# The Dynamic Fetch Event of March 27th, 2007 in the Northern California Coastal Waters

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## Event

On March 27th, 2007, sea heights in the Eureka coastal waters peaked at 27 feet, surpassing both model and forecast significant wave heights by 7 to 8 feet. Existing swell and local wind seas alone could not account for these exceptionally large waves. Examination of data following this event revealed that the sharp increase in significant wave height was entirely due to the swell portion of the wave spectrum. Prior to the onset of these large waves, an ellipse shaped area of 40 knot surface winds was observed in model isotach fields offshore of the Pacific Northwest, tracking from the north-northwest to the south-southeast. The velocity at which this fetch area traveled, coupled with the exceedingly large waves which developed as this fetch area entered the northwest California coastal waters, led us to believe that a dynamic fetch event may have been responsible for the significantly large wave heights observed.

## Background

Dynamic fetch, sometimes called trapped fetch, occurs when an area of locally strong winds over open water, also known as a fetch region, moves in the same direction and at the same speed as the waves it is generating, or acting on. Waves moving in a similar direction and speed as the dynamic fetch area will become more amplified than the other waves associated with a storm system. Waves experiencing the greatest growth however, are those waves whose group velocity **(Cg)**, move at the same speed and direction as the dynamic fetch region **(Vf).**

For dynamic fetch,

$$\mathbf{Cg = Vf}$$

The group velocity for a set of waves with a specific wave period **(T)** is given by,

$$\mathbf{Cg = 1.5 * T}$$

For dynamic fetch this becomes,

$$\mathbf{Vf = Cg = 1.5 * T}$$

We now can determine which wave periods, among the entire spectrum of waves, will experience the greatest growth, based on the velocity of the dynamic fetch region. This wave period is referred to as **T resonant.**

$$\mathbf{T_{resonant} = Vf / 1.5}$$

## Synoptic Situation

At 12UTC Monday, March 26th, 2007, a developing area of surface low pressure with a minimum central pressure of 1007 millibars was located near 46.5 degrees north, 130 degrees west, nearly due west of the Olympic Peninsula **(figures 1-3).** The low proceeded to track southeast, moving inland over the northern coastal waters of Oregon just after 06 UTC Tuesday March 27th, 2007.

