during larval life, since much of the initial lipid is likely to have been lost during storage in alcohol.

The apparent cessation of growth by larval *C. parthenopeum* is in contrast to the increases in size and biomass of nonteleplanic prosobranch larvae (*Bittium alternatum*, *Ilyanassa obsoleta*, *C. fornicata*, and *C. plana*) after they become competent to metamorphose; these increases are apparent whether the larvae are preserved in alcohol or Formalin (*11*, *14*, *15*). Lack of growth during long-distance oceanic transport of *C. parthenopeum* larvae may be due either to shifts in metabolism (*11*) or to food limitation in the open ocean (*2*). Larvae must be laboratory-reared to distinguish between these possibilities. Laboratory studies may also help in determining whether larvae retain the capacity for successful metamorphosis after transoceanic transport and in assessing the relation between rate of growth and rate of differentiation.

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19. The decalcifying agents used were 5 percent HCl for 2 hours, 10 m*M* EGTA for 1 hour, or 5 percent EDTA for 12 hours.
20. Shells were rinsed in several changes of distilled water and air dried onto double-stick tape on standard aluminum-scanning electron microscope stubs. Analyses were conducted with an AMR 1000A scanning electron microscope equipped with a Kevex detector and a Tracor Northern energy dispersive x-ray analyzer. For all analyses, the stub was set at an angle of 45° to the detector, and an accelerating voltage of 20 kV was used. The bremsstrahlung background was subtracted, and the total number of counts in each major peak was integrated by computer.
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26. Lengths of the eight empty shells in the collection were measured, and the total biomass expected for intact larvae of equivalent size was calculated. Empty shells weighed 63 percent (standard deviation = 4.5 percent, $n = 7$) of the total dry weight expected for intact larvae of equivalent size.
27. Contribution 5458, Woods Hole Oceanographic Institution, and contribution 120, Marine Science and Maritime Studies Center.

26 September 1983; accepted 7 March 1984

The Appearance of Sustained Equatorial Surface Westerlies During the 1982 Pacific Warm Event

Abstract. *In June 1982 a band of anomalous southerly surface wind, extending from the equator as far south as the Tasman Sea, formed east of Australia (150°E to 160°E). This flow crossed the equator just before the appearance of sustained westerly winds on the equator somewhat west of the date line. Because these westerly winds induced the initial strong equatorial warming of the ocean east of the date line during the 1982 El Niño–Southern Oscillation (ENSO) event, the southerly jet appears to be an important atmospheric component leading to the onset of the vigorous phase of this event. Some historical evidence suggests that anomalous southerly winds in the same region occurred prior to the appearance of sustained equatorial westerly winds in the major ENSO events of 1957, 1965, and 1972.*

Although an El Niño–Southern Oscillation (ENSO) event is a coupled ocean-atmosphere phenomenon (*1*), some stages of ENSO events can be examined usefully if one imposes the behavior of one fluid and examines the response of the other. The onset of strong equatorial warming east of the date line in the 1982 Pacific warm event appears to be such an instance. Prior to June 1982, there were only weak anomalies in the monthly mean surface zonal wind (*2*) (< 1 m/sec) along the equator west of the date line, and there was at most weak equatorial warming (anomalous sea-surface temperature < 1°C). However, westerly surface winds appeared west of the date line in late June 1982 and persisted for several months, and rapid equatorial surface warming east of the date line began subsequent to the onset of these westerlies (*3*, *4*). Harrison and Schopf have shown that the ocean surface warming between July and October 1982 can be substantially accounted for as the oceanic response to these winds (*5*). Of course, the initial warming is but part of the 1982 ENSO event; ocean and atmosphere anomalies continued to evolve after October 1982.

Because the equatorial surface westerlies that began in June 1982 can be linked to the first substantial oceanic signal of the 1982 event, it is important to understand the origin of these winds. I show here that they did not originate in the eastern Indian Ocean or far western Pacific (*6*), or as a large-scale weakening of the mid-Pacific southeast trades (*7*). Rather, they were associated with the breakdown of a jet of strongly anomalous southerly winds east of Australia between 150°E to 160°E and 40°S to 5°N. This result is based on an examination of monthly average and 10-day average winds at a nominal height of 19.5 m, produced from the U.S. Navy NOGAPS operational analysis program (*8*), and is consistent in its major features with available ship wind data and other meteorological products.

Because Fleet Numerical Ocean Central (FNOC) began operational use of the NOGAPS during 1981 and because its winds can be substantially different from those of earlier FNOC programs, no consistent climatological record is available with which to directly assess the anomalous character of the 1982 NOGAPS 19.5-m winds. However, a high-spatial-resolution global climatological wind record of merchant ship observations (*9*) provides a useful alternative and permits the detection of strongly anomalous conditions.

