热带西太平洋海气相互作用研究调查图集

AIR－SEA INTERACTION STUDIES IN THE TROPICAL WESTERN PACIFIC OCEAN OCEANOGRAPHIC ATLAS

（1986～1990）

海洋出版社

OCEAN PRESS

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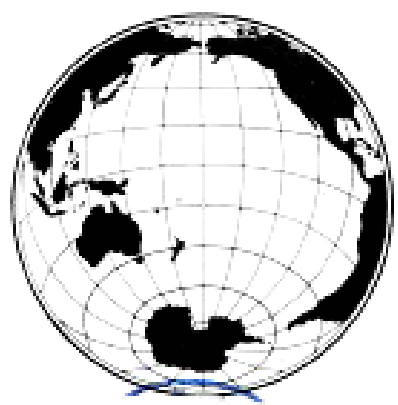

海 洋 出 版 社

OCEAN PRESS

BEIJING · CHINA · 1993

责任编辑：王如林
英文审校：林宝法
护封摄影：张伟利

（京）新登字087号

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《热带西太平洋海气相互作用研究调查图集》编辑委员会 编

海洋出版社出版发行（北京市复兴门外大街1号）

国家海洋信息中心印刷厂印刷

开本：787×1092 1/8 印张：43

1993年6月第一版 1993年6月第一次印刷

印数：1—600

ISBN 7-5027-1042-5/P·219 定价：元

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调 查 图 集

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AIR—SEA INTERACTION STUDIES IN THE TROPICAL WESTERN PACIFIC OCEAN OCEANOGRAPHIC ATLAS

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前　　言

热带西太平洋是世界大洋中表层温度最高的海域，素有"暖池"之称。它为大气提供了巨大的热能，是台风和著名洋流—黑潮的发源地。研究这个海域的海气相互作用，对探讨全球气候变化，了解厄尔尼诺和南方涛动（ENSO）现象的发生、发展规律，改善各种天气与海洋环境预报方法和模式，保证海上交通和作业安全，发展海洋开发事业等均具有重要意义。中、美科学家认识到研究热带西太平洋海气相互作用的重要性，于1984年7月19日签署了"中美热带西太平洋海气相互作用合作研究"协议。根据这个协议，中、美海上联合调查工作自1985年12月至1990年7月在11°00′S～20°00′N、116°00′E～165°00′E范围内进行了8个航次的综合调查。在调查期间除使用常规调查仪器外，还使用了CTD、XBT、ADCP等先进的设备和仪器，获取了海洋水文、气象、生化等各种要素的宝贵资料。这些资料的观测深度和精度都达到了世界先进水平。

本图集是在对现场调查资料分析、归类、总结后编绘的基础性图集。它是中、美TOGA计划合作研究的重要成果之一，无疑它将对海气相互作用研究乃至整个海洋学、气象学的发展具有重要价值。

本图集的编绘得到巢纪平教授，陈则实研究员，余宙文教授、甘子钧研究员，陈上及研究员的指导，庞玉佩，陈达熙，山广林、王德正，黄振宗等同志参加本图集定稿并提供多方面的协助。国家海洋局南海分局，国家海洋局第一海洋研究所为本图集的编绘提供有关资料和图件，在此一并感谢。

Preface

Known as the "warm pool", the tropical western Pacific is a sea area with the highest surface temperature in world oceans. It provides the atmosphere with immense heat energy and is the source of typhoon and Kuroshio—a well-known ocean current. Studying the air-sea interaction in this sea area is of great importance to exploring global climate change, climatic anomalies, understanding the generation and the developing pattern of ENSO phenomena, improving forecasting methods and models for various weathers and the marine environment, guaranteeing safety of traffic and operations at sea and promoting marine development undertakings. Recognizing the importance of studying the air-sea interaction in the tropical western Pacific, the Chinese and U. S scientists signed the agreement on "the Sino-U. S. Joint Studies on the Air-Sea Interaction in the Tropical Western Pacific" on July 19, 1984. Following the agreement, the Chinese and U. S. scientists conducted eight cruises of comprehensive survey from December, 1985 to July, 1990 within the sea area of 11°00′S～20°00′N, 116°00′E～165°00′E. During the survey, advanced equipment and instruments such as CTD, XBT, ADCP were used in addition to the routine survey instruments, obtaining valuable data for various elements in marine hydrology, meteorology and biochemistry. The observed depths and accuracy of these data have all reached the world advanced level.

The Atlas is a basic one compiled after analysing, sorting out and synthesizing the in-situ observations. As one of the achievements of the Sino-U. S. joint studies in the TOGA project, it is undoubtedly of important value to the research on the air-sea interaction and the development of oceanography and meteorology as a whole.

We are indebted to Prof. Chao Jiping, Research Scientist Chen Zeshi, Prof. Yu Zhouwen, Research Scientists Gan Zijun and Chen Shangji for their guidence to the compilation of the Atlas, and Lu Yupei, Chen Daxi, Shan Guanglin, Wang Dezheng and Huang Zhenzong who have participated in the finalization of the Atlas and provided assistance in various ways. Our thanks also go to the South Sea Branch and the First Institute of Oceanography of the State Oceanic Administration for supplying relevant data and charts for the compilation of the Atlas.

