Witness: Ralph T. Cheng

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Called by: People (prosecution)

Phase: Guilt

Examinations: Direct – David Harris; Direct (resumed)

Day 1 of 2 for this witness

Court: San Mateo County Superior Court, Redwood City (People v. Scott Peterson)

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JUDGE: All right. Let the record show the jury's been excused for the afternoon recess. And I understand the next witness is going to be Dr. Cheng?

HARRIS: Yes.

JUDGE: Is that right? C-H-E-N-G?

HARRIS: Yes.

JUDGE: Okay. And there's some -- something you want me to look at, of some maps?

GERAGOS: Yeah, I'd like you to take -- probably just best if you take a look at it, and then after you looked at it, then I'll make the arguments. Going to take you a little while to look at this stuff.

JUDGE: How much?

HARRIS: It's a PowerPoint presentation. I think there was 23 or 26 lines. I've printed it out in hard copy form so you can look at.

JUDGE: You want to pass it up here? Okay. Very interesting. I've seen that. What's the objection?

GERAGOS: There's no foundation for this as any kind of scientific theory.

JUDGE: Are you saying we need a Kelly-Frye?

GERAGOS: Yes.

JUDGE: Oh, I don't think so.

GERAGOS: It's going to become readily apparent when you hear the testimony.

JUDGE: Well, I don't -- well, I don't think we have to have a Kelly-Frye to have somebody testify as to tides. That's generally accepted in the scientific community. They've been charting tides since Sir Francis Drake went up the coast.

GERAGOS: Sir Francis Drake wasn't asked to predict where bodies were going to float based on certain --

JUDGE: Well, is he going to predict where the bodies ended up?

GERAGOS: Yes.

JUDGE: Or is he just going to say this is where the tide and this is possibly where the bodies could end up?

HARRIS: There was two phases of his work. We aren't really interested in the first phase, but we believe the defense will probably ask about that. The Modesto Police Department contacted him before the bodies were found and said, based on the currents and all the different factors in the Bay, where would a body go based on where an estimate is of where it's placed. So he did some computer simulations for them based on that. After the bodies were recovered, he then went back and plotted, based on where they were recovered, going back, based on wind conditions, tide conditions, currents, trying to predict the most likely location where it's at. With regards to that, counsel's already elicited a lot of that core information through Detective Hendee, asking about the FBI searches and saying Didn't Dr. Cheng predict this particular location.

GERAGOS: Which is that -- which is reasonable, given the fact that they testified and brought up the Bay search and why they were searching in specific areas. The second part of their prong, which is kind of a revisionist history, so to speak, has to be subject to Kelly-Frye. You can't have somebody come up -- I don't believe that there has ever been admitted into evidence the proposition which they are going to do, which is -- in actuality, in some ways, I want it to come in because I believe his ultimate conclusion is that he can't say anything about Laci.

JUDGE: Then why are you objecting?

GERAGOS: Well, because he's got a -- observations about Conner which I think, besides being ludicrous, there is no basis upon which he can come to that conclusion.

JUDGE: Well, I don't think that this is the subject matter of Kelly-Frye. I mean, you know, this is -- this is most -- a lot of this stuff is, you know, the -- the -- why the sea level rises, why the sea level goes down. That's generally accepted in the scientific community, and I don't think you have to have Kelly-Frye to determine that. And with respect to his opinion, I think that goes to the weight rather than the admissibility.

GERAGOS: What? I'm sorry, I didn't hear the last part.

JUDGE: It goes to the weight rather than admissibility.

GERAGOS: Not admissibility.

JUDGE: Pardon me?

GERAGOS: I said it goes to weight, not admissibility.

JUDGE: Yeah. It's going to come in, okay?

GERAGOS: (Nods head)

Direct Examination by David Harris

HARRIS: Doctor, can you tell us, what is your occupation?

CHENG: I'm a Senior Research Hydrologist with the U.S. Geological Survey.

HARRIS: What is a Senior Research Hydrologist?

