Tsunami Warning Markup Language (TWML)

An standards-based language for tsunami bulletins

Version 1.0

Editors: **Renato Iannella, National ICT Australia (NICTA)**
<renato@nicta.com.au>
Karen Robinson, National ICT Australia (NICTA)
<Karen.Robinson@nicta.com.au>

Status: **This is a Working Draft for review by interested parties. Comments on this document should be sent to the editors. This specification has no formal standing in any Standards Consortia or related group.**

---

1 Introduction

1.1 Background

Tsunamis are ocean waves caused by sub-marine seismic activity, such as sub-marine earthquakes and volcanic eruptions. They can travel thousands of kilometres and cause considerable destruction to coastal areas. A number of warning centres have been established to issue information bulletins when such events occur. These include (for the Pacific):

- the Pacific Tsunami Warning Center (PTWC) in Hawaii,
- the West Coast and Alaska Tsunami Warning Center (WC/ATWC) in Alaska, and
- the Northwest Pacific Tsunami Advisory Center (NWPTAC) in Japan.

Currently, the tsunami warning centres issue tsunami bulletins in a textual format. There are some variations in the content and format of the bulletins issued by the three centres. For example, the WC/ATWC issues separate public and standard tsunami bulletins, unlike the PTWC and NWPTAC, while the NWPTAC provides more detailed wave activity predictions than the PTWC and WC/ATWC. Example bulletins can be seen in Appendix A and Appendix B.

The bulletins are currently disseminated using a heterogenous set of communications services, including dedicated data and voice lines, satellite broadcast, email, fax and telex. The recipients of the bulletins include meteorological service offices and weather forecast offices, airfield facilities, weather forecast subscribers, emergency service agencies, government agencies and academic institutions [1].

Distributing textual messages in this fashion is an inefficient solution, as it removes many opportunities for automating the generation, dissemination and handling of bulletins. To enable warnings to reach the public quickly, national, sub-regional or local warning systems have been established in some areas – for example, Japan and French Polynesia – to

provide warnings within minutes of a seismic event. However, such systems provide only a partial solution, and improving the manner and form in which bulletins from the tsunami warning centres are distributed has the potential to save many lives, particularly in a large-scale disaster such as the Indian Ocean tsunami on 26 December 2004. Recently, problems related to the timeliness of distributing Tsunami warnings to the public and agencies have been highlighted [6]; these could be substantially addressed by using computer-to-computer distribution.

The standards-based language for tsunami bulletins described in this document is being developed as a first attempt to define structured semantic data models for tsunami bulletins. The benefits of structured semantic data models include:

- less ambiguity of tsunami bulletin contents than with purely textual bulletins, as elements of structured documents can have well-defined semantics,
- improved consistency of bulletins across the different tsunami warning centres,
- improved opportunities for machine processing of bulletins, allowing bulletins to be:
  - generated,
  - checked/validated,
  - disseminated,
  - combined/aggregated with related information, and
  - mapped to visual (or other) presentations suitable for decision makers and the public

  in a more efficient manner, allowing crucial information to reach the affected public faster.

The language aims to build on relevant standards wherever possible, in order to maximise opportunities for interoperability. For example, it uses selected concepts from the Geography Markup Language (GML) [3], such as GML Points for describing locations, to facilitate integration with mapping and geospatial systems (so that, for example, the observations and predictions contained in a bulletin can be automatically plotted on a map).

It is also anticipated that the language will be used in conjunction with standards that support the exchange of information in emergency situations, including the Emergency Digital Exchange Language (EDXL) Distribution Element [4] and the Common Alerting Protocol (CAP) [5]. These can be used to represent metadata about tsunami bulletins, such as the intended recipients (EDXL) and the category of alert (CAP), which can assist with routing (to the right people and organisations) and prioritization of bulletins.

1.2 Overview

This document is structured as follows:

- Section 2 describes the model that underpins the language for tsunami bulletins,
- Section 3 presents the element semantics for the language,
- Section 4 presents an XML schema for the language,
- Section 5 presents some example TWML bulletins expressed using the language,
- Section 5.3 presents a TWML example embedded inside an EDXL message, and
- the Appendices present examples of bulletins from the PTWC and WC/ATWC to show the textual bulletin formats that are currently in use.

2 TWML Model

Tsunami bulletins are directed at many different kinds of organisations, as well as the public. As such, they provide a combination of informative data for experts and plain language information and analysis for non-experts. The main contents of a tsunami bulletin are:

- Information about the issuer of the bulletin, the time of issue, and the frequency of future bulletins.
- A description of the areas for which the bulletin is applicable and information about which tsunami warning centres will issue bulletins for other areas.
- Information about watches and warnings that are in effect. Warnings are issued for places that are likely to be affected in the short term (within a matter of hours), while watches are issued for places that are likely to be affected in several hours or more. (A discussion of the operational procedure followed by the Pacific warning centres in determining when to issue warnings and watches can be found in [1], pages 12 – 13.)
- Observations about the seismic activity that triggered the tsunami, plus observations of wave activity.
- A textual evaluation of the tsunami, including expected impacts.
- Predictions of wave activity.

Not all of these elements may be present in a single bulletin. For example, information bulletins may be issued to indicate that a tsunami is *not* expected, and therefore they will omit most of the elements listed above.

Figure 1 shows the information model structure of a tsunami bulletin. The parts that make up the bulletin are described in detail in the Element Semantics that follows (Section 3).

The model was created from an analysis of the example Tsunami bulletins used in Pacific Wave 2006 Exercise [2].

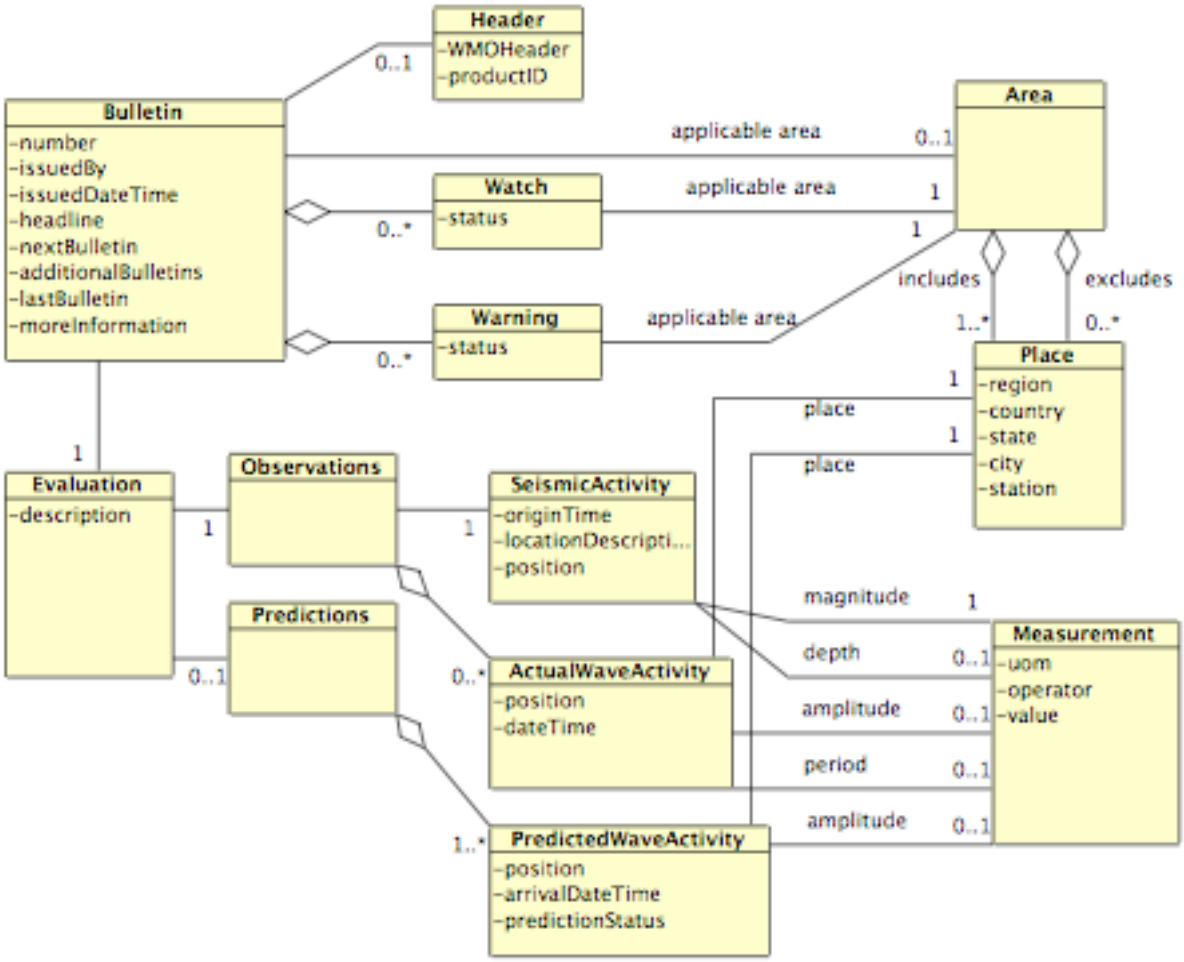

Figure 1. UML model showing the structure of a tsunami bulletin.

The TWML bulletin model consists of metadata about the bulletin and links to applicable areas for the bulletin coverage. These can be for the entire bulletin or a specific Watch or Warning area(s). The area can be specified as inclusive or exclusive.

The TWML model also consists of an evaluation of the incident, which can contain observations and/or predictions. The observations include details of the seismic activity and a number of actual wave events. The predictions include predicted wave events in the future. Each of the seismic and wave activities are associated with a specific place, time, and applicable measurement.

3 TWML Element Semantics

3.1 Bulletin elements

This section defines elements related to the **Bulletin** class shown in Figure 1.

Element	**Bulletin**
Type	XML structure
Usage	**REQUIRED**, MUST be used once and only once
Definition	The top-level container element.
Comments	
Used In	Top level element

Element	**header**
Type	XML structure containing the sub-elements described in Section 3.2.
Usage	**OPTIONAL**, MAY be used once and only once
Definition	A header that encapsulates the World Meteorological Organization (WMO) header and the product code.
Comments	This is included for use in WC/ATWC bulletins in particular. WC/ATWC issues separate public and standard bulletins, using different product codes to distinguish them (see Appendix B). Other warning centres may choose not to use the header.
Used In	**Bulletin**

Element	**number**
Type	xs:nonNegativeInteger
Usage	**OPTIONAL**, MAY be used once and only once
Definition	The bulletin number.
Comments	The number indicates the position of the bulletin in a sequence issued by a centre for a particular seismic event. Numbers start from 001.
Used In	**Bulletin**

Element	**issuedBy**
Type	xs:string
Usage	**REQUIRED**, MUST be used once and only once
Definition	The tsunami warning centre that issued the bulletin.
Comments	
Used In	**Bulletin**

Element	**issuedDateTime**
Type	XML structure containing the **TimeInstant** element (see Section 3.11)
Usage	**REQUIRED**, MUST be used once and only once
Definition	The date and time at which the bulletin was issued.
Comments	An example of the contents of this element is as follows: <TimeInstant> <gml:timePosition>2006-05-16T12:04:00-07:00</gml:timePosition> </TimeInstant> Here, -07:00 indicates the timezone. Alternatively, “Z” can be used to indicate Coordinated Universal Time (UTC), as in the example below. <TimeInstant> <gml:timePosition>2006-05-16T19:04:00Z</gml:timePosition> </TimeInstant>
Used In	**Bulletin**

Element	**headline**
Type	xs:string
Usage	**REQUIRED**, MUST be used once and only once
Definition	A short, plain-language summary of the message of the bulletin.
Comments	
Used In	**Bulletin**

Element	nextBulletin
Type	xs:string
Usage	**REQUIRED**, MUST be used once and only once
Definition	A plain language description indicating when further bulletins should be expected (for example, hourly) from the issuing warning centre.
Comments	
Used In	**Bulletin**

Element	additionalBulletins
Type	xs:string
Usage	**OPTIONAL**, MAY be used once and only once
Definition	A plain language description indicating whether bulletins should be expected from **other** warning centres, and the areas that these additional bulletins will cover.
Comments	
Used In	**Bulletin**

Element	lastBulletin
Type	xs:boolean
Usage	**OPTIONAL**, MAY be used once and only once
Definition	A truth value indicating whether the bulletin is expected to be the last from the issuing centre for this event.
Comments	
Used In	**Bulletin**

Element	moreInformation
Type	xs:anyURI
Usage	**OPTIONAL**, MAY use multiple
Definition	A pointer (URI) to further information, such as a tsunami-related Web site.
Comments	An example use is shown below: <moreInformation>http://wtatwc.arn.noaa.gov</moreInformation>
Used In	**Bulletin**