说　明

一、整编海域：13°00′S～24°00′N，120°00′E～167°00′E。

二、本图集绘制了中、美热带西太平洋联合调查的8个航次的水文、化学要素断面分布图和垂直分布图、海流矢量图、海流东分量和北分量断面分布图。绘制断面主要有6条，其中3条经向断面分别为：130°00′E、141°30′E、165°00′E；3条纬向断面分别为：18°20′N、8°00′N和赤道断面。

三、本图集绘制了水温、盐度、密度偏差、溶解氧要素的断面分布图和垂直分布图。为了便于对照使用，将这两种图安排在相邻的两页上。

1. 断面分布图：断面分布图以要素的等值线来显示要素的剖面分布状况。垂直坐标的比例为：0～400m为1∶6 250，400～1 000m为1∶12 500，1 000～6 000m为1∶62 500。每幅图的水平坐标两个端点标明断面上两端观测站的站位。其它各站位按站距比例以短线表示在相应位置上，并在其上方注明部分站号。在等值线图的下边标有整度数的经、纬度（经向断面标出纬度值；纬向断面标出经度值）。

2. 垂直分布图：垂直分布图绘出每个站要素的垂向变化。每条断面所有站都绘在同一幅图上，站的排列顺序，图幅的比例均同断面分布图。水平坐标表示要素值，其左端两点上方的数值与左端的站的要素有关。站与站之间的间距相差一个常量，这个量即为左端所注明的两点数值之差。每个站的垂直分布线下端都注明站号和最深观测层的要素值。

3. 硝酸盐和叶绿素断面分布图，只绘制赤道断面和165°00′E断面，其深度分别为300m、200m。海流北分量和东分量断面分布图是利用多普勒声学剖面海流仪（ADCP）测流资料绘制的，观测深度一般可达400m。这3种断面分布图只标出经、纬度、未注明站号。

四、本图集的资料以中、美热带西太平洋联合调查的CTD/O、ADCP和常规采样、海水营养盐自动分析仪分析的化学资料为主。

（一）CTD/O$_2$资料是经美国伍兹霍尔海洋研究所、中国国家海洋局第一海洋研究所、南海分局、国家海洋信息中心共同处理的。

1. 温度：由CTD/O$_2$观测的温度，用1968年国际温标（IPTS1968）。

2. 盐度：由CTD/O$_2$测定的压力、温度、电导率按1978年国际实用盐标计算（UNESCO T. R. 44）。

3. 密度偏差：根据1980年国际海水状态方程和1978年实用盐标计算，$\gamma_{s,t,p}=\frac{1}{V_{s,t,p}}-1000\mathrm{kg/m^3}$（UNESCO T. R. 44）。

4. 溶解氧：用Owens和Millard（1985）方法计算。

5. 压力转换成深度：采用EOS80的压力—深度转换公式计算（UNESCO T. R. 44）。

6. 计算标准层的内插方法：由相邻上、下两观测层的要素值线性内插求得标准层。

标准层的取法是根据国家海洋局《海洋调查规范》（1975）的标准来选取。

（二）ADCP资料是由国家海洋信息中心处理。

中、美热带西太平洋联合调查的ADCP资料是用RDI公司制造的标准150kHz海流剖面仪测得的。第二航次至第七航次使用的导航仪（用于计算船速）为Magnavox—1105R，第八航次为Magnavox—1105R与GPS的组合。取50～170m参考层计算绝对速度，对于第二至第四航次介于Transit两个定位点之间的参考层绝对速度用12h宽度的Blackman滤波器平滑，第五至第七航次采用滤波器的宽度为6h，第八航次为1h。每一航次，采用多种方法标订传感器安装角度偏差，第二航次存在近于1°的未知值，假设平均船速为4m/s，则造成7cm/s的系统误差。

海流矢量图中每个矢量表示每1°间隔航线内的平均海流。每幅矢量平面图均表示50m厚度水层内的平均结果（25～75m，75～125m，175～225m，275～325m）。海流断面分布图，水平坐标按0.5°间隔取平均值，垂直坐标按10m间隔取各层的平均流速值，分别按北、东分量绘制。

五、图集中各要素采用单位和等值线间隔如下表：

单位和等值线间隔表

要　素	单　位	水　深 (m)	间　隔	加密间隔	备　注
水温	℃	0～6000	1℃	5 的倍数	
盐度		0～1000	0.1	0.5 的倍数	
		1000～6000	0.05		
密度偏差	kg/m³	0～6000	0.2kg/m³	整数	
海流分量	cm/s	0～400	10cm/s	0.50.100	分正、负区，东分量以东为正，以西为负；北分量以北为正，以南为负。
溶解氧	μmol/dm³	0～6000	20μmol/dm³	100 处常值线	
硝酸盐	μmol/dm³	0～300	2.0μmol/dm³	5.10.20	
叶绿素	mg/m³	0～250	0.10 mg/m³ 0.01		

六、本图集由国家海洋信息中心负责编绘，承担内容包括：水温、盐度、密度偏差、海流、溶解氧、国家海洋局第一海洋研究所承担硝酸盐、叶绿素等要素的编绘。

参　考　文　献

1. UNESCO Technical Report 44.

2. Owens, W.B., and R.C. Millard, Jr. 1985.
A New Algorithm for CTD Oxygen Calibration. Journal of Physical Oceanography: 15: 621—631.

