Cruise Report

Shinsei-maru KS-18-1 Cruise Jan 18-30, 2018 Yokosuka - Yokosuka

KS-18-1　Cruise Report

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１．新青丸 KS-18-1 次研究航海の概要

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本航海では 2018 年 1 月 18 日から 1 月 30 日まで黒潮続流南方海域において、主に海洋表層を対象とした物理・化学・生物観測を実施した。研究題目は「春季の再成層化に伴う生物地球化学過程に中規模以下の物理現象が与える影響の解明」である。

中規模渦に満ちた西岸境界流域では冬季に海洋表面から大量の熱が大気に奪われ、深い混合層すなわちモード水が形成されるとともに、大量の人為起源二酸化炭素が海洋に吸収される。中規模以下の物理変動が生物地球化学過程に与える影響を解明することは、西岸境界流が気候変動・物質循環へ果たす役割を理解するための次の重要な課題である。黒潮続流南方の亜熱帯モード水形成域では、これまでに米国 NOAA が設置している KEO ブイデータに基づき、海洋表面から内部への有機・無機炭素の輸送が定量的に見積もられ、冬季混合層の最大深度と初春の混合層浅化速度、光環境のバランスが、植物プランクトンが利用可能な栄養塩量をコントロールしていることが示されている。また、夏季の低気圧性渦が亜表層の生物地球化学過程や海面のクロロフィル分布へ与える影響が調べられている。しかしながら、冬季の渦による水平・鉛直輸送が生物地球化学過程に与える影響は未解明である。

そこで今回我々は、冬季から春季にかけて約 3 か月間、グライダーやフロートといった自動測器による時系列観測を行い、海洋表層の物理・生物地球化学パラメタの細かい水平・鉛直構造、およびそれらと衛星海面高度データによって捉えられる中規模変動との関わりを調べることで、春季の再成層化に伴う生物地球化学過程に中規模以下の現象が与える影響の解明を目指すこととした。今回の KS-18-1 次航海では、KEO 係留ブイ（32.3N、144.6E）付近において、具体的に以下の観測を計画した。１.「混合層フロント」を探すための Underway CTD（U-CTD）航走観測を行う。２.混合層フロント上の点で生物地球化学センサー付きフロート（BGC フロート）2 台、乱流計付フロート（乱流フロート）1 台、電磁流速計付フロート（EM フロート）1 台、CTDO2 センサー付 SeaGlider 1 台を投入し、2000m までの CTD 観測を行う。３．同じ点で海面ドリフターを投入し、混合層フロントに沿って流れると期待されるドリフターを追跡しながら、混合層フロントをジグザグに横切る Underway VMP（U-VMP）航走観測を行う。航走観測中、適宜 1000m までの CTD 観測を行う。４．乱流フロートを回収する。５．時間に余裕があれば、再度 U-CTD 観測を行う。

CTD の採水項目は、塩分、溶存酸素、栄養塩、溶存無機炭素（DIC）、pH、クロロフィル、懸濁粒子である。ロゼットには ISUS 硝酸塩センサーと Deep Sea Derafet pH センサーをつけ CTD キャスト中の硝酸塩と pH の連続プロファイルをとり、加えて表面海水による硝酸塩ならびに pH の自動連続観測を行うこととした。

乗船研究者は東京大学、東北大学、東京海洋大学、海洋研究開発機構（JAMSTEC）、米国 Monterey Bay Aquarium Research Institute（MBARI)、米国 North Carolina State University からの 12 名で、株式会社マリン・ワーク・ジャパン（MWJ）の観測技術員 2 名の支援を頂いた。

1 月 17 日 09 時から JAMSTEC 岸壁にて積込を行った。その後、研究室のスペースを割り振り、各自機器の設置とテストを行った。夕方から雨模様となった。乗船予定の Stuart Bishop は 16 日の来日の前から体調を崩し、ホテルで休養していたが、病院に行ったところ A 型インフルエン

ザと診断され、残念ながら急遽乗船取りやめとなった（20 日に帰国）。

新青丸は 1 月 18 日 14 時に大勢の方に見送られ、JAMSTEC 岸壁を出港した。この時点で、22 日に南岸低気圧が東京付近を通過し、その後本州東の海上で急発達するという予報が出ていた。荒天退避の前に観測できる時間を考え、KEO を中心とする 50km 四方の正方形の測線をとり、各頂点で 1000m までの CTD 観測、CTD 測点間で 8 ノットの U-CTD 観測を行い、メソスケールの海洋構造を押さえるという計画を立てた。そして、最初の測点に戻ったところで 2000m までの CTD 観測を行い、フロートとグライダーを投入することとした。

19 日 17 時半に北西の測点 C001 に到着。海は若干荒れ気味であった。乱流フロートの浮力テストを行い、放射性セシウムの表面採水を行ったのち、18 時半から 1000m までの CTD キャストを実施した。CTD 終了後、南へ試しに走り、U-CTD 観測が問題なく行えそうだったので、一旦 C001 に戻ってから観測を開始した。C002 到着まで 8 kt で航走し、距離約 2.5 マイル、時間にして約 20 分の間隔で 10 回の U-CTD キャストを行った。ただ、U-CTD の電気伝導度センサーの調子が悪く、観測を重ねるごとに塩分がおかしな値を示すようになった。20 日 00 時南西の C002 に到着し、CTD キャストを実施。C003 へ向け離脱後、U-CTD の新たなプローブの充電が完了するまで 3 マイル間隔で XCTD 観測を 2 回行い、その後 U-CTD 観測を再開した。

20 日 07 時前に南東の C003 に到着したが、うねりが高く、待機となった。乱流フロートは投入前テストの結果が悪く、今航での投入&回収を見送ることになった。13 時前から CTD キャストを開始。終了後、うねりが東側から来ていたため、後部甲板艫側の U-CTD ウインチを右舷側から左舷側に付け替え、北に向かって U-CTD 観測を開始した。18 時半、北東の C004 に到着したが、うねりが高く、再び待機。23 時にようやく CTD キャストを開始し、終了後 21 日 01 時半から同じ位置で、基礎生産のための CTD キャスト C04P を行った。

U-CTD 観測を行いながら西進し、06 時に C001 の位置に戻るも、風が強く、2000m までの CTD キャストを断念。BGC フロートの投入は CTD 観測なしでは意味がないため、フロートとグライダーの投入も諦めた。その後急速に荒れるという予報が出ていたため、東京港に向かって航走を開始した。1 つ前の C004 でフロートを投入しておけばよかったと一同悔やむこととなった。

22 日の朝に東京湾に入り、横須賀沖に停泊。低気圧の通過後は強い冬型の気圧配置となり、少なくとも数日間は海に戻れないと予想されたため、JAMSTEC 運航部に着岸を要請し、午後 JAMSTEC 岸壁に入港した。夕方からは雪が降り始め、横須賀でも 10 センチ近い積雪となり、テレビでは都内の交通大混乱のニュースが流れた。追浜駅周辺に夕食に出る者もいたが、帰りのタクシーが 1 時間待ちとのことで、1 時間歩いて帰船していた。23 日と 24 日は各自外出するなどして過ごした。風が強かった。25 日は東京の最低気温が 48 年ぶりに-4℃となり、ニュースになった。

24 日午後に JAMSTEC 運航部と話し合い、26 日午後に出港し、館山沖で KEO 方面に向かうチャンスを伺うことにした。25 日は、28 日までの波浪予報が出て、ようやくうねりが収まる兆しが見えてきた。午後には JAMSTEC 広報部に、乗船研究者の JAMSTEC 見学ツアーを行って頂いた。26 日朝は、金沢小学校の JAMSTEC 見学に対応。13:30 に出港し、館山湾内に停泊した。