Element	applicableArea
Type	XML structure. Its sub-elements (**includes** and **excludes**) are described in Section 3.3.
Usage	**OPTIONAL**, MAY be used once and only once
Definition	Indicates the area for which the bulletin is applicable, through explicit inclusion and exclusion of places (where places may be fine-grained, such as cities, or coarse-grained, such as countries or regions).
Comments	An example usage of this element is as follows: <applicableArea> <includes> <place> <region>COASTAL AREAS AND ISLANDS IN THE PACIFIC</region> </place> </includes> <excludes> <place> <state>ALASKA</state> </place> <place> <state>BRITISH COLUMBIA</state> </place> </excludes> </applicableArea> Refer to Section 3.3 for more detailed information about the contents of this element.
Used In	**Bulletin**

Element	**Watch**
Type	XML structure. Its sub-elements are described in Section 3.4.
Usage	**OPTIONAL**, MAY use multiple
Definition	Contains a description of the areas covered by the “watch” advice and the status of the watch (“current” or “ended”).
Comments	Although not shown in any examples in this document, it may be necessary to include multiple watches in a single bulletin (for example, a “current” watch for one set of areas and an “ended” watch for a second set of areas). Refer to Section 3.4 for more detailed information about the contents of this element.
Used In	**Bulletin**

Element	**Warning**
Type	XML structure. Its sub-elements are identical to those of the **Watch** element, and are described in Section 3.4.
Usage	**OPTIONAL**, MAY use multiple
Definition	Contains a description of the areas covered by the “warning” advice and the status of the warning (“current” or “ended”).
Comments	Refer to Section 3.4 for more detailed information about the contents of this element.
Used In	**Bulletin**

Element	**Evaluation**
Type	XML structure. Its sub-elements are described in Section 3.5.
Usage	**REQUIRED**, MUST be used once and only once
Definition	Provides an analysis of the event with which the bulletin is concerned. This analysis will usually include a plain language description of the event and its likely impacts, a set of observations (including seismic activity observations and wave activity observations), and a set of predictions of future wave activities.
Comments	Refer to Section 3.5 for more detailed information about the contents of this element.
Used In	**Bulletin**

3.2 Header elements

This section defines elements related to the **Header** class shown in Figure 1.

Element	**WMOHeader**
Type	xs:string
Usage	**REQUIRED**, MUST be used once and only once
Definition	The World Meteorological Organization (WMO) header.
Comments	This element is included for use in WC/ATWC bulletins in particular (see example bulletin in Appendix B). An example value is “WEPA41 PAAQ” – the WMO header for public Tsunami Warnings, Watches, and Advisories issued by WC/ATWC.
Used In	**header**

Element	**productID**
Type	xs:string
Usage	**REQUIRED**, MUST be used once and only once
Definition	The product identifier for the bulletin.
Comments	This element is included for use in WC/ATWC bulletins in particular (see example bulletin in Appendix B). An example value is “TSUAK1” – the NWS AWIPS ID code for public Tsunami Warnings, Watches, and Advisories issued by WC/ATWC.
Used In	**header**

3.3 Area and Place elements

This section defines elements related to the **Area** and **Place** classes shown in Figure 1.

Element	**includes**
Type	XML structure containing one or more **place** elements (see below)
Usage	**REQUIRED**, MUST be used once and only once
Definition	The list of places contained in an area. This must be interpreted in conjunction with the **excludes** element – that is, an **Area** is formed by combining the places described by the **includes** element, and then removing the places described by the **excludes** element.
Comments	An example use is as follows: <includes> <place> <state>ALASKA</state> </place> <place> <state>BRITISH COLUMBIA</state> </place> </includes>
Used In	**Bulletin/applicableArea** **Watch/applicableArea** **Warning/applicableArea**

Element	**excludes**
Type	XML structure containing one or more **place** elements (see below)
Usage	**OPTIONAL**, MAY be used once and only once
Definition	The list of places excluded from an area. This must be interpreted in conjunction with the **includes** element – that is, an **Area** is formed by combining the places described by the **includes** element, and then removing the places described by the **excludes** element.
Comments	An example use is as follows: <excludes> <place> <state>WASHINGTON</state> </place> <place> <state>OREGON</state> </place> </excludes>
Used In	**Bulletin/applicableArea** **Watch/applicableArea** **Warning/applicableArea**

Element	**place**
Type	XML structure containing a combination of the following elements: **region**, **country**, **state**, **city**, **station** (see element definitions below)
Usage	**REQUIRED**, MAY use multiple
Definition	A symbolic location, which can be anything from an observation station to a large-scale region (e.g., “the Pacific Basin”). The description of a place is made up of a hierarchy of: region name, country name, state name, city name and station name. However, not all of these are required – for example, a city name by itself forms a valid place description if it is sufficiently unambiguous.
Comments	The values for the elements inside **place** are free text strings. This is not ideal, but reflects the current practice for Tsunami bulletins. The use of a structured vocabulary for place names (e.g., Getty Thesaurus of Geographic Names or UN Location Codes) would enable more precise semantics and aid in interoperability.
Used In	**includes** **excludes**

Element	**region**
Type	xs:string
Usage	**OPTIONAL**, MAY be used once and only once
Definition	A region name.
Comments	Example values: “Pacific Basin” “East Coasts of Kamchatka Peninsula” “Kuril Islands”
Used In	**applicableArea/includes/place** **applicableArea/excludes/place** **observations/waveActivity/place** (Section 3.10) **predictions/waveActivity/place** (Section 3.10)

Element	**country**
Type	xs:string
Usage	**OPTIONAL**, MAY be used once and only once
Definition	A country name.
Comments	
Used In	**applicableArea/includes/place** **applicableArea/excludes/place** **observations/waveActivity/place** (Section 3.10) **predictions/waveActivity/place** (Section 3.10)

Element	**state**
Type	xs:string
Usage	**OPTIONAL**, MAY be used once and only once
Definition	A state (or province) name.
Comments	
Used In	**applicableArea/includes/place** **applicableArea/excludes/place** **observations/waveActivity/place** (Section 3.10) **predictions/waveActivity/place** (Section 3.10)

Element	**city**
Type	xs:string
Usage	**OPTIONAL**, MAY be used once and only once
Definition	A city name.
Comments	
Used In	**applicableArea/includes/place** **applicableArea/excludes/place** **observations/waveActivity/place** (Section 3.10) **predictions/waveActivity/place** (Section 3.10)

Element	**station**
Type	xs:string
Usage	**OPTIONAL**, MAY be used once and only once
Definition	The name of an observation station.
Comments	
Used In	**applicableArea/includes/place** **applicableArea/excludes/place** **observations/waveActivity/place** (Section 3.10) **predictions/waveActivity/place** (Section 3.10)

3.4 Watch and Warning elements

This section defines elements related to the **Watch** and **Warning** classes shown in Figure 1.

Element	**status**
Type	xs:string with restrictions
Usage	**REQUIRED**, MUST be used once and only once
Definition	The current status of a watch or warning.
Comments	The value must be one of the following: – "current" – "ended" A watch/warning can be explicitly cancelled by issuing a bulletin in which the value of the **status** element is set to "ended".
Used In	**Watch** **Warning**

Element	**applicableArea**
Type	XML structure with identical content to **Bulletin/applicableArea** (see Section 3.1)
Usage	**REQUIRED**, MUST be used once and only once
Definition	The area for which the watch/warning applies.
Comments	
Used In	**Watch** **Warning**

3.5 Evaluation elements

This section defines elements related to the **Evaluation** class shown in Figure 1.

Element	**description**
Type	xs:string
Usage	**REQUIRED**, MUST be used once and only once
Definition	A plain language analysis of the seismic event, typically explaining what has been observed, the expected impact of the event, and the actions that should be taken. The description may also contain definitions that are relevant to the analysis or other parts of the bulletin.
Comments	
Used In	**Evaluation**

Element	**observations**
Type	XML structure consisting of a **seismicActivity** element followed by zero or more **waveActivity** elements – see element definitions in Section 3.6.
Usage	**REQUIRED**, MUST be used once and only once
Definition	A collection of observations that characterise the seismic event and subsequent wave activity.
Comments	
Used In	**Evaluation**

Element	**predictions**
Type	XML structure consisting of one or more **waveActivity** elements as defined in Section 3.9.
Usage	**OPTIONAL**, MAY be used once and only once
Definition	A collection of wave predictions for areas affected by the seismic event.
Comments	
Used In	**Evaluation**

3.6 Observations elements

This section defines elements related to the **Observations** class shown in Figure 1.

Element	**seismicActivity**
Type	XML structure consisting of a sequence of the following elements (some of which are optional): **originTime**, **locationDescription**, **position**, **magnitude** and **depth**. These are described in Sections 3.7 and 3.10.
Usage	**REQUIRED**, MUST be used once and only once
Definition	Container element for observations about a seismic event.
Comments	
Used In	**observations**

Element	**waveActivity**
Type	XML structure consisting of a sequence of the following elements (most of which are optional): **place**, **position**, **dateTime**, **amplitude**, **period**. These are described in Sections 3.8 and 3.10.
Usage	**OPTIONAL**, MAY use multiple
Definition	Container element for information about observed wave activity in a given place.
Comments	
Used In	**observations**

3.7 SeismicActivity elements

This section defines elements related to the **SeismicActivity** class shown in Figure 1. Additional elements (shared with other observation and prediction elements) are defined in Section 3.10.

Element	**originTime**
Type	XML structure containing the **TimeInstant** element (see Section 3.11)
Usage	**REQUIRED**, MUST be used once and only once
Definition	The date and time of the origin of the seismic activity.
Comments	The contents of this element are identical to those of the **Bulletin/issuedDateTime** element (see Section 3.1).
Used In	**seismicActivity**

Element	locationDescription
Type	xs:string
Usage	**REQUIRED**, MUST be used once and only once
Definition	A short textual description of the location of the origin of the seismic activity.
Comments	
Used In	**seismicActivity**

Element	magnitude
Type	XML structure containing the **measure** element (Section 3.11) and an optional **operator** element (Section 3.10).
Usage	**REQUIRED**, MUST be used once and only once
Definition	The magnitude of the seismic activity.
Comments	An example usage of this element is as follows: <magnitude> <measure uom="urn:x-ogc:def:uom:OGC:1.0:Richter">9.2</measure> </magnitude> The optional operator element can be used to qualify the numerical measure (for example, using an inequality such as less than or greater than): <magnitude> <measure uom="urn:x-ogc:def:uom:OGC:1.0:Richter">9.2</measure> <operator>urn:x-ogc:def:rangeMeaning:OGC:1.0:greaterOrEqual </operator> </magnitude> This example states that the magnitude is at least 9.2 on the Richter scale.
Used In	**seismicActivity**

Element	depth
Type	XML structure containing the **measure** element (Section 3.11) and an optional **operator** element (Section 3.10).
Usage	**OPTIONAL**, MAY be used once and only once
Definition	The depth of the seismic activity.
Comments	An example usage of this element is as follows: <depth> <measure uom="urn:x-ogc:def:uom:OGC:1.0:mile">12</measure> </depth> The optional operator element can be used to qualify the numerical measure (for example, using an inequality such as less than or greater than): <depth> <measure uom="urn:x-ogc:def:uom:OGC:1.0:mile">12</measure> <operator>urn:x-ogc:def:rangeMeaning:OGC:1.0:greaterOrEqual </operator> </depth> This example states that the depth is at least 12 miles.
Used In	**seismicActivity**

3.8 ActualWaveActivity elements

This section defines elements related to the **ActualWaveActivity** class shown in Figure 1. Additional elements (shared with other observation and prediction elements) are defined in Section 3.10.

Element	period
Type	XML structure containing the **measure** element (see Section 3.11) and an optional **operator** element (Section 3.10).
Usage	**OPTIONAL**, MAY be used once and only once
Definition	The observed period of a wave activity.
Comments	An example usage of this element is as follows: <period> <measure uom="urn:x-ogc:def:uom:OGC:1.0:minute">41</measure> </period> The optional operator element can be used to qualify the numerical measure (as for the **seismicActivity/magnitude** and **seismicActivity/depth** elements – see Section 3.7)
Used In	**observations/waveActivity** (Section 3.6)

3.9 Predictions elements

This section defines elements related to the **Predictions** and **PredictedWaveActivity** classes shown in Figure 1.