3. Bierkeun, R.B., and J.W. Tukey, 1959.
The Measurement of Power Spectrum. Dover Publications: 190 pp.

Notes

I. Atlas coverage: 13°01′S—24°01′N, 127°01′E—167°01′E.

II. The Atlas contains sectional and vertical distributions of hydrological and chemical elements, vertical distribution, meridional and zonal distributions of currents for the eight cruises of the Sino-U.S. joint survey in the tropical western Pacific. Six sections have been plotted including three meridional sections: 130°01′E, 141°58′E and 167°01′E and three zonal sections: 14°20′N, 9°01′S and the Equator.

III. Sectional and vertical distributions of water temperature, salinity, density, anomaly and dissolved oxygen are plotted on the Atlas. For the convenience of comparison, these two kinds of charts are arranged on the two adjacent pages.

1. Sectional distribution chart: The sectional distribution chart indicates the sectional distribution of elements with isolines of elements. The scales of vertical coordinates are 1:6250 for 0～100m, 1:12500 for 100～1000m and 1:62500 for 1000～6000 m. The two ends of the horizontal coordinates on each sheet mark the station locations in the two ends on the section. The other station locations are shown in the corresponding positions with short lines according to the scales of the distances between stations and some station numbers are marked above these locations. Below the isoline chart are given the round numbers of longitude and latitude (longitudinal value for the meridional section and latitudinal value for the zonal section).

2. Vertical distribution chart: The vertical distribution chart gives the vertical change of elements at each station. All the stations in each section are plotted on the same sheet. The sequence of stations and the scales of the sheets are the same as those in the sectional distribution chart. The horizontal coordinates represent elemental values. The numerical values above the two points at the left end relate to the elements of the stations at that end. There is a difference of a constant quantity in the intervals between stations, which is the numerical value difference between the points at the left end. The station number and the elemental value of the deepest observation layer are given below the vertical distribution lines of each station.

3. The chart of sectional distribution of nitrate and chlorophyl only plots the section of the Equator and that of 165°01′E, with the depths of 300 m and 200 m respectively. The sectional distribution of meridional and zonal currents are plotted using current data obtained with ADCP. The observing depth generally reaches 250 m. These three kinds of sectional distribution charts are marked with longitude and latitude, but not the station numbers.

IV. The data of the Atlas are primarily the CTD-O, from the Sino-U.S. joint investigation in the tropical western Pacific, the data obtained from ADCP observation and routine sampling and chemical data analysed by the seawater nutrient auto analyser.

1. CTD-O data are processed jointly by the U.S. Woods Hole Oceanographic Institution and the First Institute of Oceanography, the South Sea Branch, the National Marine Data and Information Service of the State Oceanic Administration, China.

(1) Temperature: The International Practical Temperature Scale of 1968 IPTS-1968 is used for the temperature observed by CTD-O.

(2) Salinity: The pressure-temperature and conductivity measured by CTD-O are computed using the Practical Salinity Scale 1978. (UNESCO T. R. 44).

(3) Density anomaly: Calculated by the 1980 International Seawater State Equation and the Practical Salinity Scale-1978.

$$\sigma(s,t,p)=\frac{1}{V(s,t,p)}-1000\text{kg/m}^3\text{(UNESCO T. R. 44)}.$$

(4)Dissolved oxygen.Computed using the Owens and Millard Method(1985).

(5)Pressure converted into depth.Computed using the EL0880 pressure-depth conversion formula (UNESCO T. R. 44).

(6)Calculation of the standard layer by interpolation; The standard layer is obtained by linear interpolation of the elemental values of two observation layers.

The standard layer is selected according to the criteria of the 1975 "Norms of Marine Survey" of the State Oceanic Administration.

2. The ADCP data are processed in the National Marine Data and Information Service.

The ADCP data from the Sino-U.S. Joint Studies in the Tropical Western Pacific were obtained with the Standard 150 kHz Current Profiler made in the RDI Corporation. Magnavox—1107SR was the navigator used from the second cruise to the seventh cruise to compute ship velocity. And the eighth cruise used Magnavox—1107SR and GPS. Absolute velocity is computed taking 50~170m as the reference layer. The absolute velocity of the reference layer in between the two positioning points of transit from the second cruise to the fourth cruise was smoothed with the Blackman filter. 12 h wide. Width of the filter used from the fifth cruise to the seventh cruise is 6 h and that during the eighth cruise is 4 h. During such cruises, a number of methods were applied to correct the installation errors of transducer. There was an unknown value of nearly one degree in the second cruise, which assuming the mean ship velocity to be 4 m/s, would result in a systematic error of 7 cm/s.

Each vector in the sectional distribution chart indicates the mean sea current at an interval of 1° in the course. Each sectional plane distribution chart indicates the mean results in the 50 m thick layers (25~75m, 75~125m, 175~225m, 275~325m). In each sectional distribution of current velocity, the horizontal coordinates are averaged at an interval of 0.5° and the vertical coordinates take the mean velocities of every layer at an interval of 10 m and the sectional distribution of current is drawn on the base of the meridional and zonal currents respectively.