27 日 08 時半に KEO へ向け、館山湾を出た。この時点で KEO での波高はまだ 5m を越えていると見られた。波は 28 日の午後には落ち着くも

のの、29 日は再び低気圧と前線が通過して荒れると予想されるため、KEO までは行けない見通しとなり、143E に達したところで観測を行うこととした。

28 日 04 時に 33-06N、143-00E に到着して夜明けを待ったが、うねりが時折高く、その後の予報もよくないので、海面高度分布から判断して 33-15N、142-30E に移動した。08 時到着。09 時半うねりが収まってきたので、ここを C005 とし、ようやく 2000m までの CTD を行うことができた。揚収後、BGC フロート 2 本、EM フロート 1 本、グライダー1 台を次々と投入。今後、当面の間、グライダーにはフロートの位置を中心とする butterfly 型の測線上で観測を行わせる予定である。グライダーとフロートは 2018 年 4 月 20 日～5 月 1 日に行われる新青丸 KS-18-4 次航海で回収予定である。

フロートとグライダーを投入後、13 時前から北に向かって 3 kt で走りながら約 15 分の時間間隔で U-VMP 観測を 15 回行った。17 時に離脱、横須賀へ向け航走を開始した。18 時過ぎには風が 15m/s 以上に強まり、最初から最後まで悪天候の航海となった。

29 日の 10 時に東京湾に入り、ようやく揺れが収まり、片付けを始めた。11 時半に横須賀沖に投錨、13 時後部甲板で記念撮影を行った。20 時から研究室で打ち上げを行った。30 日 09 時に JAMSTEC 岸壁に帰港し、荷下ろし作業を行った。

本航海は、数年ぶりの大寒波に見舞われるなど、航海期間を通じて外洋では一度も波高 2m 以下の状態になることがない、大荒れの航海であった。18 日の航海開始後、海で 4 泊、岸壁で 4 泊、再び海で 4 泊し、観測を行えたのはわずかに前半 1.5 日、後半 0.5 日のみであった。週に一度は低気圧通過で荒れることは織り込み済みであったが、ここまで観測が限られるとは予想しておらず、人為起源二酸化炭素を吸収する真冬の海の厳しさを実感させられた航海であった。このような悪条件にもかかわらず、長短さまざまな待機を耐え、最低限やりたい観測を遂行できたのは、ひとえに乗船研究者全員の頑張りのお蔭であり、心から感謝したい。

本航海ではいつもながら、非常に多くの方々のサポートを頂いた。青木高文船長をはじめとする新青丸乗組員の方々、東大大気海洋研の研究航海企画センター、観測研究推進室、国際・研究推進チーム、および JAMSTEC 海洋工学センター運航管理部の皆さんにはいつも通りの献身的で的確なご支援を頂いた。乗船した MWJ の押谷俊吾さんには CTD 観測、玉田晴香さんには溶存酸素測定のサポートを頂いた。加えて、東大大気海洋研の藤尾伸三さん、柳本大吾さん、高畑直人さんと JAMSTEC の熊本雄一郎さんには酸素滴定、JAMSTEC の村田昌彦さんと笹岡晃征さんにはクロロフィル・栄養塩・pH・DIC 測定、ウッズホール海洋研究所の Zhaohui Aleck Wang さんには DIC 測定、名古屋大学の三野義尚さんには懸濁粒子測定、JAMSTEC の川合義美さんには気象観測、JAMSTEC の平野瑞恵さんと藤木徹一さん、ワシントン大学の John Dunlap さん、MWJ の飯野哲治さんにはフロート観測、東北区水産研究所の奥西武さんと長谷川大介さん、日本海洋株式会社の蛯原周さんにはグライダー観測、MBARI の Kenneth Johnson さん、Luke Coletti さん、Carole Sakamoto さん、Hans Jannasch さん、Peter Walz さん、Hans Thomas さん、Larry Hawkins さんには pH ならびに硝酸塩センサーの準備と輸送手続、JAMSTEC 研究推進部と国際課の皆さんにはグライダー輸出手続に関して大変お世話になった。観測費用の面では、新学術領域研究「海洋混合学の創設」（代表：安田一郎・東京大学教授）から様々な形で多大なるご支援を頂いた。本航海の成功はこれらのサポートなしには到底不可能であり、関係者全員に厚

く御礼申し上げたい。

【本航海でとった観測データについて】

　観測データの散逸を防ぐため、生データと補正済みデータの一式を東大大気海洋研海洋物理学部門で保管し、2 年後を目処に日本海洋データセンターを通じて公開したいと思いますので、データ等の報告にご協力ください。新青丸航海でとったデータは、公式には東京大学大気海洋研究所と海洋研究開発機構に帰属しますが、同時に本航海に参加した乗船研究者の共有物でもあり、自分の研究に必要な範囲内での限られた利用や成果の公表を考えない個人的な利用には自由に使うことができます。しかし、データの公開前に印刷物や公式の場での発表に利用する場合には、そのデータの観測責任者にご相談ください。

1. Summary of R/V Shinsei-maru KS-18-1 cruise

Eitarou Oka (Cruise PI)

During this cruise from January 18 through 30, 2018, we conducted physical, chemical, and biological observations primarily within the upper water column (1000 m) of a region south of the Kuroshio Extension. The title of the cruise was "Influence of meso- and smaller-scale physical phenomena on biogeochemical processes associated with spring restratification".

In western boundary current regions where mesoscale eddies are prevalent, large oceanic heat loss during winter results in deep mixed layers, leading to mode water formation, and the oceanic uptake of huge amounts of carbon dioxide. Our primary research goal is to clarify the influence of meso- and smaller-scale physical phenomena on biogeochemical processes for a better understanding of the role of western boundary currents in ocean carbon uptake, climate variability, and material cycles. Within the North Pacific Subtropical Mode Water formation region south of the Kuroshio Extension, previous studies have analyzed data from the KEO buoy maintained by NOAA to estimate quantitatively the export of organic and inorganic carbon from the surface to the interior ocean. These studies demonstrate that the amount of nutrients available for phytoplankton is controlled by the balance between the maximum winter mixed layer depth, shallowing speed of the mixed layer in spring, and the light environment. Other studies have also examined the influence of cyclonic eddies on subsurface biogeochemical processes and surface chlorophyll distributions during summer. However, the impact of horizontal/vertical eddy transports on biogeochemical processes during winter has not yet been explored.

We therefore planned to make autonomous time-series observations using a glider and profiling floats for about three months from winter to spring to examine the small-scale horizontal/vertical structure of physical and biogeochemical parameters in the surface layer and its relation to the mesoscale variability detected by satellite altimeter observation. In this KS-18-1 cruise, following observations were planned in the vicinity of the KEO buoy at 32.3N, 144.6E. (1) Conduct underway CTD (U-CTD) survey to find a "mixed layer front". (2) At a particular point on the mixed layer front, deploy 2 floats with biogeochemical sensors (BGC floats), 1 microstructure float, 1 float with electromagnetic current meter (EM float), and 1 SeaGlider with CTDO2 sensor, and conduct a CTD cast to 2000 m. (3) Deploy a surface drifter at the same point, and conduct underway VMP (U-VMP) surveys across and along the front while chasing the drifter that is expected to flow along the front. CTD casts to 1000 m would be performed occasionally. (4) Recover the microstructure float. (5) If time permits, conduct U-CTD survey again.

Parameters to be analyzed from discrete water samples were salinity, dissolved oxygen, nutrients, dissolved inorganic carbon (DIC), pH, total alkalinity (TA), chlorophyll, and suspended particles. We planned to attach an ISUS nitrate sensor and a Deep Sea Derafet pH sensor to the rosette to collect high vertical resolution observations of nitrate and pH during CTD casts.

The cruise was planned to have 12 scientists from Univ. of Tokyo, Tohoku Univ., Tokyo Univ. of Marine Science and Technology, Japan Agency for Marine-Earth Science and Technology (JAMSTEC), Monterey Bay Aquarium Research Institute (MBARI), and North Carolina State Univ. as well as 2 technicians from Marine Works Japan Ltd.

We loaded instruments at the JAMSTEC pier in Yokosuka from 09:00 on Jan. 17th, and then set up and tested them until evening when it started raining. Stuart Bishop had been ill since before his arrival to Japan on the 16th and was diagnosed with influenza A on the 17th. Unfortunately his participation was therefore cancelled.