Element	**waveActivity**
Type	XML structure consisting of a sequence of the following elements (most of which are optional): **place**, **position**, **dateTime**, **amplitude**, **predictionStatus**.
Usage	**REQUIRED**, MAY use multiple
Definition	Container element for information about predicted wave activity in a given place.
Comments	
Used In	**predictions**

Element	**predictionStatus**
Type	xs:string with restrictions
Usage	**OPTIONAL**, MAY be used once and only once
Definition	The status of a prediction (with respect to previous bulletins). This element can be used to indicate that a prediction has been added or revised since previous bulletins, or to indicate that a wave predicted in a previous bulletin has now arrived.
Comments	The value must be one of the following: – “already arrived” – “addition” – “revision”
Used In	**predictions/waveActivity**

3.10 Common Predictions and Observations elements

This section describes common elements for the **Observations** and **Predictions** classes shown in Figure 1 (specifically, the **observations/seismicActivity**, **observations/waveActivity** and **predictions/waveActivity** elements).

Element	**place**
Type	XML structure containing a combination of the following elements: **region**, **country**, **state**, **city**, **station** (see definitions in Section 3.3)
Usage	**REQUIRED**, MUST be used once and only once
Definition	The place of the observed or predicted wave activity.
Comments	
Used In	**observations/waveActivity** (Section 3.6) **predictions/waveActivity** (Section 3.9)

Element	**position**
Type	XML structure containing the **Point** element (see Section 3.11)
Usage	**OPTIONAL**, MAY be used once and only once
Definition	The coordinates of observed seismic activity, or of observed or predicted wave activity. The coordinates are typically a pair consisting of a latitude and longitude – however, they can potentially be coordinates from any spatial reference system.
Comments	An example usage of this element is as follows: <position> <Point srsName="urn:ogc:def:crs:OGC:1.3:CRS84"> <gml:pos>-30.0 -72.0</gml:pos> </Point> </position> This example describes a point 30 degrees south and 72 degrees west in the WGS 84 spatial reference system.
Used In	**observations/seismicActivity** (Section 3.6) **observations/waveActivity** (Section 3.6) **predictions/waveActivity** (Section 3.9)

Element	**dateTime**
Type	XML structure containing the **TimeInstant** element (see Section 3.11)
Usage	**OPTIONAL**, MAY be used once and only once
Definition	The date and time of a wave prediction or observation.
Comments	The contents of this element are identical to those of the **Bulletin/issuedDateTime** element (see Section 3.1).
Used In	**observations/waveActivity** (Section 3.6) **predictions/waveActivity** (Section 3.9)

Element	**amplitude**
Type	XML structure containing the **measure** element (Section 3.11) and an optional **operator** element (Section 3.10).
Usage	**OPTIONAL**, MAY be used once and only once
Definition	The observed or predicted amplitude of a wave activity.
Comments	An example usage of this element is as follows: <amplitude> <measure uom="urn:ogc:def:uom:OGC:1.0:metre">2.9</measure> </amplitude> The optional operator element can be used to qualify the numerical measure (as for the **seismicActivity/magnitude** and **seismicActivity/depth** elements – see Section 3.7)
Used In	**observations/waveActivity** (Section 3.6) **predictions/waveActivity** (Section 3.9)

Element	**operator**
Type	xs:string with restrictions
Usage	**OPTIONAL**, MAY be used once and only once
Definition	An operator used to qualify an imprecise numerical value, such as an expected or observed wave amplitude. The operators are described by URNs in the experimental x-ogc namespace.
Comments	Value must be one of: – urn:x-ogc:def:rangeMeaning:OGC:1.0:min – urn:x-ogc:def:rangeMeaning:OGC:1.0:max – urn:x-ogc:def:rangeMeaning:OGC:1.0:lessThan – urn:x-ogc:def:rangeMeaning:OGC:1.0:greaterThan – urn:x-ogc:def:rangeMeaning:OGC:1.0:equalTo – urn:x-ogc:def:rangeMeaning:OGC:1.0:lessOrEqual – urn:x-ogc:def:rangeMeaning:OGC:1.0:greaterOrEqual – urn:x-ogc:def:rangeMeaning:OGC:1.0:notEqual
Used In	**seismicActivity/magnitude** **seismicActivity/depth** **observations/waveActivity/amplitude** **observations/waveActivity/period** **predictions/waveActivity/amplitude**

3.11 GML-based element types

This section describes three additional elements used for describing times, places and measurements in TWML. All are based on types from the Geography Markup Language (GML) [3].

Element	**TimeInstant**
Type	XML structure defined as per GML **TimeInstantType** (see the GML **temporal** schema)
Usage	**REQUIRED**, MUST be used once and only once
Definition	A date and time, described using the **gml:timePosition** element.
Comments	An example of the contents of this element is as follows: <gml:timePosition>2006-05-16T12:04:00-07:00</gml:timePosition> Here, -07:00 indicates the timezone. Alternatively, "Z" can be used to indicate Coordinated Universal Time (UTC), as in the example below. <gml:timePosition>2006-05-16T19:04:00Z</gml:timePosition>
Used In	**Bulletin/issuedDateTime** **seismicActivity/originTime** **observations/waveActivity/dateTime** **predictions/waveActivity/dateTime**

Element	**Point**
Type	XML structure defined as per GML **PointType** (see the GML **geometryBasic** schema)
Usage	**REQUIRED**, MUST be used once and only once
Definition	A point in space representing the location of an observation or prediction. This is represented by a set of coordinates, as per the GML definition of **PointType**.
Comments	For an example usage, see the **position** element in Section 3.10.
Used In	**observations/seismicActivity/position** **observations/waveActivity/position** **predictions/waveActivity/position**

Element	**measure**
Type	XML structure defined as per GML **MeasureType** (see the GML **basicTypes** schema)
Usage	**REQUIRED**, MUST be used once and only once
Definition	The value of a numerical observation or prediction. The units of measure for the observation are specified by the mandatory **uom** attribute.
Comments	For an example usage, see the **magnitude** element in Section 3.7.
Used In	**seismicActivity/magnitude** **seismicActivity/depth** **observations/waveActivity/period** **observations/waveActivity/amplitude** **predictions/waveActivity/amplitude**

3.12 Notes

Note the use of experimental URNs (x-ogc and x-hazard namespaces) for some of the units of measure and operator values. This is a temporary solution until more stable URNs are identified.

4 XML Schema

This section presents a formal XML schema for the TWML. Example bulletins formulated using the language follow in Section 5.

```
<?xml version="1.0" encoding="UTF-8"?>
<xs:schema xmlns:xs="http://www.w3.org/2001/XMLSchema"
    xmlns:gml="http://www.opengis.net/gml"
    xmlns="urn:x-hazard:tsunami:1.0"
    targetNamespace="urn:x-hazard:tsunami:1.0"
    elementFormDefault="unqualified"
    attributeFormDefault="unqualified">
    <xs:import namespace="http://www.opengis.net/gml"
        schemaLocation="http://schemas.opengis.net/gml/3.1.1/base/gml.xsd"/>
    <xs:element name="Bulletin" type="BulletinType"/>
    <xs:complexType name="BulletinType">
        <xs:sequence>
            <xs:element name="header" type="HeaderType" minOccurs="0"/>
            <xs:element name="number" type="xs:nonNegativeInteger" minOccurs="0"/>
            <xs:element name="issuedBy" type="xs:string"/>
            <xs:element name="issuedDateTime" type="DateTimeType"/>
            <xs:element name="headline" type="xs:string"/>
            <xs:element name="nextBulletin" type="xs:string"/>
            <xs:element name="additionalBulletins" type="xs:string" minOccurs="0"/>
            <xs:element name="lastBulletin" type="xs:boolean" minOccurs="0"/>
            <xs:element name="moreInformation" type="xs:anyURI" minOccurs="0"
maxOccurs="unbounded"/>
            <xs:element name="applicableArea" type="AreaType" minOccurs="0"/>
            <xs:element name="Watch" type="AdviceType" minOccurs="0"
maxOccurs="unbounded"/>
            <xs:element name="Warning" type="AdviceType" minOccurs="0"
maxOccurs="unbounded"/>
            <xs:element name="Evaluation" type="EvaluationType"/>
        </xs:sequence>
    </xs:complexType>
    <xs:complexType name="HeaderType">
        <xs:sequence>
            <xs:element name="WMOHeader" type="xs:string"/>
            <xs:element name="productID" type="xs:string"/>
        </xs:sequence>
    </xs:complexType>
    <xs:complexType name="AreaType">
        <xs:sequence>
            <xs:element name="includes" type="PlaceList"/>
            <xs:element name="excludes" type="PlaceList" minOccurs="0"/>
        </xs:sequence>
    </xs:complexType>
    <xs:complexType name="PlaceList">
        <xs:sequence>
            <xs:element name="place" type="PlaceType" maxOccurs="unbounded"/>
        </xs:sequence>
    </xs:complexType>
    <xs:complexType name="PlaceType">
        <xs:sequence>
            <xs:element name="region" type="xs:string" minOccurs="0"/>
            <xs:element name="country" type="xs:string" minOccurs="0"/>
            <xs:element name="state" type="xs:string" minOccurs="0"/>
            <xs:element name="city" type="xs:string" minOccurs="0"/>
            <xs:element name="station" type="xs:string" minOccurs="0"/>
        </xs:sequence>
```

```
    </xs:complexType>
    <xs:complexType name="AdviceType">
        <xs:sequence>
            <xs:element name="status" type="AdviceStatusType"/>
            <xs:element name="applicableArea" type="AreaType"/>
        </xs:sequence>
    </xs:complexType>
    <xs:simpleType name="AdviceStatusType">
        <xs:restriction base="xs:string">
            <xs:enumeration value="current"/>
            <xs:enumeration value="ended"/>
        </xs:restriction>
    </xs:simpleType>
    <xs:complexType name="EvaluationType">
        <xs:sequence>
            <xs:element name="description" type="xs:string"/>
            <xs:element name="observations" type="ObservationsType"/>
            <xs:element name="predictions" type="PredictionsType" minOccurs="0"/>
        </xs:sequence>
    </xs:complexType>
    <xs:complexType name="ObservationsType">
        <xs:sequence>
            <xs:element name="seismicActivity" type="SeismicActivityObservationType"/>
            <xs:element name="waveActivity" type="WaveActivityObservationType" minOccurs="0"
                maxOccurs="unbounded"/>
        </xs:sequence>
    </xs:complexType>
    <xs:complexType name="PredictionsType">
        <xs:sequence>
            <xs:element name="waveActivity" type="WaveActivityPredictionType"
maxOccurs="unbounded"
            />
        </xs:sequence>
    </xs:complexType>
    <xs:complexType name="SeismicActivityObservationType">
        <xs:sequence>
            <xs:element name="originTime" type="DateTimeType"/>
            <xs:element name="locationDescription" type="xs:string"/>
            <xs:element name="position" type="PositionType" minOccurs="0"/>
            <xs:element name="magnitude" type="MeasurementType"/>
            <xs:element name="depth" type="MeasurementType" minOccurs="0"/>
        </xs:sequence>
    </xs:complexType>
    <xs:complexType name="MeasurementType">
        <xs:sequence>
            <xs:element name="measure" type="gml:MeasureType"/>
            <xs:element name="operator" type="OperatorType" minOccurs="0"/>
        </xs:sequence>
    </xs:complexType>
    <xs:simpleType name="OperatorType">
        <xs:restriction base="xs:string">
            <xs:enumeration value="urn:x-ogc:def:rangeMeaning:OGC:1.0:min"/>
            <xs:enumeration value="urn:x-ogc:def:rangeMeaning:OGC:1.0:max"/>
            <xs:enumeration value="urn:x-ogc:def:rangeMeaning:OGC:1.0:lessThan"/>
            <xs:enumeration value="urn:x-ogc:def:rangeMeaning:OGC:1.0:greaterThan"/>
            <xs:enumeration value="urn:x-ogc:def:rangeMeaning:OGC:1.0:equalTo"/>
            <xs:enumeration value="urn:x-ogc:def:rangeMeaning:OGC:1.0:lessOrEqual"/>
            <xs:enumeration value="urn:x-ogc:def:rangeMeaning:OGC:1.0:greaterOrEqual"/>
            <xs:enumeration value="urn:x-ogc:def:rangeMeaning:OGC:1.0:notEqual"/>
        </xs:restriction>
    </xs:simpleType>
    <xs:complexType name="WaveActivityType">
```

```
        <xs:sequence>
            <xs:element name="place" type="PlaceType"/>
            <xs:element name="position" type="PositionType" minOccurs="0"/>
            <xs:element name="dateTime" type="DateTimeType" minOccurs="0"/>
            <xs:element name="amplitude" type="MeasurementType" minOccurs="0"/>
        </xs:sequence>
    </xs:complexType>
    <xs:complexType name="WaveActivityObservationType">
        <xs:complexContent>
            <xs:extension base="WaveActivityType">
                <xs:sequence>
                    <xs:element name="period" type="MeasurementType" minOccurs="0"/>
                </xs:sequence>
            </xs:extension>
        </xs:complexContent>
    </xs:complexType>
    <xs:complexType name="WaveActivityPredictionType">
        <xs:complexContent>
            <xs:extension base="WaveActivityType">
                <xs:sequence>
                    <xs:element name="predictionStatus" type="PredictionStatusType"
minOccurs="0"/>
                </xs:sequence>
            </xs:extension>
        </xs:complexContent>
    </xs:complexType>
    <xs:simpleType name="PredictionStatusType">
        <xs:restriction base="xs:string">
            <xs:enumeration value="already arrived"/>
            <xs:enumeration value="addition"/>
            <xs:enumeration value="revision"/>
        </xs:restriction>
    </xs:simpleType>
    <xs:complexType name="DateTimeType">
        <xs:sequence>
            <xs:element name="TimeInstant" type="gml:TimeInstantType"/>
        </xs:sequence>
    </xs:complexType>
    <xs:complexType name="PositionType">
        <xs:sequence>
            <xs:element name="Point" type="gml:PointType"/>
        </xs:sequence>
    </xs:complexType>
</xs:schema>
```

5 TWML Examples

This section shows several example bulletins expressed using the tsunami bulletin language. These are based on the example tsunami bulletins that are shown in the appendices. All of the bulletins are taken from the *Exercise Pacific Wave 06* manual [2].