V. Units and scales intervals for various elements in the Atlas:

Table of Units and Isoline Intervals

Element	Unit	Water depth (m)	Interval	Interval of thickness km	Remarks
Temperature	℃	0~1000	1℃	Multiples of 1	
Salinity		0~100	0.1	Multiples of 0.1	
		100~1000	0.05		
Density Anomaly	kg/m³	0~1000	0.2kg/m³	Round numbers	
Current Velocity	cm/s	0~450	10cm/s	0~50, 100	Data fall into the positive and negative zones respectively. For the zonal velocity, the velocities using east as positive and those going west as negative. For the meridional current, the velocities using north as positive and those going south as negative.
Dissolved Oxygen	μmol/dm³	0~1000	20μmol/dm³	Natural multiples of 100	
Nitrate	μmol/dm³	0~700	1.0μmol/dm³	7~10, 20	
Chlorophyll	mg/m³	0~200	0.10 mg/m³ 0.05 mg/m³		

VI. The Atlas is compiled by the National Marine Data and Information Service with respect to water temperature, salinity, density anomaly, sea current, and dissolved oxygen. The First Institute of Oceanography of the State Oceanic Administration undertakes compiling such elements as nutrient, chlorophyll, etc.

References

1. UNESCO Technical Report 44.

2. Owens, W. B. and R. C. Millard, Jr. 1985.
A New Algorithm for CTD Oxygen Calibration. Journal of Physical Oceanography, 15: 621~631.

3. Blackman, R. B. and J. W. Tukey, 1959.
The Measurement of Power Spectrum. Dover Publications, 190. pp.

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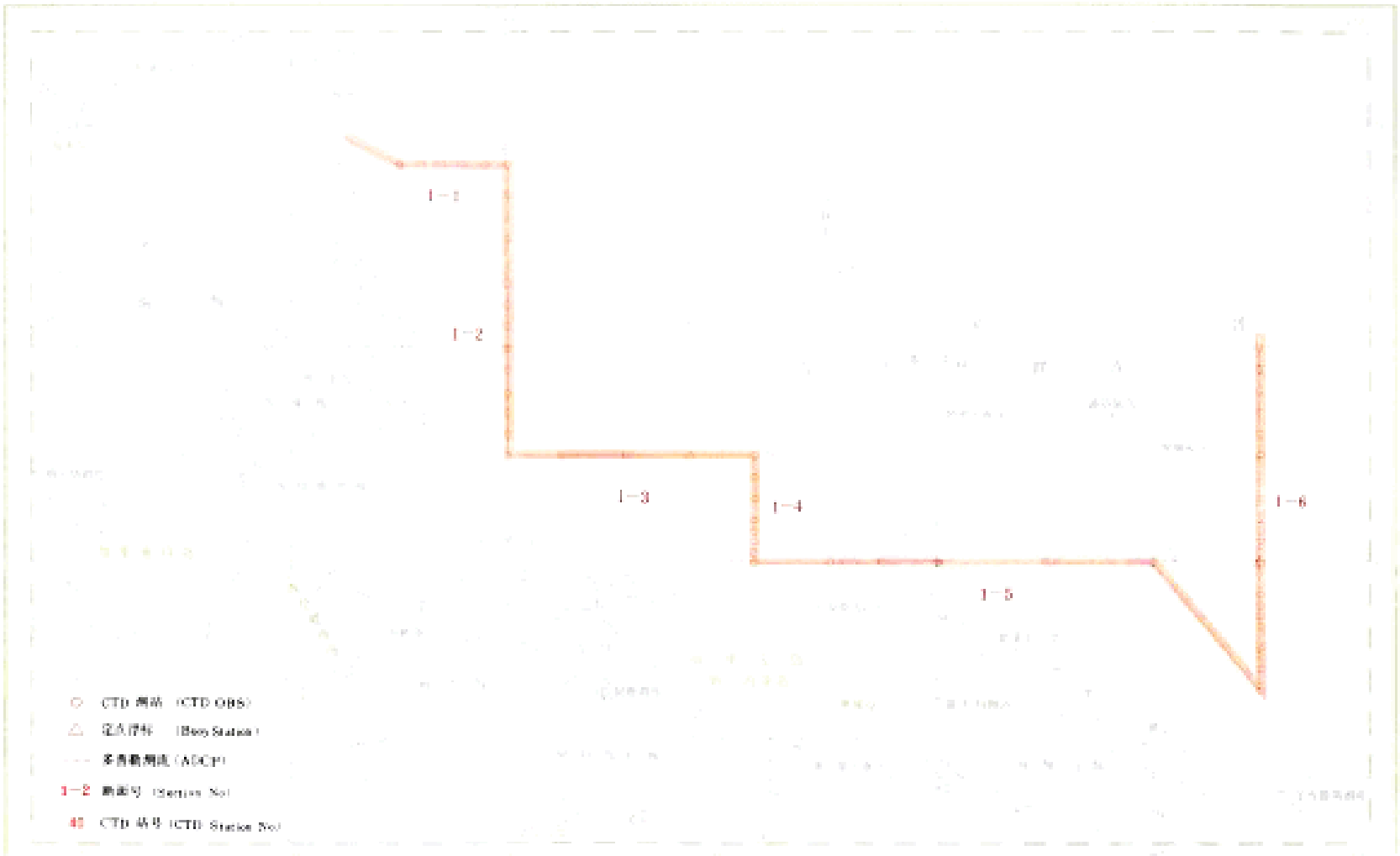
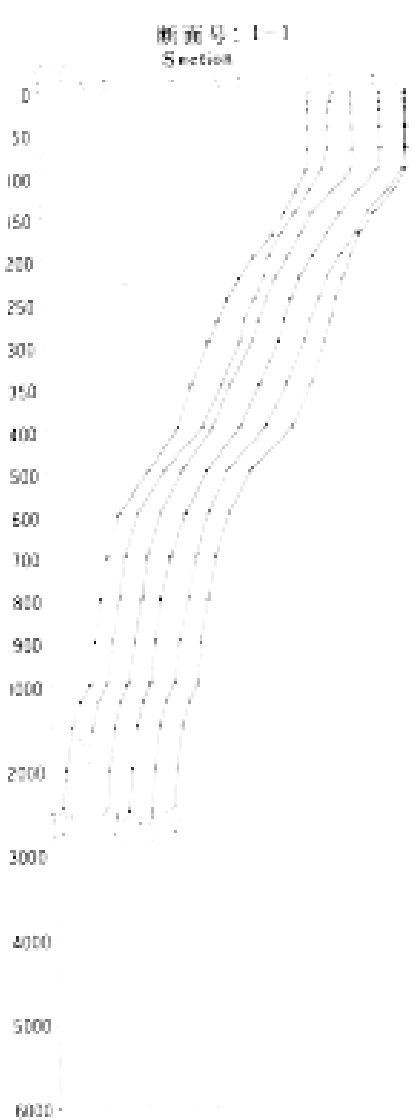
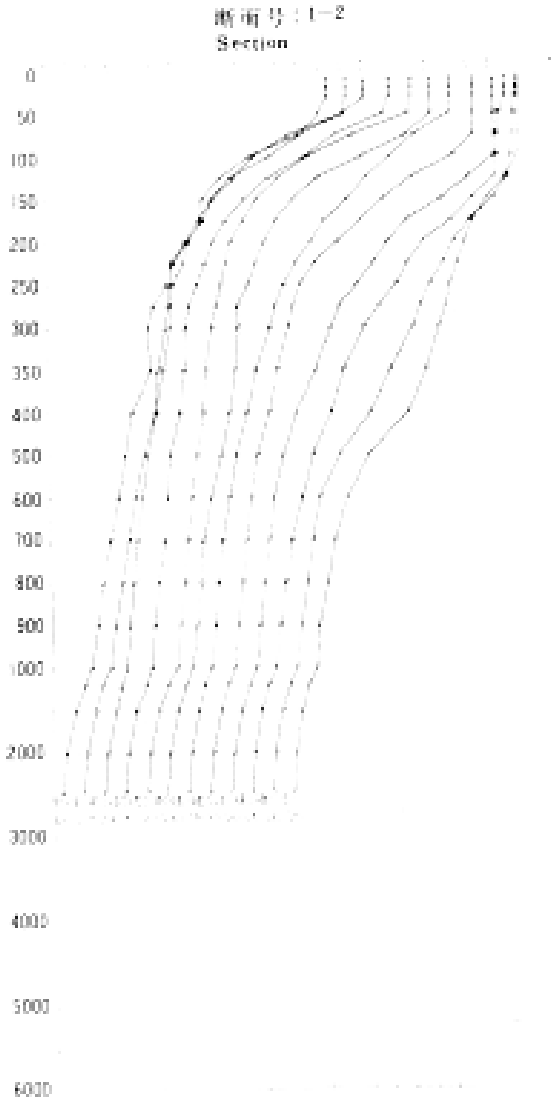