CHENG: My occupation is to conduct research, to investigate certain water properties and physical movement of water. My particular assignment is study the movement of water in San Francisco Bay.

HARRIS: And the movement of water in the San Francisco Bay, or in bays in particular, does it have a particular label or title?

CHENG: Currents. That is what you are referring to.

HARRIS: Are you also referred to as an Estuary Hydrologist?

CHENG: You can say that. Sometimes call ourself Shallow Water Oceanographer.

HARRIS: Okay. Regardless what the title is for what it is that you do for the U.S. Geological Service, do you have a background or education and training that allows you to do your job?

CHENG: Yes, I do. I'm educated from Berkeley with the higher degree from Berkeley studying aerodynamics actually transferred my field to study fluid movements in water bodies in the natural environment and water bodies. So the basic principles are the same, whether we study the flow around aircraft or flow in the lakes, or estuaries in this case. San Francisco Bay is one of the examples.

HARRIS: You indicated it was an advanced degree. Do you have a Masters and a PhD from Berkeley?

CHENG: That is correct.

HARRIS: And what were the actual fields of study that the degrees are in?

CHENG: Both were involving investigation of applied mathematics and fluid dynamics.

HARRIS: When you -- I don't want to date you. But when was it that you graduated from Berkeley?

CHENG: My higher degree is obtained in 1967.

HARRIS: And have you been working for the USGS since then?

CHENG: No. Actually I taught -- took a teaching job in the State University of New York in Buffalo for several years before I joined the U.S. Geological Survey in 1974.

HARRIS: And have you been working for the Federal Government since 1974?

CHENG: That is correct.

HARRIS: What is -- what is it that you do in terms of the work that you do for the USGS since 1974?

CHENG: Well, primarily I'm studying San Francisco Bay, among others. But my research involved in the team work. We have a team of scientists, researchers, looking at issues of San Francisco Bay, involving the movement of water, the chemistry, water quality, and biological activities in the bay. Of course, the task is huge. So my responsibility is studying the hydraulics, that is now the physical processes, how does the water move within The Bay.

HARRIS: This physical process of how water moves, can you explain that a little bit to us?

CHENG: In bays and estuaries, the movement of water is mostly driven by the tides. Tides are processes, the balancing of forces of the sun, the moon rotating around each other. And, of course, sometimes also affected by the river inflow. In our case, in San Francisco Bay the fresh water coming in from Sacramento River and San Joaquin River.

JUDGE: Before we get to the substance of his testimony, are you offering him as an expert?

HARRIS: I will in a moment. I was going to ask him a few more questions.

JUDGE: Okay.

HARRIS: Now, doctor, to help explain what currents are, tides, and how the moon, all those things relate, did you prepare a Power Point presentation prior to coming to court?

CHENG: Yes, I did.

HARRIS: And would that help us understand what some of your testimony is going to be?

CHENG: I hope so.

HARRIS: Okay. Prior to getting to the Power Point, in this particular field of hydrology, you have been doing this for a long period of time. Have you written anything, or published any works in

this particular area?

CHENG: Sure. I have published, I don't know -- I didn't count -- but many papers, scientific papers in the referee reviewed journals, and so forth, yes.

HARRIS: When you say refereed journals, that is a peer-review process?

CHENG: Peer-reviewed, yes. Independently refereed, then passing certain quality control criteria before it's published.

HARRIS: Have you also won any awards, or had any recognition for your work in this particular field?

CHENG: I have.

HARRIS: Could tell us about some of those?

CHENG: Well, I think I was promoted to Senior Research Hydrologist in early nineties. That was a recognition. That's actually a very rare recognition in the organization in the Federal Government in the research position. I have been awarded as the Engineer of the Year. I don't remember the exact year. Maybe in 1995. And been serving as advisor, serving on international conference organizations, boards, and so forth.

HARRIS: Just looking at your CV in front of me. In 1967 there was a Freeman Memorial Prize in Berkeley. Is that an award that you won?

CHENG: That was an award derived from my PhD thesis.

HARRIS: In 1984 was a service award from the USGS?