5.1 Example PTWC bulletin

This example is based on the PTWC bulletin shown in Appendix A. Some predictions have been omitted here for brevity.

```
<?xml version="1.0" encoding="UTF-8"?>
<twml:Bulletin xmlns:gml="http://www.opengis.net/gml"
    xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
    xsi:schemaLocation="urn:x-hazard:tsunami:1.0 TsunamiBulletin.xsd"
    xmlns:twml="urn:x-hazard:tsunami:1.0">
    <number>008</number>
    <issuedBy>PACIFIC TSUNAMI WARNING CENTER/NOAA/NWS</issuedBy>
    <issuedDateTime>
        <TimeInstant>
            <gml:timePosition>2005-05-16T20:45:00Z</gml:timePosition>
        </TimeInstant>
    </issuedDateTime>
    <headline>A PACIFIC-WIDE TSUNAMI WARNING IS IN EFFECT</headline>
    <nextBulletin>BULLETINS WILL BE ISSUED HOURLY OR SOONER IF CONDITIONS
WARRANT.  THE TSUNAMI WARNING WILL REMAIN IN EFFECT UNTIL FURTHER
NOTICE.</nextBulletin>
    <additionalBulletins>THE WEST COAST/ALASKA TSUNAMI WARNING CENTER WILL
ISSUE BULLETINS FOR ALASKA - BRITISH COLUMBIA - WASHINGTON - OREGON -
CALIFORNIA</additionalBulletins>
    <lastBulletin>false</lastBulletin>
    <applicableArea>
        <includes>
            <place>
                <region>ALL AREAS OF THE PACIFIC BASIN</region>
            </place>
        </includes>
        <excludes>
            <place>
                <state>ALASKA</state>
            </place>
            <place>
                <state>BRITISH COLUMBIA</state>
            </place>
            <place>
                <state>WASHINGTON</state>
            </place>
            <place>
                <state>OREGON</state>
            </place>
            <place>
                <state>CALIFORNIA</state>
            </place>
        </excludes>
    </applicableArea>
    <Warning>
        <status>current</status>
        <applicableArea>
            <includes>
```

```
            <place>
                <region>COASTAL AREAS AND ISLANDS IN THE PACIFIC</region>
            </place>
        </includes>
        <excludes>
            <place>
                <state>ALASKA</state>
            </place>
            <place>
                <state>BRITISH COLUMBIA</state>
            </place>
            <place>
                <state>WASHINGTON</state>
            </place>
            <place>
                <state>OREGON</state>
            </place>
            <place>
                <state>CALIFORNIA</state>
            </place>
        </excludes>
    </applicableArea>
</Warning>
<Evaluation>
    <description>SEA LEVEL READINGS CONFIRM THAT A TSUNAMI HAS BEEN
GENERATED WHICH COULD CAUSE WIDESPREAD DAMAGE TO COASTS AND ISLANDS IN
THE PACIFIC.  AUTHORITIES SHOULD TAKE APPROPRIATE ACTION IN RESPONSE TO
THIS THREAT.  THIS CENTER WILL CONTINUE TO MONITOR SEA LEVEL DATA TO
DETERMINE THE EXTENT AND SEVERITY OF THE THREAT.
A TSUNAMI IS A SERIES OF WAVES AND THE FIRST WAVE MAY NOT BE THE LARGEST.
TSUNAMI WAVE HEIGHTS CANNOT BE PREDICTED AND CAN VARY SIGNIFICANTLY
ALONG A COAST DUE TO LOCAL EFFECTS.  THE TIME FROM ONE TSUNAMI WAVE TO
THE NEXT CAN BE FIVE MINUTES TO AN HOUR, AND THE THREAT CAN CONTINUE FOR
MANY HOURS AS MULTIPLE WAVES ARRIVE.
FOR ALL AREAS - WHEN NO MAJOR WAVES ARE OBSERVED FOR TWO HOURS AFTER
THE ESTIMATED TIME OF ARRIVAL OR DAMAGING WAVES HAVE NOT OCCURRED FOR AT
LEAST TWO HOURS THEN LOCAL AUTHORITIES CAN ASSUME THE THREAT IS PASSED.
DANGER TO BOATS AND COASTAL STRUCTURES CAN CONTINUE FOR SEVERAL HOURS
DUE TO RAPID CURRENTS.  AS LOCAL CONDITIONS CAN CAUSE A WIDE VARIATION IN
TSUNAMI WAVE ACTION THE ALL CLEAR DETERMINATION MUST BE MADE BY LOCAL
AUTHORITIES.
    </description>
    <observations>
        <seismicActivity>
            <originTime>
                <TimeInstant>
                    <gml:timePosition>2006-05-16T19:00:00Z</gml:timePosition>
                </TimeInstant>
            </originTime>
            <locationDescription>OFF COAST OF CENTRAL CHILE</locationDescription>
            <position>
                <Point srsName="urn:ogc:def:crs:OGC:1.3:CRS84">
                    <gml:pos>-30.0 -72.0</gml:pos>
                </Point>
            </position>
            <magnitude>
                <measure uom="urn:x-ogc:def:uom:OGC:1.0:Richter">9.2</measure>
            </magnitude>
        </seismicActivity>
        <waveActivity>
            <place>
                <city>COQUIMBO</city>
```

```
        </place>
        <position>
            <Point srsName="urn:ogc:def:crs:OGC:1.3:CRS84">
                <gml:pos>-29.8 -71.3</gml:pos>
            </Point>
        </position>
        <dateTime>
            <TimeInstant>
                <gml:timePosition>2006-05-16T19:20:00Z</gml:timePosition>
            </TimeInstant>
        </dateTime>
        <amplitude>
            <measure uom="urn:ogc:def:uom:OGC:1.0:metre">9.5</measure>
        </amplitude>
        <period>
            <measure uom="urn:x-ogc:def:uom:OGC:1.0:minute">35</measure>
        </period>
    </waveActivity>
    <waveActivity>
        <place>
            <city>VALPARAISO</city>
        </place>
        <position>
            <Point srsName="urn:ogc:def:crs:OGC:1.3:CRS84">
                <gml:pos>-33.0 -71.6</gml:pos>
            </Point>
        </position>
        <dateTime>
            <TimeInstant>
                <gml:timePosition>2006-05-16T19:22:00Z</gml:timePosition>
            </TimeInstant>
        </dateTime>
        <amplitude>
            <measure uom="urn:ogc:def:uom:OGC:1.0:metre">2.9</measure>
        </amplitude>
        <period>
            <measure uom="urn:x-ogc:def:uom:OGC:1.0:minute">40</measure>
        </period>
    </waveActivity>
    <waveActivity>
        <place>
            <city>CALDERA</city>
        </place>
        <position>
            <Point srsName="urn:ogc:def:crs:OGC:1.3:CRS84">
                <gml:pos>-27.1 -70.8</gml:pos>
            </Point>
        </position>
        <dateTime>
            <TimeInstant>
                <gml:timePosition>2006-05-16T19:24:00Z</gml:timePosition>
            </TimeInstant>
        </dateTime>
        <amplitude>
            <measure uom="urn:ogc:def:uom:OGC:1.0:metre">8.0</measure>
        </amplitude>
    </waveActivity>
    <waveActivity>
        <place>
            <station>DART CHILE</station>
        </place>
        <position>
```

```
            <Point srsName="urn:ogc:def:crs:OGC:1.3:CRS84">
                <gml:pos>-19.7 -74.8</gml:pos>
            </Point>
        </position>
        <dateTime>
            <TimeInstant>
                <gml:timePosition>2006-05-16T19:27:00Z</gml:timePosition>
            </TimeInstant>
        </dateTime>
        <amplitude>
            <measure uom="urn:ogc:def:uom:OGC:1.0:metre">0.4</measure>
        </amplitude>
        <period>
            <measure uom="urn:x-ogc:def:uom:OGC:1.0:minute">39</measure>
        </period>
    </waveActivity>
    <waveActivity>
        <place>
            <city>ANTOFAGASTA</city>
        </place>
        <position>
            <Point srsName="urn:ogc:def:crs:OGC:1.3:CRS84">
                <gml:pos>-23.5 -70.5</gml:pos>
            </Point>
        </position>
        <dateTime>
            <TimeInstant>
                <gml:timePosition>2006-05-16T19:30:00Z</gml:timePosition>
            </TimeInstant>
        </dateTime>
        <amplitude>
            <measure uom="urn:ogc:def:uom:OGC:1.0:metre">2.1</measure>
        </amplitude>
        <period>
            <measure uom="urn:x-ogc:def:uom:OGC:1.0:minute">34</measure>
        </period>
    </waveActivity>
    <waveActivity>
        <place>
            <city>ARICA</city>
        </place>
        <position>
            <Point srsName="urn:ogc:def:crs:OGC:1.3:CRS84">
                <gml:pos>-18.5 -70.3</gml:pos>
            </Point>
        </position>
        <dateTime>
            <TimeInstant>
                <gml:timePosition>2006-05-16T19:35:00Z</gml:timePosition>
            </TimeInstant>
        </dateTime>
        <amplitude>
            <measure uom="urn:ogc:def:uom:OGC:1.0:metre">2.2</measure>
        </amplitude>
        <period>
            <measure uom="urn:x-ogc:def:uom:OGC:1.0:minute">35</measure>
        </period>
    </waveActivity>
    <waveActivity>
        <place>
            <city>CORRAL</city>
        </place>
```

```
        <position>
            <Point srsName="urn:ogc:def:crs:OGC:1.3:CRS84">
                <gml:pos>-39.9 -73.4</gml:pos>
            </Point>
        </position>
        <dateTime>
            <TimeInstant>
                <gml:timePosition>2006-05-16T19:37:00Z</gml:timePosition>
            </TimeInstant>
        </dateTime>
        <amplitude>
            <measure uom="urn:ogc:def:uom:OGC:1.0:metre">1.0</measure>
        </amplitude>
        <period>
            <measure uom="urn:x-ogc:def:uom:OGC:1.0:minute">41</measure>
        </period>
    </waveActivity>
    <waveActivity>
        <place>
            <city>CALLAO</city>
        </place>
        <position>
            <Point srsName="urn:ogc:def:crs:OGC:1.3:CRS84">
                <gml:pos>-12.1 -77.2</gml:pos>
            </Point>
        </position>
        <dateTime>
            <TimeInstant>
                <gml:timePosition>2006-05-16T19:50:00Z</gml:timePosition>
            </TimeInstant>
        </dateTime>
        <amplitude>
            <measure uom="urn:ogc:def:uom:OGC:1.0:metre">2.2</measure>
        </amplitude>
        <period>
            <measure uom="urn:x-ogc:def:uom:OGC:1.0:minute">32</measure>
        </period>
    </waveActivity>
    <waveActivity>
        <place>
            <region>EASTER</region>
        </place>
        <position>
            <Point srsName="urn:ogc:def:crs:OGC:1.3:CRS84">
                <gml:pos>-12.1 -77.2</gml:pos>
            </Point>
        </position>
        <dateTime>
            <TimeInstant>
                <gml:timePosition>2006-05-16T20:24:00Z</gml:timePosition>
            </TimeInstant>
        </dateTime>
        <amplitude>
            <measure uom="urn:ogc:def:uom:OGC:1.0:metre">3.0</measure>
        </amplitude>
        <period>
            <measure uom="urn:x-ogc:def:uom:OGC:1.0:minute">20</measure>
        </period>
    </waveActivity>
    <waveActivity>
        <place>
            <region>BALTRA GALAPAGS</region>
```

```
            </place>
            <position>

                <Point srsName="urn:ogc:def:crs:OGC:1.3:CRS84">
                    <gml:pos>-0.4 -90.3</gml:pos>
                </Point>
            </position>
            <dateTime>
                <TimeInstant>
                    <gml:timePosition>2006-05-16T20:27:00Z</gml:timePosition>
                </TimeInstant>
            </dateTime>
            <amplitude>
                <measure uom="urn:ogc:def:uom:OGC:1.0:metre">0.6</measure>
            </amplitude>
        </waveActivity>
    </observations>
    <predictions>
        <waveActivity>
            <place>
                <country>CHILE</country>
                <city>COQUIMBO</city>
            </place>
            <position>
                <Point srsName="urn:ogc:def:crs:OGC:1.3:CRS84">
                    <gml:pos>-29.8 -71.3</gml:pos>
                </Point>
            </position>
            <dateTime>
                <TimeInstant>
                    <gml:timePosition>2006-05-16T19:02:00Z</gml:timePosition>
                </TimeInstant>
            </dateTime>
        </waveActivity>
        <waveActivity>
            <place>
                <country>CHILE</country>
                <city>VALPARAISO</city>
            </place>
            <position>
                <Point srsName="urn:ogc:def:crs:OGC:1.3:CRS84">
                    <gml:pos>-33.0 -71.6</gml:pos>
                </Point>
            </position>
            <dateTime>
                <TimeInstant>
                    <gml:timePosition>2006-05-16T19:08:00Z</gml:timePosition>
                </TimeInstant>
            </dateTime>
        </waveActivity>
        <waveActivity>
            <place>
                <country>CHILE</country>
                <city>CALDERA</city>
            </place>
            <position>
                <Point srsName="urn:ogc:def:crs:OGC:1.3:CRS84">
                    <gml:pos>-27.0 -70.8</gml:pos>
                </Point>
            </position>
            <dateTime>
                <TimeInstant>
```

```
                <gml:timePosition>2006-05-16T19:08:00Z</gml:timePosition>
            </TimeInstant>
        </dateTime>
    </waveActivity>
    <waveActivity>
        <place>
            <country>CHILE</country>
            <city>ANTOFAGASTA</city>
        </place>
        <position>
            <Point srsName="urn:ogc:def:crs:OGC:1.3:CRS84">
                <gml:pos>-23.5 -70.5</gml:pos>
            </Point>
        </position>
