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# Hydrographic Atlas of the Gulf of Carpentaria

P. C. Rothlisberg, N. J. White, A. M. G. Forbes

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## Abstract

Hydrographic data from six cruises, between April 1976 and March 1977 in the Gulf of Carpentaria are presented. Physical quantities (temperature, salinity and $s_t$) and chemical properties (dissolved oxygen, nitrate and silicate) are presented both as values at the stations and contour maps. The original hydrographic data set can be ordered from the CSIRO Marine Laboratories, Hobart.

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# Introduction

The Gulf of Carpentaria is a large (approximately 370,000 $km^2$) shallow (<70 m) embayment in tropical northern Australia between 12° and 17.5° S (Rothlisberg and Jackson, 1982). Hydrographic sampling on a large scale has been limited to 25 cruises in the past 24 years (Table 1). The earliest Gulf-wide cruise, on the HMAS *Gascoyne* (G 5/64), was purely hydrographic (Rochford, 1966). The Japanese research vessel MV *Osoro Maru* was the first to undertake systematic hydrographic and biological sampling, but only in the northern Gulf (OS 30, Table 1) (Anon., 1970; Motoda *et al.*, 1972). The five MV *Islander VI* cruises (Is 1/70–1/71) were the first to give a seasonal coverage, from which came the first interpretation of seasonal hydrographic events (Newell, 1973). These cruises were, however, limited in their spatial coverage (3 transects, 31–35 stations; Table 1) and did not include the shallow inshore zone.

In 1975, with the initiation of the CSIRO Tropical Prawn Research Project (Dall, 1986), a new series of Gulf-wide cruises was undertaken (KL 1/75–TP 5/77) to study the larval ecology of penaeid prawns (Rothlisberg and Jackson, 1982). On these two-monthly cruises the sampling station array was more dense (6 transects, about 70 stations) and included the coastal zone to a depth of about 10 m. A series of maps showing the temporal and spatial variation in zooplankton biomass from nine of the cruises (KL 1/75–TP3/75) was published (Rothlisberg and Jackson, 1982). The hydrographic features and seasonal dynamics from these cruises have been summarised by Forbes (1984). The relationship between temperature and salinity and the early larval stages of some species of penaeid prawns has also been established (Rothlisberg and Jackson, 1987). The hydrographic data set from these cruises, along with current-meter moorings during the FV *Judy B* cruises (TP 10/78–16/78; Table 1), has laid the foundation of our understanding of the tidal and wind-driven currents in the Gulf (Church and Forbes, 1981, 1983; Forbes and Church, 1983).

Research in the Gulf is continuing and a new era of oceanographic sampling has recently started with the first cruise of RV *Franklin* into the area in February 1988 (FR 2/88). This has given Australian scientists the opportunity, for the first time, to undertake simultaneous, multidisciplinary studies in the region (Nichols *et al.*, 1988).

**Table 1:** Large-scale cruises in the Gulf of Carpentaria (GOC) on which hydrographic sampling was undertaken.

| Ship | Cruise | Date | Stations | Transects & Location |
|---|---|---|---|---|
| HMAS *Gascoyne* | G 5/64 | August 1964 | 36 | 2 Arafura Sea, 5 GOC |
| MV *Oshoro Maru* | OS 30 | December 1968 | 51 | 3 Arafura Sea, 3 N GOC |
| MV *Islander VI* | Is 1/70 | May 1970 | 29 | 3 GOC |
| | Is 2/70 | July 1970 | 32 | 3 GOC |
| | Is 3/70 | September 1970 | 35 | 3 GOC |
| | Is 4/70 | November 1970 | 32 | 3 GOC |
| | Is 1/71 | March 1971 | 31 | 3 GOC |
| FRV *Kalinda* | KL 1/75 | August 1975 | 33 | 4 N & E GOC |
| | KL 3/75 | October 1975 | 68 | 6 GOC |
| | KL 6/75 | November 1975 | 72 | 6 GOC |
| | KL 4/76 | April 1976 | 64 | 6 GOC |
| | KL 7/76 | June 1976 | 32 | 3 S GOC |
| | KL 9/76 | September 1976 | 70 | 6 GOC |
| FV *Judy B* | JB 2/76 | November 1976 | 72 | 6 GOC |
| FV *Raptis Pearl* | TP 1/77 | January 1977 | 71 | 6 GOC |
| RV *Sprightly* | TP 3/77 | March 1977 | 70 | 6 GOC |
| | TP 5/77 | May 1977 | 29 | 2 N GOC |
| FV *Judy B* | TP 10/78 | September 1978 | 60 | 6 S GOC |
| | TP 11/78 | September 1978 | 60 | 6 S GOC |
| | TP 12/78 | October 1978 | 59 | 6 S GOC |
| | TP 14/78 | October 1978 | 61 | 6 S GOC |
| | TP 15/78 | November 1978 | 60 | 6 S GOC |
| | TP 16/78 | November 1978 | 40 | 5 S GOC |
| RV *Sprightly* | Sp 3B/82 | March 1982 | 18 | 1 N GOC |
| RV *Franklin* | FR 2/88 | February 1988 | 63 | 5 GOC |

## Materials and Methods

In the following set of figures we present the hydrographic parameters measured on six cruises (KL 4/76–TP 3/77), which cover the calender year from April 1976 through March 1977.

### Sampling

Approximately 70 stations were occupied on each cruise, with the exception of KL 7/76, which made only three transects in the southern Gulf (Fig. 3). Two types of hydrographic stations were undertaken. Type 'A' stations consisted of Nansen casts with bottles every 10 m from the surface to the bottom, sampling temperature, salinity, oxygen, nitrate plus nitrite, nitrogen and silicate. Type 'B' stations were Nansen casts with three bottles (at the surface, at 10 m depth and within 10 m of the bottom) sampling the same parameters as the Type 'A' stations. The $s_t$ values were calculated from the temperature and salinity values, and the percentage of oxygen saturation was calculated from the oxygen concentration, temperature and salinity data. The difference between surface and bottom values was also calculated for all properties.

### Chemical analysis

Temperature was obtained with calibrated protected and unprotected thermometers. Salinities were measured in the laboratory with a Hamon ST meter (Lockwood, 1970). The meter was calibrated with International Standard Salinity water (Charlottenlund, Denmark). Oxygen concentration was measured by Winkler titration; nitrate and nitrite nitrogen were measured by the strychnidine method; silicate concentration was measured by the reduced beta silico-molybdate method (Major *et al.*, 1972). The accuracies of these methods were as follows:

| | |
|---|---|
| Temperature | 0.02° C |
| Salinity | 0.02 psu |
| Oxygen | 0.05 mg/l |
| Nutrients | 5% of concentration |

### Units

The units of temperature are degrees celsius (°C). Salinities are presented as psu (practical salinity units). At the time the data were collected, the appropriate units were parts per thousand (‰), but they have been reported here in the currently accepted units (numerically they are the same for the purposes of this report). The units of $s_t$ are kg $m^{-3}$, but they are not given explicitly in the figures because the units are implicit in the term $s_t$. All nutrient concentrations are micro-molar.

### Plotting and contouring

The data for each frame were triangulated, interpolated onto a regular grid, smoothed and then contoured, using the NCAR package on the CSIRO Marine Laboratories VAX 11/750. After some tidying up and editing, the figures were plotted on a laser printer. Due to the smoothing, some fine detail is lost, especially where single stations have values greatly different from adjacent stations. Some detail has also been lost around the edges due to the removal of fragments of contours that could not be continued unambiguously. There has been no thinning of contours.

## Availability of Data

The hydrology data can be ordered from the CSIRO Marine Laboratories. All requests should be addressed to: ORV Data Librarian, CSIRO Marine Laboratories, GPO Box 1538, Hobart, Tasmania, 7001. A nominal charge may be made. Station numbers have been omitted from Figure 3 because there are two set of numbers in use; data can be requested by specifying cruise numbers, dates and locations.

## References


Anonymous (1970) The "Oshoro Maru" Cruise 30 to the north and tropical Pacific Ocean and the Gulf of Carpentaria, November 1968–January 1969. pp. 217-313 in "Data Record of Oceanographic Observations and Exploratory Fishing No. 14". The Faculty of Fisheries, Hokkaido University, Hakodate, Hokkaido, Japan.

Church, J. A. and Forbes A. M. G. (1981) Non-linear model of the tides in the Gulf of Carpentaria. *Australian Journal of Marine and Freshwater Research* 32: 685–697.

Church, J. A. and Forbes, A. M. G. (1983) Circulation in the Gulf of Carpentaria. I. Direct observations of currents in the south-east corner of the Gulf of Carpentaria. *Australian Journal of Marine and Freshwater Research* 34: 1–10.

Cresswell, G. R. (1971) Current measurements in the Gulf of Carpentaria. *CSIRO Division of Fisheries and Oceanography Report* 50, 6 pp.

Dall, W. (1986) Management-oriented research: penaeid prawns. pp. 134-139. in T. J. A. Hundloe (ed.) "Fisheries Management Theory and Practice in Queensland". Griffith University Press, Brisbane.

Forbes, A. M. G. (1984) The contribution of local processes to seasonal hydrology of the Gulf of Carpentaria. *Oceanographie Tropicale* 19: 193–201.

Forbes, A. M. G. and Church, J.A. (1983) Circulation in the Gulf of Carpentaria. II. Residual currents and mean sea level. *Australian Journal of Marine and Freshwater Research* 34: 11–22.

Lockwood, D. R. (1970) Portable temperature–chlorinity bridge (S–T meter) instruction manual. *CSIRO Division of Fisheries and Oceanography Report* 47, 32 pp.

Major, G. A., Dal Pont, G., Klye, J. and Newell, B. (1972) Laboratory techniques in marine chemistry. *CSIRO Division of Fisheries and Oceanography Report* 51, 60 pp.

Motoda, S., Kawamura, T. and Taniguchi, A. (1978) Differences in productivities between the Great Australian Bight and the Gulf of Carpentaria, Australia, in summer. *Marine Biology* 46: 93–99.

Newell, B. S. (1973) Hydrology of the Gulf of Carpentaria, 1970–71. *CSIRO Division of Fisheries and Oceanography Technical Paper* 35, 29 pp.

Nichols, P., Forbes, A. M. G., Rothlisberg, P. C., Moriarty, D. J. W. and Pollard, P. C. (1988) The Gulf of Carpentaria: results from an interdisciplinary study. pp 1-5 in *Proceedings of the Australian Marine Sciences Association Silver Jubilee Annual Conference.*

Rochford, D. J. (1966) Some hydrological features of the eastern Arafura Sea and the Gulf of Carpentaria in August 1964. *Australian Journal of Marine and Freshwater Research* 17: 31–60.

Rothlisberg, P. C. and Jackson, C. J. (1982) Temporal and spatial variation of plankton abundance in the Gulf of Carpentaria, Australia 1975–1977. *Journal of Plankton Research* 4: 19–40.

Rothlisberg, P. C. and Jackson, C. J. (1987) Larval ecology of penaeids of the Gulf of Carpentaria, Australia. II. Hydrographic environment of *Penaeus merguiensis, P. esculentus, P. semisulcatus* and *P. latisulcatus* zoeae. *Australian Journal of Marine and Freshwater Research* 38: 19–28.

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The differences are between surface and bottom; negative contours are dashed.


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Figure 1. The Gulf of Carpentaria

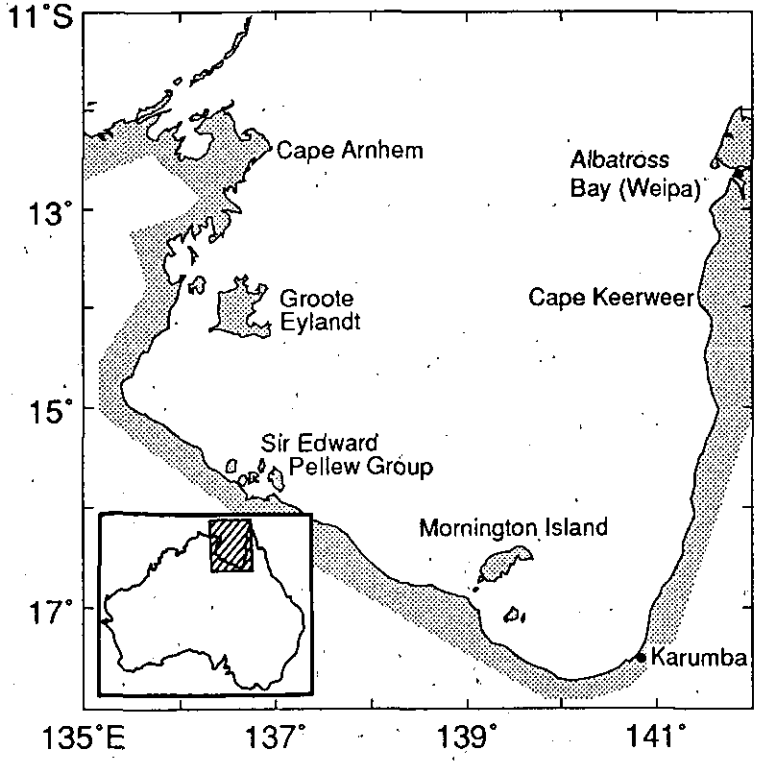
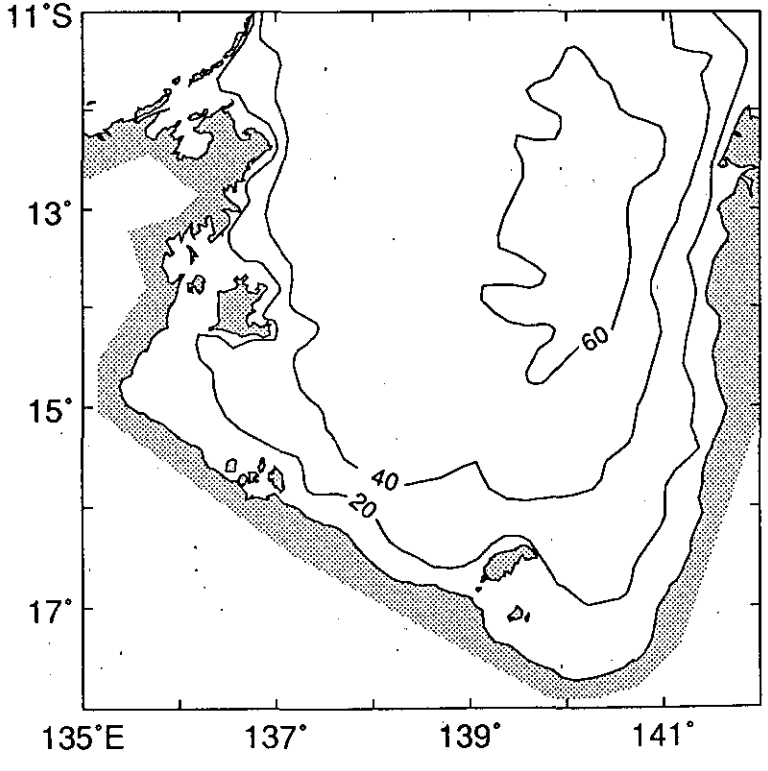



Figure 2. Bathymetry — depths in metres



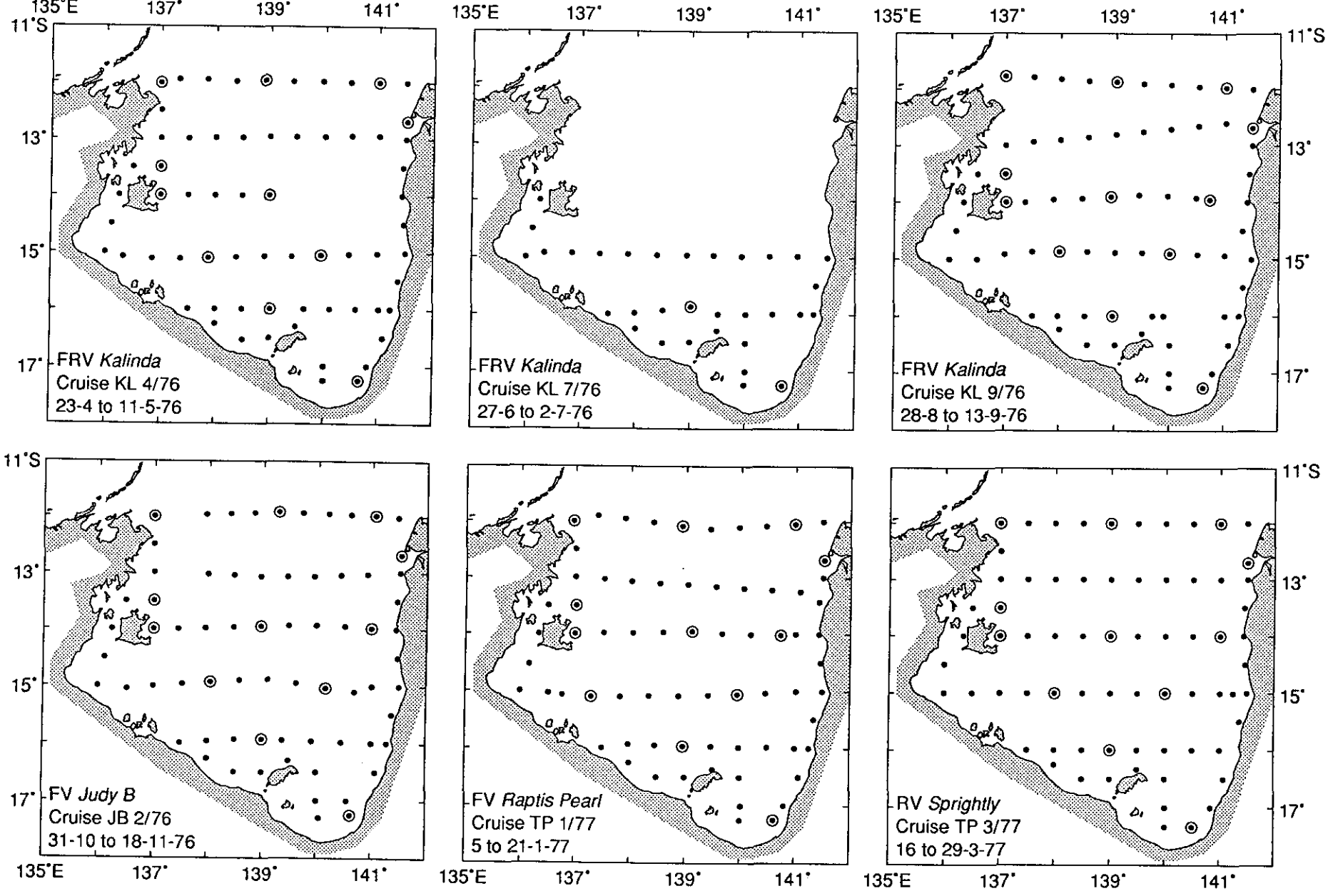
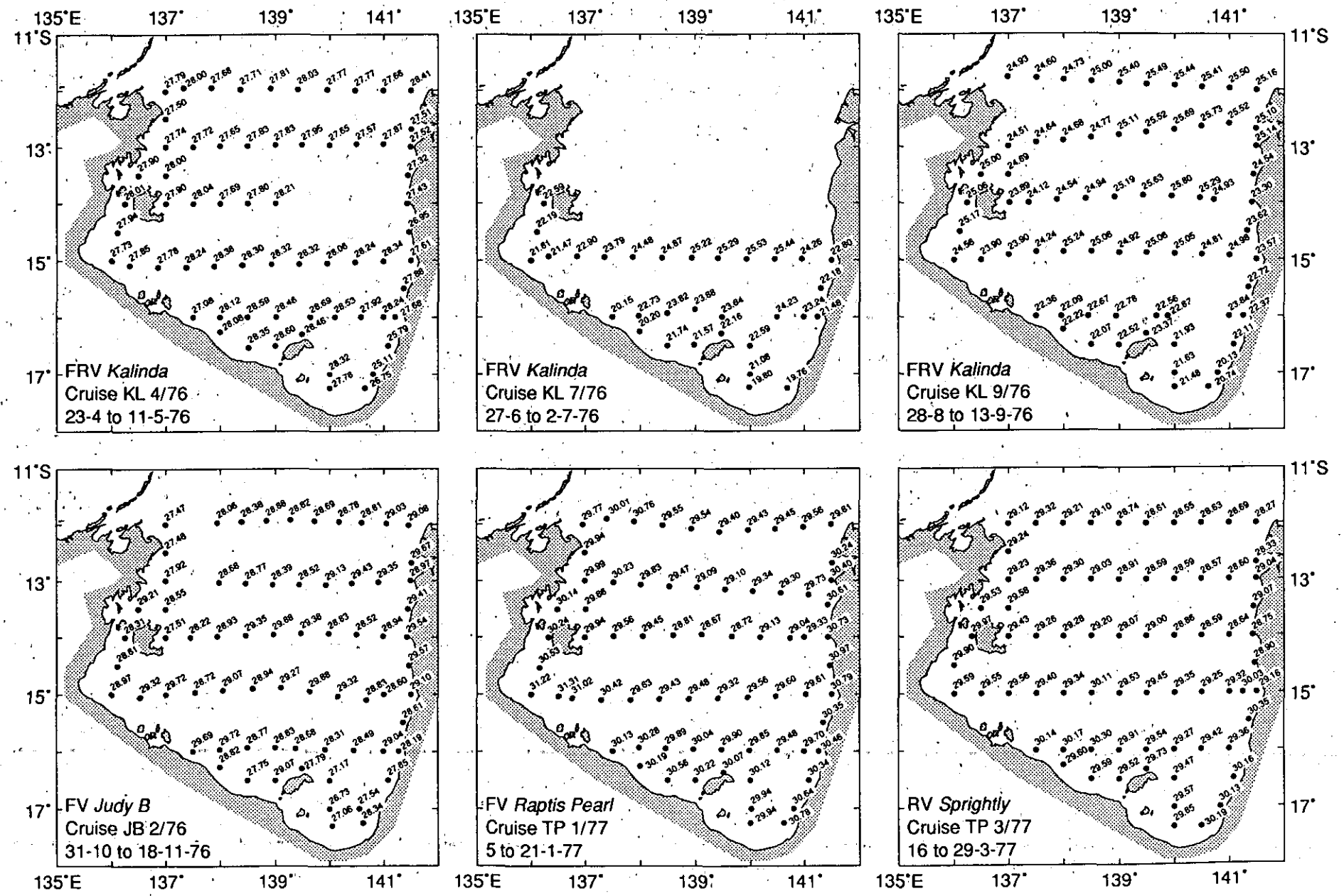