The region of particular interest is 150°E to 170°E and 10°N to 50°S, although data over a much larger area have been examined. The large-scale patterns of the NOGAPS winds from January through April 1982 were similar in direction and amplitude to the corresponding climatological winds. The winds subsequent to April 1982 are of primary interest here. Fig. 1 shows the monthly mean winds for May through July 1982 from NOGAPS and climatological winds for May through July derived from ship reports. For this comparison it is most useful to focus on the directions of the wind vectors between 150°E and 170°E. Along the equator between 150°E and 170°E in May 1982 (Fig. 1a) the easterlies were a little stronger than normal, and between 170°E and the date line the easterlies were perhaps somewhat weaker than normal. There was more southerly flow than normal just south of the equator and less southerly flow than normal between 30°S and 40°S and between 150°E and 170°E.

The first dramatic departure from the climatological record is seen in the June 1982 winds (Fig. 1b). There was strongly anomalous southerly flow concentrated between 150°E and 160°E. Anomalous southerly wind speeds of 2 to 7 m/sec were present equatorward of 40°S, and a southerly jet was seen as far south as ~ 45°S in the Tasman Sea. On the equator the flow was mostly southerly (at up to 5 m/sec) in contrast to the weak (< 2 m/sec) easterlies expected from the climatological record. The northeast trades appeared to be normal. From 160°E to 170°E the winds were also strongly anomalous; between 10°S and 30°S the monthly mean flow was much weaker than that of the climatological record and lacked its normal southeasterly or south-southeasterly direction. Between 30°S and 50°S there were easterlies, whereas the climatological record indicates southerlies (30°S to 40°S) or westerlies (40°S to 50°S). The strong prevailing westerlies of the Roaring Forties were far south of their climatological location.