        <dateTime>
            <TimeInstant>
                <gml:timePosition>2006-05-16T19:14:00Z</gml:timePosition>
            </TimeInstant>
        </dateTime>
    </waveActivity>
    <waveActivity>
        <place>
            <country>CHILE</country>
            <city>TALCAHUANO</city>
        </place>
        <position>
            <Point srsName="urn:ogc:def:crs:OGC:1.3:CRS84">
                <gml:pos>-36.7 -73.1</gml:pos>
            </Point>
        </position>
        <dateTime>
            <TimeInstant>
                <gml:timePosition>2006-05-16T19:19:00Z</gml:timePosition>
            </TimeInstant>
        </dateTime>
    </waveActivity>
    <waveActivity>
        <place>
            <country>CHILE</country>
            <city>IQUIQUE</city>
        </place>
        <position>
            <Point srsName="urn:ogc:def:crs:OGC:1.3:CRS84">
                <gml:pos>-20.2 -70.1</gml:pos>
            </Point>
        </position>
        <dateTime>
            <TimeInstant>
                <gml:timePosition>2006-05-16T19:21:00Z</gml:timePosition>
            </TimeInstant>
        </dateTime>
    </waveActivity>
    <waveActivity>
        <place>
            <country>CHILE</country>
            <city>ARICA</city>
        </place>
        <position>
            <Point srsName="urn:ogc:def:crs:OGC:1.3:CRS84">
                <gml:pos>-18.5 -70.3</gml:pos>
            </Point>
```

```
        </position>
        <dateTime>
            <TimeInstant>
                <gml:timePosition>2006-05-16T19:25:00Z</gml:timePosition>
            </TimeInstant>
        </dateTime>
    </waveActivity>
    <waveActivity>
        <place>
            <country>CHILE</country>
            <city>CORRAL</city>
        </place>
        <position>
            <Point srsName="urn:ogc:def:crs:OGC:1.3:CRS84">
                <gml:pos>-39.8 -73.5</gml:pos>
            </Point>
        </position>
        <dateTime>
            <TimeInstant>
                <gml:timePosition>2006-05-16T19:27:00Z</gml:timePosition>
            </TimeInstant>
        </dateTime>
    </waveActivity>
    <waveActivity>
        <place>
            <region>GOLFO DE PENAS</region>
            <country>CHILE</country>
        </place>
        <position>
            <Point srsName="urn:ogc:def:crs:OGC:1.3:CRS84">
                <gml:pos>-47.1 -74.9</gml:pos>
            </Point>
        </position>
        <dateTime>
            <TimeInstant>
                <gml:timePosition>2006-05-16T19:46:00Z</gml:timePosition>
            </TimeInstant>
        </dateTime>
    </waveActivity>
    <waveActivity>
        <place>
            <country>CHILE</country>
            <city>PUERTO MONTT</city>
        </place>
        <position>
            <Point srsName="urn:ogc:def:crs:OGC:1.3:CRS84">
                <gml:pos>-41.5 -72.8</gml:pos>
            </Point>
        </position>
        <dateTime>
            <TimeInstant>
                <gml:timePosition>2006-05-16T20:16:00Z</gml:timePosition>
            </TimeInstant>
        </dateTime>
    </waveActivity>
    <waveActivity>
        <place>
            <region>EASTER IS.</region>
            <country>CHILE</country>
        </place>
        <position>
            <Point srsName="urn:ogc:def:crs:OGC:1.3:CRS84">
```

```
                <gml:pos>-27.1 -109.4</gml:pos>
            </Point>
        </position>
        <dateTime>
            <TimeInstant>
                <gml:timePosition>2006-05-16T20:19:00Z</gml:timePosition>
            </TimeInstant>
        </dateTime>
    </waveActivity>
    <waveActivity>
        <place>
            <country>CHILE</country>
            <city>PUNTA ARENAS</city>
        </place>
        <position>
            <Point srsName="urn:ogc:def:crs:OGC:1.3:CRS84">
                <gml:pos>-53.8 -71.7</gml:pos>
            </Point>
        </position>
        <dateTime>
            <TimeInstant>
                <gml:timePosition>2006-05-16T20:36:00Z</gml:timePosition>
            </TimeInstant>
        </dateTime>
    </waveActivity>
    <waveActivity>
        <place>
            <country>CHILE</country>
            <city>PUERTO WILLIAMS</city>
        </place>
        <position>
            <Point srsName="urn:ogc:def:crs:OGC:1.3:CRS84">
                <gml:pos>-54.8 -68.2</gml:pos>
            </Point>
        </position>
        <dateTime>
            <TimeInstant>
                <gml:timePosition>2006-05-16T20:36:00Z</gml:timePosition>
            </TimeInstant>
        </dateTime>
    </waveActivity>
    <waveActivity>
        <place>
            <country>PERU</country>
            <city>MOLLENDO</city>
        </place>
        <position>
            <Point srsName="urn:ogc:def:crs:OGC:1.3:CRS84">
                <gml:pos>-17.2 -72.0</gml:pos>
            </Point>
        </position>
        <dateTime>
            <TimeInstant>
                <gml:timePosition>2006-05-16T19:27:00Z</gml:timePosition>
            </TimeInstant>
        </dateTime>
    </waveActivity>
    <waveActivity>
        <place>
            <country>PERU</country>
            <city>SAN JUAN</city>
        </place>
```

```
        <position>
            <Point srsName="urn:ogc:def:crs:OGC:1.3:CRS84">
                <gml:pos>-15.3 -75.2</gml:pos>
            </Point>
        </position>
        <dateTime>
            <TimeInstant>
                <gml:timePosition>2006-05-16T19:32:00Z</gml:timePosition>
            </TimeInstant>
        </dateTime>
    </waveActivity>
    <waveActivity>
        <place>
            <country>PERU</country>
            <city>LA PUNTA</city>
        </place>
        <position>
            <Point srsName="urn:ogc:def:crs:OGC:1.3:CRS84">
                <gml:pos>-12.1 -77.2</gml:pos>
            </Point>
        </position>
        <dateTime>
            <TimeInstant>
                <gml:timePosition>2006-05-16T19:45:00Z</gml:timePosition>
            </TimeInstant>
        </dateTime>
    </waveActivity>
    <waveActivity>
        <place>
            <country>PERU</country>
            <city>TALARA</city>
        </place>
        <position>
            <Point srsName="urn:ogc:def:crs:OGC:1.3:CRS84">
                <gml:pos>-4.6 -81.5</gml:pos>
            </Point>
        </position>
        <dateTime>
            <TimeInstant>
                <gml:timePosition>2006-05-16T19:57:00Z</gml:timePosition>
            </TimeInstant>
        </dateTime>
    </waveActivity>
    <waveActivity>
        <place>
            <country>PERU</country>
            <city>CHIMBOTE</city>
        </place>
        <position>
            <Point srsName="urn:ogc:def:crs:OGC:1.3:CRS84">
                <gml:pos>-9.0 -78.8</gml:pos>
            </Point>
        </position>
        <dateTime>
            <TimeInstant>
                <gml:timePosition>2006-05-16T19:58:00Z</gml:timePosition>
            </TimeInstant>
        </dateTime>
    </waveActivity>
    <waveActivity>
        <place>
            <country>PERU</country>
```

```
            <city>PIMENTAL</city>
        </place>
        <position>
            <Point srsName="urn:ogc:def:crs:OGC:1.3:CRS84">
                <gml:pos>-6.9 -80.0</gml:pos>
            </Point>
        </position>
        <dateTime>
            <TimeInstant>
                <gml:timePosition>2006-05-16T20:06:00Z</gml:timePosition>
            </TimeInstant>
        </dateTime>
    </waveActivity>
    <waveActivity>
        <place>
            <country>ECUADOR</country>
            <city>LA LIBERTAD</city>
        </place>
        <position>
            <Point srsName="urn:ogc:def:crs:OGC:1.3:CRS84">
                <gml:pos>-2.2 -81.2</gml:pos>
            </Point>
        </position>
        <dateTime>
            <TimeInstant>
                <gml:timePosition>2006-05-16T20:02:00Z</gml:timePosition>
            </TimeInstant>
        </dateTime>
    </waveActivity>
    <waveActivity>
        <place>
            <country>ECUADOR</country>
            <city>ESMERELDAS></city>
        </place>
        <position>
            <Point srsName="urn:ogc:def:crs:OGC:1.3:CRS84">
                <gml:pos>1.2 -79.8</gml:pos>
            </Point>
        </position>
        <dateTime>
            <TimeInstant>
                <gml:timePosition>2006-05-16T20:14:00Z</gml:timePosition>
            </TimeInstant>
        </dateTime>
    </waveActivity>
    <waveActivity>
        <place>
            <region>BALTRA IS.</region>
            <country>ECUADOR</country>
        </place>
        <position>
            <Point srsName="urn:ogc:def:crs:OGC:1.3:CRS84">
                <gml:pos>-0.5 -90.2</gml:pos>
            </Point>
        </position>
        <dateTime>
            <TimeInstant>
                <gml:timePosition>2006-05-16T20:22:00Z</gml:timePosition>
            </TimeInstant>
        </dateTime>
    </waveActivity>
    <waveActivity>
```

```
        <place>
            <country>COLOMBIA</country>
            <city>TUMACO</city>
        </place>
        <position>
            <Point srsName="urn:ogc:def:crs:OGC:1.3:CRS84">
                <gml:pos>1.8 -78.9</gml:pos>
            </Point>
        </position>
        <dateTime>
            <TimeInstant>
                <gml:timePosition>2006-05-16T20:19:00Z</gml:timePosition>
            </TimeInstant>
        </dateTime>
    </waveActivity>
    <waveActivity>
        <place>
            <country>COLOMBIA</country>
            <city>BAHIA SOLANO</city>
        </place>
        <position>
            <Point srsName="urn:ogc:def:crs:OGC:1.3:CRS84">
                <gml:pos>6.3 -77.5</gml:pos>
            </Point>
        </position>
        <dateTime>
            <TimeInstant>
                <gml:timePosition>2006-05-16T20:27:00Z</gml:timePosition>
            </TimeInstant>
        </dateTime>
    </waveActivity>
    <waveActivity>
        <place>
            <country>COLOMBIA</country>
            <city>BUENAVENTURA</city>
        </place>
        <position>
            <Point srsName="urn:ogc:def:crs:OGC:1.3:CRS84">
                <gml:pos>3.8 -77.2</gml:pos>
            </Point>
        </position>
        <dateTime>
            <TimeInstant>
                <gml:timePosition>2006-05-16T20:29:00Z</gml:timePosition>
            </TimeInstant>
        </dateTime>
    </waveActivity>
    <waveActivity>
        <place>
            <country>PANAMA</country>
            <city>PUERTO PINA</city>
        </place>
        <position>
            <Point srsName="urn:ogc:def:crs:OGC:1.3:CRS84">
                <gml:pos>7.3 78.2</gml:pos>
            </Point>
        </position>
        <dateTime>
            <TimeInstant>
                <gml:timePosition>2006-05-16T20:28:00Z</gml:timePosition>
            </TimeInstant>
        </dateTime>
```

```
            </waveActivity>
            <waveActivity>
                <place>
                    <country>PANAMA</country>
                    <city>PUNTA MALA</city>
                </place>
                <position>
                    <Point srsName="urn:ogc:def:crs:OGC:1.3:CRS84">
                        <gml:pos>7.5 -79.8</gml:pos>
                    </Point>
                </position>
                <dateTime>
                    <TimeInstant>
                        <gml:timePosition>2006-05-16T20:30:00Z</gml:timePosition>
                    </TimeInstant>
                </dateTime>
            </waveActivity>
            <waveActivity>
                <place>
                    <country>PANAMA</country>
                    <city>PUNTA BURICA</city>
                </place>
                <position>
                    <Point srsName="urn:ogc:def:crs:OGC:1.3:CRS84">
                        <gml:pos>8.0 -82.8</gml:pos>
                    </Point>
                </position>
                <dateTime>
                    <TimeInstant>
                        <gml:timePosition>2006-05-16T20:31:00Z</gml:timePosition>
                    </TimeInstant>
                </dateTime>
            </waveActivity>
            <waveActivity>
                <place>
                    <country>PANAMA</country>
                    <city>BALBOA HTS.</city>
                </place>
                <position>
                    <Point srsName="urn:ogc:def:crs:OGC:1.3:CRS84">
                        <gml:pos>8.8 -79.7</gml:pos>
                    </Point>
                </position>
                <dateTime>
                    <TimeInstant>
                        <gml:timePosition>2006-05-16T20:52:00Z</gml:timePosition>
                    </TimeInstant>
                </dateTime>
            </waveActivity>
            <!-- REMAINDER OF PREDICTIONS OMITTED FOR BREVITY -->
        </predictions>
    </Evaluation>
</twml:Bulletin>
```