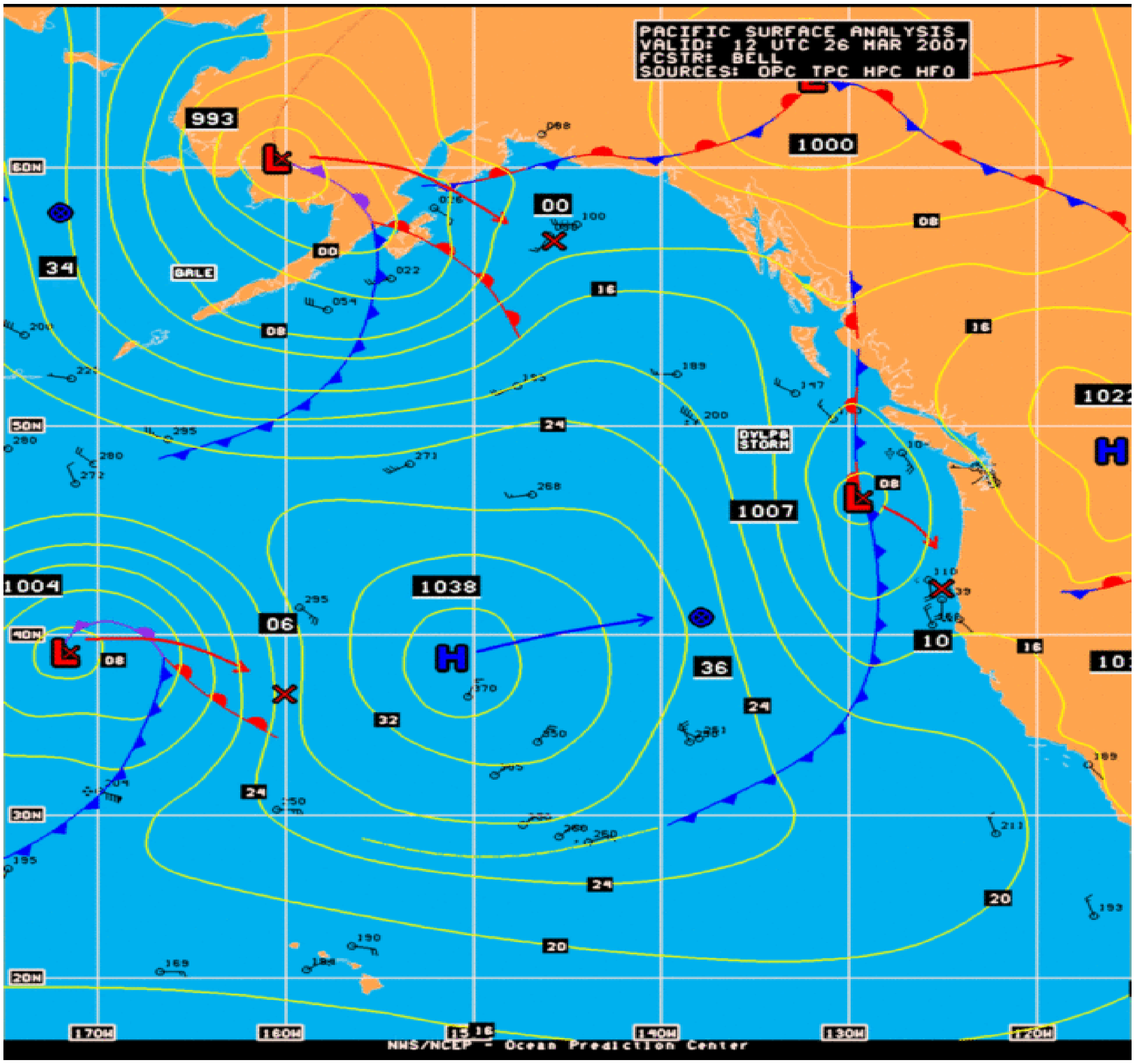


**Figure 1**. OPC East Pacific Surface Analysis, valid 12 UTC 26 Mar 2007.

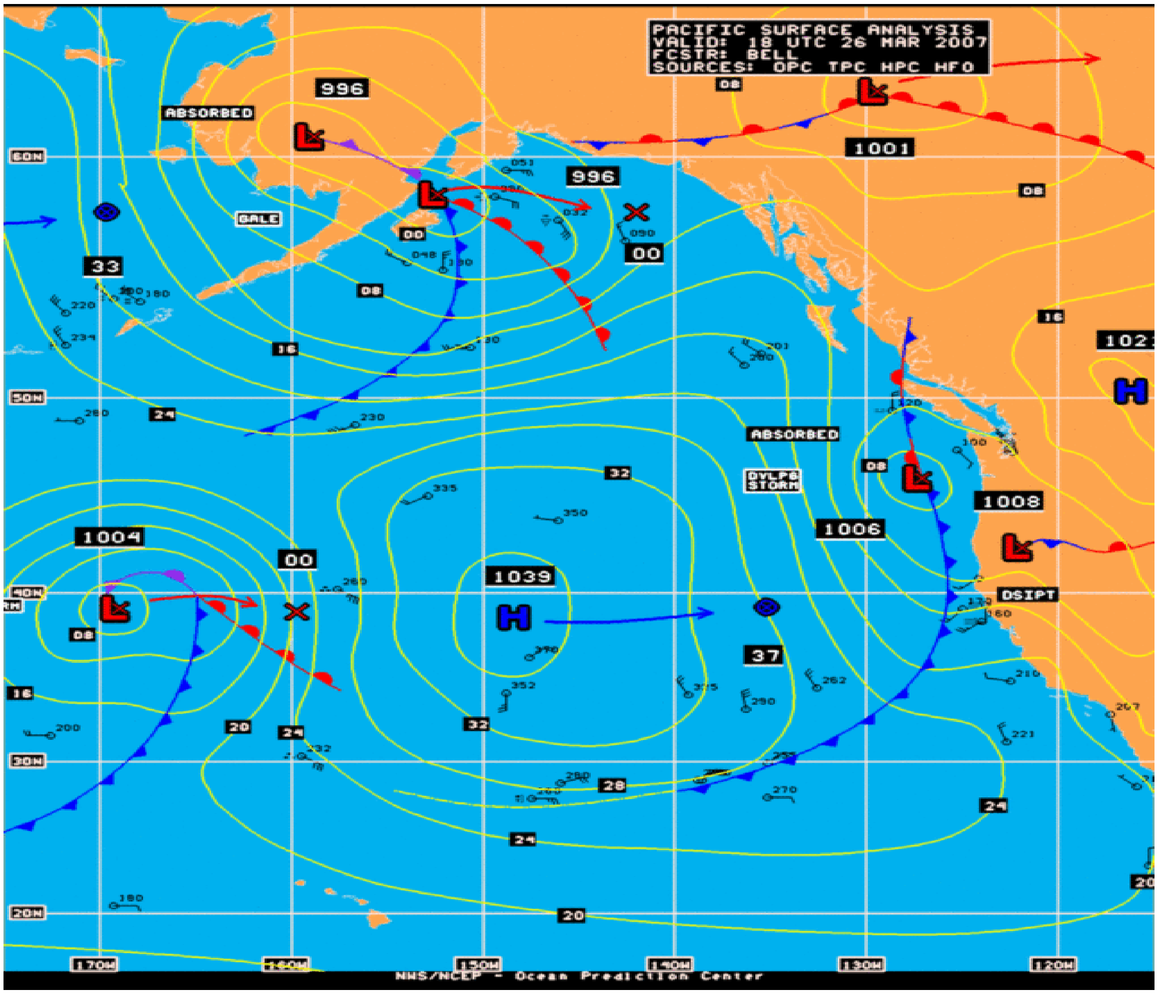


**Figure 2**. OPC East Pacific Surface Analysis, valid 18 UTC 26 Mar 2007.

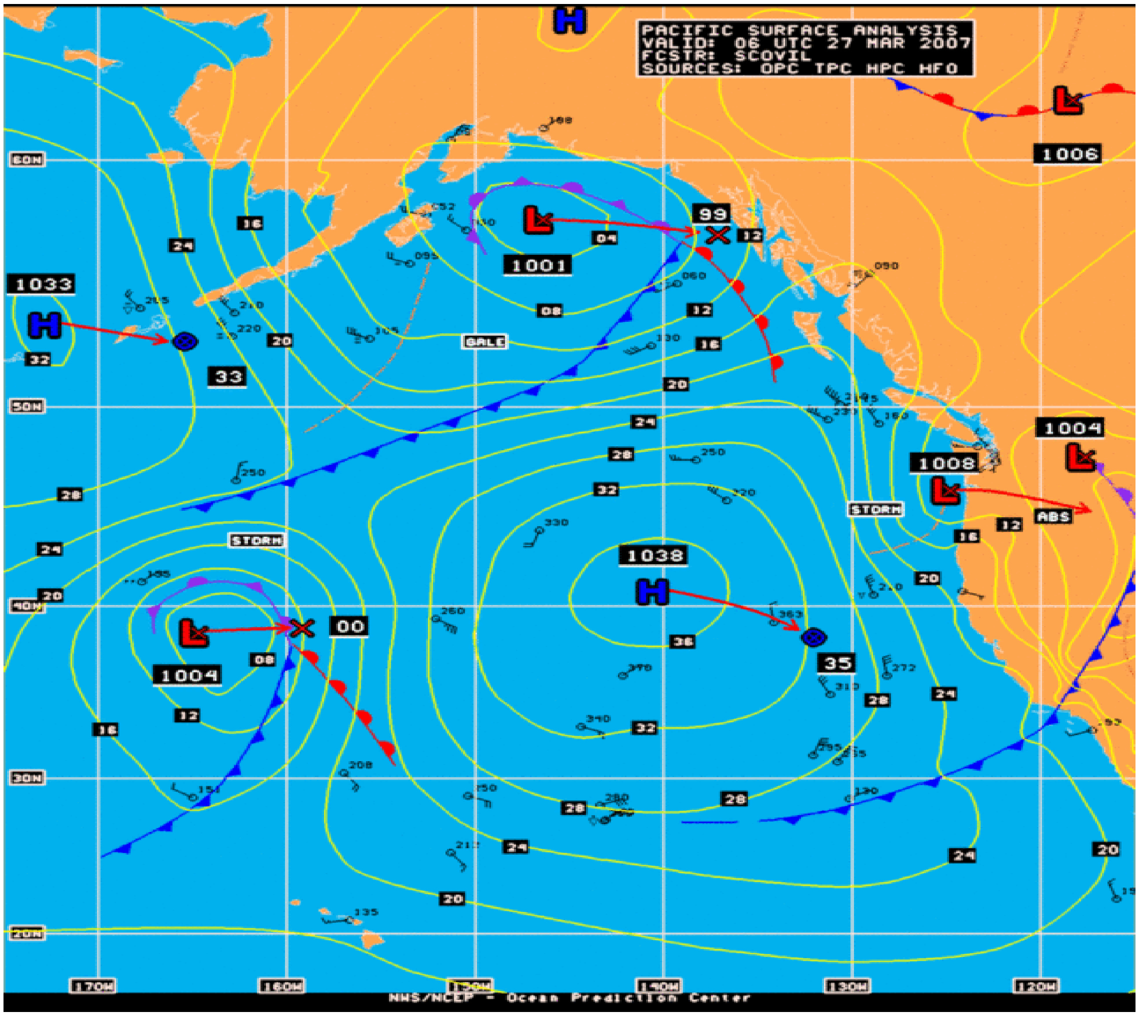


**Figure 3**. OPC East Pacific Surface Analysis, valid 06 UTC 27 Mar 2007.

An associated upper level trough was located over the Gulf of Alaska on Monday, March 26th, 2007 **(figures 4-7)**. The upper trough experienced amplification as it propagated southeast toward southwest Oregon, moving onshore over northwest California at 12UTC Tuesday, March 27th, 2007.