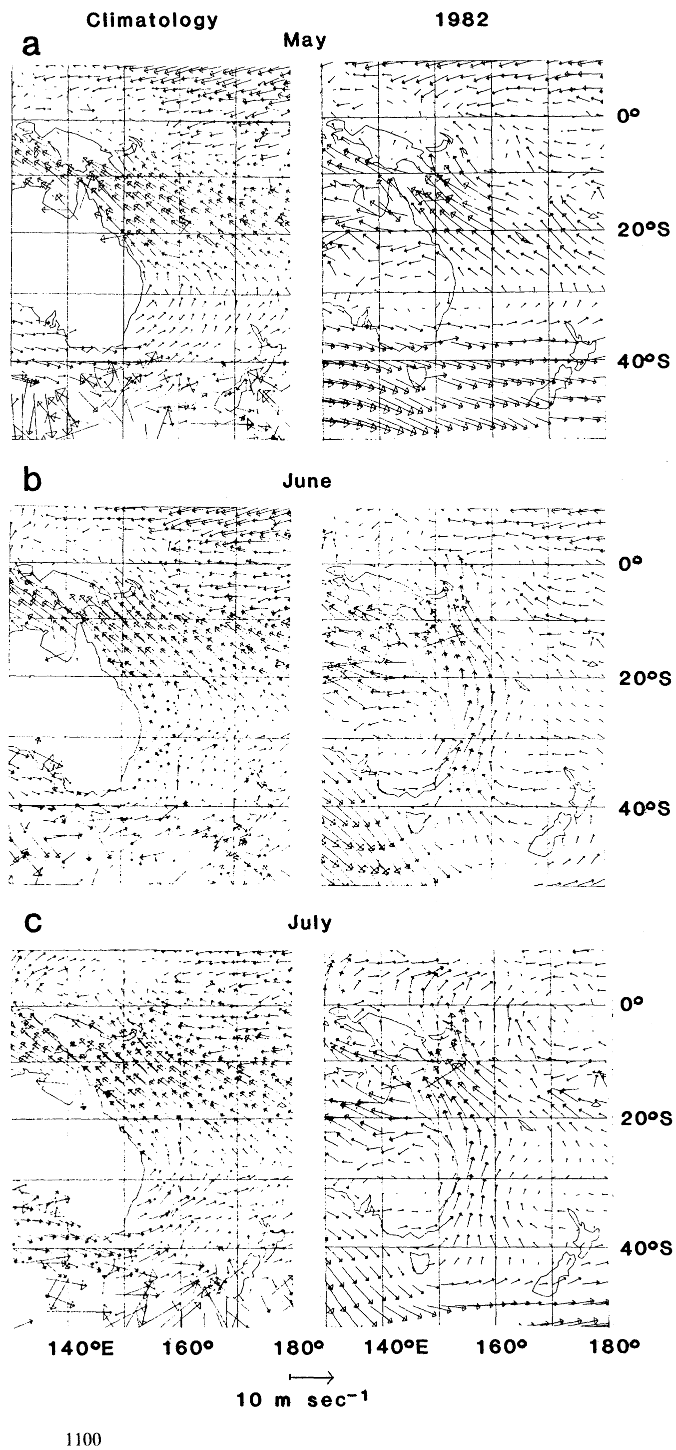

Fig. 1. Near-surface winds, monthly averages, for May, June, and July 1982 and for climatological May, June, and July. Note the band of anomalous southerly flow east of Australia in June and July 1982 (see text).

The anomalous southerly jet was also evident in the July 1982 winds (Fig. 1c). Although the southeast trades off northeast Australia were appearing again, reduced westerlies and increased southerly flow are clear between 150°E to 170°E and 30°S to 40°S, and the most anomalous winds in July 1982 in the longitudes of interest were between 10°N and 10°S. The southerly flow extended as far north as 5°N, and the zonal flow was westerly at the equator from 155°E to ~ 175°E. The NOGAPS maximum westerly anomaly at the equator was 5 to 7 m/sec, roughly in accord with the results of the National Oceanic Atmospheric Administration (NOAA) Climate Analysis Center (*3*).

The anomalous southerly jet did not appear simultaneously in the form shown in Fig. 1b. In order better to reveal the formation and evolution of the jet, I show in Fig. 2 six fields of 10-day averaged wind, beginning with the last third of May 1982 and continuing through the second third of July 1982. There is substantial variance in the wind field on periods shorter than a month in the region of interest even near the equator (*10*), so there is much more spatial structure in these fields than in the monthly means. Given the limitations of space, it is only possible to discuss the behavior within the region 150°E to 170°E by 40°S to 10°N. Figure 2a shows little that is worthy of notice during the last 10-day period of May, but Fig. 2b shows the jet forming, during the first third of June, between 40°S and ~ 15°S; there was no coherent flow yet on or just south of the equator. In the second third of June the southerly flow became coherent between 20°S and the equator, but the flow south of 20°S was dominated by a strong midlatitude disturbance in the Forties (Fig. 2c). A small region of weak westerlies was also indicated on the equator around 165°E. During the last third of June the entire southerly jet of the monthly mean field was visible, albeit in somewhat distorted form. There remained coherent southerly flow across the equator between 150°E and 160°E, and there were weak easterlies generally east of 160°E (Fig. 2d). During the first third of July the southerly flow reached 5°N to 7°N and was developing a significant westerly component on and north of the equator; the southeasterlies between 10°S and 20°S appeared to be reforming (Fig. 2e). In the second third of July, there was westerly flow along the equator between 150°E and 180°E with speeds of ~ 2 m/sec, a flow anomaly of > 5 m/sec (Fig. 2f).

By August 1982 the southeast trades off northeast Australia were reestablished at full strength, but anomalous westerly winds along the equator were still strong as far east as the date line. By this time the sea-surface temperature of the eastern central Pacific was more than 2°C above normal and increasing rapidly; the vigorous oceanic phase of the 1982 warm event was well under way. The region of equatorial anomalous westerly wind continued to expand eastward and dramatic oceanic and atmospheric changes occurred for many months (*11*), but these changes are beyond the scope of this report.

The southerly jet is an unusual atmospheric surface circulation feature of the western Pacific, with its zonal extent of ~ 10° of longitude, meridional extent of up to 50° of latitude, maximum monthly mean meridional anomalous wind speed of ~ 7 m/sec, and duration of about 2 months. To my knowledge, no similar feature has been described, but reexamination of the historical data base suggests that such flows may have occurred in 1957, 1965, and 1972 (*12*). Substantial anomalies in the zonal pressure gradient are required to balance geostrophically such a meridional flow in middle latitudes. A recent study (*13*) of 3-month average pressure differences between Chatham Island (177°W, 45°S) and Hobart, Tasmania (150°E, 42°S), also shows evidence of anomalous southerly flow between 150°E and 170°E prior to the midyear anomalous westerlies typical (*14*) of ENSO events, consistent with the flow observed in 1982.

