DECLARATION OF ROBINSON HORDOIR, Ph.D.

I, Robinson Hordoir, Ph.D., state and declare as follows:

1. I make this declaration subject to penalties for perjury pursuant to 28 U.S.C. § 1746.

2. I am employed as a researcher by the Swedish Meteorological and Hydrological Institute ("SMHI"). SMHI is an agency of the Swedish government. Information about SMHI can be found at http://www.smhi.se/en. I am a French national and I am fluent in English, among other languages.

3. I received by doctorate degree from the University of Caen which is located in Caen, Normandy, France. I received my Ph.D. in 2007 in Physical Oceanography. My curriculum vitae is attached to this Declaration. A significant research topic that I undertook in earning my Ph.D. degree was an investigation into the extent to which freshwater discharged from the Mekong River influences ocean water in the coastal area adjacent to the Mekong Delta. The results of this study were published in *Journal of Geophysical Research*, a peer-reviewed journal of the American Geophysical Union (AGU). The article is referenced as: Hordoir, R., K. D. Nguyen, and J. Polcher (2006), *Simulating Tropical River Plumes, A Set Of Parametrizations Based On Macroscale Data: A Test Case In The Mekong Delta Region*, J. Geophys. Res., 111, C09036, *doi:10.1029/2005JC003392* (hereafter referred to as the "Mekong Delta Plume Study").

4. The object of the Mekong Delta Plume Study was to model the Mekong River plume and its impact along the coastal waters of southern Vietnam. Most rivers create plumes. A plume is formed when the outflow of fresh water from a river system empties into a larger body of water. The plume, generally speaking, is the area of the larger body that is influenced by the fresh water discharge. The existence of the plume is mostly related to the salinity difference between river water (ie. : freshwater) and that of the larger body that is the sea in most cases. Because of their density difference, river water and sea water do not mix immediately but create a density front. The presence of the front usually creates a coastal current that is influence by the Earth rotation (also known as the "Coriolis Force"). This phenomenon is extremely close, from a physical point of view, to that of "Thermal Wind" that most people also refer to as "Sea Breeze". The input of freshwater creates what is called a "baroclinic" current in the coastal area. "Baroclinic" is a term that is used both in Ocean and Atmospheric dynamics, and that refers to this density difference. This baroclinic current is made of two layers, the upper layer that is a mix of freshwater and sea water, and the lower layer that is mostly sea water. This dual system can be described as a "coastal overturning" : the input of freshwater attracts sea water below the river plume and that sea water eventually becomes mixed with freshwater when it reaches the vicinity of the river mouth. This mix of freshwater and sea water is the main body of the upper part of the plume. If wind blows in the same direction as the coastal current, or if wind can be negated, this coastal current becomes "coastally trapped". This means it flows with the coast on its right (in the Northern Hemisphere), and flows parallel to the coast. For major river systems, like the

Mekong River, or the Amazon or Mississippi, the river's plume can be considerable. Depending on latitude, on meteorological, oceanographic and other conditions, a river's plume may extend hundreds of kilometers from the river's delta area. Some coastal currents like the Norwegian Coastal Current that flows all along the Norwegian coast, extend from the South of Norway up to the Arctic Ocean. In the case of the Norwegian Coastal Current, it is mostly explained by the freshwater outflow from the Baltic Sea. Because of their nature, the width of these currents are highly influenced by latitude. In tropical regions, such currents have a higher width because of the lower Coriolis force, whereas this width is smaller closer to the poles. Obviously, the closer the plume to the mouth of the river, the higher the percentage of river water that is mixed in thewater of the receiving body. These dynamics are now quite well understood to Physical Oceanographers around the world thanks to measurements and numerical models.

5. The Mekong River is one of the world's major rivers. It is the world's 12th-longest river and the 7th-longest in Asia. Its estimated length is 4,350 km (2,703 mi), and it drains an area of 795,000 km2 (307,000 sq mi), discharging 475 cu. km. (114 cu mi) of water annually. The Mekong flowing southwesterly through Vietnam and empties into the South China Sea through several channels that form the very extensive Mekong Delta.

6. Ships anchored or operating off the coast and in the territorial seas of southern Vietnam would have been within the plume of the Mekong and other rivers. The phenomena would be greatest off the Mekong Delta due to the force of the river discharge and the length of the plume. Bays and harbors that were surrounded on three sides by lands, would somewhat concentrate the effect of the fresh water discharge and the water in those bays and harbor would be expected to have a lower salinity than in the area seaward of the bay or harbor.

7. In Southeast Asia and, specifically in the Mekong River basin, the month of November can be considered as the end of the wet season from a climatological point of view. During that period, I calculate the total freshwater discharge of the Mekong delta at 10,000 - 15,000 cubic meter per second (approximately 353,000 - 529,000 cu. ft per second). At that time of the years, the prevailing wind in the area of the Mekong Delta would be out of the northeast blowing southwest.