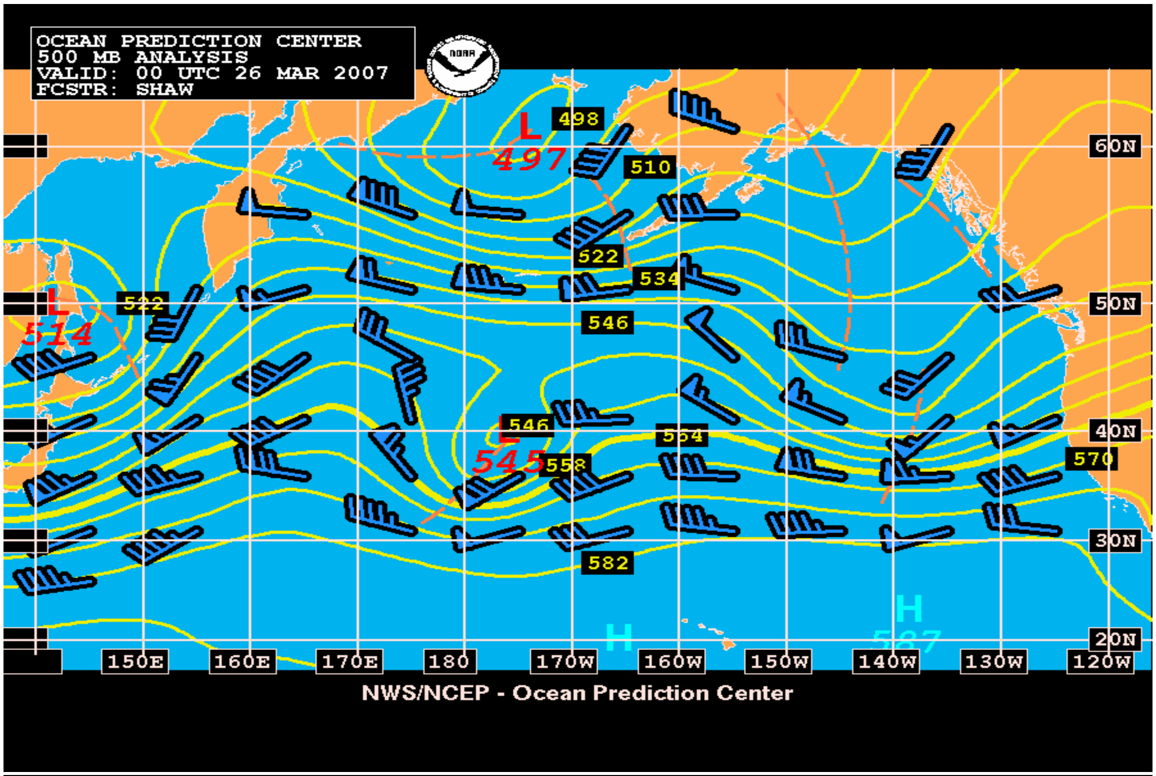


**Figure 4.** OPC Pacific 500 MB Analysis, valid 00 UTC 26 Mar 2007.

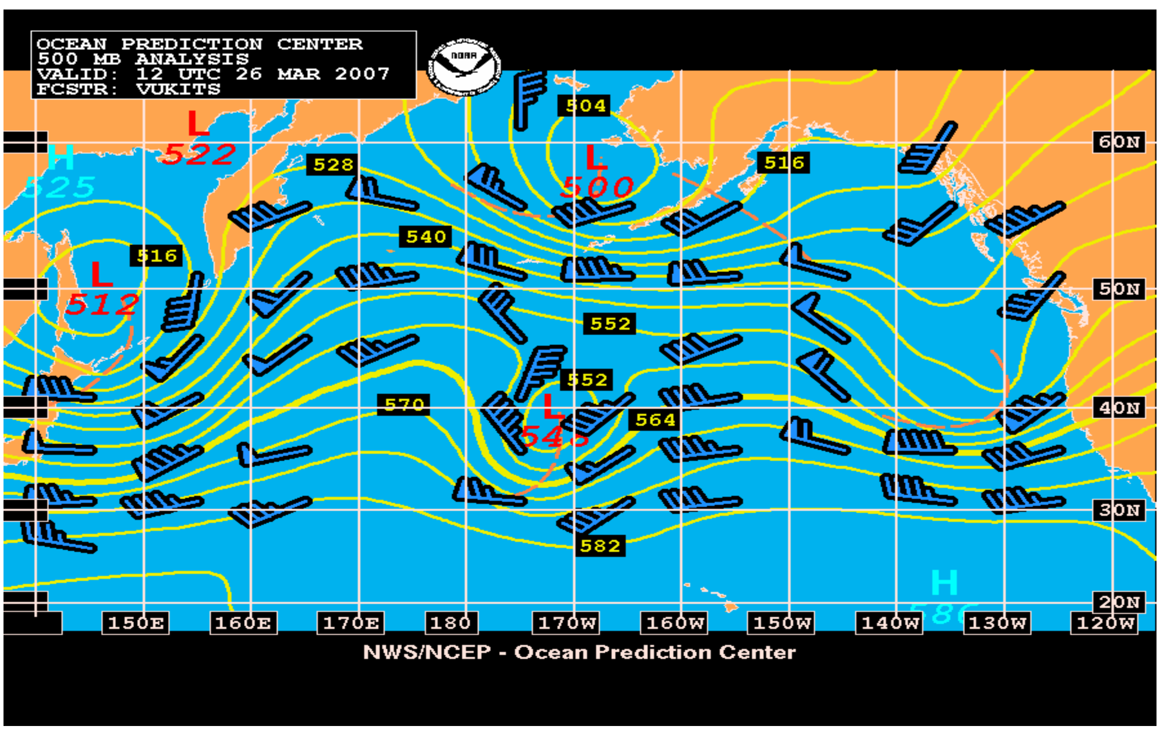


**Figure 5**. OPC Pacific 500 MB Analysis, valid 12 UTC 26 Mar 2007.

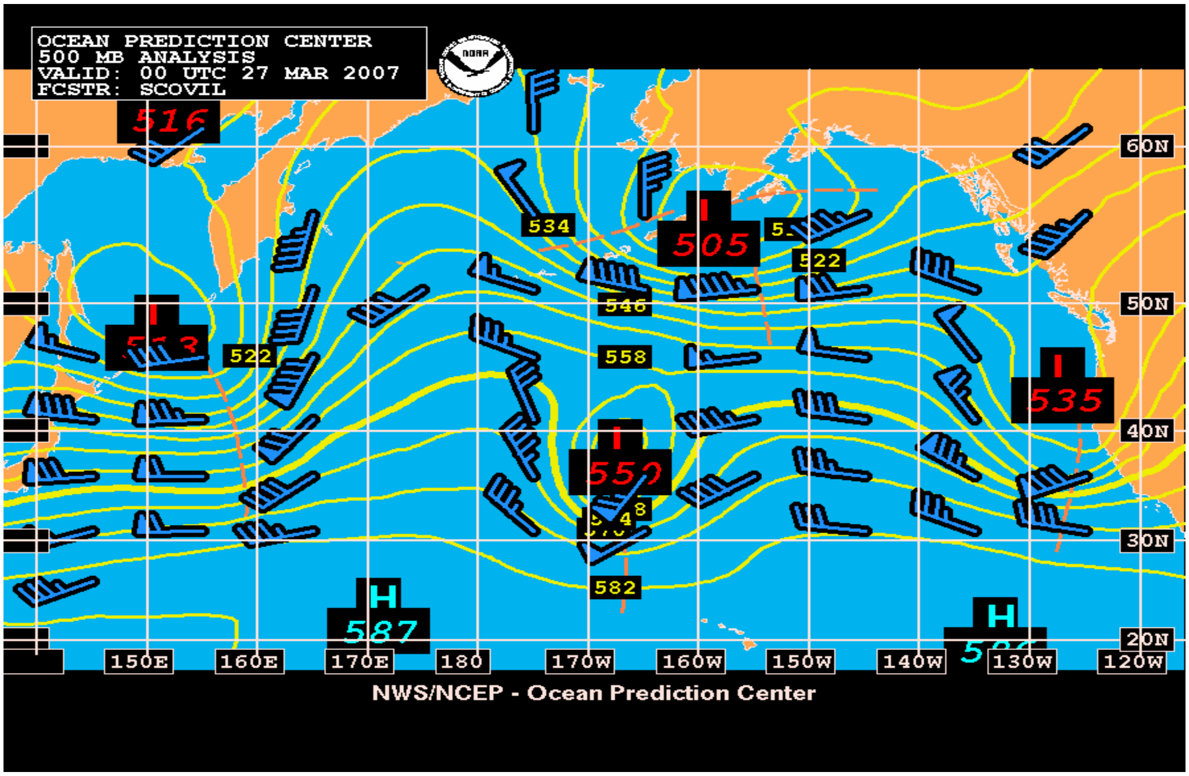


**Figure 6**. OPC Pacific 500 MB Analysis, valid 00 UTC 27 Mar 2007.

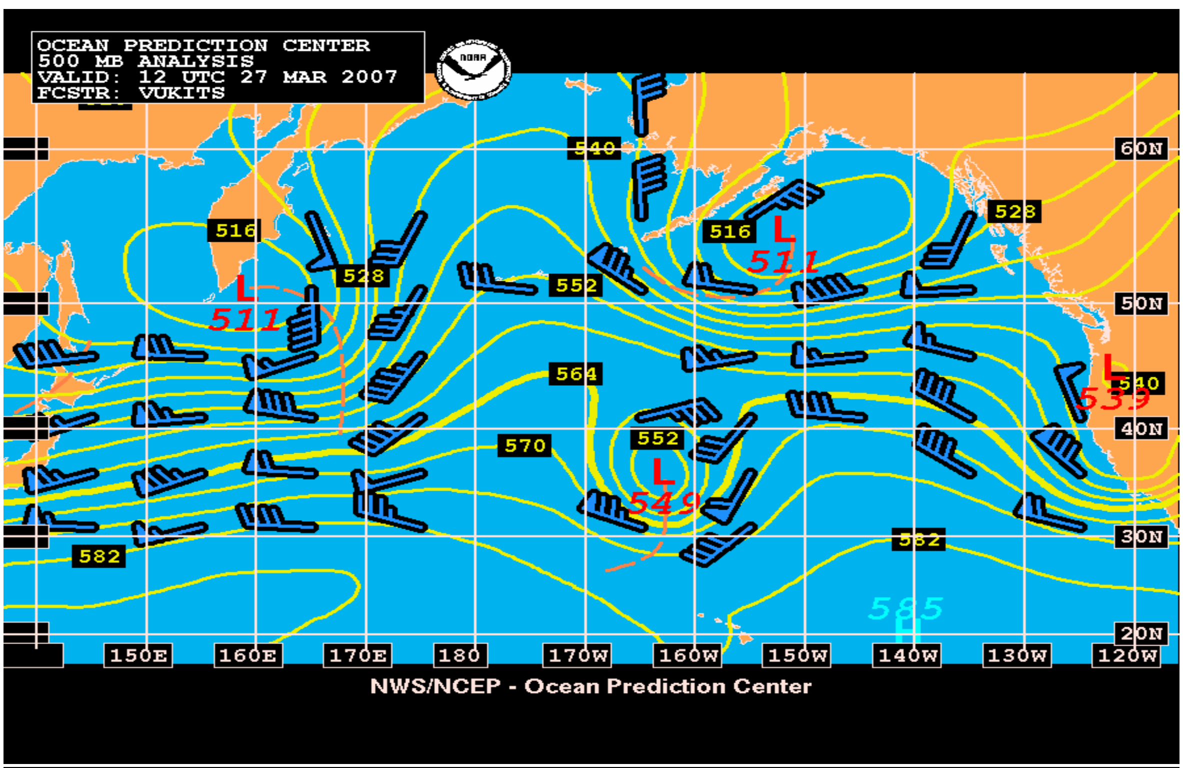


**Figure 7.** OPC Pacific 500 MB Analysis, valid 12 UTC 27 Mar 2007.

## Model Guidance

Guidance from the North American Model **(NAM),** Global Forecast System **(GFS)** model, and Eastern North Pacific **(ENP)** model, were available for forecast guidance **(figures 8-17)**. The NAM handled the movement of the surface low and associated surface winds most accurately among available model guidance. The NAM 1800 UTC March 26$^{th}$, 2007 run initialized the area of low pressure very well, placing the low center near 46.5 degrees north, 130 degrees west at 2100 UTC on March 26$^{th}$, 2007. This position was confirmed by satellite analysis not included.

Closer examination of NAM surface winds revealed a dynamic fetch region was present. The dynamic fetch region was depicted in the NAM model as a south-southeastward moving ellipse of 35 to 40 knot, north-northwest winds, over the western portion of the surface low (**figures 8-11)**. Winds were strongest over the western portions of the surface low due to its interaction with eastern Pacific surface high pressure located further west. The NAM maintained a nearly constant 20 knot movement of the dynamic fetch region, traveling from the north-northwest to the south-southeast. The dynamic fetch region traveled a distance of just over 300 miles in 15 hours, tracking from the offshore waters of the Pacific Northwest, to the coastal waters just offshore of Humboldt Bay, CA. The same fetch region from the GFS run of the same time is also provided for comparison **(figures 12-14).**

