*Initial Survey of Major Air Basins in California* (SAPRC Report No. 1, Statewide Air Pollution Research Center, Univ. of California, Riverside, 1972).

13. In the case of a power plant plume the $NO\text{-}NO_2$ system does not reach true photochemical equilibrium because the average ozone level in the plume slowly changes with distance due to the entrainment of ambient air by the plume and to free radical chemistry. It would be appropriate, therefore, to refer to the relatively constant ratio found for $NO/NO_x$ at moderately long distances from the stack as indicative of a pseudo-photochemical equilibrium.
14. Values obtained for $NO/NO_2$ on several daytime flights from October 1973 to August 1974 ranged from 0.9 to 0.4. In each case these values were in reasonably good agreement with those calculated from the equation $NO/NO_2 = J_2/k_1[O_3]$ when $J_2$ was calculated from the expression $J_2 = 1 \times 10^{-2} \exp(-0.38 \sec X)$, where $X$ is solar zenith angle, and plume $O_3$ concentrations were plugged in.
15. J. Heicklen, C. Westberg, N. Cohen, in *Chemical Reactions in Urban Atmospheres*, C. E. Tuesday, Ed. (Elsevier, New York, 1971), p. 95.
16. The reaction sequence suggested is

$$OH + CO \rightarrow CO_2 + H \quad (a)$$
$$H + O_2 + M \rightarrow HO_2 + M \quad (b)$$
$$HO_2 NO \rightarrow NO_2 + OH \quad (c)$$
$$NO_2 + h\nu \rightarrow NO + O \quad (d)$$
$$O + O_2 + M \rightarrow O_3 + M \quad (e)$$
$$CO + 2O_2 \rightarrow CO_2 + O_3 \quad \text{(net reaction)}$$

However, the chain length for this sequence is strongly controlled by the ratio $CO/NO_2$. In all such chain processes the OH free radical is initially generated by the reaction sequence [H. Levy, *Science* **173**, 141 (1971)]

$$O_2 + h\nu (< 3100\ \text{Å}) \rightarrow (^1D) + O_2 \quad (f)$$
$$O(^1D) + N_2 \rightarrow O(^3P)\, N_2 \quad (g)$$
$$O(^1D) + H_2O \rightarrow 2\ OH \quad (h)$$

where $O(^1D)$ is a metastable state of atomic oxygen containing approximately 23 kcal/mole excess energy. Step g, which deactivates $O(^1D)$, reduces the overall efficiency of the OH-producing scheme, making the rate of production of OH linearly dependent on the absolute $H_2O$ concentration. Thus, the rate of the $O_3$ generating chemistry should also depend linearly on the $H_2O$ concentration, and hence on the season of the year.

17. Heicklen *et al.* (*15*). Although the hydrocarbon reaction scheme is much more complex, the key reactions which replace (b) and (c) in the above scheme are

$$R + O_2 \rightarrow RO_2 \quad (i)$$
$$RO_2 + NO \rightarrow NO_2 + RO \quad (j)$$

where R is a hydrocarbon free radical.

18. During several flights, CO and total hydrocarbons were measured as close as 1½ km from the Morgantown stack. The CO found was only 1 ppm above background and no hydrocarbons other than ambient methane could be detected.
19. W. Payne, L. Stief, D. D. Davis, *J. Am. Chem. Soc.* **95**, 7614 (1973); D. D. Davis, R. Schiff, W. Bollinger, S. Fischer, in preparation. At a $N_2$ pressure of 760 torr, $k_6 \sim 8 \times 10^{-13}$ cm$^3$ molecule$^{-1}$ sec$^{-1}$.
20. The rate constant for the reaction of $HSO_4$ with $O_2$ has not yet been measured in the laboratory. We have suggested this process as one possible explanation for the observed $O_3$ bulge.
21. $k_9 = 7.5 \times 10^{-12}$ cm$^3$ molecule$^{-1}$ sec$^{-1}$ ($M = N_2$). D. D. Davis, W. Bollinger, G. Machado, S. Fischer, in preparation.
22. Supported by NSF grant GI-36338X. The work reported is part of a thesis to be submitted by G. Klauber to Johns Hopkins University in partial fulfillment of the requirements for the Ph.D. degree in electrical engineering. The authors would like to express their appreciation to Dr. Hiram Levy for his many helpful suggestions.

