N° 488
NATIONAL ASSEMBLY
CONSTITUTION OF 4 OCTOBER 1958
THIRTEENTH TERM
Registered with the Presidency of the National Assembly
on 7 December 2007

N° 117
SENATE
REGULAR MEETING OF 2007-2008
Appendix to the minutes of the
7 December 2007 session

PARLIAMENT OFFICE FOR THE EVALUATION OF SCIENTIFIC AND TECHNOLOGICAL CHOICES (OPECST)

REPORT

on

Evaluating and preventing the tsunami risk for France's metropolitan and overseas coasts

by

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Filed with the Bureau of the National Assembly
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INTRODUCTION

The Parliamentary Office for the Evaluation of Scientific and Technological Choices (OPECST) has already had the opportunity to examine the subject of natural risks and their prevention, thanks to **the work carried out by our colleague, Mr. Christian Kert, Deputy, author of two benchmark reports**, the first of which[1] dealt with earthquakes and ground movements and the second of which[2] dealt with other natural hazards: hazards due to the weather, avalanches, **inundations**, droughts, forest fires, volcanism, collapsing mines and underground cavities.

In addition, following the dramatic Indonesian tsunami of 26 December 2004, our colleague, Mr. Christian Kert, organized **public hearings** before the National Assembly on 17 February 2005. These hearings were again held on 18 March 2005 in Port-la-Nouvelle (in the Aude *département*), in cooperation with your rapporteur and our colleague Mr. Jacques Bascou, Deputy. This work shined a light on a risk that had up until then generated little concern in France. These hearings also allowed us to take stock of the situation with regard to tsunami-detection research and international cooperation in the field of tsunami prevention and early-warning systems.

On 22 March 2005, the OPECST was commissioned to prepare a report by the Bureau of the National Assembly, in accordance with Article 6 (section B) of edict no. 58-1100 of 17 November 1958 concerning earthquake- and tidal wave-related hazards in the Mediterranean Sea. Your rapporteur was put in charge of this study, the title of which was later modified following the feasibility study.

The title of the study was modified following the presentation of the feasibility study.

Firstly, the term "tidal wave" turned out to be inappropriate, since it refers to a meteorological phenomenon, while tsunamis are always seismic in origin.

Secondly, an analysis of the tsunami risk limited to the Mediterranean area proved too narrow in scope, in so far as tsunamis can occur in any large ocean basin and France is present in every ocean of the world, via its overseas *départements* and territories.

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[1] "Les techniques de prévision et de prévention des risques naturels : séismes et mouvements de terrain", *report no. 261 (Senate) and no. 2017 (National Assembly) by Mr. Christian Kert, Deputy, on behalf of the Parliamentary Office for the Evaluation of Scientific and Technological Choices (1995).*

[2] "Les techniques de prévision et de prévention des risques naturels en France", *report no. 312 (Senate) and no. 1540 (National Assembly) by Mr. Christian Kert, Deputy, on behalf of the Parliamentary Office for the Evaluation of Scientific and Technological Choices (1999).*

The final report therefore deals with evaluating and preventing the risk posed by tsunamis to all French coasts, both in metropolitan France and overseas.

Your rapporteur first examined in detail the characteristics of this hazard and concluded that in order to decrease our vulnerability to tsunamis, a sophisticated early-warning system must be established.

Indeed, tsunamis are relatively rare phenomena compared to other natural events, such as storms and inundations; however, they often have a devastating impact on coastal populations. As a result, their prevention (or, at the very least, the limitation of their impact) demands a dense system of instruments for measuring earthquakes and sea level, a dependable, high-speed data-transmission system, and a preestablished, operational plan for alerting the concerned populations. The effectiveness of any early-warning system ultimately depends upon an informed, aware population, that must also be able to adopt the appropriate responses.

These significant budgetary and logistical constraints, combined with the fact that tsunamis most frequently occur in the Pacific Ocean, have led to diverse measures for the management of this risk. These measures vary according to the particular ocean basin: while the Pacific states began to set up an international warning system in the second half of the 20th century, efforts to manage the tsunami risk in the other ocean basins are much more recent and directly linked to the shock of the tsunami of 26 December 2004.

On the one hand, it was necessary to recognize the vulnerability of all the oceans and seas. Statistically speaking, the Indian Ocean is considered the safest (large) ocean basin with regard to tsunamis, since it accounted for only 4% of tsunamis generated during the 20th century. However, the 2004 tsunami claimed more victims than all other (known) tsunamis combined since ancient times.

On the other hand, it was necessary to explain to the concerned governments that, even if the risk is rare, the public no longer accepts to be left unprotected when a warning system that saves human lives could be set up.

Under the aegis of the United Nations, it was therefore decided in 2005 to create a tsunami warning system for the Indian Ocean, the Caribbean and the Mediterranean/Northeast Atlantic zone.

Two years later, this project has achieved unequal results: while the assessment is generally positive for the Indian Ocean, the setting up of an early-warning system for the Caribbean and Mediterranean/Northeast Atlantic zone has fallen far behind schedule due to the wait-and-see policy of the concerned countries.

Due to the dispersal of its overseas territories, France is particularly sensitive to the risk of tsunamis. Indeed, it began to set up its tsunami warning system for French Polynesia in the 1960s. Following the Sumatra tsunami, France pushed strongly for the setting up of an early-warning system to cover the three other ocean basins, particularly the Indian Ocean.

Nevertheless, it is clear that once the initial shock had faded away, this movement quickly ran out of steam, due to a lack of political will and insufficient funding. While the last meeting dedicated to the setting up of an early-warning system for the Mediterranean and the North Atlantic represented a real break from the waiting game that France had been playing for over a year, no concrete decision has yet been made and numerous questions remain concerning the structure of the national tsunami warning system, its geographical coverage and, above all, the means it is to be allocated.

Your rapporteur will therefore make structural proposals concerning the four ocean basins, as well as recommendations for each sea/ocean, in order for France to quickly set up a national tsunami warning centre for the Mediterranean, the Caribbean and the Indian Ocean.

I. WHAT IS A TSUNAMI?

Your rapporteur would first like to consider in detail the following questions: What is a tsunami? How are tsunamis generated? How do they manifest themselves? How can this natural phenomenon become a major risk for coastal populations?

A. A NATURAL HAZARD

Tsunamis are phenomena of geological origin, whose frequency varies depending on location.

1. A phenomenon of geological origin

If one excludes those very rare tsunamis generated by a man-made explosion or the impact of a meteorite, it can be said that **tsunamis are always of geological origin**. They are caused by the sudden penetration or retreat (when speaking of earthquakes, the terms "uplift", "upheaval", "sinking" and/or "subsidence" are often used) of a large quantity of geological material in the ocean depths, resulting in the displacement of a large mass of water.

a) The different causes

Three natural phenomena are liable to cause a tsunami: underwater and coastal earthquakes, landslides and volcanic eruptions.

(1) Underwater earthquakes

On the surface, an earthquake manifests itself by ground vibrations. It is caused by the fracturing of rocks deep below the surface. This fracturing results from the release of a great accumulation of energy, creating or reactivating faults[1], when the rocks' rupture threshold has been reached.

The earth's crust is made up of several large lithospheric plates which move about in relation to one another. While the plates normally move from a few millimetres to a few centimetres per year, in those regions on two plates boundary, this movement is discontinuous. The faults can remain locked during long periods of time, while the plates' regular movement (convergence, divergence and sliding) continues. This locking of the plate boundaries is the cause of local and regional deformations, such as the buckling of the plates on either side of the oceanic trenches.

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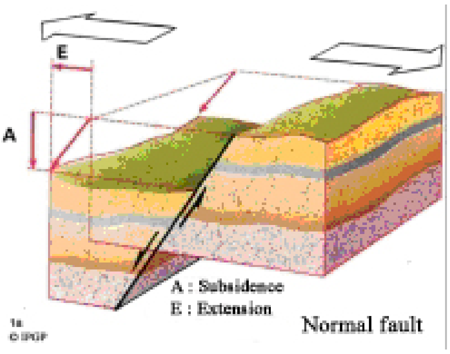
[1] *A discontinuity or fracture in the earth's crust, showing evidence of relative movement between the two blocks of rock separated by the fault.*

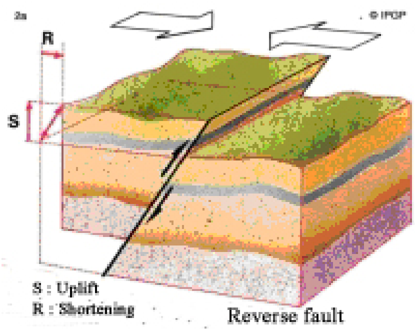
In brief, the situation is as follows: the region of the blocked fault is progressively deformed (slow elastic deformation) as it accumulates energy, up until the time this energy is suddenly released, resulting in a seismic rupture; with the subsequent relaxing of the tectonic constraints, the fault is once again blocked, and the same seismic cycle begins all over again.

There are three types of fault line:

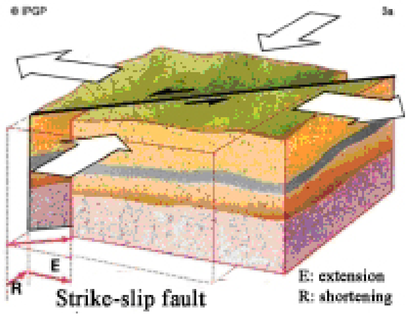
- Normal faults: the horizontal displacement provoked by the slip corresponds to an extension of the crust (E), with one of the blocks sinking downward relative to the second.



- Reverse faults: the horizontal displacement provoked by the slip corresponds to a shortening of the crust (R), with one of the blocks overlapping the second.



- Strike-slip faults: this third type of fault corresponds to a horizontal shift along a vertical fault surface.



Source: IPGP

For a submarine earthquake to generate a tsunami, it must result in a vertical movement of the sea floor. **Therefore, the hypocentre must be situated at a depth of less than 100 km. In addition, it must have a magnitude of at least 6.5.**

Subduction (or reverse-fault) earthquakes are particularly dangerous, because the activated faults are often very long and an earthquake's magnitude is proportional to this length, as well as the seismic sliding along the fault line. The tsunami that ravaged Indonesia on 26 December 2004 was provoked by an earthquake with a magnitude of 9.3, which occurred off the northwestern tip of the island of Sumatra. At this location, the Indo-Australian Plate converges with and sinks below the Eurasian Plate. The fault ruptured along 1,200 km. This rupture lasted 9 minutes and caused water displacements of 15 to 25 metres. With a plate convergence speed of 6 cm/year in this region, the last major earthquake would have taken place between 400 and 600 years ago.

Normal-fault earthquakes are provoked by much smaller fault lines (with a maximum length of 200 to 300 km) and, therefore, are of a weaker magnitude. However, since the angles are generally steeper (30° to 40°, as compared to 10° to 20° for subduction earthquakes), the tsunami risk is not negligible. The underwater earthquake of 21 November 2004 with a magnitude of 6.3, which occurred some ten kilometres south of the Iles des Saintes, generated a tsunami that hit Guadeloupe and Martinique.

One could easily suppose that strike-slip fault earthquakes do not generate tsunamis, since the sliding is horizontal. However, although the tsunami risk is, in fact, low, it still exists and depends on the angle of the underwater fault. A perfect example is the Izmit earthquake in Turkey, which provoked a local tsunami.

(2) Landslides

The Bureau de Recherches Géologiques et Minières (BRGM) defines a landslide as the shearing off and displacement of a mass of loose or rocky ground along a rupture area, often corresponding to a pre-existing discontinuity. Landslides are provoked by a combination of factors, that can be:

- either permanent in other words, only slightly or not at all variable over time (the nature and mechanical properties of the materials, the presence of preferred fracture planes, the ground slope, etc.);

- or semi-permanent in other words, variable over time (the water content of the materials, erosion at the bottom of the slope, anthropic activity, earthquakes, the collapse of a volcano, etc.).

Landslides have caused numerous tsunamis.

On 16 December 1979, a section of the Nice Airport embankment fell into the sea. A few minutes later, after a relative lowering of the sea level, a tsunami submerged the coast and a wave with an estimated height of between 2.5 and 3.5 metres hit the beach of La Salis in Antibes.

There is little consensus over the supposed causes of this tsunami. Two competing arguments point the finger at either 1) work being carried out to expand the Nice Airport or 2) the natural geological instability of the coast aggravated by the heavy rains which fell on the region a few days prior to the incident.

The most recent studies call attention to two landslides: the first landslide (with a volume of 10 million m^3) consisted of the collapsed airport embankment, while the second and much larger landslide (150 million m^3) would have taken place off the shore of Nice.

What's more, on 13 September 1999, the collapse of a section of basalt cliff (between 2 and 5 million m^3) on the island of Fatu Hiva in the Marquesas Islands provoked a tsunami that struck the village of Omoa.

Landslides can also be caused by collapsing volcanoes. On 30 December 2002, on the island of Stromboli, two landslides of several million m^3 of rock blocks and ashes carried away the volcanic emissions that had accumulated since 28 December. Following a retreat of the sea, waves several metres high struck the island, injuring 6 persons and causing material damage.

While tsunamis caused by landslides can be highly destructive, they are geographically limited. Indeed, while the vertical deformation can exceed several dozen metres, the horizontal dimensions (generally a few hundred metres) rarely exceed a dozen kilometres; for this reason, the resulting waves have relatively short wavelengths.

(3) Volcanic explosions

Volcanic explosions can also produce tsunamis, by suddenly sending an immense volume of rock into the sea.

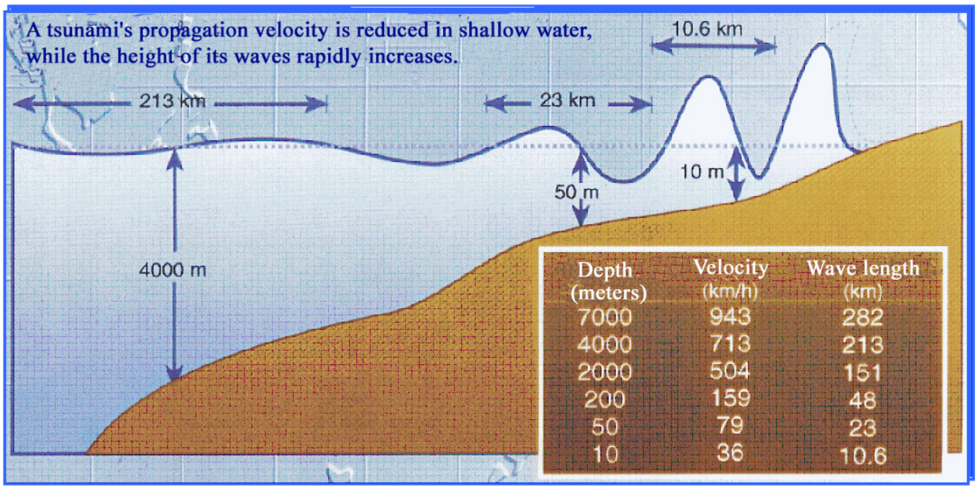
The volcanic eruption on Santorini around 1650 B.C. generated a devastating tsunami that some argue led to the demise of the Minoan civilization. The tsunami is thought to have struck the eastern Mediterranean coasts with waves estimated at around forty metres high in the vicinity of the island.

Likewise, the volcanic explosion of Krakatoa, in Indonesia, on 27 August 1883 generated waves 41 metres high which destroyed villages located along the Sunda Straight between the islands of Java and Sumatra, claiming some 36,000 victims.

b) A description of the tsunami phenomenon

Following an earthquake, a landslide or a volcanic eruption, the oceanic layer is disrupted, with an uplift and, sometimes, a subsidence of up to several metres. The water surface, acted upon by the forces of gravity, begins to oscillate and waves are generated in every direction outward from the source of origin.

The propagation of a tsunami



Source: CEA

In deep water, tsunamis move at very fast speeds (between 700 and 900 km/h in depths of between 4,000 and 7,000 metres), with very long wave lengths[1] (from 100 to more than 200 km). In comparison, a wind-generated wave has a period of around 10 seconds and a length of some 150 m.

The energy of a tsunami wave forms a moving wall from the surface to the bottom of the sea, even in the deepest of waters. This energy corresponds to a mechanical energy (or total energy) that is the sum of the wave's kinetic energy (velocity) and potential energy (linked to the height of the wave).

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[1] *Wave length is the distance between two successive crests of a periodic wave.*

Out at sea, the waves' speed is very great; therefore, the kinetic energy is also very great and the potential energy very weak. For this reason - and because the waves' period is very long (between a few minutes and several dozen minutes) - the tsunami waves remain undetected by ships at sea.

However, as the waves near the coast, they are slowed down by the rising sea bottom and a shift occurs between the kinetic energy and the potential energy. The kinetic energy decreases (the wave velocity falls to as low as 36 km/h), while the potential energy increases, with the waves growing in height and provoking a rapid rise of the sea level in harbours and bays or an overflowing of the sea onto the coast: in other words, a tsunami.

c) Various manifestations

When a tsunami arrives on the coast, it can manifest itself in various ways, depending on the sources put in play. For instance, the greater the amount of displaced water, the greater the distance travelled by the tsunami, the greater the number of concerned countries, and the greater the risk of destruction. Scientists distinguish between 3 types of tsunami:

- **local tsunamis**, which are unobservable over a hundred kilometres and are generally provoked by earthquakes with a magnitude of between 6.5 and 7.5, by landslides and by volcanic eruptions;

- **regional tsunamis**, which travel a distance of between 100 and 1,000 km and are almost always generated by subduction earthquakes (with the exception of the Santorini eruption of 1650 B.C.);

- **tsunamis that are capable of devastating coasts thousands of kilometres from their source of origin are known as teletsunamis** and are almost always provoked by subduction earthquakes (with the exception of the Krakatoa eruption of 1883). The most recent teletsunami struck the Indian Ocean on 26 December 2004, but one can also cite the tsunami of 1 November 1755 provoked by an earthquake off the coast of Lisbon and which crossed the Atlantic, as well as the tsunami of 22 May 1960 provoked by an earthquake in Chile and which crossed the entire Pacific Ocean, generating 5-metre-high waves on the Japanese coast 24 hours later.

In addition, tsunamis are affected by the coastal relief. While steep slopes reflect waves, gentle slopes increase their amplitude. Likewise, an island can be protected by its corral reef "breaking" the waves. These "site effects" explain why the Tuamotu archipelago are well protected from tsunamis, while the Marquesas Islands are particularly vulnerable; they also explain why tsunamis often have a greater impact on harbours and estuaries.

What are the concrete manifestations of a tsunami?

First of all, a tsunami can cause the sea to retreat far from the coast, followed by its very rapid rise engendering violent, destructive currents. The water's backward surge is also very destructive, for both lightweight installations and persons who find themselves being "sucked away".

Tsunami waves can be amplified by the coastal relief. This is the case of rivers which penetrate deep inland, forming a narrow gully through which the rushing water creates a tidal bore.

Likewise, in closed spaces such as harbours and bays, the waves will succeed one another at 10- to 20-minute intervals, creating a successive emptying-filling effect, with strong currents and eddies.

The particular vulnerability of harbours explains why several boats were damaged in certain harbours along the French Riviera following the earthquake in Boumerdès, Algeria on 21 May 2003 (although the news media incorrectly reported that the French coasts had escaped unscathed). For example, in the port of Théoule-sur-Mer, a significant, rapid rise in the water level was observed, followed by a retreat which partially "pumped" the harbour dry. In the harbour of Figueirette, the water level dropped some 1.5 meters in all of the basins, with very strong currents entering and leaving the harbour.

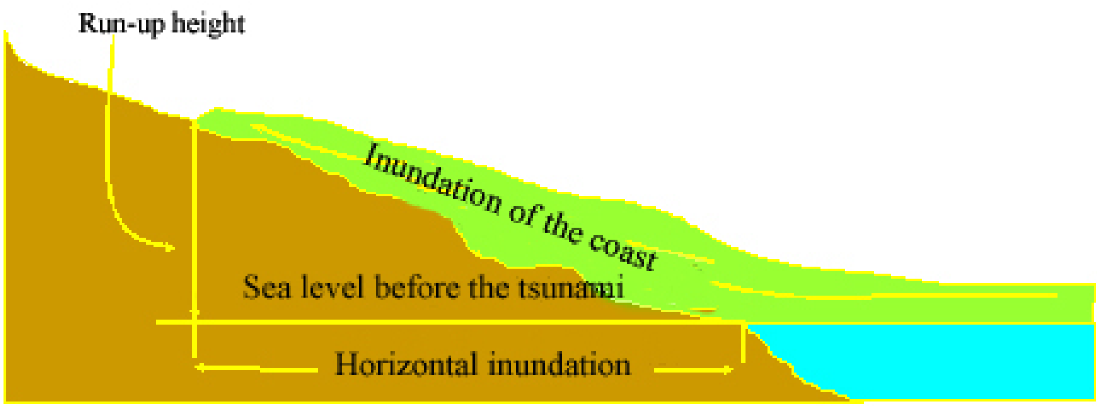
Finally, in extreme cases, the tsunami can manifest itself by a series of giant waves capable of reaching heights of up to several dozen metres. Their period (between 20 and 40 minutes) makes them particularly dangerous, because those persons having escaped the first wave often think that the danger has passed and so descend to the shore to observe the damage and aid survivors.

What's more, the largest wave is rarely the first, but rather one of the succeeding waves which, in addition to its own potential energy, recovers the energy of a broken wave that is returning to sea. In Banda Aceh, during the Sumatra tsunami of 2004, the first wave measured between 1.5 and 2 metres in height, while the second reached a height of more than 30 metres at certain points along the coast.

In the general consciousness, tsunamis are dangerous because they are associated with waves several metres high striking the coast and destroying everything in their path. In reality, the destructive force of a tsunami has less to do with the height of its wave (or waves) than with its velocity (30 to 40 km/h) and the quantity of water it is carrying, allowing it to penetrate up to several hundred metres inland over flat terrain without any natural obstacles (up to 5 km in Banda Aceh). While a classic wave, with a period of up to a minute, does not raise the water level for a sufficient amount of time to penetrate very far inland, a tsunami wave results in an increased water level for a period of between 5 and 30 minutes.

Therefore, it is the quantity of water which determines the extent of inundationing and the height of the "run-up", or the rise in the water level above sea level.

Tsunami propagation on the coast

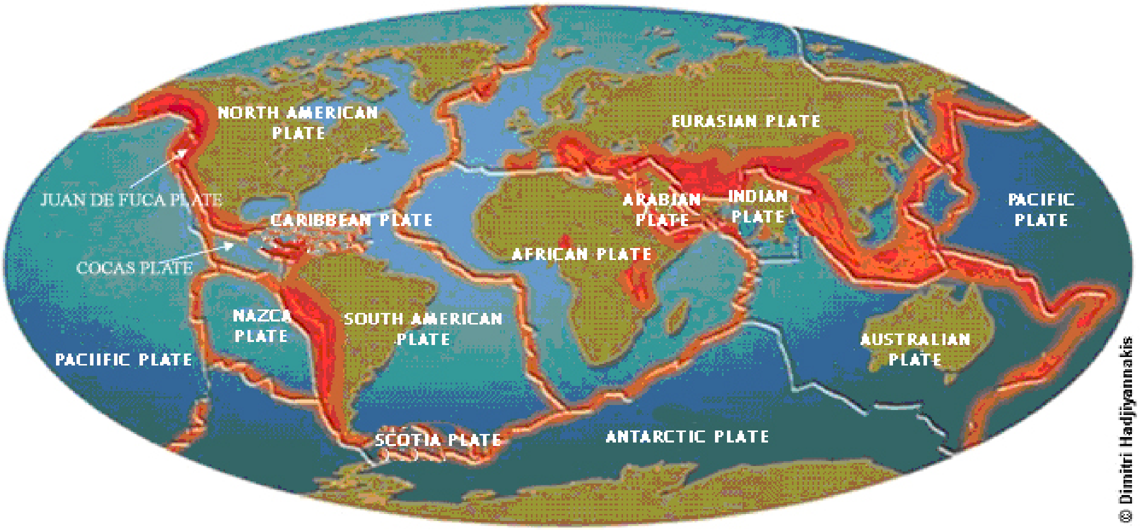


Source: CEA

2. A natural phenomenon of unequal geographical distribution

The most dangerous zones are those with the greatest seismic activity: in other words, those zones where the tectonic plates converge, either by subduction (with one plate sliding beneath another) or collision.

Tectonic plate map



Source: CEA

Since the beginning of the 20th century, 911 tsunamis have been reported in the world (for an average of 9 per year). 98 tsunamis were characterized by waves of between 1 and 5 metres (an average of 1 per year). 6 teletsunamis occurred with waves of over 5 metres and a distance travelled of over 5,000 km.

a) A greater frequency in the Pacific

According to the information gathered by your rapporteur during his hearings, of the 2,180 tsunamis recorded all over the world between the years - 1650 (supposed date of the Thera Volcano eruption on Santorini) and 2005, 59% occurred in the Pacific, 25% in the Mediterranean, 12% in the Atlantic and 4% in the Indian Ocean.

However, the geographic distribution of tsunamis recorded over a long period of time is not necessarily pertinent information, in so far as the available historic data varies according to the region. For instance, we have much more knowledge of past events to have occurred in the Mediterranean area than in the West Indies or the Pacific zone.

Therefore, it is preferable to limit our examination of tsunami distribution to the 20th century, even if this period of time is too short for us to be able to draw definitive conclusions.

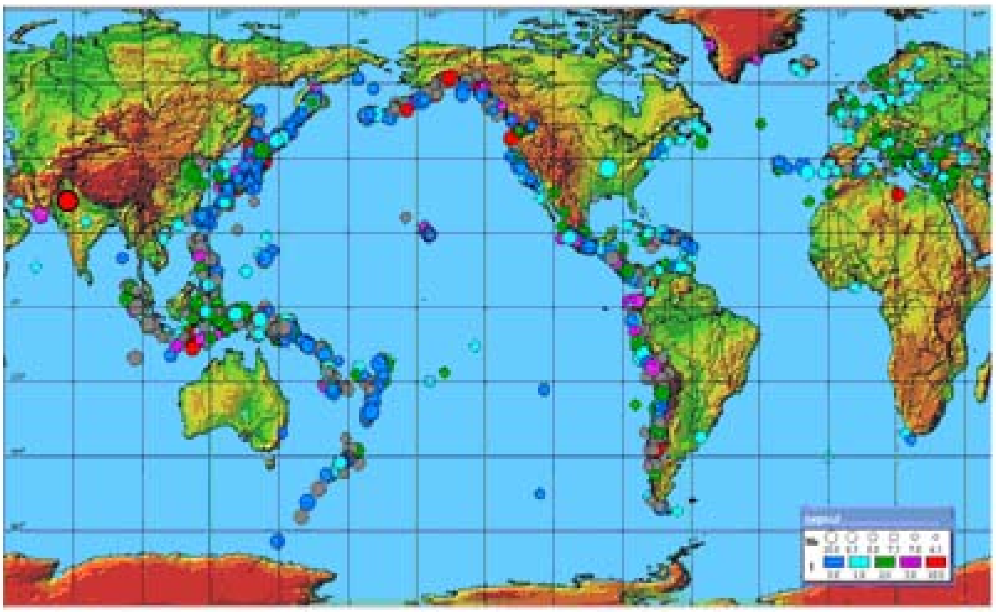
These 20th-century figures show that 77% of tsunamis were generated in the Pacific, as compared to 9% in the Mediterranean, 10% in the Atlantic and 4% in the Indian Ocean.

In addition, the 5 most important teletsunamis of the 20th century all occurred in the Pacific:

- On 1 April 1946, an earthquake with a magnitude of 8.6 in the Aleutian Islands (Alaska) provoked a tsunami that killed 165 persons and caused more than $26 million worth of damage (in 1946 terms);
- On 4 November 1952, an earthquake with a magnitude of 9.0 off the Kamchatka Peninsula (Russia) generated a tsunami which claimed no human victims;
- On 9 March 1957, an earthquake with a magnitude of 9.1 in the Aleutian Islands provoked a tsunami which killed 5 people in Hawaii, no less than 3,600 km away;
- On 22 May 1960, an earthquake with a magnitude of 9.5 off the coast of Chile generated a tsunami which claimed 2,000 victims;
- Finally, on 28 March 1964, an earthquake with a magnitude of 9.2 in Alaska's Prince William Sound generated a tsunami which killed 122 persons and provoked damages estimated at more than $106 million.

Tsunamis occur most frequently in the Pacific Ocean due to the intense seismic activity of the earth's crust in this region of the world. As shown in the map below, it is on the "Ring of Fire" (chains of volcanoes whose origin is directly related to the sinking plates of the subduction zones) that one observes the strongest earthquakes as well as the most active volcanoes.

Sources of tsunamis in the world
(2,180 events from - 1628 to 2005)



Source: International Tsunami Data Base (UNESCO)

That said, the other ocean basins remain vulnerable.

b) No ocean basin is safe from tsunamis

In **the Mediterranean**, the collision between the African and Eurasian Plates makes this region particularly prone to earthquakes and tsunamis. The large tsunamis to have struck this area in the past are relatively well known (see table below). Historically, it appears that the most destructive source of origin is that of the subduction zone located beneath the Hellenic Arc (Crete in 365 and Rhodes in 1303). The eastern Mediterranean is still considered the most dangerous zone.

The most important Mediterranean tsunamis

Date	**Place of origin**	**Remarks**
ca. - 1650	Santorini	Tsunami generated by the eruption of the Thera volcano, with a wave estimated at 40 m.
365	Crete	Tsunami generated by an earthquake with a magnitude of around 8,5, with a wave estimated at 10 m.
373	Helike	Tsunami generated by an earthquake with a magnitude of around 7, with a wave estimated at 10 m.
1303	Rhodes	Tsunami generated by an earthquake with a magnitude of around 8.
1365	Algiers	Tsunami generated by an earthquake with a magnitude of around 7.
1755	Lisbon	Tsunami generated by an earthquake with a magnitude of around 8, with a wave estimated at 4 m.
1908	Messina	Tsunami generated by an earthquake with a magnitude of around 7, with a wave of 8 m.

The northeast Atlantic seems less prone to tsunamis. However, the tsunami of 1 November 1755 off the coast of Lisbon was one of the most destructive ever recorded anywhere in the world, with 5-metre-high waves striking the harbour and killing 20,000 persons.

The West Indies, characterized by significant volcanic and seismic activity, also run the risk of tsunamis. The West Indies are affected by tsunamis generated in either the Caribbean or the Atlantic (subduction earthquakes or teletsunamis).

According to a 2001 study by Narcisse Zahibo and Efim Pelinovsky, around 24 tsunamis have been reported in the Lesser Antilles over the past 400 years.[1]

Finally, **the Indian Ocean** is not safe from tsunamis, either. While it is true that the area accounts for only 4% of recorded tsunamis, following the Sumatra catastrophe, the tsunami risk can no longer be ignored in this region. What's more, 3 large tsunamis have since been provoked by strong earthquakes on 28 March 2005, 17 July 2006 and 12 September 2007.

B. THE TSUNAMI RISK

Tsunami hazard and tsunami risk are different. Tsunami risk represents a potential danger which, if and when it occurs, can have catastrophic results.

1. The risk factors

In environmental terms, risk can be defined as "the possibility that an event occurs which is likely to disrupt the natural equilibrium". Risk results from the combination of three factors: 1) a hazard, 2) stakes and 3) the stakes' vulnerability to the hazard.

a) The hazard

The "hazard" represents the source of danger. To evaluate the risk, it is necessary to determine the hazard's probability of occurrence, as well as its intensity and frequency. However, the risk is not limited to the hazard alone. For instance, a tsunami generating a 3-metre-high wave on a desert island represents a minor risk; however, if the same wave were to strike the beaches at Antibes (French Riviera) on a national holiday in the middle of July, the results would be dramatic. Therefore, the notion of risk is linked to the notion of what is at stake.

b) The stakes

The "stakes" are those persons, property, facilities and/or environments threatened by the hazard and likely to suffer damage should it occur. These stakes can be divided into five separate categories:

- the human stakes;

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[1] *The Lesser Antilles are a string of small islands of volcanic or calcareous origin, which form an arc stretching from the Virgin Islands east of Puerto Rico to Grenada to the south.*

- the economic and financial stakes which concern commercial, craft, industrial, agricultural and tourist activities;
- the social stakes, which include everything that affects social cohesion and the functioning of society;
- the environmental stakes, which cover the possible damage to ecosystems and biodiversity;
- the heritage stakes, which concern historical and cultural monuments and a region's "public image".

These stakes can suffer varying degrees of damage, depending on the hazard's intensity:

- physical injuries to persons;
- structural damage to the urban fabric, to goods and property and to networks;
- functional damage disrupting day-to-day activities (cut telephone and gas lines, power outages, disrupted modern communication networks such as the Internet);
- environmental damage to the ecosystem;
- damage to the historical and cultural heritage.

c) Vulnerability

The hazard's capacity to damage the stakes varies according to their vulnerability. Faced with a tsunami, a few simple actions can save lives: a strong shaking and a retreating sea are forerunners of a tsunami and should incite people to leave the coast and seek refuge in buildings above the third floor.

The Sumatra tsunami of 26 December 2004 is a case in point: many lives would have been saved if the concerned populations had had a basic understanding of this hazard. We could have spared ourselves these horrible images of the receding sea, the large waves already forming on the horizon and numerous tourists in the process of gathering shells or watching the approach of the oncoming waves. In this case, the population was made all the more vulnerable for its not having been properly informed.

Being vulnerable means being physically exposed to a hazard and presenting a certain fragility to the catastrophe that could occur. Vulnerability can vary over time, since its depends principally on human activity. Today, the world's population is particularly vulnerable to tsunamis due to densely inhabited coastlines.

Indeed, the transportation revolution and a globalized economy have greatly increased international trade flows and pushed industry to the coast, resulting in increased harbour traffic and the creation of vast industrial harbour areas. Likewise, tourist and leisure-activity development is concentrated on the coasts. The rapid development of these activities has led to the massive urbanization of the concerned coastlines.

The following figures allow for a quantification of this "coastalizing" trend.

Today, nearly half of Europe's population lives within 50 kilometres of the continent's 70,000 kilometres of coastline (nearly 40% of the world's population lives within 100 kilometres of the coast). Average population density in France is slightly higher than 100 inhabitants per square kilometre; however, this figure rises to over 250 inhabitants for the coastal districts and is over 600 for the Provence-Alpes-Côte-d'Azur region.

In addition, the mountainous relief of volcanic islands – as much in the Pacific as in the Indian Ocean and the Caribbean – concentrates these islands' populations along the coast.

One must not underestimate the subjective component of vulnerability linked to how the threat is perceived. Risk only exists when the social group or individual considers it or himself as being "fragile" faced with a given natural phenomenon. Different groups react differently to the same event: while some do not recognize the existence of any danger, others do but accept to live with it, while still others refuse to accept it.

In the developed world, our notion of risk has evolved from a fatalistic vision of risk as something divinely determined (and so largely unaffected by human-based protective measures) to the notion of managed risk (and, consequently, a right to protection).

One might think that in the case of natural risks, the question of "responsibility" is irrelevant. However, recent changes in our understanding of risk and responsibility demonstrate that, in fact, this is not the case and increasingly society is looking to protect itself against these "natural" risks. The creation of legal and institutional structures, such as risk-prevention agencies and policies (the establishment of earthquake-construction standards, for example) illustrates the desire of governments to both protect their citizens and limit their liability in the event of a catastrophe.

2. Managing risk

As stated earlier, risk necessitates a vulnerability to the natural hazard. Managing risk, therefore, entails a better understanding of the hazard in question, as well as a reduction of the concerned societies' vulnerability vis-à-vis the said hazard through the establishment of an operational early-warning system.

a) A better understanding of the hazard

Since reducing the frequency of tsunamis is not an option, we must instead work to reduce their possible impact by better understanding both the processes that provoke tsunamis and their mechanisms of propagation, followed by the setting up of an appropriate protection system.

Therefore, a better understanding of the hazard means being capable of not only understanding the phenomenon (how it manifests itself, its frequency and intensity, and the area affected), but also predicting it (in other words, specifying where and when it will occur).

As will be shown, understanding the hazard in order to consider the risk necessitates our calling upon diverse scientific fields, such as seismology, geography, oceanography, geology and biology.

As it turns out, it is essential to collect data allowing for a better understanding of the hazard's characteristics. To do this, we must rely upon not only eyewitness accounts and photographs, but also hydraulic and geographic records in order to determine the run-up level and the areas inundationed. That is why post-tsunami surveys are so important, for they allow for a close, reliable examination of the hazard, especially in sparsely populated regions.

Tsunami-mapping in French Polynesia rests, to a large extent, on meticulous observations made by scientists in the aftermath of a tsunami.

Understanding tsunamis also depends upon a correct understanding of their causes: earthquakes, landslides and volcanic eruptions. The data that must be collected is two-fold:

- On the one hand, data directly linked to a specific event (the localization and magnitude of a tsunami-generating earthquake, the localization of a landslide and the volume of displaced rocks, the localization of a volcanic eruption and the volume of rocks either expelled or displaced following the volcano's collapse, etc.); this information allows for a better understanding of the phenomenon.

- On the other hand, a more global understanding of the causes of tsunamis and their localization via the study of faults, active volcanoes and instable rocky zones along the seashore or underwater. For example, studying tsunami directivity allows scientists to better determine the concerned zones. Indeed, while a tsunami will spread outward in all directions from its source of origin, a large amount of its energy will propagate in a direction perpendicular to the fault zone. As a result, the longer the earthquake's rupture area, the greater the number of concerned zones. In addition, a zone outside the tsunami's angle of maximum energy will be relatively safe, even if located near the source of origin, while a zone within the angle of maximum energy will receive the full force of the tsunami, even if located thousands of kilometres away. Therefore, this data facilitates the prediction and mapping of tsunamis.

Insofar as the hazard is characterized by its intensity and frequency, it is important to have access to long series of data and to reconstruct and determine the scale of past events. To this end, **several historical catalogues have been drawn up:**

- An American catalogue covering the entire globe, established by the National Geophysical Data Center, part of the United States Department of Commerce's National Oceanic and Atmospheric Administration (NOAA[1]);
- Two Russian catalogues, one covering the Pacific zone and the other the Mediterranean zone, established by the Russian Academy of Sciences;
- A European catalogue, financed by the European Commission within the framework of the Fifth Research Framework Programme, entitled *The Genesis and Impact of Tsunamis on European Coasts* (2001);
- An Italian catalogue;
- Studies concerning the West Indies carried out by O'Loughlin and Lander (2003), Lander et al. (2002), and Zahibo and Pelinovsky (2001).

It should be pointed out that this task proves to be quite difficult for ancient (and, sometimes, even recent) events, insofar as there exists little direct data and the events must be reconstructed from diverse documents (written texts, eyewitness accounts, photographs or drawings). This historical work is quite delicate and demands both a critical examination of the sources and a verification of the data's coherency, in order to use the information in the most pertinent and reliable manner. In addition, this work is never completed, since technological advances and the discovery of new sources are liable to provide additional information.

It is in this context that **computer simulations play an important role**.

Firstly, they allow scientists to test various hypotheses concerning the triggering and propagation of tsunamis.

The Nice tsunami of 16 October 1979 is a case in point: because simulations showed that the landslide observed in the area of the airport extension was insufficient to explain the magnitude of the observed waves, the scientists directed their research towards a second, much larger landslide. This hypothesis was later confirmed by underwater observations.

Likewise, simulations can be used to complement *in situ* observations and refine tsunami maps. For example, in French Polynesia, several simulations were carried out in the most vulnerable bays, in certain harbours and in the area of the airport, in order to best determine those areas concerned by tsunamis. Taking into account the population density along the coast, it is difficult for the Polynesian authorities to set strict regulations with regard to

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[1] *The NOAA is a federal agency dependent on the United States Department of Commerce. Its writ extends to all issues relative to the state of the oceans and atmosphere. In particular, it is in charge of evaluating the risk and limiting the impact of tsunamis.*

construction; they therefore opt for a precise delimitation of the evacuation zones.

Secondly, simulations allow scientists to "test" tsunamis in the zones considered vulnerable, but which lack reliable observations. Therefore, these simulations allow us to predict a possible tsunami, to determine its potential intensity and to take the appropriate precautionary measures. These simulations have the added advantage of being able to make decisions in the case of a tsunami without having to wait for a confirmation of the risk. Such simulations are all the more useful for those tsunamis endangering nearby zones, thereby greatly reducing the reaction time available.