Shinsei-maru left the JAMSTEC pier at 14:00 on the 18th. At this time, it was forecasted that a cyclone off the south coast of Japan would pass through the Tokyo area on the 22nd and then develop rapidly east of Japan. After considering the time allowed for observations before necessary evacuation, we made a plan to conduct U-CTD survey at a speed of 8 kt along a 50-km square centered by KEO as well as CTD casts to 1000 m at the four corners of the square to capture the mesoscale oceanic structure around KEO. We also planned to conduct a CTD cast to 2000 m and deploy the floats and glider when we returned to the first CTD station.

We arrived at the northwest station C001 at 17:30 on the 19th. The sea condition was a little rough. After a buoyancy test for the microstructure float and surface water sampling for radioactive caesium, we conducted a CTD cast to 1000 m from 18:30. Then, we performed 10 U-CTD casts at an interval of 2.5 nm in distance and 20 minutes in time while moving southward to C002 at 8 kt. The U-CTD conductivity sensor was performing poorly, showing erroneous values as we repeated the measurements. We reached the southwest station C002 at midnight on the 20th, and conducted a CTD cast. After that, we performed 2 XCTD casts at an interval of 3 nm until the battery of the alternative U-CTD probe was charged, and then restarted the U-CTD survey as we transited to C003.

We arrived at the southeast station C003 at 07:00 on the 20th, but had to wait to conduct the next CTD cast due to high waves. We abandoned the deployment (and recovery) of the microstructure float because it did not pass the pre-deployment test. After conducting a CTD cast at 13:00, we moved northward with U-CTD casts. We reached the northeast station C004 at 18:30, but had to wait again due to wave state. We started the CTD cast at 23:00 and subsequently made another shallow CTD cast (C04P) for primary production at the same location at 01:30 on the 21st.

We then moved westward with U-CTD casts and returned to C001 at 06:00, but had to abandon the CTD cast to 2000 m due to strong winds. As BGC floats cannot be deployed without a concurrent CTD cast for calibration, we also abandoned the deployment of the floats and glider. As the forecast said that the sea condition would become rough rapidly, we immediately started to evacuate to the Tokyo Bay, regretting that we should have deployed the floats at C004.

We entered Tokyo Bay on the morning of the 22nd, and anchored off Yokosuka. Since the forecast predicted a strong winter pressure pattern after the cyclone passed, and it seemed unlikely we would return to the sea for at least several days, we entered the JAMSTEC pier in the afternoon. It started snowing that evening, reaching more than 10 cm in Yokosuka (and more in Tokyo). The participants had a day off on 23rd and 24th (Some members visited Kamakura and bought an amazingly large number of handkerchiefs). On the 25th, the air temperature in Tokyo went down to -4°C, the lowest in 48 years. We left the JAMSTEC port on the 26th morning and anchored off Tateyama, located near the entrance of Tokyo Bay.

We left Tokyo Bay at 08:30 on the 27th. At this point in time, the wave height at KEO was still expected to exceed 5 m. Since it was forecasted that the waves would calm down, but then become high again on the 29th due to the passage of another cyclone with a front, it seemed unlikely that we would be able to get back to KEO. As a result, we decided to make observations and deploy the floats and glider when we reach 143E.

We arrived at 33-06N, 143-00E at 04:00 on the 28th, and waited for dawn. As waves were sometimes high and the forecast was not good, we examined the sea surface height map and shifted westward to 33-15N, 142-30E at 08:00. As the wave height decreased, we set this point to be station C005 and finally conducted a CTD cast to 2000 m at 09:30. Subsequently, we deployed 2 BGC floats, 1 EM float, and 1 glider. The glider was programmed to repeat CTD observations along a butterfly-shaped pattern centered around the floats. The BGC floats and glider will be recovered during the Shinsei-maru KS-18-4 cruise scheduled from April 20 through May 1, 2018.

After the float and glider deployment, we moved northward at a speed of 3 kt from 13:00 and conducted 15 U-VMP casts at a time interval of 15 minutes. We finished the observation at 17:00 and started going back to Yokosuka. One hour later the wind exceeded 15 m/s.

We entered the Tokyo Bay at 10:00 on the 29th, and started packing up the instruments. We anchored off Yokosuka at 11:30, took group photos at 13:00, and had a job-well-done party from 20:00. The Shinsei-maru entered the JAMSTEC pier at 09:00 on the 30th, and we unloaded the instruments from the ship.

In this cruise, the sea condition was always bad, as we never had waves lower than 2 m. Overall, we stayed on the sea for 4 nights, at the JAMSTEC pier for 4 nights, and on the sea again for 4 nights, during which the observations were made only for 1.5 days in the first period and for 0.5 days in the second period. Although we expected the sea condition to be bad during passage of the cyclone, the actual conditions exceeded our expectation, making us realize the severity of winter air-sea dynamics that result in large ocean carbon dioxide uptake. Despite such bad conditions, we endured various waiting periods and accomplished the minimum necessary observations. This is thanks to the effort of all scientists and technicians onboard, which I

thank from the bottom of my heart.

In this cruise, we were supported by many people. As usual, we were supported by the captain and crew of Shinsei-maru, Center for Cruise Coordination, Field Research Support Section, International Affairs and Research Promotion Team of the Atmosphere and Ocean Research Institute (AORI), Univ. of Tokyo and Department of Ship Operation of JAMSTEC. We were also supported by the two technicians onboard, Shungo Oshitani and Haruka Tamada, for the CTD observations and the dissolved oxygen measurements, respectively. In addition, we were helped by Shinzo Fujio, Daigo Yanagimoto, and Naoto Takahata at AORI and Yuichiro Kumamoto at JAMSTEC for the dissolved oxygen measurements, Akihiko Murata and Kosei Sasaoka at JAMSTEC for the chlorophyll, nutrient, pH, and DIC measurements, Zhaohui Aleck Wang at Woods Hole Oceanographic Institution for the DIC measurements, Yoshihisa Mino at Nagoya Univ. for the suspended particle measurements, Yoshimi Kawai at JAMSTEC for the meteorological observations, Mizue Hirano and Tetsuichi Fujiki at JAMSTEC, John Dunlap at Univ. of Washington, Tetsuharu Iino at Marine Works Japan Ltd. for the float observation, Takeshi Okunishi and Daisuke Hasegawa at Tohoku National Fisheries Research Institute, and Shu Ebihara at Nippon Kaiyo Co., Ltd. for the glider observations, Kenneth Johnson, Luke Coletti, Carole Sakamoto, Hans Jannasch, Peter Walz, Hans Thomas, and Larry Hawkins at MBARI for the pH and nitrate sensor preparation and outbound shipment handling, and the Research Support Department and International Affairs Division of JAMSTEC for the export procedure of the glider. We also acknowledge various financial support from "Ocean Mixing Processes" (Grant-in-Aid for Scientific Research in Innovative Areas of MEXT; PI: Prof. Ichiro Yasuda at AORI, Univ. of Tokyo). Our cruise would not have been successful without this support, and I would like to thank all people involved.

[On the data obtained in this cruise]

To prevent scatter of the data, we plan to archive raw and corrected data at Department of Physical Oceanography, Atmosphere and Ocean Research Institute, the University of Tokyo and release them to the public in about 2 years through Japan Oceanographic Data Center, so I would appreciate your cooperation. The data obtained in the cruise of Shinsei-maru officially belong to AORI and JAMSTEC, but at the same time should be shared by scientists participating the cruise and can be used freely for your personal use. If, however, you use the data in the printed matters or official presentations before their release, please consult with the PI of each observation.