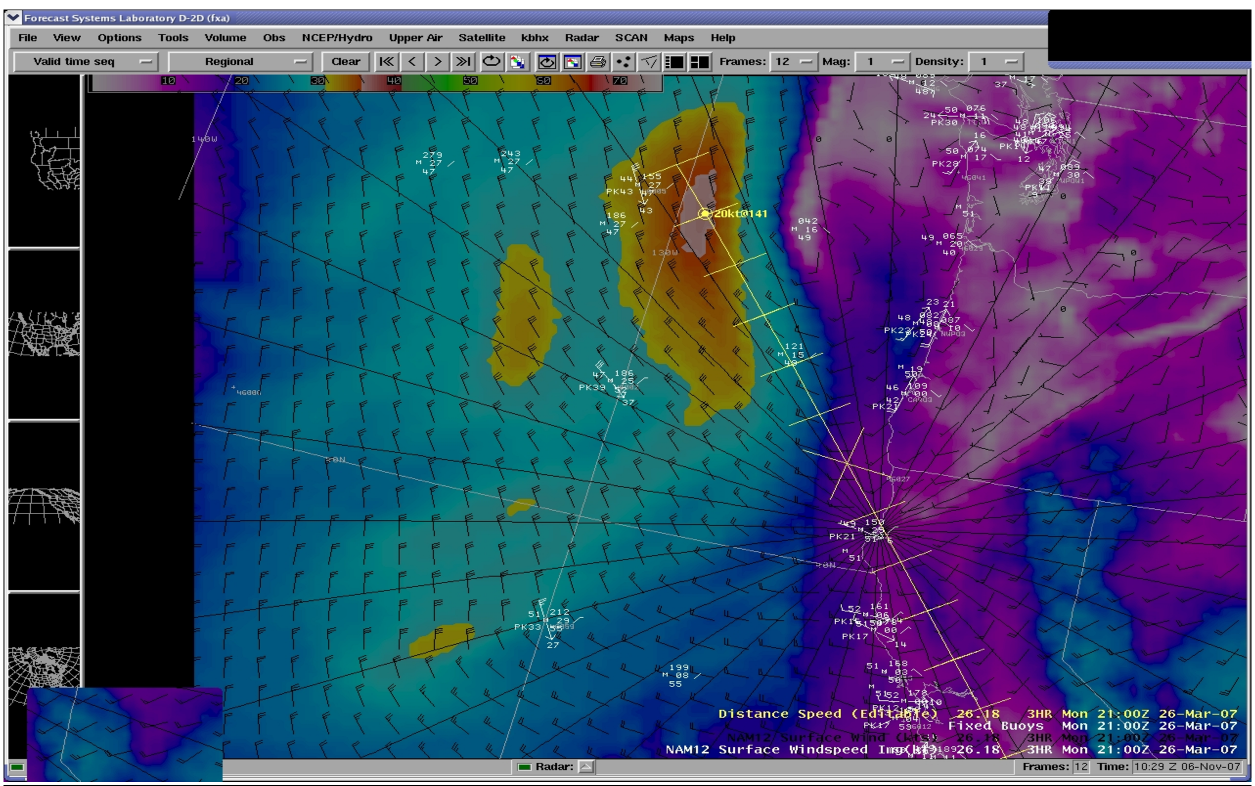


**Figure 8**. 18 UTC 26 Mar 07 NAM12, Surface Wind Speed, Direction, valid 21 UTC 26 Mar 07.

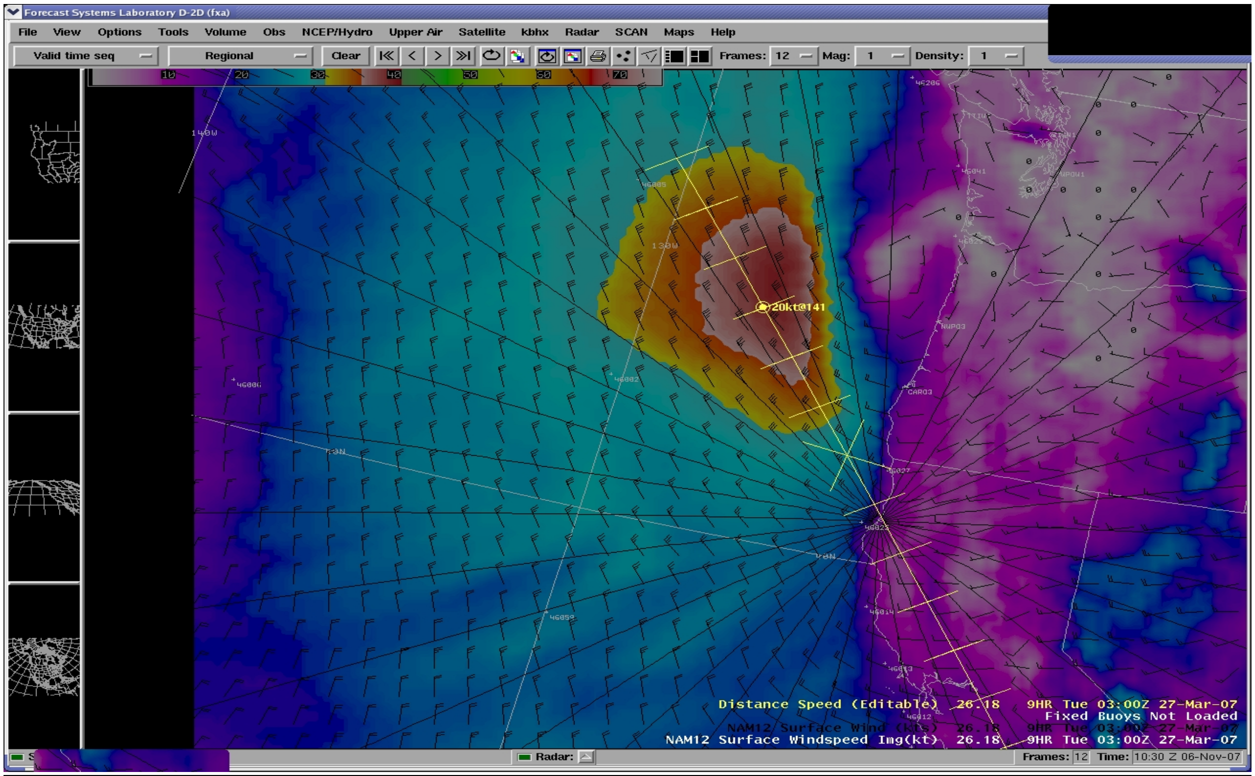


**Figure 9**. 18 UTC 26 Mar 07 NAM12, Surface Wind Speed, Direction, valid 03 UTC 27 Mar 07.

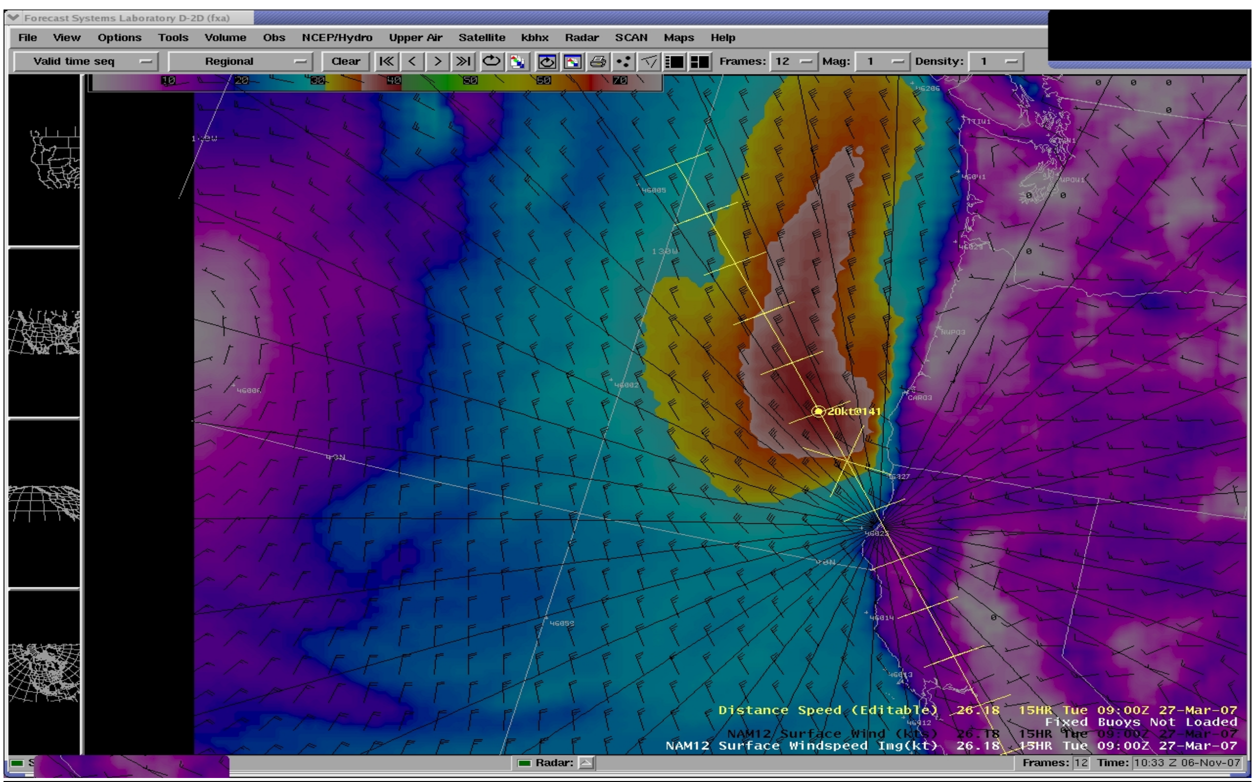


**Figure 10**. 18 UTC 26 Mar 07 NAM12, Surface Wind Speed, Direction, valid 09 UTC 27 Mar 07.

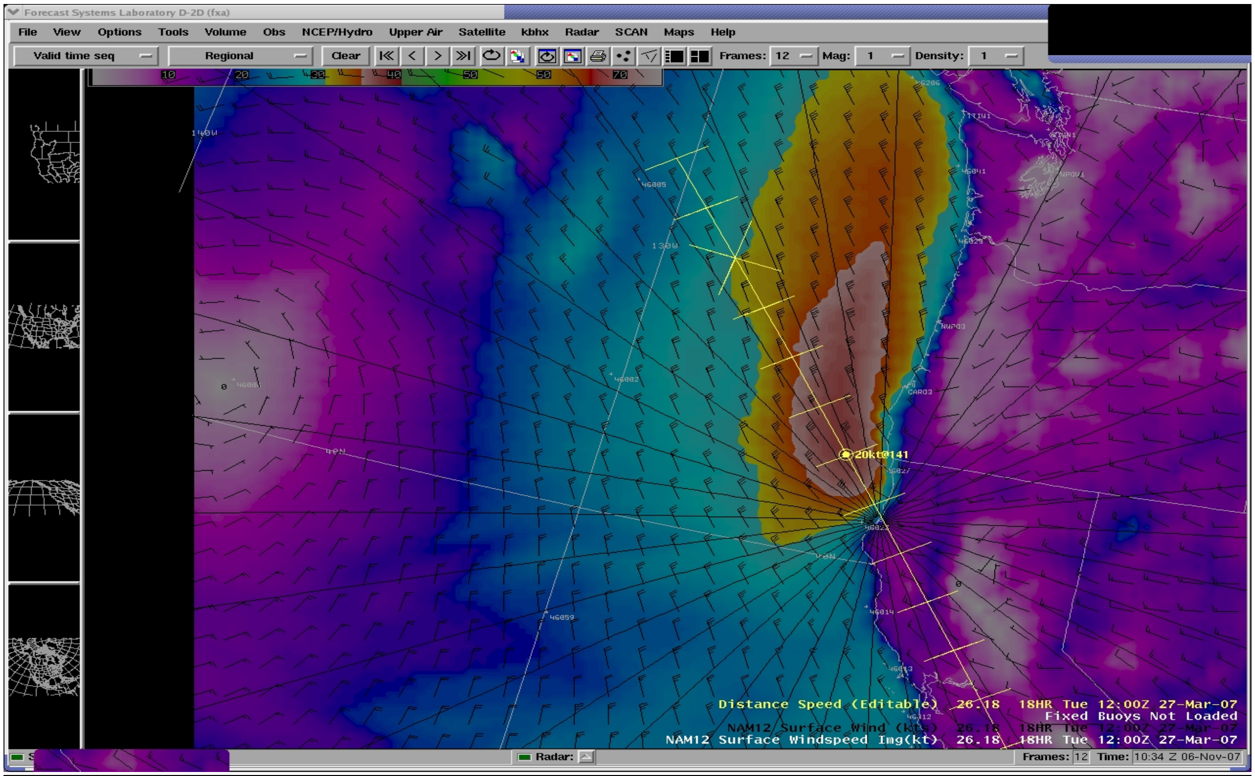


**Figure 11**. 18 UTC 26 Mar 07 NAM12, Surface Wind Speed, Direction, valid 12 UTC 27 Mar 07.

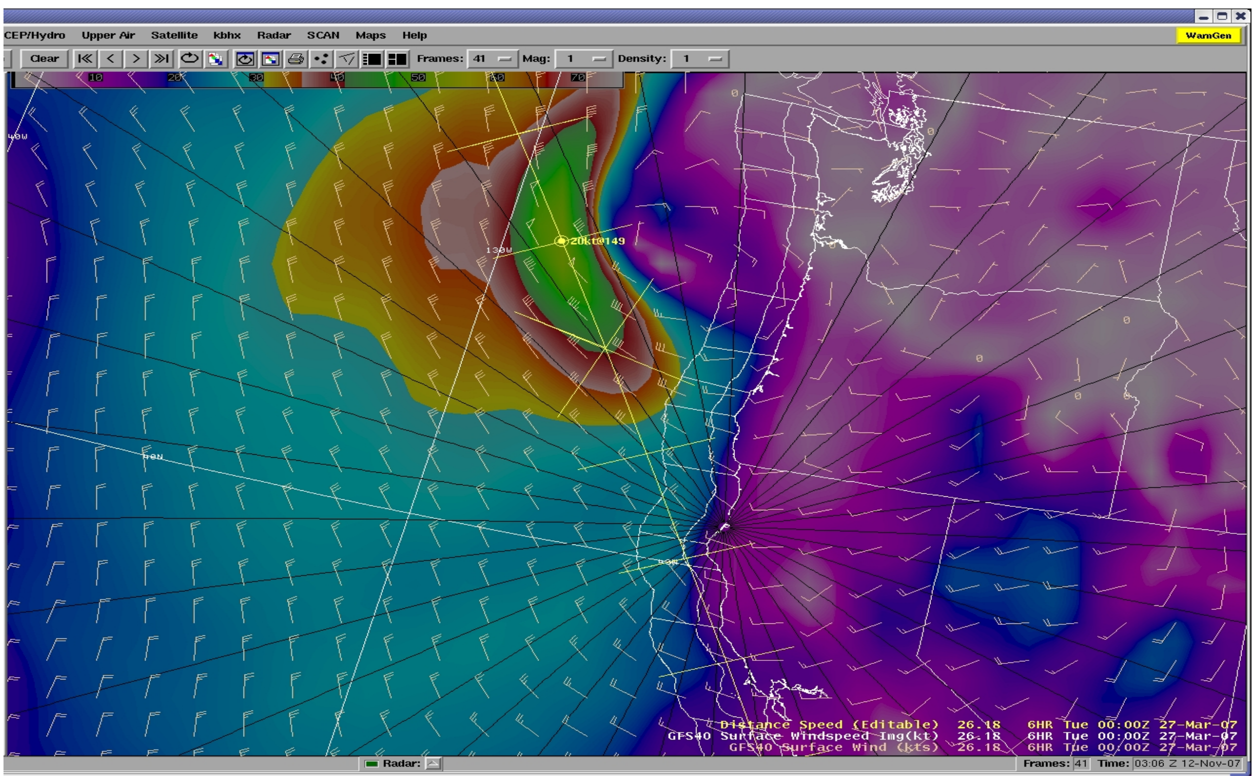