CHENG: Yes.

HARRIS: 1988 you won a National Science Foundation award?

CHENG: I don't recall any particular one. I believe so. If that's the record, yeah.

HARRIS: And you also, as part of the International Conference on Physics of Shallow Estuaries and Bays, did you do -- in 1989 receive a Special Achievement Award?

CHENG: That is correct.

HARRIS: Another Superior Service Award from the Department of Interior, 1989?

CHENG: That's correct.

HARRIS: And you were not sure of the year, see if this is the same the one. 1994, Federal Engineer of the year award from the National Society of Professional Engineers?

CHENG: That is correct.

HARRIS: And then also 1996 a Meritorious Service Award from the Department of Interior?

CHENG: Correct.

HARRIS: And 1999 a Legacy Award from the California State Lands Commission?

CHENG: Yes.

HARRIS: At this point in time –

Voir dire by Judge Delucchi

JUDGE: One other question. Have you ever qualified as an expert in court in the field hydrology?

CHENG: Never served as an expert witness before.

JUDGE: Qualified before?

CHENG: What do you mean by qualified?

JUDGE: Have you ever qualified as an expert in a court of law and given an opinion about hydrology prior to today?

CHENG: No.

JUDGE: This would be the first time?

CHENG: That's correct.

Voir dire by Mark Geragos

JUDGE: Did you have any questions you want to ask him, Mr. Geragos?

GERAGOS: It goes to just to his qualifications, to voir dire on the qualifications as an expert on hydrology?

JUDGE: Yes. If you want to voir dire him as to his qualifications. Do you have the CV there?

GERAGOS: Yes, I do. Doctor, as to your qualifications as a hydrologist, could I ask you, is that how you are employed by the USGS?

CHENG: Yes.

GERAGOS: And what do they have you do at the USGS?

CHENG: My particular position is to conduct basic research. As I explained, my particular assignment is to study those physical processes in San Francisco Bay in a team that addresses broad questions about San Francisco Bay.

GERAGOS: What kind of broad questions?

CHENG: Water quality, biological processes, and plankton balance. Basic environmental issues that come to pass.

GERAGOS: Okay. So is it fair to say that most of your experience or your work is involved in the environmental issues of The Bay?

CHENG: Well, that is the bigger brush question. My particular responsibility is concerning with the movement ofthe water that supports the research of broader issues.

GERAGOS: And the movement of the water as to how that affects things that are in the water?

CHENG: That is correct.

GERAGOS: And meaning, specifically, environmental factors in the water? When you say plankton, you are talking about biological organisms, correct?

CHENG: I'm providing the physical information, physical science information. The biologists and chemists take over that aspect of the research.

GERAGOS: Right. So you give them the research, if you will, on the --

CHENG: The results of the movement of water, how that -- when it happens, in what fashion, and at what degree and magnitude of the movement, in what direction, and so forth.

GERAGOS: And is it a -- is it a fair statement that nowhere in your work have you been asked, prior to this case, to ever give an opinion as to bodies floating up anywhere in the bay?

CHENG: That is correct.

GERAGOS: And is it a fair statement that you had said that this would not be -- or you made a statement that what they were asking you to do was not science, but just a estimate?

CHENG: Well, that -- it's based on science. But as you know being a lawyer, that you know that that's a disclaimer that all science has a little room of tolerance.

GERAGOS: Did you say that -- you called this just bold assumptions?

CHENG: Well, all science starts with bold assumptions, yes.

GERAGOS: Okay.

CHENG: But the important thing, the end result of validation. You can prove the assumption, then the result is valid.

GERAGOS: Right. But all what I'm asking you specifically, is, did you tell these people when they came to talk to you that the -- what they were asking you --

JUDGE: This goes to his opinion not to his qualifications.

GERAGOS: Well, I believe the qualifications -- I mean he is qualified as a hydrologist. What he's -- what they are asking him to do is a completely different matter.

JUDGE: Well, that may go to the weight the jury wants to assign his opinion, and that's a subject of cross examination. Any other questions as to his qualifications?