水温垂直分布图

Vertical Distribution of Temperature





水温断面分布图

Sectional Distribution of Temperature

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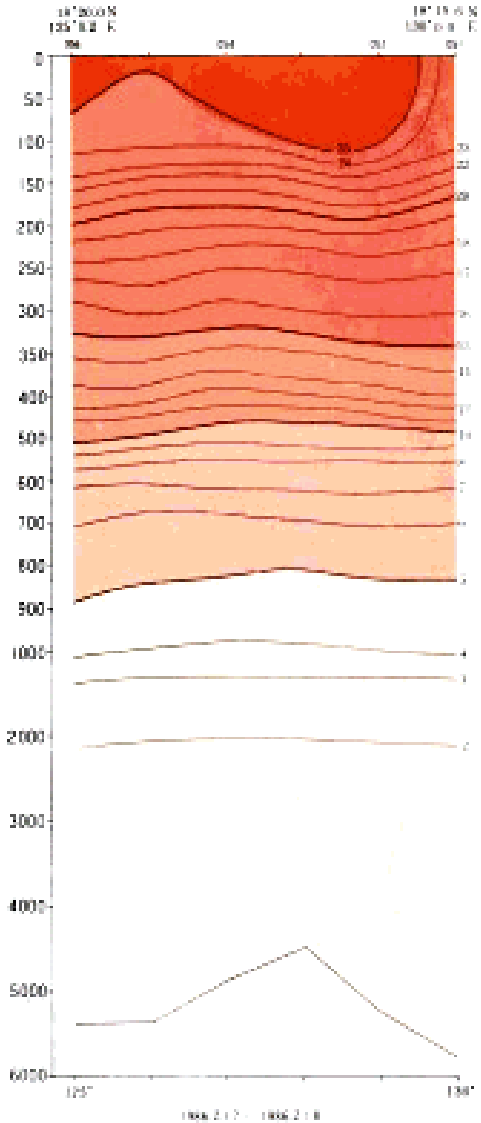

