) Scientific Steering Group (also IOCCP Reports, 6), Paris, France, 20 April 2007 (*electronic copy only*)
221. Third Session of the IOC-SCOR International Ocean Carbon Coordination Project (IOCCP) Scientific Steering Group (also IOCCP Reports, 10), Villefranche-sur-mer, France, 3–4 October 2008 (*electronic copy only*)
222. Fourth Session of the IOC-SCOR International Ocean Carbon Coordination Project (IOCCP) Scientific Steering Group (also IOCCP Reports, 15), Jena, Germany, 14 September 2009 (*electronic copy only*)
223. First Meeting of the joint IOC-ICES Study Group on Nutrient Standards (SGONS) (also IOCCP Reports, 20), Paris, France, 23–24 March 2010 (*Executive Summary in E, F, R, S included*)
224. Third Session of the Working Group on Tsunamis and Other Hazards Related to Sea-Level Warning and Mitigation Systems (TOWS-WG), Lisbon, Portugal, 5–6 May 2010 (*Executive Summary in English, French, Russian and Spanish included*)
225. Eleventh Session of the IOC Group of Experts on the Global Sea level Observing System (GLOSS), Paris, 13–15 May 2009 (*electronic copy only*)
226. Second Session of the Panel for Integrated Coastal Observation (PICO-II), Paris, 24–26 February 2009 (*electronic copy only*)
227. First meeting of the Task Team on Seismic Data Exchange in the South West Pacific of the ICG/PTWS Regional Working Group for the Southwest Pacific, Port Vila, Vanuatu, 19–20 October 2009 (*electronic copy only*)