GERAGOS: No.

Judge Deluchi: Okay. Based upon his answers and his background, the Court will accept Doctor Cheng as an expert hydrologist and qualified to give an opinion about the movement of water in San Francisco Bay, among other things. Go ahead.

Direct Examination, resumed

HARRIS: If can he could have marked at this time a Power Point presentation.

JUDGE: That would be 283.

HARRIS: Doctor, if I can show you, 283 is a hard cop, a printout of the Power Point presentation that you prepared before coming to court?

CHENG: Yes, it is.

HARRIS: And is this Power Point presentation, as you indicated, something that you believe will help the jury understand your testimony?

CHENG: I believe so.

HARRIS: If I could go ahead and show you the Power Point presentation.

JUDGE: Are you going to have him use the laser?

HARRIS: We'll try it with the laser and, if not, we have the pointer available for him.

CHENG: Maybe the lady should move, otherwise I'll laser her hair.

HARRIS: Doctor, just starting right at the very beginning. This is kind of a title page of this particular Power Point. This is -- it says A Brief Overview of Tides, Tidal Currents, Winds, and Waves?

GERAGOS: No pun intended.

HARRIS: That's what we were about to talk about with this presentation?

CHENG: Yes.

HARRIS: Can you go through the next -- this particular slide and describe for us -- start to talk about what it is that happens with the movement of water in the San Francisco Bay?

CHENG: Really just an introductory slide to show what's to come. Preview the contents of this presentation. I'm going to address somewhat the property of the astronomical tides, that is referring to the movement of celestial bodies and tides in San Francisco Bay, and moving on to what tidal currents, typically referring to the rise and fall of water level alone, tidal currents, meaning the movement, the water velocity in particular in Central Bay using Central Bay tidal current movement in Central Bay as an example. Following that, I show -- I will discuss the wind

pattern over San Francisco Bay region. And wind, of course, generates the waves. Then I will go into the wave movement and what waves will do to the water body. Generally generates what we call the wind-driven drift, how the body floating in the wavy water condition that will be drifting along with the waves and current, and so forth.

HARRIS: Let me go to the next slide. This one we see is a tide definition. Could you take us through this?

CHENG: This is the typical illustration -- not to scale mind you, that it shows the pulling forces and the centrifugal forces that I mentioned. Now, these -- one of these, the moon, the sun, the earth. And for that matter, here they are in sort of rotational balance here. Therefore, we have two typical forces here. One is centrifugal force. Put this another way of seeing it, it's just like you have you and your friend holding your hands together. You are spinning together. You feel like you are being pulled away. That's called centrifugal force. And, again, there is certain force you need to hold your hands together. That's the attractive force, based on Newton's First Law which says big masses have a tendency to attract each other. They actually are in balance. However, there is a layer of water schematically on the surface of earth, and on the face of the side of the earth facing the moon is subject to stronger attractive force. Therefore, the water surface bulges up. That's how the water level rises. That's the high tide. The opposite side of the water of the earth here, because centrifugal force, it's in balance, because distance is large, have also a bulging up there. The tides caused by the moon actually there is two highs and two lows each day. The earth is spinning around itself here. Most observers standing on the surface of the earth, you experience basically, like you quickly walk around the earth here, one high, one low, and another high and another low. And sun will work in the same way. The combination of these heavenly bodies here causing the water to rise and fall. That's the basic definition of tide.

HARRIS: Let me go to the next slide. This one is titled "Spring Tide". And if you can tell us what a Spring Tide is?

CHENG: Typically tides in the system here is not equal in magnitude throughout the months here. So, therefore, we qualify that. Called first tide. Basically you have a higher magnitude than later. The next slide you will see the Neap tide is higher. Not when the sun and noon line up. They joint forces, the pulling forces on centrifugal forces are lined up. Basically have the additive effect therefore causing higher rise, higher fall of the water. So we are now in the full moon for example in the last few days here, we have Spring Tide right at the moment here. This is the so-called Spring Tide.

HARRIS: Going to the next slide.