To clarify, let us consider the following example: Suppose that an earthquake of magnitude 7.5 occurs off the coast of Japan. Taking into account its magnitude and its location at sea, there is a strong chance that the earthquake provokes a tsunami. However, in order to predict its amplitude and the height of the waves that will strike the coast, scientists must have instruments for measuring sea level (tsunamimeters) out at sea. If there are not enough of these instruments or if the earthquake is centred too close to the coast for the information provided by the tsunamimeters to be of any use (due to a lack of time), the concerned populations cannot be protected. On the other hand, if the authorities responsible for their safety benefit from similar (simulated) scenarios prior to the current event, they can take the necessary measures.[1] As we will see, this is the solution that Japan has chosen to limit the impact of tsunamis on its population.

It should be pointed out that the quality of any given simulation depends in large part on the reliability of the data used. In particular, an excellent understanding of the concerned zone's bathymetry and coastal topography is essential for a correct analysis of the tsunami's propagation and amplification upon reaching the coast.

b) The role of operational warning systems

Tsunami warning systems are meant to reduce the vulnerability of populations to this hazard. For them to be effective, three conditions must be met:

- the warning system is fast, reliable and operational;
- measures for protecting the population are the subject of a preestablished plan;
- the population is informed of the tsunami risk.

Let us now examine each of these conditions in detail.

In order to be operational, the warning system must be capable of detecting a tsunami early on, of predicting its propagation, its time of arrival

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[1] *In which case, the "only" risk run is that of issuing a false warning.*

and the height of its waves along the threatened coasts, and of transmitting this information to the authorities responsible for civil protection.

Tsunamis are detected via measuring instruments. Seismometer networks allows scientists to locate the epicentre and focus of an earthquake and to measure its magnitude, in order to determine if the latter can provoke a tsunami.[1] In the event of the answer being yes, the data gathered by the tsunamimeters and tide gauges allows scientists to confirm the presence of a tsunami and to refine the information concerning its amplitude. Therefore, the quick detection of a tsunami requires not only a sufficient number of measuring devices and networks, but also networks with advanced means of communication for the real-time transmission of their data. As for the early-warning centre, it must not only have access to this data, it must also be capable of processing and analyzing the data; this necessitates round-the-clock monitoring, seven days a week.

The role of tsunamimeters and tide gauges

A tsunamimeter is a pressure sensor installed at sea and capable of detecting waves of very low amplitude (a few centimetres). Indeed, when a wave passes by, the pressure increases due to the greater volume of water located above the sensor. Tsunamimeters are used not only to detect tsunamis, but also to predict the development and impact of both regional and distant tsunamis. There are two types of tsunamimeter:

- The first type of sensor is linked to an underwater cable which transmits its data. Such a device has the advantages of being less expensive to maintain and having little chance of being damaged. However, there are two limits to this system: firstly, the tsunamimeter cannot be installed very far from the coast (150 km max); secondly, a violent earthquake can snap the cable. Such cable-linked tsunamimeters are principally used by the Japanese.
- The second type of sensor is installed on the seafloor and transmits its data via an acoustical link to a buoy on the surface which then relays the data via satellite to the warning centre. The Americans began to develop this type of device starting in 1997 with their Deep-Ocean Assessment and Reporting of Tsunamis (DART) buoys, within the framework of their national programme for limiting the impact of tsunamis. These sensors are impressively precise, for they are capable of detecting waves of only one centimetre in depths of 6,000 metres. In addition, they can be installed in the middle of the ocean, thereby allowing for a real forecasting of tsunami events. However, they are very expensive to install and maintain: according to the information gathered by your rapporteur, this type of instrument costs between €70,000 and €200,000, its installation costs €100,000, and its obligatory annual visit costs between €50,000 and €70,000; what's more, the device must be replaced every 5 to 10 years.

A tide gauge is a device which measures the sealevel at a specific location. It is generally situated in a harbour and sometimes combined with a GPS station. This instrument is most often used to measure tides. In addition, its data is rarely transmitted

[1] *Seismometers can also be used to detect volcanic eruptions and landslides.*

in real-time, but rather stored and recovered once a day or once a month. Insofar as they are installed along the shore, they cannot be used to forecast tsunamis affecting the same zone. However, they are still useful for two reasons. Firstly, they are an integral part of the early-warning system, providing precious information to the neighbouring countries/regions/islands, as well as to the civil protection services that can then take immediate safety measures in the case of strong waves being detected. Secondly, the measurements (wave amplitude, number and time of arrival) are later used to reconstruct the phenomenon and by the simulation models. For all that, their integration into the early-warning system necessitates their being able to transmit their data in real-time.

When a tsunami risk is detected, the information must be quickly transmitted to the authorities in charge of civil security, so that they can take the necessary measures.

Taking into account the limited amount of time available (anywhere between a few minutes and a few hours), the chain of command and the civil protection plan cannot be improvised.

The authorities chosen to receive the warning messages must be clearly identified. That is why in the warning system coordinated by the Intergovernmental Oceanographic Commission (IOC), each country must designate a focal point: an organization charged with receiving these messages. For an effective transmission of this information, the said organization must provide round-the-clock monitoring, seven days a week. In the case of an alert, it is responsible for informing the civil security services.

In addition, emergency plans must be established and tested beforehand and each person's role and responsibilities clearly defined. In general, these plans rely on both evacuation maps based on past tsunamis and inundation maps provided by numerical simulations.

The population, therefore, will be encouraged to play an active role in protecting itself from the impact of a tsunami: depending on the amplitude of the tsunami, the population will have to evacuate the beaches and/or certain other low-lying coastal zones and seek refuge either on higher ground or in a sufficiently high and strong building. In some cases, the population will have to wait several hours before being able to return to the coast. What's more, if it feels an earthquake or hears a siren, the population must be capable of making the right decisions. Therefore, an early-warning system is only effective if the population is informed and well-aware of the tsunami phenomenon. A policy of prevention is therefore essential and can be divided into two necessary parts:

- Educating children at school, with both theoretical instruction (e.g., understanding tsunamis, eyewitness accounts) and practical instruction (e.g., evacuation exercises);

- Regular communication of the tsunami risk via the publishing of pamphlets and books, the holding of conferences, the inauguration of tsunami-specific signals, or organizing exercises simulating the arrival of a tsunami and the evacuation of the endangered zone.

Most of the persons interviewed by your interlocuteur pointed out that this policy of raising the population's awareness of the tsunami risk often represents the weak link in the early-warning chain. Not only must it be continually repeated to remain effective, but the population's receptiveness depends on its perception of the danger and its cultural and social behaviour. However, a tsunami is a relatively rare phenomenon and therefore of little weight in the collective consciousness, especially among the young. On the other hand, preventive measures, such as evacuations, have a heavy impact, because they can paralyze the economy of an entire region during several hours. Therefore, many warning systems have been designed in order to both protect the population and avoid false alarms (deemed catastrophic economically and financially, and which undermine the credibility of the policy seeking to limit the impact of tsunamis).

Therefore, it would seem that the policies for managing tsunami risk cannot be uniform: to be acceptable, suitable and long-lasting, they must take into account the concerned population's behaviour, which can be deeply rooted in its culture, tradition and social practices, thereby determining which measures would be accepted by the population.

II. A MANAGEMENT OF THE TSUNAMI RISK WHICH VARIES DEPENDING ON THE BASINS

While the tsunami warning system for the Pacific Ocean was put in place more than forty years ago, it was not until the Sumatra tsunami of 2004 that the international community finally decided to provide the other basins with a similar system.

A. A RISK TAKEN INTO CONSIDERATION FOR THE PAST SEVERAL DECADES IN THE PACIFIC

As stated earlier, the Pacific Ocean is the region the most often struck by tsunamis. Therefore, it is only logical that this basin benefited from the very first warning system.

1. The existence of an international tsunami-warning system...

a) History

The creation of an international tsunami warning system in the Pacific Ocean is the direct result of the increased frequency of teletsunamis in this zone between 1946 and 1964: over a period of twenty years, no less than 5 teletsunamis crossed the Pacific, claiming several thousand victims and causing considerable damage.

Following the tsunami of 1 April 1946 which originated in the Aleutian Islands and devastated the island of Hilo, the United States decided to create the national Tsunami Warning Center at the site of its geomagnetic observatory in Honolulu.

Following the 4 November 1952 tsunami off the Kamchatka Peninsula, Japan decided to create its own national warning centre, which was entrusted to the Japan Meteorological Agency (JMA). A form of cooperation would eventually emerge between the Japanese and American warning centres, through the exchange of seismic data.

On 22 May 1960, a teletsunami devastated Chile and several Pacific islands. A few months later, the United Nations Educational, Scientific and Cultural Organization (UNESCO) set up the Intergovernmental Oceanographic Commission (IOC), charged with developing global cooperation in oceanic research. Since its creation, the IOC has established as its mission the prevention of ocean-related risks, including tsunamis.

The tsunami of 28 March 1964 which originated off the coast of Alaska accelerated the setting up of a tsunami warning system for the Pacific: as early as 1965, an international coordination group for the tsunami warning system in the Pacific (known as ICG/Pacific) [11]was created.

The IOC accepted the offer of the United States to expand the services of its national tsunami warning centre in Hawaii, which has since been used as the operational warning centre for all Pacific states.
At the same time, the International Tsunami Information Centre (ITIC) was created, whose initial mandate was to mitigate the impact of tsunamis by:

- helping the member states of the ICG/Pacific to develop and improve their tsunami-prevention policies;

- improving the tsunami warning system in the Pacific;

- encouraging tsunami research;

- informing the non-member states of and encouraging them to join the said warning system;

- conducting post-tsunami surveys in order to document and better understand these disasters.

In 1968, the Honolulu observatory officially became the Pacific Tsunami Warning Center (PTWC).

b) The current situation

Today, the Intergovernmental Coordination Group for the Tsunami Early Warning and Mitigation System in the Pacific Ocean has 30 member states: Canada, Chile, Ecuador, El Salvador, the Fiji Islands, France, Guatemala, Indonesia, Japan, Malaysia, Mexico, New Zealand, Nicaragua, Papua New Guinea, Peru, the Philippines, South Korea, Russia, Samoa, Singapore, Thailand, Tonga, the United States and Vietnam.

The first Master Plan was published in 1989. The current version dates from 1999. It describes the situation of the warning system at that date, points out the inadequacies and proposes solutions. It also describes the warning-system strategy, which has four main parts:

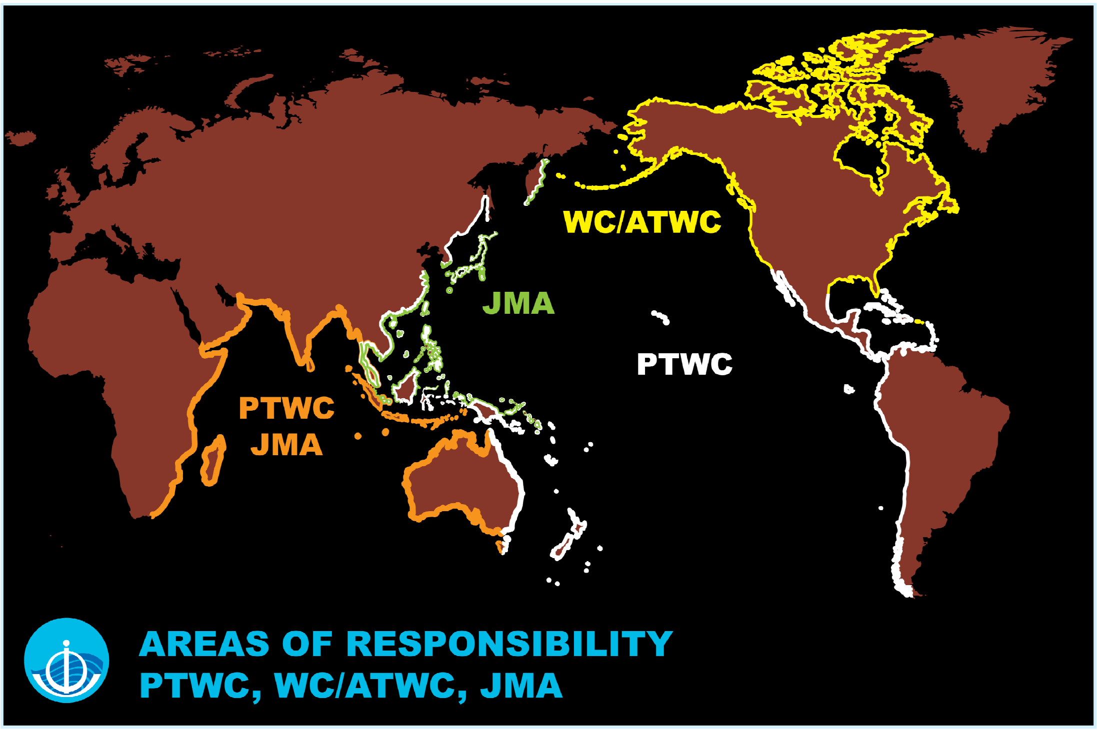
- evaluating the hazard and risks (historical data, on-the-ground research, computer modelling);

[1] *Since its creation, the ICG/Pacific group has been responsible for making recommendations with respect to the prevention programmes set up by member states whose coasts are threatened by tsunamis and to coordinate these various programmes. To meet these objectives, the group is invited to meet every two years or so in one of the member states. The ICG/Pacific assesses both the measurements taken and any inadequacies observed, and establishes an action programme to solve the latter. If necessary, working groups are created.*

- warning (warning centres, monitoring networks, data transmission);
- prevention (education, evacuation, environmental planning);
- research.

Concerning those aspects linked to the evaluation of this phenomenon and to research, the ICG/Pacific has closely cooperated since the 1990s with the Tsunami Commission of the International Union of Geodesy and Geophysics (IUGG), with which it has organized 6 international workshops centred around tsunamis. The ICG/Pacific has funded the creation of a database compiling an inventory of all tsunamis to have occurred in and outside the Pacific, as well as the creation of a computer program for modelling tsunamis that is available to all UNESCO member states.

Three international warning centres are currently in place: PTWC in Hawaii, the West Coast and Alaska Tsunami Warning Center (WC-ATWC) and the Northwest Pacific Tsunami Advisory Center (NWPTAC), managed by JMA.[1] Each of these three centres is responsible for a separate zone, as shown in the map below.



Source: ITIC

[1] *The WC-ATWC and NWPTAC will be considered in detail in the following sections on the American model and the Japanese model, respectively.*

(1) The role of the Pacific Tsunami Warning Center (PTWC)

PTWC, which is administered and financed by the National Oceanic and Atmospheric Administration (NOAA) of the United States, serves as the operational centre for the Pacific tsunami warning system. PTWC has a current staff of twelve, which provides round-the-clock monitoring, seven days a week. It has direct, real-time access to more than 150 seismic stations spread out all over the world, which inform PTWC of all earthquakes with a magnitude of over 5.5. It also has access to data from nearly 100 tide gauges and 26 tsunamimeters installed in the Pacific, which verify if a tsunami has indeed been generated and estimate its amplitude.

The installation of tsunamimeters since 1997 has greatly improved the system's effectiveness by significantly reducing the number of false alerts. Indeed, up until then, evaluating the tsunami risk essentially depended on data from the seismic stations: once an earthquake with a magnitude of over 7.5 was detected, the alert was immediately given. While the tide gauges near the epicentre were still needed to verify whether a tsunami had indeed been generated, for these zones, the information arrived at the same time as the tsunami. It was therefore necessary to evacuate these areas as a precaution. However, not all earthquakes, even those of great magnitude, generate tsunamis. In addition, the number of potentially concerned countries depends on the formation and propagation of the tsunami, information which seismic data is currently unable to provide with sufficient precision. Therefore, tsunamimeters allow scientists to refine the analysis, follow the tsunami's propagation and issue (or cancel) a warning up until the very last minute.

PTWC, ATWC and NWPTAC currently issue three types of information bulletin. The content of these messages is regularly revised; indeed, a study is currently under way to revise the contents so as to make them more precise.

When an earthquake with a magnitude of between 6.5 and 7.5 occurs, an **information message** is sent to all civil authorities, specifying the hour and location of the earthquake and the fact that no tsunami has been generated.

Example of an information message

```
PACIFIC TSUNAMI WARNING CENTER/NOAA/NWS
TSUNAMI BULLETIN NUMBER 001
ISSUED AT 2117Z 16 OCT 2007

THIS BULLETIN APPLIES TO AREAS WITHIN AND BORDERING THE PACIFIC
OCEAN AND ADJACENT SEAS...EXCEPT ALASKA...BRITISH COLUMBIA...
WASHINGTON...OREGON AND CALIFORNIA.

... TSUNAMI INFORMATION BULLETIN ...

THIS BULLETIN IS FOR INFORMATION ONLY.

THIS BULLETIN IS ISSUED AS ADVICE TO GOVERNMENT AGENCIES. ONLY
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NATIONAL AND LOCAL GOVERNMENT AGENCIES HAVE THE AUTHORITY TO MAKE
DECISIONS REGARDING THE OFFICIAL STATE OF ALERT IN THEIR AREA AND
ANY ACTIONS TO BE TAKEN IN RESPONSE.

AN EARTHQUAKE HAS OCCURRED WITH THESE PRELIMINARY PARAMETERS

 ORIGIN TIME -  2106Z 16 OCT 2007
 COORDINATES -  25.5 SOUTH  179.6 EAST
 DEPTH       -  411 KM
 LOCATION    -  SOUTH OF FIJI ISLANDS
 MAGNITUDE   -  6.6

EVALUATION

 A DESTRUCTIVE TSUNAMI WAS NOT GENERATED BASED ON EARTHQUAKE AND
 HISTORICAL TSUNAMI DATA.

THIS WILL BE THE ONLY BULLETIN ISSUED FOR THIS EVENT UNLESS
ADDITIONAL INFORMATION BECOMES AVAILABLE.

THE WEST COAST/ALASKA TSUNAMI WARNING CENTER WILL ISSUE PRODUCTS
FOR ALASKA...BRITISH COLUMBIA...WASHINGTON...OREGON...CALIFORNIA.
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Source: PTWC

PTWC's reaction time is very short (never more than 20 minutes): in the above example, the earthquake occurred at 9:06 p.m. and the information message was sent at 9:17 p.m.

If an earthquake with a magnitude of between 7.5 and 7.9 occurs, there is a risk of a regional tsunami being generated. Depending on the supposed direction taken by the tsunami – and, therefore, the risk run by the concerned countries – PTWC will issue a **warning bulletin** (for those countries considered the most at risk) and/or a **watch bulletin** (for those countries considered less at risk). The warning is canceled if the data provided by the tide gauges and/or tsunamimeters confirms the absence of a tsunami. Otherwise, supplementary bulletins will be issued with additional information.

Example of a warning/watch bulletin

```
WEPA40 PHEB 081908
TSUPAC
TSUNAMI BULLETIN NUMBER 001
PACIFIC TSUNAMI WARNING CENTER/NOAA/NWS
ISSUED AT 1908Z 08 MAY 2007

THIS BULLETIN IS FOR AREAS WITHIN AND BORDERING THE PACIFIC
OCEAN AND ADJACENT SEAS...EXCEPT ALASKA...BRITISH COLUMBIA...
WASHINGTON...OREGON AND CALIFORNIA.

... A TSUNAMI WARNING AND WATCH ARE IN EFFECT ...