Figure 3. Station locations

⊙ 'A' stations

Figure 4a. Temperature — surface (°C)



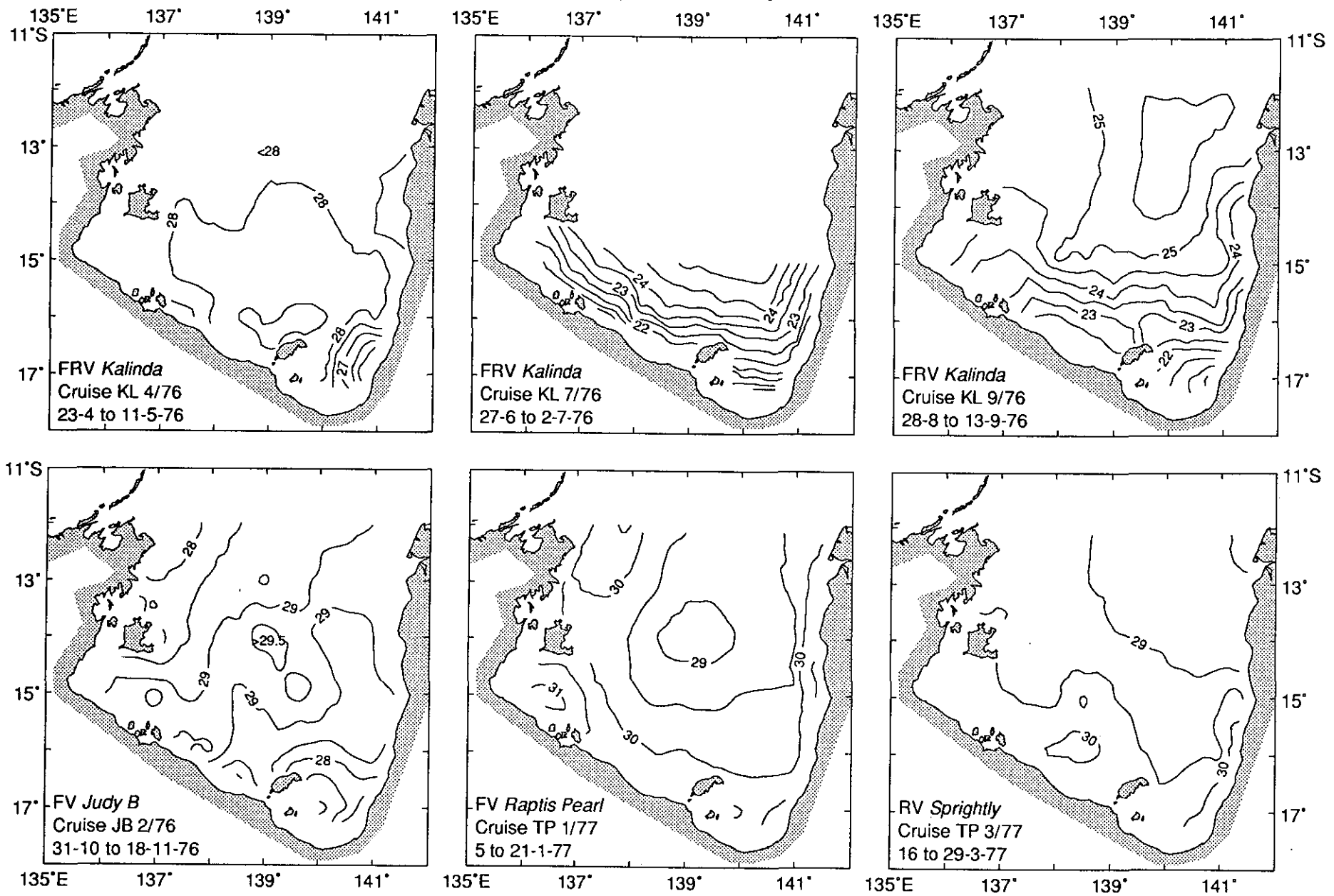
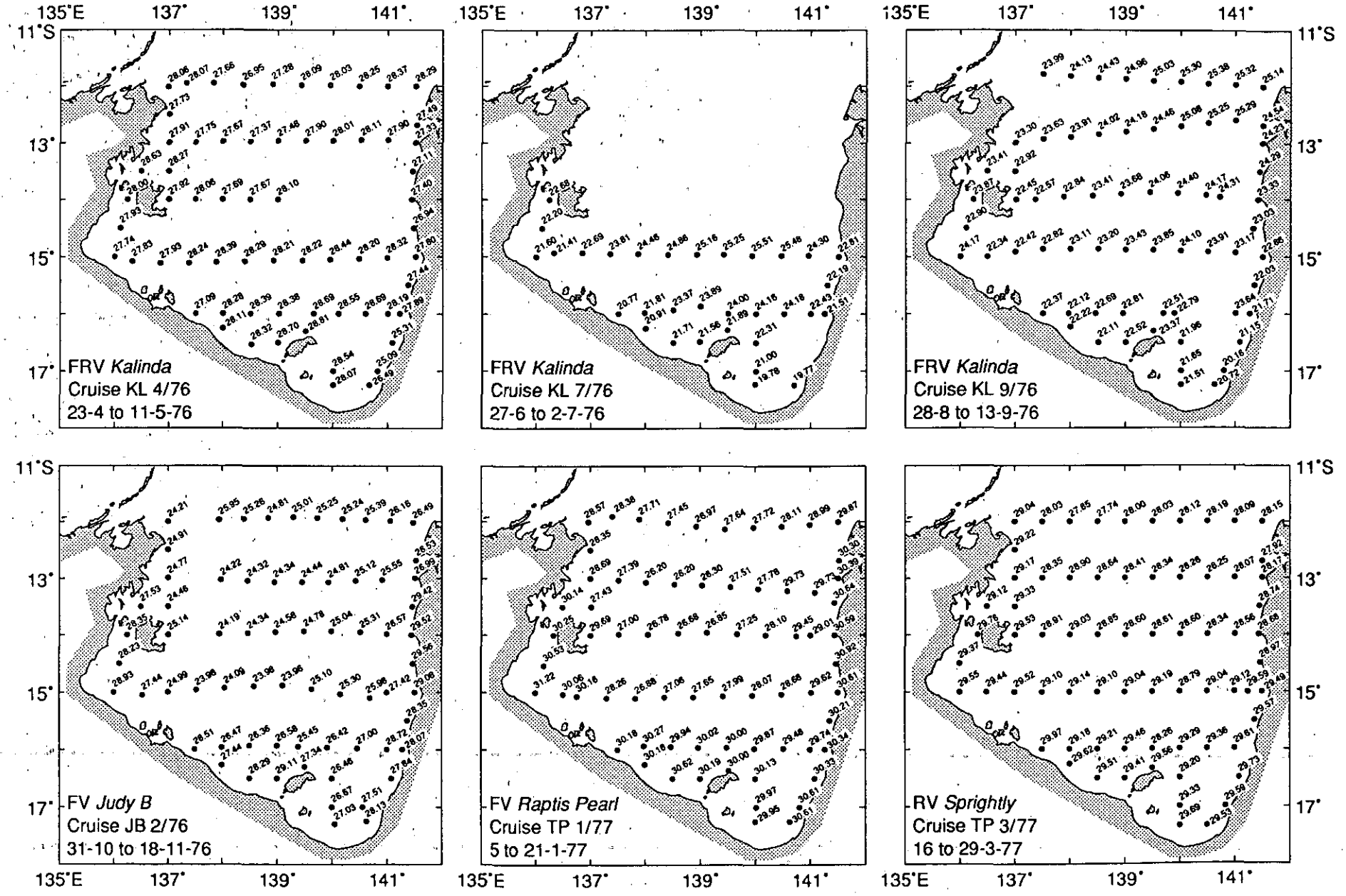



Figure 4b. Temperature — surface (°C)

Contour interval = 0.5

Figure 5a. Temperature — bottom (°C)



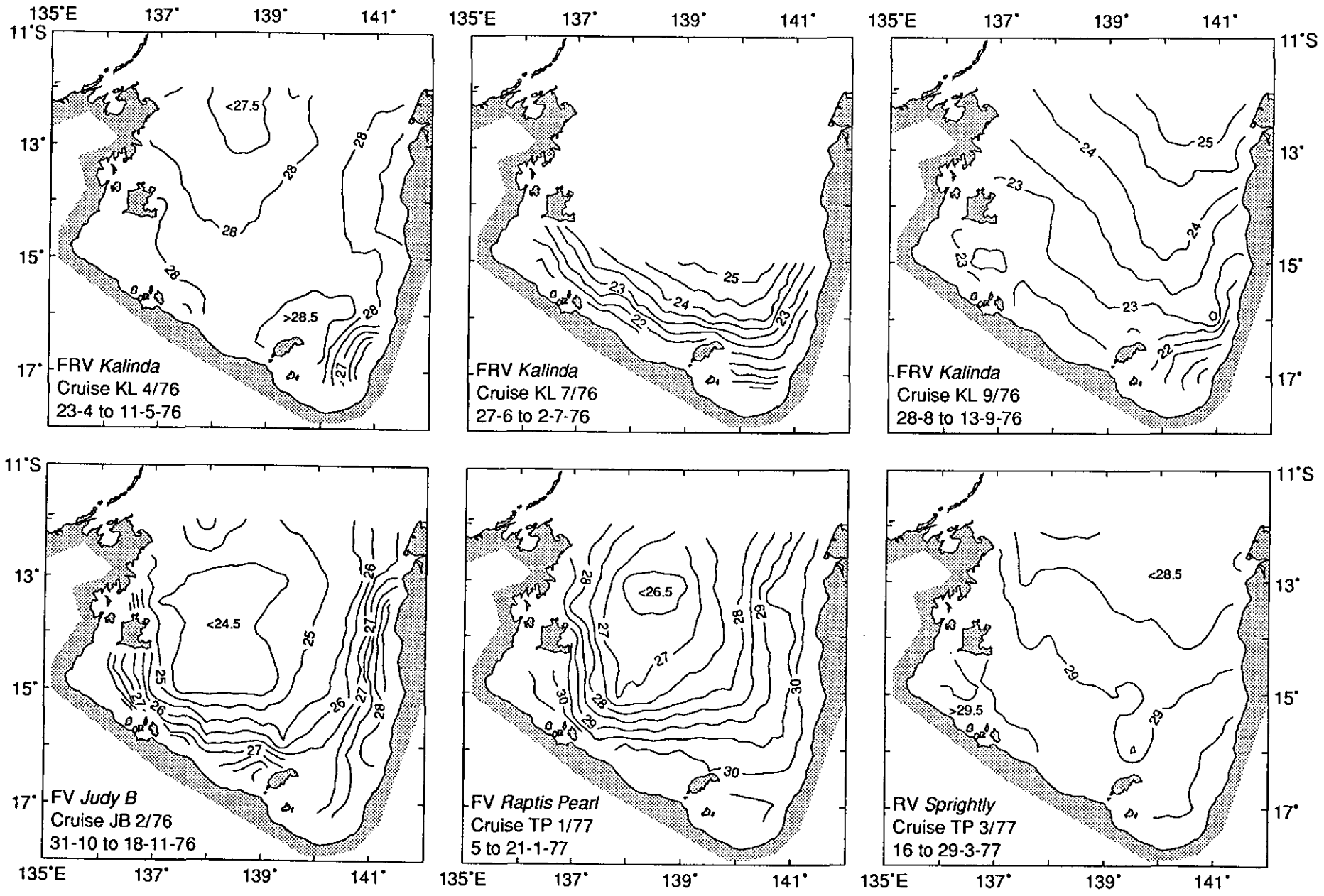
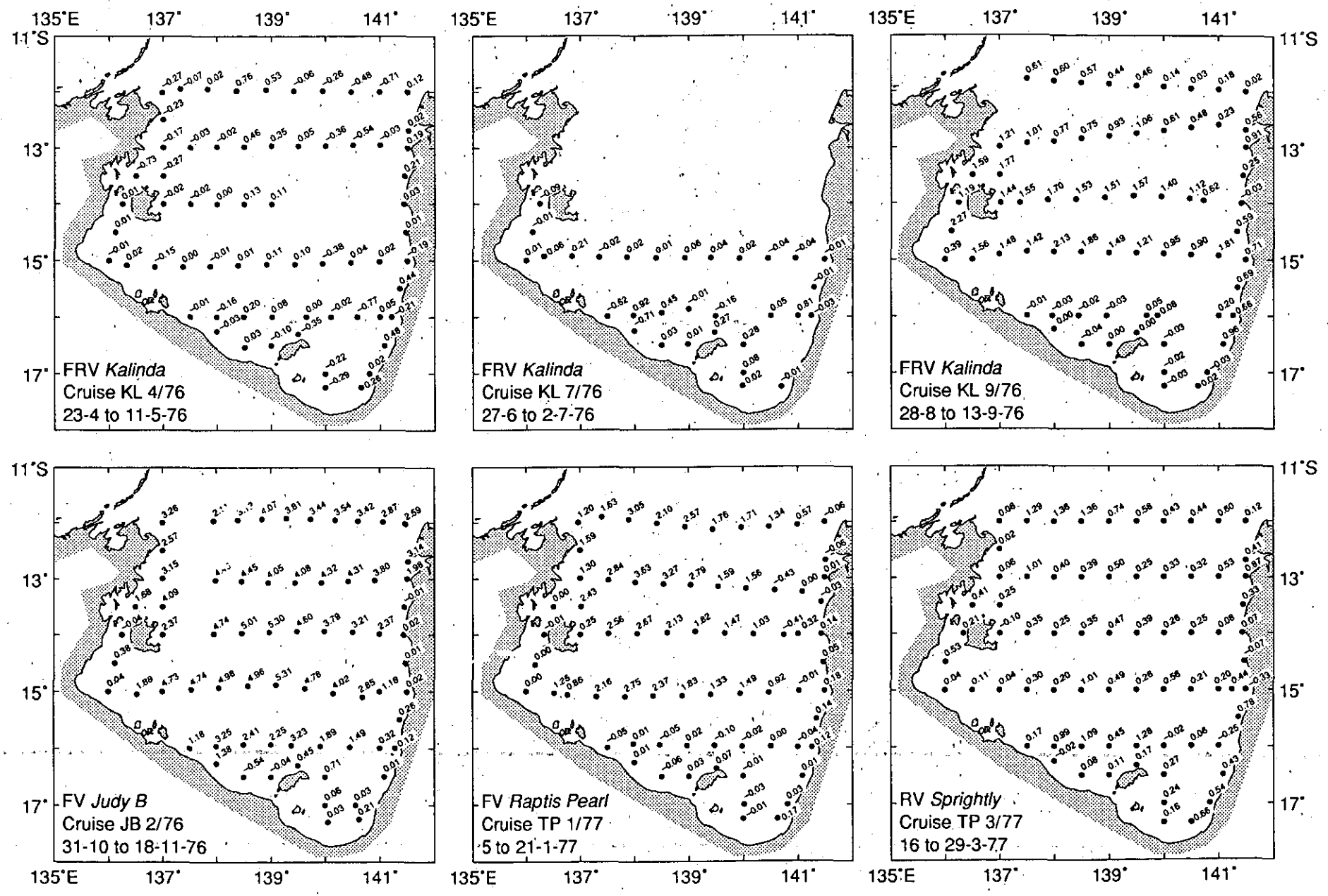



Figure 5b. Temperature — bottom (°C)

Contour interval = 0.5

Figure 6a. Temperature — difference (°C)



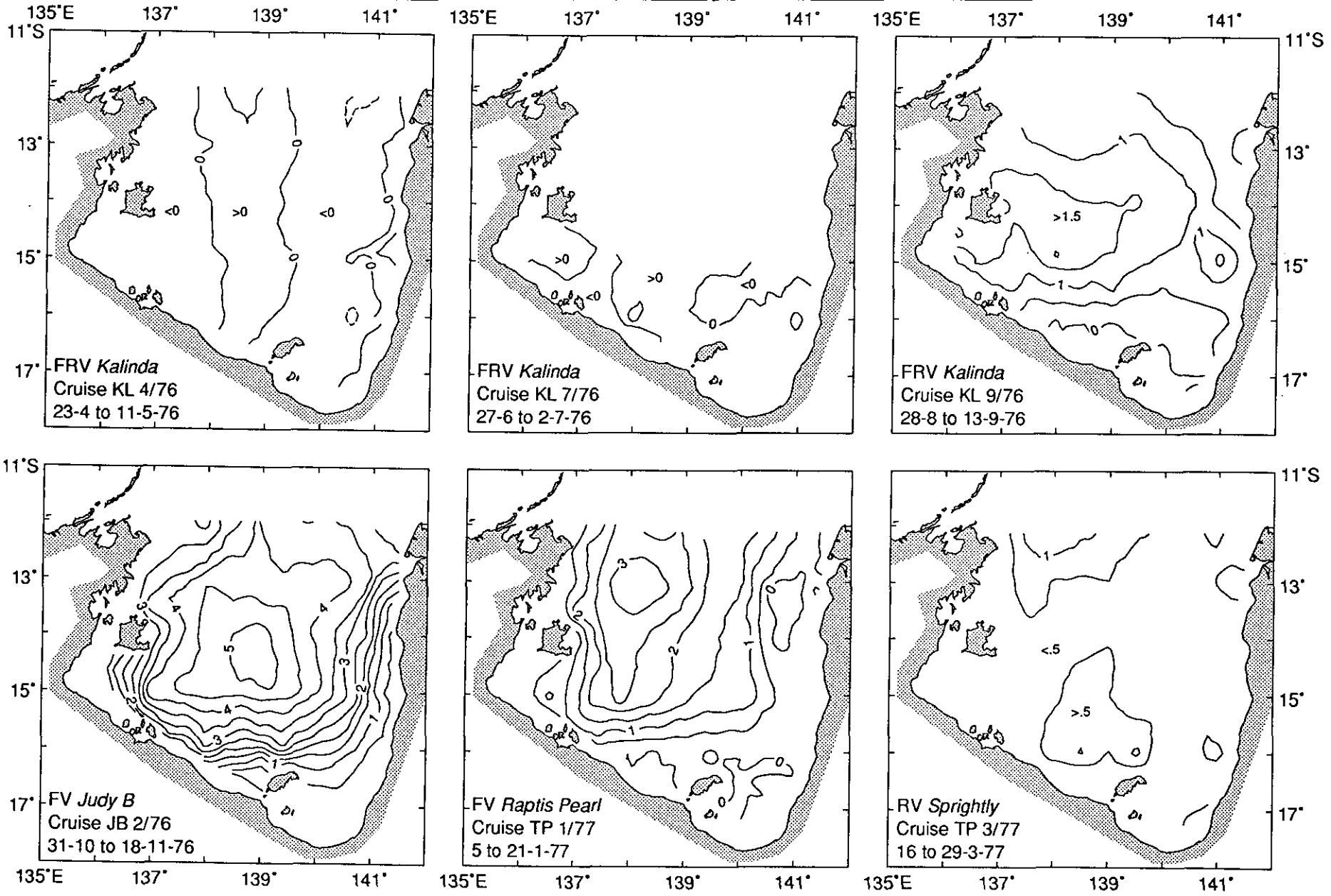
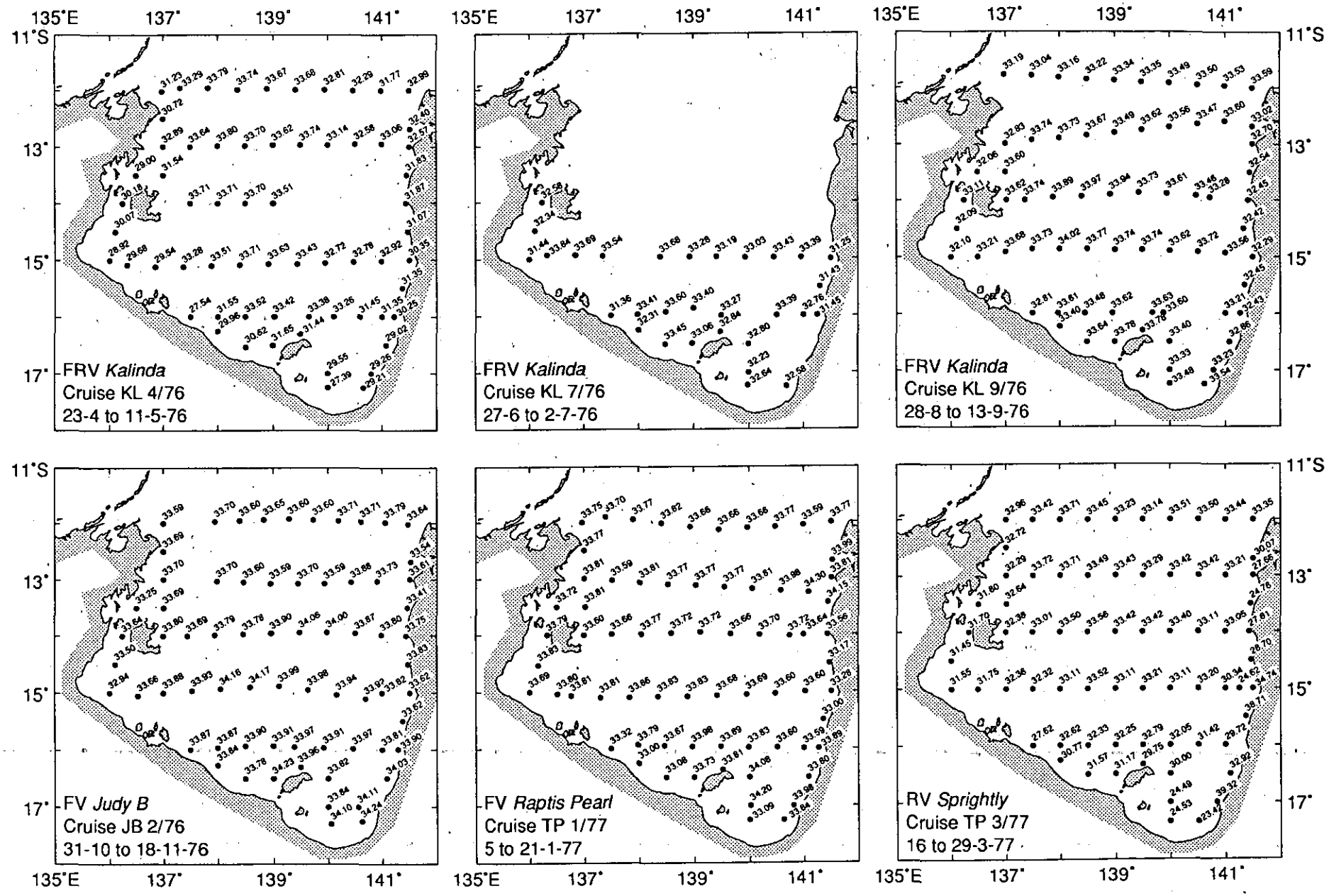