CHENG: When they are not aligned up, some of the forces tend to cancel each other. We still will see the high and lows two times, except now the magnitude will not be as large, and some effect from the sun will cancel some effect from the moon, and so forth. Here that particular period of time is called a Neap Tide. Relatively speaking it's a weaker tide.

HARRIS: Going to the next slide. Looks like an math equation. If you can explain this to us.

CHENG: These not math equation this is summarizing. Maybe I can use the words here that now tides typically have two kinds. One we call Semi-diurnal tides. And the basic process happens twice a day. Two highs and two lows. There are certain other effects here, because the earth and moon are not really in a perfect plane. There are some other effects here which we really don't need to get into detail. There are certain tidal components we call -- happen once a day. The combination of these tides is the final result that we will see.

HARRIS: Now, how that relates here in The Bay is when we see the water come in, we see the water go out. And so you are saying that there is like two high tides a day, two low tides a day?

CHENG: That is correct. They are not equal. The point -- I used the slide here. All of the tidal motion, tides are generated by various different components, all add up together. So that they are not equal, just like a perfect science function here. They are unequal. And throughout the month you will see the Spring Tidal Period, Neap Tidal Period. I think I have a slide illustrating that particular part.

HARRIS: Look at the next slide, use that example?

CHENG: This is precisely what I am referring to. Now try to use plottings. This is the observation of water level at the Golden Gate, San Francisco Bay. And here you can see the whole month here. There is a whole cycle, about 28 days. Roughly ten days from the New Moon to Full Moon to New Moon again. So we are at the Full Moon stage here. This is what I referred to as the Spring Tide, that the sun and moon are lining up. They join forces to pull centrifugal forces. And during other periods of time -- for example, during these seven days here tidal amplitudes are relatively week. We call Neap Tides. We are going from Spring Tides to Neap Tides to Spring Tide to Neap Tide, and so forth, here. And enlarging, giving you some definition of terminology here. Enlarging a period of 24 hours -- 25 hours here. That here we see a higher -- we call higher high water. Then you go into a low water. But this time it's lower low water. Then you come to high tide again. However, this high tide is not as high as the higher high tide. So it's given the name called Lower High Water. Then this is a Higher Low Water. So we are going through these four cycles here. In the definition, when you pick up a NOAA Bathymetric chart, how deep the water is, they refer to how deep water. You will see the water depth is referred to Mean Lower Low Water. These are all the Lower Low Water. The average of the Lower Low Water is termed the Mean Lower Low Water. That's how the water depth is referenced.

HARRIS: Let me just stop you there for a second. If you look behind you at what's previously been marked as this

JUDGE: Doctor, you can use the pointer. Why don't you get it for him?

HARRIS: I'm just going to ask him a couple of questions. In particular chart, this is a nautical chart of the San Francisco Bay. You are referring to that Mean Lower Low Water. Which we see numbers on these type of nautical charts. Is it typically the Mean Lower Low Water mark that's being marked with those numbers?

CHENG: I think somewhere on the chart it should label the -- these numbers are water depths and reference to Mean Lower Low Water, that is correct.

HARRIS: In the area of navigation and hydrology, these tides and currents, is that Mean Lower Low Water, that kind of the mark that's used as a general rule?

CHENG: Well, you need to know what these numbers referred to, so you know what the actual water depth is. If you also know at what phase of the tide you are in when you sail into The Bay -- if you are at the phase of the tide, you can have an exact knowledge in that location what the water depth is there. It is important for navigation.

HARRIS: Looking at this particular slide, you were saying 24 hours 50 minutes, or 25 hours I think is what your testimony was. This cycle of going from the Higher High and to the Lower Low, is that a 24 -- is it a day cycle?

CHENG: It's -- well, we -- roughly at the -- actually the high water shifts by, roughly speaking, you see 50 minutes, roughly speaking. Just for estimate, the high water shifts one hour each day, because there is roughly 25 hours.

HARRIS: Looking at those particular things, I mean there is terminology that we may not be used to. So, again, you have got the tides just coming in higher at different parts of the day than other parts of the day?