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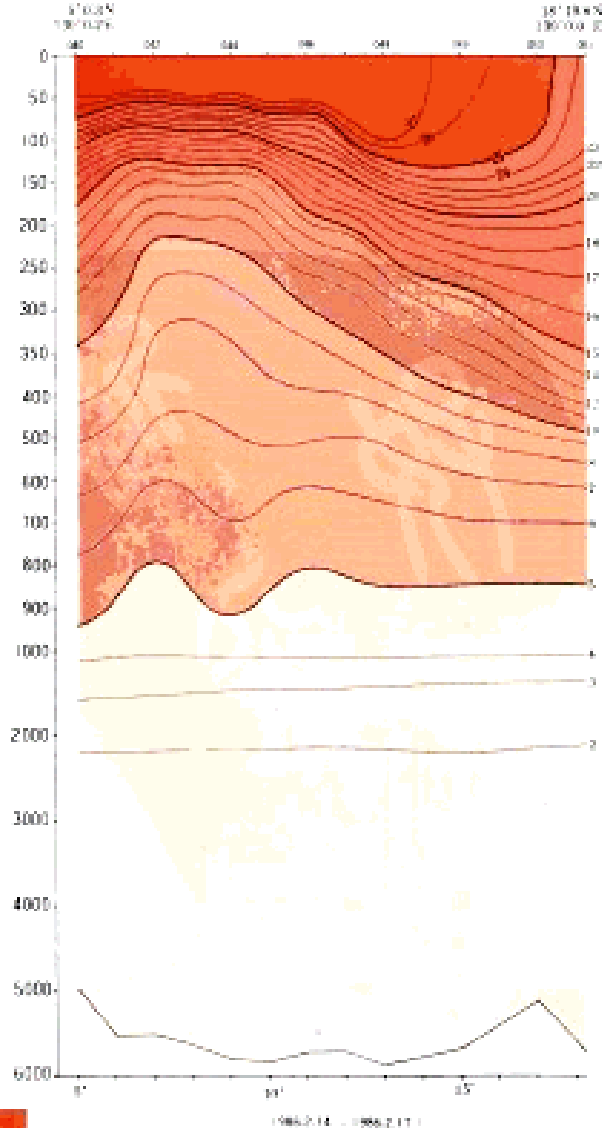
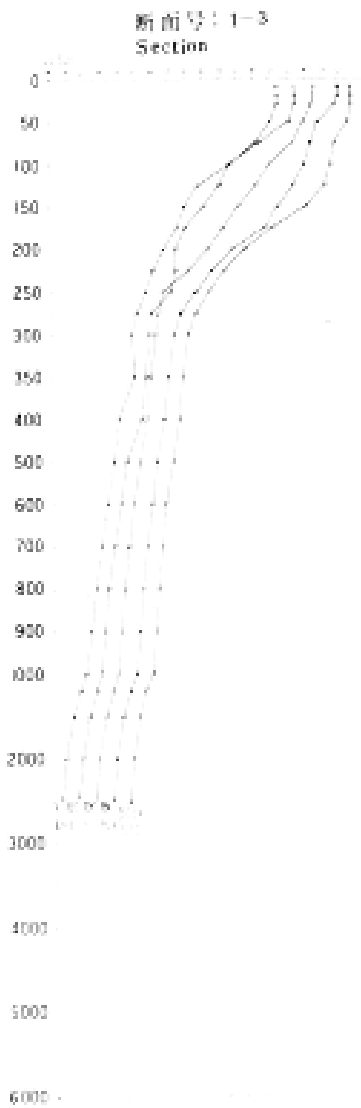
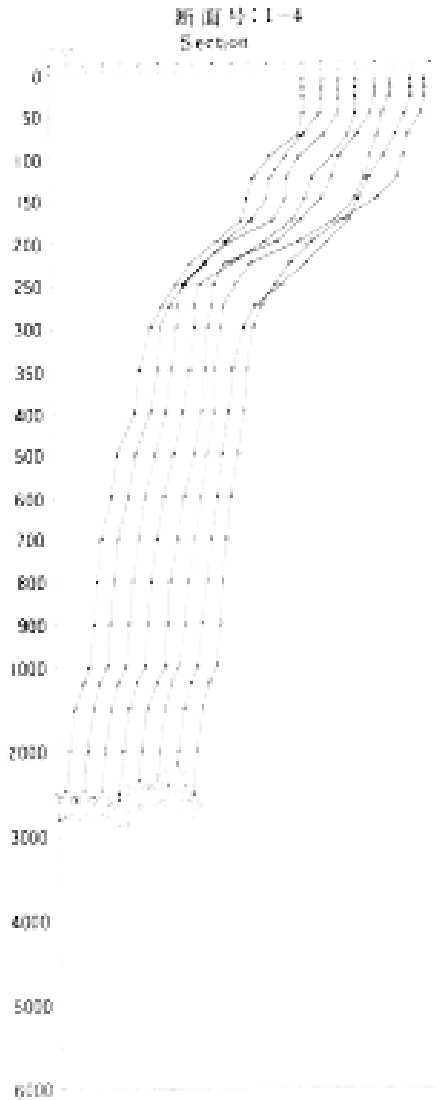
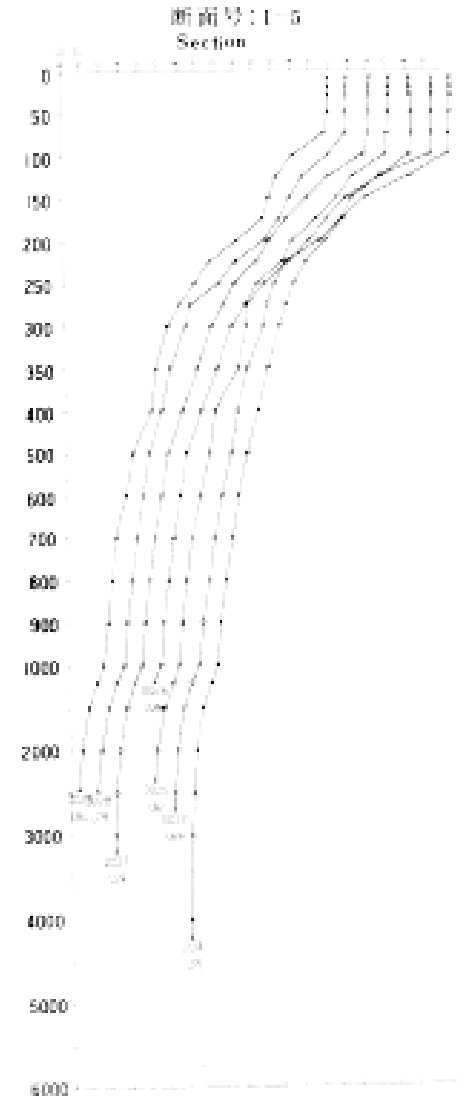