Figure 6b. Temperature — difference (°C)

Contour interval = 0.5

Figure 7a. Salinity — surface (psu)



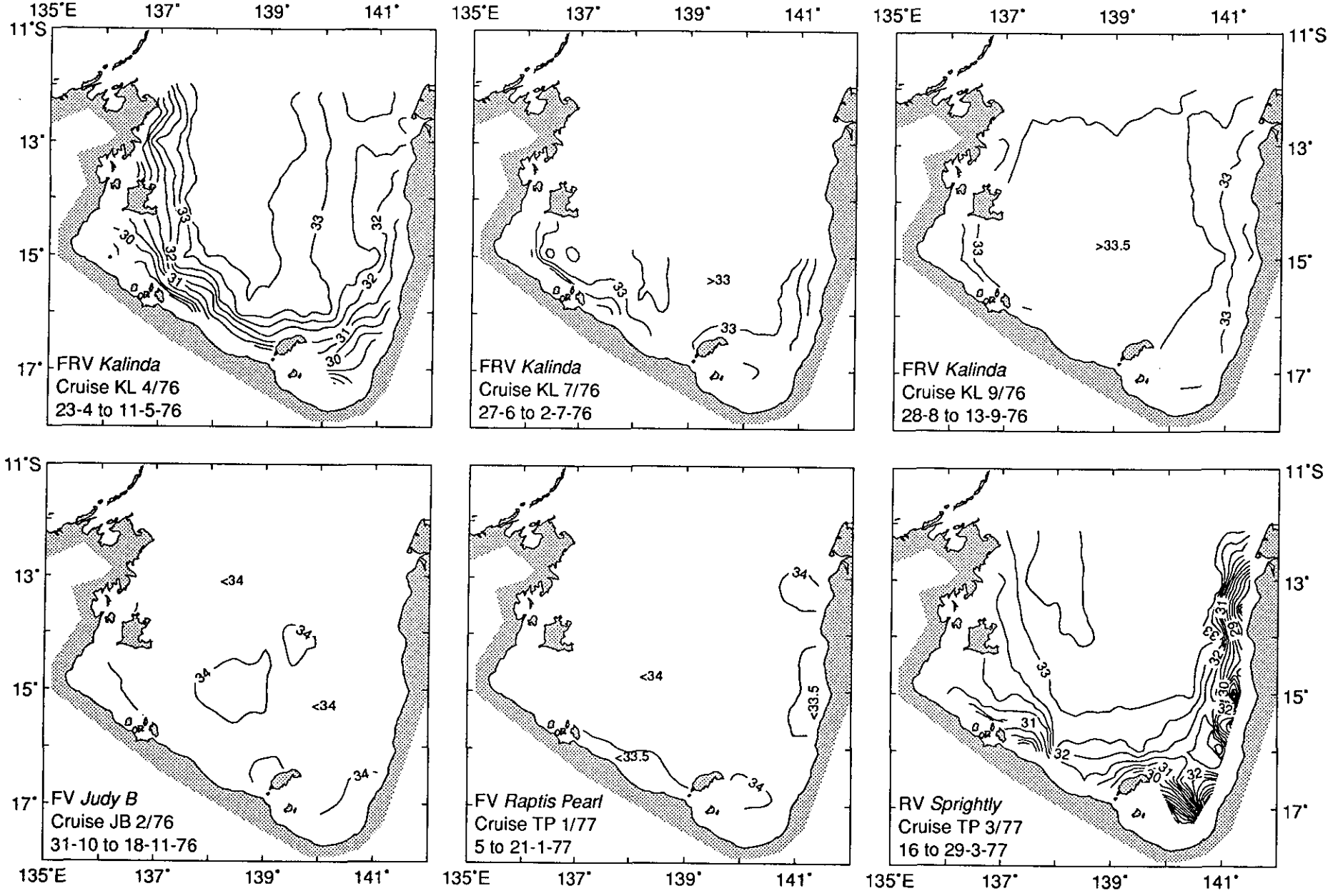
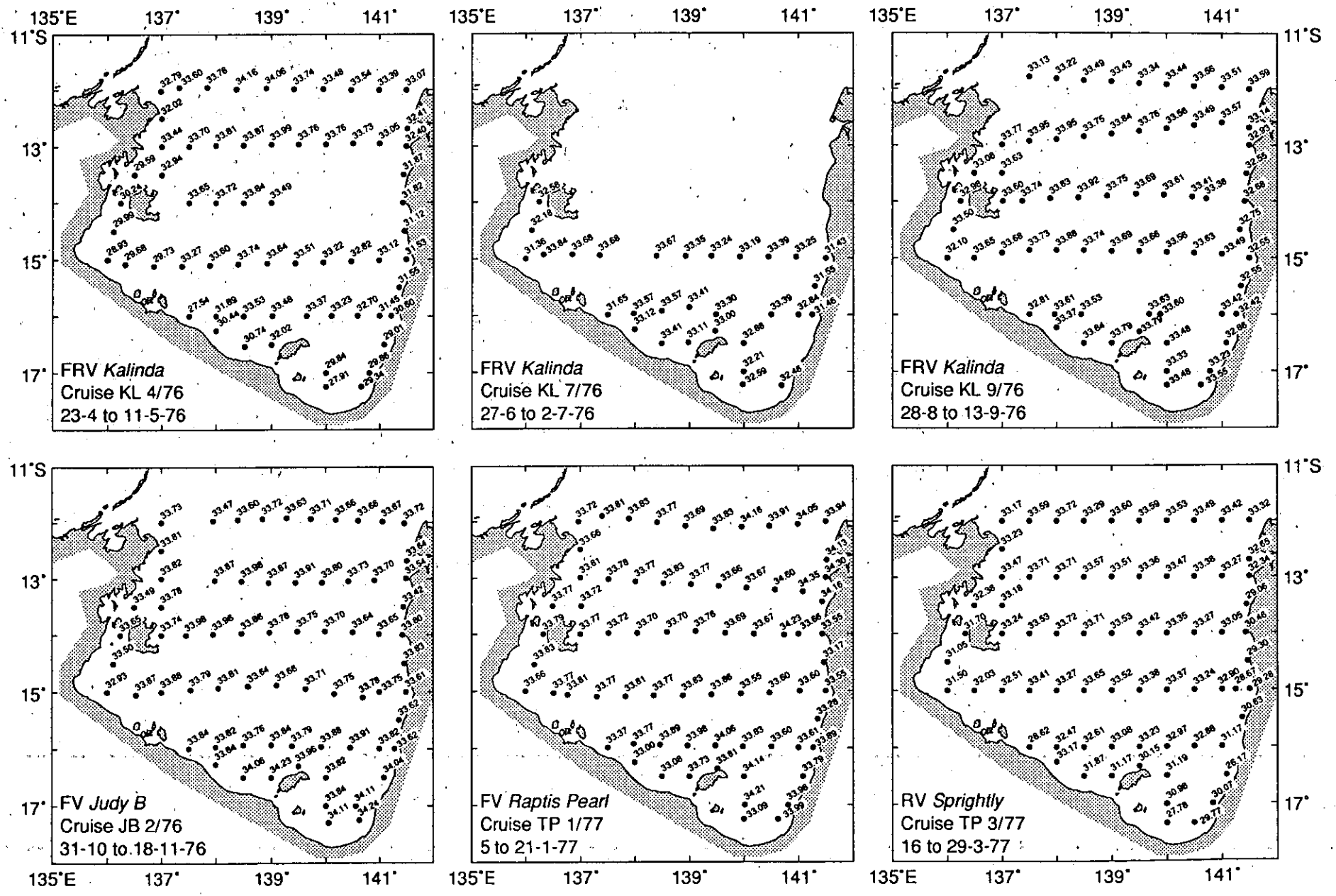



Figure 7b. Salinity — surface (psu)

Contour interval = 0.5

Figure 8a. Salinity — bottom (psu)



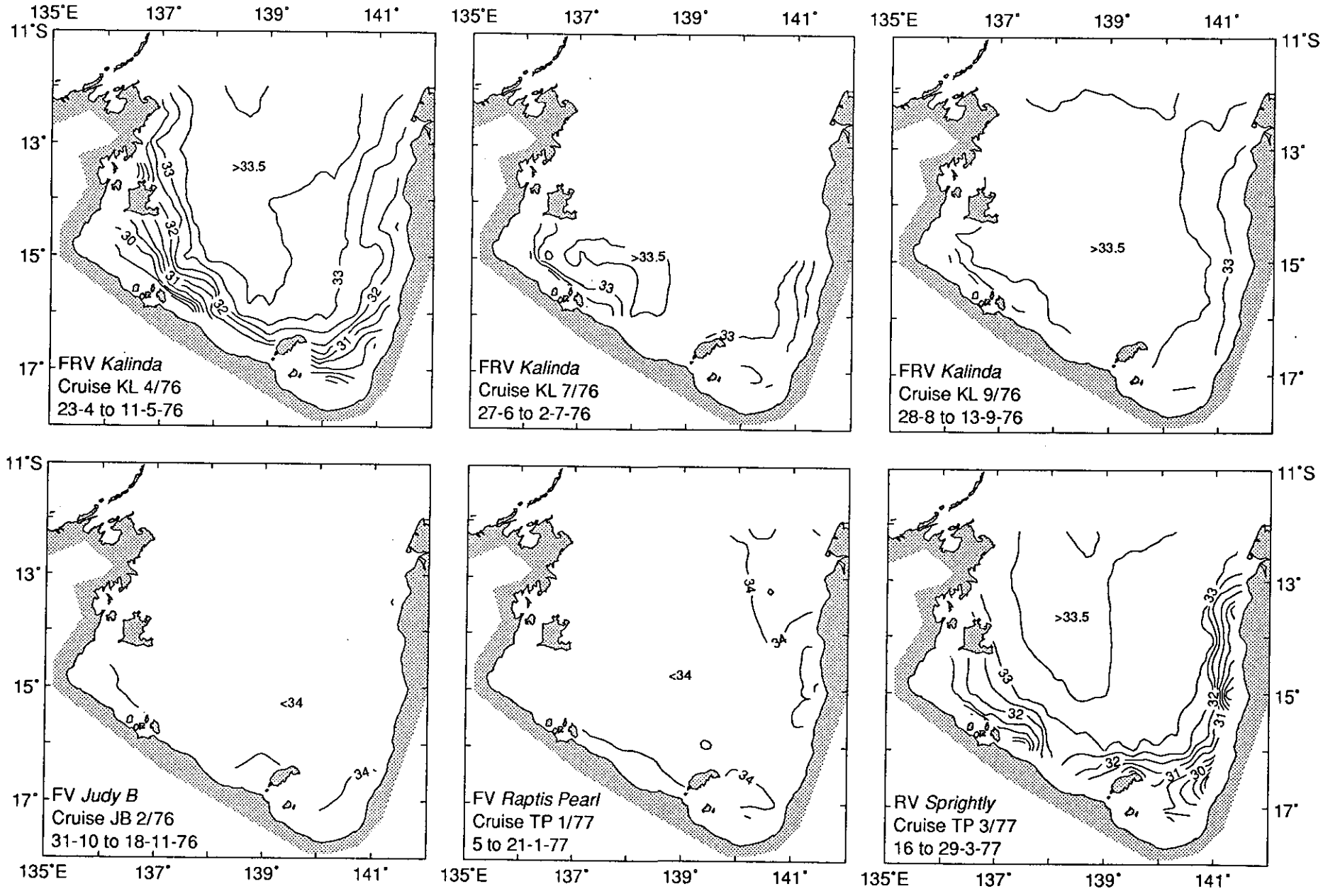
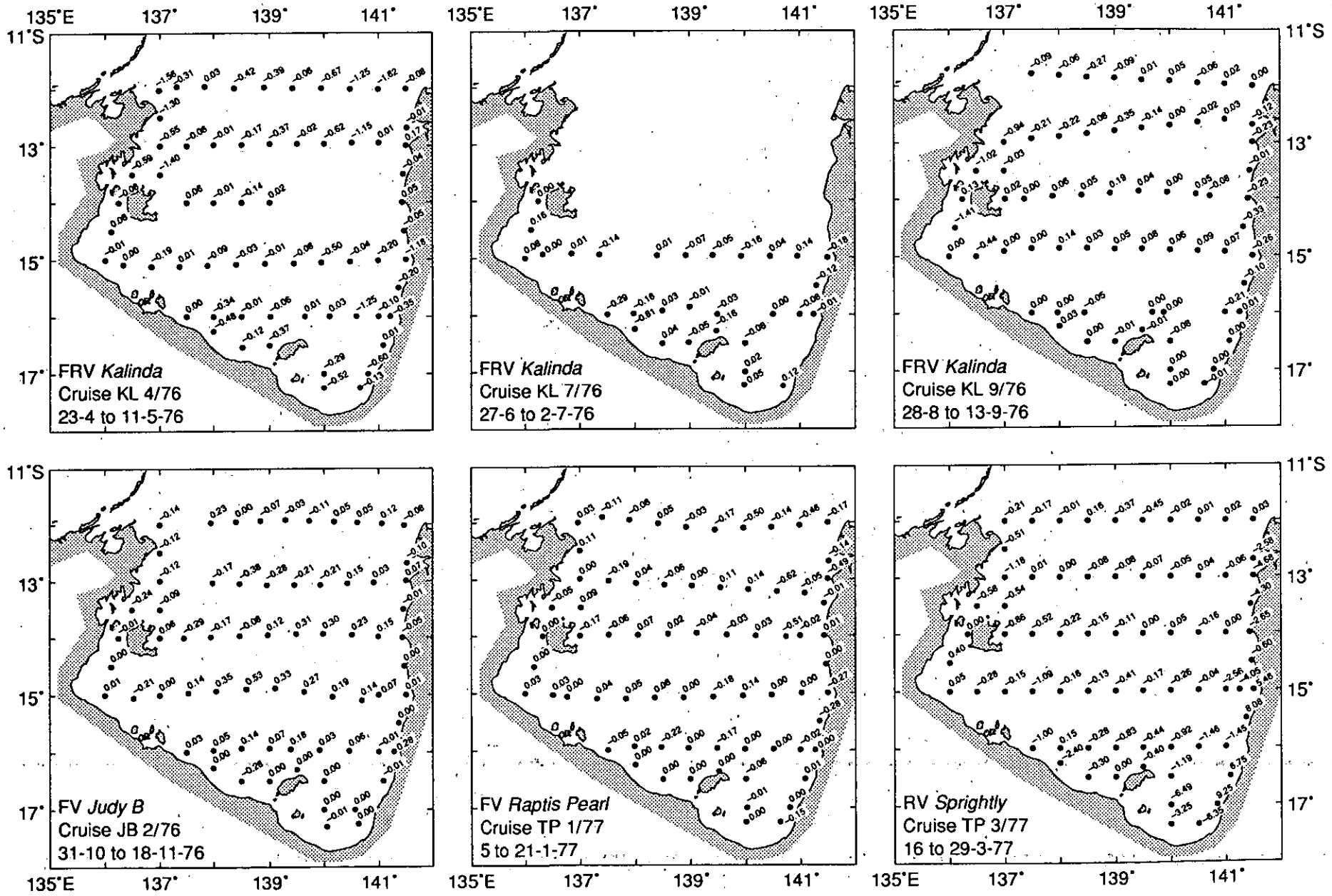



Figure 8b. Salinity — bottom (psu)

Contour interval = 0.5

Figure 9a. Salinity — difference (psu)



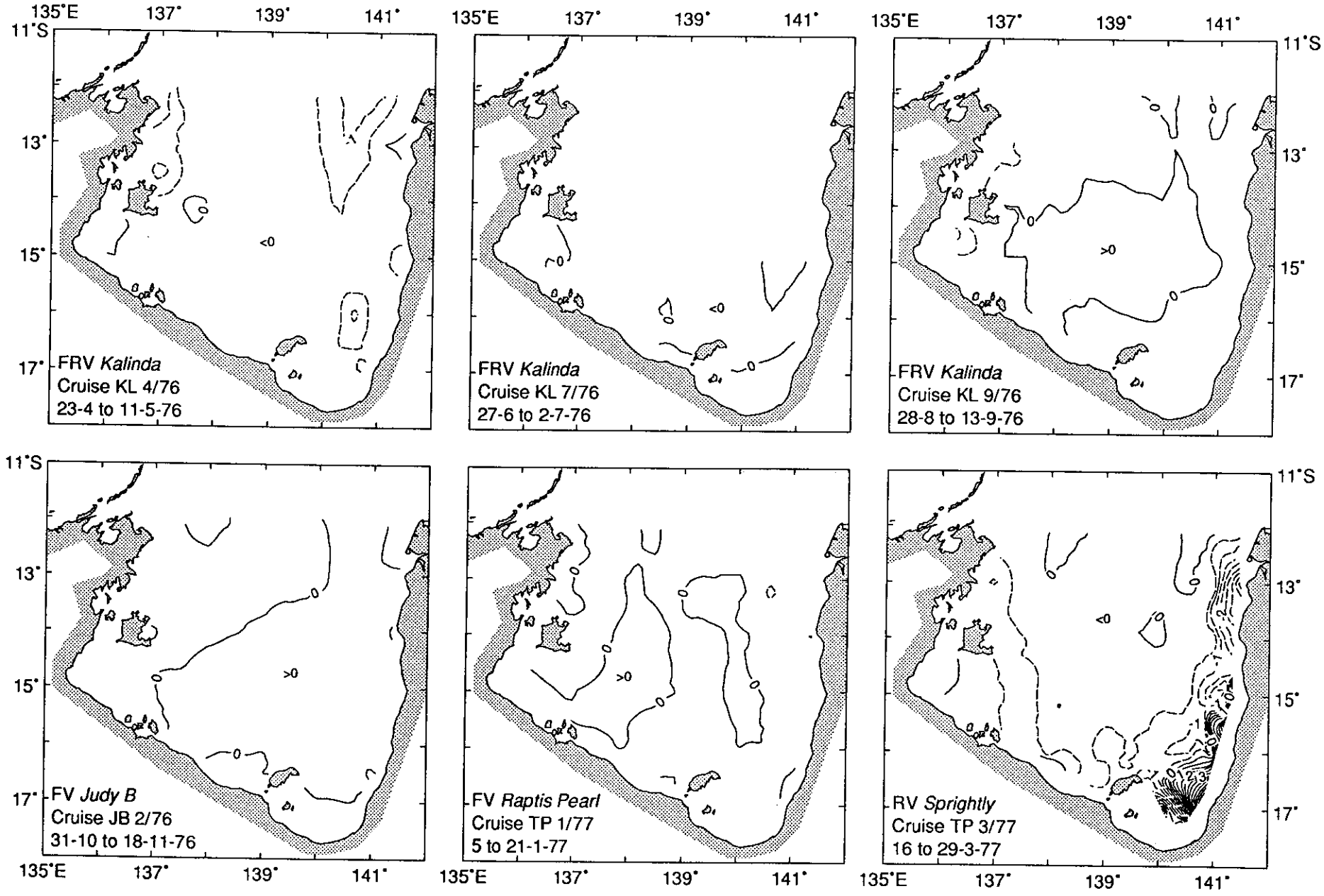
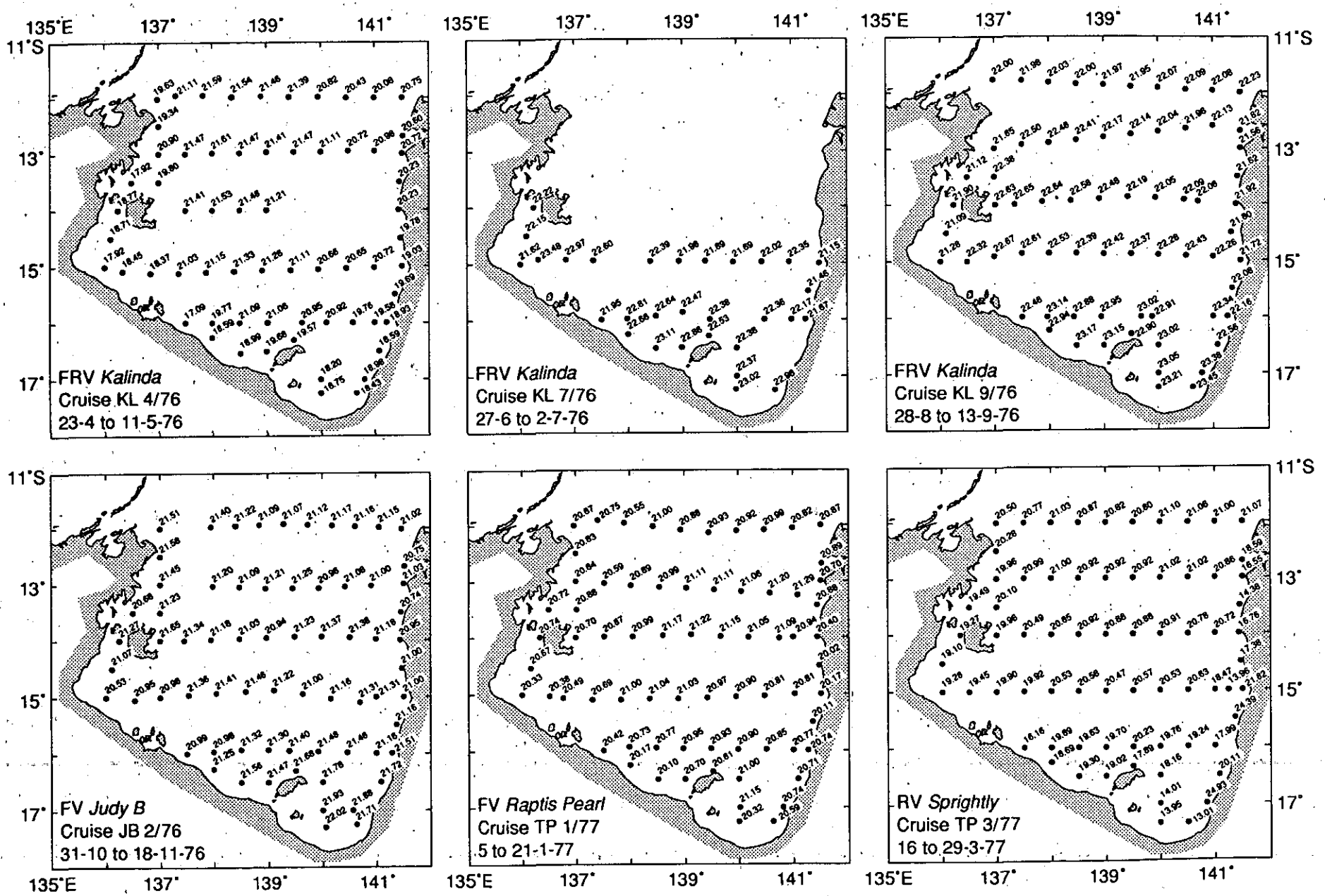