5.2 Example WC/ATWC bulletin

This example is based on the WC/ATWC bulletin shown Appendix B.

```
<?xml version="1.0" encoding="UTF-8"?>

<twml:Bulletin xmlns:gml="http://www.opengis.net/gml"
    xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
    xsi:schemaLocation="urn:x-hazard:tsunami:1.0 TsunamiBulletin.xsd"
    xmlns:twml="urn:x-hazard:tsunami:1.0">
    <header>
        <WMOHeader>WEPA41 PAAQ</WMOHeader>
        <productID>TSUWCA</productID>
    </header>
    <number>1</number>
    <issuedBy>NWS WEST COAST/ALASKA TSUNAMI WARNING CENTER PALMER
AK</issuedBy>
    <issuedDateTime>
        <TimeInstant>
            <gml:timePosition>2005-05-16T12:04:00-07:00</gml:timePosition>
        </TimeInstant>
    </issuedDateTime>
    <headline>NO - REPEAT NO - TSUNAMI WATCH OR WARNING IS IN EFFECT FOR
ALASKA - BRITISH COLUMBIA - WASHINGTON - OREGON - CALIFORNIA</headline>
    <nextBulletin>ADVISORIES WILL BE ISSUED HOURLY TO KEEP YOU INFORMED OF THE
PROGRESS OF THIS EVENT. REFER TO THE INTERNET SITE WCATWC.ARH.NOAA.GOV
FOR MORE INFORMATION AND EXPECTED ARRIVAL TIMES.</nextBulletin>
    <additionalBulletins>THE PACIFIC TSUNAMI WARNING CENTER AT EWA BEACH HAWAII
WILL ISSUE MESSAGES FOR HAWAII AND OTHER AREAS OF THE PACIFIC OUTSIDE THE
STATES AND PROVINCES LISTED ABOVE.</additionalBulletins>
    <lastBulletin>false</lastBulletin>
    <moreInformation>WCATWC.ARH.NOAA.GOV</moreInformation>
    <applicableArea>
        <includes>
            <place>
                <state>ALASKA</state>
            </place>
            <place>
                <state>BRITISH COLUMBIA</state>
            </place>
            <place>
                <state>WASHINGTON</state>
            </place>
            <place>
                <state>OREGON</state>
            </place>
            <place>
                <state>CALIFORNIA</state>
            </place>
        </includes>
    </applicableArea>
    <Evaluation>
        <description>A TSUNAMI MAY HAVE BEEN GENERATED THAT COULD BE
POTENTIALLY DANGEROUS TO THE COASTS OF ALASKA - BRITISH COLUMBIA -
WASHINGTON - OREGON AND CALIFORNIA. THE TSUNAMI WARNING CENTERS ARE
INVESTIGATING THE EVENT TO DETERMINE THE LEVEL OF DANGER. MORE
INFORMATION WILL BE ISSUED AS IT BECOMES AVAILABLE.</description>
        <observations>
            <seismicActivity>
                <originTime>
```

```
                <TimeInstant>
                    <gml:timePosition>2006-05-15T19:00:00Z</gml:timePosition>
                </TimeInstant>
            </originTime>
            <locationDescription>OFF COAST OF CENTRAL CHILE</locationDescription>
            <magnitude>
                <measure uom="urn:x-ogc:def:uom:OGC:1.0:Richter">8.2</measure>
            </magnitude>
            <depth>
                <measure uom="urn:x-ogc:def:uom:OGC:1.0:mile">12</measure>
            </depth>
        </seismicActivity>
    </observations>
    <predictions>
        <waveActivity>
            <place>
                <state>CALIFORNIA</state>
                <city>LA JOLLA</city>
            </place>
            <dateTime>
                <TimeInstant>
                    <gml:timePosition>2006-05-16T15:13:00-07:00</gml:timePosition>
                </TimeInstant>
            </dateTime>
        </waveActivity>
        <waveActivity>
            <place>
                <state>CALIFORNIA</state>
                <city>SAN FRANCISCO</city>
            </place>
            <dateTime>
                <TimeInstant>
                    <gml:timePosition>2006-05-16T15:36:00-07:00</gml:timePosition>
                </TimeInstant>
            </dateTime>
        </waveActivity>
        <waveActivity>
            <place>
                <state>CALIFORNIA</state>
                <city>CRESCENT CITY</city>
            </place>
            <dateTime>
                <TimeInstant>
                    <gml:timePosition>2006-05-16T15:41:00-07:00</gml:timePosition>
                </TimeInstant>
            </dateTime>
        </waveActivity>
        <waveActivity>
            <place>
                <state>WASHINGTON</state>
                <city>NEAH BAY</city>
            </place>
            <dateTime>
                <TimeInstant>
                    <gml:timePosition>2006-05-16T16:02:00-07:00</gml:timePosition>
                </TimeInstant>
            </dateTime>
        </waveActivity>
        <waveActivity>
            <place>
                <state>BRITISH COLUMBIA</state>
                <city>TOFINO</city>
```

```
            </place>
            <dateTime>
                <TimeInstant>
                    <gml:timePosition>2006-05-16T16:04:00-07:00</gml:timePosition>
                </TimeInstant>
            </dateTime>
        </waveActivity>
        <waveActivity>
            <place>
                <state>ALASKA</state>
                <city>SITKA</city>
            </place>
            <dateTime>
                <TimeInstant>
                    <gml:timePosition>2006-05-16T15:23:00-07:00</gml:timePosition>
                </TimeInstant>
            </dateTime>
        </waveActivity>
        <waveActivity>
            <place>
                <state>ALASKA</state>
                <city>KODIAK</city>
            </place>
            <dateTime>
                <TimeInstant>
                    <gml:timePosition>2006-05-16T15:36:00-07:00</gml:timePosition>
                </TimeInstant>
            </dateTime>
        </waveActivity>
        <waveActivity>
            <place>
                <state>ALASKA</state>
                <city>SHEMYA</city>
            </place>
            <dateTime>
                <TimeInstant>
                    <gml:timePosition>2006-05-16T15:50:00-07:00</gml:timePosition>
                </TimeInstant>
            </dateTime>
        </waveActivity>
    </predictions>
</Evaluation>
</twml:Bulletin>
```

5.3 Example “No Tsunami” bulletin

This example shows a TWML bulletin that includes no observed or predicted tsunami wave activity.

```
<?xml version="1.0" encoding="UTF-8"?>
<twml:Bulletin xmlns:gml="http://www.opengis.net/gml"
    xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
    xsi:schemaLocation="urn:x-hazard:tsunami:1.0 TsunamiBulletin.xsd"
    xmlns:twml="urn:x-hazard:tsunami:1.0">
    <issuedBy>WEST COAST/ALASKA TSUNAMI WARNING CENTER/NWS/NOAA</issuedBy>
    <issuedDateTime>
        <TimeInstant>
            <gml:timePosition>2006-05-30T21:27:00-08:00</gml:timePosition>
        </TimeInstant>
    </issuedDateTime>
    <headline>AN EARTHQUAKE WITH PRELIMINARY MAGNITUDE 4.8 OCCURRED 50 MILES
SOUTHEAST OF DUTCH HARBOR, ALASKA.  A TSUNAMI WILL NOT BE
GENERATED.</headline>
    <nextBulletin>THIS WILL BE THE ONLY WC/ATWC BULLETIN ISSUED FOR THIS
EVENT.</nextBulletin>
    <lastBulletin>true</lastBulletin>
    <moreInformation>http://earthquake.usgs.gov/</moreInformation>
    <applicableArea>
        <includes>
            <place>
                <region>WEST COAST STATES</region>
                <country>USA</country>
            </place>
            <place>
                <state>ALASKA</state>
            </place>
            <place>
                <state>BRITISH COLUMBIA</state>
            </place>
        </includes>
    </applicableArea>
    <Evaluation>
        <description>THE LOCATION AND MAGNITUDE ARE BASED ON PRELIMINARY
INFORMATION.  FURTHER INFORMATION WILL BE ISSUED BY THE UNITED STATES
GEOLOGICAL SURVEY.</description>
        <observations>
            <seismicActivity>
                <originTime>
                    <TimeInstant>
                        <gml:timePosition>2006-05-30T21:19:00-08:00</gml:timePosition>
                    </TimeInstant>
                </originTime>
                <locationDescription>50 MILES SOUTHEAST OF DUTCH HARBOR,
ALASKA</locationDescription>
                <magnitude>
                    <measure uom="urn:x-ogc:def:uom:OGC:1.0:Richter">4.7</measure>
                </magnitude>
            </seismicActivity>
        </observations>
    </Evaluation>
</twml:Bulletin>
```

6 TWML & EDXL Example

In many cases, the TWML bulletin may be distributed as the payload to an EDXL Distribution Element message as EDXL is fast becoming the framework for all-hazard early warning notifications. The advantage of using EDXL is that the recipients can be specified, as well as other critical emergency information and routing information.