**Figure 12.** 18 UTC 26 Mar 07 GFS40, Surface Wind Speed, Direction, valid 00 UTC 27 Mar 07.

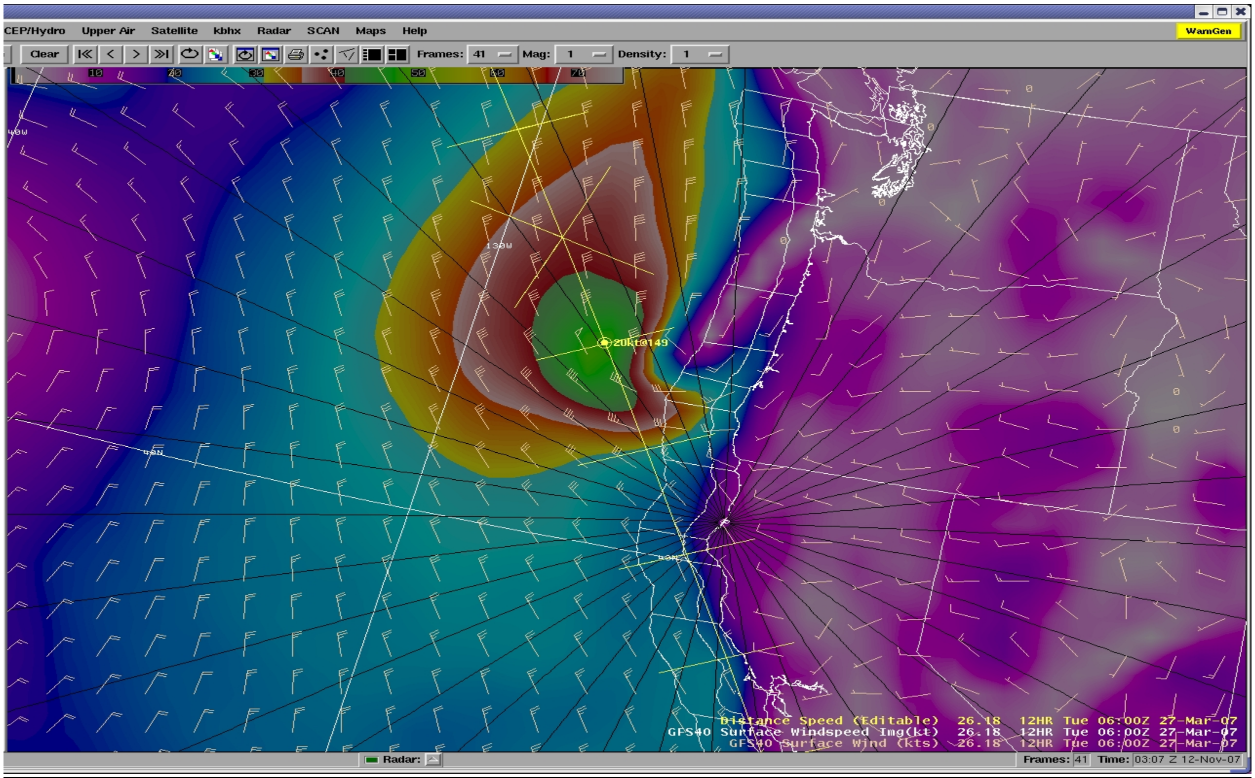


**Figure 13.** 18 UTC 26 Mar 07 GFS40, Surface Wind Speed, Direction, valid 06 UTC 27 Mar 07.

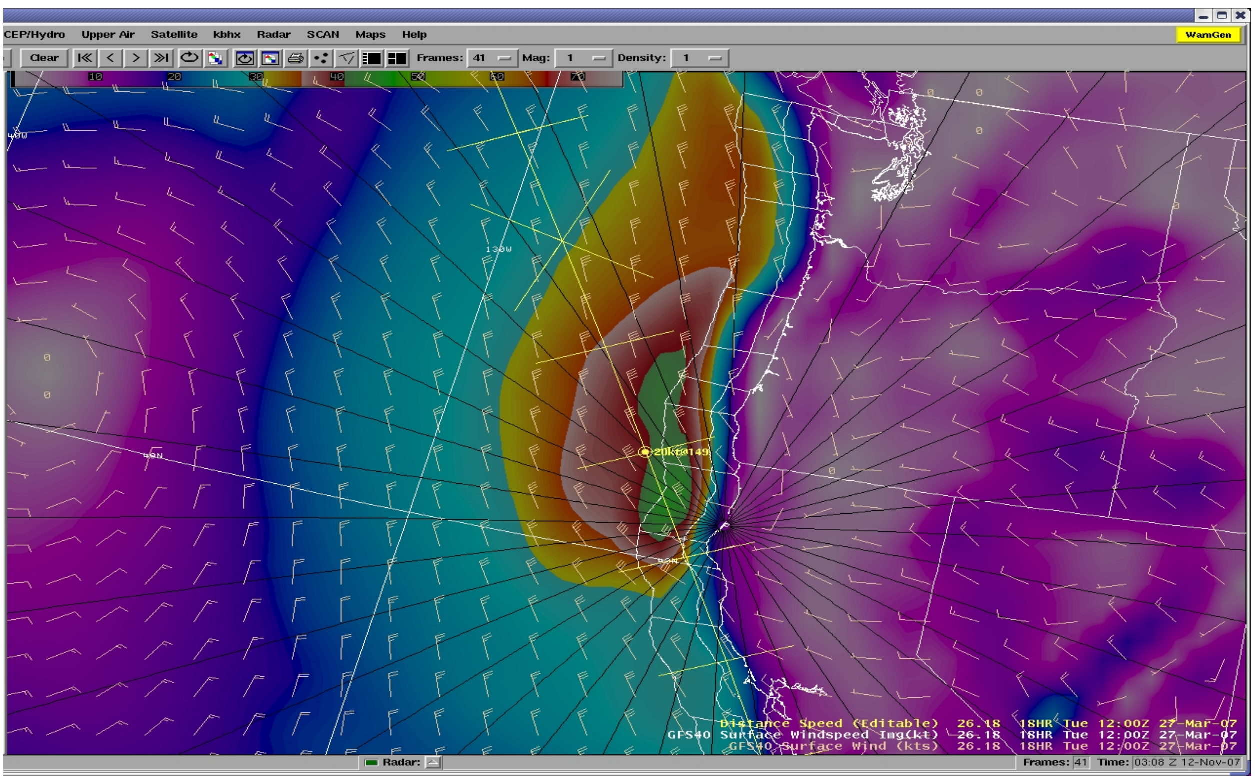


**Figure 14.** 18 UTC 26 Mar 07 GFS40, Surface Wind Speed, Direction, valid 12 UTC 27 Mar 07.

ENP wave model forecasts depicted significant wave heights near 20 feet arriving at the northwest California coast between 1200 UTC and 1800 UTC on March 27th, 2007. The ENP maintained wave heights near 20 feet along the coast through the event period, ending around 00 UTC, March 28th **(figures 15-17).**