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# Counterclockwise Circulation in the Pacific Subantarctic Sector of the Southern Ocean

Abstract. *The distribution of isohalines in the upper 500 meters of Pacific subantarctic waters can be interpreted as evidence for an endemic counterclockwise circulation, the westward component of which is at 40 to 45 degrees south latitude. The distributions of a number of lanternfish species (family Myctophidae) lend support to such an interpretation.*

A recently completed analysis of the distribution of the oceanic fish family Myctophidae (lanternfish) in the World Ocean south of 30°S (*1*) required a detailed description of the hydrology of the Southern Ocean. An important part of that task included locating dominant hydrographic boundaries in the Southern Hemisphere, particularly the Subtropical Convergence (STC) and the Antarctic Polar Front (APF). Extensive published studies and knowledge of the APF (*2, 3*) facilitated its relatively precise location on a reference map. The region of the STC, however, has received less attention, and its extent and dynamics are poorly understood. Deacon (*2*), in his classical study of the Southern Ocean, defined the STC on the basis of surface temperature gradients and most subsequent workers have referred to his "line" as the Subtropical Convergence. The fact that the convergence between the southern anticyclonic gyres and the West Wind Drift is a broad and transitional region characterized by temporal and spatial variability, particularly in surface layers, makes such a line unrealistic. Inspection of a number of sources (*2, 4–6*) for more comprehensive parameters to identify the STC region resulted in selection of the isohalines of the 34.6 and 34.8 per mil at 200 m,