水温垂直分布图

Vertical Distribution of Temperature







水温断面分布图

Sectional Distribution of Temperature

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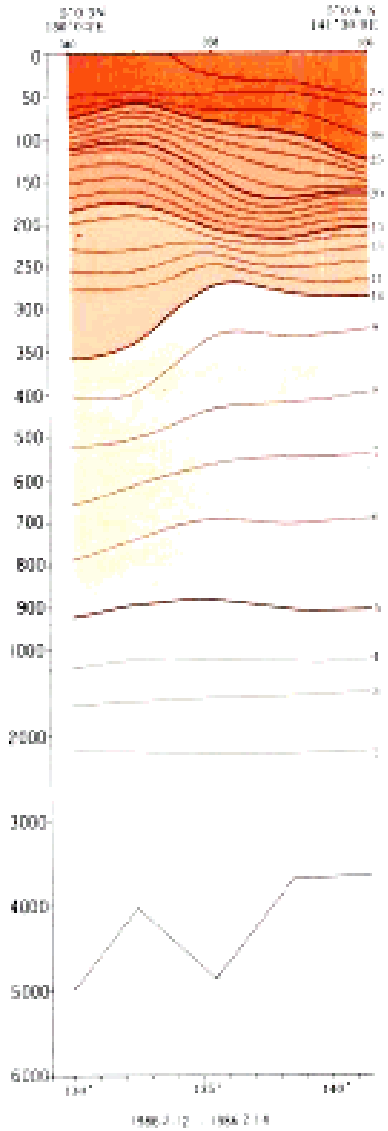
Section



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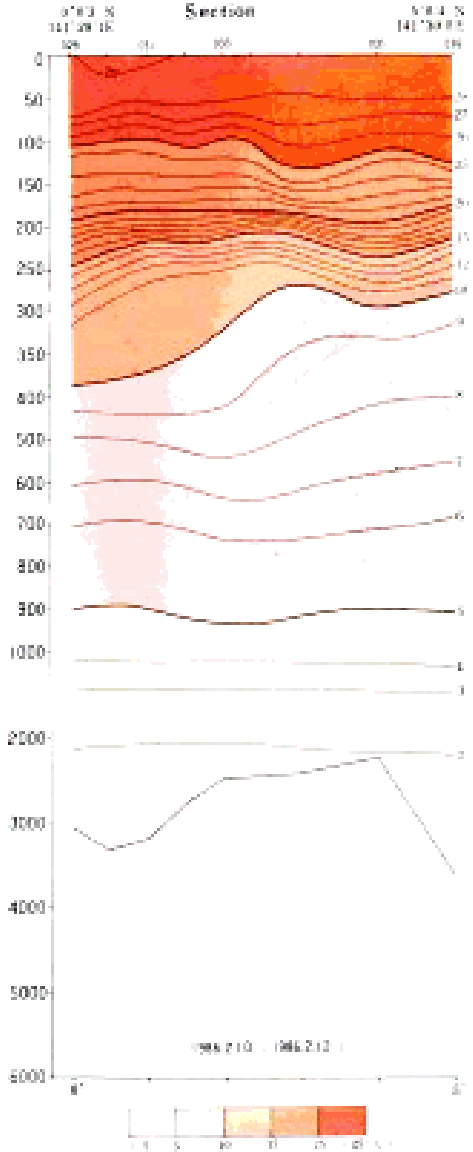