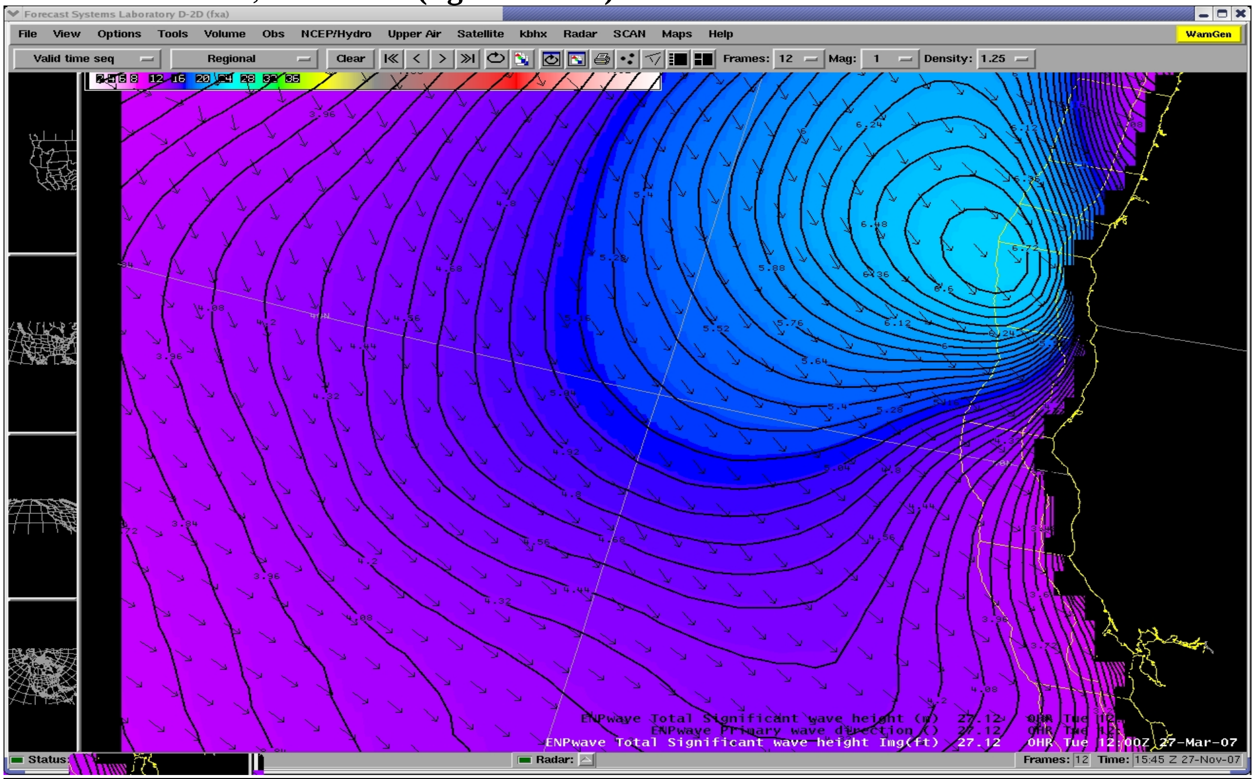


**Figure 15.** 12 UTC 27 Mar 07 ENP, Significant Wave Height and Direction, valid 12 UTC 27 Mar 07.

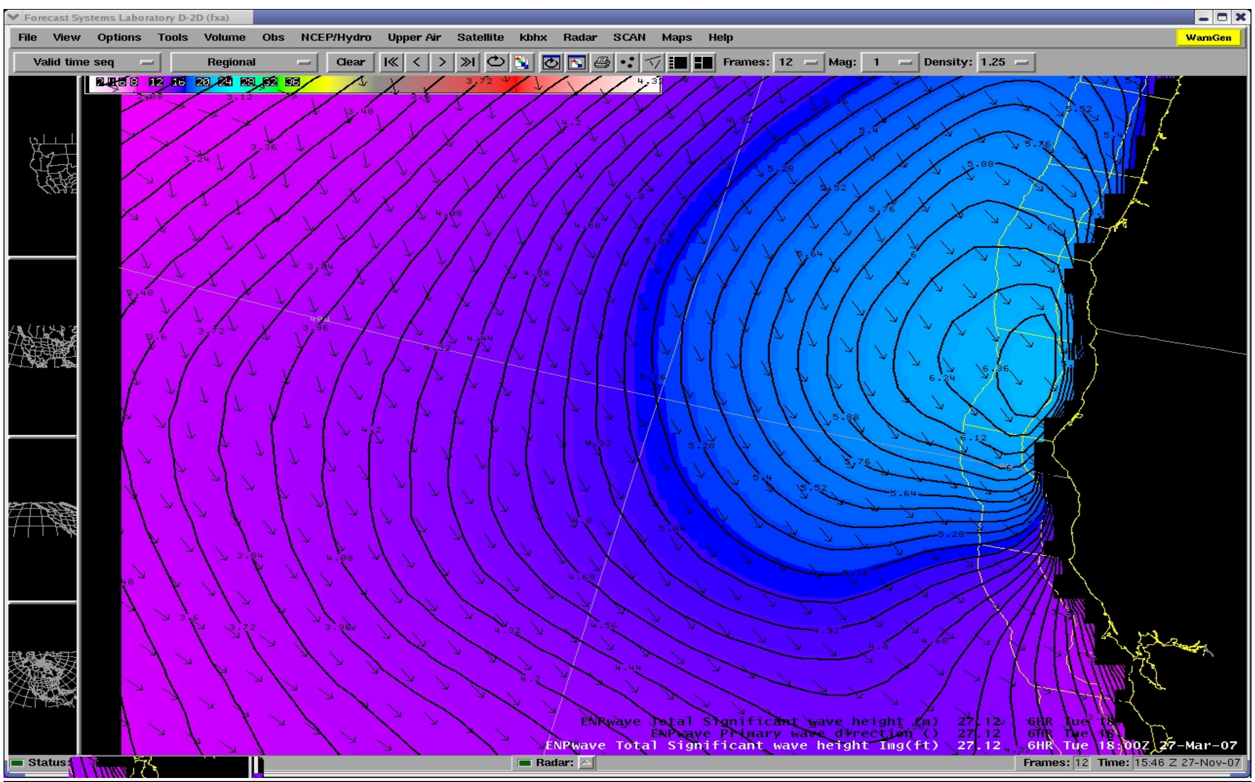


**Figure 16.** 12 UTC 27 Mar 07 ENP, Significant Wave Height and Direction, valid 18 UTC 27 Mar 07.

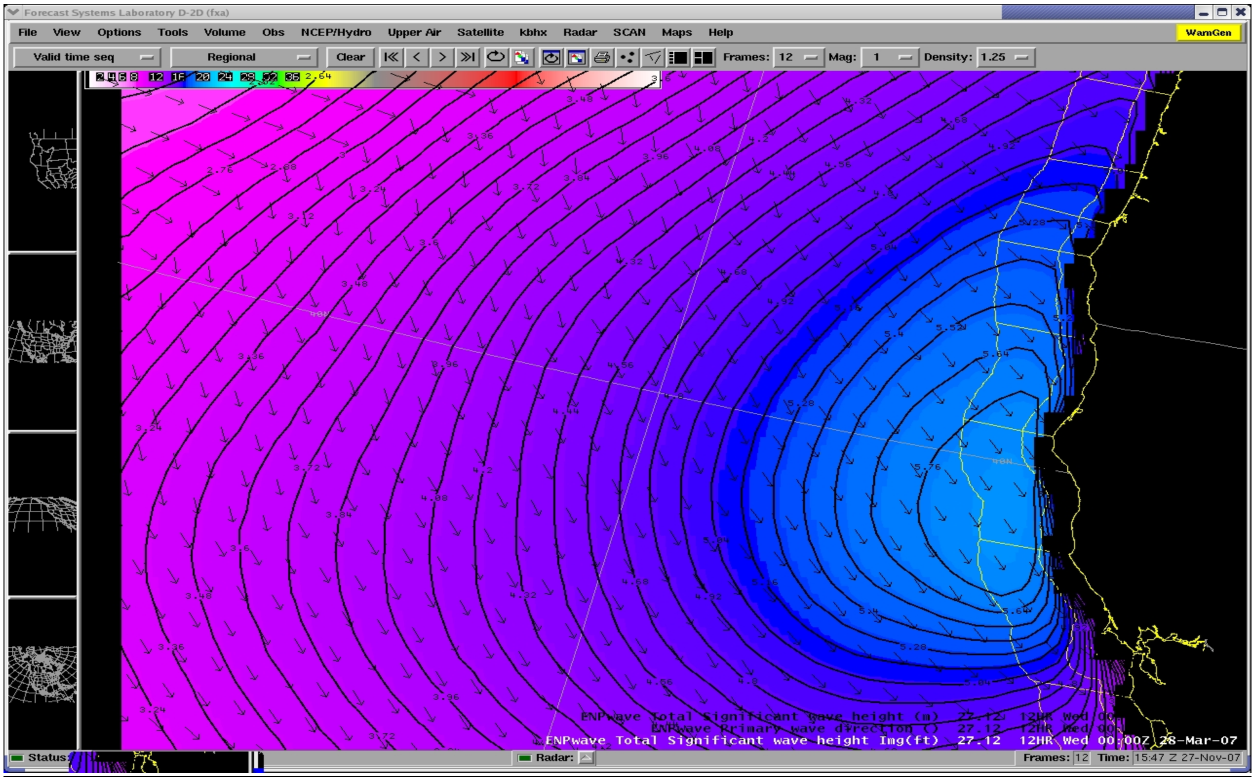

**Figure 17.** 12 UTC 27 Mar 07 ENP, Significant Wave Height and Direction, valid 00 UTC 28 Mar 07.

## Observed Data

A spike in significant wave heights is clearly evident on plots registered from Scripps buoys 46212 and 46213, and in tabular data generated from NOAA buoy 46022, **(see figures 18 and 19).** The dominant wave energy associated with this sharp increase in significant wave heights was comprised of waves whose periods ranged between 13 and 14 seconds. Wave directionality plots seen in these figures during the peak in significant wave heights, showed a slight and brief veering of the primary wave direction to 330 degrees. This is the same azimuth along which the dynamic fetch area traveled.