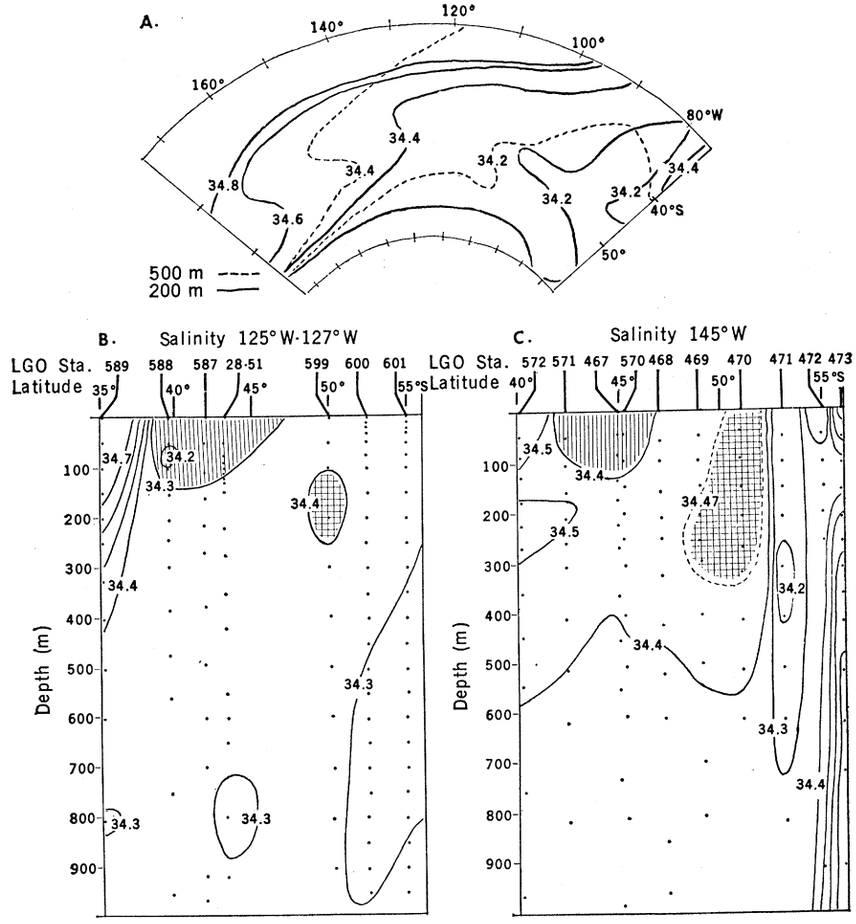


Fig. 1. Salinity distribution in Pacific subantarctic waters. (A) Isohalines at 200 and 500 m. (B) Profile at 0 to 1000 m, 125°W to 127°W. (C) Profile at 0 to 1000 m, 145°W. Salinity values are per mil. Vertical hatching indicates the region of relatively low salinity. Cross-hatching indicates the region of relatively high salinity. Abbreviation: LGO Sta., Lamont Geological Observatory Station. Based on data in (*6*).

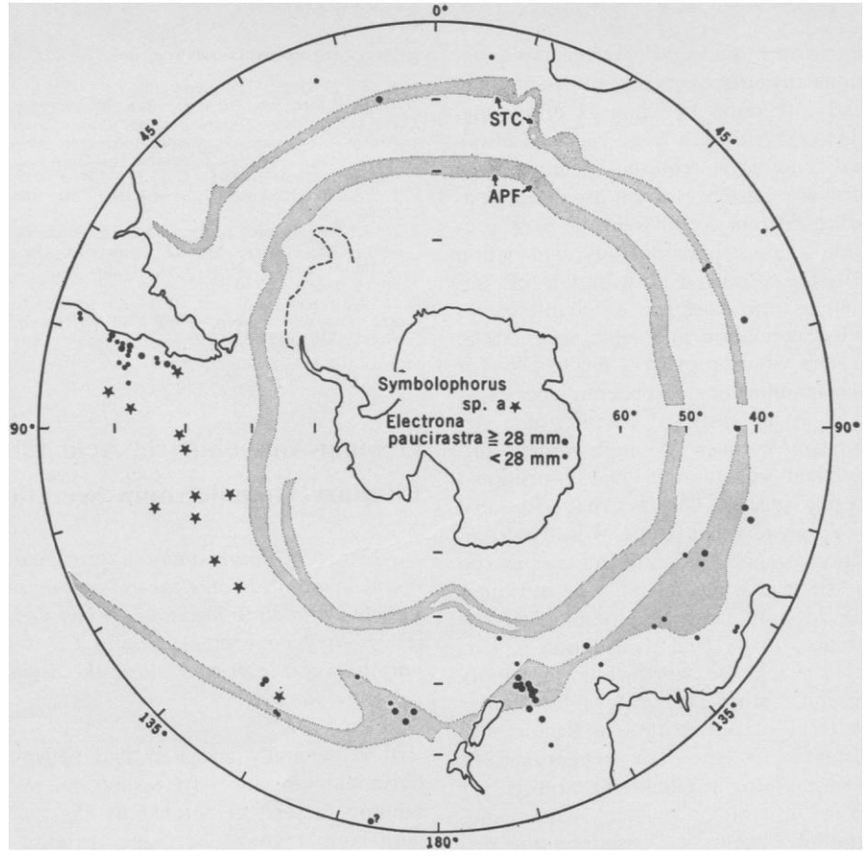


Fig. 2. Distribution of *Symbolophorus sp. a* and *Electrona paucirastra*. Shaded areas represent the Subtropical Convergence (STC) and the Antarctic Polar Front (APF). Modified from (*1*).

a region which includes the STC as defined by Deacon. The particular isohalines were chosen because they generally approximate the southern region of sharpest gradient between warm saline subtropical waters and fresher subantarctic waters, and because 200 m is deep enough to avoid most seasonal changes.

Of interest here is the apparent southeastward extension of the transitional region southeast of New Zealand. This tongue of saline water has been noted previously and attributed to the extension of the South Pacific subtropical gyre into the West Wind Drift (*4*). Its existence raises a question about the origin of the complementary tongue of less saline water to its north.