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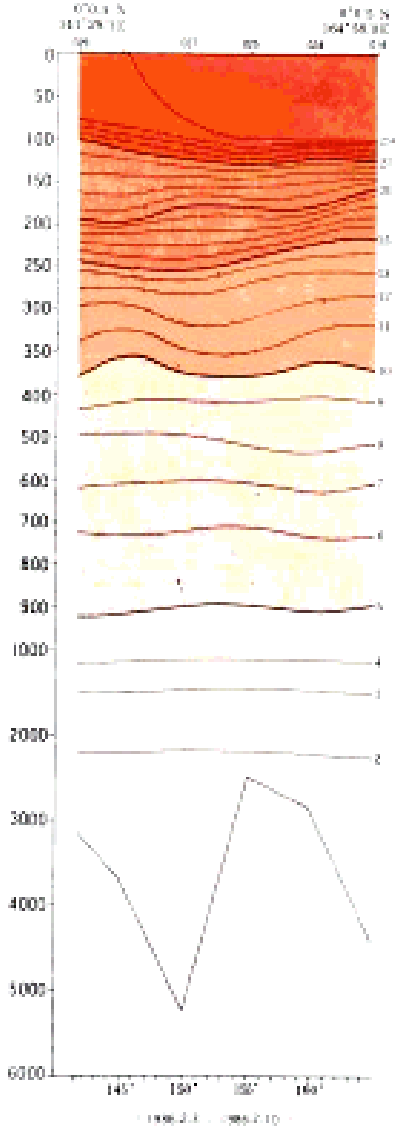
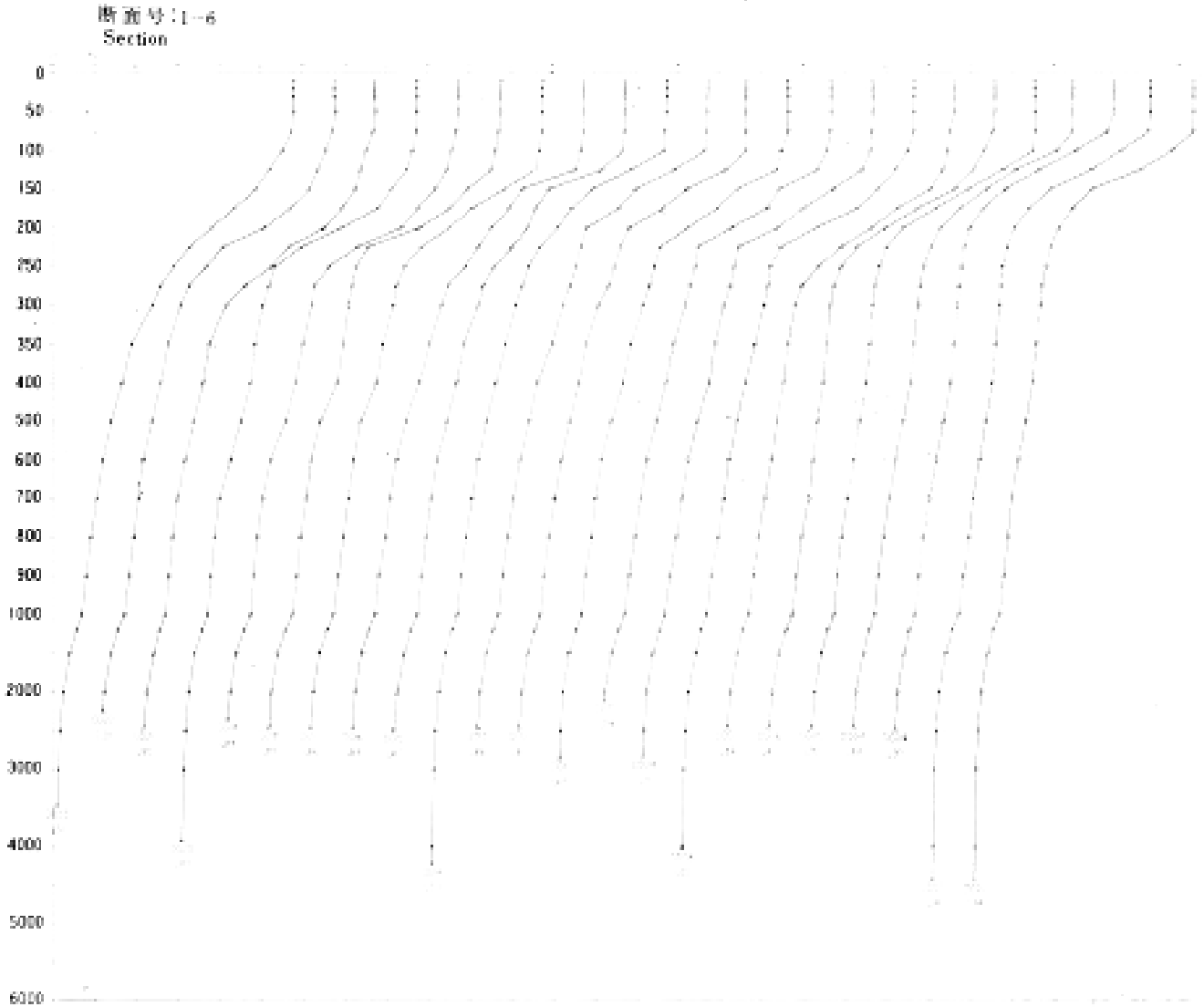


水温垂直分布图

Vertical Distribution of Temperature



水 温 断 面 分 布 图

断面号：t-6

Section

Sectional Distribution of Temperature