CHENG: Sure. The tides vary throughout The Bay. The tide generated basically becomes a much larger body of water. Generally in the ocean, as the water rises and falls then pushes into The Bay, because of the bathymetry in The Bay I modified the tide here. We'll see it isn't similar on a Lower Low water and so -- but the magnitude and the phases -- so-called phases of the time of arrival will vary from different points in The Bay.

HARRIS: Okay. Let's go to the next slide.

CHENG: This might be a little bit too busy, but just to illustrate a point. This particular plot I have shows one month worth of tides. We can separate these are contributions from the two types of information. The 1- 0-1,and so forth, and so on. They are basically -- the point I'm seeing is now -- the end result of these tides is the combination of effect of these tidal components.

HARRIS: Okay. Going on to the next slide. Relating this to the San Francisco Bay.

CHENG: Yes. Now, as I have already mentioned, the tides are generated in the ocean. So as the high water rises in the ocean on this side here, the -- let me orient you a little bit. This is taken from navigation chart. Here is Marin County over here. Richardson Bay refers to -- Sausalito over here. Here is Raccoon Strait, Angel Island. There is the famous Alcatraz. And the City of San Francisco over here. That's the orientation of the map. And here it Golden Gate Bridge right on this. And the sailor, and the ocean -- the captain of the ocean liner, ship captain uses these charts which they have for navigation. Here they are marked sort of channel you should sail into, and so forth, on this side. I'll now show, outside of this slide is the Pacific Ocean. As the water rises -- as I say, the water sea level rises, the ocean -- I was referring to the Pacific Ocean -- pushes the water into The Bay generating the movement of water here. These arrows indicating the movement of water now. Not only indicating -- the arrow indicating -- the arrows indicate the direction and also the magnitude by its size. In other words, now, the larger arrow I employed on the slide meaning the water is moving faster. And the arrow orients according to the bathymetry that modified the slide.

HARRIS: Going to the next slide.

CHENG: Likewise as the sea level falls in the ocean, then actually it draws the water from the inside of The Bay into the ocean. Water moves out in a terminology we call it ebbing. The ebbing tidal cycle, current goes out. The Bay again, because of the geometry -- bathymetry distribution in the bay that varies, causes of the tidal current distribution. The stronger in the deeper channel over here, and weaker in other parts. Again the arrow represents the magnitude and the direction of the tidal current.

HARRIS: Now, looking at this particular slide, it looks like right around the Golden Gate Bridge area, those are pretty big arrows compared to looking at up by Angel Island around to the right side of Angel Island that are pretty small arrows.

CHENG: That is correct.

HARRIS: Can you explain that, why there is that difference?

CHENG: I think from our research, we have -- in our research we typically do some measurement by deploying instruments in The Bay. And so does NOAA, National Ocean and Atmospheric Administration. We collaborate. We put instruments in The Bay, measure, and from analyzing the data, we have come to a general conclusion water moves faster in the system in proportion to the water depths. In that, very clearly, the water depth under the Golden Gate is the deepest in this area. Water moves the fastest in a shallow area. I believe I have another slide that illustrates that point. In the Richardson Bay in relatively short -- water moves -- there are some small arrows. May not be able to see it, just because, as I say this arrow is meant to represent the intensity of the currents here. So currents are very weak in that low water, and very strong right underneath the Golden Gate.

HARRIS: Go to the next slide.

CHENG: So later I might have used terminology called Numerical Model. What Numerical Model is, I thought I would give a few words about the definition. Numerical Model, as I said now, the Numerical Model is based on the first principles, that is very basic assumption that we can base on those equations and compute the movement of water based on the conservation of mass, momentum, and energy. And these equations, by the way, are the same equations that we use to compute the flow around aircraft. I always find that to be amazing that we can turn metal, can fly in the sky a 747, then with the same equation we use -- more important, you can say people can generate and generate a bunch of numbers and the plots here, what make it the creditable or the reliable result is based on so-called validation. That is we now, not only have to just generate computer models, we need to go to the field to make measurements. To actually measure how fast water moves. We know that. Then we use numerical model and compare it with the observations. That particular process is called validation. So if a numerical model is not validated, it's not a valid result. So it's important that we go through these processes to develop credence, to give credence to the numerical model.