Although water movement is generally regarded to be eastward in the subantarctic latitudes, the salinity distribution in this sector indicates that the flow at 40°S to 45°S may be to the west. The 200-m isohalines near 50°S, between 165°W and South America, have higher salinity values than those in adjacent northern and southern waters; at 500 m relatively high salinities extend east of at least 100°W (Fig. 1A). Meridional profiles at 125°W and 145°W reveal that the tongue of relatively saline water near 50°S is isolated vertically and meridionally from more saline water and that its salinity is higher in the western profile than in the eastern one (Fig. 1, B and C). Conversely, the tongue of low-salinity water in the upper 200 m at 40°S to 45°S is isolated vertically and meridionally from more dilute water, and it is fresher in the eastern profile than in the western one. These features indicate that the core layers of high and low salinity are flowing in opposite directions, the more saline southern water to the east and the more dilute northern water to the west, and that each is mixing with adjacent waters. Significantly, Deacon (*2*, p. 55) remarked that subantarctic water at 40°S in this area may flow to the west, but his remark has evidently gone unnoticed by subsequent authors.

The existence of what would essentially be a counterclockwise flow of surface and subsurface oceanic water between the STC and the APF in the Pacific sector would account for the distributions of a number of lanternfish species in the Southern Ocean. Several major zonal patterns of lanternfish distribution have been defined south of 30°S (*1*). The distributions of certain species within two of the patterns are of particular interest.

1) Of ten species whose distributions are essentially restricted to subantarctic waters between the APF and the STC, only four are circumglobal. Four additional subantarctic species are widely distributed in the Atlantic, Indian, and Pacific sectors, but are generally excluded from oceanic subantarctic waters of the east-central Pacific sector. Disjunct populations of two of these species occur between 40°S and 55°S near the coast of Chile, a third species is found only near the APF in the east-central Pacific sector, and the fourth species is not found east of about 120°W. The two remaining subantarctic species are endemic to oceanic subantarctic waters of the east-central Pacific sector: for example, *Symbolophorus sp. a* (Fig. 2).

2) As with the subantarctic species, relatively few of 21 species essentially restricted to the transitional region of the STC appear to be circumglobal. Of particular interest are seven species distributed in the Atlantic, Indian, and western Pacific sectors, which are absent from oceanic waters of most of the east-central Pacific sector. Five of these seven species are represented by disjunct populations in the nearshore waters of Chile: for example, *Electrona paucirastra* Bolin (Fig. 2). Eleven species of another group of widely distributed transitional water species do occur in oceanic waters of the east-central Pacific sector. Many of these species reach their southernmost occurrence relative to the STC in this sector, and inconclusive data suggest that they live at greater depth than the former groups of species.

The absence of a significant number of rather widely distributed subantarctic species and transitional region species from oceanic waters of the east-central Pacific sector of the Southern Ocean and the presence of the same area of endemic species would be difficult to explain if, as is widely accepted, the dominant flow of water is to the east. Myctophids are small organisms (varying in maximum standard length from about 23 to 250 mm) that are planktonic during a substantial fraction, if not all, of their life spans. It is improbable that lanternfish would be capable of maintaining discrete distributions by actively responding to environmental cues in the presence of diffuse and undirectional flow. In general, however,

the distribution of lanternfish populations suggests that they are maintained and integrated by patterns of circulation (*1*). Although more rigorous physical analysis is required to either confirm the existence of the proposed westward current at 40°S to 45°S or provide a more parsimonious explanation for the observed distribution of isohalines, the existence of counterclockwise circulation in Pacific subantarctic waters would provide a mechanism for the maintenance of endemic species as well as the eastward attrition of a significant number of more widely distributed subantarctic and transitional region species. The fact that additional widespread subantarctic as well as transitional-region lanternfish species do occur in this region might be attributable to differences in physiological tolerances or vertical distribution.