Figure 9b. Salinity — difference (psu)

Contour interval = 0.5

Figure 10a. Sigma t — surface



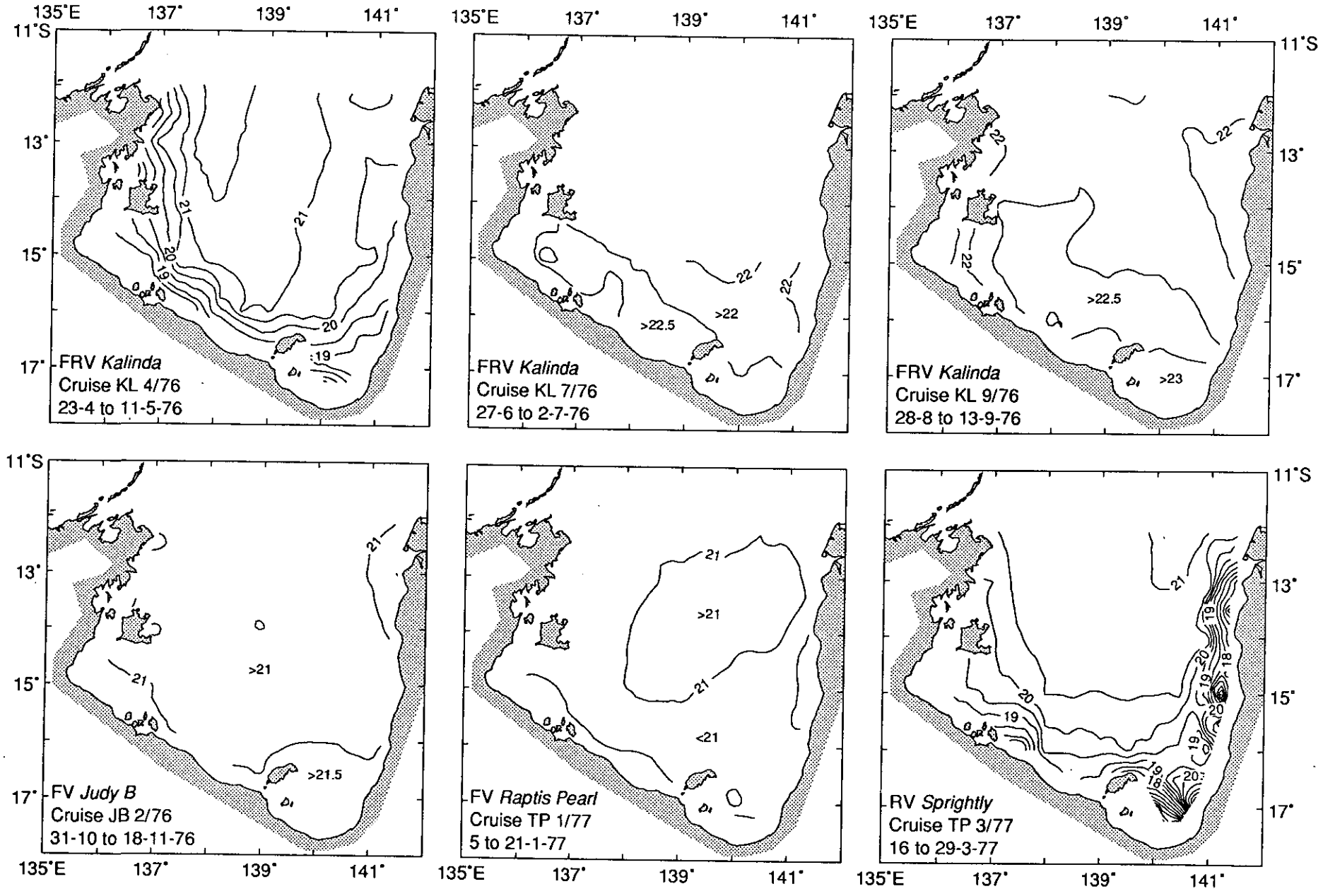
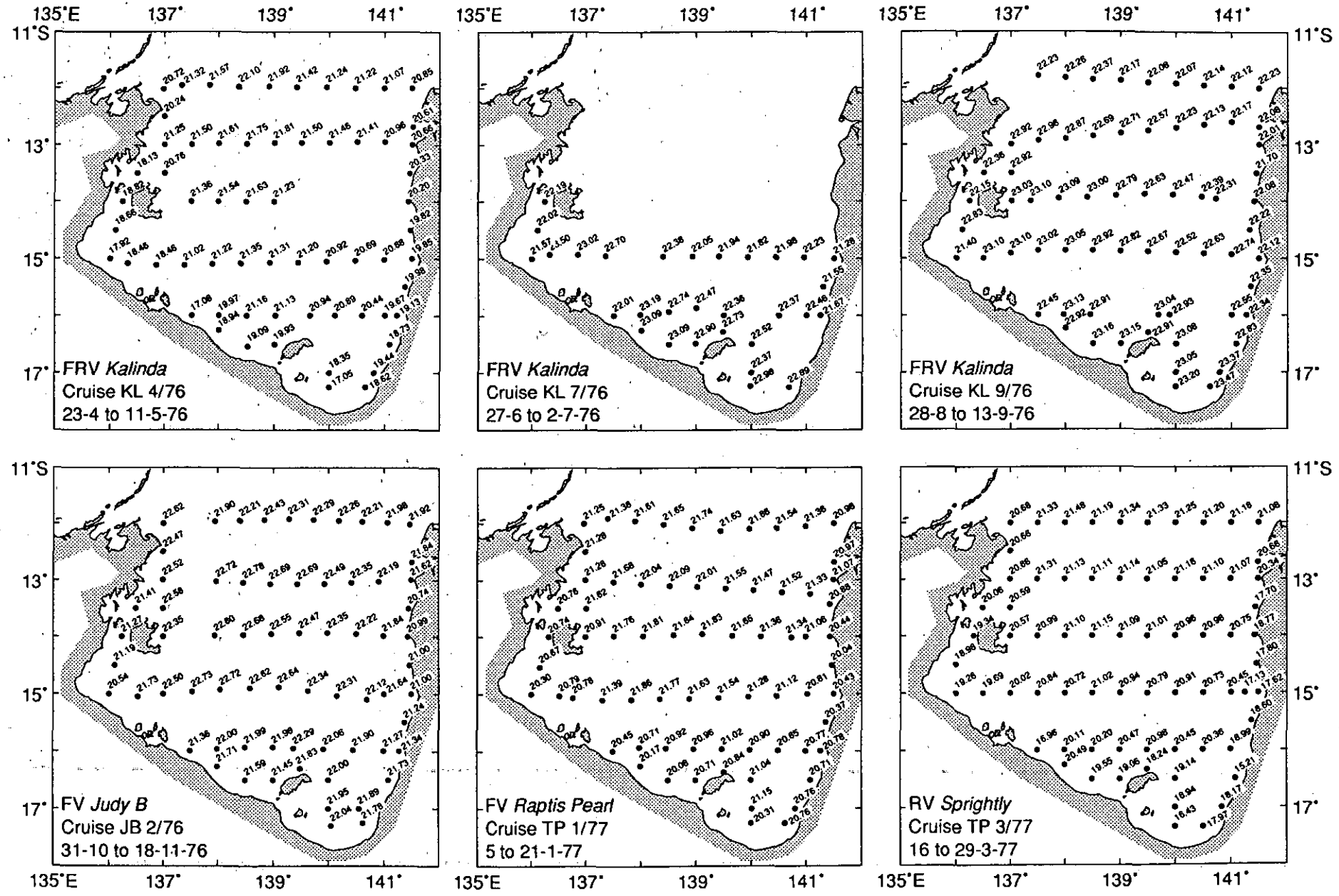



Figure 10b. Sigma t — surface

Contour interval = 0.5

Figure 11a. Sigma t — bottom



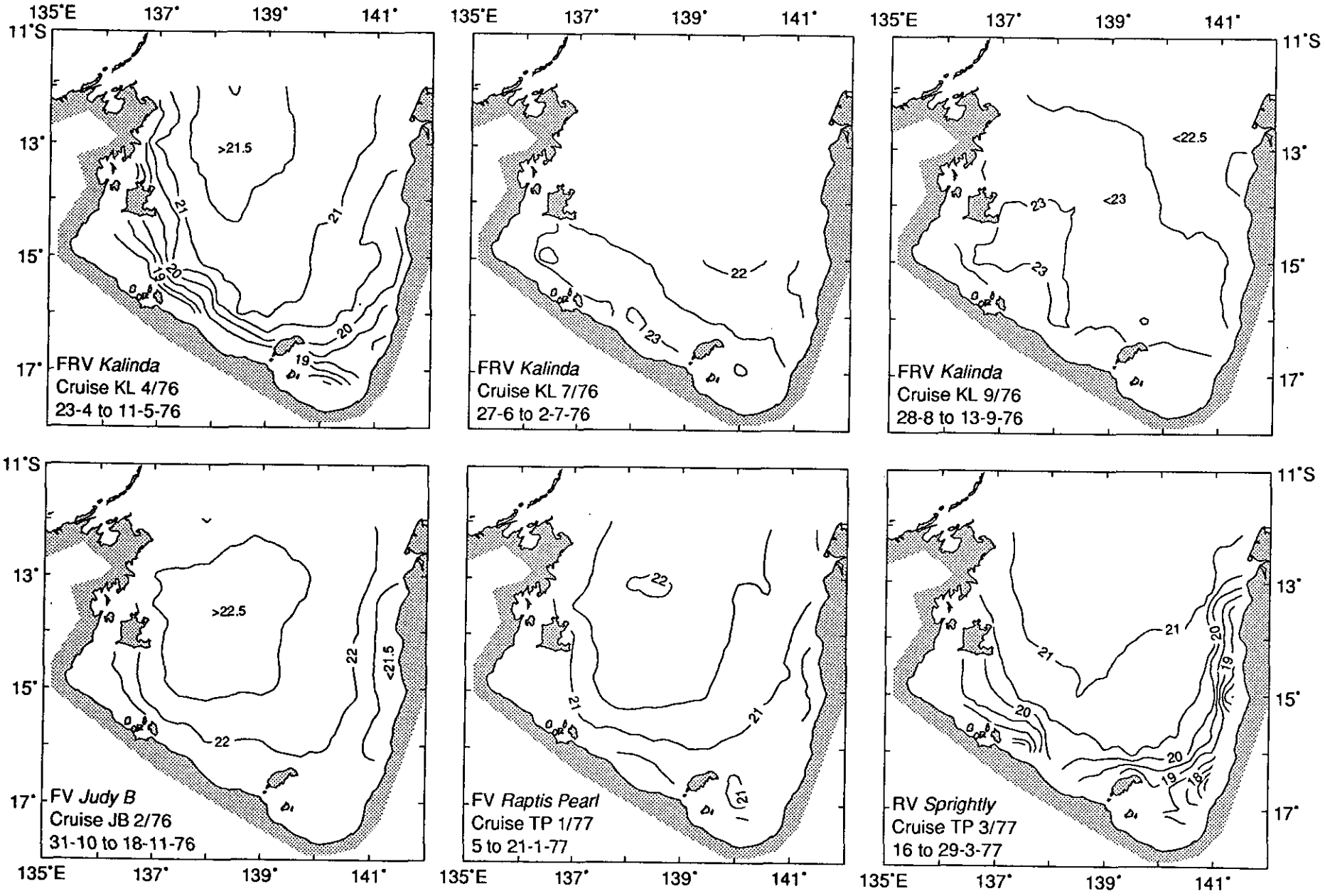
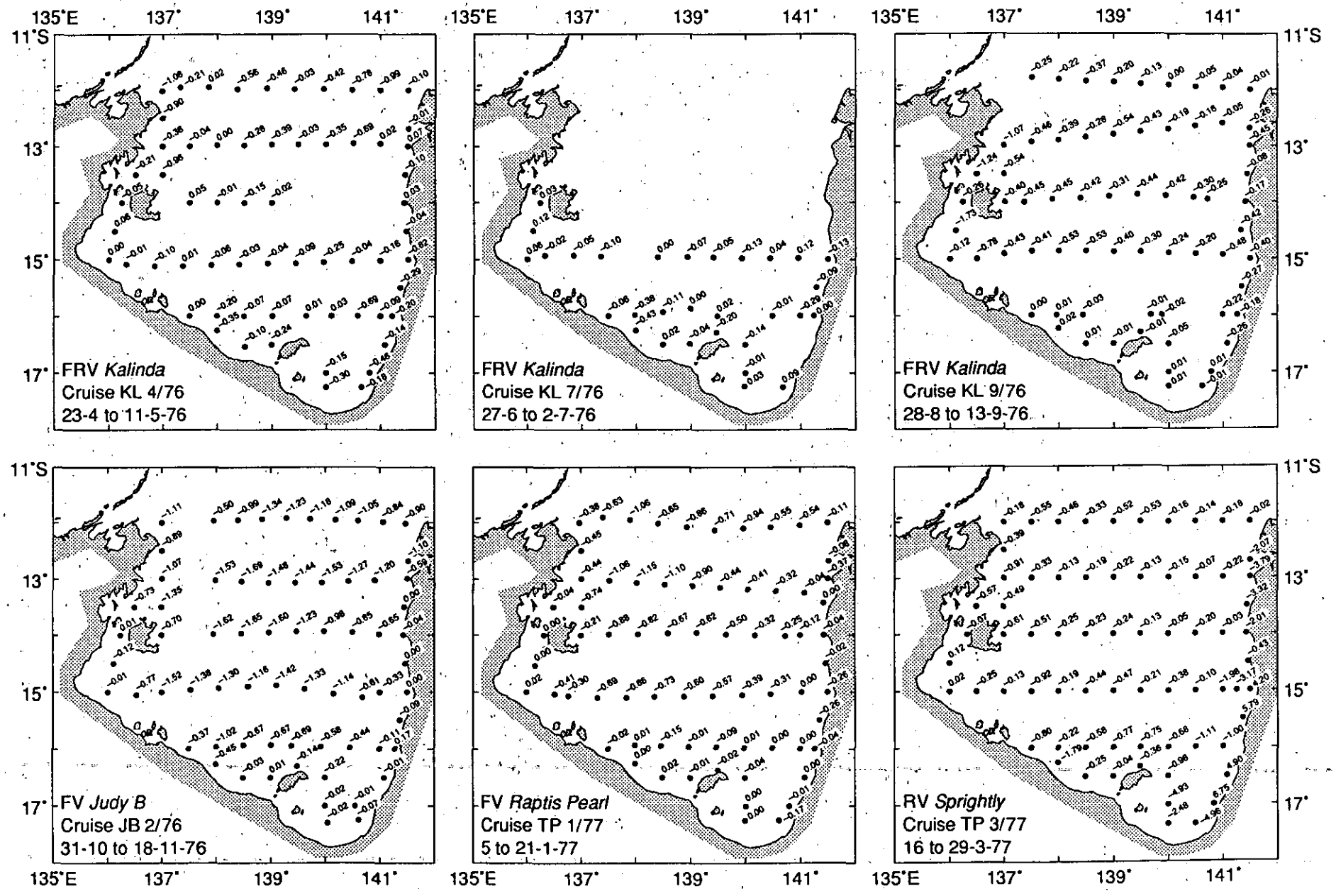



Figure 11b. Sigma t — bottom

Contour interval = 0.5

Figure 12a. Sigma t — difference



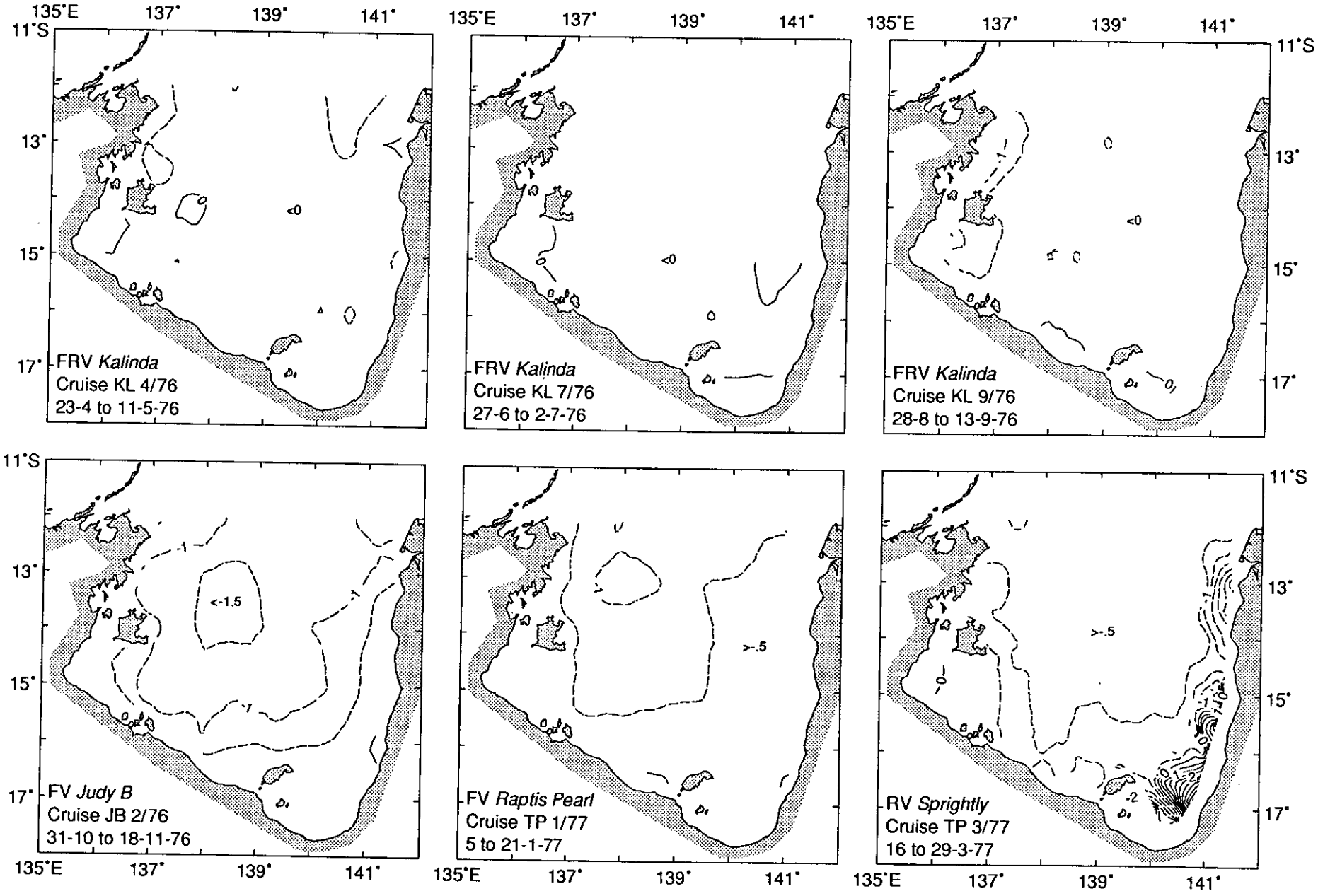
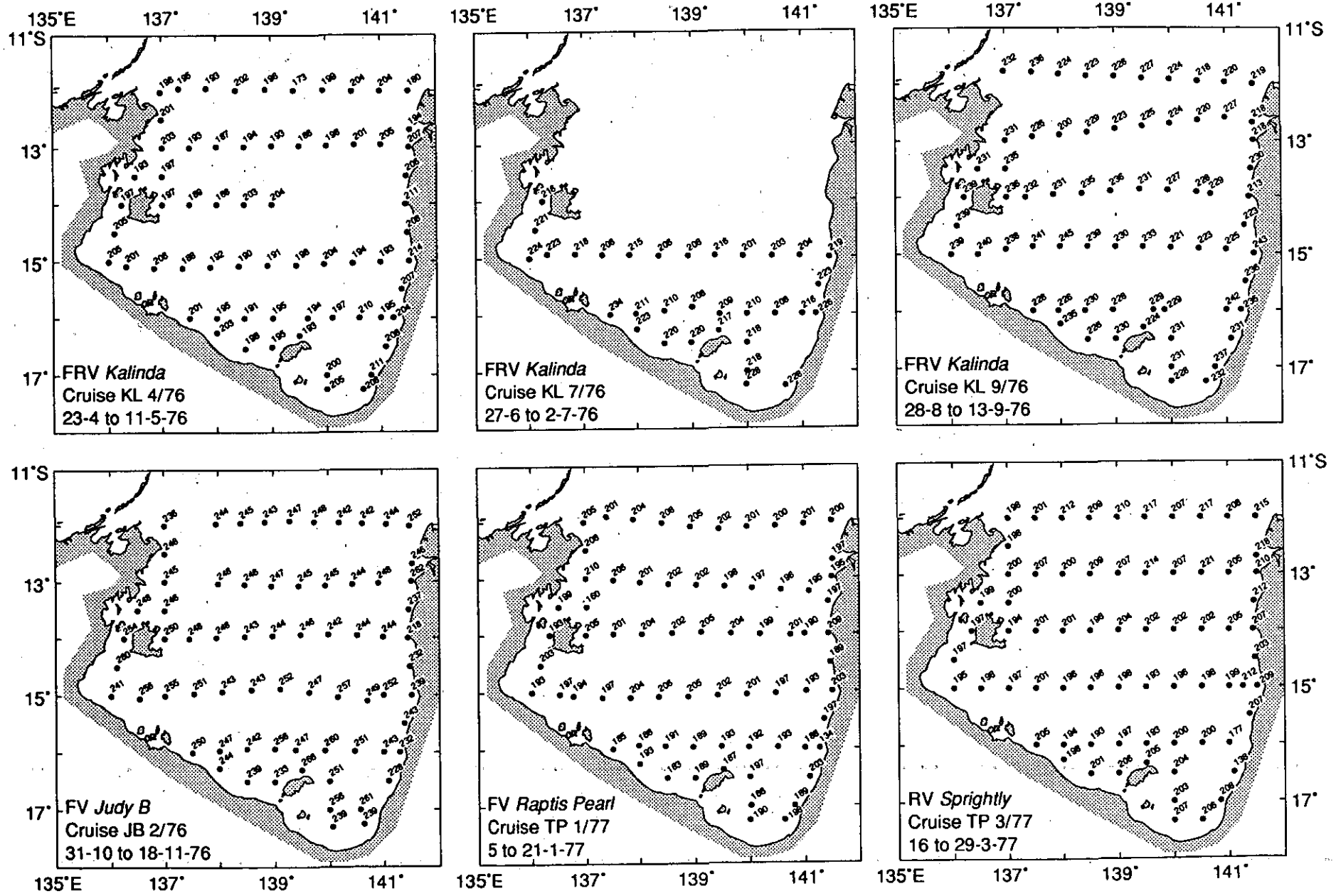