2. 乗船研究者名簿(Participants List)

所 属 機 関
所 属 機 関 住 所

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* cancelled embarkation due to flu

3. 作業分担表 (Assignments List)

Working Groups

Watch	
03-15	〇Inoue Oka Iskandar Aoyama
15-03	〇Nagai Yamaguchi Rosales Wada
Chemistry	Fassbender Takeshita Tamada
Biology	Sukigara
CTD	Oshitani

PIs of observations and instruments

CTD and Water Sampling		
	CTD sensor	Oshitani
	Niskin bottles	Oshitani
	DO titration	Oka
	Salinity determination	Oka
	Nutrients	Inoue
	Dissolved Inorganic Carbon	Fassbender, Takeshita
	Chlorophyll	Sukigara
	Suspended particle	Sukigara
	Data calibration	Oka
UCTD		Nagai
UVMP		Nagai
XCTD		Oka
Nitrate and pH (with CTD)		Fassbender, Takeshita
Nitrate and pH (intake)		Fassbender, Takeshita
Profiling float		Inoue, Nagai
Glider		Inoue
Radiometer		Inoue, Kawai
Shipboard ADCP		Oka
BATHY report		Oshitani
Cruise report		Oka

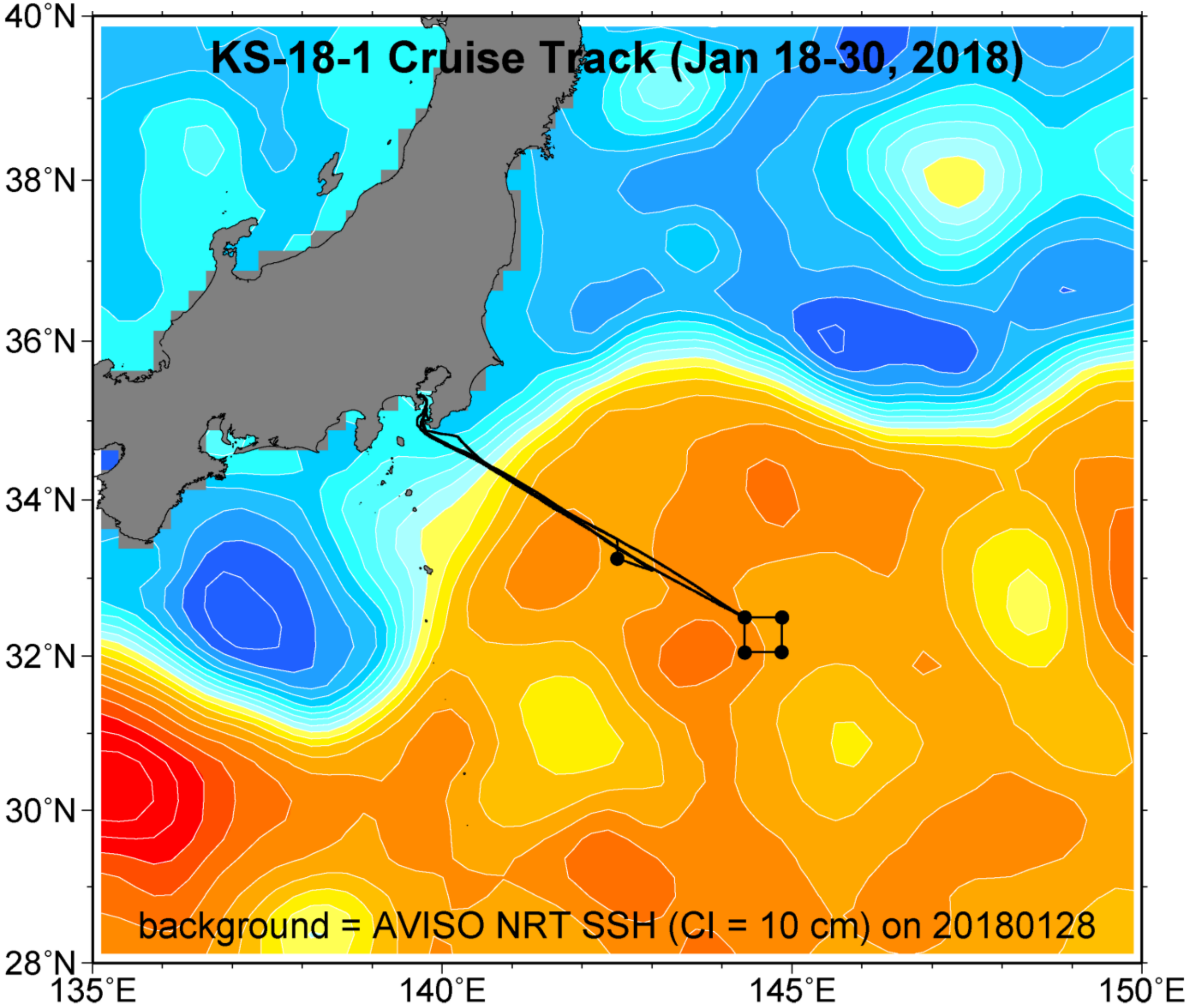
4. 測点一覧表 (Station List)

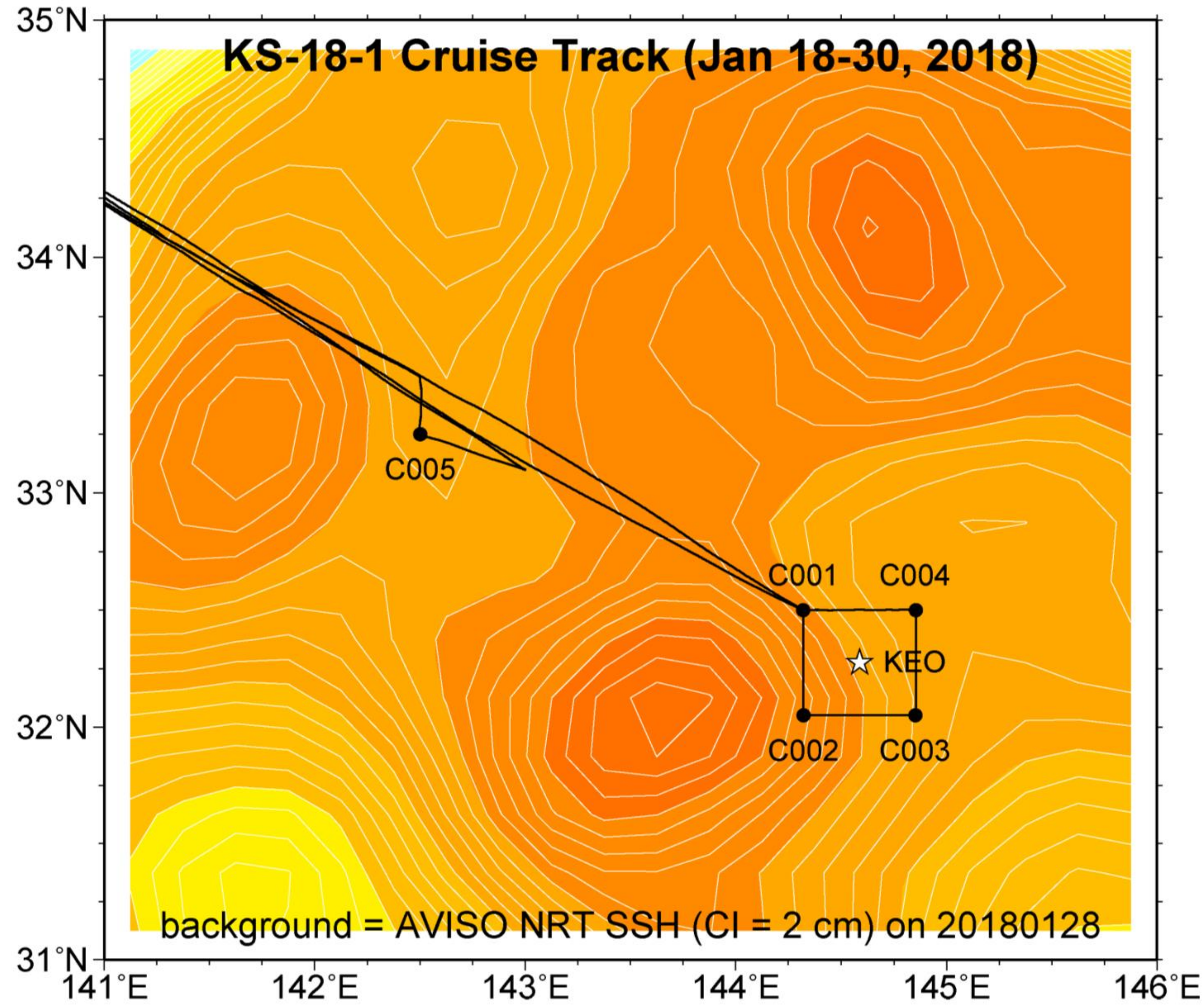
STN: Station number
TYPE: ROS=CTD plus water sampler, UCTD=underway CTD, UVMP=underway VMP, XCTD=XCTD, FLOAT=float, GLDR=glider
CODE: BE=Beginning of cast, EN=End of cast, BO=Bottom, DE=Deployment of UCTD, UVMP, XCTD, float, glider
DEPTH: Water depth in meters
MAXPR: Maximum pressures in decibars
PARAM: Sampling parameters
1=Salinity, 2-5=Nutrients (PO_4, SiO_2, NO_2+NO_3, NO_2), 6=Dissolved Oxygen, 7=Dissolved Inorganic Carbon, 8=pH, 9=Chlorophyll a, 10==Suspended Particle
COMMENTS are included in the columns of MAXPR/PARAM