It would be worthwhile to closely examine other pelagic taxa for similar patterns of distribution in Pacific subantarctic waters. The appearance of such patterns in planktonic protists, for example, might affect paleoceanographic conclusions based on the distribution of protistan microfossils in subantarctic sediments. On the other hand, it seems possible that myctophid fossils might be common enough in pelagic sediments to at least provide an additional reference for paleoceanographic studies. Not only are the lanternfish very abundant and the most speciose group of oceanic fish, they are frequently present in exposed Cenozoic and Pleistocene fossil deposits and are known to occur (especially otoliths) in pelagic sediments. The approximately 200 Recent species, the distributions of which appear to dramatically reflect hydrology, represent a remarkable radiation of low-level carnivores in the World Ocean pelagic environments. It seems probable that the Myctophidae could become increasingly important for deciphering the evolution of oceanic ecosystems.

Should the existence of the proposed westward current at 40°S to 45°S be confirmed by more rigorous physical analysis, it could appropriately be named the Deacon Current, in honor of Sir George Deacon, who first suggested its possible existence and who gave oceanography a model of the Southern Ocean which has withstood the demanding test of time.

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7. I thank B. Nafpaktitis, R. Lavenberg, J. Fitch, and J. Reid for helpful discussion and criticism, and personnel at Pacific Lutheran University for assistance.

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# Gamma-Aminobutyric Acid Effects on Pituitary Gonadotropin Secretion

Abstract. *Gamma-aminobutyric acid (GABA) injected into the third ventricle of male rats promotes the release of pituitary luteinizing hormone (LH) but not follicle-stimulating hormone. When GABA was injected directly into the pituitary it was ineffective in promoting LH release. This evidence suggests that GABA may play a role in controlling the discharge of hypothalamic luteinizing hormone releasing factor.*

It is generally accepted that neurohormonal substances (releasing and inhibiting factors) elaborated by the hypothalamus control hormone secretion from the anterior pituitary gland. However, the neural pathways and neurotransmitters that regulate neurohormone secretion have not been completely established. Recently, considerable interest has focused on putative neurotransmitters that may alter the secretion of these hypothalamic neurohormones. For example, certain biogenic amines appear to promote secretion of the pituitary gonadotropins, luteinizing hormone (LH) and follicle-stimulating hormone (FSH), and this effect is presumably mediated by a hypothalamic releasing factor (*1*).

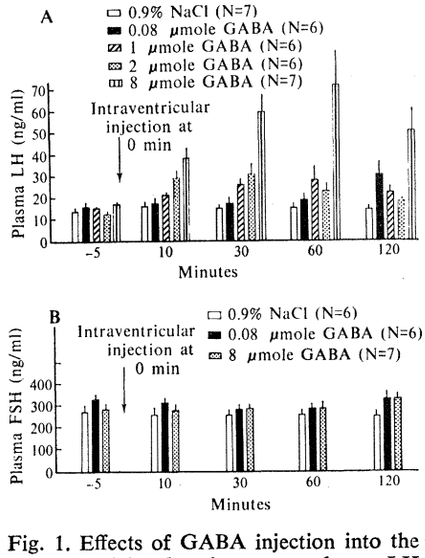


Fig. 1. Effects of GABA injection into the third ventricle of male rats on plasma LH (A) and FSH (B). Numbers of animals per group are in parentheses, and vertical lines are standard errors of the mean.

For several years certain amino acids within the central nervous system have been found to produce alterations in neuronal function, possibly acting as neurotransmitters (*2*). Gamma-aminobutyric acid (GABA), for example, is found in high quantities in the rat brain and may account for transmission at a large number of synapses (*3*). This acid has also been detected within nerve terminals in various brain regions, with high concentrations found in the diencephalon (*3*), an area known to participate in the physiologic control of reproductive function. Until now, however, there has been no evidence for the participation of GABA in the regulation of pituitary gonadotropin secretion. This preliminary report provides evidence that GABA can alter pituitary secretion of LH and that this effect is mediated by the hypothalamus.

Male Sprague-Dawley rats weighing 275 to 350 g were anesthetized with sodium pentobarbital (35 to 40 mg/kg). Throughout each experiment, the animals were ventilated through an endotracheal tube by means of a rodent respirator. The ventral diencephalon and pituitary were exposed by using a parapharyngeal approach (*4*). Test solutions were then injected into the cerebrospinal fluid of the third ventricle or into the anterior pituitary. A glass microcannula was used for all injections. GABA was dissolved in 0.9 per-