Figure 12b. Sigma t — difference

Contour interval = 0.5

Figure 13a. Dissolved oxygen — surface (μM)



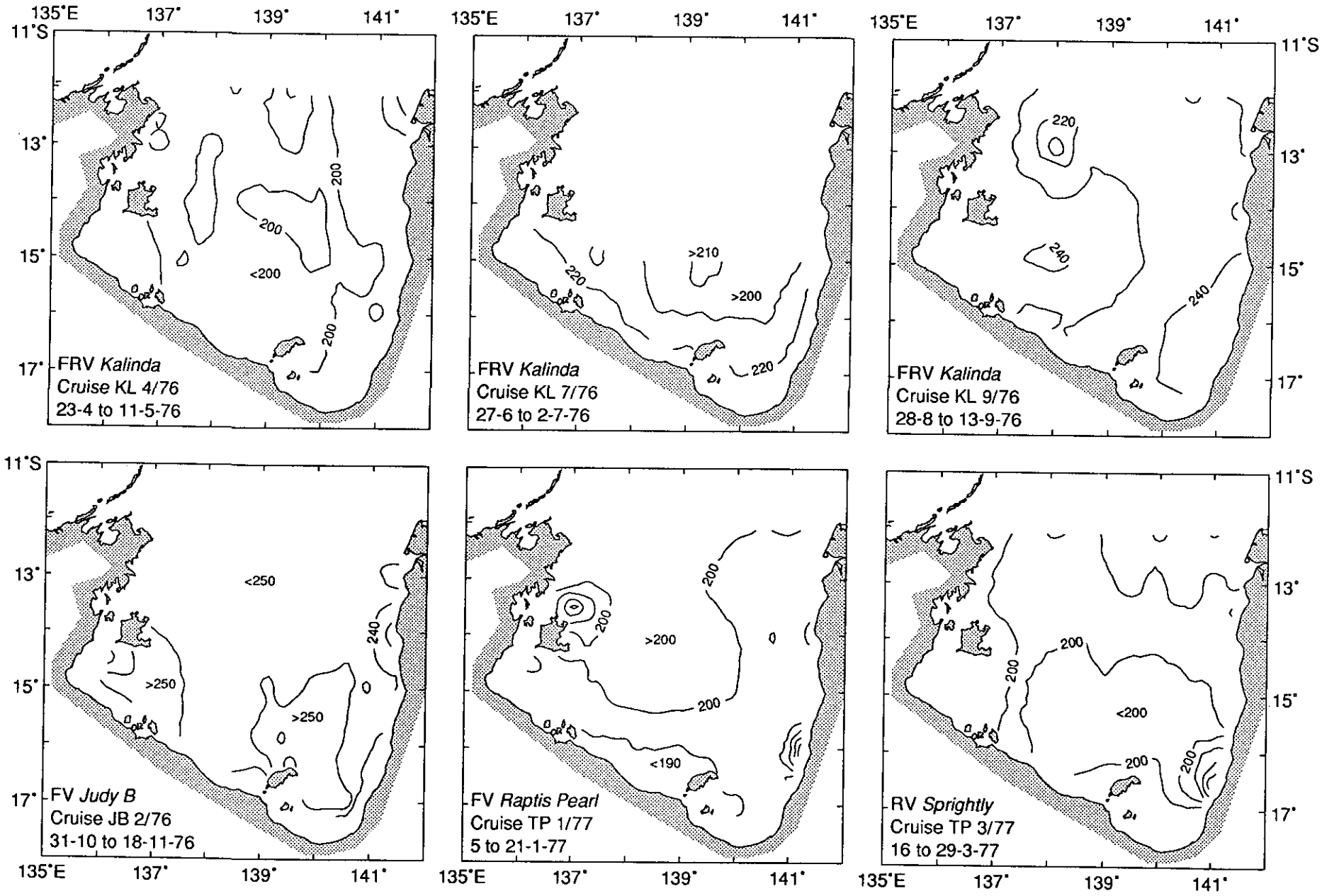
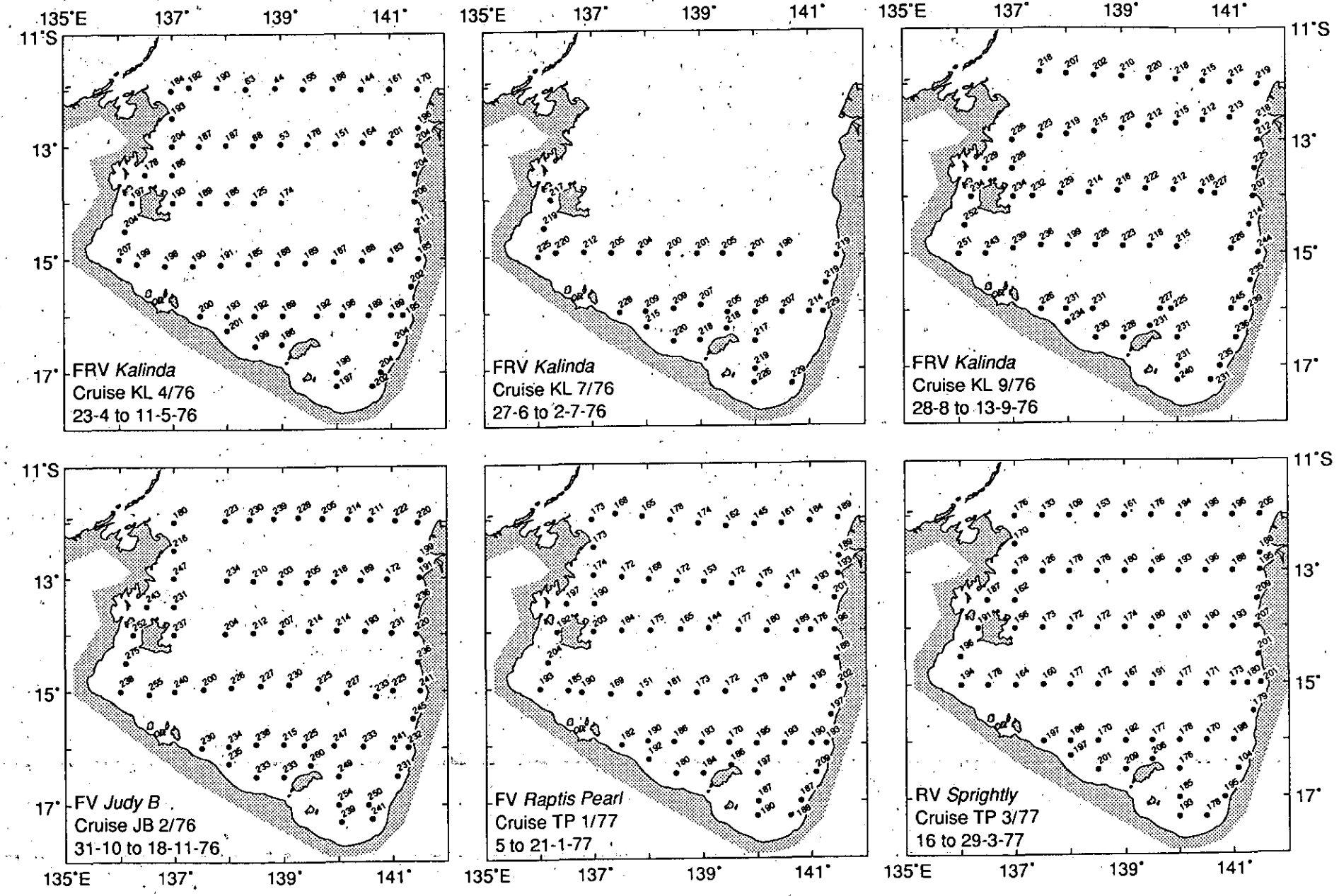



Figure 13b. Dissolved oxygen — surface (μM)

Contour interval = 10.0

Figure 14a. Dissolved oxygen — bottom (μM)



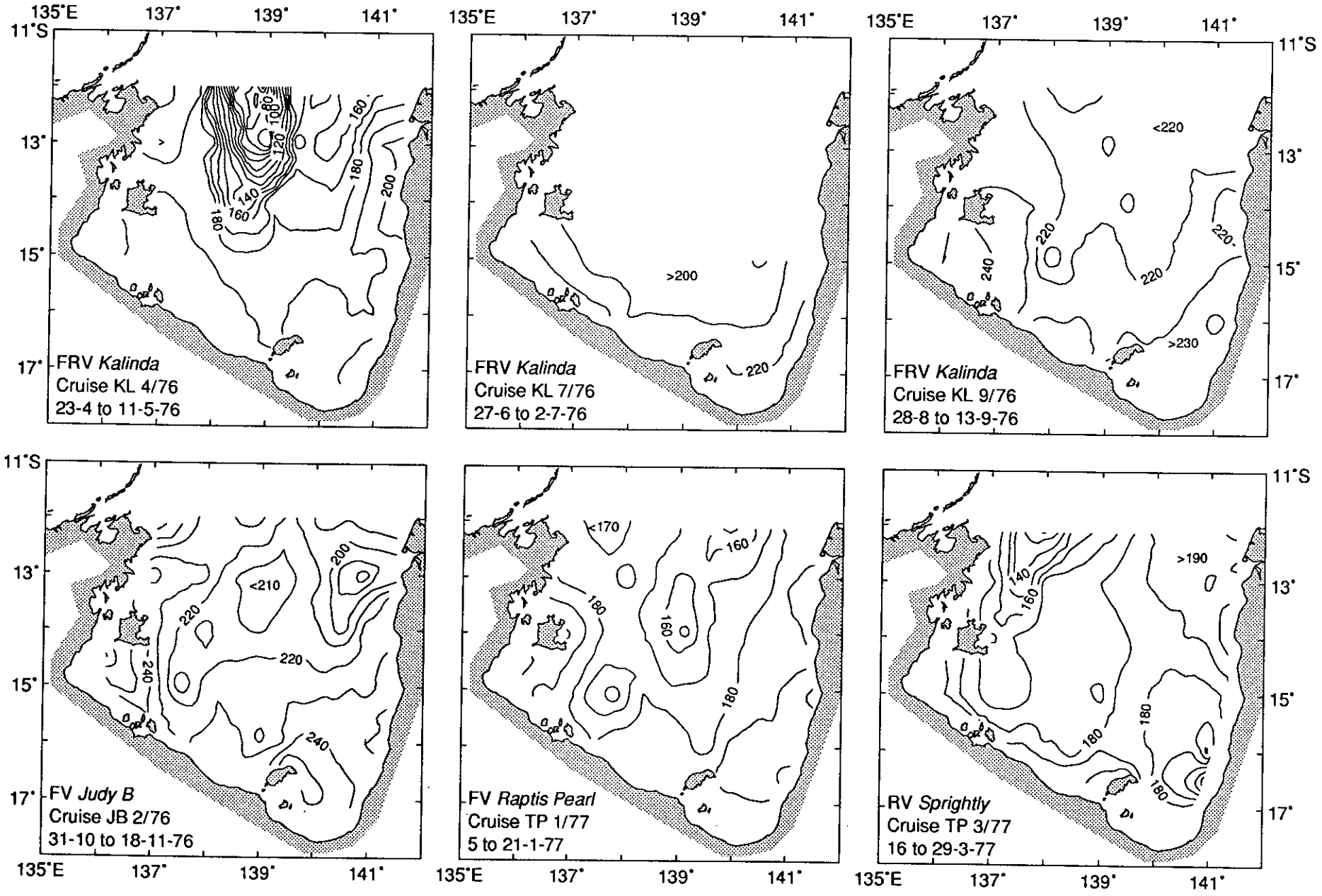
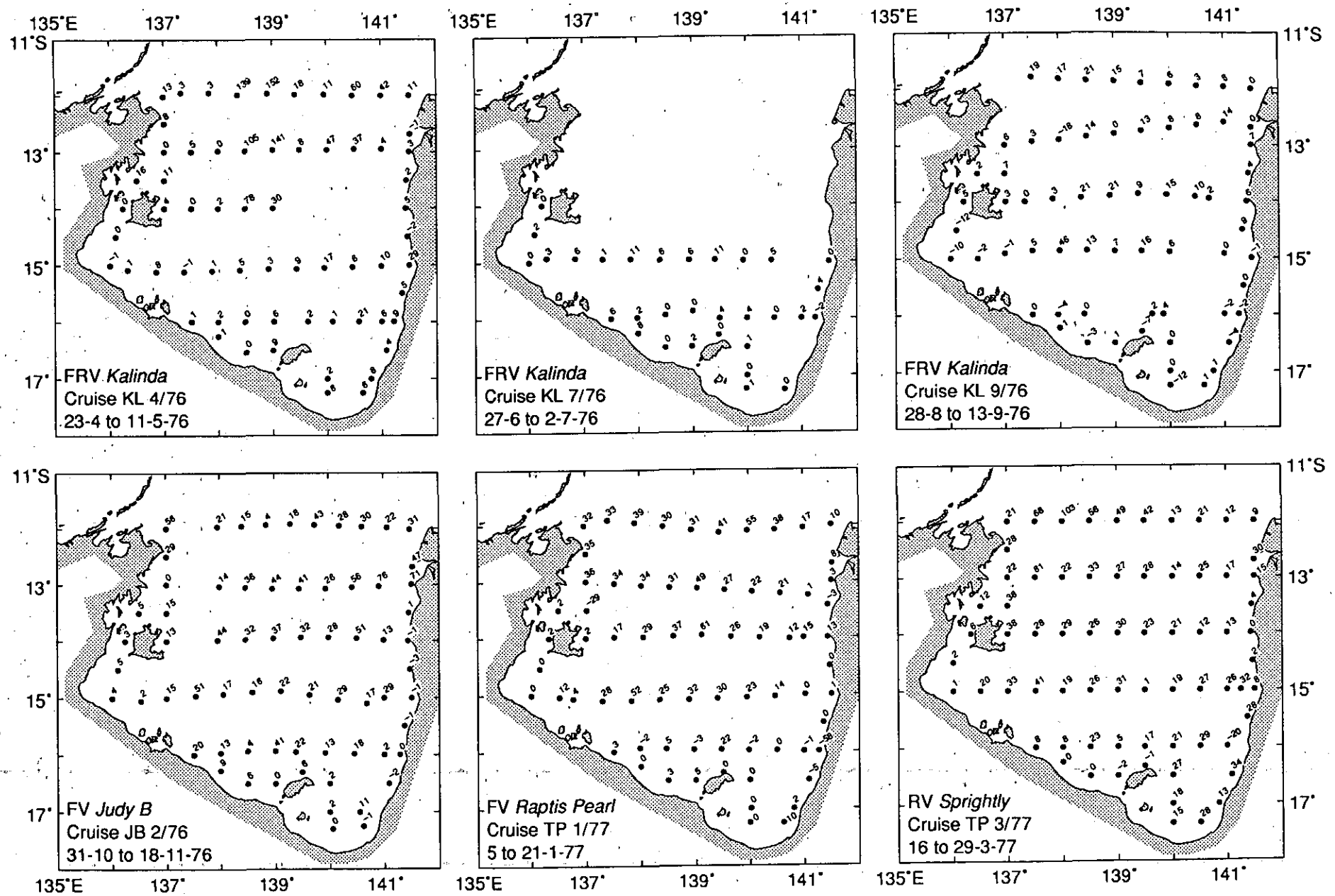



Figure 14b. Dissolved oxygen — bottom (μM)

Contour interval = 10.0

Figure 15a. Dissolved oxygen — difference (μM)



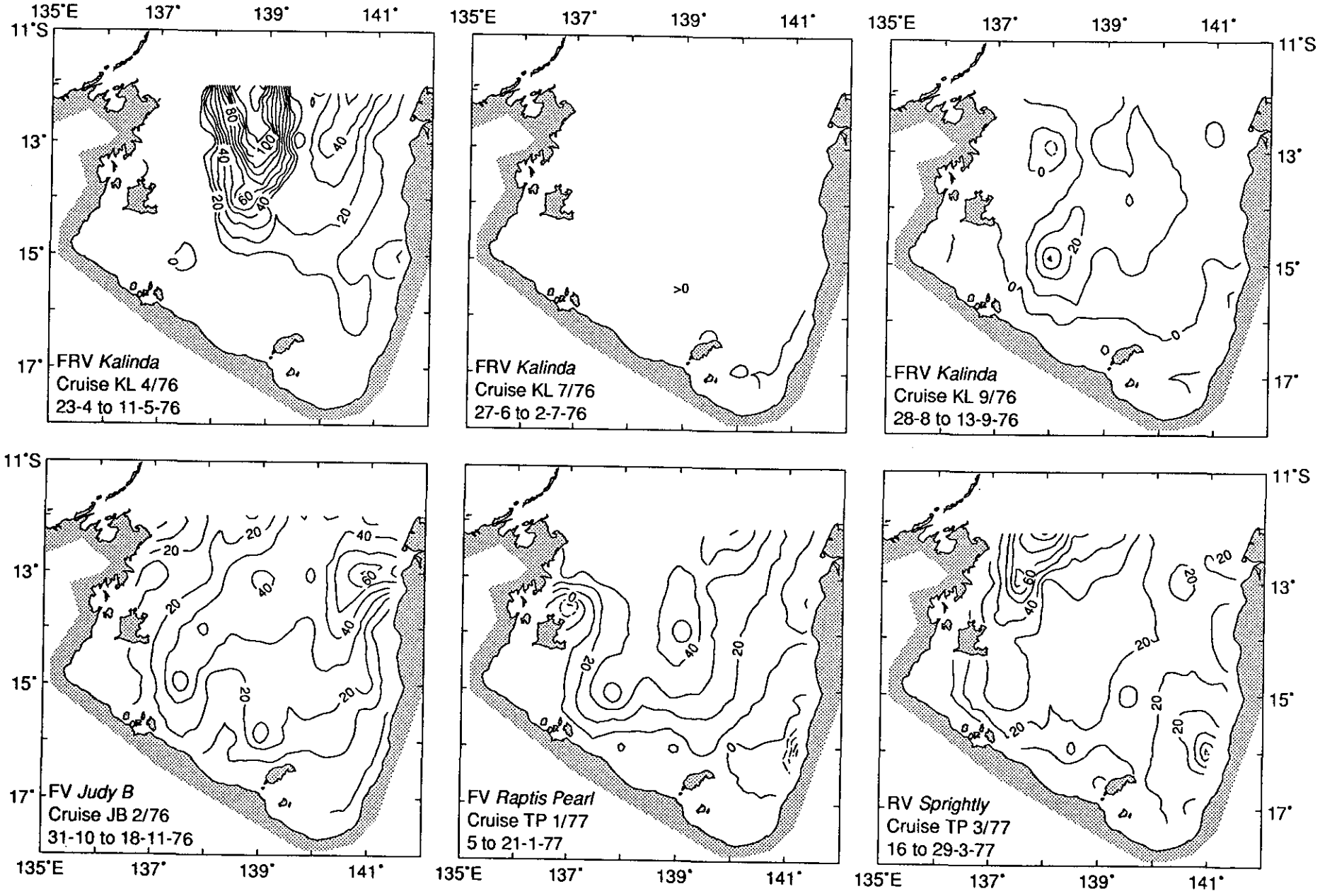
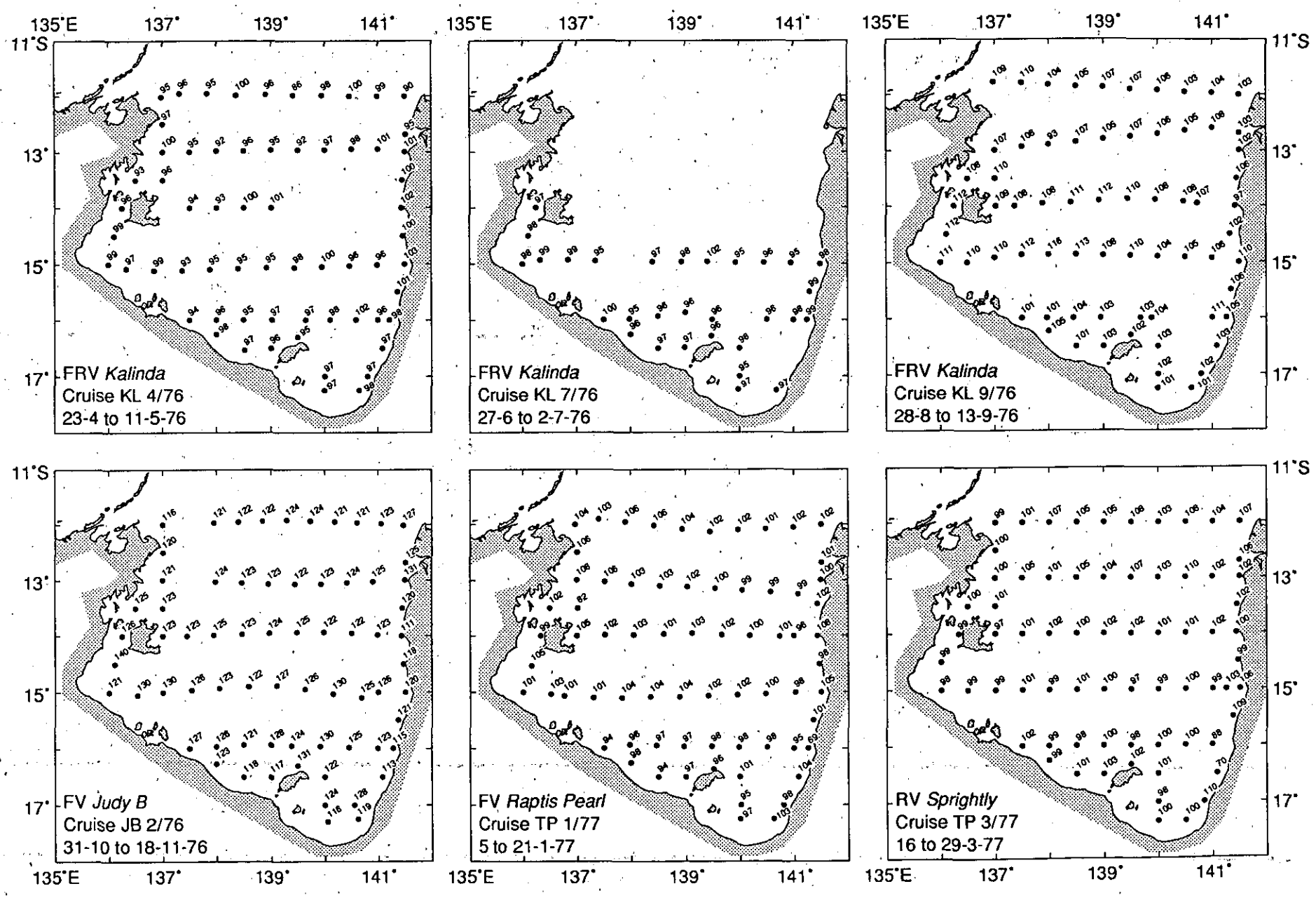