KS-18-1

STN	TYPE	DATE	GMT	CODE	LATITUDE	LONGITUDE	DEPTH	MAXPR	PARAM/*COMMENT*
C001	ROS	011918	0941	BE	32°30.05′N	144°19.15′E	5623		ISUS
C001	ROS	011918	1002	BO	32°30.09′N	144°19.08′E	5626	1000	1-9 *SBE9p1132 CTDO*
C001	ROS	011918	1044	EN	32°30.09′N	144°19.06′E	5626		Deep Sea Derafet
U001	UCTD	011918	1154	DE	32°29.95′N	144°19.30′E	5615	484	*UCTD 0245*
U002	UCTD	011918	1216	DE	32°27.25′N	144°19.30′E	5714	483	*UCTD 0245*
U003	UCTD	011918	1237	DE	32°24.58′N	144°19.31′E	5742	482	*UCTD 0245*
U004	UCTD	011918	1256	DE	32°22.16′N	144°19.31′E	5738	481	*UCTD 0245*
U005	UCTD	011918	1315	DE	32°19.64′N	144°19.30′E	5754	487	*UCTD 0245*
U006	UCTD	011918	1335	DE	32°16.99′N	144°19.30′E	5781	493	*UCTD 0245*
U007	UCTD	011918	1354	DE	32°14.44′N	144°19.29′E	5833	489	*UCTD 0245*
U008	UCTD	011918	1413	DE	32°11.78′N	144°19.30′E	5907	477	*UCTD 0245*
U009	UCTD	011918	1433	DE	32°08.94′N	144°19.30′E	5599	472	*UCTD 0245*
U010	UCTD	011918	1451	DE	32°06.34′N	144°19.30′E	5456	485	*UCTD 0245*
C002	ROS	011918	1543	BE	32°03.03′N	144°19.30′E	5512		ISUS
C002	ROS	011918	1637	BO	32°02.98′N	144°19.38′E	5501	1000	2-9 *SBE9p1132 CTDO*
C002	ROS	011918	1728	EN	32°02.98′N	144°19.40′E	5501		Deep Sea Derafet
X001	XCTD	011918	1824	DE	32°03.11′N	144°22.88′E	5840		*TSK XCTD-1 16027430*
X002	XCTD	011918	1849	DE	32°03.09′N	144°26.33′E	5794		*TSK XCTD-1 16027431*
U011	UCTD	011918	1907	DE	32°03.10′N	144°28.74′E	5771	488	*UCTD 0281*
U012	UCTD	011918	1927	DE	32°03.09′N	144°31.55′E	5742	512	*UCTD 0281*
U013	UCTD	011918	1946	DE	32°03.09′N	144°34.18′E	5719	498	*UCTD 0281*
U014	UCTD	011918	2007	DE	32°03.09′N	144°37.13′E	5674	506	*UCTD 0281*
U015	UCTD	011918	2027	DE	32°03.11′N	144°39.87′E	5652	501	*UCTD 0281*
U016	UCTD	011918	2046	DE	32°03.09′N	144°42.55′E	5060	508	*UCTD 0281*
U017	UCTD	011918	2105	DE	32°03.10′N	144°45.22′E	5566	498	*UCTD 0281*
U018	UCTD	011918	2124	DE	32°03.10′N	144°47.80′E	5408	514	*UCTD 0281*
C003	ROS	012018	0350	BE	32°03.06′N	144°51.08′E	5927		ISUS
C003	ROS	012018	0414	BO	32°03.15′N	144°50.79′E	5916	1000	1-9 *SBE9p1132 CTDO*
C003	ROS	012018	0459	EN	32°03.15′N	144°50.79′E	5915		Deep Sea Derafet
U019	UCTD	012018	0542	DE	32°04.03′N	144°51.30′E	6014	503	*UCTD 0281*
U020	UCTD	012018	0600	DE	32°06.03′N	144°51.28′E	6008	499	*UCTD 0281*
U021	UCTD	012018	0619	DE	32°08.17′N	144°51.29′E	5916	500	*UCTD 0281*
U022	UCTD	012018	0637	DE	32°10.24′N	144°51.30′E	5867	513	*UCTD 0281*
U023	UCTD	012018	0654	DE	32°12.23′N	144°51.31′E	5866	498	*UCTD 0281*
U024	UCTD	012018	0712	DE	32°14.35′N	144°51.30′E	5848	488	*UCTD 0281*
U025	UCTD	012018	0731	DE	32°16.58′N	144°51.30′E	5867	506	*UCTD 0281*
U026	UCTD	012018	0749	DE	32°18.66′N	144°51.30′E	5880	514	*UCTD 0281*
U027	UCTD	012018	0807	DE	32°20.81′N	144°51.32′E	5927	500	*UCTD 0281*
U028	UCTD	012018	0826	DE	32°23.21′N	144°51.30′E	5900	510	*UCTD 0281*
U029	UCTD	012018	0845	DE	32°25.53′N	144°51.31′E	5776	495	*UCTD 0281*
U030	UCTD	012018	0903	DE	32°27.66′N	144°51.31′E	5630	513	*UCTD 0281*
C004	ROS	012018	1408	BE	32°30.09′N	144°51.28′E	5601		ISUS
C004	ROS	012018	1427	BO	32°30.10′N	144°51.30′E	5601	1000	2-9 *SBE9p1132 CTDO*
C004	ROS	012018	1506	EN	32°30.11′N	144°51.30′E	5601		Deep Sea Derafet
C04P	ROS	012018	1635	BE	32°30.09′N	144°51.31′E	5602		
C04P	ROS	012018	1641	BO	32°30.07′N	144°51.31′E	5601	100	6 *SBE9p1132 CTDO*
C04P	ROS	012018	1650	EN	32°30.02′N	144°51.33′E	5599		Deep Sea Derafet
U031	UCTD	012018	1724	DE	32°30.10′N	144°49.81′E	5661	501	*UCTD 0281*
U032	UCTD	012018	1743	DE	32°30.13′N	144°47.04′E	5791	509	*UCTD 0281*
U033	UCTD	012018	1804	DE	32°30.12′N	144°44.08′E	5831	519	*UCTD 0281*
U034	UCTD	012018	1823	DE	32°30.08′N	144°41.48′E	5867	525	*UCTD 0281*
U035	UCTD	012018	1843	DE	32°30.08′N	144°38.95′E	5838	525	*UCTD 0281*
U036	UCTD	012018	1902	DE	32°30.11′N	144°36.39′E	5696	519	*UCTD 0281*
U037	UCTD	012018	1925	DE	32°30.10′N	144°33.32′E	5589	510	*UCTD 0281*
U038	UCTD	012018	1944	DE	32°30.05′N	144°30.76′E	5634	528	*UCTD 0281*
U039	UCTD	012018	2003	DE	32°30.01′N	144°27.99′E	5671	514	*UCTD 0281*
U040	UCTD	012018	2025	DE	32°30.06′N	144°24.83′E	5656	522	*UCTD 0281*
U041	UCTD	012018	2047	DE	32°30.10′N	144°21.92′E	5681	526	*UCTD 0281*
C005	ROS	012818	0042	BE	33°14.98′N	142°30.01′E	6718		ISUS
C005	ROS	012818	0121	BO	33°14.98′N	142°30.01′E	6602	2000	1-10 *SBE9p1132 CTDO*
C005	ROS	012818	0218	EN	33°14.98′N	142°30.01′E	6605		Deep Sea Derafet
F001	FLOAT	012818	0241	DE	33°15.06′N	142°30.00′E	6589		*BGCi Navis F0883*
F002	FLOAT	012818	0245	DE	33°15.11′N	142°30.00′E	6585		*BGCi Navis F0884*
F003	FLOAT	012818	0251	DE	33°15.20′N	142°29.99′E	6592		*EM-Apex 7823*
G001	GLDR	012818	0317	DE	33°15.49′N	142°29.90′E	6611		*Seaglider SG551*
V001	UVMP	012818	0353	DE	33°16.91′N	142°29.95′E	6463	230	*UMVP 212*
V002	UVMP	012818	0409	DE	33°17.74′N	142°30.00′E	6479	224	*UMVP 212*
V003	UVMP	012818	0425	DE	33°18.63′N	142°30.12′E	6513	223	*UMVP 212*
V004	UVMP	012818	0441	DE	33°19.51′N	142°30.25′E	6618	228	*UMVP 212*
V005	UVMP	012818	0456	DE	33°20.30′N	142°30.29′E	6911	225	*UMVP 212*
V006	UVMP	012818	0511	DE	33°21.11′N	142°30.32′E	6928	227	*UMVP 212*
V007	UVMP	012818	0528	DE	33°22.05′N	142°30.35′E	6954	220	*UMVP 212*
V008	UVMP	012818	0543	DE	33°22.91′N	142°30.38′E	6912	218	*UMVP 212*
V009	UVMP	012818	0559	DE	33°23.82′N	142°30.42′E	6950	229	*UMVP 212*
V010	UVMP	012818	0615	DE	33°24.70′N	142°30.40′E	6950	220	*UMVP 212*
V011	UVMP	012818	0633	DE	33°25.66′N	142°30.44′E	6937	232	*UMVP 212*
V012	UVMP	012818	0649	DE	33°26.47′N	142°30.38′E	6929	237	*UMVP 212*
V013	UVMP	012818	0704	DE	33°27.21′N	142°30.30′E	6868	230	*UMVP 212*
V014	UVMP	012818	0719	DE	33°27.92′N	142°30.15′E	6794	225	*UMVP 212*
V015	UVMP	012818	0735	DE	33°28.72′N	142°30.04′E	6703	225	*UMVP 212*