Because appropriate upper-air data are not conveniently available at present, it is not possible to discuss here the vertical structure of the 1982 jet. However, it is possible to gain some perspective on the larger scale, lower frequency circulation of the atmosphere over the area and period of interest from the NOAA Climate Analysis Center maps of 3-month-average 850-mbar and 200-mbar winds from the National Weather Service operational analysis fields (*15*). Their 1982 850-mbar anomalous wind field for March through May 1982 shows an anomalous ridge across most of Australia with its axis roughly along 30°S; at 200 mbar there are no significant Australian anomalies, but there is a broad band of anomalous westerlies between 20° and 40°S, from ~ 160°E to 90°W. During the period from June to August 1982, the NOAA Climate Analysis Center 850-mbar winds indicate a large-scale strong anomalous anticyclone centered just east of Tasmania at ~ 40°S and also show anomalous equatorial westerlies west of the date line. At 200 mbar in the same period, a huge anomalous anticyclonic flow system extends from north of the equator to 45°S across most of the Pacific basin. Clearly, the surface jet described here formed in the midst of important large-scale atmospheric circulation anomalies that extend throughout the troposphere.

The genesis of the typical midyear anomalous westerlies in ENSO events is the focus of much research interest at present. Very simple models suggest that anomalously warm surface temperatures on the equator can force anomalous westerly winds up to a few tens of degrees of longitude to the west of the

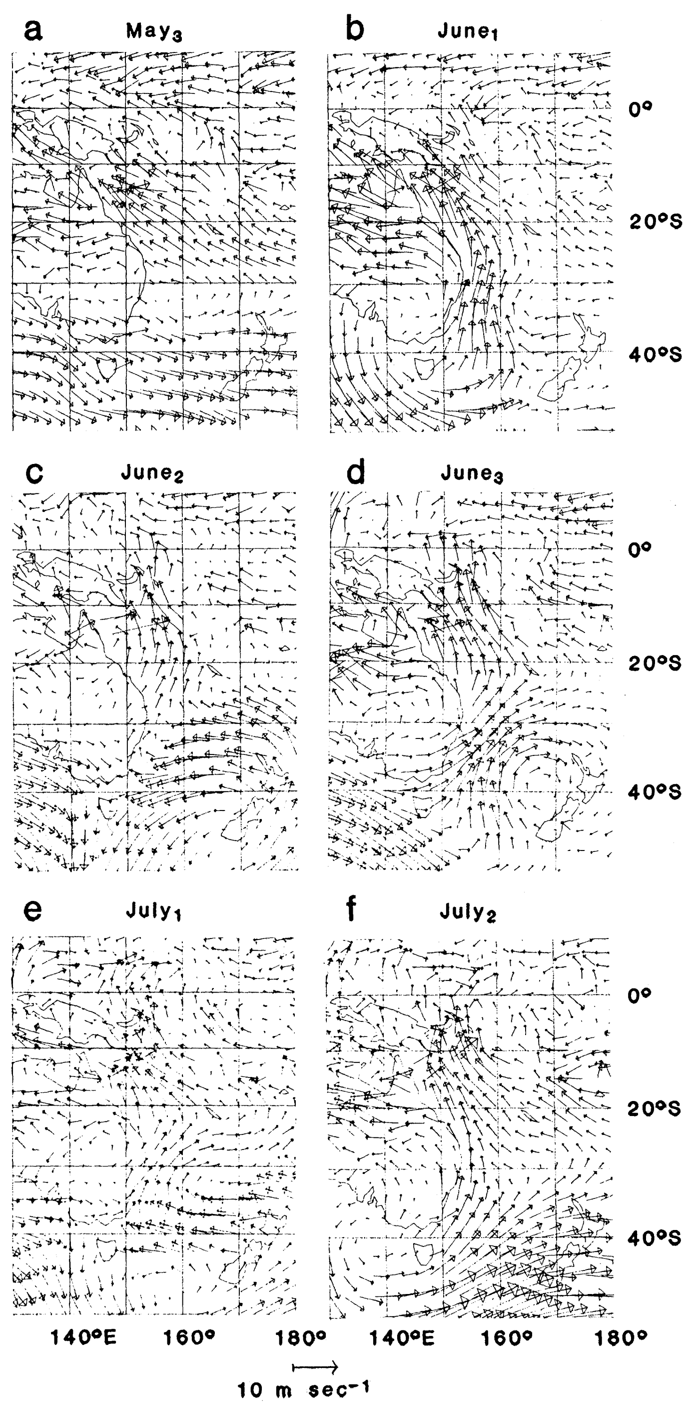

Fig. 2. Near-surface winds, six 10-day averages, for the formation period of the southerly flow shown in Fig. 1 (see text).

warm water (*16, 17*), but island wind data suggest the rather abrupt appearance of remote westerlies prior to the main period of central Pacific equatorial warming for the post-1950 ENSO events (*18*). Certainly in 1982 the June westerlies appeared prior to the appearance of warm ocean surface water in the eastern central Pacific. The mechanisms of coupling between the ocean and atmosphere remain unclear.