Figure 15b. Dissolved oxygen — difference (μM)

Contour interval = 10.0

Figure 16a. Dissolved oxygen % saturation — surface



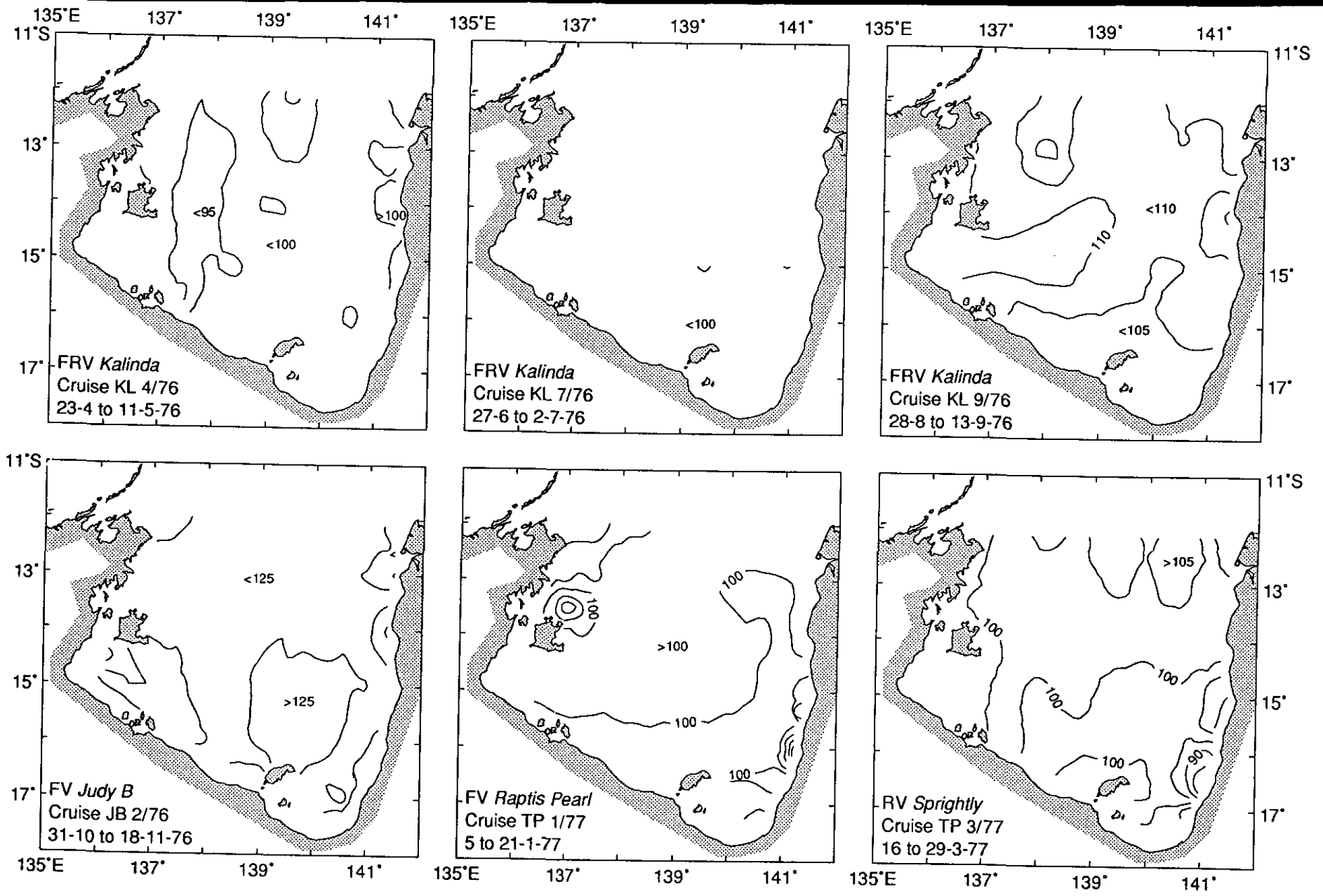
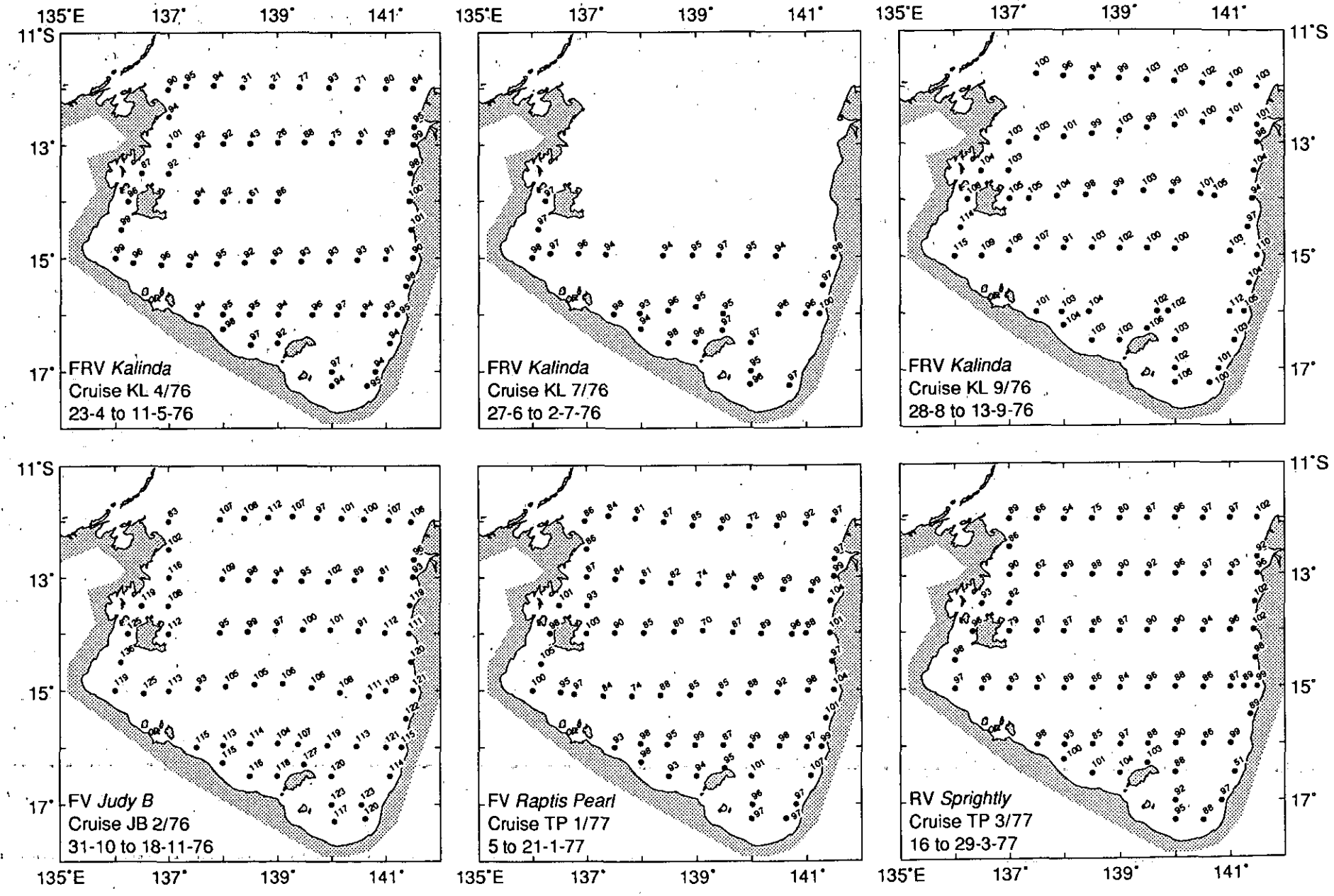



Figure 16b. Dissolved oxygen % saturation — surface

Contour interval = 5.0

Figure 17a. Dissolved oxygen % saturation — bottom



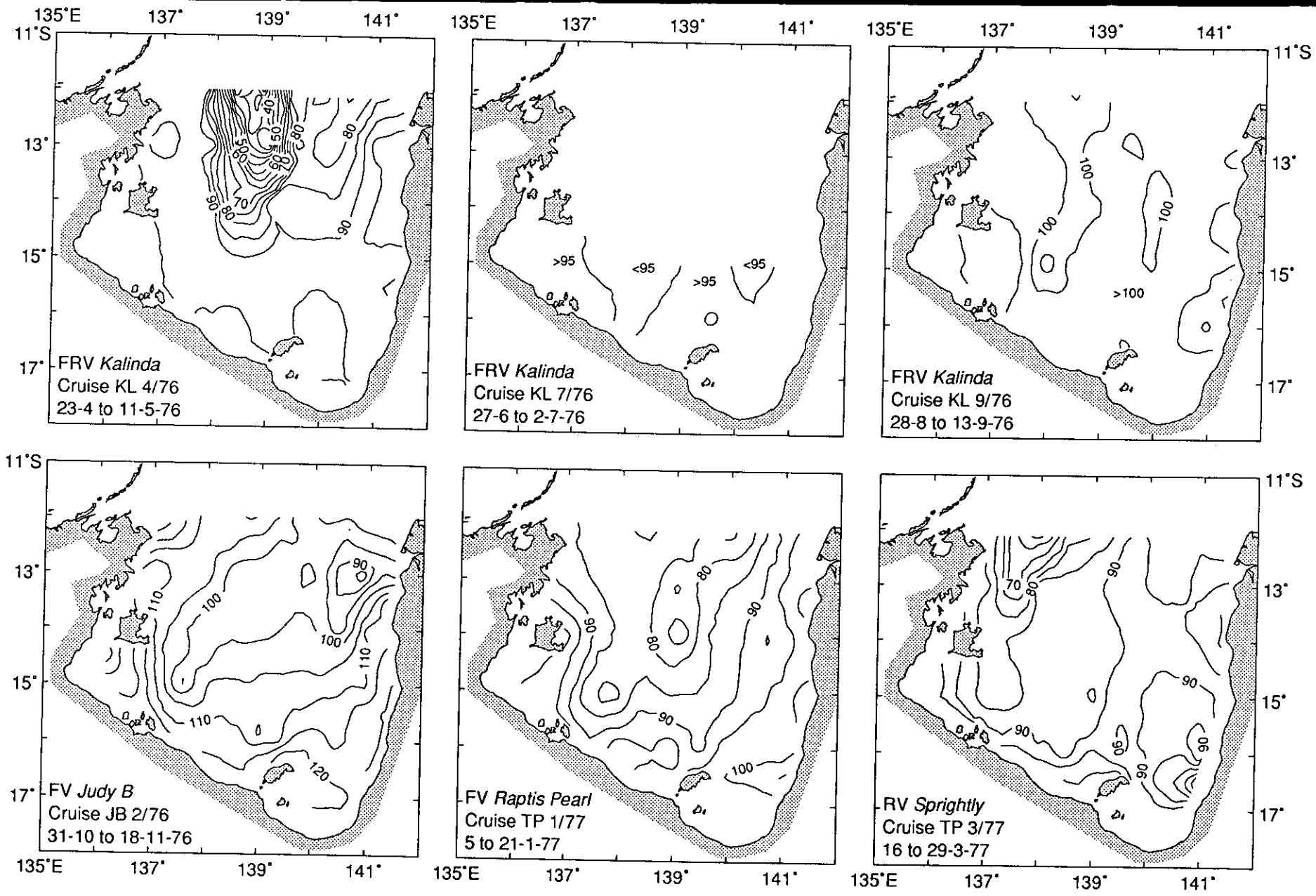
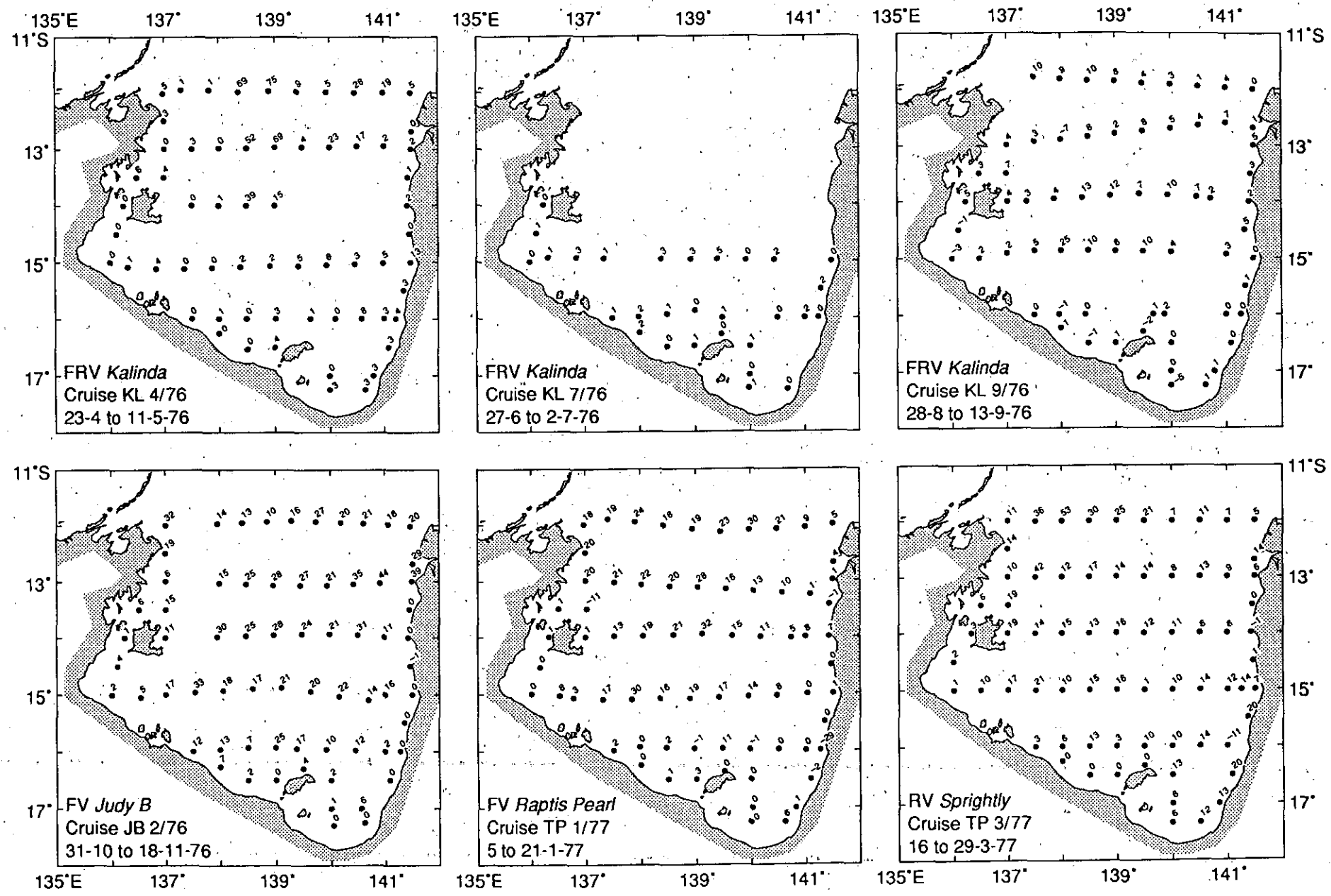



Figure 17b. Dissolved oxygen % saturation — bottom

Contour interval = 5.0

Figure 18a. Dissolved oxygen % saturation — difference



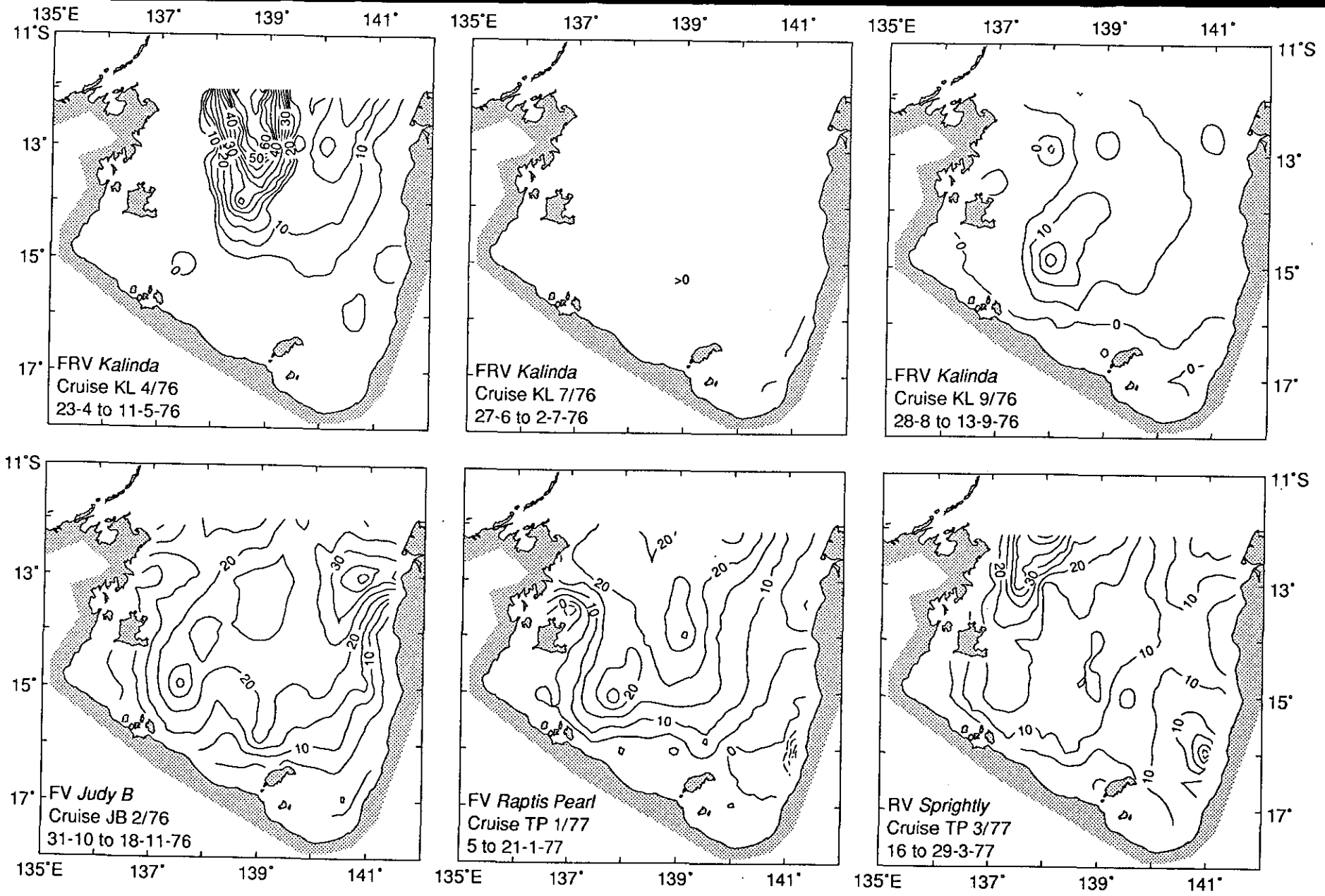
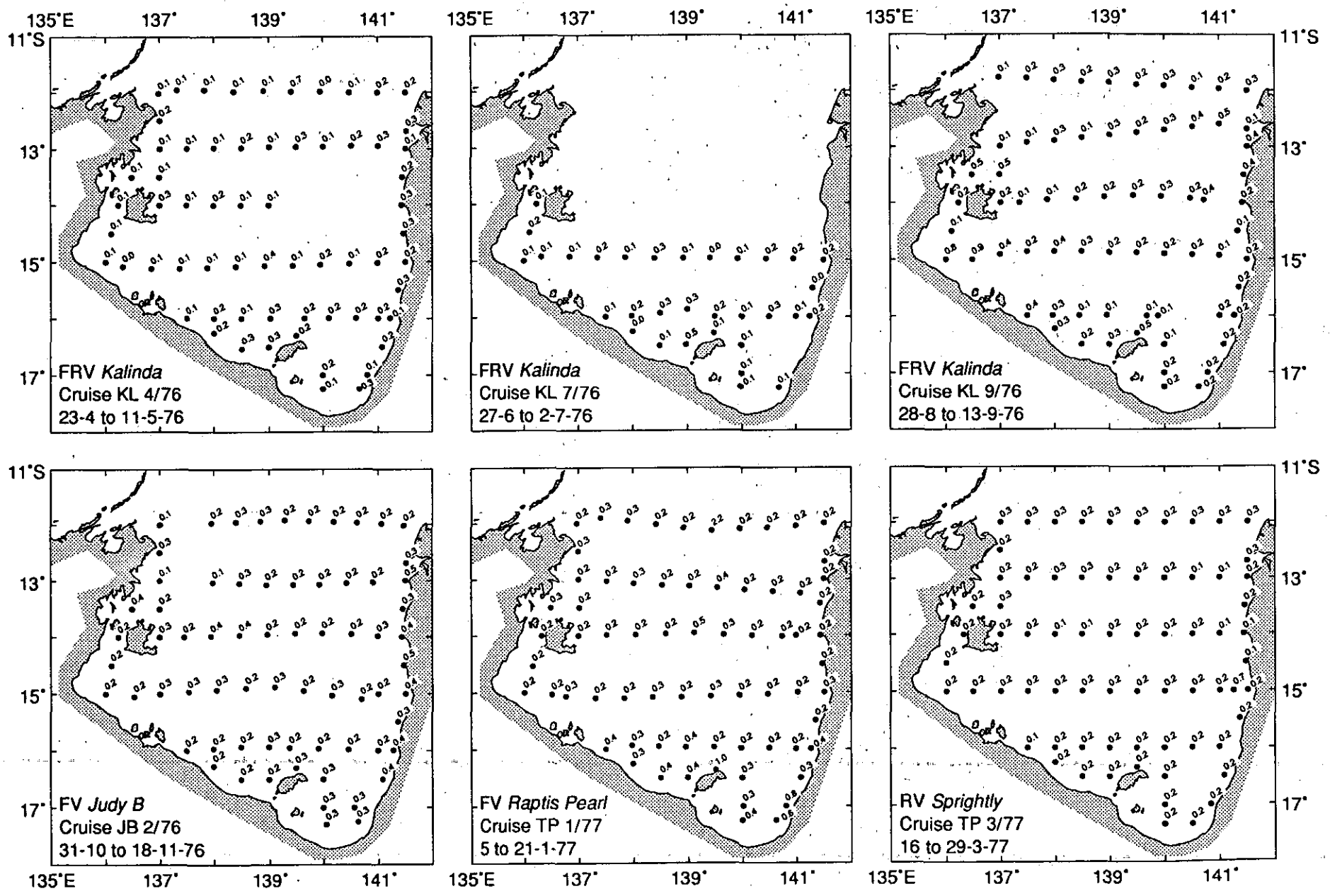