５．測点図（Station Map）



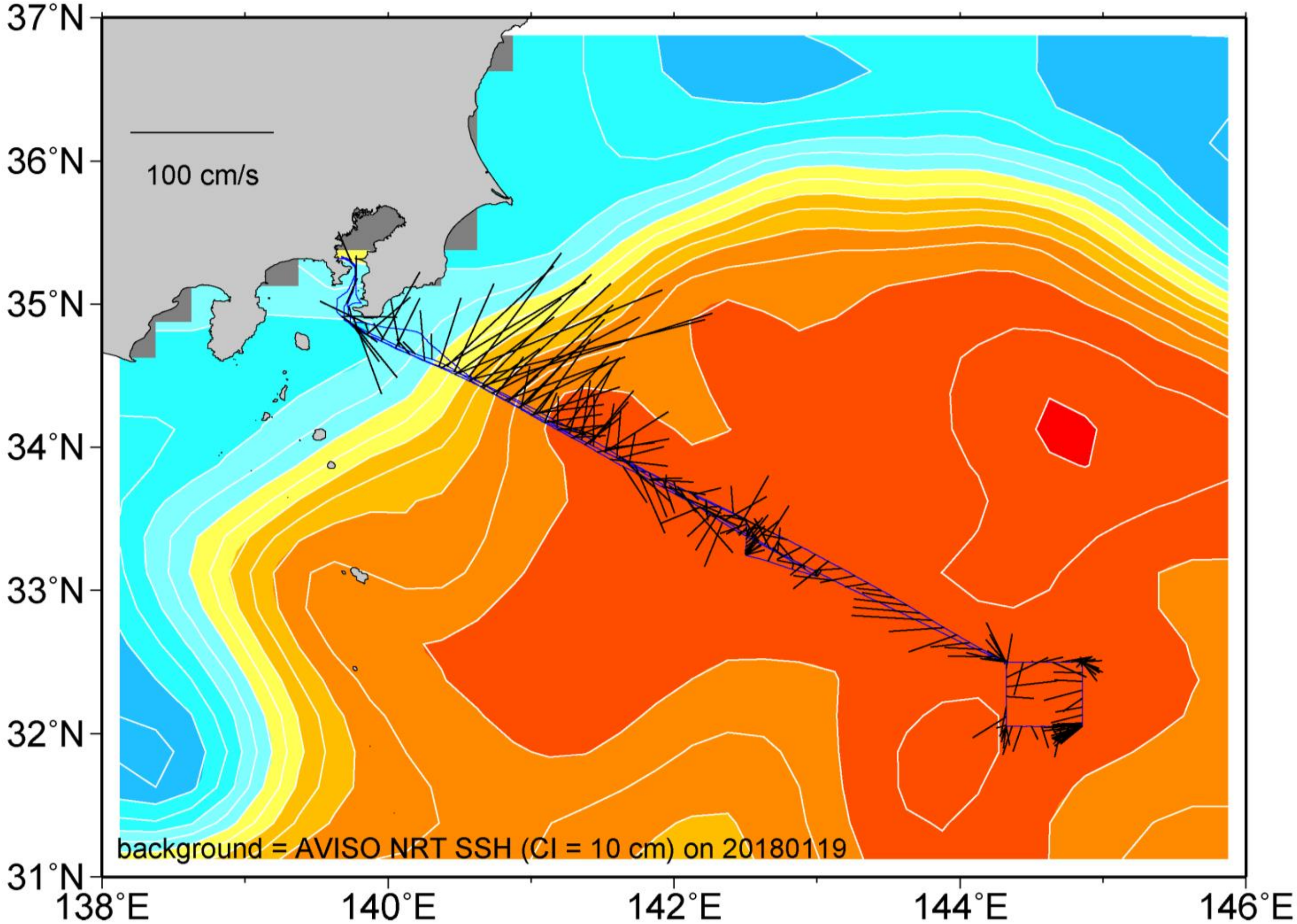

KS-18-1 Cruise Track (Jan 18-30, 2018)
35°N
34°N
33°N
32°N
31°N
141°E
142°E
143°E
144°E
145°E
146°E
C005
C001
C004
KEO
C002
C003
background = AVISO NRT SSH (CI = 2 cm) on 20180128