HARRIS: Going on to the next slide. This is -- it says an example of an application.

CHENG: Well, since we're talking about San Francisco Bay, I'm referring to one of the papers we published in 1993, talking about tidal and currents in San Francisco Bay using the model. The model has been carefully calibrated based on hundreds of measurements and so forth here. So that now the model results can be considered reliable. As I say, the paper was published in the refereed, reviewed journal. That's now gone through close scrutiny of the quality of the work, and dependable results. And based on that particular paper, we came to the general conclusion that the magnitude of tidal current is generally proportional to the water depth.

HARRIS: So then going on to the next slide. Is this kind of showing us --

CHENG: To further follow up that particular point here, as I say again, a snapshot. Remember now, tides are moving at every instance of time. Water rises and falls. This is just only a snapshot of tidal current distribution in the Central Bay. Here we show that now the current is strongest where the water is deepest right underneath the Golden Gate, this region here. We -- actually, if you look closely, marked shipping channels here, real larger vessels should follow those, travel through that region. Current is also very strong. And as they follow into the shallow area, current is very weak. When going to -- you can see, even to navigate in the chart here so a lighter color is a reflection of water depth. It is shallower in that area here than the water -- current there is very weak.

HARRIS: You have been talking about water current. Is water current different than waves?

CHENG: Very different. Waves, that's referring to the up-and-down motion. So it is similar to the tides, but they are talking -- we are talking about long wave and short wave. Up-and-down motion is called a wave. The current meaning the actual movement of water mass.

HARRIS: Going on to the next slide. This one is about wind pattern.

CHENG: Yeah. In San Francisco Bay region here, we typically see two different wind patterns in the summer. In particular it is almost predictable. We call it the sea-land breeze. It's actually a very simple physics here, because inland is a desert region. Here the sun rises in the summer months here, heats up the land. Therefore now we know that the hotter air will tend to go up like hot air balloon goes up. Then we need some mass to replace the vacuum that the air goes up, so it draws the air from the sea area here. Therefore, now, you call that -- every afternoon you can predict almost that way, going over, it cools from going the other way. Locally it will be modified by the local topography. However, in the winter, since now the heat -- the temperatures in the coastal regions are not that different in the winter, the wind patterns here are not usually predictable. Okay. You are going -- this is a summer pattern. Then these are the

patterns. That's good. Might as well jump into this. This is what I referred to as the summer pattern here. Wind typically coming from north and northwest here because, as I say, it's heated up in the inland, then creates a vacuum. Then the air being pulled from the ocean goes over the Bay region. Then the wind distribution will be modified by the locality, topography, mountain ranges in the south. Here it is not easy to see. Berkeley is over here. That's the south based mountain range. However, in the winter - -

HARRIS: If I can just jump in here for a -- looking at this particular slide, it's from a website. Is this the USGS website?

CHENG: That is the results of the collaboration with the USGS and San Jose State and Frank Ludwig, who used to work for us, but he's now retired.

HARRIS: And in this particular overlay that we are looking in this map in the middle, this is the map of The Bay, and has a bunch of arrows up there. That represents the direction of the wind that's going across that geographic region?

CHENG: Yes, the concept. Same answer, I discussed the tidal current. This is talking about movement of air, air mass movement. The arrow points out the wind speed and the direction.

HARRIS: Let's move on to -- you were describing for us the -- there is a difference with --

CHENG: Here in the winter pattern here, winter typically is weak and variable. We cannot predict the direction of the wind. Occasionally there were some storms typically the windstorms came from the south, because the mechanism that generates the wind is the weather front from the south. It's north in the winter. Either we see this type of variable very weak wind, variable directions. Almost like undefined. Or we see a strong wind pattern coming from the south.