Figure 18b. Dissolved oxygen % saturation — difference

Contour interval = 5.0

Figure 19a. Nitrate plus nitrite — surface (μM)



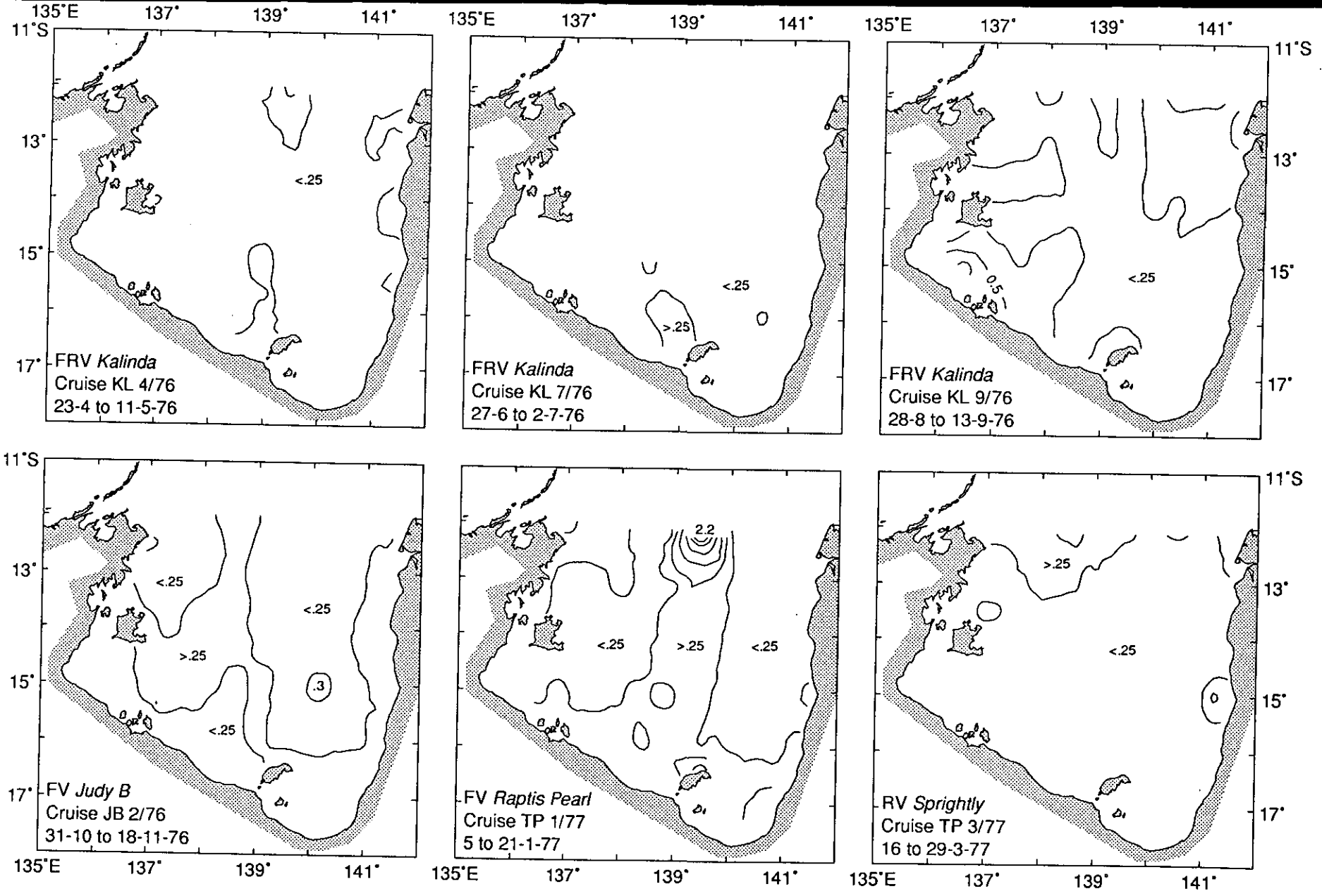
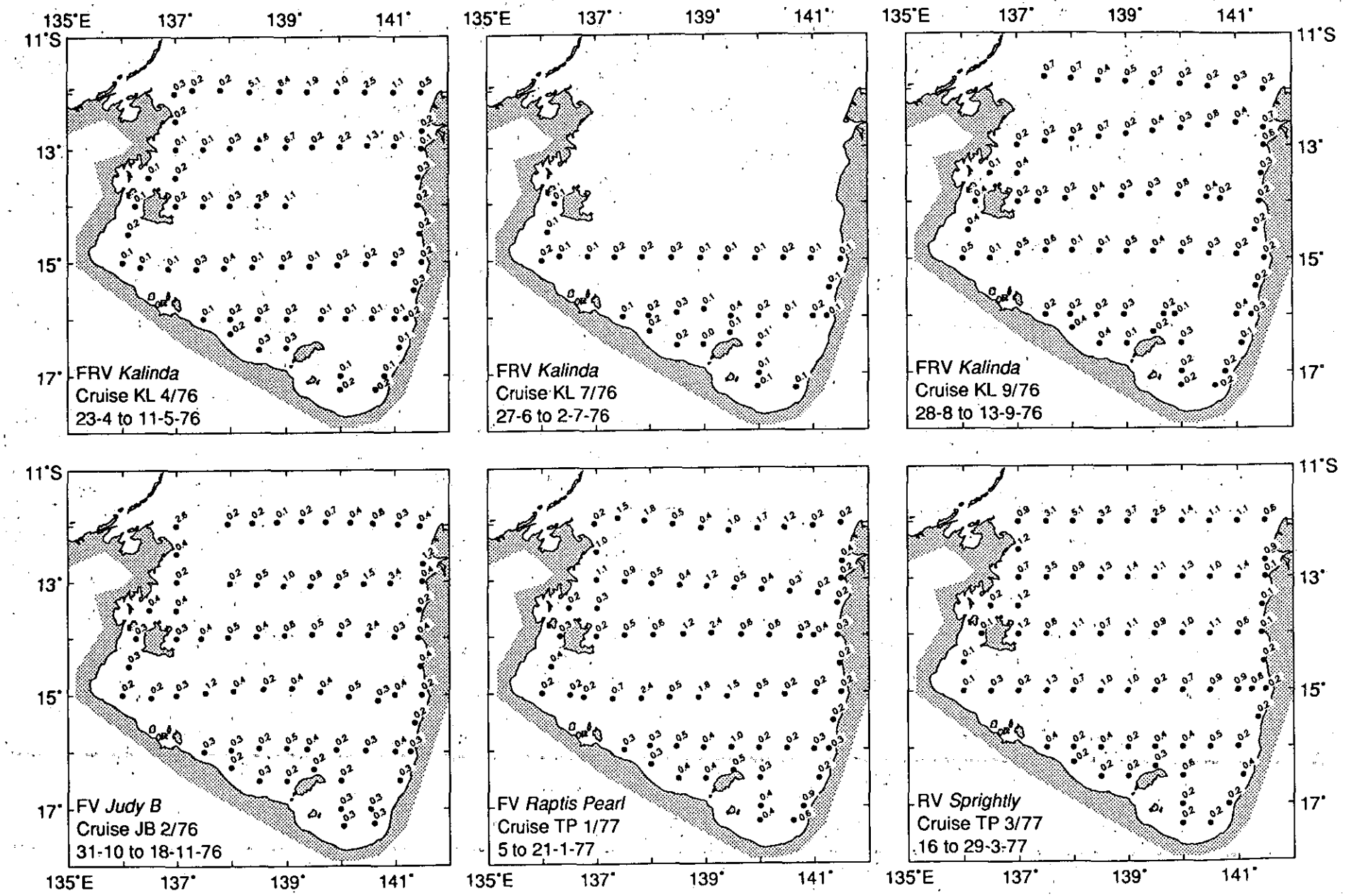



Figure 19b. Nitrate plus nitrite — surface (uM)

Contour interval = 0.25

Figure 20a. Nitrate plus nitrite — bottom (μM)



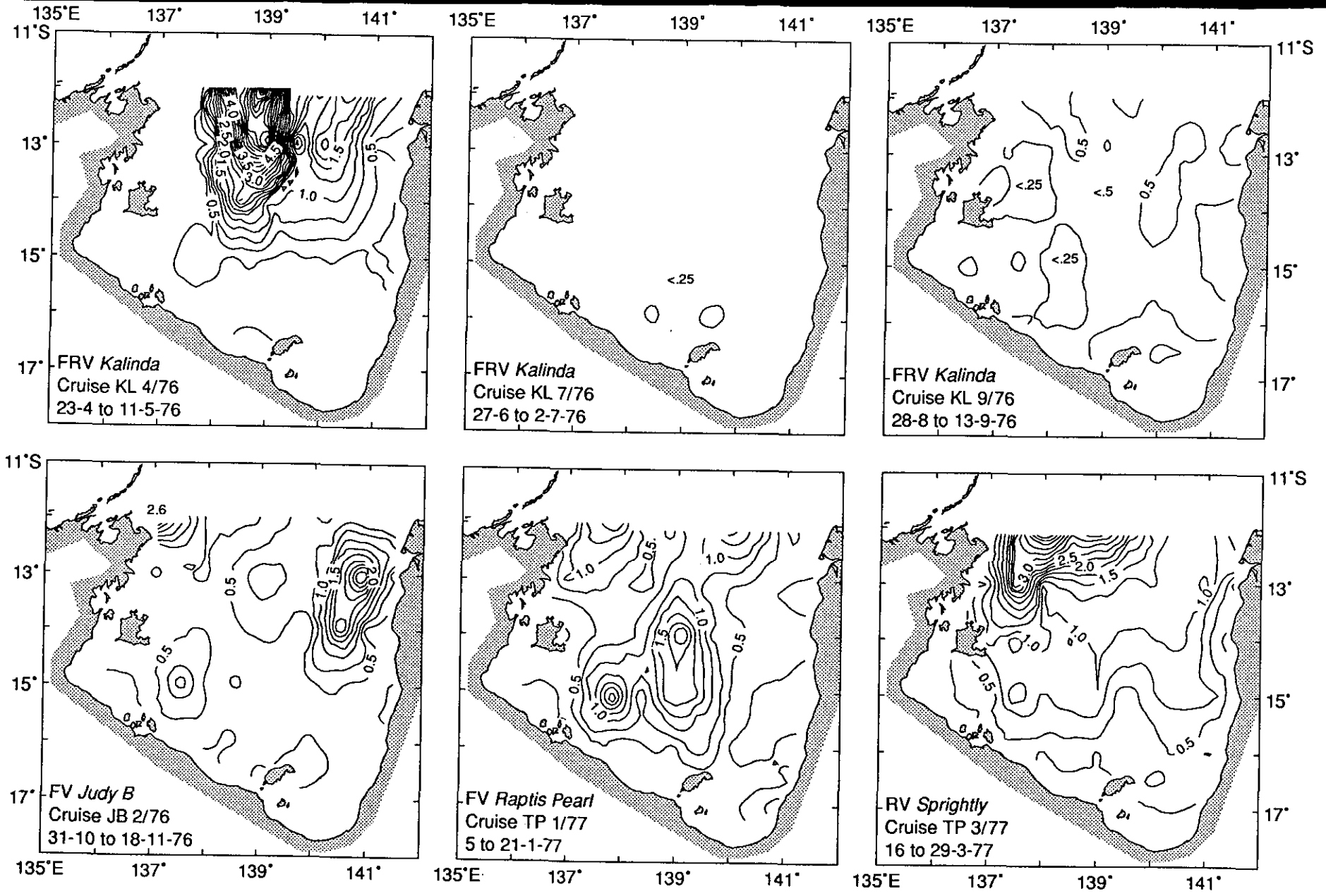
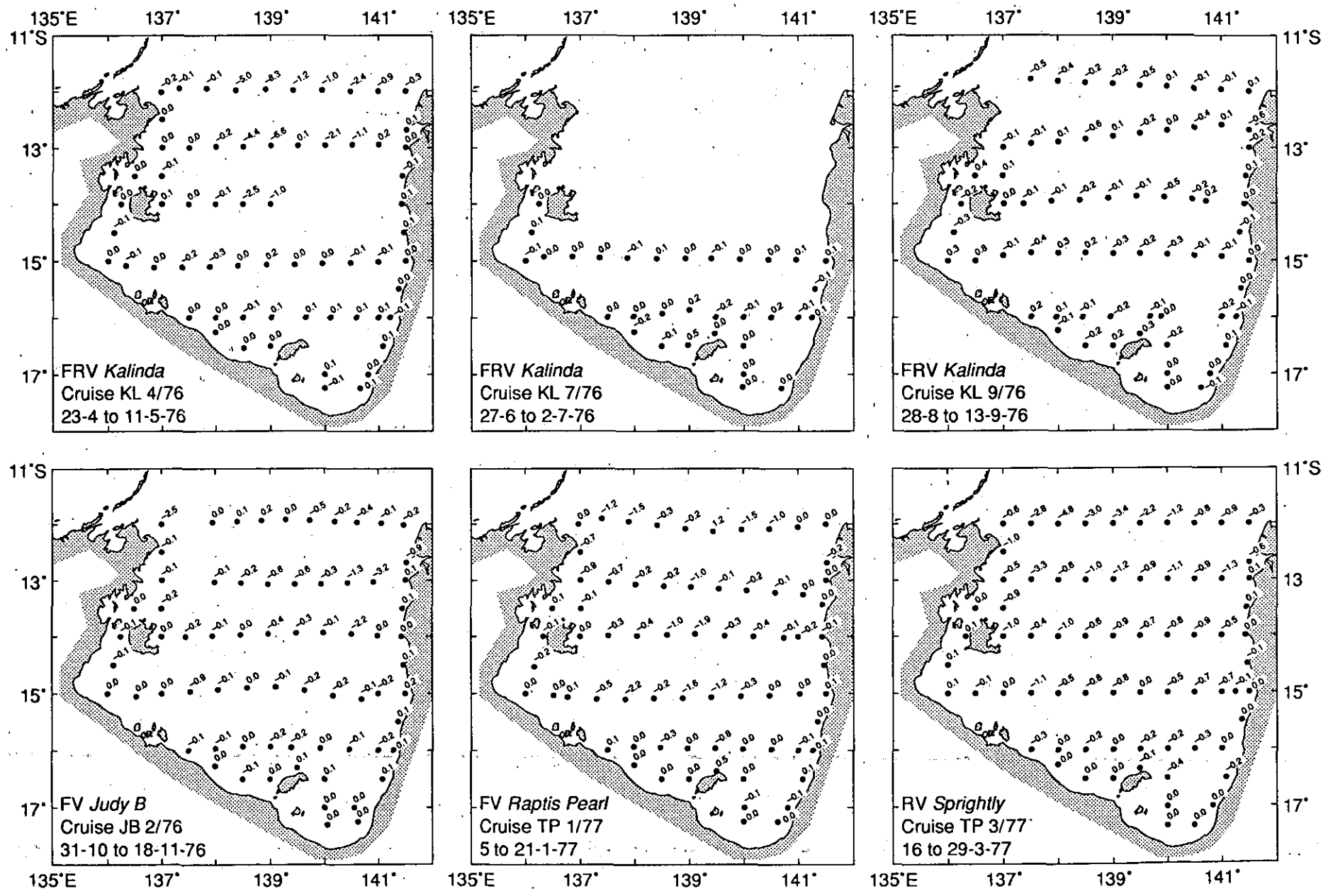



Figure 20b. Nitrate plus nitrite — bottom (μM)

Contour interval = 0.25

Figure 21a. Nitrate plus nitrite — difference (μM)



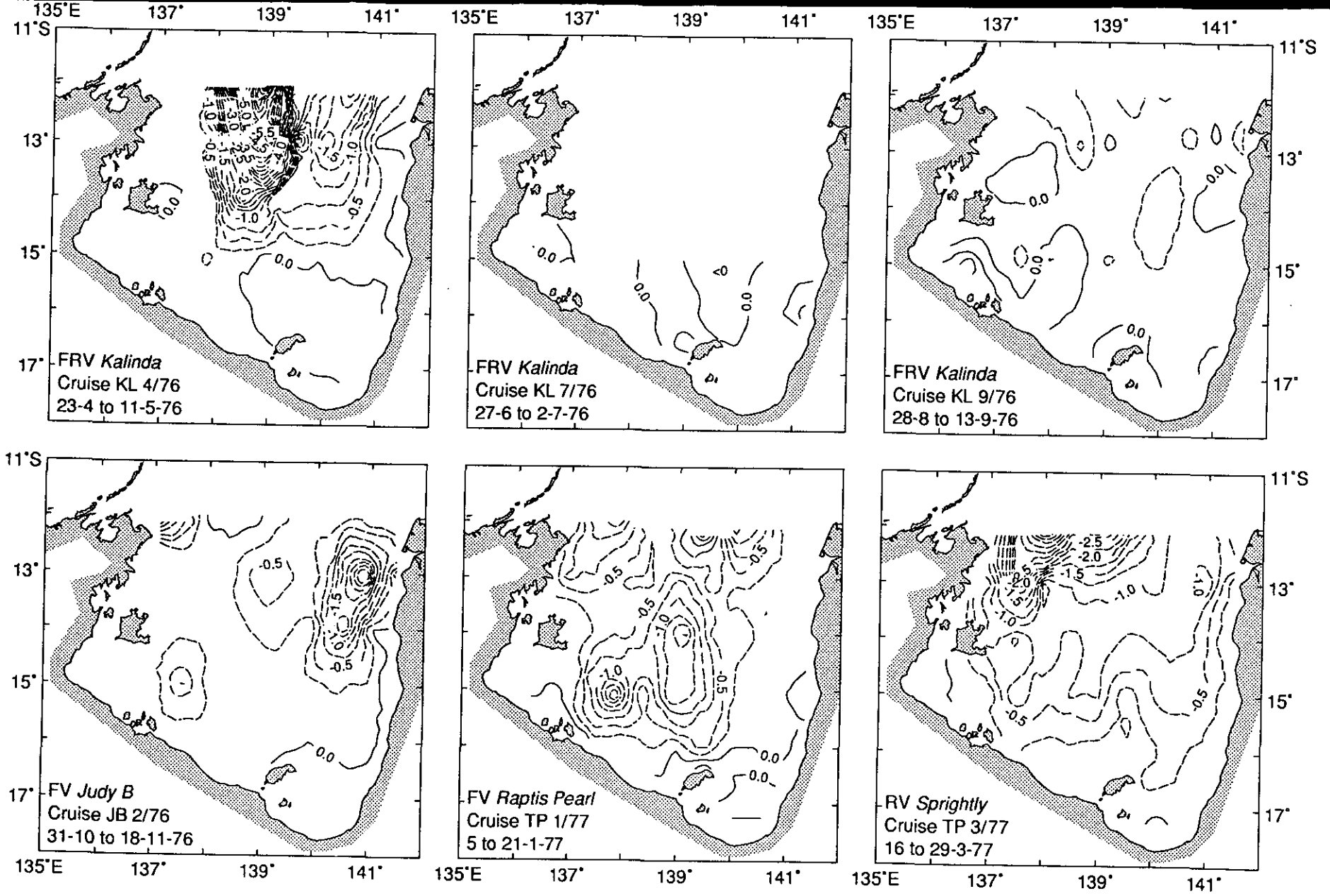
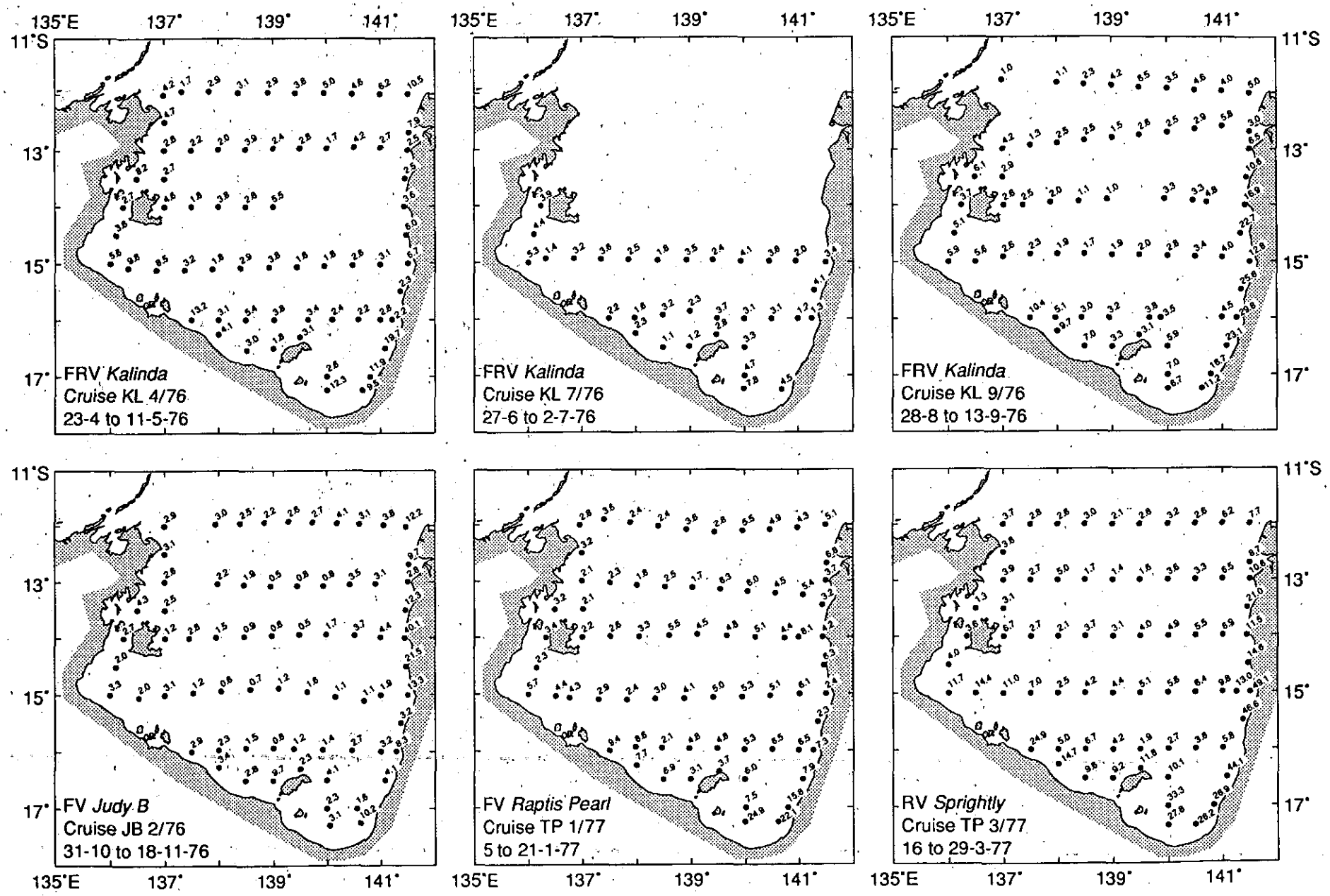