We can determine the group velocity of those waves that experienced the greatest growth, that is, those waves whose periods range between 13 and 14 seconds, from the equation

$$\mathbf{Cg = 1.5 * T}$$

Thus, the group velocity for waves possessing wave periods between 13 and 14 seconds is around 20 knots, nearly identical to the velocity of the dynamic fetch region.

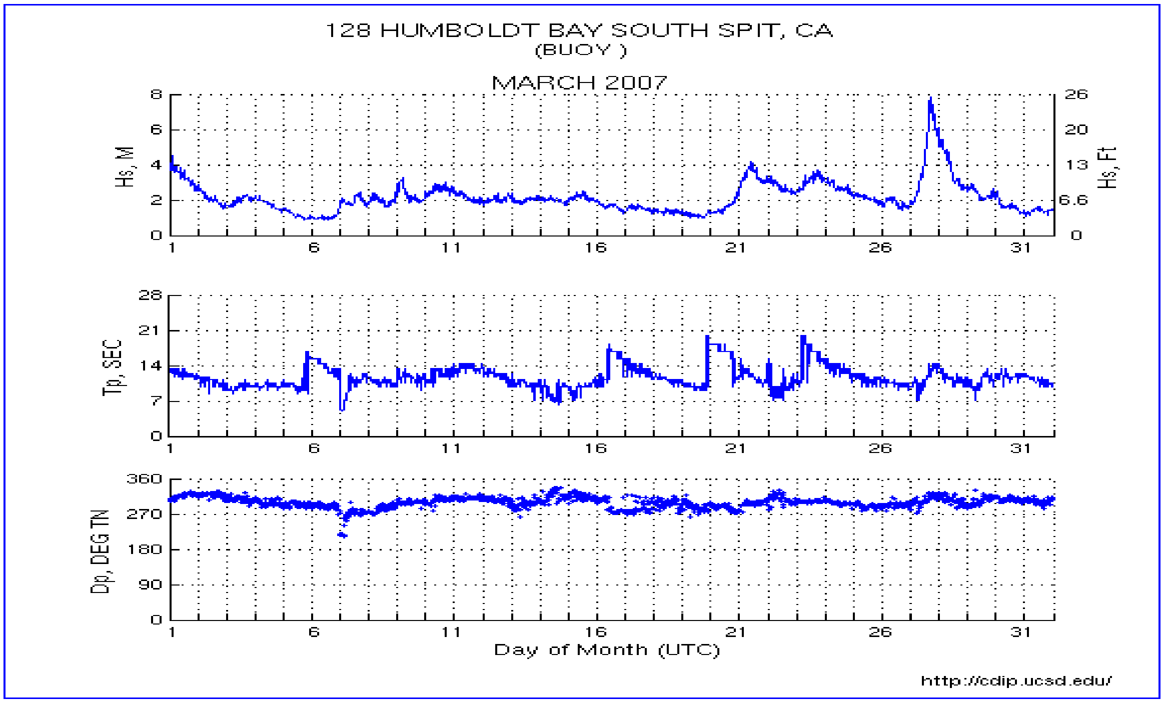


**Figure 18**.Scripps Buoy 46212 Significant Wave Height, Period, Direction, March 2007.

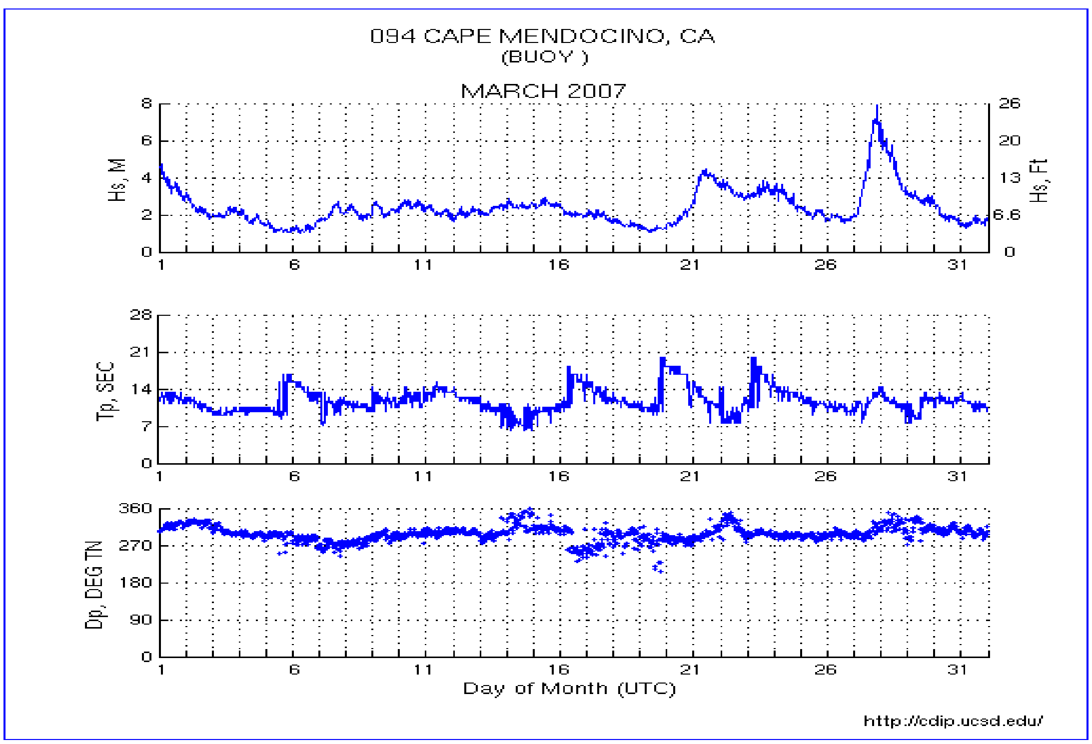


**Figure 19.** Scripps Buoy 46213, Sig.Wave Height, Period, Direction, March 2007.

| *NDBC Buoy 46022* | | | *NDBC Buoy 46014* | | |
|---|---|---|---|---|---|
| **Date, Time (UTC)** | **Wave Height (m)** | **Period (s)** | **Date, Time (UTC)** | **Wave Height (m)** | **Period (s)** |
| 3/28/07 12:50 | 4.0 | 11 | 3/28/07 12:50 | 4.4 | 11 |
| 3/28/07 11:50 | 4.3 | 11 | 3/28/07 11:50 | 4.6 | 11 |
| 3/28/07 10:50 | 4.6 | 11 | 3/28/07 10:50 | 4.3 | 12 |
| 3/28/07 9:50 | 5.1 | 11 | 3/28/07 9:50 | 4.9 | 12 |
| 3/28/07 8:50 | 4.6 | 11 | 3/28/07 8:50 | 5.3 | 13 |
| 3/28/07 7:50 | 5.2 | 11 | 3/28/07 7:50 | 4.9 | 12 |
| 3/28/07 6:50 | 5.4 | 12 | 3/28/07 6:50 | 5.1 | 13 |
| 3/28/07 5:50 | 6.1 | 12 | 3/28/07 5:50 | 5.4 | 13 |
| 3/28/07 4:50 | 6.2 | 12 | 3/28/07 4:50 | 5.6 | 13 |
| 3/28/07 3:50 | 6.4 | 13 | 3/28/07 3:50 | 5 | 14 |
| 3/28/07 2:50 | 6.0 | 13 | 3/28/07 2:50 | 5.9 | 13 |
| 3/28/07 1:50 | 7.2 | 13 | 3/28/07 1:50 | 5.9 | 12 |
| 3/28/07 0:50 | 6.7 | 12 | 3/28/07 0:50 | 5.7 | 11 |
| 3/27/07 23:50 | 6.9 | 14 | 3/27/07 23:50 | 5.8 | 12 |
| 3/27/07 22:50 | 7.7 | 14 | 3/27/07 22:50 | 6.2 | 13 |
| 3/27/07 21:50 | 6.8 | 13 | 3/27/07 21:50 | 6 | 12 |
| 3/27/07 20:50 | 7.3 | 14 | 3/27/07 20:50 | 6 | 13 |
| 3/27/07 19:50 | 7.4 | 11 | 3/27/07 19:50 | 5.6 | 12 |
| 3/27/07 18:50 | 8.0 | 13 | 3/27/07 18:50 | 5.6 | 11 |
| 3/27/07 17:50 | 8.1 | 13 | 3/27/07 17:50 | 5.3 | 11 |
| 3/27/07 15:50 | 6.7 | 13 | 3/27/07 15:50 | 4.6 | 11 |
| 3/27/07 14:50 | 6.8 | 12 | 3/27/07 14:50 | 3.8 | 11 |
| 3/27/07 13:50 | 6.0 | 11 | 3/27/07 13:50 | 3.8 | 9 |
| 3/27/07 12:50 | 5.0 | 12 | 3/27/07 12:50 | 3.9 | 10 |
| 3/27/07 11:50 | 4.6 | 11 | 3/27/07 11:50 | 3.9 | 9 |
| 3/27/07 10:50 | 4.6 | 11 | 3/27/07 10:50 | 3.4 | 8 |
| 3/27/07 9:50 | 4.0 | 11 | 3/27/07 9:50 | 3.1 | 9 |
| 3/27/07 8:50 | 3.3 | 10 | 3/27/07 8:50 | 2.7 | 8 |
| 3/27/07 7:50 | 3.4 | 9 | 3/27/07 7:50 | 2.6 | 7 |
| 3/27/07 6:50 | 3.0 | 8 | 3/27/07 6:50 | 2.5 | 8 |
| 3/27/07 5:50 | 2.8 | 11 | 3/27/07 5:50 | 2.2 | 7 |
| 3/27/07 4:50 | 2.4 | 8 | 3/27/07 4:50 | 2.3 | 7 |
| 3/27/07 3:50 | 2.5 | 11 | 3/27/07 3:50 | 2.1 | 8 |
| 3/27/07 2:50 | 2.1 | 11 | 3/27/07 2:50 | 2.1 | 7 |
| 3/27/07 1:50 | 1.9 | 10 | 3/27/07 1:50 | 2 | 6 |
| 3/27/07 0:50 | 1.8 | 10 | 3/27/07 0:50 | 2 | 9 |