The 1982 ENSO event in the ocean was unlike the composite post-1950 ENSO events in many ways (*19*), but each major event has included a period of at least weak central Pacific westerlies on the equator. There are indications that anomalous southerly flow between 150°E and 170°E preceded the main appearance of westerlies on the equator in the three major post-1950 events. However, the surface wind data for earlier events are very limited; 1982 may have been a special event. In any case, the southerly jet was a prominent feature of the low-frequency wind field of 1982 that appeared prior to the onset of both equatorial westerly winds west of the date line and significant ocean surface warming to the east of the date line, and deserves further study.

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Impulse Activity Differentially Regulates [Leu]Enkephalin and Catecholamine Characters in the Adrenal Medulla

Abstract. *Regulation of the putative peptide neurohumour [Leu]enkephalin and the catecholaminergic enzymes tyrosine hydroxylase and phenylethanolamine-*N*-methyl-transferase was examined in the rat adrenal medulla in vivo and in vitro. Surgical denervation of the adrenal gland or pharmacologic blockade of synaptic transmission, treatments known to decrease catecholamine traits, increased [Leu]enkephalin content. Medullas explanted to culture exhibited a 50-fold rise in [Leu]enkephalin in 4 days, whereas tyrosine hydroxylase remained constant, and phenylethanolamine-*N*-methyltransferase decreased to a new baseline level. Veratridine-induced depolarization prevented the accumulation of [Leu]enkephalin, an effect that was blocked by tetrodotoxin, which antagonizes transmembrane* Na^+ *influx. These studies suggest that enkephalinergic and catecholamine characters are differentially regulated by impulse activity and depolarization in the adrenal medulla.*

Although the sympathoadrenal axis has long been known to play a role in adaptation to the environment, the complexity of molecular mechanisms underlying these responses has been appreciated only recently. Sympathoadrenal catecholamines integrate multisystem responses to stress, for example, but the function of adrenal opiate peptides is only now emerging. Nevertheless, opiate peptides and catecholamines already seem to participate in physiologic responses to hypotensive shock (*1*) and hypoxemia (*2*), and the peptides seem to mediate stress-induced analgesia (*3*). How does the adrenal medulla coordinate metabolism of these physiologically critical, diverse neurohormones?

Answers to this question may simultaneously elucidate new areas of physiologic regulation and define mechanisms governing neuroendocrine phenotypic plasticity. Neural crest derivatives, such as the adrenal medulla, are useful, simple model systems for studying cellular

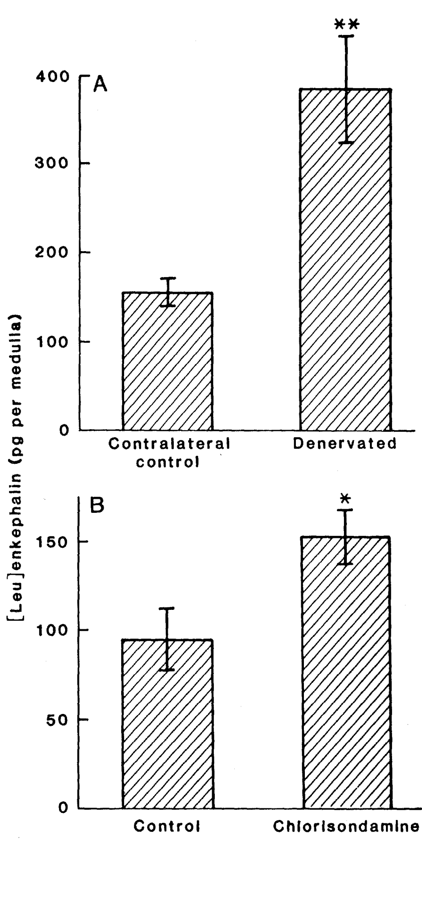

Fig. 1. Effects of decreased impulse activity on adrenal [Leu]enkephalin content. (A) Seven adult rats weighing 350 g were subjected to unilateral, surgical denervation of the adrenal gland. Denervated, contralateral control, and sham-operated adrenal glands were examined 4 days later for [Leu]enkephalin immunoreactivity (*11*). There was no significant differences in [Leu]enkephalin content between sham-operated and contralateral control adrenals. (B) Seven rats were treated with chlorisondamine (5 mg/kg, injected subcutaneously every 12 hours for 7 days). Adrenals were examined for [Leu]enkephalin content 12 hours after the last dose. Values for [Leu]enkaphalin are expressed as means ± standard errors. *Differs from control at $P < 0.05$. **Differs from control at $P < 0.01$ (two-tailed *t*-test).