A TSUNAMI WARNING IS IN EFFECT FOR
```

JAPAN / RUSSIA / MARCUS IS. / N. MARIANAS

A TSUNAMI WATCH IS IN EFFECT FOR

GUAM / WAKE IS. / TAIWAN / YAP / PHILIPPINES / MARSHALL IS. / CHUUK / POHNPEI / BELAU / MIDWAY IS. / KOSRAE / INDONESIA / PAPUA NEW GUINEA / NAURU / KIRIBATI / JOHNSTON IS. / HAWAII

FOR ALL OTHER AREAS COVERED BY THIS BULLETIN, IT IS FOR INFORMATION ONLY AT THIS TIME.

THIS BULLETIN IS ISSUED AS ADVICE. ONLY NATIONAL OR LOCAL GOVERNMENT AGENCIES HAVE THE AUTHORITY TO MAKE DECISIONS REGARDING THE OFFICIAL STATUS IN EACH AREA AND ANY ACTIONS TO BE TAKEN IN RESPONSE.

AN EARTHQUAKE HAS OCCURRED WITH THESE PRELIMINARY PARAMETERS

ORIGIN TIME - 1848Z 08 MAY 2007
COORDINATES - 38.2 NORTH 143.1 EAST
DEPTH - 47 KM
LOCATION - OFF EAST COAST OF HONSHU JAPAN
MAGNITUDE - 8.2

EVALUATION

IT IS NOT KNOWN THAT A TSUNAMI WAS GENERATED. THIS WARNING IS BASED ONLY ON THE EARTHQUAKE EVALUATION. AN EARTHQUAKE OF THIS SIZE HAS THE POTENTIAL TO GENERATE A DESTRUCTIVE TSUNAMI THAT CAN STRIKE COASTLINES NEAR THE EPICENTER WITHIN MINUTES AND MORE DISTANT COASTLINES WITHIN HOURS. AUTHORITIES SHOULD TAKE APPROPRIATE ACTION IN RESPONSE TO THIS POSSIBILITY. THIS CENTER WILL MONITOR SEA LEVEL DATA FROM GAUGES NEAR THE EARTHQUAKE TO DETERMINE IF A TSUNAMI WAS GENERATED AND ESTIMATE THE SEVERITY OF THE THREAT.

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
JAPAN	HACHINOHE	40.5N 142.0E	1932Z 08 MAY
	KUSHIRO	42.5N 144.5E	1933Z 08 MAY
	KATSUURA	35.1N 140.3E	1934Z 08 MAY
	SHIMIZU	32.5N 133.0E	2047Z 08 MAY
	OKINAWA	26.2N 127.8E	2148Z 08 MAY
RUSSIA	URUP IS	46.1N 150.5E	2016Z 08 MAY
	PETROPAVLOVSK K	53.2N 159.6E	2123Z 08 MAY
	SEVERO KURILSK	50.8N 156.1E	2130Z 08 MAY
	UST KAMCHATSK	56.1N 162.6E	2148Z 08 MAY
	MEDNNY IS	54.7N 167.4E	2150Z 08 MAY
MARCUS IS.	MARCUS IS.	24.3N 154.0E	2055Z 08 MAY
N. MARIANAS	SAIPAN	15.3N 145.8E	2159Z 08 MAY
GUAM	GUAM	13.4N 144.7E	2216Z 08 MAY
WAKE IS.	WAKE IS.	19.3N 166.6E	2223Z 08 MAY
TAIWAN	HUALIEN	24.0N 122.0E	2234Z 08 MAY
YAP	YAP IS.	9.5N 138.1E	2252Z 08 MAY

PHILIPPINES	PALANAN	17.1N 122.6E	2253Z 08 MAY
	LEGASPI	13.5N 124.0E	2312Z 08 MAY
	DAVAO	6.5N 126.0E	2339Z 08 MAY
MARSHALL IS.	ENIWETOK	11.4N 162.3E	2256Z 08 MAY
	KWAJALEIN	8.7N 167.7E	2341Z 08 MAY
	MAJURO	7.1N 171.4E	0010Z 09 MAY
CHUUK	CHUUK IS.	7.4N 151.8E	2258Z 08 MAY
POHNPEI	POHNPEI IS.	7.0N 158.2E	2312Z 08 MAY
BELAU	MALAKAL	7.3N 134.5E	2316Z 08 MAY
MIDWAY IS.	MIDWAY IS.	28.2N 177.4W	2325Z 08 MAY
KOSRAE	KOSRAE IS.	5.5N 163.0E	2340Z 08 MAY
INDONESIA	GEME	4.6N 126.8E	2346Z 08 MAY
	BEREBERE	2.5N 129.0E	2356Z 08 MAY
	PATANI	0.4N 128.8E	0022Z 09 MAY
	WARSA	0.6S 135.8E	0022Z 09 MAY
	MANOKWARI	1.0S 134.5E	0032Z 09 MAY
	JAYAPURA	2.4S 140.8E	0042Z 09 MAY
	SORONG	0.8S 131.1E	0045Z 09 MAY
PAPUA NEW GUINE	KAVIENG	2.5S 150.7E	0025Z 09 MAY
	MANUS IS.	2.0S 147.5E	0029Z 09 MAY
	VANIMO	2.6S 141.3E	0040Z 09 MAY
	RABAUL	4.2S 152.3E	0044Z 09 MAY
	WEWAK	3.5S 144.0E	0053Z 09 MAY
	AMUN	6.0S 154.7E	0109Z 09 MAY
	KIETA	6.1S 155.6E	0112Z 09 MAY
	MADANG	5.2S 145.8E	0112Z 09 MAY
	LAE	6.8S 147.0E	0150Z 09 MAY
	PORT MORESBY	9.3S 146.9E	0308Z 09 MAY
NAURU	NAURU	0.5S 166.9E	0043Z 09 MAY
KIRIBATI	TARAWA IS.	1.5N 173.0E	0056Z 09 MAY
	KANTON IS.	2.8S 171.7W	0224Z 09 MAY
	CHRISTMAS IS.	2.0N 157.5W	0337Z 09 MAY
	MALDEN IS.	3.9S 154.9W	0412Z 09 MAY
	FLINT IS.	11.4S 151.8W	0506Z 09 MAY
JOHNSTON IS.	JOHNSTON IS.	16.7N 169.5W	0059Z 09 MAY
HAWAII	NAWILIWILI	22.0N 159.4W	0153Z 09 MAY
	HONOLULU	21.3N 157.9W	0207Z 09 MAY
	HILO	20.0N 155.0W	0228Z 09 MAY

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

THE JAPAN METEOROLOGICAL AGENCY MAY ALSO ISSUE TSUNAMI MESSAGES FOR THIS EVENT TO COUNTRIES IN THE NORTHWEST PACIFIC AND SOUTH CHINA SEA REGION. IN CASE OF CONFLICTING INFORMATION... THE MORE CONSERVATIVE INFORMATION SHOULD BE USED FOR SAFETY.

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

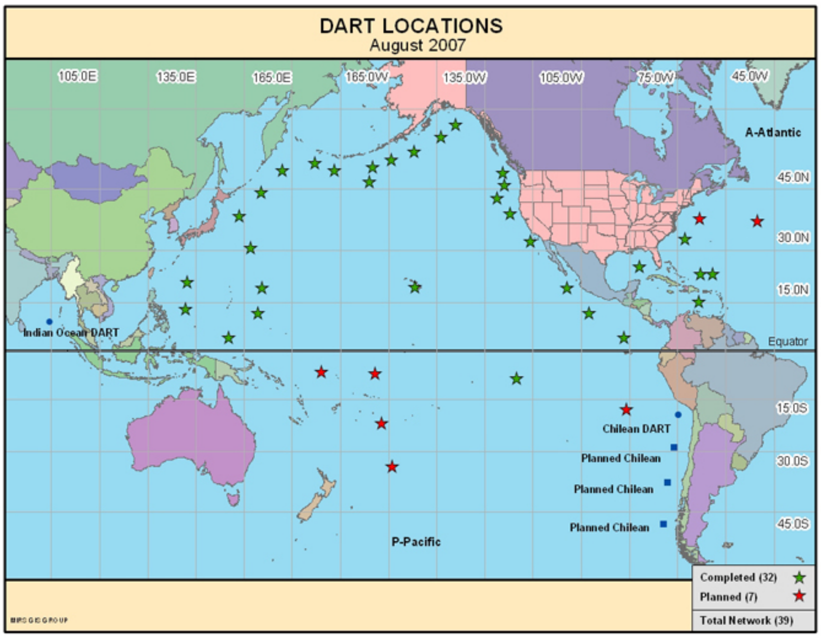
Source: PTWC

An earthquake with a magnitude of over 7.9 risks provoking a tsunami that will cross the entire Pacific. For the Pacific zone, PTWC sends its bulletins to more than 100 different sites.

At this stage, it became clear that the system could only be effective if it benefited from excellent international cooperation. While it is true that the United States has its own seismic stations and tide gauge stations, as well as accounting for most of the tsunamimeters, the system also collects data from the measuring devices of other countries. Therefore, the rapid, free exchange of all of the data is essential. PTWC must therefore work in close collaboration with other international, national and regional warning centres, which make their data available to PTWC. In particular, the WC-ATWC[1] is meant to be able to stand in for PTWC in the case of technical difficulties.

Furthermore, improving the system is dependent on the installations of each subzone, meaning a sufficient number of tide gauges and tsunamimeters.

For instance, the following map illustrates the work remaining to be done in the South Pacific, which appears underequipped, both off the coast of Chile and around the Tonga Archipelago.



Source: International Tsunami Information Centre

1 *West Coast/Alaska Tsunami Warning Center.*

(2) The actions of the International Tsunami Information Centre (ITIC)

The International Tsunami Information Centre (ITIC) continues to play a fundamental role in the tsunami warning system: as secretary of the intergovernmental coordination group for the tsunami warning system in the Pacific, it coordinates its members' preventive measures and recommends necessary improvements with regard to data collection and dissemination. It has organized 3 ICG/Pacific meetings since 2004, as well as the first warning exercise for the entire Pacific zone, which was held on 16 and 17 May 2006 and for which it later published the assessment.

It also helps the member states set up national and regional tsunami warning systems.

The role of national and regional warning systems

On the one hand, they serve to better protect the populations of certain zones poorly covered by the tsunami warning system in the Pacific. Indeed, the Honolulu warning centre's original mission was to protect Hawaii from teletsunamis. However, computer simulations have since shown that the seismic zones liable to provoke a tsunami which could threaten Hawaii are the North Pacific (Alaska and Russia), off the coast of Chile and the Mariana Islands. The Solomon Islands, the Loyalty Islands and the Tonga Archipelago do not endanger Hawaii. As a result, the United States has not installed DART buoys in these two regions. However, other computer simulations have shown that a tsunami provoked by an earthquake in the Solomon or Loyalty Islands could affect Australia, New Caledonia and French Polynesia. It is therefore in the interest of these territories to set up a regional tsunami warning centre, which would take into account their geographic specificities.

On the other hand, the national and regional centres complement and improve the effectiveness of the international system by increasing the number of measuring devices in service, thereby increasing the amount of available data; they also add to the overall capacity for analysis and assessment.

The ITIC also publishes a newsletter and educational pamphlets, including *The Great Waves* and *The Tsunami Glossary* (both edited and published in France). It carries out public-awareness campaigns and has even developed, in cooperation with Chile, educational programmes for children which have been integrated into this country's school programmes. In addition, every year it organizes in Hawaii or some other location training courses for those persons responsible for managing its members' national warning centres.

Finally, its writ has been extended since the Sumatra tsunami of 2004, and it is now in charge of helping countries in the other basins to develop their own warning systems. The ITIC is particularly active in the Indian Ocean, where it plays an advisory role with regard to data communication, the interoperability of seismic and tide gauge networks and the methods used for forecasting tsunamis. It also organizes on-site assessments[1], training courses, symposiums and work group meetings.

Overall, the warning system in the Pacific works well and represents the most sophisticated and operational system. That is why PTWC has been put in charge of issuing warnings for the Indian Ocean zone, until this basin has its own warning system up and running.

Likewise, in the interim, PTWC covers the Caribbean zone and issues warnings to those countries surrounding the South China Sea (China, Macao, Hong Kong, Taiwan, the Philippines, Malaysia, Brunei, Indonesia, Singapore, Thailand, Cambodia and Vietnam).[2]

Nevertheless, certain improvements could be made to render the system more effective in the Pacific. Several regional warning centres should be set up, so as to better take into account the risks posed by regional tsunamis. The concerned regions are the Southwest Pacific, Central America, South America and the China Seas.

What's more, the absence of any devastating trans-Pacific tsunamis for over 40 years could make it difficult to fund the system in the long term. As has already been pointed out, maintaining the DART buoys is particularly expensive and the United States is the main contributor to the warning system. The decisions made by the United States Congress are therefore closely monitored by all the other countries of the intergovernmental coordination group.

During the last meetings of the ICG/Pacific, two priorities were established:

- improve the warning messages, so that they include information on the expected magnitude of the tsunamis along the Pacific coasts;

- revise the warning system, to make it operational in the event of local tsunamis.

2. ... that relies on effective national systems

The three national systems here presented constitute the most successful warning systems to date. While they may not be perfect, they endeavour to meet the three preconditions for setting up an effective warning system: 1) an operational warning centre, 2) a pre-defined, emergency action plan that has been pre-tested on the ground, and 3) a population informed and made aware of the threat.

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[1] *Assessing a country's capacity to set up a tsunami warning system.*

[2] *For this zone, both PTWC and JMA are responsible for issuing warnings.*

a) The American model

(1) Two warning centres

The Hawaiian centre has already been discussed above; however, it is necessary to emphasize the fact that this centre has retained its original warning mission for the United States. Indeed, the US National Tsunami Warning Center issues tsunami warning bulletins for Hawaii, Guam, American Samoa, Wake Island, Johnston Island, the Northern Mariana Islands and all other American interests in the Pacific not covered by the Alaskan warning centre.

What's more, as the regional tsunami warning centre for Hawaii, PTWC rapidly issues warning bulletins in the event of a local tsunami generated in the Hawaiian waters.

According to the information gathered by your rapporteur, there are 70 seismic stations located in Hawaii. PTWC requires 10 seconds to detect an earthquake, 15 seconds more for its localization, and 1.5 minute to determine its magnitude. However, considering the very short time lapse between the generation of a tsunami and its arrival on the coasts (10 minutes for the local tsunami of 29 November 1975), teaching the concerned population the right reflexes remains the most effective protective measure: when someone along the coast feels the ground shake, he/she must immediately seek higher ground, without waiting for an official warning.

In addition to PTWC, the United States created a second warning centre for Alaska in 1967, following the teletsunami of 27 March 1964 which originated in this region.[1]

In 1982, the geographical zone for which the centre issues its warning bulletins was extended to the states of California, Oregon, Washington and British Colombia, in the event of a tsunami-generating earthquake occurring in their coastal zones.

In 1996, the Alaskan centre once again had its mission extended, for it is now in charge of warning the four previously mentioned states in the event of a tsunami originating anywhere in the Pacific.

Following the devastating Sumatra tsunami of 26 December 2004, the WC/ATWC could also issue tsunami warnings to the Atlantic coast of the United States, as well as the Gulf of Mexico region, Puerto Rico, the Virgin Islands and the Atlantic coast of Canada.

Therefore, the United States has two tsunami warning centres which ensure the protection of its coasts and can replace one another if need be (should one centre encounter technical difficulties which prevent it from functioning correctly, or should several tsunamis originate in different areas at the same time).

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[1] *The West Coast/Alaska Tsunami Warning Center (WC/ATWC).*

Tsunamis on the American coasts: local or transoceanic tsunamis?

The zones most at risk of local and transoceanic tsunamis are the Hawaiian islands and the Pacific coasts of California, Oregon and Washington. Alaska and the Caribbean islands (Puerto Rico and the Virgin Islands) are, for the most part, threatened by local tsunamis.

(2) A national plan to limit the impact of tsunamis

While the risks run by Hawaii in the event of a tsunami have long been known, it is only rather recently that the states of Washington, Oregon and California are also recognized as being vulnerable.

An earthquake in the Cascades subduction zone[1] in April 1992, which provoked a tsunami in northern California, underlined the shortcomings of the warning system. On 4 October 1994, a Pacific-wide tsunami warning was issued following a strong, tsunami-generating earthquake in the Kuril Islands. In the United States, this event provoked enormous confusion between the various emergency services, resulting in the costly evacuation of Hawaii which drew sharp criticism when the warning turned out to be false.

To remedy this situation, Congress decided to launch in 1995 the National Tsunami Hazard Mitigation Program (NTHMP) under the direction of the NOAA and covering both the coastal states and America's island protectorates.

This programme relies on three main lines:

- tsunami evaluation: a better understanding of past tsunamis will produce more refined inundation maps based on long-term tsunami forecasting;

- the quality of the warning system, through the improved collection and processing of seismic data, the deployment of a network of tsunami-detection buoys, and a better transmission of the warning information to the competent authorities;

- preventive measures, via the early elaboration of prevention and evacuation plans, as well as the development of educational materials to help raise public awareness.

Taking into account the subsidiarity rules linked to federalism, a close partnership has developed between the federal, state and local authorities.

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[1] *This zone is located off the coasts of Washington, Oregon and California.*

In addition, the NOAA launched a programme entitled "TsunamiReady", which encourages the at-risk communities and states to adopt those measures necessary to effectively mitigate the effects of a tsunami.

Based on the principle of voluntary participation, this programme sets the criteria which must be respected in order to earn this label, including:

- establishing a 24-hour warning point and emergency operations centre;

- have more than one way to receive tsunami warnings and alert the public;

- increase public awareness through the distribution of information and community education;

- develop a formal tsunami plan, which includes holding periodic emergency exercises.

To this day, 47 sites[1] (cities, counties, beaches, harbours) in 10 different states have earned this label. Hawaii is the only state considered "tsunami ready".

In addition, following the devastating Sumatra tsunami, the President of the United States proposed a $37.5 million package to improve the national warning systems. In May 2005, the Emergency Supplemental Appropriations Act was passed, which granted an additional $17.24 million to the NOAA in order to extend and improve its tsunami-detection capabilities, to make the warning centres more effective, to produce inundation maps and to extend the TsunamiReady programme to all coastal states. A new law was passed in August 2006 to extend the NOAA's budget from $25 million in 2008 to $29 million in 2012.

The mixed assessment of the National Tsunami Hazard Mitigation Program (NTHMP) by the Government Accountability Office (GAO)

The GAO is an independent, non-partisan agency that works for the American Congress. With a staff of 3,260, a budget of $484.70 million and 11 offices scattered around the United States, its mission is to monitor the use of public funds and evaluate federal programmes and policies. Between April 2005 and March 2006, the GAO studied the National Tsunami Hazard Mitigation Program (NTHMP) and afterwards issued a rather mixed assessment of its actions.

1. An incomplete evaluation of the risks

The GAO remarked that in those states and territories at risk (Alaska, Washington, Oregon, California and Hawaii for the Pacific zone, Puerto Rico and the Virgin Islands for the Caribbean), numerous regions either had not established inundation maps, or depended on unreliable documents, even though the NTHMP had

[1] *Out of an eventual 500 sites.*

planned on furnishing updated inundation maps to all at-risk communities by 1999. The GAO also criticized the absence of any detailed forecasting concerning the loss of human life and damages to infrastructure, government and vital installations (power stations, hospitals, telecommunication networks, etc.). It pointed out that computer programs already existed for quantifying the damages caused by other natural disasters (inundations, tornadoes, earthquakes) and urged the NOAA to develop a similar program for tsunamis.

2. A poorly-calibrated warning system

In addition, the GAO criticized the number of false warnings issued by the Hawaiian and Alaskan centres. While it applauded the decreased delay in the sending of warning bulletins, it nevertheless pointed out that since 1982, all 16 warnings announcing a destructive tsunami for the American coasts proved to be false. However, these false warnings damage the system's credibility and prove quite costly: the evacuation of Hawaii in 1994 cost an estimated $58.2 million (in current terms). The GAO also estimated that the list of regions receiving initial warning messages was too long and did not take into account their geographic distance from the event, which allows for more refined forecasting during the tsunami's propagation.

3. Shortcomings in the warning-transmission system

The GAO discovered technical malfunctions in the transmission of messages. It pointed out that the warning centres transmit their messages to the forecasting services of the National Weather Service, which then transmits them via the NOAA's weather radio and the "emergency broadcast system". The NOAA's weather radio is a 24-hour, nationwide network of radio stations that continuously broadcasts weather information, including warnings of natural risks. The emergency broadcast system is a means of communication that was originally reserved for the President of the United States, allowing him/her to directly address the public in the event of an emergency. This system can also decode and retransmit warning messages emitted by the NOAA's weather radio via the network of radio stations and television channels, as well as by cable. However, the GAO discovered that certain coastal towns were unable to receive information sent out by the NOAA's weather radio and/or the emergency broadcast system. It therefore recommended that the entire information-transmission chain be tested.

4. Weaknesses in the tsunami-prevention system

The GAO investigated the effectiveness of those prevention systems which rely on the telephone network, such as sirens without satellite transmission and Internet-based warning messages. These infrastructures would be out of service in the event of a strong earthquake. In any case, past experience shows that they would be saturated immediately after the first warning message, which can compromise communications between the various services in charge of civil security if they do not have satellite phones. In addition, the GAO emphasized the necessity of carrying out training exercises to uncover any weaknesses in the system, citing as examples the often underestimated evacuation time and problems related to traffic control (certain access roads can become inundated and therefore unusable).

5. An inconsistently-informed public

The GAO observed that few regions at risk had verified that their populations were indeed aware of the existence of evacuation plans, either through their generalized distribution or their insertion in the phone book. Likewise, raising tsunami-awareness among school children and the carrying out of evacuation exercises varied greatly from state to state.

6. Urban planning that ignores the tsunami risk

The GAO criticized at-risk regions for not taking into consideration tsunamis in their urban planning. Oregon is the only state to have set limitations on the construction of dense residential complexes in areas prone to inundationing.

7. Questioning the extension of the national tsunami mitigation programme's range of application

The GAO questioned the usefulness of extending this prevention programme to regions little or not at all concerned by tsunamis, such as the Atlantic coast and the Gulf of Mexico, and feared a too-thin spreading of the budget to the detriment of those zones really at risk. After observing that local tsunamis represented the greatest risk for most regions of the United States, it questioned the NOAA's strategy to extend the network of DART buoys and improve the effectiveness of the warning centres, when, in fact, teaching the public the right reflexes (such as seeking refuge on higher ground in the event of a strong earthquake) should be a priority.

In conclusion, the GAO regretted that the programme's effectiveness had never been evaluated before the decision to extend the programme had been made. No study had been carried out on the effectiveness of the education and public-awareness programmes and no assessment had been made concerning the system's strengths and weaknesses.

Source: Government Accountability Office

(3) A permanent prevention policy

The state of Hawaii is certainly the most advanced with regard to its tsunami-mitigation policy. During his visit to Hawaii, your rapporteur was able to observe the mobilization of various stakeholders involved in every level of civil protection in the case of a tsunami warning being issued. On the Big Island of Hawaii, the city of Hilo, which was particularly affected by the tsunamis of 1946, 1960 and 1975, has provided itself with a very complete warning system under the impetus of its mayor.

First of all, the warning plans are decided upon in advance: the evacuation maps have already been prepared and distributed to all public services. They are also included in the telephone directory. There is only one commander (the mayor) and each official's responsibilities are clearly defined.

Secondly, to ensure that all officials give out the same information, the messages to be emitted are prepared from preprinted, fill-in-the-blank style texts (officials fill in the date, hour and location of the earthquake, the expected date of the tsunami's arrival, and the deadline for evacuating at-risk zones).

For a rapid dissemination of the information, an agreement was passed with the radio stations, by which they agree to interrupt their programmes in order to read the warning messages transmitted by the civil protection officials.

In addition, a network of sirens has been installed, in order to alert the population in the event of a tsunami warning.

Also, under the authority of the mayor, the lessons learned from past tsunamis have been incorporated into the city's urban planning: following the tsunami of 1946, a large section of the inundated zone was converted into a park. Following the tsunami of 1960, the buffer zone was enlarged and the debris were used to build a natural barrier separating the coastline from the interior. In addition, the building of hospitals, schools and retirement homes was prohibited in those zones prone to inundation, while those buildings located on the seashore are subject to strict safety standards (the buildings must be capable of resisting a tsunami, no ground-floor bedrooms).

Finally, in memory of the devastating tsunami of 1 April 1946, the month of April is used to raise public awareness of the tsunami risk. A training exercise simulating the arrival of a tsunami is carried out throughout the entire state of Hawaii, with the participation of PTWC, state officials, the departments of education and transportation, the harbour authorities and hotel associations. Evacuation drills are also carried out in certain schools located in at-risk zones.

Everyone your rapporteur spoke with insisted on the need to form close, long-lasting ties with the media, in order to both avoid the diffusion of incomplete or erroneous information and to raise public awareness of this phenomenon and how to behave in the event of a tsunami.

b) The Japanese model

(1) A system especially well-suited to local tsunamis

With an average of 2,000 earthquakes per year (almost 5 per day) liable to be felt by the population, Japan is the most earthquake-prone country in the world. Many of these earthquakes occur at sea, which explains why Japan is also the most tsunami-prone country in the world. The following table lists the most destructive tsunamis since the beginning of the 20th century.

List of Japanese tsunamis
since the beginning of the 20th century

Year	Epicentre location	Depth (km)	Magnitude	Maximum amplitude of the tsunami, as measured by a tide gauge	Damages (according to the Japanese rating system) (*)
1933	Off Sanriku	0	8.1	143	6
1944	Off Kii peninsula	40	7.9	115	5
1946	Off Kii peninsula	24	8.0	280	5
1952	Off Kushiro (Hokkaido)	54	8.2	100	1
1960	Near coast of northern Pen	0	8.5/9.5	305	4
1964	Off Nigata pref.	34	7.5	140	2
1968	Off east of Kyushu	30	7.5	116	2
	Off Sanriku	0	7.9	295	2
1969	Off east of Hokkaido	30	7.8	130	2
1973	Off SE of Nemuro (Hokkai)	40	7.4	>280	2
1983	Off Akita pref.	14	7.7	194	4
1993	Off SW Hokkaido	35	7.8	>175	5
1994	Off east of Hokkaido	28	8.2	168	2
1996	Near Irian Jaya (Indonesia)	33	8.1	104	1
2003	Off Kushiro (Hokkaido)	45	8.0	255	3
2004	Off Kii peninsula	38	7.1	66	1
	Off Kii peninsula	44	7.4	101	

(*)	Rating system for damages (for Japan)
1.	Minor damages observed on boats and farms.
2.	Minor damages observed on houses and roads.
3.	Victims/destroyed houses (less than for class 4).
4.	Victims (less than 20) or destroyed houses (less than 1,000).
5.	More than 200 victims or more than 10,000 destroyed houses.
6.	More than 2,000 victims or more than 100,000 destroyed houses.
7.	More than 20,000 victims or more than 1,000,000 destroyed houses.

Source: Japan Meteorological Agency

In addition, while Japan is concerned by transpacific teletsunamis, it is above all affected by local tsunamis that are often devastating. Therefore, this country has set up a warning system capable of alerting the population in only a few minutes.

The Japan Meteorological Agency (JMA), under the authority of the Ministry of Infrastructure and Transportation, constitutes the country's nation-wide, multi-risk warning centre. JMA collects data on natural phenomena and issues warnings to the authorities and the public should the need arise.

Insofar as local tsunamis leave little time to act, the Japanese warning system favours rapidly emitting a warning message, even if it should later turn out to be false. Within three minutes following the detection of a tsunami, JMA will issue a message with the estimated time of the tsunami's arrival, the concerned coasts and the estimated height of the wave(s).

There are two types of local tsunami forecast messages: warning messages (the wave must be higher than 1 metre) and information messages (when the wave is between 50 cm and 1 metre in height).

In addition, there exist two categories of warning messages: messages for tsunamis with estimated waves of up to two metres and messages for major tsunamis with waves of three metres or higher.

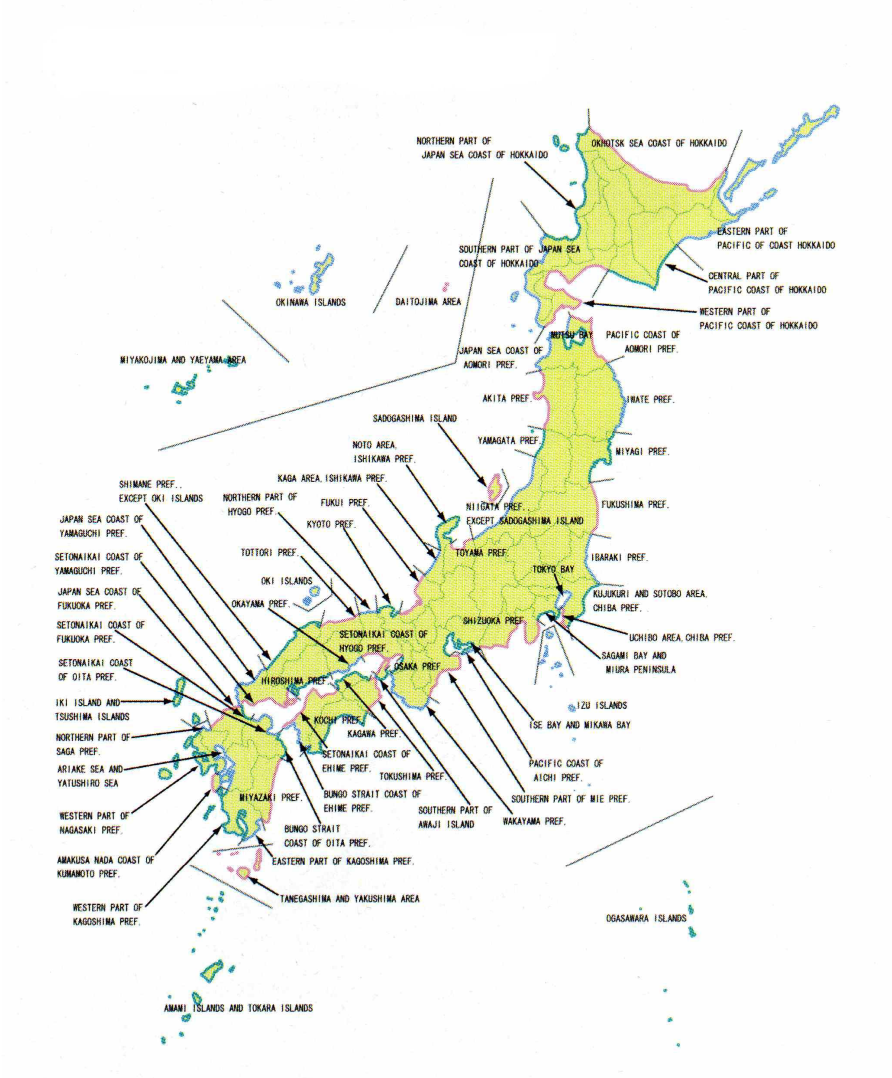
Tsunami forecast and information

<table>
<tr><td rowspan="5">Tsunami forecast</td><td colspan="3">Created within 3 to 5 minutes following the earthquake.
Distributed according to the height of the tsunami.</td></tr>
<tr><td>Category</td><td colspan="2">Height of the tsunami mentioned in the warning message.</td></tr>
<tr><td rowspan="2">Tsunami warning</td><td>Major tsunami</td><td>"3 m", "4 m", "6 m", "8 m", "10 or more metres high"</td></tr>
<tr><td>Tsunami</td><td>"1 m", "2 m"</td></tr>
<tr><td>Tsunami notice</td><td>Tsunami</td><td>"0.5 m"</td></tr>
<tr><td colspan="4">Information on the estimated time of arrival and the height of the tsunami for each coastal region.</td></tr>
<tr><td colspan="4">Information on the time of arrival of the high tide and the tsunami on the coasts.</td></tr>
<tr><td colspan="4">Information on the actual time of arrival and height of the tsunami.</td></tr>
</table>

Source: Japan Meteorological Agency

In addition, JMA has divided the Japanese coast into 66 regions, which receive warning messages and information when they are concerned by a tsunami risk.

Division of the Japanese coast into 66 regions



Source: Japan Meteorological Agency

JMA benefits from a very dense network of seismic stations (182) and tide gauges (80), whose data is supplemented by that provided by the measuring devices of the local governments, the NIED[1] and the coast guard. This information is transmitted via satellite in real time to JMA, where it is processed by computer in order to determine as quickly as possible the earthquake's hypocentre and magnitude and if a tsunami has indeed been generated.

However, the extremely short amount of time (3 minutes) allowed JMA to issue a warning message does not, in fact, allow it to verify if the detected earthquake has actually provoked a tsunami (the network of stations for measuring sea level is not sufficiently dense to detect a tsunami in under 3

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[1] *National Research Institute for Earth Science and Disaster Prevention.*

minutes). In reality, JMA relies on tsunami simulations based on 100,000 tsunami-generating earthquakes, comparing the detected earthquake to the simulation of the earthquake with the most similar characteristics. At the same time, once the information on the detected earthquake has been collected, a new simulation is carried out to refine the information given on the potential tsunami.

The warning messages are very widely distributed.

Firstly, they are sent to local authorities and disaster-control bodies.

Secondly, JMA has passed a cooperative agreement with the public television network NHK for the broadcasting of warning messages. NHK manages 10 TV channels and 3 radio stations, which all issue warnings in the event of a tsunami. When an alert is given, the TV and radio programmes are interrupted and a message is broadcast, accompanied with a map of Japan with the at-risk zones coloured yellow, orange or red, depending on the amplitude of the forecast tsunami.

During the Kobe earthquake of 17 January 1995, serious systemic failures were observed, due, in particular, to an insufficient distribution of earthquake information. For this reason, the tsunami warning system now favours diverse channels for the transmission of information to persons capable of making decisions. For example, in the Wakayama Prefecture, at least three bodies now receive JMA messages and are liable to activate the sirens to alert the public to the danger.

(2) A well-prepared population

Local tsunamis necessitate very short reaction times. In at-risk zones, the local authorities have set up evacuation plans detailing the routes to take, the buildings that can serve as a refuge and the zones to reach in order to be safe. Particular attention has been paid to signalling and several types of signs have been created:

- signs indicating the direction and distance to the safety zones;
- warning signs for those zones prone to inundation in the event of a tsunami;
- signs indicating safety zones (out of reach of the tsunami) and "refuge" buildings.

These signs rely almost entirely on drawings, allowing them to be understood by everyone.

Sirens have also been installed along the coasts, with a range of 1 to 2 kilometres, in order to warn persons on the beaches and along the seashore.

In addition, numerous measures have been taken to inform and raise the awareness of the public. For example, the department responsible for dealing with catastrophes and fires, placed under the authority of the Ministry of Internal Affairs and Communications, has developed an informative CD for shoreline residents. This CD explains how tsunamis are generated and spread, and then describes what to do should the sirens be sounded and/or a strong earthquake be felt.

The inhabitants of certain districts are involved in the process of designing the evacuation plans. The objective is to inform the public of the damages caused by past tsunamis, convince it of the usefulness of such plans, and profit from their knowledge of the area in order to choose the best evacuation routes.

Training exercises are also carried out, to test the chosen escape routes and solve any observed failures or shortcomings. Your rapporteur learned of a group of residents that worked during two years to construct an escape route (using railway tracks) providing rapid access to a zone located 10 metres above sea level.

For all that, Japan must still deal with public apathy in the face of such a rare phenomenon. Several persons pointed out to your rapporteur the worrying fact that during the last warnings of November 2006 and 13 January 2007, most residents remained at home, despite orders to evacuate. One possible explanation, other than a changing Japanese society, resides in the fact that the issuance of numerous false warnings has damaged the system's credibility.

(3) Considerable means dedicated to constructing protective structures and improving the warning system

Japan is the only country building more and more structures to protect against tsunamis.[1] The municipality of Tokyo, which is responsible for the security of the islands off its coast, has sought to reduce the vulnerability of certain coasts by installing tetrapods and artificial reefs.

According to the information gathered by your rapporteur, more than 15,000 km of dikes have been built along the Japanese coast.

For those areas without a nearby building offering refuge and whose relief does not allow residents to rapidly access a zone several metres above sea level, the Japanese have constructed steel platforms with stairways. These platforms are earthquake-resistant and capable of resisting tsunami waves. They can shelter between 70 and 100 persons and are sometimes equipped with a siren.

Likewise, concrete walls or dikes are sometimes built in harbours threatened by tsunamis. These walls, whose height can be adjusted according to the estimated amplitude of the tsunami, are meant to "break" the waves and limit inundation.

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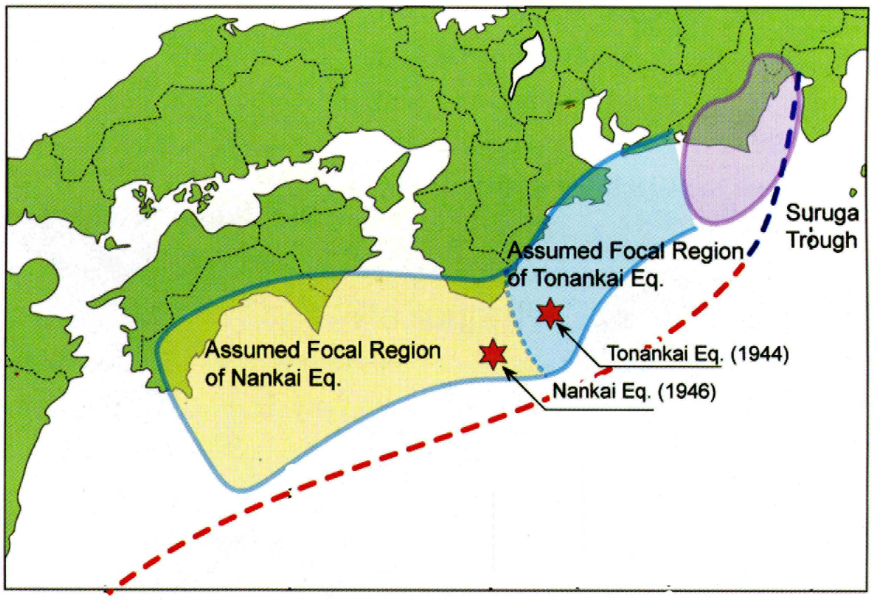
[1] *Most are multi-risk structures, because Japan must also confront cyclonal swells and typhoons.*

In addition, Japan continues to invest heavily in the improvement of its warning system. JAMSTEC[1] has launched a programme entitled DONET[2], whose objective is to equip the Tonankai zone with a network of 20 seismometers linked by cable that also act as pressure sensors, in order to more rapidly detect earthquakes and tsunamis originating in this zone. It should be pointed out that the study of past earthquakes has shown that the zone between the Bay of Suroga and the island of Shikoku produces an earthquake with a magnitude of 8 or greater every 100 to 150 years, at three different locations: in the regions of Tokai, Tonankai and Nankai.

The strong earthquakes liable to touch the regions of Tokai, Tonankai and Nankai



Source: Japan Meteorological Agency

In addition, in this same zone, two strong earthquakes have already occurred more or less instantaneously or were separated by only one or two days. Such an event would produce enormous damage. That is why this zone is under high monitoring.

Finally, Japan is greatly involved in the overall improvement of the world's tsunami warning systems, thanks to its very active policy of cooperation, in particular with the other Asian and Pacific countries.

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1 *Japan Agency for Marine-Earth Science and Technology, which corresponds to France's IFREMER.*

2 *Dense Oceanfloor Network System for Earthquakes and Tsunamis.*

Since 1960, the IISEE[1] has organized a one-year training course for a dozen engineers from developing countries on seismology and earthquake prevention and mitigation techniques. Up until 1972, Japan and UNESCO codirected this training programme. However, in 1973, Japan's JICA[2] became the sole director of the programme and in 2005 transformed it into a Masters in natural disaster prevention. In 2006, a tsunami module was introduced; when your rapporteur visited Japan in January 2007, this module was being followed by 5 students, or half of the programme's participants.

In addition, NIED and JICA have begun to set up a seismic network in Indonesia (the JISNET project): 23 broadband seismic stations have already been installed.

In the southwest Pacific, JICA has financed a programme to upgrade the seismic networks of the Fiji and Tonga islands: the South Pacific broadband seismic NETwork (SPANET). 6 broadband seismic stations have already been installed.

c) The French model in Polynesia

(1) CEA at the heart of the Polynesian warning system

The creation of a national tsunami warning centre in Polynesia is directly linked to France's nuclear activities in the Pacific.

Set up by CEA ("Atomic Energy Commissariat") in the beginning of the 1960s, France's geophysical laboratory (or "LDG") in Tahiti has, since 1964, been responsible for providing information on those tsunamis liable to affect the coasts of French Polynesia. For this reason, it set up the Polynesian seismic network and has developed ever more advanced methods for evaluating the tsunami-generating potential of earthquakes.

Today, the activities of the Pamatai geophysical laboratory can be divided into three categories:

Firstly, within the framework of the Comprehensive Nuclear-Test-Ban Treaty, LDG/Pamatai is part of the international nuclear-explosion monitoring system.

Secondly, LDG/Pamatai's seismic network for Polynesia is responsible for the round-the-clock monitoring of French Polynesia's seismicity; this includes earthquakes, underwater volcanoes, landslides and storm surges. Within this framework, since 1962, LDG/Pamatai has made use of 9 seismic stations located in Tahiti, Rangiroa, Tubuai and Rikitea.

Finally, LDG/Pamatai manages the Polynesian tsunami prevention centre, which ensures 24-hour tsunami monitoring for the Pacific zone, in partnership with PTWC.

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[1] *International Institute of Seismology and Earthquake Engineering.*

[2] *Japon International Cooperation Agency.*

The Comprehensive Nuclear-Test-Ban Treaty

This treaty, adopted on 10 September 1996 and signed by 71 countries (including the 5 official nuclear powers) on 24 September 1996, forbids nuclear testing. It complements the treaty of 5 November 1963, which prohibs underwater, outer-space and atmospheric nuclear testing, by extending the ban to underground testing.

This treaty set up an international monitoring system for the air, water and oceans via stations scattered throughout the world.

Stations for detecting radionuclides (airborne radioactive elements) and infrasonic vibrations are used for the atmosphere.

Seismometers are used to detect seismic waves generated by earthquakes or underground explosions. These sensors can also be used to monitor the oceans, by detecting and identifying propagating hydroacoustic T waves.

DASE[1], which oversees LDG/Pamatai, is responsible for France's contribution to the international monitoring system (IMS), with regard to the various technologies (seismic, radionuclide, infrasonic-vibration and hydroacoustic) used.

The Polynesian geophysical network includes IMS stations whose data is sent to DASE and the international data centre in Vienna.

Due to its central location in the Pacific, the seismic station in Tahiti is a key site for seismic and hydroacoustic monitoring. The radionuclide-analysis station is located at the Pamatai site. Two infrasonic-vibration stations are located in Taravao (on the Tahitian peninsula) and the Marquesas Islands.

Source: DASE

When LDG/Pamatai detects an earthquake with an underwater focus less than 60 km deep and a magnitude of 7 or greater, it informs the State Authority and the civil protection service.

It should here be pointed out that LDG/Pamatai has developed a highly effective system for the automatic, real-time detection and localization of tsunami-generating earthquakes called TREMORS®[2] (Tsunami Risk Evaluation through seismic MOment from a Realtime System).

The energy released during an earthquake constitutes its "magnitude". The greater the magnitude, the more energy released by the earthquake. It consists of a logarithmic scale; in other words, an increase of 1 step corresponds to a 30 fold increase in the amount of energy released. While the Richter Scale (Ms) is the best known magnitude scale, it has the disadvantage of becoming saturated in the case of a strong earthquake: the magnitude

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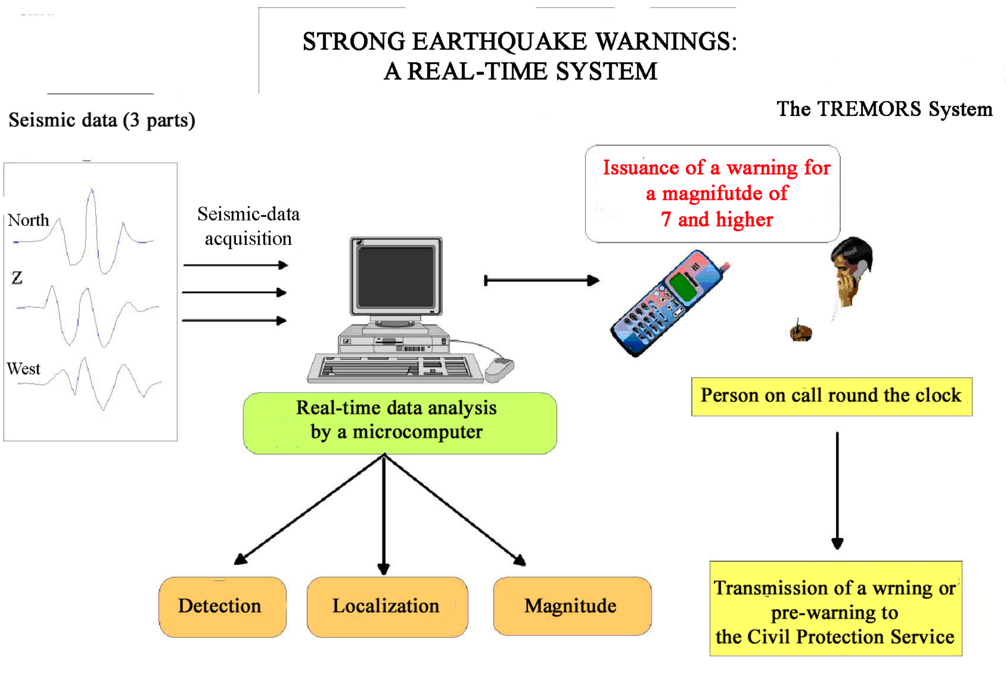
[1] *The Département Analyse, Surveillance, Environnement ("Department of Analysis, Surveillance and the Environment") of CEA ("Atomic Energy Commissariat").*

[2] *This trademark was first registered with the INPI in 1994 and was renewed in 2004 for a further 10 years.*

reaches a ceiling that it has difficulty passing, even while the amount of released energy continues to increase. To solve this saturation problem, the moment magnitude scale (Mw) was developed in the 1980s. This scale is in line with the Ms scale and acts as its extension for earthquakes of greater magnitude, so as to avoid the saturation effect. For example, the earthquake of 22 May 1960 in Chile had a magnitude of 8.4 on the Richter Scale and a magnitude of 9.5 on the Moment Scale. Therefore, it was in fact 30 times greater than the instruments indicated at the time.

Using the Richter Scale to measure the magnitude of strong earthquakes can result in greatly underestimated tsunami forecasts. That is why a precise measurement of magnitude is essential. However, according to the information obtained by your rapporteur, the Moment Scale requires numerous seismic stations and considerable calculation means.

To overcome these difficulties, LDG/Pamatai has introduced a new magnitude scale, the Mm (Mantle Scale), which avoids the saturation effect plaguing the Richter Scale and requires only one seismic station. Beyond a certain magnitude threshold (currently set at 7), a warning is issued by GMS to the geophysicist on duty.



Source: CEA/DASE/LDG/Pamatai

In addition, LDG/Pamatai uses four tide gauges installed in Papeete (1), the Gambier Islands (1) and the Marquesas Islands (2). Only one of these stations was financed by France via a FIDES project ("Investment Fund for

Socio-Economic Development"). It also receives data from some twenty tide gauges installed, for the most part, in the South Pacific on islands located between the tsunami-generating zones and French Polynesia.

These activities are complemented by studies and simulations meant to better evaluate the tsunami hazard in Polynesia (see above).

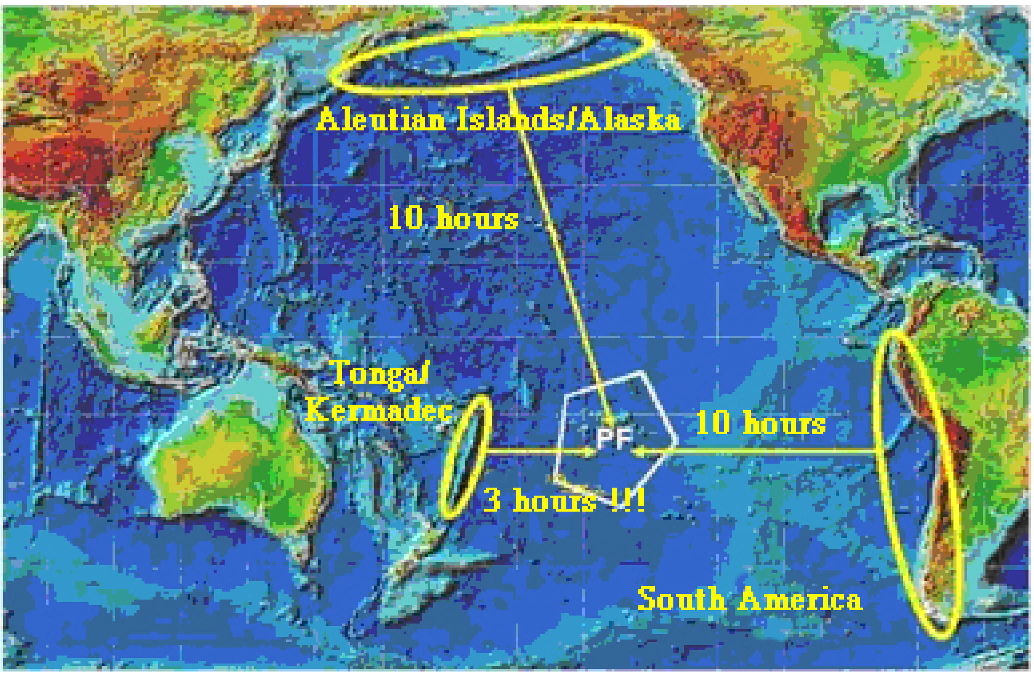
It is not surprising that CEA represents France at the ICG/Pacific, for which it has assumed first the vice-presidency, then the presidency, and that it was actively involved in establishing the specialized tsunami emergency plan ("PSS") for French Polynesia[1].

(2) A warning system based on a deep understanding of tsunamis

As has already been pointed out, the effectiveness of any warning system depends on a good prior understanding of the hazard. That is why several studies were entrusted to CEA, in order to produce a tsunami map.

The analysis of earthquakes in the Pacific zone between the years 1837 and 2005 suggests that the Polynesian coasts were touched by at least 15 tsunamis during this period (11 of which caused damage and 2 of which were deadly).

The tsunami risk in French Polynesia



Source: CEA/DASE

[1] *This plan defines the missions and responsibilities of all concerned services in the event of a tsunami warning and establishes the steps to be taken to evacuate the population, if need be.*

Only exceptionally strong subduction earthquakes (an Mm magnitude greater than 9) threaten to generate a transpacific teletsunami that could endanger all of Polynesia. The main subduction zones capable of producing such an earthquake are those of the South American coast (Chile, Peru), the Aleutian island arc and the Pacific Northwest (the Kuril island arc, Japan, Kamchatka). However, with regard to the last zone, the risk would seem to be less great, insofar as Polynesia lies outside the area of maximum effect for tsunamis originating in this zone.

Therefore, we can identify three seismic zones liable to generate the most devastating tsunamis:

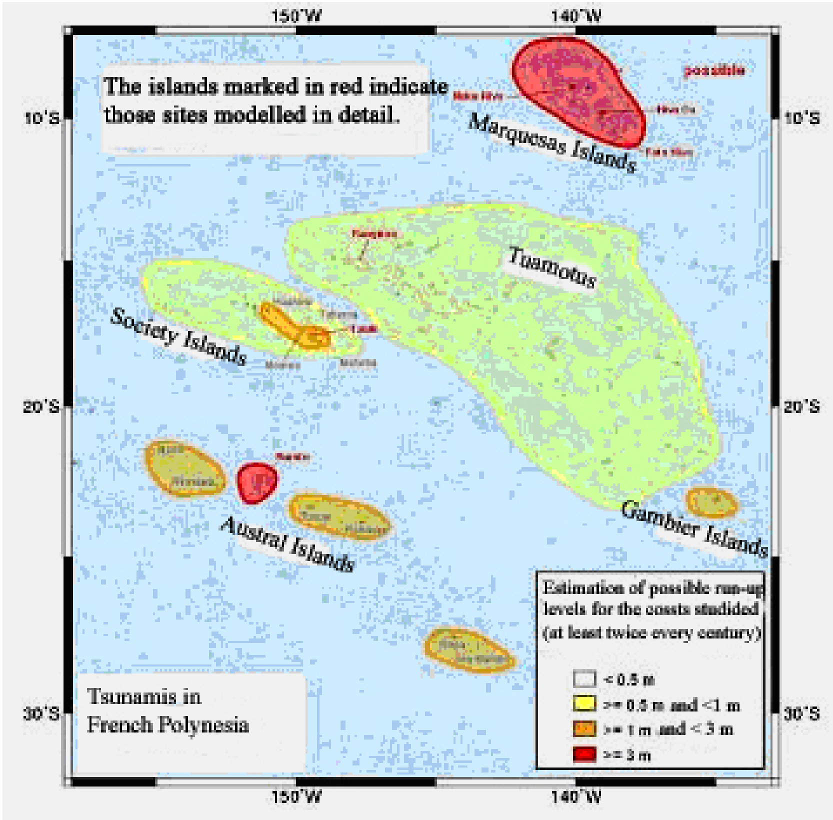
- The South American coastal zone (Chili, Peru). It should be pointed out that a seismic gap exists north of Chile: sometime in the next 20 to 30 years, a magnitude 9 earthquake is expected to occur in this zone, generating a particularly destructive tsunami in the Marquesas Islands, with simulations predicting a wave 11 metres high and inland penetrations of up to 1 km on the island of Hiva Oa;

- The Aleutian island arc;

- The Tonga-Kermadec zone to the west. The seismic history of this region is not well known, but computer simulations suggest that a devastating tsunami originating in the Tonga Archipelago could touch French Polynesia. In addition, a seismic gap has been identified in the Kermadec Islands, suggesting that a strong earthquake is to be expected in this zone.

Moreover, on-site observations and computer simulations reveal a strong variation of the tsunami hazard depending on the islands, as shown in the following map prepared by CEA:

French Polynesia tsunami exposure levels



Source: CEA/DASE

The Marquesas Islands appear particularly vulnerable to tsunamis, because they can be affected by major tsunamis more than 4 times per century. What's more, tsunamis generated by earthquakes off the South American coast are significantly amplified in this area. For example, during the magnitude-7.3 earthquake off the coast of Peru on 21 February 1996, a tsunami of 2-3 metres was observed in the Marquesas Islands, compared to only 10 cm in Papeete. This amplification is linked to the local bathymetry: these islands have gently sloping underwater reliefs and are not protected by coral reefs.

In the Austral Islands, the island of Rurutu is also liable to be touched twice per century by tsunamis. The other islands are protected by the barrier reef, thereby mitigating the effects of tsunamis.

As for Tahiti, this island is relatively protected by its coral reef, except for its north and northeastern coasts.

The map indicating those zones likely to generate the most devastating tsunamis for French Polynesia and the tsunami exposure level map have both served as references in setting up the warning system.

As for the American and Japanese systems, the warnings are divided into different risk levels. Three colour codes have been defined, according to the seriousness of the threat.

The level 2 warning (yellow) is set off by earthquakes with an Mm magnitude of greater than 8 and when the tsunami's estimated time of arrival on the Polynesian coasts is announced less than 9 hours in advance. In this case, LDG/Pamatai notifies the civil protection service and the High Commissioner.

The level 3 warning (orange) is set off by earthquakes with an Mm magnitude of between 8.7 and 9 and when the tsunami's estimated time of arrival on the Polynesian coasts is announced less than 6 hours in advance. In this case, the threat of a tsunami is certain and all local authorities are informed.

Finally, the level 4 alert (red) is set off either by an earthquake with an Mm magnitude of above 9, or when the tsunami's expected time of arrival on the Polynesian coasts is announced less than 3 hours in advance. Concretely, this means that an earthquake with a magnitude of greater than 8 in the Tonga Islands zone would automatically set off a maximum warning. The general alert is therefore given, in order to evacuate the coastal population, to evacuate the boats from the harbours and to evacuate the airport. Indeed, a study of the area has demonstrated that Papeete's Faa Airport would be inundated and rendered useless.

Warning levels

Place of Origin	Tonga	South America	All zones except Tonga		
Magnitude	Mm >8 (Mw >7.9)	Mm >7 (Mw >7.2)	8 < Mm < 8.7 (7.9 < Mw < 8.3)	8.7 < Mm < 9 (8.3 < Mw < 8.7)	Mm >9 (Mw>8.7)
Archipelago	**French Polynesia**	**Marquesas Islands**	**French Polynesia**		
9 hrs		2	2	2	3
6 hrs		2	2	3	4
3 hrs	4	4	4	4	4
Cancelation	1	1	1	1	1

Level 1	Normal situation	
Level 2	Alert authorities	High authorities (state and territorial)
Level 3	Alert local authorities	Districts and local authorities (the mayor)
Level 4	Global warning	Evacuation of the population

Considering the Marquesas Islands' great exposure to tsunamis, a warning level of 2 is set off by an earthquake with a magnitude of greater than 7 occurring off the South American coast.

(3) A warning system best suited to the characteristics of French Polynesia

As has been pointed out several times, a warning system is only effective if it affects the population and if the population reacts accordingly. However, the distinctive characteristics of French Polynesia make setting up a warning system difficult.

Firstly, this territory has a surface area of 4,200 km² scattered over 5 million km² of ocean, with 256,000 inhabitants divided between dozens of islands. While it is true that 80% of the population is concentrated on Tahiti and Moorea, 8,000 persons people the 5 Marquesas Islands and 5,000 inhabitants live on the 44 islands of the Tuamotus. Therefore, the warning must quickly touch a widely-scattered population.

Secondly, there are many interlocutors. Civil security is shared between the French government, responsible for the coordination of assistance efforts, and the Assembly of French Polynesia, responsible for tsunami prevention. In addition, the districts lack their own resources and the mayors, who are meant to take over in the event of a warning being issued, are not always reachable or even present in their districts, residing as they often do in Tahiti.

Taking into account these constraints, it was decided to create a centralized, automatic alert system.

By the end of the year, 144 sirens will have been installed in French Polynesia. Both the High State Authoriy and local authorities will be able to set off these sirens. So as not to be dependent on the local or international telephone or Internet networks[1], each siren may be activated via the Inmarsat mini-C satellite network.

The Inmarsat network

The Inmarsat network is the first global satellite network for both fixed and mobile terminals. It is used by all of the world's ships to transmit distress and emergency signals, as well as for commercial communications.

For the Pacific zone, it is made up of a geostationary satellite and two backup satellites. If need be, Inmarsat can transfer from the satellite in use to one of the two backup satellites without having to reconfigure or repoint the Inmarsat-C terminals. This operation is therefore transparent for network users and practically instantaneous.

In addition, the emission and reception of the fixed or mobile terminals are not disturbed by meteorological events, such as cyclones.

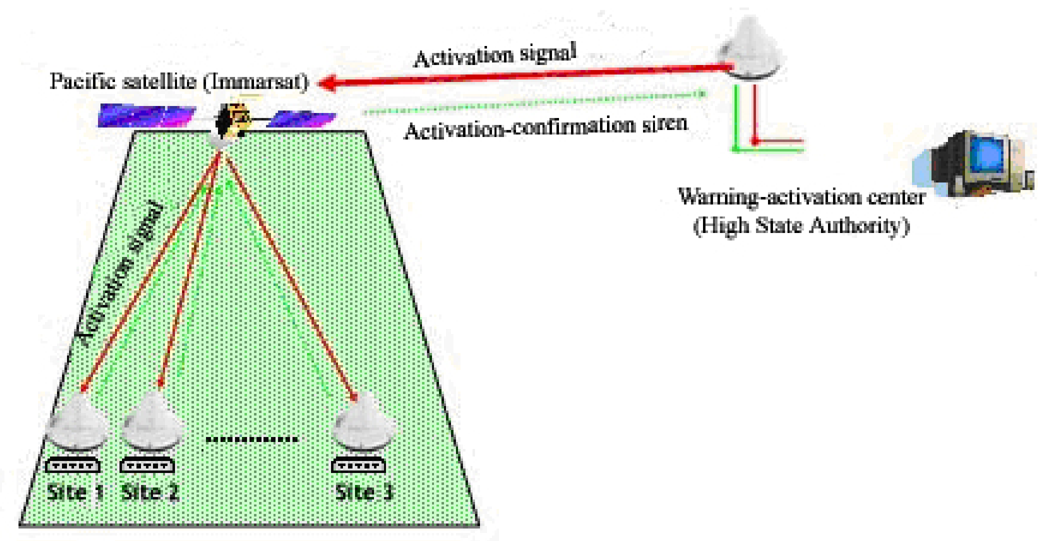
Finally, the Inmarsat-C terminals' incorporated antennas require no pointing; they

[1] *Experience has shown that as soon as a disaster is announced, the telephone network is immediately saturated. In addition, Papeete's "Postal and Telecommunications Service" is located on the shoreline: it would be put out of service - and the area's telephone communications would be interrupted - by 1.5 metre or higher waves.*

enjoy a vertical reception of 360° and a below-horizontal reception of up to 5°.

The sirens can be set off individually or in groups (an island, an archipelago or all sirens in French Polynesia). The sirens can be activated within 2 minutes by sending a message, with the confirmation message arriving within 4 minutes (see diagram below).

The manual activation process



Source: Assystem

Furthermore, the local authorities have portable satellite telephones (also Inmarsat), allowing them to communicate with the services of the High State Authority even in the event of the local telephone lines being down.

The civil protection services have also passed an agreement with Réseau France Outremer (RFO; "French Overseas Network"): in the event of a tsunami warning, a message is broadcast on television.

While the Assembly of French Polynesia is theoretically responsible for tsunami prevention, the High State Authority is also involved. During your rapporteur's visit to Tahiti, an information brochure entitled "tsunami warnings in French Polynesia" had just been published. Finally, in the Marquesas and Austral Islands, full-scale training exercises are organized, along with the evacuation and transfer of the population.

B. A RISK THAT BEGAN TO BE TAKEN SERIOUSLY IN THE OTHER BASINS FOLLOWING THE TSUNAMI OF 26 DECEMBER 2004

While the scientific community and several international organizations[1] were already interested in tsunamis phenomena before the Sumatra catastrophe struck, it must be admitted that the general public only became aware of this hazard then.

1. The "shock" of Sumatra

Several factors explain the veritable shock provoked by the tsunami that ravaged the Indian Ocean on 26 December 2004:

- Its uniqueness, with regard to both its size and the number of victims. With a magnitude of 9.3, the earthquake which provoked the tsunami was the second most violent earthquake ever recorded, with a fracture zone 1,200 kilometres long. In addition, the tsunami claimed 250,000 victims and displaced more than one and a half million persons on the coasts of twelve countries.

- The date on which this event occurred and the immense media coverage it attracted: the Christmas season is supposed to be a happy and festive time of the year. Therefore, this natural disaster strongly affected the world's population, generating an unprecedented show of generosity: private individuals donated more than €1.5 billion to humanitarian organizations. The media certainly contributed to this generosity, by broadcasting only hours after the tsunami struck footage for the most part recorded by private individuals via their digital cameras or cell phones, which showed this wave submersing the beaches and seaside resorts. This event, therefore, quickly took on a planetary dimension, all the more so considering the many Western tourists who figured among the tsunami's victims.

Also, the fact that the Indian Ocean had, up until then, been considered a relatively tsunami-safe zone generated increased public awareness.

a) The realization that all basins are vulnerable

Statistically speaking, the Indian Ocean is considered the safest ocean basin with regard to tsunamis, since it accounted for only 4% of tsunamis generated during the 20th century. However, the tsunami of 26 December 2004 claimed more victims than all other (known) tsunamis combined since ancient times.

In addition, it served as a reminder that certain regions that had not been struck by a tsunami in human memory had nevertheless been completely

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[1] *In particular, UNESCO via the IOC.*

devastated in the distant past, with the volcanic eruption on Santorini being a good example.

b) Shedding light on the shortcomings of the tsunami-risk prevention system

The Sumatra tsunami above all revealed enormous shortcomings with regard to mitigating the tsunami risk.

First of all, the images showing tourists playing in those areas where the sea had withdrawn revealed the public's complete ignorance of this phenomenon and its manifestations.

Secondly, scientists were surprised by the violence of the earthquake that had generated the tsunami and it became clear that, outside the Pacific zone, the tsunami phenomenon was not well understood due to insufficient research in this domain. For example, few catalogues of past tsunamis per basin had been published and the potential sources of tsunamis had not been systematically recorded and even less frequently analyzed in order to establish tsunami-exposure maps.

Finally, many observed that if a warning system had been in place, thousands of human lives could have been saved. The international community, under the aegis of UNESCO, therefore decided to complete the existing tsunami warning system and extend it to all zones.

2. The desire for an effective tsunami warning and mitigation system that covers all basins

The international community estimated that setting up an effective warning system for the Indian Ocean, the Caribbean and the Mediterranean required, on the one hand, the creation of intergovernmental groups for each basin (following the example of the ICG/Pacific) and, on the other hand, increased scientific research to better understand tsunamis in these regions.

a) The creation of three new intergovernmental groups

Following the tsunami of 26 December 2004, international cooperation grew considerably in order to establish a worldwide tsunami warning and mitigation system. The impetus came during the 3rd World Conference on Disaster Reduction, which took place in Kobe (Japan) in January 2005: a plenary session was dedicated to the creation of a warning mechanism for tsunamis in the Indian Ocean.

Taking into account its experience in the Pacific, UNESCO was put in charge of coordinating the set up of the tsunami warning system for the Indian Ocean. The IOC organized two ministerial-level meetings in February and March of 2005, which were attended by most countries of the Indian Ocean zone.

In addition, a "tsunami unit" was set up within the IOC in January 2005, to support the actions of the newly created intergovernmental coordination groups. In particular, this unit organized the initial preparatory meetings, as well as the evaluation visits in more than 18 Indian-Ocean countries.

In June 2005, the 23rd General Assembly of the Intergovernmental Oceanographic Commission adopted three resolutions for the creation of three regional coordination groups:

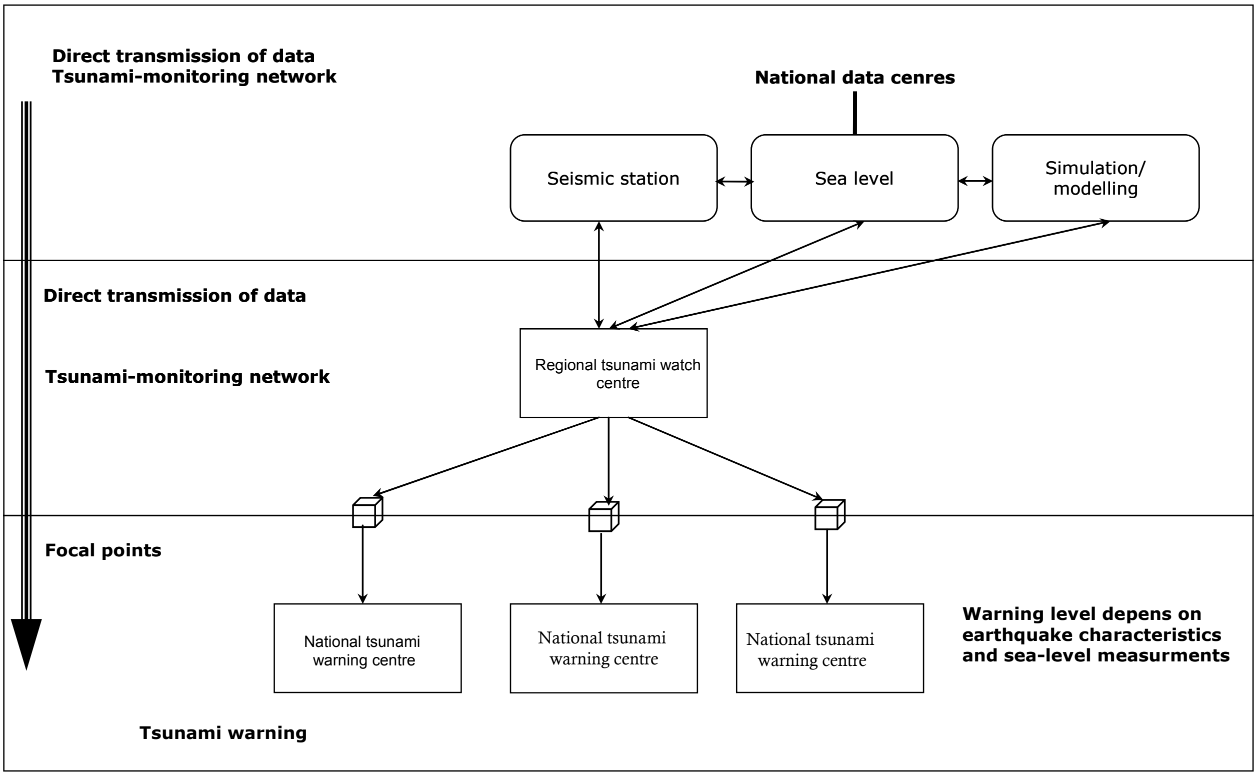
- The Intergovernmental Coordination Group for the Indian Ocean Tsunami Warning and Mitigation System (ICG/IOTWS), which groups together 28 countries, including France, which is present in this basin via La Réunion and Mayotte.

- The Intergovernmental Coordination Group of the Tsunami Early Warning and Mitigation System in the North Eastern Atlantic, Mediterranean and Connected Seas (ICG/NEAMTWS), made up of 64 countries, including France.

- The Intergovernmental Coordination Group for the Tsunami Warning System in the Caribbean and Adjacent Regions (ICG/Caribbean-TWS), made up of 27 countries, including France, which is present in this basin via Guadeloupe, Martinique, French Guiana and Saint-Martin.

The final structure of these three warning systems should be identical and based largely on the Pacific warning system.

The structure of the tsunami warning system



Source: IOC

Each country is responsible for collecting and processing the national data from its seismic stations and tide gauges. Each country must also ensure that this data is accessible in real time to all members of the warning system. In addition, the countries must carry out the necessary computer simulations to better understand this hazard, to identify the exposure zones, and to establish tsunami and inundation maps.

The data thus collected is transmitted in real time either directly or by the countries to one or several regional tsunami watch centres.[1] These centres are responsible for analyzing the earthquake data (localization of the earthquake and estimation of its depth, magnitude, date and origin time), in order to determine if a tsunami risk indeed exists. If the answer if yes, the

[1] *The varying terminology used by the three new intergovernmental groups can lead to some confusion. For example, in the Indian Ocean, the term used is "Regional Tsunami Watch Provider", while the Caribbean zone has up until now borrowed the ICG/Pacific term: "regional tsunami warning centre". According to the information gathered by your rapporteur, regardless of these formal differences, each regional centre is supposed to carry out the same missions for its geographic zone: issue a message indicating the source of origin, the possibility of a tsunami having been provoked, and (if affirmative) the estimated time of arrival and the regions liable to be affected. However, the countries remain responsible for the actual warning (in terms of informing and protecting the population).*

regional centres send a warning message indicating the hour of arrival and the concerned zones to the Focal Points of the member states. The regional centres will also use the data relative to the sea level to confirm the presence of a tsunami and either refine their forecasts or cancel the warning.

Focal Points and National Contacts for the Intergovernmental Oceanographic Commission's warning system.

- ***The ICG Tsunami Warning Focal Points***

  The Focal Point is the person to contact, reachable 24 hours a day, 7 days a week, and chosen by the ICG-member government to receive and rapidly send tsunami information. The IOC advises countries to choose one or several bodies, rather than persons. The Focal Point receives the bulletins and warnings issued by the regional warning centres and passes them on to the relevant emergency services (usually the civil protection services). As far as France is concerned, Météo France serves as the Focal Point in the Caribbean Sea and the Indian Ocean, while LDG/Pamatai serves as the Pacific zone's Focal Point. **However, France does not have an official Focal Point in the Mediterranean, even though CEA would be the natural choice.**

- ***The ICG Tsunami National Contacts***

  The ICG Tsunami National Contact is the person designated by the ICG-member state to act as its representative in the coordination of international tsunami warning and prevention activities. This person is a key player in the national warning system programme. He or she may be the Tsunami Warning Focal Point, someone belonging to the country's national disaster management organization, a member of a technical or scientific body, or a representative of some other tsunami warning-related organization. In the Indian Ocean, the Caribbean and the Pacific, this position is filled, respectively, by a representative of Météo France, a representative of IPGP ("Paris Global Physics Institute") and a representative of CEA. **As of June 2007, France no longer has a National Contact for the Mediterranean zone.**

Source: UNESCO/IOC

Finally, the Focal Points are responsible for transmitting the regional centres' warning bulletin(s) to the national authorities, so that the latter may take the necessary measures: implementation of the specialized tsunami emergency plan (see the analysis of the warning system in French Polynesia, below), which mobilizes all parties liable to be involved in preventing the tsunami and in crisis management after the tsunami; warning the population; evacuating the beaches and coasts.

At this point, your rapporteur would like to emphasize the fact that this system will only be truly effective when the national civil protection services have access to precise information on the expected effects of the announced tsunami. As was explained above, these effects are very difficult to predict, insofar as they depend on many different factors: the position of the source, the tsunami's directivity, the coastal bathymetry and topography. As a result, the regional centre's general message will have to be refined by a national body. This assumes an organization in France that is capable of analyzing the issued bulletins and comparing the current event with computer simulations, so as to specify those zones truly exposed. Otherwise, the national authorities will be faced with two types of risk: a false warning and the under estimation of the risk if the tsunami amplification effects of certain zones are not taken into account (see the high exposure of the Marquesas Islands compared to that of the Society Islands, including Tahiti).

In addition, the tsunamis liable to affect France's Mediterranean and Caribbean coasts are local or regional tsunamis, resulting in very short reaction times (between a few minutes and a half hour). Therefore, it is essential that the scientific organization in charge of advising the public authorities on the seriousness and localization of the tsunami risk be continuously on-duty - 24 hours a day, 7 days a week - and enjoy real-time access to the seismic data and sea-level measurements.

The three intergovernmental coordination groups have committed themselves to laying the foundations of a warning system by the end of 2007 (nomination of the member states' Focal Points and National Contacts; designation of regional and national warning centres). By 2010, the warning systems should be operational and all basins should be covered.

Each intergovernmental group has established an action plan and created specialized work groups that are meant to meet with one another on a regular basis. For example, the ICG/Caribbean-TWS has created the following four groups:

- Tsunamis hazard assessment;

- Monitoring and detection system. This group is divided into two subgroups specialized in seismology and sea-level monitoring;

- Warning and communication;

- Emergency and training

Depending on the region, a yearly or half-yearly meeting is organized, to record the progress made by the member states and workgroups, and to define the group's future actions.

Other initiatives of the international community should strengthen the effectiveness of the tsunami warning and prevention systems.

These systems should rely, in the midterm, on the sharing of terrestrial observation means: the Third Earth Observation Summit, held in

February 2005, agreed to a 10-year implementation plan for a Global Earth Observation System of Systems (GEOSS[1]).

At the European level, this system will be able to depend on the GMES (Global Monitoring of Environment and Security) initiative.

The GMES initiative

Initiator	The European Space Agency, the European Union.
Participants	The European Space Agency, the European Union (the European Commission and member states).
Status	Currently being developed.
Objectives	Create an autonomous, multi-level (local, regional, global) European monitoring system for the environment and security, in support of European policy (on the environment, agriculture, etc.) and the EU's international commitments.
Implementation of initial services	2008

Source: CNES

According to the information obtained by your rapporteur, the last general assembly of the IOC in June 2007 sanctioned the idea of cooperation between the four regional tsunami warning systems, as well as the necessity to integrate the tsunami warning system into a more global system that would encompass the warning and mitigation of all oceanic risks (tempests, cyclonal swells, typhoons, cyclones, rising sea level).

Furthermore, the policy of increasing public awareness and education with regard to the tsunami risk has authority to be carried out within the framework of the International Strategy for Disaster Reduction (ISDR).

International Strategy for Disaster Reduction (ISDR)

This initiative, supported by the United Nations (UN), is meant to help communities to better withstand natural disasters by considering risk reduction an essential part of sustainable development. The strategy favours four lines of action:

- Raise public awareness of the notions of natural-disaster risk, vulnerability and reduction.
- Encourage decision makers at every level to take measures to predict and mitigate the impact of natural disasters.
- Encourage interdisciplinary and intersectorial partnerships all over the world, for a

[1] *Responsible for federating all observation resources, in order to better understand the climate and the environment and help predict natural disasters. Its marine component is the Global Sea Level Observing System (GLOSS).*

better understanding of the risks and of the measures under consideration.

- Further scientific understanding to reduce the risks.

To carry out its programme, the ISDR relies on two organizations:

The ISDR's special team plays the primary role in the elaboration of disaster-prevention policies. This team, managed by the Deputy Secretary General of the UN's Office for the Coordination of Humanitarian Affairs, gathers together 25 UN, international, regional and civil-society organizations. Twice yearly, it meets in Geneva to debate problems of shared and global interest related to disaster prevention (climate variability, rapid warning systems, vulnerability and risk analysis, fires in wild areas, droughts, etc.).

The ISDR "interorganizational" secretariat serves as an international exchange centre for information on disaster prevention. It organizes public awareness campaigns and publishes articles, revues and other tools to promote natural disaster prevention.

Source: UN

Finally, the rapid and reliable transmission of tsunami warning system data demands close cooperation with the World Meteorological Organization (WMO). This United Nations body specialized in meteorology manages the Global Telecommunication System (GTS), whose objective is to rapidly collect, exchange and transmit meteorological observation data. The GTS is used to transmit tide gauge data and warning messages.[1]

b) A strong increase in funding for tsunami-related research

At both the national and European Commission level, the Sumatra tsunami led to the funding of numerous tsunami-related research projects.

In 2005, the ANR (France's National Research Agency) launched its Telluric Disaster and Tsunami Programme (CATTELL), in order to develop fundamental research on those phenomena generating great telluric disasters. Four main lines were established:

- Seismotectonic risks: Promoting research on active continental and underwater faults, decrypting the history of seismogenic zones, modelling the propagation of seismic waves, early warning systems for earthquakes, and the seismic vulnerability of buildings/structures;

- Tsunami-related risks: Selected projects must study tsunami-generating processes and technological research on the tsunami warning systems;

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[1] *More bulky seismic data is transmitted via a different system [in general, via the Very Small Aperture Terminal (VSAT) network, which uses geostationary satellites, or the more robust VAST system; the General Pocket Radio Service (GPRS) and Internet play a secondary, backup role, due to their being very "unwieldy"].*

- Gravity-related risks: Research on the processes of terrestrial and submarine landslides, physical phenomena of flows/slides, and technology related to the monitoring of these phenomena;

- A transversal line of study: Supporting technological and methodological research on these natural risks and developing the socio-economic dimension of early warning systems.

In 2005, 17 projects were selected for a total budget of €5.17 million. 61% of the projects were related to seismic risk, but tsunami-related risks represented the second most funded theme, accounting for 17% of the financed projects.

In 2006, €4.2 million were attributed to the CATTELL Programme. 14 projects were selected, with 69% of the funding going to earthquake-related studies; no tsunami-related study was selected.

The European Commission also financed numerous research programmes following the Sumatra tsunami of 26 December 2004.

Certain projects had already been carried out prior to this devastating tsunami. GITEC (Genesis and Impact to Tsunamis in the European Community) and GITEC TWO (Tsunami Warning and Observations) had allowed for the creation of a European tsunami catalogue (with 228 events recorded from 6000 B.C. to 2003 A.D.) and the improvement of simulation techniques. In addition, several experimental tsunami warning systems had been tested off the coast of Portugal, in the Ionian Sea and in the Peloponnese.

Likewise, the BIGSETS (Big Sources of Earthquake and Tsunami in South West Iberia) project improved our understanding of the origins of the 1755 tsunami that devastated Lisbon.

In the 6th Research Framework Programme (2002-2006), €48 million were dedicated to natural disasters, €7.45 million of which went to the study of tsunamis within the framework of three projects: TRANSFER, NEAREST and SEAHELLARC.

The TRANSFER (Tsunami Risk and Strategies For the European Region) project enjoys funding of €3.3 million and groups together 29 partners. The project began 1 October 2006 and will continue until April 2009. Its objective is to improve our understanding of tsunami propagation in the Mediterranean and help set up a tsunami warning system for this zone. 9 workpackages have been formed around the following themes:

- Improving and updating the European tsunami catalogue and integrating it into the global tsunami catalogue;

- Identifying and characterizing the seismic and nonseismic sources of tsunamis in the European-Mediterranean zone;

- Analyzing the current seismic and tide gauge observation and data-processing systems, as well as identifying the necessary adjustments for setting up an effective tsunami warning system;

- Improving tsunami modeling, for it to better take into account the propagation and coastal impact of tsunamis.

In addition, seven geographical zones have been chosen for the application of tsunami scenarios: inundation maps will be created and warning and prevention plans established.

The NEAREST (Integrated observations from NEAR shore sourcES of Tsunamis) project has a budget of €2.8 million and groups together 11 partners. Its objective is to identify and characterize those sources liable to generate local tsunamis in the Gulf of Cadiz. An underwater observatory equipped with seismic and pressure sensors will be installed and serve as a prototype for a tsunami warning system. New simulations will be carried out in the Algarve zone, which was strongly affected by the tsunami of 1755 and new inundation maps will be drawn up.

Likewise, the objective of the SEAHELLARC (Seismic risk Assessment and mitigation scenarios in the western HELLenic ARC)[1] project is to set up a network of land and sea-based sensors to better observe the seismicity of the Hellenic Arc and any eventual tsunamis. The zone's bathymetry will be precisely mapped, in order to identify the area's faults and those zones where landslides are liable to occur. The objective is to identify all tsunami sources. In addition, a study on tsunami vulnerability will be carried out on the town of Pylos, which will serve as a base for setting up a tsunami prevention and warning plan.

Furthermore, other projects financed by the European Commission indirectly contribute toward the setting up of an effective tsunami warning system.

For example, the objective of the SAFER[2] project is to develop civil-protection tools to allow for an earlier warning, above all in densely populated areas. In particular, this project seeks to create new algorithms for the rapid localization of earthquakes and characterization of faults. In addition, new tools will be developed for the real-time creation of warning maps, as well as simulations of damages caused by the earthquake.

Earthquakes that occur in the European-Mediterranean region are currently recorded by 100 different observation systems managed by 46 countries. The objective of the NERIES (Network of Earthquake Research Institutes for Earthquake Seismology) project is to bring all of these monitoring systems together into a single network, to improve data access, and to harmonize data distribution and storage.

Moreover, the ESONET (European Seas Observatory Network of Excellence) project proposes laying the groundwork for a marine component of the Global Monitoring for Environment and Security (GMES) programme,

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1 *This project enjoys €1.3 million in funding and gathers together 7 partners.*

2 *This project enjoys €3.6 million in funding and gathers together 29 partners.*

consisting of a network of permanent, multi-disciplinary observatories installed on the sea floor in key zones on the European continental margins and allowing for continuous geophysical, biochemical, oceanographic and biological monitoring. ESONET will pay particular attention to the oceanic margins beyond the limit of the continental shelf and down to depths of 4,000 metres: this zone is not nearly as well known as the continental shelf itself and is not covered by the current systems for gathering oceanic data. The European continental margins extend for some 15,000 km, from the Arctic Ocean to the Black Sea, covering a surface area of nearly 3 million km². The EMSO (European Multidisciplinary Seas Observation) project is responsible for installing the observatories on the sea floor. 5 sites (each of which has its own specific research theme) have been identified. The Liguria Sea site has the authority to attach its measuring devices to the ANTARES[1] project cable; this observatory will study the geophysical risks near densely populated zones and test devices either installed on the seafloor or used for core sampling.

Finally, the 6th Research Framework Programme has provided €4 million to the DEWS (Distant Early Warning System) project, supported by the Information Society and Media Directorate-General of the European Commission. Its objective is to complement the warning system currently being set up by the Germans in Indonesia[2], by using information technology to

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1 *The objective of the Antares project is to detect and study very high-energy cosmic neutrinos in the Mediterranean. Cosmic neutrinos are elementary particles that pass almost undisturbed through matter and can therefore travel great distances in the Universe without being absorbed by the interplanetary mediums. Used in addition to electromagnetic radiation, they represent an exceptional means of studying distant corners of the universe. They can also provide us with indirect information on the nature of the universe's hidden mass. Due to their very weak interactivity with matter, very large detectors isolated from cosmic radiation must be used. Indeed, cosmic rays are constantly bombarding the Earth's surface, creating significant background noise. For this reason, the sea floor, which is naturally protected from such radiation by its depth, represents an ideal environment for the detection of neutrinos. In the Antares experiment, a thousand photodetectors are immerged at a depth of 2,400 m in the Mediterranean on a site located south of the island of Porquerolles (the Var département) chosen for the quality of its water. These sensitive photodetectors directed towards the ground will capture the light emitted by the neutrino products that have passed through the Earth and interact with it near the sea bottom. This arrangement will allow the detectors to study the southern hemispheric sky, which includes the centre of the galaxy, the location of several phenomena of intense energy. These large systems can therefore be considered "neutrino telescopes".*

2 *Following the tsunami of 26 December 2004, Germany very quickly manifested a desire to come to the aid of those countries devastated by the tsunami and on 13 January 2005 decided to set up the German Indonesian Tsunami Early Warning System (GITEWS). This project, directed by the Ministry of Education and Research and allocated €45 million in funding, should allow for rapid, reliable warnings; it relies on a network of earth observations (seismic and geodesic sensors), sea observations (tide gauges and sea-based pressure sensors), a precise bathymetry of the regions to be protected, computer simulations and a warning centre in charge of receiving and processing the data and, if need be, issuing warnings. This regional tsunami warning centre is supposed to integrate the warning system for the Indian Ocean managed by the IOC. The German engineers have developed a computer program capable of determining the location, magnitude and depth of a strong earthquake within 4 minutes of its first manifestation.*

increase the performance of the sensor networks, decrease the warning messages' transmission times, and improve cooperation not only between countries, but also between the concerned authorities.

3. Unequal results

a) The Indian Ocean: a successful international mobilization effort

Following the Sumatra tsunami, the countries of the Indian Ocean touched by this natural disaster were the object of an unprecedented show of solidarity. The United States donated €1.95 billion, €714 million of which came from the government and €1.2 billion from private donators. Germany was the second largest contributor, with €536 million being donated by the German government and €553 million in private donations. In addition to donating money for humanitarian aid and the reconstruction of the devastated areas, numerous countries wanted to help set up a tsunami warning system for the Indian Ocean. As has already been pointed out, Germany committed €45 million to the installation of a warning system in Indonesia. Likewise, Japan has installed 23 wideband seismic stations in this country.

Since the tsunami warning system in the Indian Ocean is not yet operational, the Hawaiian (PTWC) and Japanese warning centres provide this region with information messages[1] in the interim.

The Intergovernmental Coordination Group for the Indian Ocean Tsunami Warning System has already met four times. During its last meeting in Kenya in February and March of 2007, the group observed that important progress had been made.

The assessment visits for evaluating the countries' ability to set up warning systems, carried out between June and September of 2005 with the funding of donor countries, proved very effective. Thanks to the presence of experts sent by the UN bodies (UNESCO, WMO and ISDR), these assessments helped raise awareness among these countries, which then actively supported setting up a warning system.

For example, most countries have begun installing the necessary measuring devices for the analysis of tsunamis and the real-time transmission of data. India is currently modernizing its network of seismic stations and plans on installing 50 tide gauges and 12 pressure sensors (tsunamimeters). In Indonesia, 67 of the planned 160 seismic stations already transmit their data in real-time; 25 tsunamimeters and 80 tide gauges should complete this system.

Certain countries have also already taken measures to alert their populations. In Malaysia, sirens are to be installed in densely populated areas.

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1 *Information (rather than warning) messages are issued, because the data available to these two centres is not sufficient to allow them to issue reliable warning bulletins. These two centres currently base their analysis on the data transmitted by 30 seismic stations, 41 tide gauges and one DART buoy installed off the coast of Thailand.*

In Thailand, the national warning centre for natural disasters can now interrupt the programmes of the country's 14 television channels and numerous radio stations in order to broadcast its messages.

In addition, training sessions on risk evaluation have been organized in Dubai and on the drawing up of inundation maps in Perth. Each workgroup has defined a precise programme of action and there is a significant sharing of information between the participants of each group. In this regard, the logistical support provided by Australia - which, in particular, finances the group's secretariat - represents an important asset.

Finally, a tsunami information centre, modeled after the Hawaiian centre and financed by Canada, is to be set up in Jakarta.

For all that, certain gaps remain and must be remedied by the ICG/IOTWS countries.

First of all, a test carried out by the tsunami warning centre in Hawaii in February 2007 revealed certain malfunctions in the reception of warning messages by the national Focal Points; not every country was able to confirm having received the warning message. In addition, this test demonstrated the unequal effectiveness of the three communication tools used, depending on the particular country: while transmitting the message via the Global Telecommunication System necessitated between 1 and 15 minutes, 10 to 15 minutes were required to successfully transmit the message by fax and 1 to 59 minutes by email.

Secondly, the correct evaluation of the tsunami hazard when an earthquake occurs in the region runs up against several difficulties: the number of land and sea-based measuring devices providing real time data remains insufficient; there are no high-resolution bathymetric and topographic data for those areas near the coasts; no paleotsunami study has been carried out to better understand ancient events.

Furthermore, the national networks' integration into a regional warning system is proving difficult. The sharing of seismic and sea level data between the ICG/IOTWS countries remains very partial, while the structure initially chosen for the system (i.e., one or several regional centres issuing warning messages to national centres) has been challenged. Indeed, the countries do not want to be dependent on a single centre for the issuing of warning messages for a precise geographical zone; instead, they favour increasing the sources of information. Therefore, the warning system will not be made up of "regional tsunami warning centres", but rather "Regional Tsunami Watch Providers"[1] with which each country will pass an agreement in order to receive the issued bulletins.

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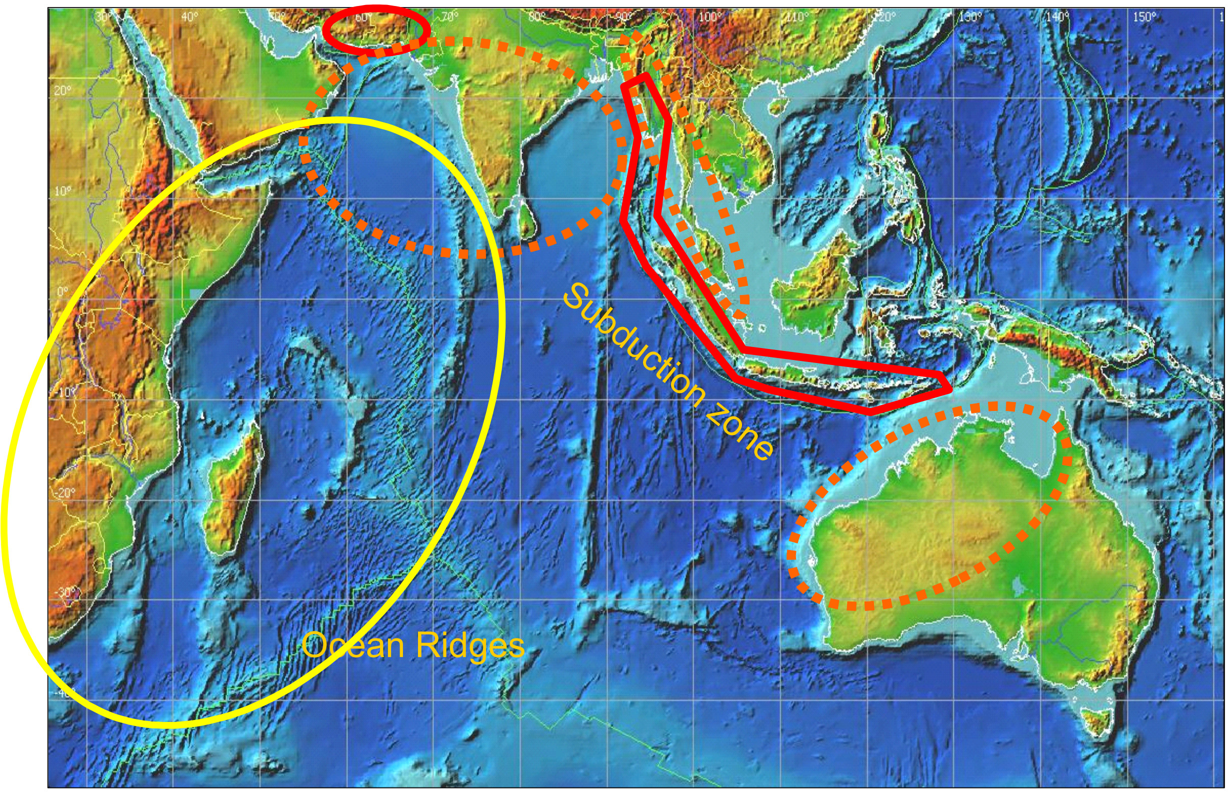
[1] *As has already been pointed out, the terminology used often differs according to region. The terminology chosen for the Indian Ocean zone is meant to avoid offending national susceptibilities by maintaining a balance between the ICG member states.*

Finally, much work remains to be done with regard to warning the concerned populations. According to the information obtained by your rapporteur, few countries have implemented a national and local emergency plan defining the responsibilities and missions of all concerned parties in the event of a tsunami. The tsunami of 17 July 2006, which claimed more than 500 victims in Indonesia, revealed shortcomings in the warning system: although PTWC had transmitted an information bulletin to the Indonesian authorities, they were unable to protect the population by rapidly broadcasting precise information on the threatened coastal zones.

Despite these inadequacies, the assessment of actions undertaken by the ICG/IOTWS is rather positive. It must not be forgotten that this initiative was launched only two years ago and that it took almost 40 years to set up a truly effective tsunami warning system for the Pacific. The setting up of a tsunami warning system in the Indian Ocean benefitted from an unprecedented financial godsend from the many donor countries. As of April 2005, it could also rely on the messages issued by the Pacific centres and the experience accumulated by the ICG/Pacific; it has also been able to profit from recent technological advances (tsunamimeters, increasingly effective computer models, etc.). However, a certain number of years will be needed to not only set up an effective national and international warning system, but also to build confidence between the concerned countries and develop a regional system based on cooperation and the sharing of data.

It should be pointed out that the structure of the Indian Ocean monitoring systems is much simpler than those of the other basins, as shown in the following map:

The different types of tsunami
liable to touch the Indian Ocean countries



- The zones circled in red are subject to local tsunamis.
- The zones delineated by dotted orange lines are subject to regional tsunamis.
- The zones circled in yellow are subject to distant tsunamis.

Source: CEA/DASE

Indeed, as compared to other regions whose countries are threatened by local, regional and sometimes distant tsunamis, all the Indian Ocean countries - with the exception of Burma and India - are exposed to only one type of tsunami:

- Myanmar, the Andaman and Nicobar Islands, Timor, Iran and Pakistan can be touched by local tsunamis. Therefore, for the warning system to be effective, these countries must be equipped with dense monitoring systems and very rapid warning centres, with teams on-duty 24 hours a day, 7 days a week.

- Myanmar, Thailand, Malaysia, Singapore, Sri Lanka, India, Australia and Oman are threatened by regional tsunamis: they therefore have more time to react in the event of a warning being given.

- Finally, the 16 countries located within the yellow circle are exposed to teletsunamis: their monitoring systems can therefore be less dense and their warning centres need only be on-call.

As a result, the overall investment and operating costs are (in proportion to the size of the Indian Ocean) 3 to 5 times less than in the other basins, whose countries must be equipped to face all types of tsunami.

On the other hand, the relative isolation of the various warning systems could explain the difficulties encountered in trying to integrate the national systems into a regional warning system.

b) The Caribbean: numerous obstacles to setting up an effective warning system

Since the creation of the Intergovernmental Coordination Group for the Tsunami Warning System in the Caribbean, only two meetings have taken place (in Barbados in 2006 and in Venezuela in 2007) and little progress has been made.

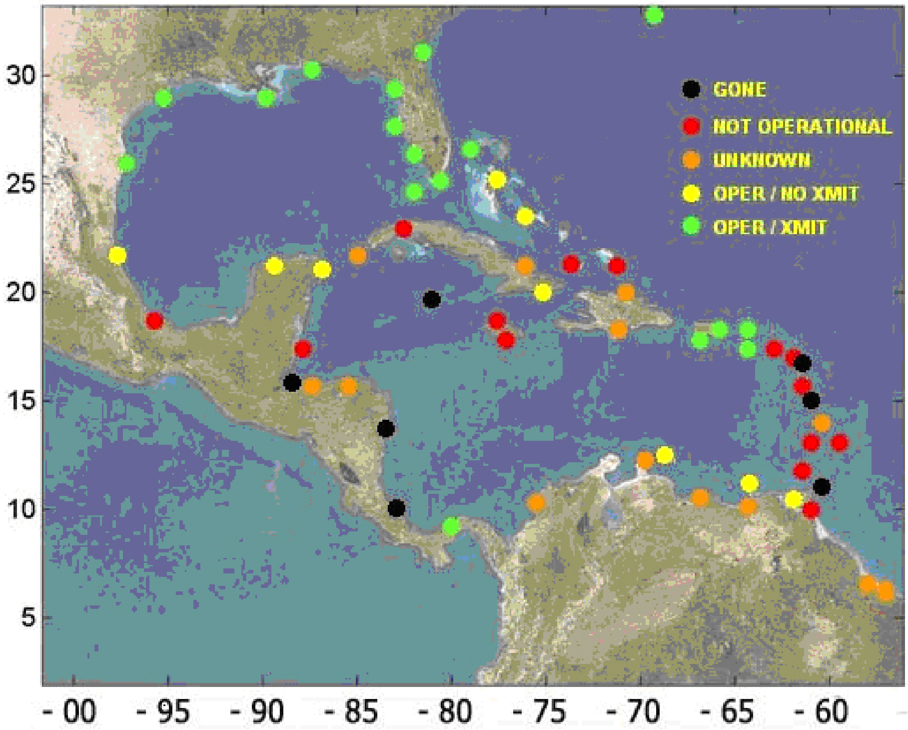
First of all, the Caribbean zone suffers from several disadvantages: it is a "multi-hazard" region (cyclones, earthquakes, volcanic eruptions, tsunamis) made up of many small islands and countries with meager financial and logistical resources.

Since the tsunami risk has long been ignored in this region, it is poorly equipped with measuring devices capable of detecting tsunamis and issuing reliable warning messages. Considering this zone's significant seismic risk, several seismological networks exist, even though certain regions, such as Mexico and Cuba, remain poorly covered. Ultimately, each island will have to have a seismic station, for the very rapid detection of earthquakes.