Figure 21b. Nitrate plus nitrite — difference (μM)

Contour interval = 0.25

Figure 22a: Silicate — surface (μM)



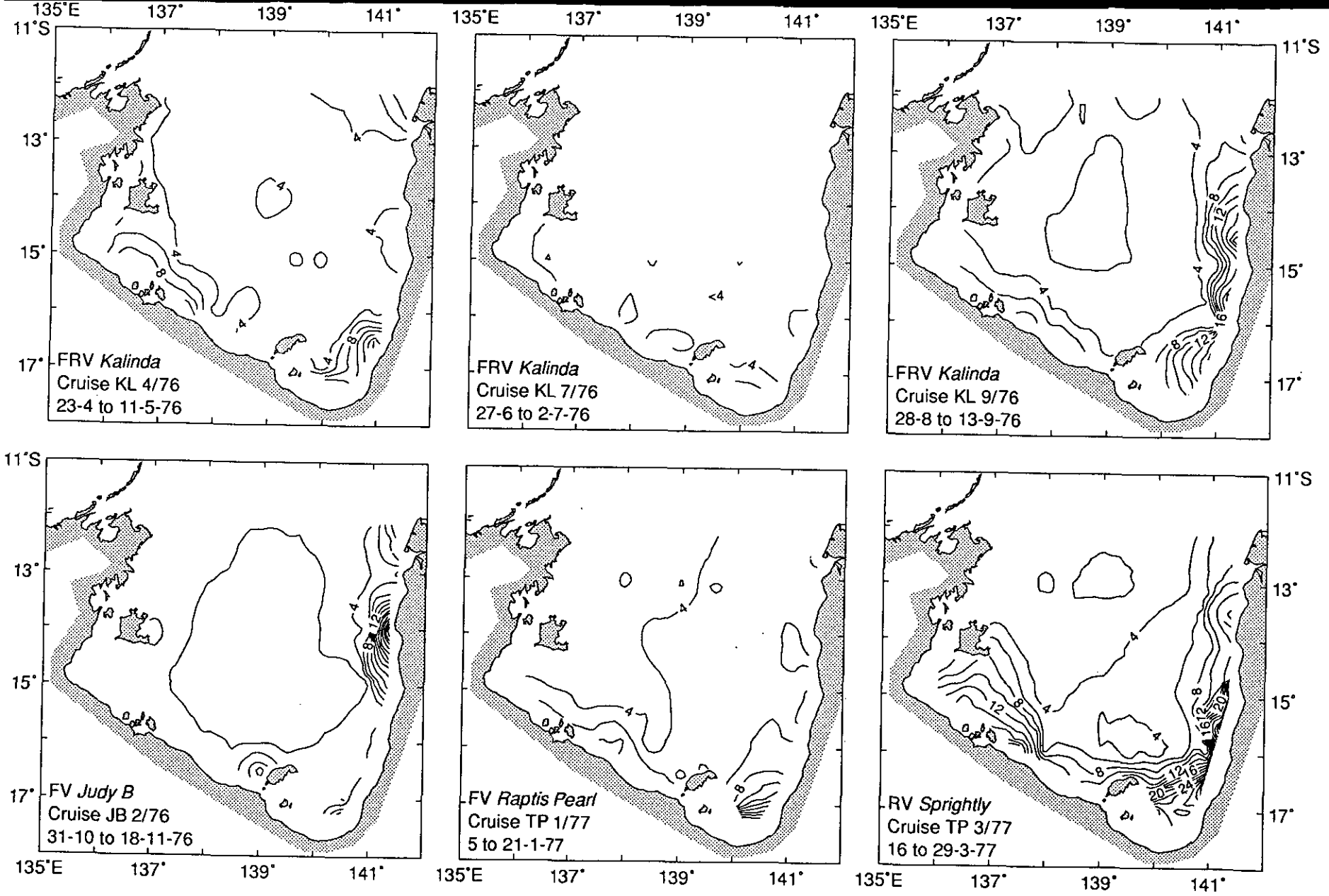
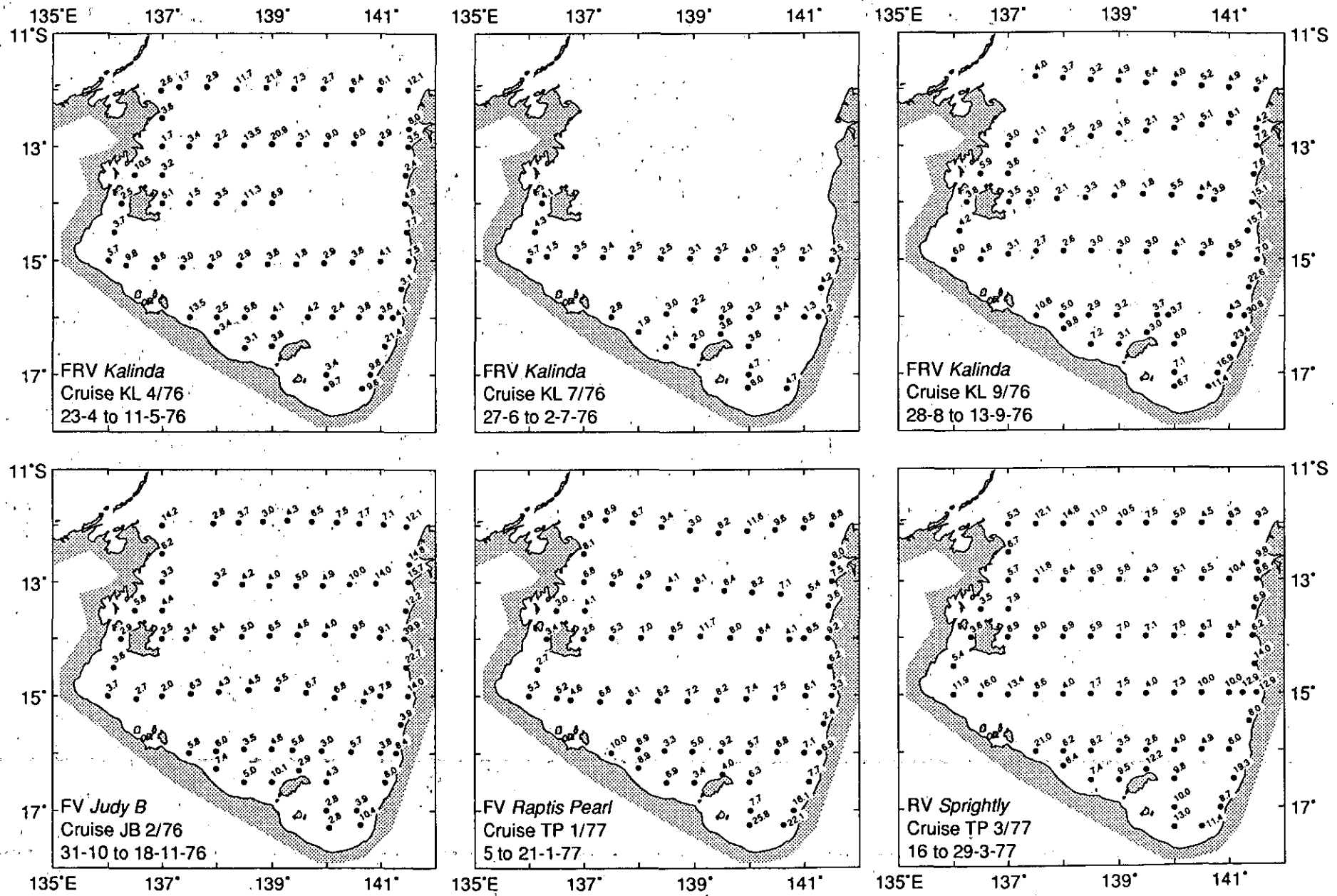



Figure 22b. Silicate — surface (μM)

Contour interval = 2.0

Figure 23a. Silicate — bottom (μM)



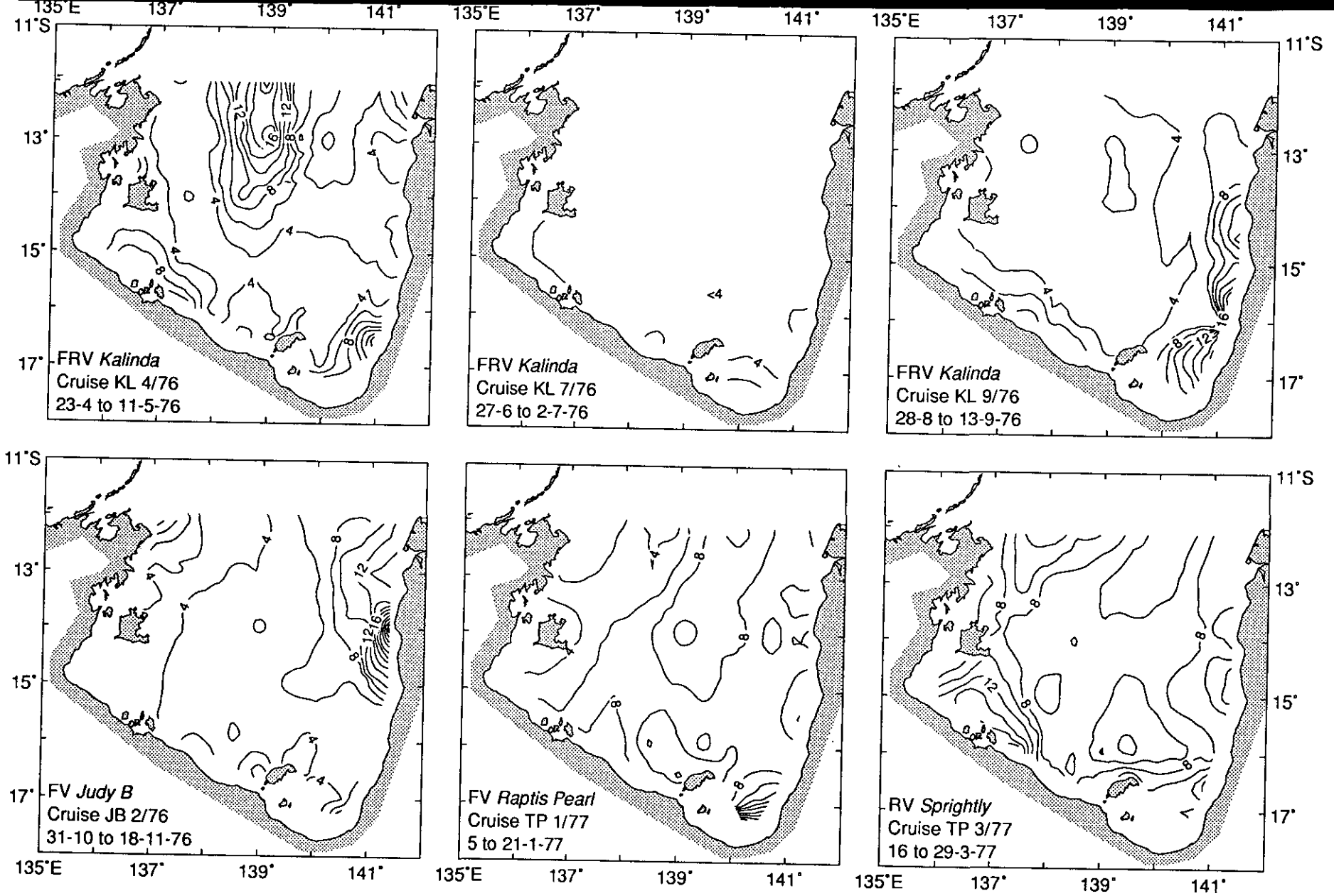
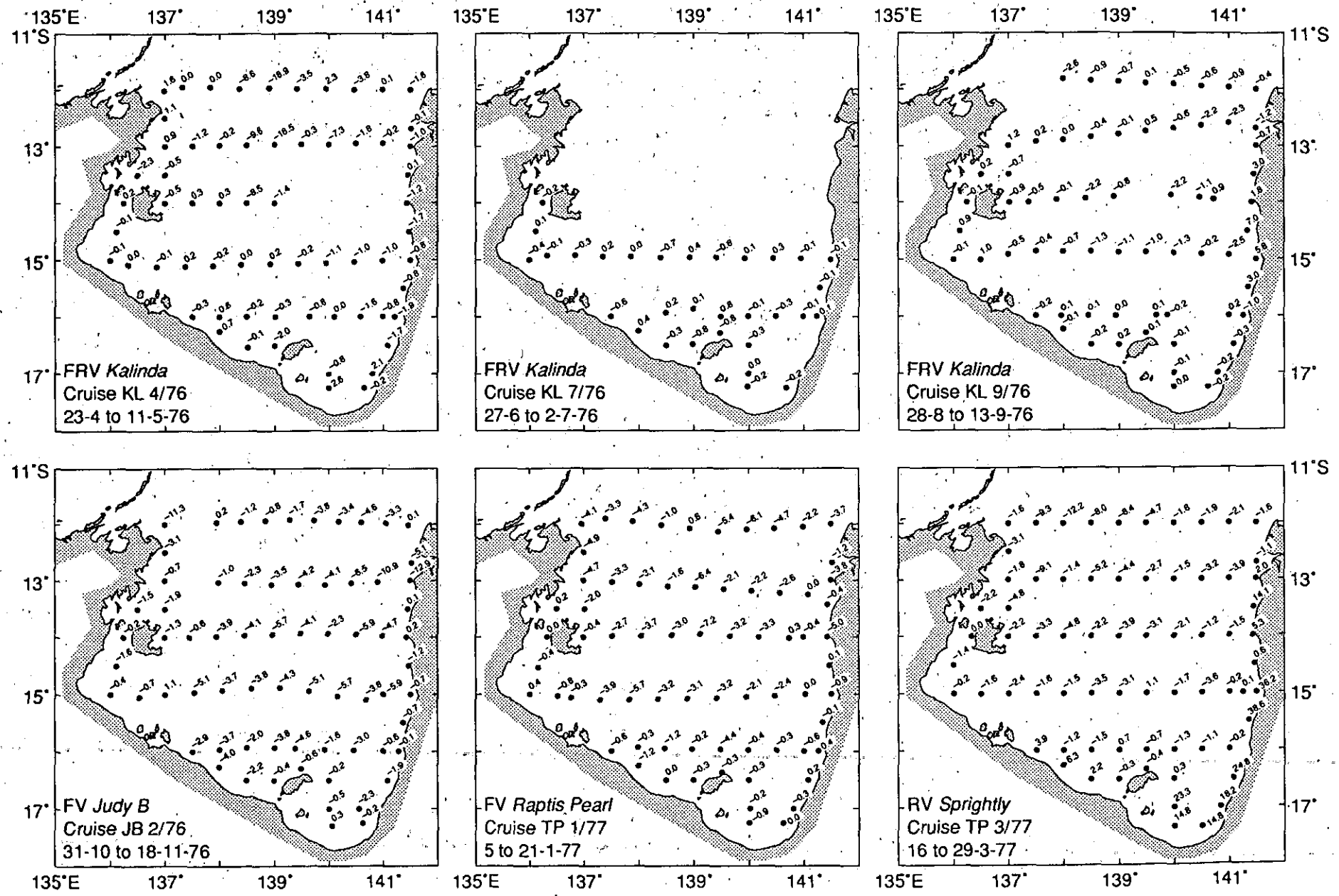



Figure 23b. Silicate — bottom (μM)

Contour interval = 2.0

Figure 24a. Silicate — difference (μM)



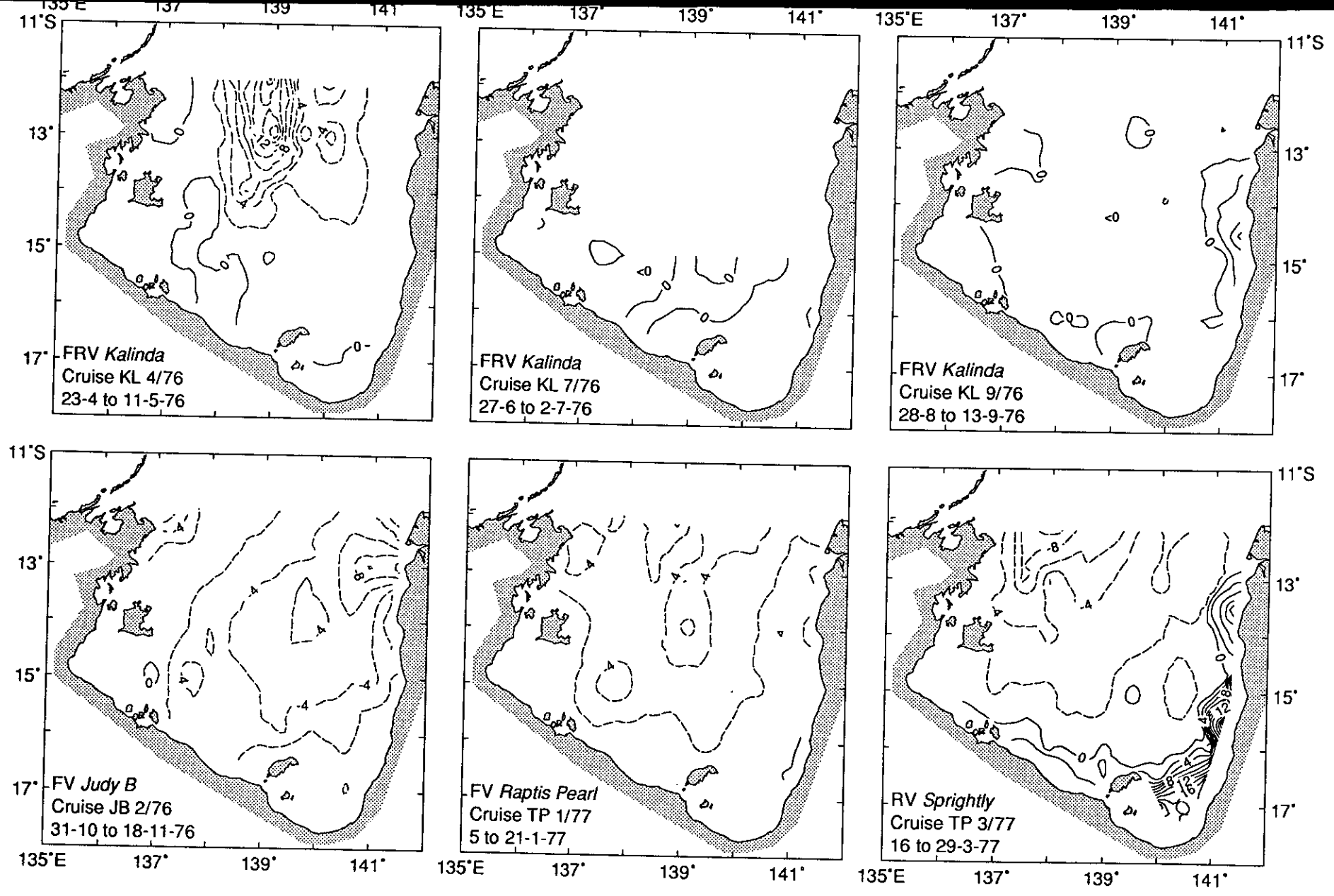



Figure 24b. Silicate — difference (μM)

Contour interval = 2.0

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