**Table 1**. NDBC Buoy 46022 and 46014 data, March 27$^{th}$ through March 28$^{th}$, 2007.

In **figures 20** and **21** below we can see that the dramatic increase in significant wave heights resulting from this dynamic fetch event was almost entirely due to an equally dramatic increase in the swell portion of the wave spectrum. These figures show that wind-sea heights did not exceed 13 feet for the majority of this event, exhibiting only minor changes when compared to the more dramatic increase in the swell portion of the wave spectrum.

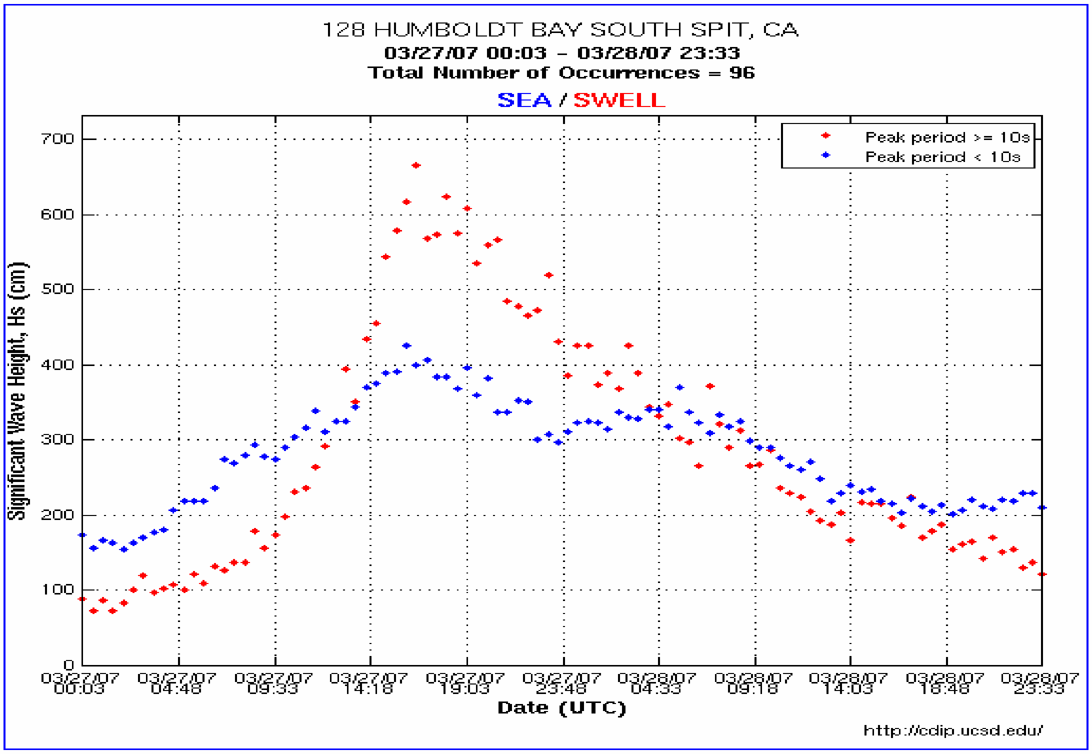


**Figure 20.** Scripps Buoy 46212, Sea and Swell Heights, March 2007.

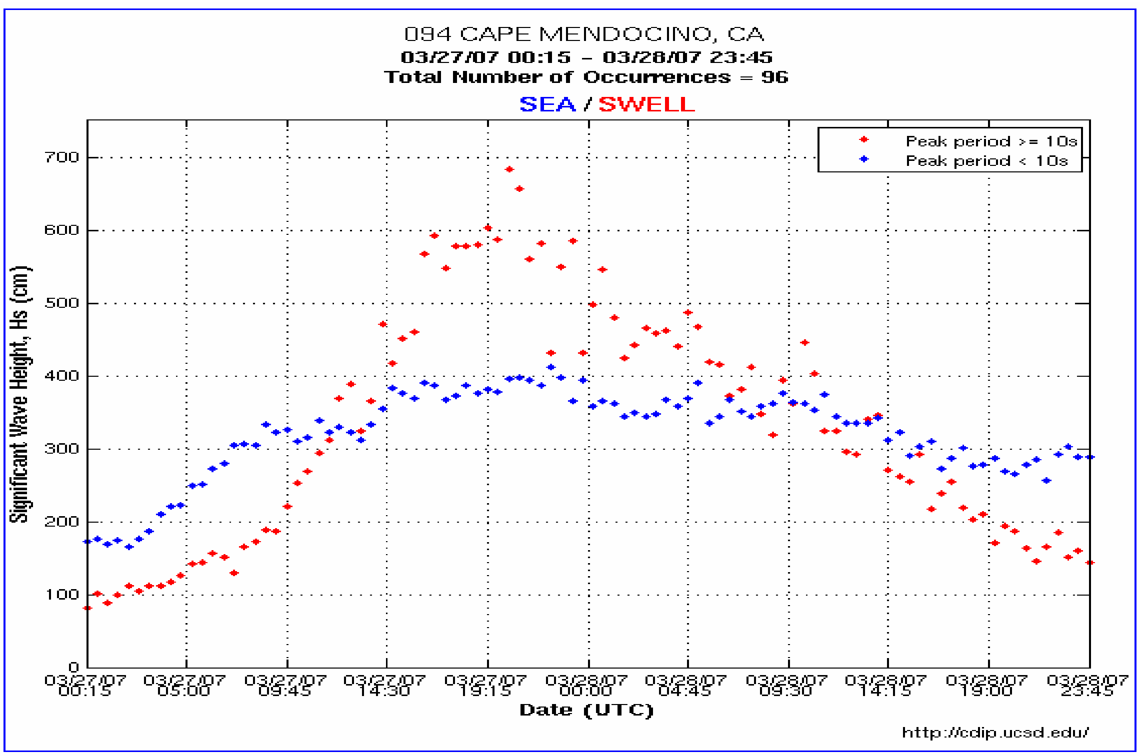


**Figure 21.** Scripps Buoy 46213, Sea and Swell Heights, March 2007.

## Conclusion

A south-southeastward moving dynamic fetch region was produced on March 26th and 27th 2007, due to the interaction of a surface low moving southeast over the coastal waters of Washington and Oregon, with eastern Pacific surface high pressure positioned further offshore. The fetch region tracked from the Pacific Northwest coastal waters, south-southeastward to just offshore of Humboldt Bay over a period of about 15 hours, moving at a velocity of 20 knots. The velocity of the fetch region was nearly identical to the group velocity of dominant waves, whose periods ranged between 13 and 14 seconds. Detailed wave measurements during the peak of sea heights showed that the swell portion of the wave spectrum was almost entirely responsible for the rapid and significant wave growth that occurred. The dominant wave direction during the peak in sea heights corresponded closely to the direction the dynamic fetch region traveled.

Recognition and awareness of developing dynamic fetch regions will help promote more accurate forecasts of swell and significant wave heights. In cases of dynamic fetch, wave heights are typically under-forecast by wave models. Recognizing an approaching dynamic fetch region will allow forecasters to make adjustments prior to the onset of exceedingly large wave heights often associated with dynamic fetch events. Incorporating great circle route maps in AWIPS can assist forecasters in determining if a developing dynamic fetch region is going to impact beaches and surf zones within their warning area.

## References and additional reading


Arnott, Justin, 2005: Typhoons in Alaska? Extratropical Transition and its Implications for Northern Alaska, NWS Alaska Region Research Notes.

Bigio, Ralph, 2000: Upper Limit on Wave Height in Dynamic Fetch. *Meteorological Services of Canada/Aviation and Defense Services.*

Bowyer, P. J. and A. W. MacAfee, 2005: The Theory of Trapped-Fetch Waves with Tropical Cyclones – An Operational Perspective, *Weather Forecasting,* in press.

Churchill, D. D., S. H. Houston, and N. A. Bond, 1995: The Daytona Beach wave of 3-4 July 1992: A shallow water gravity wave forced by a propagation squall line. *Bulletin of the American Meteorological Society*., 76, 21-32.

Kinsman, B., 1984: *Wind Waves: The Generation and Propagation on the Ocean Surface*. Dover Publications, 676 pp.

MacAfee, A. W., 2005: A Synthetic Trapped-Fetch Wave Climatology For The North Atlantic and Eastern Pacific, National Lab for Marine and Coastal Meteorology, Meteorological Service of Canada.

MacAfee, A. W. and P. J. Bower, 2005: The Modeling of Trapped-Fetch Waves with Tropical Cyclones – A Desktop Operational Model, *Weather Forecasting,* in press.