As regards the region's tide gauges, it was observed during the last meeting that 60% of these devices are out of service and that only a very few of those that do function transmit their data in real time.

CARRIBEAN TIDE GAUGES

Intra-Americas Sea Water Level Network



Source: Puerto Rico Seismic Network

In addition, this region demands very fast reaction times. For example, a tsunami generated in the Virgin Islands will arrive in one hour and fifteen minutes in Guadeloupe, but in only 10 minutes if generated in Montserrat. Therefore, the warning system methodologies used in the Pacific region, where the distances covered are much greater, are simply not pertinent for the Caribbean zone. However, the last conference revealed that half of the zone's countries have yet to name their Focal Point.

The group's actions are considerably slowed down by the lack of financial means. The ICG/Caribbean-TWS does have at its disposal the Caribbean offices of the IOC in Cartagena (Colombia). However, contrary to the ICG/IOTWS, it does not have any personnel specifically in charge of managing its actions and, in particular, organizing local work sessions: during the last meeting of 2007, it was observed that three out of four workgroups had not met for over a year, due to a lack of funding.

Finally, one must emphasize the difficulties related to the at times difficult relations that exist between this zone's countries, which constitute significant obstacles to setting up a warning system based on the sharing of information. For example, during the meeting in Venezuela, the Venezuelan institute responsible for seismic research[1] announced that it did not want to take part in the international tsunami monitoring system via the sharing of seismic data.

Nevertheless, the Caribbean zone does have an advantage: the presence of American territories (Puerto Rico and the Virgin Islands) and the proximity of Florida. Within the framework of its National Tsunami Hazard Mitigation Program, the United States has taken several measures originally intended to protect its own coasts, but which also benefit the entire region.

First of all, beginning in 2006, it was decided that PTWC and WC-ATWC tsunami warning centres would extend their activities to the entire zone until a regional system was set up.

Furthermore, Puerto Rico quickly emerged as the most advanced country with regard to tsunami preparedness. After launching, with the aid of the ICG/Pacific, a tsunami warning and mitigation programme in 2000, a tsunami warning system was established in 2003. Puerto Rico's seismic station was put in charge of detecting tsunami-generating earthquakes, in collaboration with PTWC.

This system has slowly but surely been improved. In 2006, the United States Geological Survey installed 9 seismological stations linked by satellite to Puerto Rico's seismic network, in order to complete the networks' coverage. Furthermore, one DART buoy was installed in the Caribbean Sea, one in the Gulf of Mexico and two north of Puerto Rico.

As a result, even if Puerto Rico's seismic network does not yet meet all the necessary conditions of a warning centre[2], in practice, it has been recognized as such by most countries in the region. Indeed, more than 50 broadband seismological stations in the Caribbean zone transmit their data in real time to the Puerto Rican network. During the last meeting, Puerto Rico's seismic network distributed to all participants a funding request for €815,000 addressed to the American Congress in order to ensure the operating costs of the future warning centre for the period of 2007-2010.

c) The waiting game in the Northeast Atlantic and Mediterranean zones

The intergovernmental coordination group for the Northeastern Atlantic and Mediterranean zone has already met four times: in Rome in November 2005, in Nice in May 2006, in Bonn in February 2007 and in Lisbon in late November 2007. However, it would appear to be difficult to set up a tsunami warning system for this zone.

The seismic coverage of the Mediterranean zone countries is far from being homogeneous, with regard to both the number of seismic stations and the type of seismometer installed. In addition, many countries, particularly the

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[1] "*La Fundación Venezolana de Investigaciones Sismológica"s (FUNVISIS).*

[2] *For example, it does not function 24 hours a day, 7 days a week.*

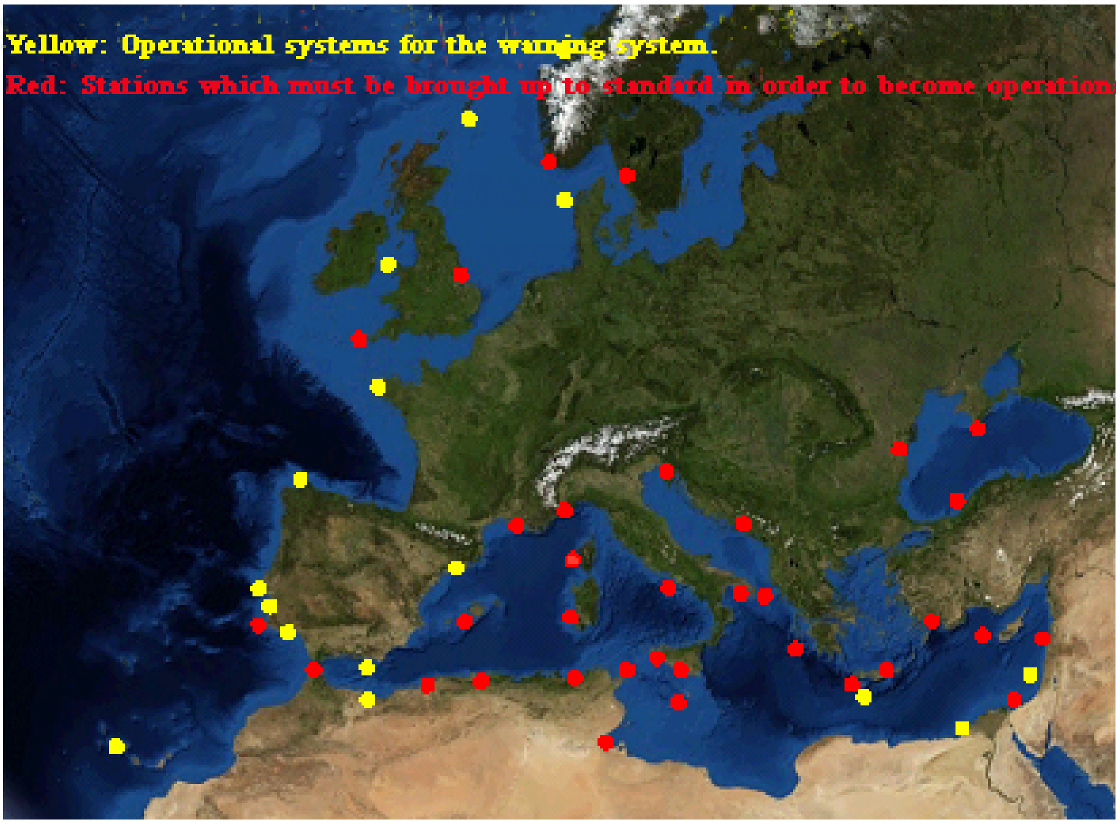
North African states, refuse to provide access to their data. However, the rapid detection of an earthquake and the reliable localization of its epicentre, depth and magnitude require a dense network of seismometers, whose data is available to everyone. Insofar as those sources liable to provoke a Mediterranean-wide tsunami are located along the faults off the coast of North Africa, the unaccommodating attitude of these countries constitutes a major obstacle.

Furthermore, very few tide gauge stations transmit their data in real time, which means this information cannot be used to generate tsunami warnings or verify whether a tsunami has indeed been induced. As regards the most modern tide gauge stations (as well as many seismic stations), data transmission is carried out not by satellite but by Internet, even though this means of communication may be disrupted by an earthquake.

The working group on instruments for measuring sea level has selected some thirty particularly strategic tide gauges and urged those countries responsible for managing and processing their data to render them operational for the detection of tsunamis[1] before the end of 2007. However, its success depends on the goodwill of these countries, since no specific funding has been set aside for this action. Therefore, this programme risks to be delayed, considering the difficulty encountered by the organizations responsible for the tide gauges in obtaining funds for their improvement. For example, SHOM ("Marine Hydrographic and Oceanographic Service"), responsible for improving the performance of tide gauges located on the French coasts, has already announced that, due to a lack of funding, only data from Le Conquet tide gauge will be transmitted in real time in 2007.

[1] *Initially, these tide gauges must be capable of sending a signal every minute when they are located more than 1 hour (or 100 km) from a tsunami-generating source, with eventually messages being sent every 15 seconds.*

List of tide gauges judged to have priority for the setting up of a tsunami warning system in the Mediterranean



Source: IOC

In addition to an unwillingness to share seismic data, the setting up of an effective tsunami warning system meets with the refusal of numerous North African countries to transmit their tide gauge data.

Likewise, the lack of funds makes installing pressure sensors at sea difficult.

In addition to the question of tsunami detection, it seems that no country has begun to elaborate a warning plan laying out the measures to be taken by all the various authorities responsible for civil protection. No inundation zone has been delineated, no evacuation plan is operational. The warning methods have not been defined (sirens, radio messages, etc.) and no public awareness and education programme has been carried out.

Your rapporteur has observed that the European Union, represented by the European Commission, was not involved in setting up the tsunami warning system for the Mediterranean/Northeast Atlantic zone. This absence is surprising for several reasons.

Firstly, this project is by its very nature European: all the European countries are concerned, some because they border the Mediterranean, the others because a significant portion of their population spends its holidays on the coasts of the Mediterranean countries.

In addition, this project necessitates the installation of infrastructures (seismic stations, tide gauges, tsunamimeters) that are useful to all the countries, but which still rely on national funding. Therefore, the European Union should take responsibility for a portion of this instrumentation via European programmes; this would certainly accelerate the setting up of a warning system.

Finally, this project will only become operational if the North African countries decide to cooperate. The European Union can encourage them to do so within the framework of its European-Mediterranean policy.

In the opinion of your rapporteur, the elaboration of a clear tsunami warning strategy for the Mediterranean/Northeast Atlantic zone is confused by two additional factors: the diversity of tsunami sources and the desire to create a multi-risk system.

The warning systems currently being set up in the Indian Ocean, the Caribbean and the Mediterranean/Northeast Atlantic are designed to detect regional tsunamis and teletsunamis; in other words, tsunamis which are mainly provoked by earthquakes and whose source is sufficiently distant to provide an interval of between 20 minutes and several hours before their arrival on the coasts. For those coasts touched sooner (i.e., located nearer the source), the planned warning system is not yet operational, because the delays are too short and no country has decided to automate its warnings using sirens.

However, research on the sources of Mediterranean-zone tsunamis shows that the danger is not simply seismic in origin, but also linked to landslides and volcanic eruptions. There is therefore a significant risk of local tsunamis, even though this risk cannot be suitably managed by the proposed system. Therefore, certain countries are questioning the validity of this system, because it does not address local tsunamis.

In the opinion of your rapporteur, this attitude is hardly justified: considering the difficulties already encountered in setting up a regional tsunami warning system, it would be unrealistic to want to make the system operational at this stage for local tsunamis. Indeed, local tsunamis demand a very dense network of instruments and a permanent monitoring of zones of "gravitational instability" and volcanoes, both of which can only be ensured by the concerned countries. It should be pointed out that in the Pacific system, PTWC also functions as the local warning centre for Hawaii. Therefore, those countries of the Mediterranean/Northeast Atlantic zone particularly vulnerable to local tsunamis will eventually be induced to develop national or even local warning systems. For instance, Italy has installed a permanent monitoring system for Stromboli, following the tsunami of 30 December 2002.

Furthermore, this geographical zone (Mediterranean/Northeast Atlantic) is not homogeneous in its exposure to tsunamis. Northern Europe is less concerned by tsunamis than it is by storm surges. Therefore, these countries have accepted to participate in setting up a tsunami warning system only if the said system takes into account all risks of oceanic origin.

The supporters of this multi-risk approach believe that it should be easier to finance instruments for measuring sea level, because they can be used for the detection of several types of risk. However, extending the warning system to include several risks could also delay its implementation. Indeed, the necessary scientific knowledge is not the same: tsunami detection relies on a seismological network, while tempests fall within the competence of the meteorological services. Likewise, the prevention plans are independent, insofar as the necessary reaction times vary greatly. Even though establishing a system to manage a single risk proves to be a rather laborious process, requiring many meetings before any consensus can be formed, the decision-making process risks to be slowed down even further if other hazards must also be taken into account.

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Since the Sumatra tsunami, the international community has realized that the tsunami risk is not limited to the Pacific, but rather concerns all of the world's oceans and seas. Therefore, each basin has set about setting up a tsunami warning system.

The results have been unequal: the countries of the Indian Ocean, still very much affected by the disaster of 26 December 2004 and the three following tsunamis[1], remain strongly motivated. However, in the Caribbean and Mediterranean/Northeast Atlantic zones, with the populations having gotten over the initial shock provoked by Sumatra, most of these countries (including France) now seem reticent to invest in a permanent warning system, considering the rarity of the hazard.

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[1] *The three tsunamis generated after that of 26 December 2004 are the tsunamis of 28 March 2005, 17 July 2006 and 12 September 2007, each of which claimed victims. This has put into perspective the "exceptional" character of the Sumatra tsunami, which certain persons have used to justify the absence of a warning system in this region.*

III. FRANCE'S POSITION: A WAIT-AND-SEE POLICY THAT IS UNACCEPTABLE CONSIDERING THE SERIOUSNESS OF THE STAKES

Via its overseas *départements* and territories, France is present in all of the world's oceans, which should encourage it to play a central role in the setting up of tsunami warning systems. In reality, once the initial shock provoked by the Sumatra catastrophe had faded away, the political will to take action soon followed suit, leaving the technical services on their own and without the necessary means to assume the commitments taken by France only just over two years ago.

A. A HIGH VULNERABILITY TO TSUNAMIS WHICH SHOULD INDUCE FRANCE TO MAKE A STRONG COMMITMENT

All French coasts are concerned by tsunamis; therefore, it is in the country's interest to develop an international warning system.

1. Important security stakes

a) A particularly high vulnerability due to its geography

France's Exclusive Economic Zones (ZEE) cover more than 10 million km² in the Atlantic, Indian and Pacific Oceans. Therefore, France is second only to the United States.

French overseas territories

Conversely, this means France is particularly vulnerable to tsunamis.

Metropolitan France has 5,800 km of coastline. As regards its Mediterranean coast, the following events have been recorded:

- On 20 July 1564, an earthquake provoked an inundation in Antibes and caused damages in Nice.

- On 4 February 1808, an ebb and flow were observed in Marseilles following an earthquake.

- On 9 December 1818, an earthquake provoked violent waves in Antibes.

- On 23 February 1887, an earthquake in the Liguria Sea provoked a retreat of the sea followed by waves of up to 2 metres in Cannes and Antibes, inundating the beaches and causing material damages.

- On 16 October 1979, the collapse of a section of the Nice Airport generated waves 3 metres high in Antibes.

- On 21 May 2003, the tsunami generated by the Boumerdès earthquake in Algeria (with a magnitude of 6.8 on the Richter Scale) caused damages in several French harbours.

The last two events are symptomatic of the types of tsunami that could affect the French Riviera in the future.

Firstly, a landslide is liable to provoke a local tsunami, with a very short propagation time. In the case of the Nice Airport, the accident was undoubtedly caused by both the construction work and the zone's instability. Generally speaking, the Liguria Sea coast (from Fréjus to Menton for France) is deemed unstable and deep, resulting in a maximum risk level.

Secondly, the geodynamic context of the Mediterranean coast makes this a dangerous zone. An earthquake provoking a landslide or an underwater earthquake could generate a tsunami that would make the event even worse. Such an earthquake could occur in the Liguria Sea, where there are active faults. It could also occur in Algeria. The Boumerdès earthquake occurred on the border between the Eurasian Plate and the African Plate, in a region where the African Plate moves in a northwesterly direction against the Eurasian Plate, at a speed of a few millimetres per year. The relative displacement of the plate creates a tectonic environment favourable to high-magnitude earthquakes that could generate tsunamis several metres high, with very short propagation times (no more than one hour).

France also has more than 12,000 km of overseas coasts, in every ocean of the world. The tsunami risk is especially high in La Réunion, the Pacific and the West Indies.

Some 7 hours following the Sumatra earthquake of 26 December 2004, the tsunami had reached the coast of La Réunion with waves of up to 2.5 metres, causing nearly €500,000 worth of material damages.

In the Pacific, while the tsunami risk is not ignored in French Polynesia, up until now, it has nevertheless not been the subject of any monitoring programme in Wallis and Futuna and New Caledonia. However, several events testify to the reality of this risk in these two regions.

Tsunamis observed in New Caledonia

DATE	PLACE OF ORIGIN	REMARKS
28.3.1875	Earthquake (8) Vanuatu	Devastating tsunami in Lifou.
4.10.1931	Earthquake (7.9) Solomon Islands	1.5 m tsunami in Hienghene, boats capsized.
19.7.1934	Earthquake (7.8) East Solomon Islands	1.3 m tsunami in Hienghene, Touho.
21.7.1934	Earthquake (7) East Solomon Islands	Tsunami in Hienghene, Touho, Thio.
1951	Exact date and origin unknown.	Tsunami north of Ouvéa.
1993	Earthquake (6.3) Futuna	Local tsunami that did not cause any damage.
1 April 2007	Earthquake (8.3) Solomon Islands	Tsunami in Hienghene, Poindimié and Touho.

Source: CEA, IOC

The tsunami history of the West Indies is still not well known; however, we do know that the Lisbon earthquake of 1755 generated 3 to 6-metre-high waves there. This region's seismicity is dominated by ruptures between the North Atlantic and Caribbean Plates, with the first sinking below the second at a speed of 2 cm per year. This region is also highly volcanic.

The past decade has been marked by several events:

• On 21 November 2004, an earthquake occurred off the coast of Guadeloupe, some ten kilometres south of Les Saintes. With a magnitude of 6.3, this was the strongest earthquake to have hit the archipelago since 1897. A "hollow" formed on the sea floor, inducing water movements that generated a tsunami with a propagation velocity of some 100 km/h. The water retreated by some 80 metres. Measurements taken by geologists a few weeks later on the neighbouring coasts showed, by the debris left by the tsunami, that the sea had risen several metres in certain locations along the southern coast of Les Saintes. Luckily, the tsunami caused only material damages.

• Successive collapses of the volcanic dome on the neighbouring island of Montserrat generated tsunamis on the coasts of Guadeloupe in 2003 (with a height of 8 m in Montserrat and 70 cm in Guadeloupe) and in 2006 (with waves of up to 1 m in Guadeloupe).

The Montserrat volcano's landslides have sent 200 million m3 of volcanic material into the sea since 1997. However, it has been demonstrated that other volcanoes in the West Indies have generated much larger landslides in the past. For example, Mount Pelée in Martinique sent several km3 of rock into the sea 100,000, 25,000 and 9,000 years ago. A simulation has shown that a new collapse of this volcano (of some 1 km3) would generate a wave 10 to 20 metres high in the region. As for Mount Soufrière in Guadeloupe, this volcano has collapsed every thousand years or so for the past 8,000 years, the last time being 400 years ago.

Finally, there is an active underwater volcano near Grenada, called "Kick'em Jenny", that could also have a devastating impact. This volcano is currently located 180 m below sea level, but should one day form a new island.

Densely populated coastlines

In addition, the high population density of the French coasts, due to their high level of urbanization and industrialization, renders these coasts very vulnerable. The following examples are revealing:

In 1999, the population density of metropolitan France's coastal areas was 272 inhabitants per km², compared to a national average of 108 inhabitants per km². In certain locations, this figure can rise to as high as 2,500 inhabitants per km² along the French Riviera in the Alpes-Maritimes département, which welcomes nearly 10 million tourists each year[1], with peaks of up to 750,000 tourists per day during the summer.

As for Tahiti, 30,000 persons can be found on the coastal roads leading into and out of Papeete between 6:30 and 8:30 a.m. every day. The island's oil depots are located at the harbours, and its airport and "Postal and Telecommunications Service" are both on the coast.

2. Significant advantages

France can rely on its experience in Polynesia and its leading geoscientific and oceanographic organizations to help it set up international tsunami warning systems.

a) The precedent in Polynesia

France has acquired precious experience in French Polynesia through the management of the Polynesian tsunami prevention centre. It managed to set up a national, operational and autonomous warning system that is capable of managing the entire warning chain, from detecting earthquakes to evacuating the concerned population. This system has slowly been perfected over the years to take into account inadequacies observed during past tsunamis, as well as scientific advances.

[1] *Taking into account the Principality of Monaco.*

Therefore, this experience could be applied to the setting up of warning systems in the other basins. For example, the decision matrices[1] and specialized emergency plans are two fundamental tools that could be borrowed and adopted to the specificities of each basin and member state.

b) Leading organizations in the geosciences and oceanography fields

Furthermore, France has excellent organizations that can actively improve the effectiveness of the tsunami warning systems, as long as they are provided with the necessary means to do so.

Rather than listing all of the research institutes and universities that France can depend on, your rapporteur will simply name five bodies which appear to him to be essential for setting up a tsunami warning system: CEA, IPGP, SHOM, IFREMER ("French Research Institute for Sea Exploration") and BGRM.

CEA, through its DASE ("Analysis, Surveillance and Environment Department"), already plays a central role in tsunami prevention in French Polynesia and is meant to eventually become the national tsunami warning centre within the framework of the Mediterranean/Northeast Atlantic, Indian Ocean and Caribbean warning systems.

In addition to managing the 6 seismic stations within the framework of the Comprehensive Nuclear-Test-Ban Treaty, CEA ensures nation-wide seismic monitoring and is responsible for informing the civil protection authorities as soon as an earthquake of magnitude 4 or greater has been detected on French territory. To carry out this mission, CEA has at its disposal a digital seismic network made up of 40 stations, whose data is transmitted in real time to the national data centre in Bruyères-le-Châtel. This network is monitored by an automatic monitoring system liable to broadcast technical warnings in the event of a software or transmission-system failure. CEA also has a team of engineers on-call 24 hours a day, 365 days a year, made up of a dozen seismologists, three computer engineers and some ten engineers responsible for monitoring and maintaining the networks. These personnel enjoy all the necessary means for network maintenance and data processing (laptop computers, digital communication links, vehicles, etc.).

CEA's offices also host the European-Mediterranean Seismological Centre (EMSC). This centre collects in real time the seismic bulletins issued by 59 different bodies and networks using data from 1,700 stations, which are then immediately archived and broadcast via its website. The centre makes available not only the list of earthquakes (with their location, depth and magnitude), but also maps allowing for their visualization. In addition,

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[1] *These are pre-established criteria for issuing a warning. In Polynesia, 4 warning levels have been established, based on the magnitude of the earthquake, the distance of the source and the zones liable to be affected (distinguishing the Marquesas Islands from the rest of French Polynesia).*

depending on the observed magnitude, the EMSC is responsible for issuing warning messages to the Council of Europe and the civil protection centres, according to a predefined list.

Furthermore, CEA is specialized in tsunami modelling and has carried out numerous studies for French Polynesia, including the elaboration of the region's tsunami exposure map and a historic study of French Polynesian tsunamis from 1837 to the present day.

Finally, CEA staff includes one of the few internationally renowned tsunami experts, who participated during several years in efforts to improve the tsunami warning system in the Pacific, in particular as chairman of the ICG/Pacific, and is currently serving as an expert advisor in the setting up of warning systems for the three other basins.

IPGP is also an essential interlocutor for setting up warning systems in the Caribbean and in the Indian Ocean, where it is responsible for monitoring two types of tsunami-generating phenomena: volcanoes and earthquakes.[1]

First of all, IPGP's observatories are responsible for monitoring the volcanic activity of Mount Soufrière in Guadeloupe, Mount Pelée in Martinique and Piton de la Fournaise in La Réunion.

In the West Indies, IPGP has a second mission which consists of continuously monitoring and recording the regional seismicity (for Martinique, Guadeloupe and the nearby islands) linked to the tectonic activity of the Lesser Antilles island arc. The objectives are 1) to alert the authorities of the characteristics of observed earthquakes and the possible after-shocks that could occur and 2) to establish over the long term the spatiotemporal characteristics of the regional and local seismicity, in order to contribute to the elaboration of seismic maps.

Furthermore, IPGP is responsible for the GEOSCOPE programme (i.e., the French component of the broadband seismic measurement networks). GEOSCOPE is made up of 28 operational stations[2], 13 of which transmit their data in real time[3] (in particular, one in La Réunion, one in Martinique, one in

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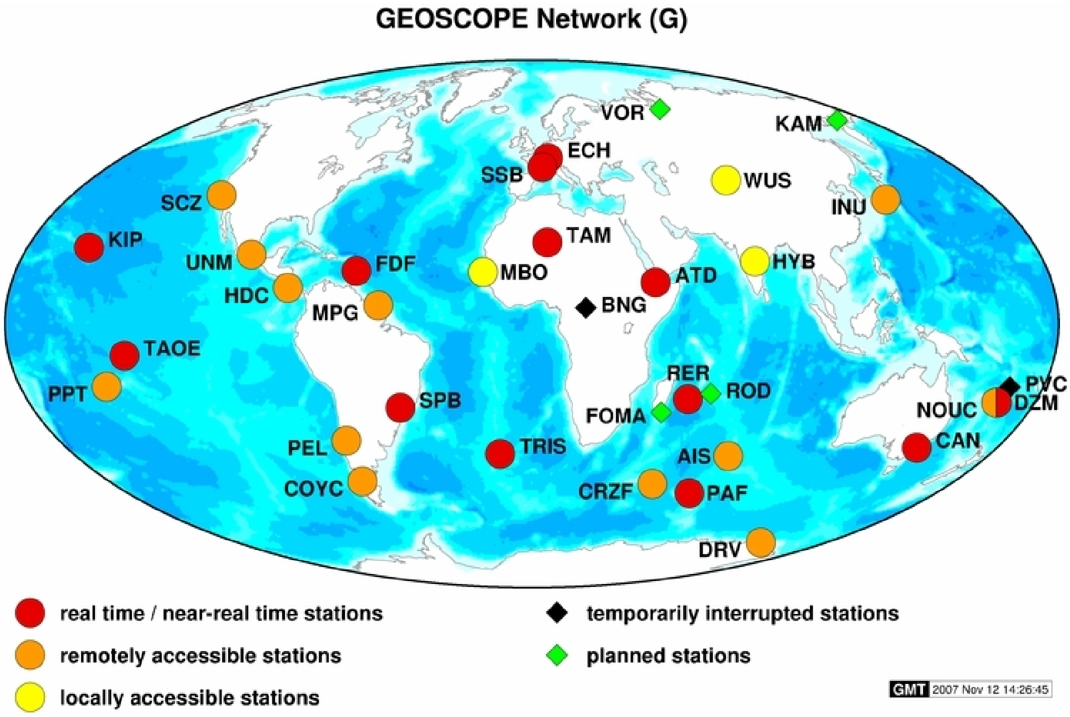
[1] *IPGP is also involved in the tsunami warning systems for the Pacific and Mediterranean zones, via the GEOSCOPE stations set up in these regions.*

[2] *Among the 28 seismic stations, 18 are managed by IPGP, 6 are managed by the Ecole et Observatoire des Sciences de la Terre (EOST) in Strasbourg, 2 are managed by CEA/DASE, and 2 are co-managed with the United States Geological Survey (USGS). Station maintenance is also carried out in collaboration with several institutes [the EOST, the Institut de Recherche pour le Developement (IRD), CEA/DASE, the Comprehensive Test-Ban Treaty Organization (CTBTO), the Centre National d'Etudes Spatiales (CNES), the USGS, and local universities housing stations].*

[3] *The data-transmission time is less than 1 minute.*

Hawaii, one in Djibouti[1], one on Kerguelen Island, one in Algeria, one in Australia and one in the Marquesas Islands). The data collected by the seismic station in New Caledonia is transmitted in less than two hours. This network helps in the localization of earthquakes all over the world. Because of the quality of its stations and their geographical distribution, it is also closely involved in setting up the international tsunami warning systems, in particular those of the Indian Ocean and the West Indies.



IFREMER also plays a central role in setting up a tsunami warning system. This public body, created in 1984, plays a dual industrial-commercial role and contributes, through its work and expertise, to our understanding of the oceans and oceanic resources, the monitoring of marine and coastal environments, and the sustainable development of marine activities.

To these ends, it designs and implements observation, experimentation and monitoring tools and manages France's oceanographic fleet for the entire scientific community. As a result, it is closely connected to all projects concerned with the sea and requiring specific instrumentation, such as the ANTARES project (the installation of a thousand photodetectors, whose data is transmitted by cable), the installation of a seabed seismometer in partnership with Géo-Azur, and the various bathymetric projects.

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1 *The Djibouti station was made to function in real-time within the framework of the Comprehensive Nuclear-Test-Ban Treaty. However, its data is not transmitted directly to IPGP, but rather to the Vienna International Data Centre.*

Indeed, it is internationally renowned for its skills and experience. Therefore, it was put in charge of testing the tsunamimeters developed by the Germans for the Indonesian warning system.

Its expertise in geophysical risks, in combination with its exploration capacities make it an essential partner for setting up tsunami warning systems in the Mediterranean, Caribbean and Indian Ocean.

SHOM, converted into a public establishment last May, also has a fundamental role to play within the framework of its mission to support public maritime policies. Its network of tide gauges and its cartographic and bathymetric data are indispensable tools in setting up an effective tsunami warning system.

Finally, BRGM constitutes an important partner. A public industrial-commercial body placed under the authority of the Ministry of Higher Education and Research and the Ministry of the Environment and Sustainable Development, BRGM's activities with regard to natural risks concern the understanding and modelling of phenomena, the evaluation of the corresponding dangers, monitoring, studying the vulnerability of exposed sites, risk and prevention analysis, crisis preparedness, information diffusion, and training. Therefore, via its synthetic studies, BRGM provides national and local authorities with the necessary tools for natural risk prevention and the resulting territorial development.

3. A strong mobilization following the Sumatra tsunami

Following the tsunami that devastated the Indian Ocean on 26 December 2004, France took several measures to protect its coasts from a possible tsunami.

a) The creation of a Post-Tsunami Interministerial Delegation

The Sumatra tsunami resulted in a significant mobilization in France, at both the private and NGO level (€312 million were collected in donations) and the public institutional level (ministries and local governments).

An interministerial body was created in mid-January 2005 for the rehabilitation and reconstruction phase: DIPT (Post-Tsunami Interministerial Delegation), which became CPT ("Post-Tsunami Coordination Commission") in July 2005. Dependent upon the Ministry of Foreign Affairs, DIPT ensured the coordination of interministerial initiatives, the coordination with the local governments and NGOs, and the allocation of public funds to the various reconstruction projects.

The role of DIPT (Post-Tsunami Interministerial Delegation)

Created on 19 January 2005 to coordinate France's actions, this institution followed other institutional endeavours, such as the Fauroux Mission for the Balkans. With its offices located in the Ministry of Foreign Affairs, the Interministerial Delegation was an interministerial body directed linked to the Prime Minister's office. The plan put into action to create DIPT enjoyed significant political clout and was truly effective. It was carried out by a team made up of both diplomats and representatives of the concerned ministeries, organized around a structure strongly supported by the DGCID (Directorate General for International Cooperation and Development). The interministerial consultation procedures were very quickly established in order to ensure a high quality of advice and the transparency of the processes.

The system of regular interministerial meetings organized by the Junior Minister for Foreign Affairs rapidly spread information on the creation of DIPT and the "one-stop" system.

Three important concepts governed the strategic functioning of DIPT:

- The budgets are allocated on a yearly basis (the "one shot" concept).
- The budgets must be rapidly allocated to have a visible, marked effect for the concerned populations while the ponderous bilateral and multilateral mechanisms are still being mobilized.
- The allocated budgets must act as levers, by providing access to additional funding (European, American).

Project selection has greatly benefitted, in terms of both speed and quality, from the setting up of this rather innovative interministerial process.

A set of criteria was established in an interministerial manner following the first interministerial missions:

- The geographical criteria which emphasized Indonesia and Sri Lanka, but not exclusively (programmes were also funded in India and the Maldives).
- The thematic criteria: the initial intervention themes (children and education, health, water and decontamination, risk prevention and crisis management) were also reconsidered with an emphasis placed on those aspects relative to boosting the affected economies.

Six types of player were mobilized:

- French NGOs with which coordination meetings were held every three weeks on average, as well as before and after each on-the-ground mission.
- French research or health institutions.
- National or local public structures in the concerned countries.
- Local NGOs (via calls for proposals for micro-projects in Indonesia and Sri Lanka).
- The United Nations; in particular, the UN's emergency-relief agencies.
- The International Committee of the Red Cross in the case of an extreme emergency.

Each institution wishing to make a project proposal was able to do so via five "channels": the Humanitarian Aid Commission of the Ministry of Foreign Affairs, the Directorate General for International Cooperation and Development, the concerned ministries, the on-site embassies and DIPT. The projects were systematically sent on to DIPT before being redistributed for evaluation by the competent persons (8 days being allowed for evaluation). This "direct-flow" system allowed for a rapid, efficient allocation of resources. Out of a total of 200 project proposals, nearly one hundred were selected by DIPT. Three to four weeks were allowed for the projects' analysis and revision. The NGOs interviewed seem to have then waited between one and four months – a relatively short amount of time - before receiving their funds.

As regards programme monitoring, DIPT relied principally on the embassies' Cooperation and Cultural Action Services (SCACs) in the concerned countries. This monitoring took several forms:

- Daily follow-up via the SCACs, which had to deal with difficult working conditions with regard to available personnel and logistics.
- Regular exchanges with the Fondation de France and international institutions such as the United Nations, which carry out their own follow-ups.
- On-site missions carried out by DIPT in order to better understand the problems, the on-site realities, etc.

DIPT was dissolved in July and replaced by CPT, an ad-hoc commission which was itself dissolved in 2005. The monitoring of post-tsunami projects has therefore fallen to the SCACs and the international community.

Source: Directorate General for International Cooperation and Development

In addition, DIPT allowed for the French contribution to the warning system currently under construction in the Indian Ocean to be defined and financed. Following the two meetings held by the Intergovernmental Oceanographic Commission to define the Indian Ocean warning system in Paris in March 2005 and in Mauritius in April 2005, the system's structure was finalized in the form of a coordinated network of national centres, with France committing to build such a centre in La Réunion.

At the behest of DIPT, this project's partners[1] met on several occasions to define the actions to be carried out and the amount of necessary funding. The initial project was ambitious, in that it called for setting up a national, multi-risk (tsunami, cyclone, abnormal-wave) warning centre capable of managing both local and far-off tsunami warnings.

Within this context, €1.59 million were allocated to finance the following priorities:

- Equipping the Météo France centre in La Réunion, to render it operational for teletsunami warnings (€20,000). Météo France is the only French body in this region to be on-duty 24 hours a day, 7 days a week; for

[1] *Météo France, IPGP, EOST, SHOM, the Direction Départementale de l'Equipement de Mayotte ("Departmental Facilities Office for Mayotte"), CNRS/INSU/LEGOS, CEA/DASE, the Institut Paul Emile Victor, the Administration des Terres Australes et Antarctiques Françaises ("French Southern and Antarctic Lands Department"), the National Committee of the IOC.*

this reason, it was chosen as the Focal Point. It receives the messages issued by PTWC and JMA and, if need be, alerts the Etat Major de Zone et de Protection Civile de l'Océan Indien ("Zone Civil-Protection Headquarters for the Indian Ocean"), as well as the sub-prefect on duty. In the initial project, the Météo France centre was meant to generate its own tsunami warnings via the installation of one TREMORS system and working in close cooperation with IPGP, which would have analyzed the seismic data and provided its scientific expertise.

- Bringing up to standard the seismological stations of the GEOSCOPE network and transmitting the data in real-time to Djibouti, Canberra, Hyberabad, La Réunion, Kerguelen, Dumont d'Urville and Île Amsterdam, as well as installing a new station in Madagascar (€511,000).

- Bringing up to standard the French tide gauges in La Réunion and Kerguelen, as well as installing two new tide gauges in Mayotte and Madagascar (€91,000).

- The carrying out by CEA/DASE of a tsunami-risk study for the coastal regions of Madagascar and Sri Lanka, as well as certain small island states located in the region (€50,000).

- Re-editing the "Tsunami, the Great Waves" brochure, initially produced for the Pacific, adapting it to the needs of the Indian Ocean (€20,000).

- Météo France's equipping Madagascar, Kenya and Tanzania with meteorological systems[1] (€157,000), setting up a weather station in Madagascar (€40,000), and carrying out a survey in Yemen, Somalia and Djibouti to evaluate the needs of these countries with regard to updating their telecommunication means linked to the Global Telecommunication System (GTS) (€40,000).

The latter measures are part of a multi-risk approach. Their immediate goal is to improve the performance of these countries' weather services by providing them with communication and weather-forecasting systems. However, insofar as these weather-forecasting systems are linked to the global network of the World Meteorological Organization, responsible for issuing tsunami warnings, the weather services equipped with said systems will be capable of receiving these warnings in real time.

Likewise, the weather station installed in Toamasina, the capital of Madagascar's eastern province regularly touched by tropical cyclones, is also meant to serve as a tsunami warning centre. This centre is therefore equipped with a Retim-Transmet-Synergie system, a meteorological observation station and a tide gauge.

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[1] *Concretely: the Transmet message switch, the Retim system for meteorological data transmission by satellite, and the Synergie weather-forecasting system.*

In addition, €420,000 were directly allocated to CEA/DASE for digitizing the data from the Indonesian analogue stations, installing 3 TREMORS systems adapted to the Indonesian stations, training the personnel of the regional warning centres, updating a seismic station to broadband, and testing the performance of the Indonesian network via simulations.

€24,000 were also allocated to LDG/Pamatai for training Thai personnel about the warning systems.

Finally, €50,000 were allocated to the French committee of the IOC for the financing of missions carried out by French experts in the Indian Ocean, training missions for local technicians in La Réunion or metropolitan France, and helping local scientists participate in scientific programmes.

b) The commitment of the Ministry of Ecology

In December 2004, Nelly Olin, then French minister of ecology and sustainable development, presented during a Cabinet meeting the main lines of the **Programme National de Prévention du Risque Sismique ("National Seismic-Risk Prevention Programme")**. Following the Sumatra tsunami, a fourth theme, dedicated to tsunami-risk prevention, was added to this programme, after it was observed that the French coasts were vulnerable to tsunamis "in several locations, in particular along France's West Indian and Mediterranean coasts".

Initiated in 2005 and placed under the direction of the Pollution and Risk Prevention Department ("Pollution and Risk Prevention Department"), this programme of action extends until 2011 and is structured around 3 main themes: evaluating the hazard, setting up a warning system, and raising public awareness.

The Pollution and Risk Prevention Department has commissioned BRGM to carry out two studies in order to better understand the French coasts' vulnerability to tsunamis.

(1) The creation of a tsunami database

BRGM was commissioned to create a computerized database on tsunamis to have touched France's *départements* (in metropolitan France, Guadeloupe, Martinique and La Réunion[1]). This catalogue may be consulted over the Internet and provides the following information for each tsunami:

- The date and time of the phenomenon;

- Its geographical location;

[1] *French Polynesia was not included in the study.*

- The original cause of the phenomenon; BRGM established 8 categories: earthquakes, explosions, meteorites, landslides, volcanic eruptions, meteorological events, and unknown events. The meteorological criterium was chosen in order to distinguish between "real" tsunamis and tidal waves provoked by sea surges or cyclonal swells which are of meteorological origin; BRGM thereby avoids giving the impression of having overlooked these events;

- Its impact: the severity of damages is broken down into 5 categories;

- Its intensity, according to the international Sieberg-Ambraseys Tsunami Intensity Scale which rates tsunami intensity on a scale from 1 to 6 ("unknown" to "disastrous");

- The concerned basin (the Mediterranean, the Atlantic, etc.).

A "tsunami-observation window" allows users to indicate where the tsunami's impact was observed and to describe its dynamic effects (wave number and height, retreat distance and height, inundation distance and height, run-up height).

Another window indicates the epicentral characteristics of the earthquake that caused the tsunami. This information is taken from databases on France's seismic history managed by BRGM.

Finally, a bibliographical window was included, specifying the type of source used, its name, date of publication, title, author and place of publication, as well as the page(s) referring to the tsunami.

In late 2006, 21 events were integrated into the database. This catalogue is meant to contribute to the evaluation of the frequency and intensity of tsunamis on France's coasts.

(2) A study on the vulnerability of the French coasts

BRGM also carried out on behalf of the Pollution and Risk Prevention Department a preliminary study on tsunamis in the Mediterranean and West Indies (Martinique and Guadeloupe) centred around three main themes:

- Identify the *a priori* most dangerous tsunami-generating zones for France's Mediterranean and West Indian coasts.

- Simulate extreme but possible events that could generate tsunamis.

- Identify France's most tsunami-vulnerable coasts.

Two tsunami-source types were chosen: earthquakes and landslides.

For the western Mediterranean, 59 seismic zones were identified for their supposedly homogeneous tectonic deformation and seismic potential.

Next, a maximum earthquake[1] was chosen as a reference for each zone. Likewise, IFREMER was charged with identifying underwater landslide zones on the continental shelf and slope off the French Mediterranean coasts; 20 zones were eventually identified and characterized by their maximum unstable volumes.

Based on seismic zonings and ground movements, 6 scenarios where chosen as *a priori* having the greatest tsunami-generating potential and/or representing the most likely sources of earthquakes or ground movements. They include:

- 3 earthquake scenarios
    - A 6.8 magnitude earthquake with and an epicentre situated some fifty kilometres off the coast of the French Riviera in the Liguria Sea.
    - A 6.7 magnitude earthquake centred in the Gulf of Lion, some one hundred kilometres from Perpignan.
    - A 7.8 magnitude earthquake situated 25 km north of the Algerian coast.

- 3 underwater ground-movement scenarios
    - A landslide located some twenty kilometres off the northwestern coast of Corsica; the destabilized volume is estimated at 0.75 km^3.
    - A landslide located some fifty kilometres off the coast of Perpignan, in the area of the Lacaze-Hérault underwater canyon, characterized by an unstable volume of 0.055 km^3.
    - A landslide estimated at nearly twenty-five kilometres southeast of Nice, with an unstable volume of 1 km^3.

Simulations of these 6 scenarios indicate:

1 *An earthquake with a known maximum historical magnitude, to which 0.5 degrees of magnitude is added to compensate for any uncertainties regarding the seismic data.*

Scenario	Magnitude or volume	Maximum onshore wave height	Time of arrival	French coast affected (amplitude >0.5 m)
North Liguria Sea earthquake	M = 6.8	2 m in Antibes	10 to 15 mins.	St. Tropez to Nice
Continental-terrace earthquake north of Algeria	M = 7.8	4 m in St. Tropez, Cannes 3 m in La Ciotat, Nice, Villefranche	95 to 100 mins.	Marseille to Menton