6．観測日程表（Timetable）

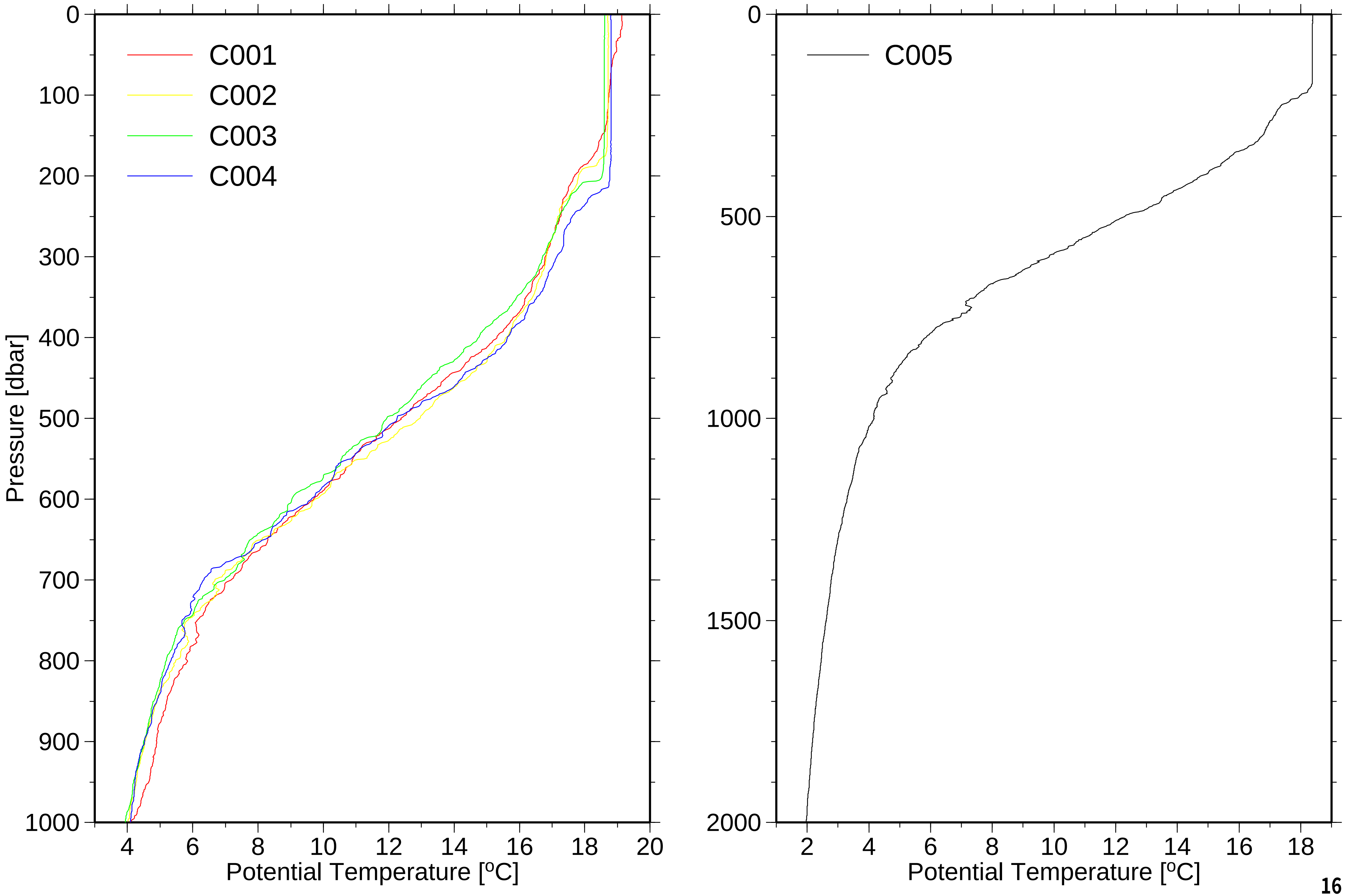
	Date	TIME (JST) 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
1	01/18	↑~~~~~~~~~~~~~~~~~~ Yokosuka
2	01/19	~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~ | C001 | ~~↑↑↑↑↑↑↑↑↑↑ U001 U010
3	01/20	~ | C002 | ~↑↑↑↑↑↑↑↑↑↑↑↑~~~~~~~~~~~~ X001 U018 | C003 | ~↑↑↑↑↑↑↑↑↑↑↑↑~~~~~~~~~ U019 U030 | C004 C04P
4	01/21	C004 C04P | ~↑↑↑↑↑↑↑↑↑↑↑↑~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~ U031 U041
5	01/22	~~~~~~~~~~~~~~~~~~~~~~~~~~~~ | Yokosuka Port
6	01/23	Yokosuka Port
7	01/24	Yokosuka Port
8	01/25	Yokosuka Port
9	01/26	Yokosuka Port | ~~~~~~~~~~~~~~~~~~~~
10	01/27	~~~~~~
11	01/28	~~~~~~~~~~~~~~~~~~ | C005 | ↑↑↑↑~↑↑↑↑↑↑↑↑↑↑↑↑↑↑↑↑↑~~~~~~~~~~~~~~ G001 V005 V015
12	01/29	~~~~~~
13	01/30	~~~~~~~~~~~~~~~~~~↑ Yokosuka