In the example below, the EDXL message indicates routing options with <recipientRole>, <keyword> and <targetArea>. EDXL systems will distribute the embedded TWML bulletin (and other embedded payloads) based on established rules pertinent to the emergency operations and governance procedures of the applicable jurisdictions.

```
<?xml version="1.0" encoding="UTF-8"?>
<EDXLDistribution xmlns="urn:oasis:names:tc:emergency:EDXL:DE:1.0"
    xmlns:cap="urn:oasis:names:tc:emergency:cap:1.1"
    xmlns:twml="urn:x-hazard:tsunami:1.0">
    <distributionID>urn:cairns.au:dist:1234567890</distributionID>
    <senderID>emergency@hazard.gov.zz</senderID>
    <dateTimeSent>2006-05-31T16:00:00-09:00</dateTimeSent>
    <distributionStatus>Exercise</distributionStatus>
    <distributionType>Report</distributionType>
    <combinedConfidentiality>UNCLASSIFIED</combinedConfidentiality>
    <recipientRole>
        <valueListUrn>urn:x-hazard:vocab:roles</valueListUrn>
        <value>emergency-manager</value>
    </recipientRole>
    <keyword>
        <valueListUrn>urn:x-hazard:vocab:incidents</valueListUrn>
        <value>tsunami</value>
    </keyword>
    <targetArea>
        <country>AU</country>
        <locCodeUN>CXXCH</locCodeUN>
    </targetArea>
    <contentObject>
        <contentDescription>TWML message about the Tsunami</contentDescription>
        <xmlContent>
            <embeddedXMLContent>
                <twml:Bulletin>
                    ….see examples in section 5….
                </twml:Bulletin>
            </embeddedXMLContent>
        </xmlContent>
    </contentObject>
</EDXLDistribution>
```

References

[1] *Communications Plan for the Pacific Tsunami Warning and Mitigation System*, April 13, 2006.
<http://ioc3.unesco.org/ptws/documents/CommPlanPTWS_1may06_public.pdf>

[2] *Exercise Pacific Wave 06 – A Pacific-wide Tsunami Warning and Communication Exercise, 16-17 May 2006* (Manual).
<http://ioc3.unesco.org/ptws/documents/Exercise_Pacific_Wave_Manual-Final_4May06.pdf>

[3] *OpenGIS Geography Markup Language (GML) Implementation Specification* V3.1.1. OpenGIS Recommendation Paper, Reference number OGC 03-105r1, February 2004.
<http://portal.opengeospatial.org/files/?artifact_id=4700>

[4] *Emergency Data Exchange Language (EDXL) – Distribution Element* V1.0. OASIS Standard, May 2006
<http://docs.oasis-open.org/emergency/edxl-de/v1.0/EDXL-DE_Spec_v1.0.pdf>

[5] *Common Alerting Protocol (CAP) V1.1*. OASIS Standard, October 2005.
<http://www.oasis-open.org/committees/download.php/15135/emergency-CAPv1.1-Corrected_DOM.pdf>

[6] *Seismograph on spot but data took detour*. The Australian, 19 July 2006
<http://www.theaustralian.news.com.au/story/0,20867,19838388-601,00.html>

Appendix A. Example PTWC bulletin

This bulletin is taken from the *Exercise Pacific Wave 06* manual [2], pages 27-31.

```
TSUNAMI BULLETIN NUMBER 008
PACIFIC TSUNAMI WARNING CENTER/NOAA/NWS
ISSUED AT 2045Z 16 MAY 2006

THE EARTHQUAKE ORIGIN TIME... LOCATION... MAGNITUDE... AND
OTHER PARAMETERS IN THIS BULLETIN ARE NOT REAL AND WERE
CHOSEN ONLY FOR THE PURPOSE OF THIS EXERCISE. IN ADDITION...
THE TSUNAMI IS ARTIFICIALLY MOVING AT FOUR TIMES ITS NORMAL
SPEED TO COMPRESS THE EXERCISE. COUNTRIES MAY ALTER THESE
PARAMETERS TO SUIT THEIR OWN CIRCUMSTANCES.

THIS BULLETIN IS FOR ALL AREAS OF THE PACIFIC BASIN EXCEPT
ALASKA - BRITISH COLUMBIA - WASHINGTON - OREGON - CALIFORNIA.

... A PACIFIC-WIDE TSUNAMI WARNING IS IN EFFECT ...

THIS WARNING IS FOR ALL COASTAL AREAS AND ISLANDS IN THE PACIFIC
OUTSIDE OF ALASKA - BRITISH COLUMBIA - WASHINGTON - OREGON -
CALIFORNIA. THOSE AREAS SHOULD REFER TO MESSAGES FROM THE WEST
COAST AND ALASKA TSUNAMI WARNING CENTER.

AN EARTHQUAKE HAS OCCURRED WITH THESE PRELIMINARY PARAMETERS

 ORIGIN TIME -  1900Z 16 MAY 2006
 COORDINATES -  30.0 SOUTH   72.0 WEST
 LOCATION    -  OFF COAST OF CENTRAL CHILE
 MAGNITUDE   -  9.2

MEASUREMENTS OR REPORTS OF TSUNAMI WAVE ACTIVITY

 GAUGE LOCATION        LAT   LON    TIME    AMPL    PER
 ------------------  ----- ------  -----  ------  -----
 COQUIMBO            29.8S  71.3W  1920Z   9.5M   35MIN
 VALPARAISO          33.0S  71.6W  1922Z   2.9M   40MIN
 CALDERA             27.1S  70.8W  1924Z   8.0M     -
 DART CHILE          19.7S  74.8W  1927Z   0.4M   39MIN
 ANTOFAGASTA         23.5S  70.5W  1930Z   2.1M   34MIN
 ARICA               18.5S  70.3W  1935Z   2.2M   35MIN
 CORRAL              39.9S  73.4W  1937Z   1.0M   41MIN
 CALLAO              12.1S  77.2W  1950Z   2.2M   32MIN
 EASTER              27.2S 109.4W  2024Z   3.0M   20MIN
 BALTRA GALAPAGS      0.4S  90.3W  2027Z   0.6M     -

 TIME - TIME OF THE MEASUREMENT
 AMPL - AMPLITUDE IN METERS FROM MIDDLE TO CREST OR MIDDLE
        TO TROUGH OR HALF OF THE CREST TO TROUGH
 PER  - PERIOD OF TIME FROM ONE WAVE CREST TO THE NEXT

EVALUATION

 SEA LEVEL READINGS CONFIRM THAT A TSUNAMI HAS BEEN GENERATED
 WHICH COULD CAUSE WIDESPREAD DAMAGE TO COASTS AND ISLANDS IN THE
 PACIFIC. AUTHORITIES SHOULD TAKE APPROPRIATE ACTION IN RESPONSE
 TO THIS THREAT. THIS CENTER WILL CONTINUE TO MONITOR SEA LEVEL
 DATA TO DETERMINE THE EXTENT AND SEVERITY OF THE THREAT.

 A TSUNAMI IS A SERIES OF WAVES AND THE FIRST WAVE MAY NOT BE THE
```

LARGEST. TSUNAMI WAVE HEIGHTS CANNOT BE PREDICTED AND CAN VARY SIGNIFICANTLY ALONG A COAST DUE TO LOCAL EFFECTS. THE TIME FROM ONE TSUNAMI WAVE TO THE NEXT CAN BE FIVE MINUTES TO AN HOUR, AND THE THREAT CAN CONTINUE FOR MANY HOURS AS MULTIPLE WAVES ARRIVE.

FOR ALL AREAS - WHEN NO MAJOR WAVES ARE OBSERVED FOR TWO HOURS AFTER THE ESTIMATED TIME OF ARRIVAL OR DAMAGING WAVES HAVE NOT OCCURRED FOR AT LEAST TWO HOURS THEN LOCAL AUTHORITIES CAN ASSUME THE THREAT IS PASSED. DANGER TO BOATS AND COASTAL STRUCTURES CAN CONTINUE FOR SEVERAL HOURS DUE TO RAPID CURRENTS. AS LOCAL CONDITIONS CAN CAUSE A WIDE VARIATION IN TSUNAMI WAVE ACTION THE ALL CLEAR DETERMINATION MUST BE MADE BY LOCAL AUTHORITIES.

ESTIMATED INITIAL TSUNAMI WAVE ARRIVAL TIMES. ACTUAL ARRIVAL TIMES MAY DIFFER AND THE INITIAL WAVE MAY NOT BE THE LARGEST. THE TIME BETWEEN SUCCESSIVE TSUNAMI WAVES CAN BE FIVE MINUTES TO ONE HOUR.

LOCATION		COORDINATES	ARRIVAL TIME
CHILE	COQUIMBO	29.8S 71.3W	1902Z 16 MAY
	VALPARAISO	33.0S 71.6W	1908Z 16 MAY
	CALDERA	27.0S 70.8W	1908Z 16 MAY
	ANTOFAGASTA	23.5S 70.5W	1914Z 16 MAY
	TALCAHUANO	36.7S 73.1W	1919Z 16 MAY
	IQUIQUE	20.2S 70.1W	1921Z 16 MAY
	ARICA	18.5S 70.3W	1925Z 16 MAY
	CORRAL	39.8S 73.5W	1927Z 16 MAY
	GOLFO DE PENAS	47.1S 74.9W	1946Z 16 MAY
	PUERTO MONTT	41.5S 72.8W	2016Z 16 MAY
	EASTER IS.	27.1S 109.4W	2019Z 16 MAY
	PUNTA ARENAS	53.8S 71.7W	2036Z 16 MAY
	PUERTO WILLIAMS	54.8S 68.2W	2036Z 16 MAY
PERU	MOLLENDO	17.2S 72.0W	1927Z 16 MAY
	SAN JUAN	15.3S 75.2W	1932Z 16 MAY
	LA PUNTA	12.1S 77.2W	1945Z 16 MAY
	TALARA	4.6S 81.5W	1957Z 16 MAY
	CHIMBOTE	9.0S 78.8W	1958Z 16 MAY
	PIMENTAL	6.9S 80.0W	2006Z 16 MAY
ECUADOR	LA LIBERTAD	2.2S 81.2W	2002Z 16 MAY
	ESMERELDAS	1.2N 79.8W	2014Z 16 MAY
	BALTRA IS.	0.5S 90.2W	2022Z 16 MAY
COLOMBIA	TUMACO	1.8N 78.9W	2019Z 16 MAY
	BAHIA SOLANO	6.3N 77.5W	2027Z 16 MAY
	BUENAVENTURA	3.8N 77.2W	2029Z 16 MAY
PANAMA	PUERTO PINA	7.3N 78.2W	2028Z 16 MAY
	PUNTA MALA	7.5N 79.8W	2030Z 16 MAY
	PUNTA BURICA	8.0N 82.8W	2031Z 16 MAY
	BALBOA HTS.	8.8N 79.7W	2052Z 16 MAY
COSTA RICA	CABO MATAPALO	8.4N 83.3W	2032Z 16 MAY
	PUERTO QUEPOS	9.4N 84.2W	2039Z 16 MAY
	CABO SAN ELENA	10.9N 86.0W	2044Z 16 MAY
ANTARCTICA	THURSTON IS.	71.8S 100.0W	2043Z 16 MAY
	CAPE ADARE	71.0S 170.0E	2141Z 16 MAY
NICARAGUA	SAN JUAN DL SUR	11.2N 85.9W	2048Z 16 MAY
	PUERTO SANDINO	12.2N 86.8W	2052Z 16 MAY
	CORINTO	12.5N 87.2W	2053Z 16 MAY
EL SALVADOR	ACAJUTLA	13.5N 89.8W	2056Z 16 MAY
GUATEMALA	SIPICATE	13.9N 91.2W	2058Z 16 MAY
MEXICO	PUERTO MADERO	14.7N 92.5W	2101Z 16 MAY
	ACAPULCO	16.8N 100.0W	2108Z 16 MAY
	MANZANILLO	19.0N 104.3W	2118Z 16 MAY
	SOCORRO	18.8N 111.0W	2126Z 16 MAY
	MAZATLAN	23.2N 106.4W	2132Z 16 MAY
	CABO SAN LUCAS	22.8N 110.0W	2133Z 16 MAY
	PUNTA ABREOJOS	26.7N 113.6W	2150Z 16 MAY
	ENSENADA	31.8N 116.8W	2204Z 16 MAY