Gulf of Lion earthquake	M = 6.7	0.6 m in Agde, Port-la-Nouvelle	60 to 80 mins.	Between Perpignan and Béziers
Continental-terrace landslide west of Corsica	V = 0.75 km^3	5-6 m north of Porto	5 to 15 mins.	Southwestern half of the coast between Porto and Bastia
Lacaze-Hérault Canyon landslide	V = 0.055 km^3	1.5 m in Perpignan 1 m in Frontignan and Beauduc (Capelude)	45 to 80 mins.	Perpignan to Beauduc
Nice-Vintimille continental-terrace landslide	V = 1 km^3	4 m in Antibes 3 m in Nice	10 to 20 mins.	St. Tropez to Menton (all the way to San Remo in Italie)

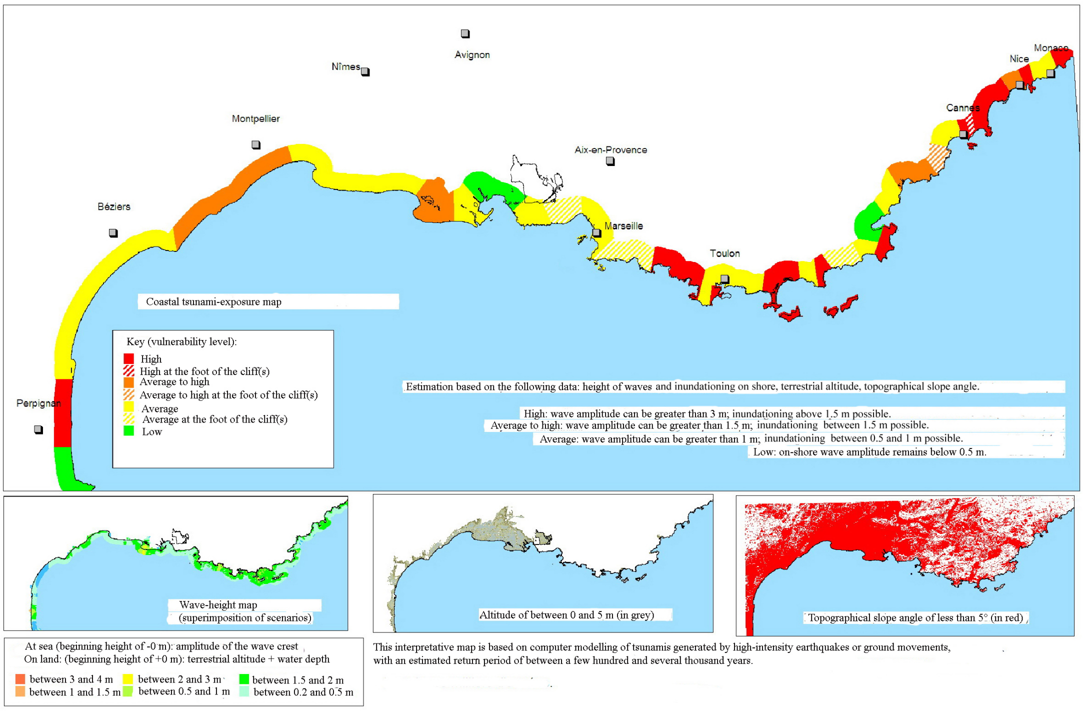
The synthesis of these 6 scenarios results in a sectioning of the French Mediterranean coast according to the estimated level of vulnerability. This sectioning takes into account the maximum estimated sea level near the coast and the *a priori* possible run-up level, irrespective of the initial source of origin (earthquake or landslide). This represents an initial evaluation of the French coasts' exposure to tsunamis.

Considering the characteristics of the 6 catastrophic scenarios chosen as benchmarks, as well as the results of additional simulations that have been carried out, this synthetic map probably indicates rather well the regional level of tsunami exposure for this part of the French coast.

This preliminary regional evaluation relies on calculations with a cartographic precision of up to around 1:100,000 (calculations based on grids with a spatial resolution of 83 m x 83 m).

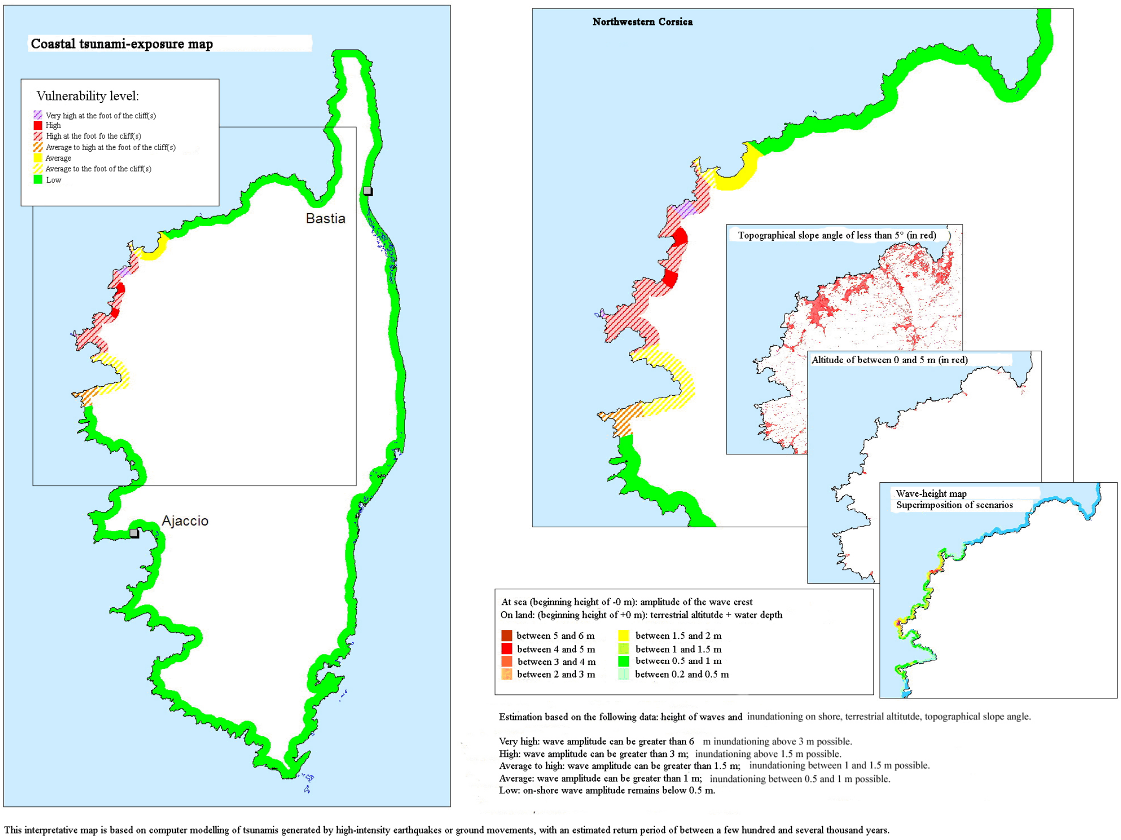
Therefore, it cannot be used for tsunami-risk planning at the local level (for example, in the elaboration of risk-prevention plans). Indeed, more precise studies remain essential for a detailed tsunami mapping at the local level according to the height, depth and duration of inundation, as well as the number of waves and the speed of the currents.

Tsunami-exposure map for the coasts of the Languedoc-Roussillon and Provence-Alpes-Côte d'Azur regions



Source: BRGM

Tsunami-exposure map for the coasts of Corsica



Source: BRGM

As regards the French West Indies, seismic zoning carried out in the area of the Caribbean Plate identified 32 seismic zones characterized by a maximum earthquake. Five seismic-source scenarios were chosen. Furthermore, based on an analysis of our current understanding of tsunami-generating landslides and volcanic eruptions/collapses, 3 additional scenarios were chosen.

Therefore, a total of 8 catastrophic scenarios were chosen as references and modelled:

The 5 seismic scenarios were the following:

- A magnitude 7.5 earthquake centred around the system of normal faults of the Marie-Galante graben.
- A magnitude 8.3 earthquake located in the Barbuda prism; in other words, in the subduction zone of the North American Plate sinking beneath the Caribbean Plate.
- A magnitude 7.5earthquake generated by the normal fault along the Anegada graben.

- A magnitude 7.6 earthquake generated by the left reverse fault of the Saint Lucia ridge.
- A magnitude 7.1 earthquake centred in the Barbados accretionary prism, generated by the reverse parallel faults along the subduction zone of the South American Plate sinking beneath the Caribbean Plate.

3 volcanic, subaerial ground-movement scenarios were also chosen:

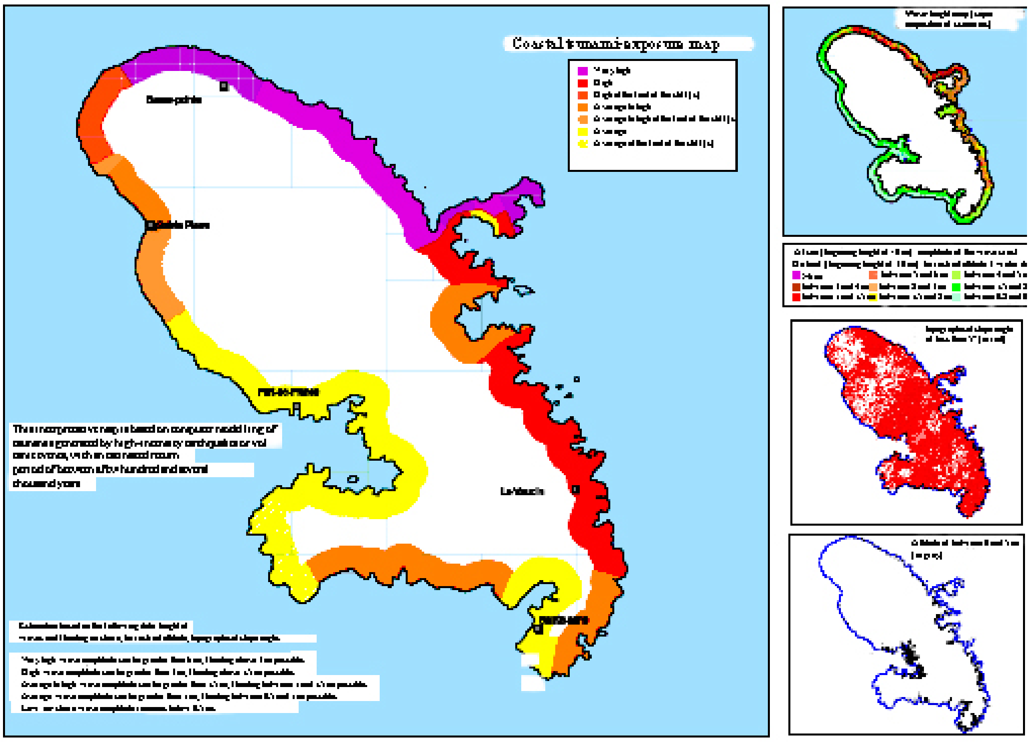
- The 2003 Soufrière-Hills (Montserrat) event, corresponding to the collapse of the volcanic dome. The volume of debris entering the sea is estimated at 16 million m^3.
- The 1902 Mount Pelée (Martinique) event, associated with the penetration into the sea of a lahar with a volume of around 5 million m^3.
- The Soufrière (Guadeloupe) paleo-event concerning the collapse of a slope of the Soufrière volcano around 3100 B.C., sending an estimated 70 million m^3 of debris into the sea.

The following table presents the results of the 8 simulations:

Scenario	Magnitude or volume	Maximum onshore wave height	Time of arrival	French coast affected (amplitude >0.5 m)
Marie-Galante graben earthquake	M = 7.5	>3,5 m in Sainte-Marie (Martinique)	10 to 15 mins.	Northeastern Martinique Southern La Désirade Southern Grande-Terre (Guadeloupe)
		~ 5 m in La Désirade	13 to 15 mins.	
		~ 3 m in Sainte-Anne (Guadeloupe)	±15 mins.	
Barbuda earthquake	M = 8.3	≥8 m in Le Moule, Anse-Bertrand, Clugny (Guadeloupe)	20 to 40 mins.	The entire coast of Grande-Terre and the northern coast of Basse-Terre (Guadeloupe) Western La Désirade Northeastern coasts of Martinique
		6 m in Le Marigot (Martinique) 4 m in La Trinité (Martinique)	35 to 45 mins.	
Anegada Passage earthquake	M = 7.5	>1 m in Deshaies (Guadeloupe)	60 mins.	Northwestern Basse-Terre (Guadeloupe)
Saint Lucia ridge earthquake	M = 7.6	~1 m in Grande-Terre, southeastern Basse Terre, and Marie-Galante	20 to 30 mins.	Southern and eastern coasts of Grande-Terre, southeastern Basse Terre, Marie-Galante
		>2 m in la Désirade	20 mins.	Southern coast of La Désirade
		>3 m in Le Marigot and La Trinité (Martinique)	15 to 30 mins.	Eastern coast of Martinique
Barbados prism earthquake	M = 7.1	<0.5 in Le François	15 to 20 mins.	Southern coast of Martinique
2003 Soufrière-Hills event (Montserrat)	Landslide, V = 0.016 km^3	>0.5 m in Deshaies and Malendure	12 to 15 mins.	Northern and western coasts of Basse-Terre (Guadeloupe)
1902 Mount Pelée event (Martinique)	Lahars, V = 0.005 km^3	>3 m in Saint-Pierre	<2 mins.	Northwestern coast of Martinique
La Soufrière event (Guadeloupe)	Landslide, V = 0.07 km^3	>3 m in Trois Rivières and Basse-Terre	<5 mins.	Southern and western coasts of Basse-Terre, Les Saintes, western coast of Marie-Galante

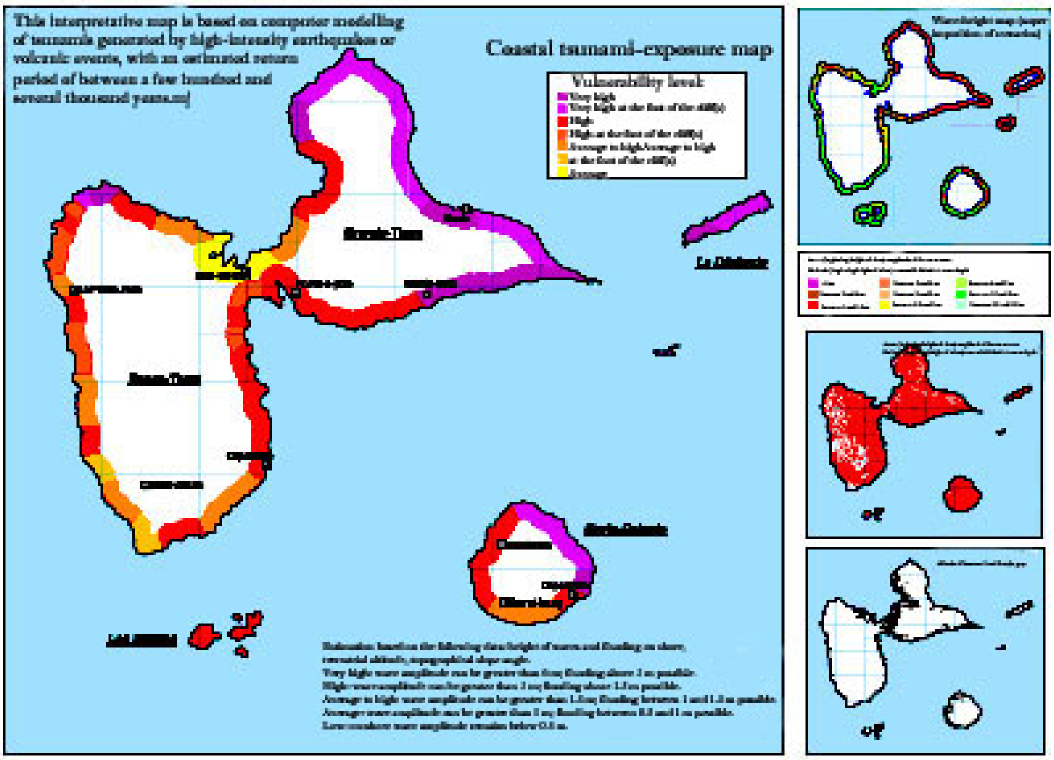
In the light of observations already made concerning the tsunami-exposure maps for the Mediterranean, these results demonstrate a high to very high level of tsunami vulnerability for almost all of Grande-Terre (Guadeloupe), eastern Basse-Terre (Guadeloupe), La Désirade, Les Saintes, Marie-Galante (except for the southern coast) and the eastern coast of Martinique.

Tsunami-exposure map for the coasts of Martinique



Source: BRGM

Tsunami-exposure map for the Guadeloupe archipelago



Source: BRGM

(3) Setting up a warning system

In addition to a better understanding of this natural hazard, the tsunami-risk prevention project plans on setting up tsunami-detection and tsunami-warning systems for the Indian Ocean, the Mediterranean and the West Indies.

The presentation document for the November 2005 "earthquake plan" points out that "*in accordance with France's position as presented during the Kobe conference and before the Intergovernmental Oceanographic Commission, it has been decided to create a national, multi-risk prevention centre in La Réunion*".

Likewise, this document states that "*the Mediterranean and Caribbean are particularly prone to tsunami-generating earthquakes [...]. In addition to bilateral partnerships, France will propose – along with the concerned European countries (in particular, Italy for the Mediterranean and the United Kingdom and the Netherlands for the West Indies) and in cooperation with the other countries ringing these basins – European-level initiatives for tsunami detection and the transmission of warnings.*"

Following the creation of intergovernmental coordination groups in the Indian Ocean, the Mediterranean and the Caribbean, a national coordination group was set up to organize regular meetings in the various basins and finalize the French position. Co-directed by the Pollution and Risk Prevention Department and the DDSC ("Defense and Civil Protection Department"), this informal body gathers together all the French players more or less directly involved in the setting up of a warning system, including both scientific and technical organizations (CEA, IFREMER, IPGP, Météo France, BRGM, SHOM, CNRS, IRD) and ministries (the Ministry of Ecology and Sustainable Development, the Ministry of the Interior, Overseas Territories and Local Governments, the Ministry of Foreign Affairs).

(4) Educating the public and raising awareness

Finally, the objective of the tsunami-risk prevention project is to raise public awareness in the most vulnerable zones.

Particular attention has been given to raising student awareness and training teachers. Certain actions are already under way; for instance, primary and secondary-school programmes already deal with major natural risks. What's more, the tsunami of 26 December 2004 gave rise to numerous school initiatives, particularly in the West Indies, La Réunion and the Mediterranean, which are largely based on already-existing projects, such as the "Sismo des écoles" (seismometer at school) project carried out in the Académie de Nice and the Académie des Antilles.

From "Sismo des écoles" to "Sismos à l'école"

The principle of the "Sismos à l'école" ("Seismometers at School") project is to create a network of schools equipped with educational seismometers. A seismic sensor is installed in each school by students from 13 to 18 years of age. The sensors' seismic data is fed into an on-line database; this veritable seismic resource centre serves as the starting point for various educational and scientific activities using new information and communication technologies.

Considering the project's orientation (emphasizing new communication technologies), its educational aspect (raising awareness of seismic risk), its scientific content (instrumentation, geophysics, earth sciences) and its importance at the both the regional and national levels (creating a network of schools), it offers teachers numerous educational paths to explore.

The project's objectives are the following:

- Favour the development of the hard and technological sciences at the secondary-school level, via a project centred around the measuring of an environmental parameter.
- Raise children's awareness of natural risks, thereby contributing to the accountability of these future citizens.
- Encourage students to become "ambassadors" within their communities for natural-disaster prevention.

Launched in 1996 at the Centre International de Valbonne, the "Sismo des Ecoles" programme rapidly spread within the Alpes-Maritimes *département* with the support of the Académie de Nice, the departmental council and the Géosciences Azur laboratory.

Today, the national network consists of a total of 20 schools: 13 in metropolitan France, 3 in the DOM-TOM and 4 in French secondary schools abroad.

In addition, specific teacher-training initiatives for academies concerned by the tsunami risk are planned, as is the development of educational tools dedicated to this theme.

Furthermore, raising the public's awareness and ensuring its appropriation of the information necessitates identifying the different categories of the exposed populations (residents, tourists, professional groups, etc.), adapting the messages, and identifying the most suitable transmission tools.

c) At the local level, a real raising of public awareness of the tsunami risks

During this study, your rapporteur observed that the level of awareness among politicians with regard to natural risks increased in proportion to their proximity to the population. Despite all the noise, tsunami-risk prevention hardly seems to be a national priority, as evidenced by the past two years of prevarication in attempting to finalize the official French position. However, this subject has generated real political involvement at the local level, essentially in response to the high level of public interest.

The policies pursued by the departmental councils of the Alpes-Maritimes and Martinique illustrate the desire of the local governments to protect against natural risks.

The Alpes-Maritimes *département* is threatened by most natural risks, from forest fires to avalanches, to landslides, droughts, earthquakes, tsunamis and inundations. At the behest of its president, Christian Estrosi, the departmental council launched a programme for natural-risk prevention, with an emphasis on geophysical risks and the aim of creating a departmental competitiveness cluster, transforming the area's dangerous geological situation into a motor of economic development.

In this context, an agreement was signed in 2003 between the departmental council of the Alpes-Maritimes and the "University Think Tank for an Environmental Risk Agency" Scientific Interest Group (or GIS CURARE)[1]. This body's mission is to demonstrate the pertinence of gathering together the scientific and technical skills in the environmental and natural-risk domain in order to better analyze and understand the environmental phenomena and meet both public demand and government orders. This project, which comes to an end in December 2007, should facilitate the creation of a natural-risk competitiveness cluster for first the Alpes-Maritimes and then the entire Provence-Alpes-Côte d'Azur region (PACA); it also prefigures the future environmental-risk agency, to be created in 2008 and which is meant to be solicited by those companies having to undertake assessments in this region and, more generally, within the entire Arco Latino. Indeed, the Languedoc-Roussillon region is also concerned by the creation of this agency, and its relations already developed with the Italian and Spanish environmental-risk agencies hint at the rapid development of a recognized expertise in geological risks for the Mediterranean area.

Since its launch, the GIS CURARE has centred its attention on three sets of issues, including that of tsunamis and landslides in the sea or ocean.[2] The objective was to precisely locate the active underwater faults and zones prone to landslides, in order to quantify the likely landslide volumes and model the importance of the resulting local tsunamis. These studies, half funded by the departmental council, have therefore improved our understanding of this hazard in a zone particularly prone to local tsunamis generated by landslides.

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1 *The GIS CURARE initially consisted of 5 members: Nice Sophia Antipolis University, Pierre and Marie Curie University, the CNRS, the Institut de Recherche et Developement (IRD), and the private company ACRI ST. BRGM, IFREMER and SHOM later joined this project, as did the Conservatoire National des Arts et Métiers ("National School of Engineering and Technology").*

2 *The two other themes concerned gravitational instabilities and landslides in the High Tinée Valley and the estimation of strong movements during major coastal earthquakes.*

Furthermore, following the Sumatra tsunami, the president of the Alpes-Maritimes departmental council requested the GIS CURARE to organize for the end of February 2005 an international conference on "Creating a tsunami warning network for the western Mediterranean". During this conference, Christian Estrosi emphasized the need to set up a Mediterranean warning system. Following the conference and due to the involvement of the GIS CURARE in actions organized by the French delegation in preparation for the ICG/NEAMTWS meetings, the director of the GIS CURARE was chosen as the national contact for the Mediterranean/Northeast Atlantic zone by the president of the National Committee for the IOC.

Finally, the organization of the second session of the ICG/NEAMTWS by France in May 2006 demonstrated the political will of this country to rapidly succeed in setting up a tsunami warning system for the Mediterranean. In addition, this meeting was held in Nice because of the strong commitment of the departmental council's president - at the time Minister for Regional Development - in favour of such a system.

During his visit to Martinique, your rapporteur observed that the departmental council of this *département*, presided over by our colleague Claude Lise, was also very active in natural-risk prevention.

Firstly, the departmental council supported the creation of Martinique's geographical information system: a geographical database consisting of digitized maps, scanned photos, all types of measurement taken in real time, land surveys, socio-economic and town-planning information, etc. and meant to be used as a tool in risk management and regional development. This database can thus be used to map the submersion risk in the event of a tsunami for the coastline of a specific district by superimposing its inundation and cadastral maps.[1]

Secondly, Martinique's departmental council launched a public-awareness campaign on natural risks via an innovative educational tool: the "major-risk prevention caravan". This caravan, made up of three 25 m² tents, houses exhibitions, educational films on major risks, a multimedia quiz and a multimedia game for children aged 6 to 12. As regards the information provided on tsunamis, one of the films presents the earthquake of 26 December 2004 and the tsunami which followed, using first-hand accounts and scientific documents. Visitors can also watch a computer model developed by CEA.

Finally, the departmental council is setting up an extensive network of measuring devices (wave recorders, weather stations, accelerometers) in order to better understand and monitor natural risks. It has also set up a tide

[1] *However, your rapporteur would like to point out that no reliable inundation map can currently be produced for the West Indies, insofar as the tsunami models suffer from the absence of a precise bathymetry for the zone extending from 0 to 200 m all around the French West Indies.*

gauge at Le Prêcheur to be used for tsunami monitoring, although its principal mission is to study sea surges during storm surges. The council also plans on installing a second tide gauge on the Atlantic coast in the district of Le François.

d) The launch of a warning system in New Caledonia and in Wallis and Futuna

While French Polynesia already benefits from an effective warning system, the system for New Caledonia and Wallis and Futuna is still in its early stages. Due to these territories' isolation and low population density, their tsunami-based observations remain very incomplete. However, several tsunamis were recorded during the 19^{th} and 20^{th} centuries, generated by earthquakes near the Solomon, Vanuatu and Loyalty Islands.

Recently two events reminded us of these territories' tsunami vulnerability.

On 3 May 2006, following a magnitude 7.8 earthquake with in the Tonga Islands, PTWC issued a warning for the islands of Tonga, Niue, Samoa, Wallis and Futuna and Fiji.

On 1 April 2007, a magnitude 8.1 earthquake in the Solomon Islands subduction zone generated a devastating local tsunami. In New Caledonia, the authorities were alerted by PTWC and the High State Authority decided to evacuate (as a precaution) the Loyalty Islands and the eastern coastal districts.

The Sumatra tsunami, combined with both the arrival in New Caledonia of the former High Commissioner for French Polynesia (who had instigated the installation of sirens on this territory) and the raised awareness of the Ministry of Overseas Territories (which has since become the Junior Minister's Office for the Overseas Territories) and the tsunami-vulnerable districts in New Caledonia and Wallis and Futuna, provided the impetus for setting up a warning system in these two territories.

In May 2007, the Junior Minister's Office for the Overseas Territories spent €22,000 to provide itself with a central warning station. In addition, New Caledonia is in the process of acquiring sirens for the districts of Ouvéa (3 sirens), Lifou (8 sirens) and Maré (3 sirens). These sirens are funded primarily by the inter-district equalization fund and, to a lesser extent, by the global allocation of equipment. The Junior Minister's Office for the Overseas Territories has also provided money for the installation of sirens in Wallis and Futuna.

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Even so, overall, nearly three years after the Sumatra tsunami, France's initial interest has waned, due to the lack of a strategic vision and insufficient funding.

B. A MOVEMENT THAT IS RUNNING OUT OF STEAM, DUE TO THE LACK OF A STRATEGIC VISION AND INSUFFICIENT FUNDING

The difference is striking between the ambitions put forward by the French government in 2005 with regard to setting warning systems in the various basins and the meager results that have been achieved two years later.

1. The observed hurdles

In reality, France's initial commitment has given way to a wait-and-see policy revealing various internal blockages.

a) In the Indian Ocean

The Indian Ocean is the only basin for which the French contribution has been the subject of a detailed action plan and which has benefited from a subsidy of over €2 million.[1] Nevertheless, two years after the programme's launch, the results do not meet the project's initial expectations.

The initial plan called for setting up a national tsunami warning centre capable of monitoring both regional and local tsunamis. Because of its volcanic and seismic experience and skills, IPGP was meant to collaborate closely with the Météo France centre to ensure the tsunami warnings. However, this ambitious project quickly encountered funding difficulties. Indeed, the subvention allocated to the French contribution to the Indian Ocean warning system only includes equipment funding. However, the warning system that was initially proposed required that both Météo France and IPGP remain on-call 24 hours a day, 7 days a week, which its operating budget simply did not cover.

In addition, Météo France questioned the pertinence of extending the national warning centre's capacities to the issuance of local tsunami warnings, estimating that the appropriateness of such an action should first be studied. However, neither CEA nor IPGP was assigned with carrying out such a study and it seems that the project has been abandoned.

As is also the case in the West Indies, Météo France currently receives the warning messages issued by PTWC and JMA, which it then

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[1] *Météo France has received €1,472 million from the Directorate General for International Cooperation and Development, to be distributed among its various partners; CEA has directly received €444,000 for the updating of its seismic stations in Indonesia; finally, the National Committee of the IOC has also directly received €50,000.*

forwards to the prefect. As a result, the €305,000 set aside for developing the national warning centre's capacities in order to render it operational in the event of a local tsunami have yet to be spent (although their reallocation has not yet been discussed).

Furthermore, the French contribution is far behind schedule in up-to-dating and installing the tide gauges entrusted to SHOM. In a document prepared by the National Committee of the IOC on the funding of the French contribution to the Indian Ocean Tsunami Warning System (IOTWS), dated 29 June 2005, this action is qualified as being "*one of the IOC's most important, in terms of both its symbolic importance and the credibility of the IOTWS*." However, only a single real-time tide gauge has so far been installed (La Réunion, October 2007), even though there is available funding.

Neither the real-time tide gauge planned for Mayotte, nor that planned for Madagascar has been installed. According to the information provided by SHOM to your rapporteur, the Mayotte tide gauge should be up and running in 2008. However, no date has been fixed for the Madagascar tide gauge, because it has not been included among SHOM's official priorities.

As regards the Kerguelen tide gauge managed by LEGOS, it has been brought updated along with the GEOSCOPE seismic station managed by the EOST in Strasbourg.

The updating of the GEOSCOPE network's seismic stations is also behind schedule, because only 2 out of the 5 initially planned stations[1] transmit their data in real-time. IPGP has not yet installed a VSAT antenna on the Djibouti station, in order to allow it to receive data in real-time. According to the information obtained by your rapporteur, IPGP has also run up against India's refusal to transmit the data from its Hyderabad seismic station in real-time. Therefore, the plan to update this station has been abandoned, so as to instead install a station on Rodriguez Island. It has therefore been necessary to increase the funds allocated to IPGP to cover the expenses of this new mission. The Madagascar seismic station should be installed in March 2008; the site is ready and the material and equipment have been sent, but work cannot begin before the end of the rainy season. Less progress has been made in setting up the Rodriguez seismic station.

During a hearing, IPGP's director, Vincent Courtillot, estimated that updating the 3 older stations and installing the 2 new stations necessitated hiring the services of two engineers over a three-year period. He regretted that IPGP had been obligated to cover these expenses, for want of the planned operational subsidy. He also expressed his anxiety regarding the budgetary costs entailed by financing the VSAT transmissions.

An assessment of the funds allocation by the Ministry of Foreign Affairs for the creation of a national tsunami warning system leads us to the following conclusions:

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[1] *Those of La Réunion and Canberra.*

- Of the €1.5 million allocated, €305,000 have yet to be spent, for want of a preliminary study on La Réunion's vulnerability to local tsunamis.

- Of the €1.1 million that have actually been spent, half were allocated to Météo France Internationale in order to improve the weather-forecasting systems of the neighbouring countries. Although this programme will enable these countries to also receive the warning messages, your rapporteur believes that these measures are only indirectly related to the setting up of a tsunami warning system. Considering the scarcity of funds so far allocated by France for tsunami prevention, this money could have been spent more wisely. Finally, although Météo France's role in the region - in particular, within the framework of the cyclone-warning system - has been strengthened, neither the seismic system nor the tide gauge system is completely operational, even though both constitute pillars of the tsunami warning system.

b) In the Caribbean

In the Caribbean, the commitment of France to set up a warning system runs up against numerous obstacles: not only has the public only recently been made aware of the tsunami risk, but the existing measuring devices are not suited to the setting up of an effective tsunami warning system. In addition, due to the lack of both political will at the national level and a specific budget to fund their actions, those scientific organizations representing France in the ICG/Caribbean-TWS enjoy little room for manoeuvre.

The civil protection authorities have only very recently taken into consideration the tsunami risk. Although the tsunami risk is certainly familiar, up until now, it has not been considered a priority due to the difficulties already encountered in dealing with those risks that are most present in the collective conscience (cyclones, earthquakes, volcanic eruptions).

During your rapporteur's visit to Martinique, he was struck by the poor preparation of this *département* with regard to natural geophysical risks.[1] Indeed, even though Martinique is exposed to a high earthquake risk, most buildings do not meet the seismic-safety standards, while the population remains unreceptive to information and public-awareness campaigns. For instance, your rapporteur learned that in the event of an earthquake comparable in magnitude to that of 1839[2], the prefecture, most fire stations and the island's hospitals would be the first buildings destroyed, thereby

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1 *France's overseas départements are exposed to a host of natural hazards besides geophysical risks such as cyclones or those linked to heavy rains such as landslides and inundations. However, considering the subject of this study, your rapporteur has chosen to focus his attention on those natural hazards liable to generate a tsunami: namely, earthquakes and collapsing volcanoes.*

2 *Martinique's last devastating earthquake dates back to 1839 and statistics on earthquake occurrency suggest that the next earthquake is imminent.*

seriously hampering the subsequent relief effort. Likewise, the volcanic and seismic observatories in Martinique and Guadeloupe do not meet the safety standards.

France's active participation in the ICG/Caribbean-TWS is also hindered by the fact that the measuring devices are not suited to the technical demands of a tsunami warning system.

Martinique is equipped with two tide gauges: one in Fort-de-France belonging to SHOM and one installed in Le Prêcheur by the departmental council, which is also expected to install a third tide gauge on the Atlantic coast.

In Guadeloupe, there are 5 tide gauges, one of which belongs to SHOM, with the remaining 4 being managed by the OVSG ("Volcanic and Seismological Observatory of Guadeloupe").[1] The regional council should fund a sixth tide gauge planned for Les Saintes.

Nevertheless, none of the tide gauges transmit their data in real-time and neither SHOM nor IPGP has the necessary funds to bring them updated and cover the cost of transmissions. What's more, SHOM has no local antenna in the West Indies. As a result, no SHOM specialist attends meetings held by the working subgroup on devices for measuring sea level within the framework of the ICG/Caribbean-TWS.

IPGP, via its two observatories, is responsible for monitoring the seismicity of the French West Indies. However, its seismic network needs to be modernized, particularly with regard to data transmission which is currently carried out by radio and therefore incompatible with the demands of an effective tsunami warning system.

The director of the OVSM ("Volcanic and Seismological Observatory of Martinique") has been chosen as the National Contact for the ICG/Caribbean-TWS, because of the fundamental role that the seismic network is supposed to play in the tsunami warning system. Nevertheless, since the OVSM is not on-call 24 hours a day, 7 days a week, the Météo France centre in Martinique has been put in charge of receiving the warning messages issued by PTWC and then transmitting them to the prefect.

During your rapporteur's visit to Martinique to evaluate France's involvement in the setting up of a tsunami warning system for the Caribbean, he was shocked to see France discard its international responsibilities by assigning them to scientific organizations that, for want of any precise ministerial orders, not only have difficulty in acting, but also cannot legitimately represent France.

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1 *The tsunami of 13 July 2003 caused by the collapsing dome of the Montserrat volcano caused some damage in Guadeloupe and served as a reminder of this island's vulnerability to tsunamis. Therefore, in 2004, the Ministry of Overseas Territories financed the installation of 4 tide gauges to continuously monitor variations in sea level, in order to analyze the site effects and propagation times of an eventual tsunami on Guadeloupe's coasts.*

Today, the silence of the French government forces IPGP to alone define, via the OVSM, the orientation of France's contribution to the warning system. Considering the lack of political support and the limited means at its disposal, the OVSM, expecting the University of Puerto Rico to eventually be chosen as the regional warning centre, has chosen to limit France's involvement to the sharing of tide gauge and seismological data with the other ICG/Caribbean-TWS member states.

To this end, the OVSM has mobilized the GEOSCOPE network and built bridges with SHOM. In addition, OVSM's actions have allowed for a real raising of awareness among public authorities and local players with regard to the tsunami risk, which is now included in the "West Indies-Guiana Risk Club" working group, which gathers together the various partners involved in the monitoring and management of natural risks.

Nevertheless, your rapporteur considers that only the government can legitimately decide French policy. In addition, only the French government has (or should have) a global view of the various negotiations currently under way in all four basins, allowing it to make the most pertinent decisions. Also, your rapporteur would like to point out that France could become the regional tsunami warning centre in the Caribbean, if CEA were to assume this responsibility in the Mediterranean.

During his visit to Martinique, your rapporteur learned that the then Minister of the Overseas Territories had instructed the prefect to set up a specialized emergency plan modeled after the French Polynesian plan. Your rapporteur recognizes that a plan for the organization of emergency prior to a warning being given is, in fact, indispensable for ensuring the population's protection. However, this request cannot be satisfied without first obtaining the necessary information for the elaboration of such a plan.

Indeed, the organization of emergency assistance measures will vary according to the time delay available (before the arrival of the tsunami) to the civil-protection services; establishing this reaction time requires an excellent understanding of those zones liable to provoke a tsunami.

In addition, the measures to be carried out depend on the tsunami-vulnerability of the concerned coasts. Your rapporteur would like to point out that BRGM has been assigned with carrying out just such a study by the Ministry of Ecology. However, due to the lack of a precise bathymetry near the coasts, the results are not sufficiently reliable to be used for the elaboration of a specialized emergency plan.

c) In the Mediterranean

In the Mediterranean, France is exposed to both regional tsunamis from Algeria and local tsunamis provoked by earthquakes in the Liguria Sea or a landslide in the zone between Nice and Vintimille. Having to deal with short reaction times, the national tsunami warning centre, in order to be effective, is best managed by a scientific body capable of refining a regional warning message[1] in less than 15 minutes, 24 hours a day, 7 days a week, and then transmitting it to the COGIC ("Operational Interministerial Crisis Management Centre") and, if need be, the regional and local civil-protection authorities.

CEA is best suited to taking charge of this mission, because it is already responsible for notifying the French authorities in the event of an earthquake with a magnitude of greater than 4 on national territory, it hosts the European-Mediterranean Seismological Centre, and it serves as a benchmark for tsunami simulations and evaluation and the management of tsunami warnings in French Polynesia. As France is vulnerable to tsunamis in several basins, we can expect the future national warning centre to manage warnings for the Mediterranean, the Caribbean[2] and the Indian Ocean.

Furthermore, because it must receive all the data from the various seismic and sea-level measurement stations (tide gauges and tsunamimeters), it could also act as the regional tsunami warning centre, although the national authorities would remain ultimately responsible for the issuance of tsunami warnings.

During the international conference held in Nice in February 2005, the then Minister of Ecology, Serge Lepeltier, stated that the European-Mediterranean Seismological Centre represented "a structure predisposed to playing a major role in the elaboration and implementation of a warning system in the Mediterranean basin."

In April 2006, the then Minister of the Interior, Nicolas Sarkozy, asked the general director of CEA if this body could act as the regional tsunami warning centre for the Mediterranean. CEA replied in the affirmative[3], so long as it was provided with the necessary human and financial means.

Concretely, CEA's proposal referred to two types of expenditure:

- The initial funding costs (€2.7 million for CEA). For the most part, this money covers: the adaptation of several CEA seismic stations; the acquisition of a GTS-reception system; the development of high-speed seismic computer programs (2-6 mins.); the integration of data-reception and GTS-message programs, as well as programs for the real-time visualization of sea-

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[1] *As has already been mentioned, the regional warning message will rely on a decision matrix that can nevertheless prove to be somewhat unsuitable at the local level. For instance, Antibes is a more tsunami-vulnerable zone than Nice due to its relief and bathymetry. Likewise, harbours are more vulnerable to tsunamis due to the currents and eddies they produce.*

[2] *At least regional and tele-tsunamis. To handle local tsunamis, the warning system must be automated via automatically-activated sirens.*

[3] *For regional-tsunami warnings; in other words, with a reaction time of at least a half hour.*

level data; the development of programs for gathering data from non-CEA seismic stations. This sum does not cover the seismic equipment of those stations set up outside France, with the exception of the VSAT antennas, updating the Madeira station (in partnership with the University of Lisbon), and setting up a seismic station in the Azores. The costs linked to the installation of 20 tide gauges and 6 tsunamimeters are estimated at €2.4 million.[1]

- The operating costs (€3.5 million). A large part of this sum covers supplementary personnel expenditures linked to the setting up of a team on duty 24 hours a day. This amount also covers: the cost of VSAT transmissions and the maintenance of the related equipment; the maintenance and updating of the means for processing and issuing tsunami warnings; database storage; the updating of scenarii modelling; participating in the meetings organized by the ICG/NEAMTWS. The cost of maintaining the tide gauges and tsunamimeters is estimated at €310,000 per year.

However, since CEA's technical proposal was officially submitted to the concerned ministries[2] in November 2006, no concrete negotiation has been opened. While it is true that several meetings have been held at the technical-service level, they were unable to succeed. Indeed, up until the Lisbon session of 20-23 November 2007, no political decision had been made concerning the nature and funding of the French contribution to the tsunami warning system, leaving such fundamental questions as the following unanswered:

- Is France - via CEA/EMSC – ready to act as a regional tsunami warning centre for the Mediterranean and, if so, for which geographic zone[3]?

- If France does not want to act as a regional warning centre, will it nevertheless set up a national tsunami warning centre and, if so, what will be its structure?

- To what extent does France want to participate in updating its territory's existing tide gauges and installing tide gauges and tsunamimeters off the coast of Algeria to protect its coasts?

However, the uncertainties weighing on France's real contribution to the tsunami warning system for the Mediterranean have placed the French delegation in a particularly uncomfortable position: for lack of any specific ministerial directive and in the absence of funding dedicated to tsunami-risk prevention, the French delegation is unable to make any proposals which would commit France financially.

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1 *These costs could be partially mutualized within the framework of a yet-to-be-defined European funding programme.*

2 *The Ministry of Ecology and Sustainable Development, the Ministry of the Interior and the Overseas Territories, and the Ministry of Foreign Affairs.*

3 *It would seem that at least three warning centres will be created: one for tsunamis from the Atlantic, one for tsunamis from the eastern Mediterranean and one for tsunamis from the western Mediterranean.*

The representatives of the various administrations and bodies that make up the French delegation have therefore reached the limits of their competences: they were able to correctly complete their missions as long as the ICG/NEAMTWS meetings consisted of, on the one hand, listing the scientific work carried out with regard to tsunami evaluation and, on the other, quantitatively and qualitatively assessing each country's seismic and tide gauge measuring devices.

However, since the Bonn session, the project for a tsunami warning system for the Mediterranean has entered the implementation phase, with the member states now spending each new meeting presenting the concrete contributions they have made. For example, in Bonn, Italy announced that it would ensure the permanent collection and processing of seismic data from the seas surrounding Europe. The tsunami information bulletins would be issued by the Istituto Nazionale di Geofisica e Vulcanologia (INGV).

On the other hand, the French scientific bodies refuse to make any commitments in the absence of any official directive or financial commitment on the part of their government. The question of updating France's tide gauges serves as a good example. SHOM manages 23 tide gauges in metropolitan France, including 5 in the Mediterranea sea; however, only Le Conquet tide gauge transmits its data in real-time. Insofar as updating its tide gauges to function in real-time does not constitute a priority for this body and no additional means have been accorded to SHOM to speed up the updating of its tide gauges and ensure that they remain operational, most data from France's tide gauges will not be useable in 2010, at which time the Mediterranean tsunami warning system is expected to be operational.

The fact that since the resignation last June of the former director of the Géoscience-Azur laboratory as acting National Contact, France has been unable to find a replacement testifies to the current log jam: unofficially, the members of the French delegation are unanimous in confirming that this mission should fall to CEA. Nevertheless, this body refuses to assume financial responsibility for this task and is therefore awaiting a commitment on the part of the French government to fund this mission.

Therefore, your rapporteur would like to point out that up until the Lisbon session, France was unable to not only specify its role within the future tsunami warning system in the Mediterranean, but also to designate its Focal Point (responsible for transmitting warning messages to the civil-protection services) and National Contact (responsible for representing France at meetings of the ICG/NEAMTWS). In addition, France's contribution to bringing the sea-level measurement devices up-to-date is hampered by a lack of funding.

Your rapporteur is nevertheless pleased with the evolution of the French position during the Lisbon session, which was held only two weeks prior to the adoption of this study by the Parliamentary Office for the Evaluation of Scientific and Technological Choices.

Before the fourth meeting of the ICG/NEAMTWS (21 to 23 November 2007), it seemed that France was once again off to a poor start, since only one day before the start of this session, the French delegation still had not received any directive from the government and was therefore preparing to maintain a low profile.

However, the head of the delegation finally received "certain indications" from the Prime Minister's departmental staff conveying a favourable evolution of French policy and the government's commitment to the setting up of a tsunami warning system.

Concretely, the French delegation announced France's interest in hosting a regional tsunami warning centre for the western Mediterranean and northeast Atlantic zones, in cooperation with the regional centre for the eastern Mediterranean.

It was therefore decided to create a task team[1] to meet in January in order to determine the structure of the Mediterranean and northeast Atlantic warning systems, as well as the project's partners, implementation schedule and necessary budget and sources of funding.

"Certain indications"

"France would like to point out that during the Kobe Conference it committed itself to participating in the design and implementation of an oceanic, multi-risk monitoring and warning system within the framework of an international effort under the direction of the IOC.

Considering the extent of its coastline, present in all of the planet's principal sea and ocean basins, risk prevention via the monitoring of natural hazards (especially marine events), whether of geophysical or meteorological origin, is today a major concern of France. Indeed, the perspectives announced by the scientific community with regard to global warming - resulting, in particular, in rising sea levels and more intense meteorological phenomena – necessitate an immediate and real mobilization, as well as a concerted effort, on the part of the concerned countries in the various basins.

Therefore, France considers that it is today important to begin an incremental process in line with the international calendar proposed by the IOC, which is based on what is currently available (or will be within 3 to 4 years) and which deals, in particular, with coastal inundationing caused by oceanic phenomena of distant

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1 *This team will include all countries concerned by this proposal, the Steering Committee of the ICG/NEAMTWS and the chairmen of the 4 working groups, as well as representatives of other organizations, such as the European Commission, the World Meteorological Organization and the European-Mediterranean Seismological Centre. It will be co-presided over by France and the United Kingdom.*

origin.

In particular, with regard to the Mediterranean and northeast Atlantic basins, France does not underestimate the decisive role it must play, considering, firstly, the extent and diversity of its coastline and the variety of natural hazards to which it is exposed and, secondly, the collaborative agreements (in particular, the emergency-assistance agreements) which it has passed with several other coastal countries. In addition, France is competent in the domains of seismology, geophysics and meteorology.