HARRIS: Can I click on the next slide, which is has that snapshot of an example of a winter storm front.

CHENG: This, as you see on the upper right-hand-side corner here, has the date April 12th. That was reference to the time of the year, the late spring, early summer, or however you want to define that. That was one of the examples of one of those typical storms here. You know, the one thing different from the summer pattern here is that now the wind was coming from the south rather than coming from the west.

HARRIS: Right. Moving on to the next slide. And when you are talking about this, how the wind affects the water, if you can explain this for us now, and how was produced.

CHENG: Well, as I mentioned, it was not movement of water mass. That is not mass. It creates a motion that generates the level of the water up and down, and this creates motion, that creates energy down to the bottom that can, in the case of The Bay, can cause sediment erosion. One typical example, since most of you live in the Bay Area here in the summer, if you drive through the San Mateo Bridge, in the shallow area you see the water almost turn chocolate color in the afternoon because of heavy strong winds that stir up the bottom sediments. And in the calm winds the water changes color back to a greenish color that is the sediment resettled back to the bottom here. Now, wind not only generates the wave on the surface here, it also has the friction, just like you blow something, that will move forward. That particular friction drags the water mass. This takes time. An actual water mass begins the up-and-down motion. That wave and actual movement of the water mass in the direction of the wind, typically you can estimate the movement. That particular motion is on the order of two or three percent of the wind speed. That's typically the rule of thumb people use. For example, we had oil spilled on the water here. The oil slick on the water surface here can be estimated using the general rule-of-thumb formula

HARRIS: You are speaking of formulation?

CHENG: We'll look at them next. It's actually formulas that allow -- I didn't mean to confuse you. But I just want to make a distinction here. That wind wave, what we call a short wave here, that

basically up-and-down motion here will not even hardly hit the bottom here. However, that so-called long shallow wave is just almost like a tide. Here we have a complete theoretical knowledge in the textbook fashion here. We can predict the properties of so-called long wave and short wave.

HARRIS: We'll move to the next slide which is a little bit less math.

CHENG: I think this is maybe more revealing, when we have a condition of the wind that is blowing over the surface of the water, that generates the up-and-down motion that I referred to as wind wave. This upand- down motion, in turn, moves the water mass in a circular pattern here, what we call orbital motion due to the waves here. The larger motion near the surface, the motion decreases as the depth goes down the -- got down here. But, on the other hand, I have already alluded to, there is a friction on the surface here that creates a little drag motion in the direction of the wind speed here. The combination -- again, the combination of the orbital motion and drag motion here give the water mass inside the water column a trajectory like this. In other words, suppose I have something suspended such as sediment, or whatever, in the water column here. You will see the movement of the particular object in the sort of circular motion; but then, at the same time, rolling forward. So that when net results, what we call wind drift, how far this suspended object is moving with the -- caused by the motion of the wind.

HARRIS: Next one.

CHENG: Also -- by the way, I gave you the reference. I mean this is really textbook material. It's on the bottom of the last slide.

HARRIS: Okay. And this one is a summary?

CHENG: Yes. So, in short here, I gave you a general summary. I hope that would help us to understand the general phenomenon that happens around us every day. The tides and tidal currents, the wind, and then waves. And these are important factors that affect movements of things in The Bay. And astronomical tides and the tidal currents are really very predictable properties, because the astronomical motion we know we can go down to very precise prediction. However, that when we come into the water body here, because of the local water depth variation, that is the symmetry that causes some variation. As I say, it's not uniform throughout The Bay. Modified by the local water depths here. And let me see. Yeah. The last one I said, I also show the wind and tides properties near Richmond very close to the area of interest.

HARRIS: Okay. That's what I want to get to know, kind of put this in some other terms. Going to the next slide here.

CHENG: This -- let me first define --

HARRIS: Doctor, if I can just ask you a question real quick. As part of the -- at some point in time were you contacted by the Modesto Police Department and asked if you could assist them in their particular investigation into the disappearance of Laci Peterson?

CHENG: Correct.

<evening recess>