8. Based on these meteorological and hydrological elements, in November 1966, a coastally trapped baroclinic circulation of Mekong River water would be headed in a southwesterly direction. Baroclinic flow would cause Mekong River water to be transported into the area where U. S. Navy ships sailed or were anchored. Prevailing winds from the northeast contribute to the trapping of the freshwater close to the coast. This baroclinic current reaches its highest width off the southern-most point of the Mekong delta where all the freshwater from all the mouths of the delta meet to form a surface current flowing parallel to the coast. I would estimate the width of this current to be in a range from 20 nautical miles to 50 nautical miles.

9. Based on the kind of computer modeling used in the Mekong River Plume Study it is evident

that the territorial seas off the Mekong Delta are heavily influenced by the freshwater outflow from the Mekong River.

10. Based on these salinity data, one can estimate that the percentage of Mekong river water at the sea surface of the area in the territorial seas off the Mekong Delta in the fall of 1966, at between 51% and 72%. To put it more simply, using our modeling techniques, about half to three quarters of the water surrounding ships in the territorial seas off the Mekong Delta would have been water from the Mekong River.

11. I am able to estimate that the baroclinic current of circulating Mekong River water would have had a depth of anywhere from 5 to 10 meters, which is well within the draft of most U. S. Navy ships operating off Vietnam. Ships operating within the ten fathom curve (18.28 meters) would be operating primarily in Mekong River water.

12. It should be noted that during the monsoon season, the prevailing winds in the Mekong Delta are out of the southwest blowing to the northeast. This change in wind direction results in Mekong River water being driven away from the coast. A ship sailing miles away from the Mekong Delta coast, would therefore sail in an area which surface water is heavily influenced by the Mekong River. On the contrary, during that precise season, a ship anchored close to the Vietnamese coast but a few miles south west of the southernmost delta branch, would notice the presence of only a small percentage of Mekong river water at the surface of the sea. I say this to make the point that it is unscientific to believe that there is a precise boundary between river water (brown water) and ocean water (blue water) within what is referred as the "Region of Freshwater Influence" of the Mekong river. In a system like the Mekong Delta, the flow of river water and its mixture with sea water is complex and subject to a number of variables. I also wish to add that in the case of the territorial sea off the Mekong river branches it is very unlikely that the percentage of Mekong river water could have been less than 20% at the sea surface regardless of the season. The end of the wet season (from October to December) coincides with the highest probability of having a high percentage of Mekong river water close to the coast. The end of the wet season is this only time of the year that makes it possible to have both a high river discharge and wind blowing from the north East which ensure freshwater is trapped close to the Mekong delta coast and flowing towards the southwest.

13. During the period January to September, the winds and currents will be running the opposite direction causing the Mekong plume to drift away from the coast towards the South East. In this precise case, the process that affects the freshwater is wind driven only from an energetical point of view. However, the high density difference created by the freshwater close to the surface traps the wind power in a thin layer, which causes this advection process to be very efficient into bringing the river water very far offshore with little mixing. It is therefore possible to find relatively high concentrations of Mekong river water close to the surface of the ocean far off the coast of Vietnam.

14. The same effect as the Mekong plume, albeit reduced in scope, will occur throughout the territorial seas of Vietnam where rivers and streams discharge into the South China Sea. As I previously stated, the effect would contain a higher percentage river water within harbors and bays surrounded on three sides by land.

15. I have reviewed the attached chart of the South China Sea and observed the dashed line marking the presence of what is believed to be the territorial seas. It is very probably that water from the Mekong and other rivers would be discharged into the territorial seas if one considers the territorial sea of Southern Vietnam. Ships operating in that area would be very likely to encounter river water at some point during their operation. For other coastal areas, especially located on the Eastern Coast of Vietnam, and not located in the region of freshwater influence of the Mekong river, there is no river that has a flow comparable to that of the Mekong. However, this coast counts many smaller rivers and estuaries, and it is most likely that the freshwater coming from such rivers accumulate into forming a slow baroclinic motion towards the south, which effect can be measured in terms of low salinity anomaly. In harbors and bays in which such rivers end up their continental journey, their effect is of course even more undeniable.

16. Sediment is included in the river discharges and the undissolved solids would accompany the river water. Ships operating within the territorial seas would be expected to steam through this sediment. Sediment that emulsified and fell to the sea bed would be disturbed by anchoring, setting the anchor and high speed runs up and down the coast. These disturbances would cause the sediment to re-suspend.

I declare under penalty of perjury under the laws of the United States of America, that the foregoing is true and correct.

Executed this 13th day of January, 2014.

Robinson Hordoir, Ph.D.