France cannot act alone, but must work in partnership with other countries sharing this same set of problems. Indeed, this is a European-Mediterranean project that, due to its complexity and costs, requires a sharing of strengths and means in which the European Union must also assume its full responsibility - in particular, with regard to its programmes relative to the environment and security.

It is in this context that France manifests its interest to host a regional tsunami monitoring centre - specifically, for the western Mediterranean and northeastern Atlantic zone - as its contribution to NEAMTWS. This centre would work in close partnership with the eastern Mediterranean centre. Remaining in permanent contact, these two centres would be able to replace each other if needed; they would issue their bulletins directly to the national authorities in charge of spreading the alert.

For this collaborative effort to succeed and in order to set up a global European-Mediterranean project by mid-2008, France proposes that a task team be formed starting in January (the exact date to be fixed in Lisbon). This team would add a political section to the project's scientific and technical dimension. Its mission would be:

- *to define the structure, means and partners of the monitoring centre for the western Mediterranean and northeast Atlantic;*
- *to establish a calendar for the centre's creation and activation;*
- *to assess the costs of the different stages of the project and to examine the conceivable contributions;*
- *to consider the possible and ultimately probable contributions of the observation and monitoring systems that already exist or are being developed.*

This task team would present the results of its study during the next meeting of the ICG/NEAMTWS, by identifying, in particular, the initial funding necessary for the creation of a monitoring and warning "kernel" to address the European-Mediterranean and international concerns with regard to coastal risks of oceanic origin.

Finally, France suggests that this task team be led by CEA, considering this body's experience in the Pacific Ocean and the fact that it hosts the European-Mediterranean Seismological Centre.

d) In the Pacific

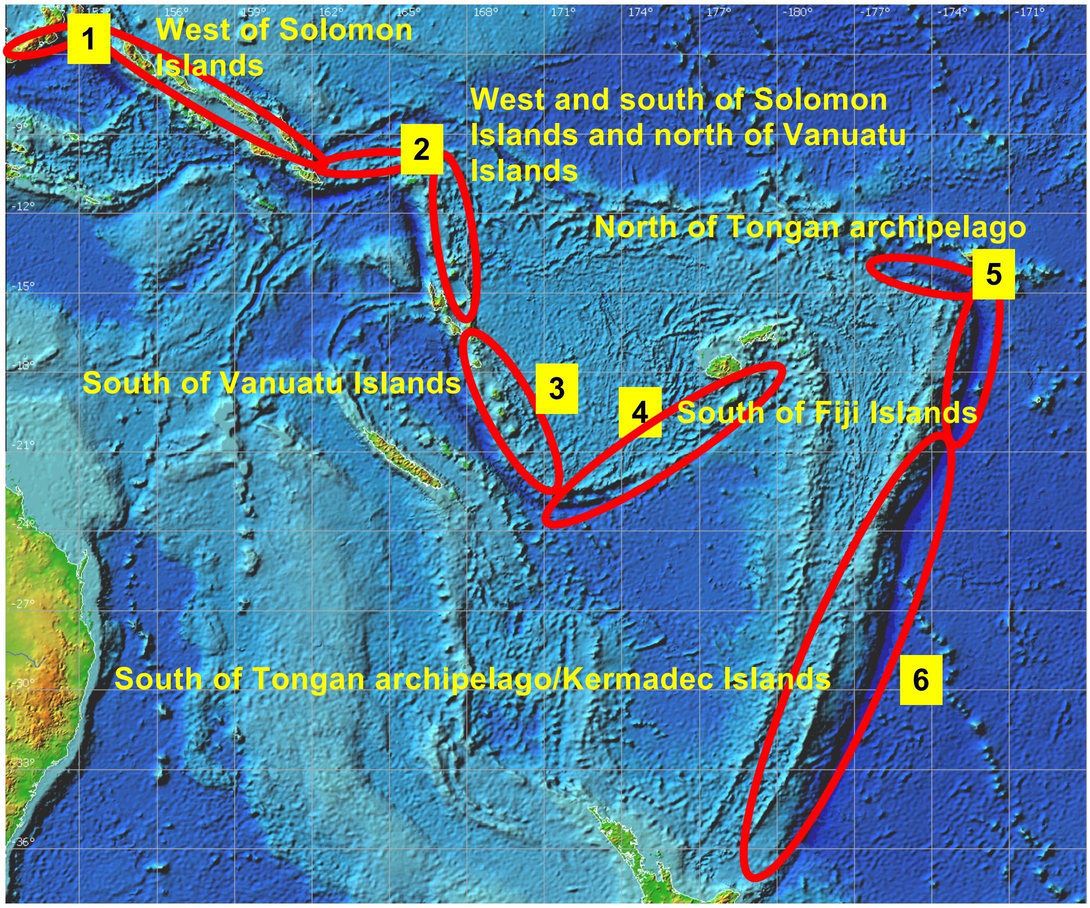
As has already been pointed out, the recognition of the vulnerability of New Caledonia and Wallis and Futuna has led France and the local authorities to begin installing sirens in these territories. However, in order for this measure to be effective, a reliable warning system must also be set up that allows sufficient time to the local authorities to activate the sirens.

Currently, there exists only one tide gauge in New Caledonia (Nouméa) and four tide gauges (Central Vanuatu, Fiji, Northern Samoa and Central Tonga) which are poorly positioned to effectively protect France's territories in the southwest Pacific.

A study - funded, in part, by the Junior Minister's Office for the Overseas Territories – was carried out last July, in order to evaluate the needs in tide gauges and tsunamimeters. The study's conclusions were as follows:

6 seismic zones were distinguished as being capable of generating tsunamis in New Caledonia and in Wallis and Futuna: the Solomon Islands, the Vanuatu Islands, the Loyalty Islands, the Fiji Islands, the Tonga Islands and the Kermadec Islands (see map below).

The tsunami-generating seismic zones threatening New Caledonia and Wallis and Futuna



Source: CEA/DASE

- To the west and south of the Solomon Islands, as well as north of the Vanuatu Islands (zone 2 on the map): 4 sea-level measuring stations are necessary to detect tsunamis generated in this region: 3 tide gauges - one northwest of Esperitu Santo (an island in the Vanuatu archipelago), one southwest of Santa Catalina and one east of Renell Island (both located in the Solomon Islands) – and a tsunamimeter to the north, between the Solomon Islands and New Caledonia (that the Australians are planning on installing).

- South of the Vanuatu Islands and in the area of the Loyalty Islands (zone 3): an earthquake with a magnitude of greater than 7.1 in this zone would generate a local tsunami with a very short reaction time for the Loyalty Islands.[1] However, the installation of a tide gauge in both Lifou and Maré would allow for a warning to be confirmed 20 minutes before the arrival of the first wave on New Caledonia and 2 ½ hours before the arrival of the tsunami in Futuna.

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[1] *In this case, the warning system for the Loyalty Islands will rely on educating the population, which must learn to automatically quit the coast for higher land should it perceive any signs of a strong earthquake having occurred.*

- North of the Tongan archipelago[1] (zone 5): two tide gauges (one in Wallis and one in Futuna), so that if one of the two islands is hit by a tsunami, the other island can be notified of its approach (the maximum reaction time is estimated at 20 minutes). These two tide gauges would also be used to confirm a warning 2 ½ hours before the arrival of a tsunami from the Loyalty Islands or New Caledonia. In addition, 2 other sea-level measuring stations are necessary to confirm as quickly as possible (10 to 30 minutes earlier) the tsunamis generated in this region: one tide gauge installed south of the Samoa Islands and one at the far northern end of the Tonga Islands. A tsunamimeter east of the Tongan archipelago (that the Americans are expected to install) will later allow for the tsunami's magnitude to be confirmed.

With regard to zone 1 (west of the Solomon Islands) and zone 6 (south of the Tonga Islands/in the area of the Kermadec Islands), these zones will be monitored by the tide gauge planned to be installed east of Renell Island, as well as by the measuring devices that Australia is expected to install.[2]

To sum up, the sea-level monitoring system for this region must include:

- 7 tide gauges in the French overseas territories (3 in New Caledonia, 1 in Lifou, 1 in Maré, 1 in Wallis and 1 in Futuna), with the Wallis and Futuna stations contributing to the warning system covering New Caledonia and the Loyalty Islands for tsunamis generated in the Tongan archipelago, and with the Loyalty Island and New Caledonia stations issuing regional warnings for tsunamis generated in the Vanuatu Islands and Loyalty Islands.

- 6 sea-level measuring stations installed off other islands, to detect as soon as possible tsunamis moving towards the French territories (2 in the Solomon Islands, 2 in the Vanuatu Islands, 1 in the Samoa Islands and 1 in the Tonga Islands).

- 1 tsunamimeter installed by the Australians north of New Caledonia.

To complete the system, two tide gauges should subsequently be installed in Ouvéa and Ouinné, as well as a tsunamimeter in the Tonga Islands and Fiji Islands.

As has already been pointed out, the Junior Minister's Office for the Overseas Territories is well aware of the stakes and is helping to fund the

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[1] *This zone also includes the island of Futuna, in the area of which a tsunami-generating earthquake could occur. However, as in the case of a tsunami-generating earthquake occurring in the area of the Loyalty Islands, the nearby earthquake would have to be immediately detected in order to warn the island's population in time, due to the very short delay between the earthquake's occurrence and the tsunami arrival.*

[2] *Australia plans on installing a tide gauge on Tagia Island, as well as a tsunamimeter north of New Caledonia, in order to monitor tsunamis from zone 1. To monitor tsunamis from zone 6, the tide gauge that already exists in Nukualofa and the two new tide gauges Australia plans to install in Raoul Island and Norfolk will suffice. Finally, zone 4 (southern Fiji) is less dangerous, due to the fault zone's orientation.*

setting up of a warning system in the southwest Pacific. Nevertheless, its finances are insufficient. Political arbitration is therefore essential to finalize the structure of the warning system for New Caledonia and Wallis and Futuna and establish a suitable budget.

2. The reasons for these blocks

The observed obstacles blocking France's participation in the setting up of a tsunami warning system for the various basins all share the same origin: due to a lack of political will, the French contribution is the subject of no global action plan and depends upon the good will of the various engineering departments, ministries and scientific bodies. As the latter do not benefit from sufficient funding due to the absence of any specific budget dedicated to setting up tsunami warning systems, progress has been very slow.

a) The absence of a global vision

France is the only country to belong to the four intergovernmental coordination groups for setting up a tsunami warning system. In addition, the design and implementation of a monitoring system necessitates a large number of partners, at both the ministerial level and the public-service, scientific-body and local-government level.

Unfortunately, ever since France agreed in 2005 to contribute to the tsunami warning systems, no government has thought strategically about this issue in order to establish a clear political line, define each actor's responsibilities, and name a national coordinator.

While it is true that the Ministry of Ecology (via the Pollution and Risk Prevention Department, or "Pollution and Risk Prevention Department") and the Ministry of the Interior (via the DDSC or "Defense and Civil Protection Department") set up in the spring of 2006 a national technical coordination group, its effectiveness is limited insofar as it depends on the good will of its members, due to a lack of any specific political directives.

This lack of coordination can engender absurdities. For example, the initial French project in the Indian Ocean called for setting up a national tsunami warning centre in La Réunion with its own expert-assessment capacities, without having first considered the needs of the other basins or the assessment means that already existed. However, this project was never carried out due to a lack of funding, but also because it turned out that Météo France was not best suited to carrying out this mission.

Similarly, the purchase of new tide gauges and the updating of already-installed devices in the four basins was the subject of neither a global development plan, nor a prior analysis to determine the most advantageous solution with regard to installation speed and maintenance costs. Although SHOM was unofficially put in charge of this task, this mission was never the subject of any specific directive issued by its board of directors, thereby engendering the observed delays.

b) The absence of funding

The French contribution to the tsunami warning systems also runs up against a lack of available funding for the necessary actions. Indeed, up until now, only the project for setting up a national warning centre in the Indian Ocean benefited from a suitable budget meant to cover all project costs - even if your rapporteur believes that the funding made available at the time was not necessarily spent on the most important measures.

What's more, this budget only provided for equipment financing. However, numerous actions also necessitate operational funding. For example, the rapid installation of new measuring devices (seismic stations and tide gauges) and updating the already existing devices require the services of one or more dedicated engineers over a period of several months. Once the equipment has been installed, the question then arises as to transmission costs. For instance, the seismic data must be transmitted by VSAT satellite, which proves quite costly. However, not only must the bodies meant to carry out these tasks often pay for these projects out of their own pockets, but also no agreement has been signed between these same bodies and their regulators specifically laying out their new tsunami-monitoring missions. Therefore, their budgets make no provision for any "tsunami projects", as such. As a result, it is very difficult for them to devote money and personnel to missions that they are not officially responsible for carrying out and for which they receive no funding.

A few measures have been financed by several ministries. For example, as has already been mentioned, the Ministry of Ecology assigned BRGM with carrying out a study on the tsunami vulnerability of the French coasts in the Mediterranean and West Indies, as well as designing a database summarizing all tsunamis to have struck metropolitan France and the West Indies.

Likewise, the Junior Minister's Office for the Overseas Territories has financed several pieces of equipment in the overseas territories, including 4 tide gauges in Guadeloupe, sirens in Wallis and Futuna and in New Caledonia, and a system of dissemination of tsunami alerts.

Nevertheless, due to the lack of a global strategic vision and an action plan put together by all the partners involved in setting up a tsunami warning system, the sums invested remain limited and there is a substantial risk of witnessing a multiplication of small, unrelated projects whose continuity is not guaranteed.

3. A change in French policy?

The Lisbon meeting of the ICG/NEAMTWS was marked by a positive change in French policy, with France officially announcing its interest to host a regional warning centre.

In addition, according to the information obtained by your rapporteur, the French Prime Minister has agreed in principle to the setting up of a national monitoring and warning centre for coastal floodings of marine origin[1], which would also be used for tsunami-risk management. The Department of the Sea, an institution under the direct authority of the Prime Minister, would be put in charge of defining and setting up this centre.

Your rapporteur fully supports this change in policy, even if it is still too early to judge the concrete measures to be taken by the French government. Indeed, the wait-and-see policy that France has pursued up until now testifies to its profound misunderstanding of the real stakes behind the setting up of a tsunami warning system.

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[1] *Coastal submersions of marine origin include: storm surges, swells, rising sea levels and tsunamis.*

IV. RECOMMENDATIONS: FOR A STRATEGIC VISION OF TSUNAMI-RISK MANAGEMENT

A. SIGNIFICANT STAKES

While the main objective of setting up a tsunami warning system is to protect the coastal populations, France's participation is also to be explained by the existence of other important economic, geostrategic and scientific stakes.

1. The security stakes

These stakes have already been discussed above; therefore, your rapporteur would here simply like to point out that while France takes great pride in its 10-million-km² exclusive economic zone, divided between all of the world's oceans, this territorial scattering also underlines its vulnerability to tsunamis. Therefore, at the international level, the setting up of tsunami warning systems constitutes a fortuitous opportunity for France, because it allows it to ensure the effectiveness of the system by multiplying the amount of seismic and sea-level data available to the concerned countries and to mutualize the investments in measuring devices.

However, considering the national security stakes at hand, it is in France's best interest to play a central role within the intergovernmental coordination groups, so that the warning systems are quickly made operational and adapted to its security needs.

What's more, France has no choice but to define at the national level the most adequate warning-system structure for the effective, affordable protection of its entire coastline. If, as your rapporteur hopes, France were to create a tsunami warning centre for the Mediterranean, this centre would also have to be put in charge of monitoring France's coasts in the Indian Ocean and the Caribbean.

2. The economic stakes

The economic stakes must not be underestimated, either: tourism constitutes an essential resource for our country. If it were later to be revealed that the effects of a devastating tsunami could have been limited by the existence of an operational warning system, this would have a catastrophic impact on our coasts' reputation.

In this regard, your rapporteur is convinced that risk aversion in the developed countries will only increase - in particular, due to their trust in science to protect them from natural disasters. Therefore, we must stop believing that by raising public awareness of natural risks, we thereby hinder economic development; we should instead steer the discussion towards a more general and positive context of natural hazard-prevention policies.

Under the influence of the media, ever avid for powerful images and prompt to point fingers, public authorities will come under increasing social pressure to develop an effective risk-prevention policy.

3. The geostrategic stakes

International coordination is essential for the successful establishment of a tsunami warning system. Indeed, quickly and reliably locating and assessing an earthquake and verifying the generation of a tsunami necessitate both 1) the installation of a large number of measuring devices, not only on French territory, but also in the neighbouring countries and earthquake-prone zones and 2) the availability and sharing of seismic and sea-level data.

Therefore, France's more or less marked involvement in setting up an operational warning system necessarily affects its international influence and relations with the other countries.

During your rapporteur's visits to the West Indies and French Polynesia, he became aware of the strategic (yet largely unknown in metropolitan France) role played by France's overseas territories and *départements* in the country's relations with the other countries present in these zones.

For example, the ICG/Caribbean-TWS brings together not only the United States (concerned by the tsunami risk in Florida) and the Caribbean countries, but also those countries of South and Central America touching the Atlantic Ocean or the Caribbean Sea.

Likewise, via the ICG/Pacific, France is in permanent contact with Japan, the United States, Australia and those South and Central American countries with a Pacific shoreline.

However, numerous countries would like to cooperate more closely with France.

In the Pacific, France (essentially through LDG/Pamatai and its civil-protection services) works in close collaboration with Australia to develop a tsunami warning system in the southwest Pacific. It has also established excellent ties with Chile, which was the first country to equip its warning centre with a TREMORS system. Because it was able to set up an effective tsunami warning system in French Polynesia, the neighbouring islands, as well as the International Tsunami Information Centre in Hawaii often ask France for help in setting up similar systems and to participate in international conferences.

However, due to a lack of sufficient funding, French cooperation remains limited and sporadic.

In the Caribbean zone, France could make use of the tensions that exist between the United States and Venezuela to strengthen its influence in the region by playing the role of mediator and acting as a counterweight to the United States. Indeed, with the exception of the US, most member states of the ICG/Caribbean-TWS do not have the funds necessary to effectively contribute to the setting up of a warning system. If France were to commit to becoming a regional warning centre alongside that of Puerto Rico, it would considerably strengthen its influence in this zone.

Furthermore, the setting up of a warning system in the Mediterranean necessitates close cooperation between not only the European Union countries, but also the countries of the Mediterranean basin. The French presidency of the European Union starting in July 2008, as well as France's special ties with the North African countries should push our country to play a major role.

Your rapporteur insists on emphasizing the fact that up until now, France has based its position on an erroneous calculation: namely, that by not becoming involved in setting up the warning systems, it would avoid having to help finance them. In reality, France will nevertheless be forced to contribute to funding these systems, without being able to take advantage of them. However, the above examples demonstrate the extent to which France's active participation could constitute an important diplomatic tool.

4. The scientific stakes

In developing a tsunami warning system, France can rely on effective bodies that serve as models in their respective fields. Nevertheless, scientific bodies are also concerned by international competition and must constantly justify how they make use of the funding they receive. It is clear that if France were to play a driving role in the building of a warning system in the Mediterranean, its scientific bodies and related national institutions (CEA, IFREMER, SHOM, BRGM, Météo France, etc.) would be closed involved in this project, thereby strengthening their international credibility.

The role of the European-Mediterranean Seismological Centre (which is hosted by CEA) could also be considerably strengthened, if it were to house the regional warning centre (under the management of CEA).

B. THE RECOMMENDATIONS

Taking into account what has already been said, your rapporteur would like to make two types of recommendation: structural recommendations that apply to all of the basins and which together constitute as many prerequisites to an effective French contribution to the setting up of a tsunami warning system, and basin-specific recommendations, which take into account the particularities of each sea or ocean and of the varying tsunami-vulnerability of the French coasts.

1. Two introductory remarks

Your rapporteur would first like to make two remarks, that the government should not only keep in mind while it considers the preferable structure for a tsunami warning system, but also communicate and comment upon.

The first remark concerns the particularities of the tsunami hazard and their consequences for risk management.

Tsunamis are rare phenomena which require the use of sophisticated detection devices and extremely reactive warning systems, considering the brevity of the reaction times and the risk of issuing false warnings. The choices made regarding the warning system's final structure will depend on weighing the system's costs against the frequency of the hazard. This arbitration must be finalized in a transparent manner and included in all of the early emergency-assistance plans.

The second remark underlines the limits of a warning system.

Contrary to popular opinion in France, there is no such thing as "zero risk". Even if an effective tsunami warning system is eventually set up, it will not be able to prevent the loss of human life under any and all circumstances. Indeed, while the impact of regional and tele-tsunamis can be greatly mitigated, the means available to protect against local tsunamis – which strike the coast only a few minutes after being generated - are more limited. The only effective course to take to protect against local tsunamis is to teach the concerned populations the correct reflexes. It is essential, therefore, that this message be communicated, in order to avoid any misunderstanding between the civil-protection authorities and the population.

2. The structural recommendations

The structural recommendations can be divided into four main lines: defining a coherent warning system; establishing a long-term, perennial budget; integrating the tsunami risk into a multi-risk approach for the acquisition of sea-level measuring devices; and experimenting (on a voluntary basis) with the management of local-tsunami warnings.

a) Defining a coherent warning system

There are five preconditions to setting up a coherent warning system: naming a general coordinator; using appropriate measuring devices; relying on a thorough understanding of the hazard; responding appropriately to the hazard; and raising public awareness.

(1) Naming a general coordinator

Designing a tsunami warning system necessitates a great many partners, with varied and sometimes contradictory operating structures, interests and concepts of the final tsunami warning system. A general coordinator is therefore doubly necessary.

The general coordinator would be responsible, firstly, for defining, along with the various bodies associated with the project, the project's main lines, in order to ensure its internal coherency. He/she would therefore have to finalize the content of and coordinate France's contributions in the four basins. He/she would also ensure, in collaboration with the National Committee of the Intergovernmental Oceanographic Commission, that France participates at the meetings of the 4 intergovernmental coordination groups and that it is represented in each working group. The National Committee must therefore enjoy sufficient funding to finance the participation of the French delegates at these meetings and assume the role of the secretariat.

Secondly, the general coordinator would be responsible for determining everyone's responsibilities and missions and establishing a project calendar.

There are two conceivable avenues of reflection:

- The creation of an interministerial delegation modeled after the Post-Tsunami Interministerial Delegation: this structure has proved effective in carrying out a concrete project involving a great many partners over a set period of time.

- The assignment of this managerial role to the Department of the Sea: several arguments could be made in favour of this solution. Firstly, this department is under the direct authority of the Prime Minister. This privileged position provides it with an indisputable authority over its partners and allows it to speed up arbitration in the event of a disagreement. Secondly, this department is used to working with several other bodies concerned with setting up a warning system (SHOM, IFREMER) and is therefore well familiar with how they operate. Finally, the success of Extraplac[1] (coordinated by the Department of the Sea) testifies to its ability to manage a similar project. It appears likely that the government will choose this solution.

While it is not the role of your rapporteur to finalize all of the details of the final structure of France's future tsunami warning system, he nevertheless believes that it should include the creation of a national warning centre managed by CEA, whose short-term field of operations would cover

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[1] *Extraplac is the French programme to extend the continental shelf. The United Nations Convention on the Law of the Sea applies to the world's oceans: the use of oceanic resources, navigation, prospecting and sea-bed mining. This convention authorizes, under certain conditions, coastal countries to extend the marine zones under their jurisdiction beyond the limits of their exclusive economic zones. Extension requests will be examined by a special UN commission before 13 May 2009. France has therefore decided, via the Extraplac project, to prepare its requests for all potential extension zones.*

warnings in the Mediterranean/northeast Atlantic, the Caribbean and the Indian Ocean in the event of a tsunami estimated to arrive 15 minutes or more after the detection of the tsunami-generating event. Once this system is up and smoothly running, a second stage could extend the mission of the national warning centre to cover local tsunamis in predefined zones equipped with the necessary measuring and warning devices.

Furthermore, this national warning centre will also have to act as a regional warning centre in the western Mediterranean, the Caribbean and the western Indian Ocean zone, in collaboration with the other regional centres.

(2) Using appropriate measuring devices

Every effective warning system relies on seismic stations, tide gauges and tsunamimeters that transmit their data in real-time. In addition, taking into consideration the tsunami-risk linked to landslides necessitates the installation of such specialized sensors as hydrophones.

With regard to tide gauges, there exist several networks. Via the RONIM[1] network, SHOM manages 30 tide gauges scattered about metropolitan France, the West Indies, the Indian Ocean and the Pacific. LEGOS[2] is responsible for the ROSAME[3] network, which includes 4 tide gauges installed off of D'Urville and Amsterdam Islands and in the Crozet and Kerguelen Islands. Furthermore, the departmental bodies responsible for public works, the harbour authorities and certain local governments also manage tide gauges. Finally, within the context of tsunami warnings, the OVSG ("Vulcanologic and Seismologic Observatory of Guadeloupe") is creating its own network in Guadeloupe and CEA proposes that tide gauges must be installed in the Pacific in order to set up a tsunami warning system to protect New Caledonia and Wallis and Futuna.

Many of the Overseas Territories' tide gauges are - or will soon be - capable of transmitting their data in real-time. On the other hand, among those tide gauges managed by SHOM in metropolitan France, only Le Conquet device meets this criterion. However, according to the information gathered by your rapporteur, 13 tide gauges belonging to SHOM (including 11 in metropolitan France) could be rapidly updated to transmit their data in real-time, because they already have the necessary outlets. The estimated cost is €2,500 in equipment and one work day per tide gauge. It is therefore urgent that SHOM's governing body provide it with the necessary means to rapidly adapt the tide gauges in question.

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[1] *Sea-level monitoring network.*

[2] *Laboratoire d'Etudes en Géophysique et Océanographie Spatiales ("Space-Based Geophysics and Oceanography Research Laboratory").*

[3] *Réseau d'Observation Subantarctique et Antarctique du niveau de la MEr ("Subantarctic and Antarctic Sea-Level Observation Network").*

In the Mediterranean, only 2 tide gauges could rapidly transmit their data in real-time: that of Port-Vendres and that of Sète. It is therefore essential to accelerate SHOM's planned replacement in the medium term of the sea-level measuring devices off Ajaccio, Toulon, Marseille and Nice, so that they may be integrated into the warning system before the end of 2008.

Furthermore, your rapporteur insists on the fact that data transmission can be free, if the tide gauges allows for the direct sending of data via the Global Telecommunication System. Therefore, all that needs to be done is to acquire a receiving system to receive the data from all of the tide gauges using GTS. This system, whose energy source and transmissions are autonomous, is particularly recommended for the more isolated islands and coastlines, which is the case with many sites in the Overseas Territories and in foreign countries.

Given the multitude of sea-level networks, it is particularly important to create a "one-stop" set up, by designating a single body in charge of centralizing and archiving the data, as well as making it available to all interested users. In addition, this body could advise all those organizations interested in installing sea-level measuring devices in order to ensure that the planned devices meet the criteria defined by the Global Sea-Level Observing System (GLOSS), and thereby serve as many applications as possible.

Your rapporteur would like to point out that SHOM is responsible for navigational security in the French zones via the establishment of nautical charts and tide tables. Therefore, all bathymetric and tidal information is supposed to be transmitted to SHOM – though, in reality, this is not done by the various organizations on a systematic basis. Indeed, SHOM only learned of the existence of the network managed by the OVSG after these tide gauges were damaged by Hurricane Dean.

To get round this difficulty, the GLOSS national representative[1] has taken charge of this mission. However, this solution is not ideal, because it relies on the good will of a single individual, which renders the initiative very vulnerable over time.

Therefore, SHOM should be officially commissioned to coordinate the sea-level measurement activities in France by its board of governors and it should be provided with all the financial and human-resource means necessary for it to carry out this task.

In this regard, your rapporteur would like to point out that the board of governors is currently negotiating SHOM's "objective-means agreement" for the next five years. It would therefore be appropriate to take into account during this process France's needs with regard to the national coordination of its sea-level measuring activities and the network's rapid updating to real-time. The presence of a representative of the Ministry of Ecology and Sustainable Development and a representative of the Ministry of the Interior and of the Overseas Territories on the governing board of SHOM should raise this

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[1] *Also a research professor at the University of La Rochelle.*

board's awareness of the fundamental role that SHOM is brought to play in rendering the tsunami warning system effective.

With regard to the seismic stations, France's broadband network should be installed within a few years in metropolitan France. It should correctly cover our territory, while the network's communications are switched over to satellite. Nevertheless, the data-transmission costs are great and should be included in the operating costs of the various organizations responsible for managing the seismic stations.

Finally, the French Mediterranean coastline will only be well protected if at least two tsunamimeters are installed off the coast of Algeria. Other tsunamimeters will be necessary in the Mediterranean basin, including one between Corsica and the mainland and another in the northeast Atlantic. The significant costs engendered by these measuring devices in terms of equipment, installation and maintenance should be shared out at least partially at the European level.

(3) Relying on a thorough understanding of the hazard

In order to be effective, a tsunami warning system must rely on a thorough understanding of the hazard. While several studies have already been carried out and numerous simulations have been developed, this work has been entrusted to numerous research institutes without any overall coordination. Therefore, it would be advisable to make an inventory of the past and present research and to finalize a guiding line concerning the existing needs.

Several avenues should be given priority:

Firstly, a deeper understanding of the sources is necessary. The study carried out by BRGM on the vulnerability of the French coasts in the Mediterranean and the West Indies represents a first step in this direction. However, according to the information obtained by your rapporteur, the zones chosen and the associated earthquakes are a subject of contention in the scientific community. Therefore, the studies seeking to specifically identify the tsunami-vulnerable zones must be continued.

With regard to landslides, the research is less complete, even if remarkable studies have been carried out, such as those by the GIS/CURARE in the Marcel Cirque. Therefore, this long-term work must also be continued.

The creation of a tsunami database, begun by BRGM, must also be brought to completion. Nevertheless, its current specifications should be modified. Up until now, BRGM has only used written documents which mention an event whose characteristics resemble those of a tsunami. However, this approach is too limited in scope to include very old tsunamis or those to have struck more isolated areas. The Solomon Islands tsunami of April 2007 is a case in point: to judge by the local press, this tsunami had hardly any effect on New Caledonia. However, a mission meant to gather eyewitness accounts of this event revealed several phenomena characteristic of a tsunami (a retreating sea, tidal bores, eddies in the harbours) that no one had thought to report since they had caused no material damage or loss of life. On-site and post-tsunami studies are therefore essential for a better understanding of this phenomenon.

With the prospect of setting up a warning system, modelling is also essential to understanding a tsunami's impact on a given coast. However, it is only effective if the bathymetry near the coast is sufficiently precise to take into account site effects. But, the sea charts near the coasts are incomplete. In 1998, a marine campaign carried out by IPGP on an IFREMER ship was meant to chart the underwater relief around Martinique and Guadeloupe. Unfortunately, due to a dockers' strike, the multi-beam echo sounder was not delivered in time and the team was unable to chart the zone between 0 and -200 m. A 24-nautical-day mission would be necessary to complete the current bathymetry of this area, with each day at sea costing anywhere between €10,000 and €20,000.

There currently exist several national programmes, for the most dedicated to territorial waters (12 nautical miles):

- The Litto 3 D project launched conjointly by SHOM and the IGN ("National Geographic Institute") for that section between -10 and +10 m around the coastline.

- IFREMER's REBENT project, for pilot zones in the band located between sea level and -20 m.

- One-off projects, via scientific programmes or programmes carried out with the support of the regional councils, to map shallow formations.

The Litto 3 D programme seeks to precisely map the coastal band between +10 m for the terrestrial section and 6 nautical miles for the marine section. The surveying is carried out via an airborne system (bathymetric LIDAR) and a hydrographic launch equipped with a multi-beam echo sounder, allowing it to achieve an up-until-now unequalled precision that is essential for effective modeling.

The bathymetric and altimetric data collected by the two institutes has been compiled, adapted to be presented in a "seamless" manner[1], and made available via the Géoportail server. In addition, two bathymetric-survey programmes have been carried out in the Gulf of Morbihan and off of Toulon, in order to demonstrate the quality of the charts obtained via these modern measuring devices.

Your rapporteur supports this project, which has the double advantage of 1) having made an inventory of what already exists, in order to avoid any redundancies, and 2) providing precise surveys, which are indispensable to expertly manage and prevent coastal-submersion risks of marine origin. In the

[1] *In other words, using the same altitude-based system of reference.*

medium term, the bathymetric surveys must be completed to cover the zone between 0 and -200 m.

In addition, considering the ever greater role played by the local governments in the collection of bathymetric data, we should avoid their financing the acquisition of data that risks not meeting the standards established by SHOM and the IGN.

(4) Responding appropriately to the hazard

The setting up of a warning centre capable of issuing a message 24 hours a day, 7 days a week indicating the occurrence of an earthquake liable to have generated a tsunami constitutes but the first step in building an effective warning system. The said message must also reach the competent authorities in charge of organizing emergency assistance and these same authorities must know exactly what needs to be done at every level, as is the case for the ORSEC plans. Considering the very short reaction times and the many organizations involved[1], there can be no place for improvisation.

The creation of inundation and evacuation maps must be encouraged, because they allow, in particular, for a prior evaluation of the extent of damages and an identification of the routes that can be used for emergency assistance efforts. The principal harbours and densely-inhabited coastal areas must be the first zones covered.

Furthermore, training exercises are indispensable to identify any problems/malfunctions and improve the system's effectiveness.

The question of installing sirens to warn the population must also be raised. Your rapporteur is well aware that this is a very sensitive issue for the local elected representatives. Nevertheless, the sirens' effectiveness should be underlined. Indeed, when the population is scattered about the territory, it is impossible for the civil-protection services to warn everyone threatened in time. In this case, sirens become indispensable. In addition, one must remember that the traditional communications network is often rendered useless, either because the tsunami-generating earthquake is near enough to affect the telephone and/or electricity network, or because it is saturated as soon as the first warning messages are issued. Therefore, the option of installing sirens must be studied during the definition of the future national warning system by the steering committee coordinated by the Department of the Sea.

Finally, the specialized emergency-assistance plans must be defined in the French West Indies, the Mediterranean/northeast Atlantic, New Caledonia and Wallis and Futuna.

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[1] *Nearly 60 local governments are involved in La Réunion's specialized emergency plan.*

(5) Raising public awareness

This question has already been raised; however, it remains crucial, insofar as it clearly represents the weak link in the warning chain.

Your rapporteur has already discussed the public-awareness policies carried out at the national level (essentially meant to raise awareness of the tsunami risk among young people), but also at the local level. He draws from these experiences the following conclusion: if it is necessary to improve the public awareness campaign at the national level, targeting the entire French population, then it is essential to also carry out an information campaign specifically targeting the most at-risk populations: namely, the coastal populations, both permanent residents and tourists.

It is not up to your rapporteur to define the contents of the public-awareness campaigns. However, he believes that in order for them to be effective, they must be repeated and use several communication vehicles in order to touch a diverse public (exhibitions, news reports, scientific television/radio programmes, conferences).

At the local level, the effectiveness of the public-awareness campaigns will depend strongly on the involvement of the local stakeholders (local governments, chambers of commerce and industry, tourist offices, hotels, harbour authorities, lifeguards, etc.). Your rapporteur is aware of the reticence of the local elected officials and the tourist professionals to communicate on the tsunami risk, on the pretext that the subject scares away tourists.

Your rapporteur disagrees with this argument. Indeed, every hotel displays an emergency evacuation map in the event of a fire, yet no one has observed that this discourages tourists from staying at hotels - even though, as in the case of a tsunami, a fire is a relatively low-risk event that could have dire consequences.

In reality, a well-thought-out communication campaign – one which describes the hazard[1], soberly explains its mechanisms, and indicates the simple measures to take to protect against it – can only have a positive effect on the community broadcasting the information, because it testifies to the local government's concern for the safety of the area's inhabitants. This information can be provided in the form of brochures and posters, in both French and English; it can also be included in magazines presenting the activities of the local government. In addition, a partnership with the press must be developed, so that any measures taken by the local government to protect the population from tsunamis receive media coverage.

Finally, raising awareness of the tsunami risk among children and teenagers should be a priority. In coastal zones particularly vulnerable to

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[1] *By focusing on not only its relatively low occurence, but also the serious consequences it can have for the coastal population.*

tsunamis, the teaching materials used must refer to real, historical phenomena and teach the right reflexes in a fun manner.

For schools located in inundation-prone areas, evacuation exercises represent the best means of educating the children.

b) Establishing a long-term, perennial budget

A tsunami warning system cannot be set up and function properly in the long-term if it does not benefit from a perennial budget that takes into account not only the initial equipment costs, but also the operating costs (salaries, missions, equipment maintenance, telecommunications, updating of software, etc.).

This funding must be clearly defined, in agreement with the various bodies involved in setting up the system and which must also be officially commissioned to carry out their new missions linked to tsunami monitoring and the issuance of warnings.

In addition, the government must clearly commit itself to the sums it is willing to spend in the long-term to maintain a tsunami warning system, in order to avoid this system being questioned a few years after its creation.

c) Integration of the tsunami risk into a multi-risk approach?

As the head of CEA/DASE pointed out, the future national tsunami warning centre will be confronted with the same constraints as the national centre for the monitoring of nuclear explosions: although the surveilled event occurs only rarely, when it does, the information on it must be gathered quickly and reliably; this requires high-performance equipment that is also sometimes redundant (for greater security).