HONDURAS	AMAPALA	13.2N 87.6W	2102Z 16 MAY
PITCAIRN	PITCAIRN IS.	25.1S 130.1W	2105Z 16 MAY
FR. POLYNESIA	RIKITEA	23.1S 135.0W	2116Z 16 MAY
	HIVA OA	10.0S 139.0W	2136Z 16 MAY
	PAPEETE	17.5S 149.6W	2149Z 16 MAY
COOK ISLANDS	RAROTONGA	21.2S 159.8W	2158Z 16 MAY
	PENRYN IS.	8.9S 157.8W	2212Z 16 MAY
	PUKAPUKA IS.	10.8S 165.9W	2222Z 16 MAY
KIRIBATI	FLINT IS.	11.4S 151.8W	2159Z 16 MAY
	MALDEN IS.	3.9S 154.9W	2210Z 16 MAY
	CHRISTMAS IS.	2.0N 157.5W	2222Z 16 MAY
	KANTON IS.	2.8S 171.7W	2242Z 16 MAY
	TARAWA IS.	1.5N 173.0E	2310Z 16 MAY
KERMADEC IS	RAOUL IS.	29.2S 177.9W	2214Z 16 MAY
NIUE	NIUE IS.	19.0S 170.0W	2214Z 16 MAY
TONGA	NUKUALOFA	21.0S 175.2W	2220Z 16 MAY
AMERICAN SAMOA	PAGO PAGO	14.3S 170.7W	2223Z 16 MAY
NEW ZEALAND	NAPIER	39.5S 177.0E	2223Z 16 MAY
	DUNEDIN	45.8S 170.7E	2223Z 16 MAY
	GISBORNE	37.8S 176.7E	2225Z 16 MAY
	WELLINGTON	41.2S 174.7E	2229Z 16 MAY
	NORTH CAPE	34.4S 173.3E	2229Z 16 MAY
	MILFORD SOUND	44.5S 167.7E	2229Z 16 MAY
	EAST CAPE	36.2S 175.1E	2234Z 16 MAY
	LYTTELTON	43.5S 172.8E	2234Z 16 MAY
	BLUFF	46.6S 168.3E	2235Z 16 MAY
	AUCKLAND(E)	36.7S 175.0E	2247Z 16 MAY
	WESTPORT	41.7S 171.5E	2249Z 16 MAY
	NELSON	41.2S 173.3E	2250Z 16 MAY
	AUCKLAND(W)	37.1S 174.2E	2252Z 16 MAY
	NEW PLYMOUTH	39.1S 174.1E	2300Z 16 MAY
JARVIS IS.	JARVIS IS.	0.4S 160.1W	2223Z 16 MAY
SAMOA	APIA	13.8S 171.7W	2226Z 16 MAY
HAWAII	HILO	19.8N 155.0W	2230Z 16 MAY
	HONOLULU	21.2N 157.8W	2238Z 16 MAY
	NAWILIWILI	22.0N 159.4W	2240Z 16 MAY
WALLIS-FUTUNA	WALLIS IS.	13.2S 176.2W	2231Z 16 MAY
TOKELAU	NUKUNONU IS.	9.2S 171.8W	2232Z 16 MAY
PALMYRA IS.	PALMYRA IS.	6.3N 162.4W	2236Z 16 MAY
FIJI	SUVA	18.1S 178.4E	2241Z 16 MAY
AUSTRALIA	HOBART	43.3S 147.6E	2242Z 16 MAY
	SYDNEY	33.9S 151.4E	2256Z 16 MAY
	BRISBANE	27.2S 153.3E	2316Z 16 MAY
	GLADSTONE	23.8S 151.4E	2347Z 16 MAY
	CAIRNS	16.7S 145.8E	2356Z 16 MAY
	MACKAY	21.1S 149.3E	0013Z 17 MAY
TUVALU	FUNAFUTI IS.	7.9S 178.5E	2248Z 16 MAY
VANUATU	ANATOM IS.	20.2S 169.9E	2250Z 16 MAY
	ESPERITU SANTO	15.1S 167.3E	2304Z 16 MAY
JOHNSTON IS.	JOHNSTON IS.	16.7N 169.5W	2253Z 16 MAY
HOWLAND-BAKER	HOWLAND IS.	0.6N 176.6W	2253Z 16 MAY
NEW CALEDONIA	NOUMEA	22.3S 166.5E	2300Z 16 MAY
SOLOMON IS.	KIRAKIRA	10.4S 161.9E	2316Z 16 MAY
	AUKI	8.8S 160.6E	2323Z 16 MAY
	HONIARA	9.3S 160.0E	2324Z 16 MAY
	MUNDA	8.4S 157.2E	2327Z 16 MAY
	GHATERE	7.8S 159.2E	2328Z 16 MAY
	FALAMAE	7.4S 155.6E	2331Z 16 MAY
	PANGGOE	6.9S 157.2E	2332Z 16 MAY
MIDWAY IS.	MIDWAY IS.	28.2N 177.4W	2317Z 16 MAY
NAURU	NAURU	0.5S 166.9E	2318Z 16 MAY
MARSHALL IS.	MAJURO	7.1N 171.4E	2320Z 16 MAY
	KWAJALEIN	8.7N 167.7E	2328Z 16 MAY
	ENIWETOK	11.4N 162.3E	2341Z 16 MAY
KOSRAE	KOSRAE IS.	5.5N 163.0E	2332Z 16 MAY
PAPUA NEW GUINE	AMUN	6.0S 154.7E	2335Z 16 MAY

	KIETA	6.1S 155.6E	2337Z 16 MAY
	RABAUL	4.2S 152.3E	2341Z 16 MAY
	PORT MORESBY	9.3S 146.9E	2347Z 16 MAY
	LAE	6.8S 147.0E	2349Z 16 MAY
	KAVIENG	2.5S 150.7E	2351Z 16 MAY
	MADANG	5.2S 145.8E	2356Z 16 MAY
	MANUS IS.	2.0S 147.5E	0000Z 17 MAY
	WEWAK	3.5S 143.6E	0006Z 17 MAY
	VANIMO	2.6S 141.3E	0012Z 17 MAY
WAKE IS.	WAKE IS.	19.3N 166.6E	2339Z 16 MAY
POHNPEI	POHNPEI IS.	7.0N 158.2E	2343Z 16 MAY
RUSSIA	MEDNNY IS	54.7N 167.4E	2350Z 16 MAY
	UST KAMCHATSK	56.1N 162.6E	2356Z 16 MAY
	PETROPAVLOVSK K	53.2N 159.6E	0000Z 17 MAY
	URUP IS	46.1N 150.5E	0008Z 17 MAY
	SEVERO KURILSK	50.8N 156.1E	0012Z 17 MAY
CHUUK	CHUUK IS.	7.4N 151.8E	2358Z 16 MAY
MARCUS IS.	MARCUS IS.	24.3N 154.0E	0002Z 17 MAY
N. MARIANAS	SAIPAN	15.3N 145.8E	0011Z 17 MAY
GUAM	GUAM	13.4N 144.7E	0012Z 17 MAY
INDONESIA	JAYAPURA	2.4S 140.8E	0013Z 17 MAY
	WARSA	0.6S 135.8E	0024Z 17 MAY
	MANOKWARI	0.8S 134.2E	0029Z 17 MAY
	SORONG	0.8S 131.1E	0036Z 17 MAY
	BEREBERE	2.5N 128.7E	0041Z 17 MAY
	PATANI	0.4N 128.8E	0043Z 17 MAY
	GEME	4.6N 126.8E	0045Z 17 MAY
	MANADO	1.6N 124.9E	0054Z 17 MAY
	TARAKAN	3.3N 117.6E	0116Z 17 MAY
	PANGKALPINANG	2.0S 106.2E	0238Z 17 MAY
	SINGKAWANG	1.0N 108.8E	0319Z 17 MAY
JAPAN	KUSHIRO	42.9N 144.3E	0019Z 17 MAY
	HACHINOHE	40.5N 141.7E	0026Z 17 MAY
	KATSUURA	35.0N 140.3E	0027Z 17 MAY
	SHIMIZU	32.8N 133.0E	0046Z 17 MAY
	OKINAWA	26.2N 127.8E	0052Z 17 MAY
YAP	YAP IS.	9.5N 138.1E	0023Z 17 MAY
BELAU	MALAKAL	7.3N 134.5E	0030Z 17 MAY
PHILIPPINES	DAVAO	6.8N 125.7E	0049Z 17 MAY
	PALANAN	17.1N 122.6E	0056Z 17 MAY
	LEGASPI	13.2N 123.8E	0058Z 17 MAY
	ZAMBOANGA	6.9N 122.1E	0059Z 17 MAY
	LAOAG	18.2N 120.5E	0107Z 17 MAY
	SAN FERNANDO	16.7N 120.2E	0111Z 17 MAY
	ILOILO	10.7N 122.5E	0116Z 17 MAY
	PUERTO PRINCESA	9.8N 118.8E	0117Z 17 MAY
	MANILA	14.7N 120.8E	0131Z 17 MAY
TAIWAN	HUALIEN	24.0N 121.6E	0102Z 17 MAY
MALAYSIA	SANDAKAN	5.9N 118.1E	0126Z 17 MAY
	BINTULU	3.2N 113.0E	0214Z 17 MAY
	K TERENGGANU	5.3N 103.2E	0333Z 17 MAY
VIETNAM	QUI NHON	13.7N 109.3E	0138Z 17 MAY
	VINH	18.7N 105.8E	0213Z 17 MAY
	BAC LIEU	9.2N 105.8E	0250Z 17 MAY
CHINA	HONG KONG	22.3N 114.3E	0155Z 17 MAY
BRUNEI	MUARA	5.0N 115.1E	0201Z 17 MAY
SINGAPORE	SINGAPORE	1.2N 103.8E	0349Z 17 MAY
CAMBODIA	SIHANOUKVILLE	10.7N 103.5E	0433Z 17 MAY
THAILAND	NK SI THAMMARAT	8.7N 100.0E	0437Z 17 MAY
	PRA KHIRI KHAN	11.7N 99.8E	0504Z 17 MAY

BULLETINS WILL BE ISSUED HOURLY OR SOONER IF CONDITIONS WARRANT.
THE TSUNAMI WARNING WILL REMAIN IN EFFECT UNTIL FURTHER NOTICE.

THE WEST COAST/ALASKA TSUNAMI WARNING CENTER WILL ISSUE BULLETINS
FOR ALASKA - BRITISH COLUMBIA - WASHINGTON - OREGON - CALIFORNIA.

Appendix B. Example WC/ATWC standard bulletin

This bulletin is taken from the *Exercise Pacific Wave 06* manual [2], pages 41-42.

```
WEPA41 PAAQ 161904
TSUWCA
PKZ176-175-170>172-155-150-132-136>138-141-140-120-121-125>130-
051>053-041>043-011>013-021-022-031>036-PZZ130>135-150-153-156-
110-250-210-255-350-353-356-450-455-550-530-535-555-670-673-650-
655-750-AKZ191-185-181-171-145-111-101-121-125-131-135-017>029-
WAZ001-002-005>011-013>016-021-ORZ001-002-021-022-CAZ001-002-
005>007-075-074-009-034-035-039>043-087-162004-

TSUNAMI MESSAGE NUMBER 1
NWS WEST COAST/ALASKA TSUNAMI WARNING CENTER PALMER AK
1204 PM PDT TUE MAY 16 2006

...THIS MESSAGE IS PART OF THE PACIFIC WAVE 06 EXERCISE AND
   RELATES TO THE EXERCISE ONLY. THE EARTHQUAKE ORIGIN TIME
   LOCATION AND MAGNITUDE AND OTHER PARAMETERS IN THIS BULLETIN
   ARE NOT REAL AND WERE CHOSEN ONLY FOR THE PURPOSE OF THIS
   EXERCISE. IN ADDITION... THE TSUNAMI IS ARTIFICIALLY MOVING
   AT FOUR TIMES ITS NORMAL SPEED TO COMPRESS THE EXERCISE.
   COUNTRIES MAY ALTER THESE PARAMETERS TO SUIT THEIR
   OWN CIRCUMSTANCES...

...THIS TSUNAMI ADVISORY IS FOR ALASKA - BRITISH
   COLUMBIA - WASHINGTON - OREGON AND CALIFORNIA ONLY...

NO - REPEAT NO - WATCH OR WARNING IS IN EFFECT FOR THE STATES
AND PROVINCES LISTED ABOVE.

EVALUATION
 A TSUNAMI MAY HAVE BEEN GENERATED THAT COULD BE POTENTIALLY
 DANGEROUS TO THE COASTS OF ALASKA - BRITISH COLUMBIA -
 WASHINGTON - OREGON AND CALIFORNIA. THE TSUNAMI WARNING
 CENTERS ARE INVESTIGATING THE EVENT TO DETERMINE THE LEVEL OF
 DANGER.  MORE INFORMATION WILL BE ISSUED AS IT BECOMES AVAILABLE.

A FEW SELECTED ETA'S FOLLOW FOR INFORMATION AND REFERENCE
ETAS ARE ADJUSTED FOR EXERCISE TIMING
LA JOLLA-CA      1513 PDT MAY 16   TOFINO-BC        1604 PDT MAY 16
SAN FRANCISCO-CA 1536 PDT MAY 16   SITKA-AK         1523 ADT MAY 16
CRESCENT CITY-CA 1541 PDT MAY 16   KODIAK-AK        1536 ADT MAY 16
NEAH BAY-WA      1602 PDT MAY 16   SHEMYA-AK        1550 ADT MAY 16

PRELIMINARY EARTHQUAKE PARAMETERS
 MAGNITUDE - 8.2
 TIME      - 1100 ADT 05/16/2006
             1200 PDT 05/16/2006
             1900  Z  05/16/2006
 LOCATION  - 30.0S    72.0W
           - OFF COAST OF CENTRAL CHILE
 DEPTH     - 12 MILES

THE PACIFIC TSUNAMI WARNING CENTER AT EWA BEACH HAWAII WILL
ISSUE MESSAGES FOR HAWAII AND OTHER AREAS OF THE PACIFIC
OUTSIDE THE STATES AND PROVINCES LISTED ABOVE.

ADVISORIES WILL BE ISSUED HOURLY TO KEEP YOU INFORMED OF
THE PROGRESS OF THIS EVENT. REFER TO THE INTERNET SITE
WCATWC.ARH.NOAA.GOV FOR MORE INFORMATION AND EXPECTED ARRIVAL
```

```
TIMES.

THIS MESSAGE IS PART OF THE PACIFIC WAVE 06 EXERCISE AND
RELATES TO THE EXERCISE ONLY.
$$
```