Therefore, the idea behind extending the mission of the tsunami warning system to include the monitoring and prevention of other coastal-submersion risks of marine origin is to make the best use of the significant investments required to set up a tsunami warning system and to ensure the longevity of the government's financial commitment by strengthening the legitimacy of the warning centre through a multiplication of its missions.

This idea is also based on the observation that tide gauges are used to verify and quantify all coastal-inundation risks. Communicating on the multiple applications of the sea-level measuring devices should therefore contribute to justifying their acquisition and updating. Similarly, a precise cartography (both bathymetric and altimetric) of the coastal zones can be used to both forecast and manage all coastal-inundationing risks of marine origin.

While your rapporteur recognizes the pertinence of these arguments, he nevertheless remains convinced that the modalities of integrating a tsunami warning system into a multi-risk warning system are much more difficult than the supporters of this approach believe, insofar as the "competent" body for analyzing the hazard and issuing the warning to the concerned civil-protection services differs according to the nature of the risk.

Most tsunamis for which an effective warning is conceivable are generated by an earthquake. The warning system must therefore be able to be set off by a body specialized in the monitoring and evaluation of earthquakes, such as CEA in France or INGV in Italy.

The other coastal-inundationing risks of marine origin (storm surges, cyclonal swells, rising sea level) are all of meteorological origin and must therefore be managed by such weather services as Météo France.

How would these different areas of competence be divided up within the framework of a multi-risk system here in France? Would one organism be called upon to absorb another?

Your rapporteur would like to point out that in Japan, the weather services are responsible for managing all natural hazards and, as a result, include a seismological department. Nevertheless, this structure has not been adopted in France and the obstacles with which such a reform would be confronted must be weighed against the gains that could be made. In this regard, your rapporteur would like to point out the failure to set up a national multi-risk warning centre in La Réunion, which was meant to rely on Météo France. While it is true that Météo France issues tsunami as well as cyclone warnings, in reality, it is a Focal Point that is content with retransmitting the bulletins issued by PTWC and JMA, due to a lack of seismological expertise.

Therefore, your rapporteur believes that, in the short term, the multi-risk approach must primarily seek 1) the acquisition of a network of "multi-use" measuring devices whose data must be made available to all risk-management bodies and 2) the mutualization of the data-transmission means.

d) Voluntary experiments with the management of local-tsunami warnings

Throughout this study, your rapporteur has insisted on the fact that it is particularly difficult to predict the impact of local tsunamis: considering the short reaction times, the warning centres hesitate to assume this responsibility, insofar as they run the risk of seeing their messages arrive after the wave has already struck the coast.

During the last session of the ICG/NEAMTWS in Lisbon, the member states agreed that the regional warning centres would only deal with those tsunamis with a reaction time of over 15 minutes. For tsunamis with shorter reaction times, the responsibility for issuing the warning falls to the national centres. Indeed, issuing an effective warning when the reaction time does not exceed 15 minutes requires a much denser network of sensors than that necessary to monitor regional tsunamis, as well as an automated warning system using sirens. This therefore entails a significant investment, which must be related to the frequency of the expected hazard. In addition, the warning's success is not guaranteed and depends more than ever on the correct reaction of the population and therefore on raising the public's awareness of the tsunami risk.

Therefore, it would be unrealistic to want to generalize a local-tsunami warning system to all of France's coasts. However, your rapporteur believes that in certain zones that are exposed to a high local-tsunami risk, and whose local elected officials are well aware of the risk, a warning system suited to local tsunamis could be experimented with.

In metropolitan France, the greater Nice area could be interested in this trial: in this area, the local tsunami hazard represents a real risk, as was demonstrated on 16 April 1979; this zone is particularly vulnerable, considering its dense coastal population all year long, with peaks in the summer; our understanding of the hazard in this zone is good, thanks to the many geophysical studies that have already been carried out on gravitational instabilities in the Marcel Cirque; finally, this region can be considered a model in terms of raising the local government's awareness of the tsunami risk.

Therefore, an experiment could be developed, that brings together in close collaboration various government services (in particular, the civil-protection services), the key scientific bodies studying tsunamis, local governments and harbour authorities, as well as manufacturers to design an effective data-transmission system. If the trial proves successful, the system could be extended to other coastal regions, both in metropolitan France and overseas.

In this regard, your rapporteur would like to point to the project elaborated by the "marine" and "territorial risk and vulnerabilities" competitiveness clusters of the Provence-Alpes-Côte d'Azur region, which seeks to set up a RATCOM ("Tsunami Warning System for the Mediterranean Coasts"). This project's objective is to establish an automated warning system for local tsunamis.

The proposed system is designed around two main functional components:

- A "descending component", which seeks to offer effective and reliable communication means allowing for the transmission of warnings via first a local network, then a mass broadcast.

- A "rising component", which is meant to deliver - based on automatically processed measurements gathered both at sea and on land - a qualified, coordinated tsunami warning bulletin, meant to minimize, in particular, the chance of issuing a false warning. In addition to the processing of this data in real-time, decision-making tools based on prior modelling will have to be created and made available to those bodies responsible for crisis management and intervention.

3. Basin-specific proposals

a) In the Mediterranean/northeast Atlantic

CEA must be commissioned to act as the national representative of the ICG/NEAMTWS, as well as the national and regional tsunami warning centre. Currently, no fewer than 7 Mediterranean countries[1] have officially expressed their interest in becoming a regional warning centre (without necessarily having the financial and human-resource means), while 2 to 3 regional centres would seem to be sufficient. Therefore, France should perhaps propose a solution that is sensitive to the national interests of the other interested countries. This would amount to using a European-based structure, such as the European-Mediterranean Seismological Centre located at CEA's Bruyères-le-Châtel site, to house the regional warning centre that France would create, which would nevertheless be managed by CEA/DASE.

Furthermore, it is urgent to transmit in real-time the data gathered by the 11 metropolitan tide gauges that already have the appropriate outlet and to finish modernizing the remaining tide gauges managed by SHOM before the next meeting of the ICG/NEAMTWS in October 2008. This network should be complemented by two stations in Corsica (Bonifacio and Porto Vecchio). It should be pointed out that, in order to protect France's costs, the national warning centre will have to receive real-time data from some twenty tide gauges spread out between Spain, Portugal, Sardinia, Morocco, Tunisia and Algeria. Therefore, France should verify that the already-existing stations are updated or, if necessary, propose the installation of new stations.

In the short term, France will have to ensure the installation of two tsunamimeters north of Algeria in order to effectively protect France's coasts. For this to be done quickly, France will have to declare itself willing to finance the station's equipment and installation and negotiate with the other member states of the ICG/NEAMTWS a mutualization of the maintenance costs.

In the medium term, we should come to a decision regarding the opportunity of setting up a warning system for local tsunamis in well-defined zones and, if need be, carry out a feasibility study on the automated management of this type of warning.

In addition, the setting up of a tsunami warning system must represent a priority of the French presidency of the European Union starting in July 2008 and mobilize all the member states and concerned directorate generals of the European Commission, in order to define and finance a plan for the modernization of the national tide gauges and the installation of tsunamimeters.

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[1] *The candidate countries are: Italy, the United Kingdom, Portugal, Greece, Turkey, Spain and France.*

In order to overcome the difficulties encountered with regard to the North African countries' reticence to share their seismic data, it seems essential to launch a diplomatic mission involving both the Ministry of Foreign Affairs and the French presidency. On this occasion, a bilateral or European partnership could be proposed, so as to speed up the installation of tide gauges and tsunamimeters off the North African coast.

Finally, the specialized emergency plan for tsunamis must be finalized for the metropolitan coast by the civil protection authorities, in collaboration with CEA for its scientific expertise.

b) In the Caribbean

Your rapporteur believes that France must become more involved in the work being carried out by the ICG/Caribbean-TWS. It must therefore attend each session and be represented in each working group.

Your rapporteur also supports the initiative launched by the French delegation during the Venezuelan session to host the ICG/Caribbean-TWS session in 2009. This date could serve as a deadline for defining the French strategy with regard to regional tsunami warnings in the West Indies, as well as the installation and updating of the seismic stations and tide gauges required for the protection of the French West Indies. Your rapporteur would like to once again point out that the 3 tide gauges managed by SHOM have to be rapidly brought up to date to transmit their data in real-time[1] and that 3 supplementary tide gauges have to be installed east of La Désirade, south of Martinique and north of Guadeloupe.

Furthermore, we must ensure that the sea-level network that is currently being installed by the OVSG could serve other applications and, consequently, meet the criteria set by GLOSS in its sea-level measuring devices manual. The data gathered by these tide gauges should also be transmitted to SHOM for archiving.

Furthermore, we must make sure that the planned national tsunami warning centre manages the tsunami warnings in the Caribbean, for those tsunamis with a reaction time of greater than 15 minutes (from the time of their generation to their arrival on the coast). On this occasion, it will certainly be necessary to clarify the respective tasks of IPGP (responsible for seismic monitoring in the West Indies) and CEA (responsible for issuing the tsunami warnings).

Once the system is up and running, CEA should be commissioned to carry out a feasibility study on extending its mission, for it to become the regional tsunami-warning centre for the Caribbean zone, in cooperation with Puerto Rico, PTWC and the ATWC.

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[1] *According to the information obtained by your rapporteur, those in Fort-de-France and Pointe-à-Pitre are already equipped with the necessary outlets for real-time data transmission.*

In the medium term, we must study the possibility of setting up an automated warning system for local tsunamis in certain coastal zones which remain to be determined and, if need be, carry out an experimentation in partnership with the interested local governments.

Finally, during the last session of the ICG/Caribbean-TWS, it was observed that France has up until now focused its attention on Martinique and Guadeloupe, effectively ignoring French Guiana and Saint Martin. This situation should therefore be clarified by launching a study on these zone's tsunami vulnerability and, if need be, integrating them into the national tsunami warning strategy for the West Indies (installing sea-level measuring devices and seismic stations, defining a specialized emergency-assistance plan, raising public awareness, etc.).

c) In the Indian Ocean

Your rapporteur has already observed that €305,000 attributed to Météo France for the creation of a national tsunami warning centre in the Indian Ocean remain to be spent, due to the modification of the initial project. Therefore, this money must be recovered and redirected to the budget dedicated to setting up a coherent, perennial national warning system. A portion of this sum could also be directed to the installation of a tide gauge in Madagascar (initially planned but never carried out) and a second station in La Réunion.

Your rapporteur regrets that France has effectively ceased to participate in the ICG/IOTWS sessions and recommends that it once again become involved in the work of the ICG/Caribbean-TWS and the working groups that this body has formed.

Furthermore, your rapporteur would like to see the mission of the planned national tsunami warning centre extended to cover the French territories in the Indian Ocean.

In addition, once the system is up and running, CEA should be commissioned to carry out a feasibility study on extending its mission, for it to become the "regional tsunami-watch provider" for those countries of the western Indian Ocean, in cooperation with other "regional tsunami-watch providers".

d) In the Pacific

In order to complete the warning system that already exists and effectively protect New Caledonia and Wallis and Futuna, your rapporteur supports setting up the warning system for the southwest Pacific presented earlier, which requires the installation of 15 tide gauges and 1 tsunamimeter, if Australia's planned tsunamimeter proves worthless for the protection of New Caledonia.

Your rapporteur would like to once again point out that the number of necessary sirens must be decided upon and an equipment-development plan for the islands finalized, in collaboration with the High State Authority of New Caledonia, the Overseas Ministry and the local elected officials of the French territories in this zone.

In addition, the civil-protection authorities must finalize the specialized emergency plan for New Caledonia and for Wallis and Futuna.

The system in French Polynesia must also be completed with the installation of 3 tide gauges on the furthest boundaries of Polynesia, transmitting their data in real-time.

Finally, your rapporteur believes that it is in France's best interest to respond to the cooperation requests of the Pacific-zone countries. He therefore proposes providing CEA with an official mandate, so that LDG/Pamatai can take on a mission of cooperation with regard to tsunami warnings and enjoy sufficient funding for it to carry out several assessment and training missions per year.

SUMMARY OF PROPOSALS

1. The proposals applying to all four basins:

- Commission CEA to act as the national tsunami warning centre for the Mediterranean/northeast Atlantic, the West Indies and the Indian Ocean and to develop a method for forecasting regional and teletsunamis.
- Allow the future national warning centre to also act as a regional warning centre in the western Mediterranean/northeast Atlantic, the West Indies and the western Indian Ocean, in collaboration with the other regional warning centres present in each basin.
- Create a steering committee coordinated by the Department of the Sea, responsible for setting up a national tsunami warning system and made up of representatives of:
  - those ministries concerned by tsunami-risk management (Ministry of the Environment and Sustainable Development; Ministry of the Interior and the Overseas Territories; Ministry of Foreign Affairs; Ministry of Higher Education and Research; Ministry of Education);
  - those bodies competent in this domain (CEA, Météo France, SHOM, IFREMER, BRGM, CNRS, CETMEF[1], IPGP, ANR, Conservatoire du Littoral, etc);
  - the local governments of tsunami-vulnerable areas.
- Provide the Department of the Sea with a long-term budget to finance the setting up of a tsunami warning system (equipping the system with tide gauges, seismic stations and tsunamimeters capable of transmitting their data in real-time; funding those bathymetric-survey programmes judged indispensable; setting up GPS geodesic networks to be able to precisely record strong earthquakes).
- Strengthen the means available to the National Committee of the Intergovernmental Oceanographic Commission, to allow it to coordinate the French position during the sessions of the four intergovernmental coordination groups for setting up a tsunami warning system and ensure that France is represented in each working group.

[1] *Centre d'Etudes Maritimes Et Fluviales ("Sea and River Research Centre").*

- Complete the "objective agreements" of those bodies involved in the tsunami warning system, so that this mission is made officially known and is funded by a specific line of credit.
- Provide SHOM with a mandate to coordinate the sea-level measurement activities in France and adapt its network of tide gauges so that their data is transmitted in real-time.
- Complete the bathymetric surveys to cover the zone from 0 to -200 m in both metropolitan France and overseas.
- Improve the satellite-based tsunami observation system by systematically including a specialized tsunami-observation mechanism in all low-orbit satellites scheduled for launch over the coming years.
- Plan on regularly updating the tsunami database entrusted to BRGM and take into account any on-site studies carried out over time.
- Encourage the National Research Agency to favour studies on geological and coastal hazards - in particular, those concerned with the evaluation and forecasting of tsunami-generating events (earthquakes, underwater landslides, cliff collapses).
- Following each tsunami, finance post-tsunami, on-site surveys in both metropolitan France and overseas.
- Carry out training exercises to test the effectiveness of the warning system, taking into account the entire decision-making chain, and identify any possible problems/malfunctions.
- Create inundation and evacuation maps for the main harbours and densely-populated coastal areas, to serve as decision-making tools for emergency-assistance management and urban development.
- Evaluate the need to install sirens to alert the population of each basin.
- Regularly raise public awareness concerning natural hazards, via exhibitions, news reports, scientific television/radio programmes, conferences, etc.
- Involve the local elected officials, harbour authorities and tourist professionals in setting up public-awareness campaigns for the harbours and coastal zones.
- Integrate natural-hazard education in the school programmes.
- Experiment with the management of certain local-tsunami warning systems, in cooperation with the interested local governments.

2. The basin-specific proposals

In the Mediterranean/northeast Atlantic zone

- Update to real-time the 11 tide gauges that already have the appropriate outlet, finish updating the Toulon, Marseille, Nice and Ajaccio tide gauges, and complete the system by installing two new tide gauges in Corsica (Bonifacio and Porto Vecchio) before the next session of the ICG/NEAMTWS in 2008.
- Install 2 tsunamimeters north of Algeria.
- Finalize the specialized tsunami emergency-assistance plan for the metropolitan coast, by relying on the scientific expertise of CEA.
- Make the setting up of a tsunami warning system a priority of the French presidency of the European Union starting in July 2008 and mobilize all the member states and concerned directorate generals of the European Commission, in order to define and finance a plan for the modernization of the national tide gauges and the installation of tsunamimeters.
- Direct French diplomacy towards encouraging the North African countries to share their seismic and sea-level data.
- Consider a bilateral or European partnership to accelerate the equipping of the North African coasts with tide gauges and tsunamimeters.
- Carry out a feasibility study on the automated management of local-tsunami warnings in certain, particularly vulnerable zones, in collaboration with the civil-protection services, local governements, concerned harbour authorities and associated manufacturers, and, if need be, carry out an exercise.

In the Caribbean

- Update the 3 tide gauges managed by SHOM, integrate the network of tide gauges currently managed by the OVSG and the local governments into the warning system, and finance the installation of 3 additional tide gauges east of La Désirade, south of Martinique and north of Guadeloupe.
- Evaluate the need to install sirens to alert the population.
- Finalize the specialized tsunami emergency plan for the West Indies, by relying on the scientific expertise of CEA.
- Clarify by agreement the respective tasks of IPGP (responsible for seismic monitoring in the West Indies) and CEA (responsible for issuing tsunami warnings).

- Carry out a feasibility study on the automated management of local-tsunami warnings in certain, particularly vulnerable zones, in collaboration with the civil-protection services, local governments, concerned harbour authorities and associated manufacturers, and, if need be, carry out an experimentation.
- Clarify the situation in French Guiana and Saint Martin by studying the tsunami vulnerability of these zones and, if need be, integrate them into the national tsunami warning strategy for the West Indies (installing sea-level measuring devices and seismic stations, defining a specialized emergency-assistance plan, raising public awareness, etc.).
- At the international level, ensure that France is represented in the working groups of the ICG/Caribbean-TWS during each of its sessions, especially if France plans on becoming a regional tsunami warning centre.
- Host the ICG/Caribbean-TWS meeting in 2009.

In the Indian Ocean

- Redirect the €305,000 attributed to Météo France for the creation of a national warning centre in the Indian Ocean (and which will not be spent, due to the modification of the initial project) to the budget for setting up a coherent, perennial national warning system.
- Ensure the installation by SHOM of a tide gauge in Mayotte and Madagascar, as specified in the agreement signed between the Ministry of Foreign Affairs and Météo France, and complete the system by installing a second tide gauge in La Réunion.
- At the international level, ensure that France is represented in the working groups of the ICG/IOTWS during each of its sessions, especially if France plans on becoming a regional tsunami warning centre.

In the Pacific

- Set up the previously presented warning system in the southwest Pacific, which necessitates the installation of 15 tide gauges and 1 tsunamimeter.
- Determine the number of necessary sirens and finalize an equipment-development plan for the islands, in collaboration with the High State Authority of New Caledonia, the Overseas Ministry and the local elected officials of the French territories in this zone.
- Finalize the specialized tsunami emergency plan for New Caledonia and Wallis and Futuna.

- Install 3 tide gauges transmitting their data in real-time on the borders of French Polynesia, in order to complete this zone's warning system.
- Provide CEA with an official mandate, so that LDG/Pamatai can take on a mission of cooperation with regard to tsunami warnings for the Pacific region and provide it with sufficient funding for it to carry out several assessment and training missions per year.

CONCLUSION

Immediately following the Sumatra tsunami, France committed itself to contributing to set up tsunami warning systems in the Indian Ocean, the Mediterranean/northeast Atlantic zone and the Caribbean.

Three years later, things have not turned out nearly as well as initially expected: insofar as La Réunion is principally threatened by regional and tele-tsunamis, with relatively long reaction times, the warning system set up is globally effective. Currently, Météo France receives the messages issued by PTWC and JMA, which it then transmits unaltered to the prefecture. However, contrary to the stated objectives during the definition of the Indian Ocean warning centre's mission in 2005, there is no scientific body carrying out complementary evaluations. In addition, the data transmitted by France to the international warning centres is limited due to the delay in installing and updating the tide gauges and seismic stations.

In the Mediterranean and the Caribbean, the situation is worrying because France remains completely powerless in the face of an eventual tsunami: France has no measuring devices for the detection of tsunamis, no specialized emergency plan has been finalized by the civil-protection services, and due to insufficient public awareness it is more than likely that the local populations would not know what to do in the event of a tsunami.

However, France's coasts could be struck by a tsunami at any time.

Tsunamis certainly represent a rare phenomenon; for example, a devastating tsunami is estimated to occur once every century in the Mediterranean basin, the last dating back to 1908 in the Straight of Messina and claiming 35,000 victims. Therefore, must we set up a tsunami warning system, given the relatively low chance of such an event occurring?

Following the Sumatra tsunami, the response of the international community, including France, was yes, we should. Indeed, all countries agreed that they could not remain inactive, when it is immediately possible to limit the dramatic consequences of a tsunami on the coastal populations. Therefore, we should respect the commitments we have made and set up the tsunami warning systems planned for each basin.

France's widely scattered territories and the vulnerability of each of its coasts in all four basins should lead it to play a driving role in the elaboration of these warning systems. Indeed, France must set up its own national warning system, in order to reduce the tsunami-vulnerability of its coastline. The setting up of warning systems at the international level must therefore be viewed as an opportunity, because their effectiveness should be reinforced by the multiplication of seismic and sea-level data, and it should also be possible to mutualize certain investment and operating costs between those countries interested in creating and maintaining such a system.

After two years of following a wait-and-see policy, France finally seems to be ready to assume its responsibilities. During the Lisbon session of the ICG/NEAMTWS in late November 2007, for the first time, France demonstrated its interest in housing a regional warning centre and set about creating a task team responsible for finalizing this future centre's structure and means, establishing a calendar for its creation and evaluating its costs. The results will be presented during the next meeting of the ICG/NEAMTWS in Greece in October 2008.

In parallel with this initiative, the government has decided to create a National Committee coordinated by the Department of the Sea, responsible for setting up a national monitoring and warning system for coastal submersions of oceanic origin.

Your rapporteur is pleased to see that the government is finally becoming aware of France's need to limit the tsunami-vulnerability of its coasts, by setting up a national warning system. In addition, the attribution of this project to the Department of the Sea should encourage the definition of a structure that takes into account the needs of each basin and the determination of the each partner's representatives.

Nevertheless, your rapporteur wonders about the financial means that the government is ready to dedicate to these two actions.

The absence of any financial commitment in the proposal made in Lisbon can be interpreted as the government's desire to question the other member states as to their eventual contributions before making its own proposals. However, it should be pointed out that the delays in setting up a warning system for the Mediterranean have resulted from this very same reluctance on the part of the concerned countries to commit themselves financially. If France believes that the security of its coasts demands the creation of such a system, it will have to accept to fund at least its initial version, without waiting for a commitment on the part of the other countries.

Furthermore, your rapporteur would like to repeat his worries concerning the integration of the tsunami warning system into a multi-risk approach that threatens to bog down the project.

Finally, your rapporteur would like to once again point out the need to accelerate the setting up of a warning system for the West Indies, due to the tsunami-vulnerability of these French *départements*. The project for a national monitoring and warning system must therefore cover not only metropolitan France, but also the overseas territories.

France's new-found enthusiasm for setting up a national tsunami-warning system should result in its rapid implementation. However, it is likely that the initial system prove imperfect, due to its dependency on data transmitted by foreign countries. Indeed, as long as the seismic and sea-level data gathered by the North African countries remains unavailable, the system will remain imperfect.

In order to verify that progress is made in setting up a tsunami warning system, your rapporteur proposes that this project be monitored. Immediately prior to the next meeting of the ICG/NEAMTWS in October 2008, the OPECST will hold public hearings to evaluate the progress made not only in setting up the national warning system, but also concerning the warning systems for the Mediterranean/northeast Atlantic, the Caribbean and the Indian Ocean.

APPENDICES

APPENDIX 1 -

LIST OF ABBREVIATIONS

ANR	Agence Nationale de la Recherche ("National Research Agency")
BIGSETS	BIG Sources of Earthquake and Tsunami in South West Iberia
BRGM	Bureau de Recherches Géologiques et Minières ("Geological and Mining Research Bureau")
CANCA	Communauté d'Agglomérations Nice-Côte d'Azur ("Urban Community of Nice-Côte d'Azur")
CEA	Commissariat à l'Energie Atomique ("Atomic Energy Commission")
CETMEF	Centre d'Etudes Techniques Maritimes Et Fluviales ("Maritime and River Technical Research Centre")
CIIT	Centre International d'Information sur les Tsunamis ("International Tsunami Information Centre")
CNES	Centre National des Etudes Spatiales ("National Space Research Centre")
CNRS	Centre National de la Recherche Scientifique ("National Scientific Research Centre")
COGIC	Centre Opérationnel de Gestion Interministérielle des Crises ("Operational Centre of Interdepartmental Crisis Management")
IOC	Intergovernmental Oceanographic Commission
EMSC	European-Mediterranean Seismological Centre
DART	Deep-ocean Assessment and Reporting of Tsunamis
DASE	Département Analyse, Surveillance, Environnement ("Analysis, Monitoring, Environment Department")
DDSC	Direction de la Défense et de la Sécurité Civiles ("Defense and Civil Security Department")
DEWS	Distant Early Warning System
DGCID	Direction Générale de la Coopération Internationale et du Développement ("Directorate General of International Cooperation and Development")
DONET	Dense Oceanfloor Network system for Earthquakes and Tsunamis

DPPR	Direction de la Prévention des Pollutions et des Risques ("Department of Pollution and Risk Prevention")
EMSO	European Multidisciplinary Seas Observation
EOST	Ecole et Observatoire des Sciences de la Terre ("Earth Sciences School and Observatory")
ESA	European Space Agency
ESONET	European Seas Observatory NETwork of excellence
FIDES	Fonds d'Investissement pour le Développement Economique et Social ("Investment Fund for Economic and Social Development")
FUNVISIS	FUNdación Venezolana de Investigaciones SISmologicas ("Venezuelan Foundation for Seismological Research")
GAO	Government Accountability Office
GEOSS	Global Earth Observation System of Systems
GIS CURARE	Groupement d'Intérêt Scientifique "Centre Universitaire de Réflexion pour une Agence des Risques Environnementaux" ("Scientific Interest Group – University Study Centre for an Environmental Risks Agency")
GITEC	Genesis and Impact of Tsunamis on European Coasts
GITEWS	German-Indonesian Tsunami Early Warning System
GLOOS	Global Ocean Observing System
GLOSS	GLObal Sea level observing System
GMES	Global Monitoring of Environment and Security
GPRS	General Pocket Radio Service
ICG / ITSU	International Coordination Group for the Tsunami Warning System in the Pacific
IFREMER	Institut Français de Recherche pour l'Exploration de la MER ("French Research Institute for Sea Exploration")
IGN	Institut Géographique National ("National Geographic Institute")
IISEE	International Institute of Seismology and Earthquake Engineering
INGV	Istituto Nazionale di Geofisica et Vulcanologia ("National Geophysics and Vulcanology Institute")
INPI	Institut National de la Propriété Intellectuelle ("National Intellectual Property Institute")

INSU	Institut National des Sciences de l'Univers ("National Space Sciences Institute")
IPGP	Institut de Physique du Globe de Paris ("Paris Institute of Global Physics")
IRD	Institut de Recherche pour le Développement ("Research Institute for Development")
IUGG	International Union of Geodesy and Geophysic
JAMSTEC	Japan Agency for Marine-earth Science and TEChnology
JICA	Japon International Cooperation Agency
JMA	Japan Meteorological Agency
LDG	Laboratoire de Géophysique ("Geophysics Laboratory")
LEGOS	Laboratoire d'Etudes en Géophysique et Océanographie Spatiales ("Research Laboratory in Spatial Geophysics and Oceanography")
NEAREST	Integrated observations from NEAR shore sourcES of Tsunamis
NERIES	Network of Earthquake Research Institutes for Earthquake Seismology
NIED	National research Institute for Earth science and Disaster prevention
NOAA	National Oceanic and Atmospheric Administration
NTHMP	National Tsunami Hazard Mitigation Program
NWPTAC	North West Pacific Tsunami Advisory Center
WMO	World Meteorological Organization
UN	United Nations
OVSG	Observatoire Vulcanologique et Sismologique de la Guadeloupe ("Vulcanological and Seismological Observatory of Guadeloupe")
OVSM	Observatoire Vulcanologique et Sismologique de la Martinique ("Vulcanological and Seismological Observatory of Martinique")
PSS	Plan de Secours Spécialisé ("Specialized Emergency-Assistance Plan")
PTWC	Pacific Tsunami Warning Center
RATCOM	Réseau d'Alerte aux Tsunamis et CÔtiers en Méditerranée ("Tsunami Warning Network for the Mediterranean Coasts")
RFO	Réseau France Outremer ("Overseas France Network")

RONIM	Réseau d'Observatoires du NIveau des Mers ("Network of Sea-Level Observatories")
ROSAME	Réseau d'Observation Subantarctique et Antarctique du niveau de la Mer ("Subantarctic and Antarctic Sea-Level Observation Network")
SAFER	Seismic eArly warning For EuRope
SEAHELLARC	SEismic risk Assessment and mitigation scenarios in Western HELLenic ARC
SHOM	Service Hydrographique et Océanographique de la Marine ("Hydrography and Oceanography Department of the Navy")
ISDR	International Strategy for Disaster Reduction
GTS	Global Telecommunication System
SPANET	South PAcific broadband seismic NETwork
ISS	International Surveillance System
CNTBT	Comprehensive Nuclear-Test-Ban Treaty
TRANSFER	Tsunami Risk ANd Strategies For the European Region
TREMORS	Tsunami Risk Evaluation through seismic MOment from a Real-time System
TWO	Tsunami Warning and Observations
UNESCO	United Nations Educational, Scientific and Cultural Organization
VSAT	Very Small Aperture Telecommunications
WC-ATWC	West Coast – Alaska Tsunami Warning Center

APPENDIX 2 -
LIST OF PERSONS INTERVIEWED

I. IN FRANCE

- Serge ALLAIN, the Navy's Hydrographic and Oceanograhic Department
- Philippe AUDEBERT, Head Clerk, Major Risk Management Office, Ministry of the Interior
- Simon BABRE, Principal Private Secretary to the Director of Political, Administrative and Financial Affaires, Junior Minister's Office for the Overseas Territories
- Patricio BERNAL, Assistant Director of the Intergovernmental Oceanographic Commission
- Pascal BERNARD, Institut de Physique du Globe de Paris ("Paris Institute of Global Physics")
- Catherine BERSANI, Chief Inspector for Equipment
- Georges BOUDON, Institut de Physique du Globe de Paris ("Paris Institute of Global Physics")
- Pierre BRIOLE, Director of Research at the CNRS ("National Scientific Research Centre"), Ecole Normale Supérieure
- François BRUN, Assistant Director, Institut Géographique National ("National Geographic Institute")
- Geoffroy CAUDE, Director, Centre d'Etudes Techniques Maritimes et Fluviales ("Maritime and River Technical Research Centre")
- Adolphe COLRAT, Director of Political, Administrative and Financial Affaires, Junior Minister's Office for the Overseas Territories
- Pierre COCHONAT, Programme and Strategy Department, IFREMER ("French Research Institute for Sea Exploration")
- Vincent COURTILLOT, Director, Institut de Physique du Globe de Paris ("Paris Institute of Global Physics")
- Bertrand DUCROS, Head of the Civil Security Mission, Junior Minister's Office for the Overseas Territories

- Bruno FEIGNIER, Director, Analysis, Monitoring, Environment Department
- René FEUNTEUN, Pollution and Risk Prevention Department, Ministry of Ecology and Sustainable Development
- François GÉRARD, President of the National Committee of the Intergovernmental Oceanographic Commission
- Bruno GOFFÉ, Centre National de la Recherche Scientifique ("National Scientific Research Centre")
- Xavier de la GORCE, General Secretary of the Department of the Sea
- Elie JARMACHE, Department of the Sea
- Anne LE FRIANT, Institut de Physique du Globe de Paris ("Paris Institute of Global Physics")
- Dominique LE QUÉAU, Director, Institut National des Sciences de l'Univers ("National Space Sciences Institute")
- Joël L'HER, Centre d'Etudes Techniques Maritimes et Fluviales ("Maritime and River Technical Research Centre")
- Philippe LOGNONNÉ, Researcher, Institut de Physique du Globe de Paris ("Paris Institute of Global Physics")
- Jean-Claude MALLET, former Post-Tsunami Interministerial Delegate
- Jean-Pierre MAC VEIGH, Associate Director for the French Overseas Territories, Météo France (French Meteorological Service)
- Hormoz MODARESSI, Bureau de Recherches Géologiques et Minières ("Geological and Mining Research Bureau")
- Denis MOUSSON, Fire and Emergency Services Department, Val d'Oise
- Rodrigo PEDREROS, Bureau de Recherches Géologiques et Minières ("Geological and Mining Research Bureau")
- Jean-Claude PETIT, Director of Programmes, Atomic Energy Commission
- Philippe SABOURAULT, Pollution and Risk Prevention Department, Ministry of Ecology and Sustainable Development
- Lieutenant Colonel SARRON, Head of the Interministerial Crisis Management Centre
- François SCHINDELE, Senior Expert on Tsunamis, Commissariat à l'Energie Atomique ("Atomic Energy Commission")
- Michel SEGARD, Pollution and Risk Prevention Department, Ministry of Ecology and Sustainable Development

- Eléonore STUTZMANN, Director, GEOSCOPE
- Monique TERRIER, Bureau de Recherches Géologiques et Minières ("Geological and Mining Research Bureau")
- Jacques VARET, Director of Prospecting, Bureau de Recherches Géologiques et Minières ("Geological and Mining Research Bureau")
- Guy WOPPELMANN, University of La Rochelle

II. VISITS

A. VISIT TO MARTINIQUE

- Sara BAZIN, Director, Volcanic and Seismological Observatory of Martinique
- Laurent BIGOT, Principal Private Secretary to the Prefect
- Jean-Marc BONNET, Director of the Inter-regional Antilles-French Guiana Department of Météo France (French Meteorological Service)
- Philippe COVA, Chief of Staff for the West Indies
- Yves DASSONVILLE, Prefect
- Raymond JEAN-NOEL, Head of the Interministerial Department of Civil, Economic, Defense and Civil-Protection Affairs
- Claude LISE, Senator of Martinique
- Lieutenant Colonel Vincent PALCY, Fire and Emergency Services Department
- Max REYAL, Météo France (French Meteorological Service)
- Yves SIDIBE, Director of Infrastructure and Water at the Departmental Council of Martinique
- Narcisse ZAHIBO, Senior Lecturer, University of the West Indies and French Guiana

B. VISIT TO NICE

- Michel BACOU, Project Head for the "Natural Risks" Mission, Regional Environmental Department
- Vincent CHERY, Departmental Head, Force 06

- Yannick DORGIGNE, Project Head, Policy and Monitoring Committee for Seismic Risk, Environmental Department, Greater Nice/Côte d'Azur
- Anne DESCHAMPS, Director of Research, CNRS ("National Scientific Research Centre")
- Anne-Marie DUVAL, Centre d'Etudes Techniques de l'Equipement ("Technical Equipment-Research Centre")
- Jean-François FABRE, Director of Aquatic Environments and the "Bay Contract", Environmental Department, Greater Nice/Côte d'Azur
- Yannick FERRAND, Engineer, Department of Urban-Risk Prevention, City of Nice
- Stéphane GAFFET, Researcher, CNRS ("National Scientific Research Centre")
- Jean-Marc GUERIN, Director, Ecology and Sustainable Development Department, Departmental Council of the Alpes-Maritimes
- Marc LAFAURIE, Deputy Mayor, Vice President of Greater Nice/Côte d'Azur
- Jessica LE PUTH, Engineer, GEOAZUR
- William MARTIN, Interministerial Director of Defense and Civil Protection, Prefecture of the Alpes-Maritimes
- Josiane NOEL, Engineer, Department of Urban-Risk Prevention, City of Nice
- Christophe PREZ, Project Head for the cabinet of Marc LAFAURIE
- Yves PRUFER, Environmental Director, Greater Nice/Côte d'Azur
- Monique RAGAZZI-CAZON, Assistant Director, Department of Strategy, Sustainable Development and Nature, Departmental Council of the Alpes-Maritimes
- Claire-Anne REIX, Project Head, GMES (Global Monitoring of Environment and Security), Thalès Alenia Space
- Olivier SARDOU, Engineer, GIS CURARE ("Scientific Interest Group – University Study Centre for an Environmental Risks Agency")
- Jean VIRIEUX, Director, GIS CURARE ("Scientific Interest Group – University Study Centre for an Environmental Risks Agency")

C. VISIT TO BRUSSELS

- Christine BERNOT, Director of Scientific and Technical Projects, General Directorate for Enterprises, European Commission

- Peter BILLING, Civil Protection Service, General Directorate for the Environment, European Commission
- Karen FABBRI, General Directorate for Research, European Commission
- Jean-Paul MALINGREAU, Service Head, Joint Research Centre
- Josiane MASSON, Director of Scientific and Technical Projects, General Directorate for Enterprises, European Commission

D. VISIT TO FRENCH POLYNESIA

- Luc FAATAU, Minister of Property and Development
- Yves HERMANN-AUCLAIR, Assystem
- Pascal MAINGUY, Director of Civil Protection
- Dominique REYMOND, Director of LDG/Pamatai ("Geophysics Laboratory")
- Alexis ROSTAND, Captain, Marines and Naval Aeronautics
- Benoît TREVISANI, Principal Private Secretary to the High Commissioner

E. VISIT TO THE UNITED STATES

- Cheryl L. ADERSON, Director Hazard, Climate & Environment Program, Social Science Research Institute, University of Hawaii
- Leighton AH COOK, Branch Chief - Training, Education and Information, Hawaii State Civil Defense
- Jeanne BRANCH JOHNSTON, Earthquake and Tsunami Program Planner, Hawaii State Civil Defense
- Kwok Fai CHEUNG, Chair and Professor - Dept of Ocean & Resources Engineering, Department of Ocean & Resources Engineering
- Delores CLARK, Public Affairs Officer, National Oceanic and Atmospheric Administration
- Walter C. DUDLEY, Professor, Kalakaua Marine Education Center, University of Hawaï
- Ken GILBERT, City and County of Honolulu
- Harry KIM, Mayor of Hilo

- Laura S.L. KONG, Director, International Tsunami Information Center
- Charles McCREERY, Director of the National Weather Service, Pacific Tsunami Warning Center
- Ed TEIXEIRA, Deputy Director, Hawaii State Civil Defense
- LTC Stanley E. TOY, Chief of Operations, Joint Task Force
- Stuart WEINSTEIN, Pacific Tsunami Warning Center
- Brian S. YANAGI, Disaster Management Specialist, International Tsunami Information Center

F. VISIT TO JAPAN

- Yushiro FUJII, International Institute of Seismology and Earthquake Engineering
- Yohei HASEGAWA, Chief Researcher, Meteorological Research Institute
- Yutaka HAYASHI, Senior Researcher, Meteorological Research Institute
- Shigeshi HORIUSHI, National Research Institute for Earth Science and Disaster Prevention
- Nobuo HURUKAWA, Director, International Institute of Seismology and Earthquake Engineering
- Hidemi ITO, Meteorological Research Institute
- Osamu KAMIGAICHI, Senior Coordinator for International Earthquake and Tsunami Information, Japan Meteorological Agency
- Kazushige OBARA, Earthquake Research Department, National Research Institute for Earth Science and Disaster Prevention
- Yasunori OTSUBO, Tokyo Town Council
- Bunichiro SHIBAZAKI, Chief Seismologist, International Institute of Seismology and Earthquake Engineering
- Hiromi TAKAYAMA, Meteorological Research Institute
- Toshio WATANABE, Tokyo Town Council
- YAMASAKI, Fire and Disaster Management Agency

G. VISIT TO ITALY

- Dr. Alessandro AMATO, Director of the seismic surveillance network at the Instituto Nazionale di Geofisica e Vulcanologia ("National Geophysics and Vulcanology Institute")
- Mauro DOLCE, Civil Protection Service
- Professor Stefano TINTI, Instituto Nazionale di Geofisica e Vulcanologia ("National Geophysics and Vulcanology Institute")