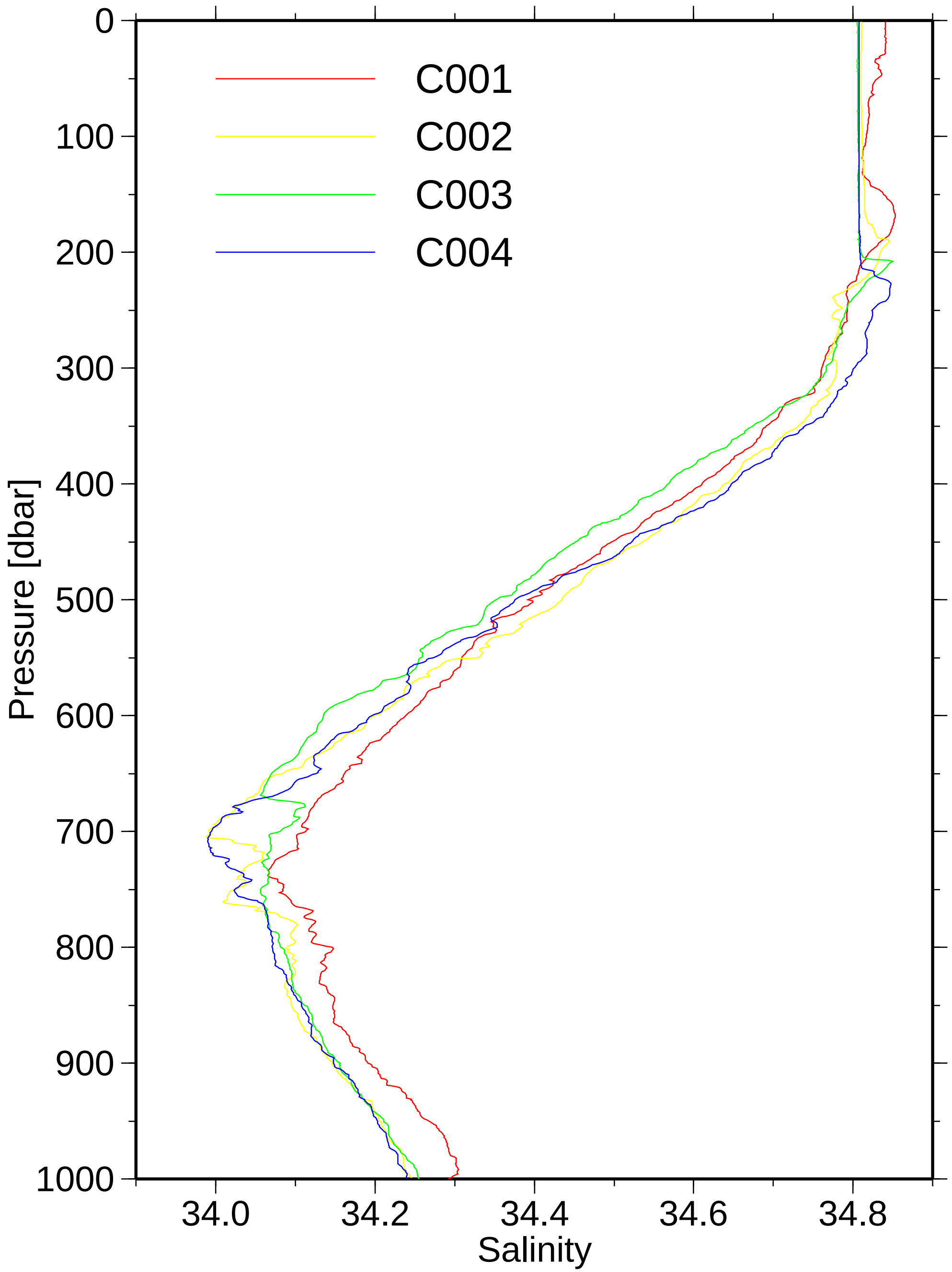
7．ADCP 流速図（ADCP velocity Map）

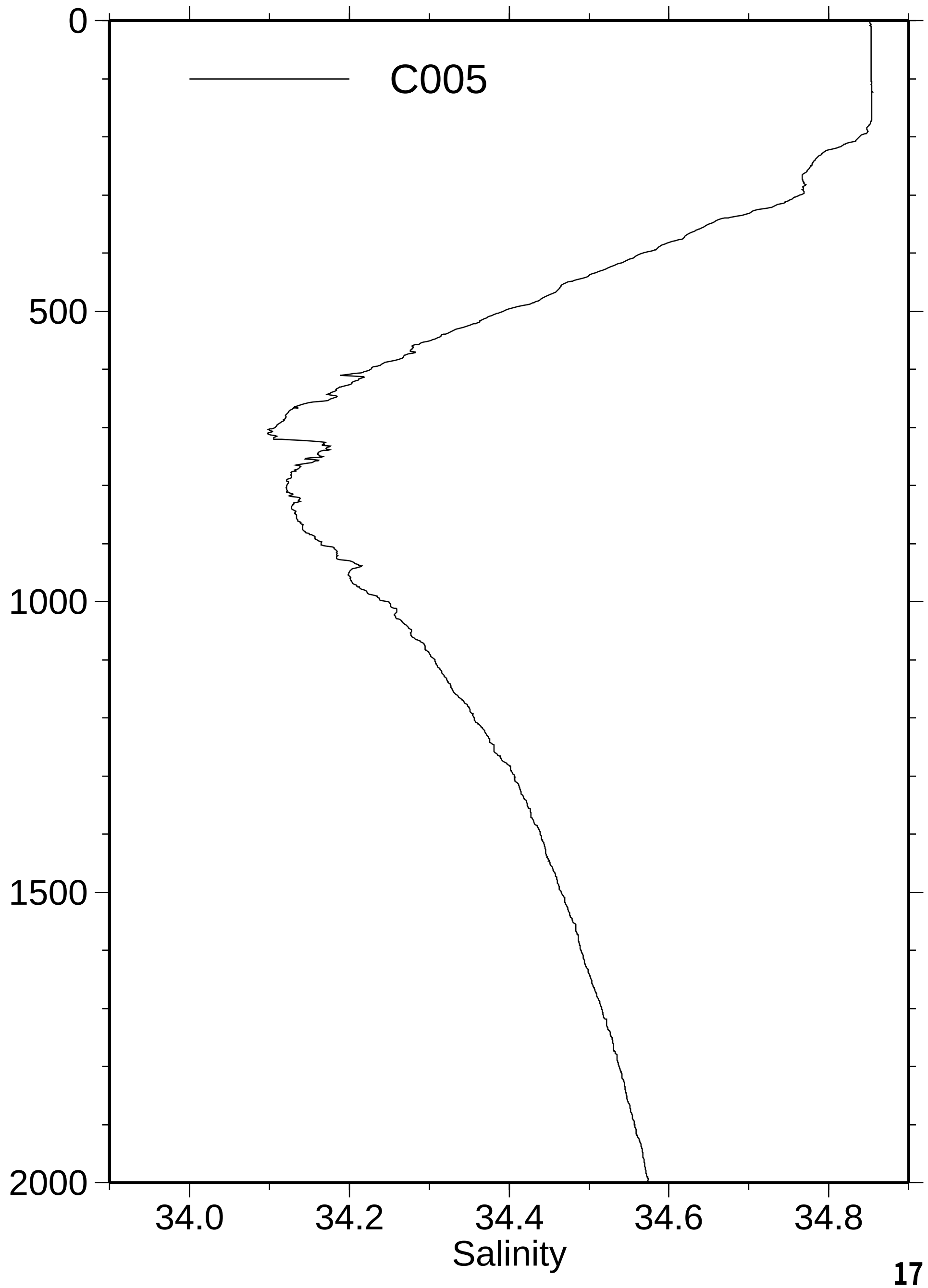
RDI　50m depth

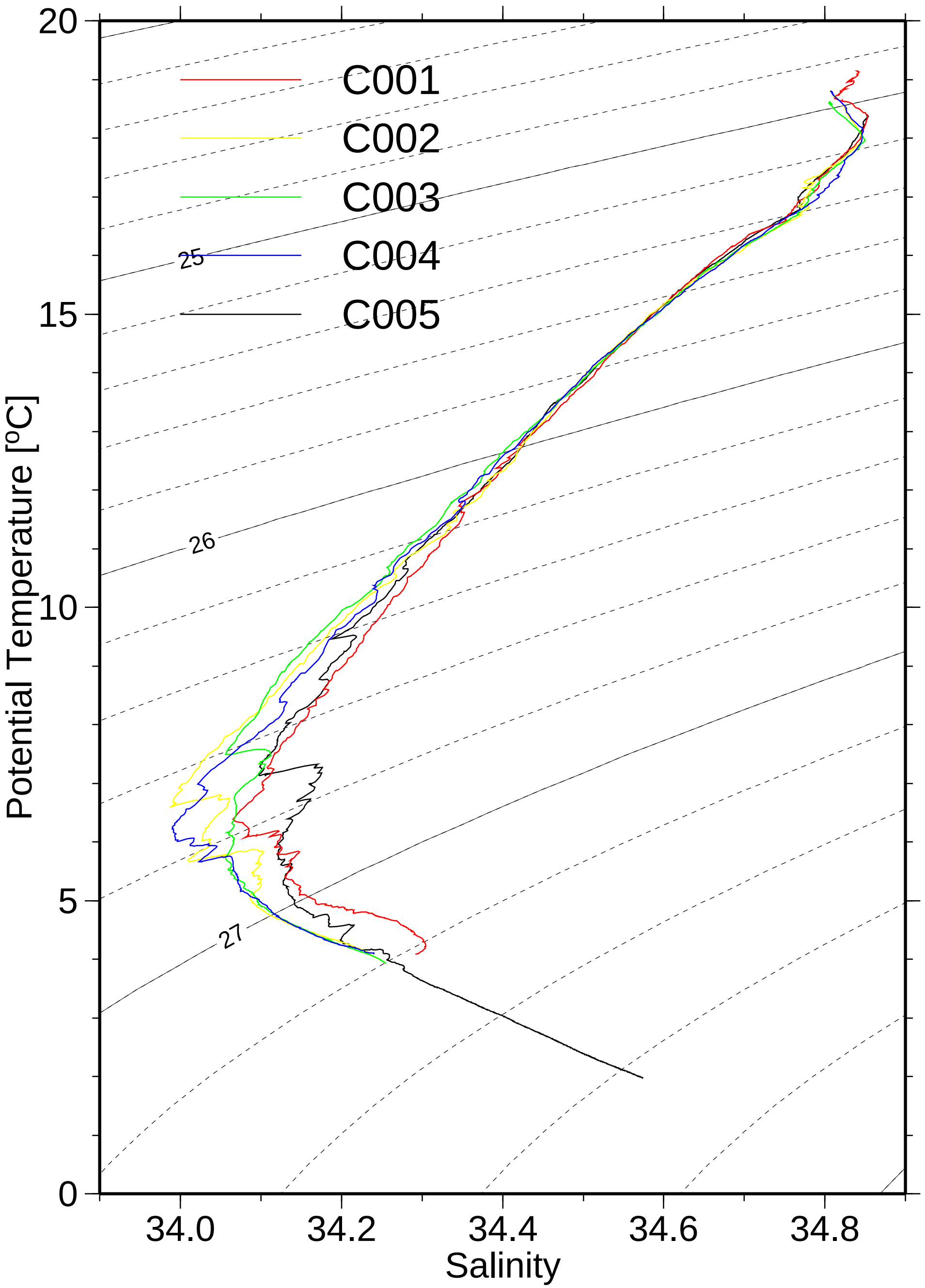


8. CTDO2観測 (CTDO2 Observation)

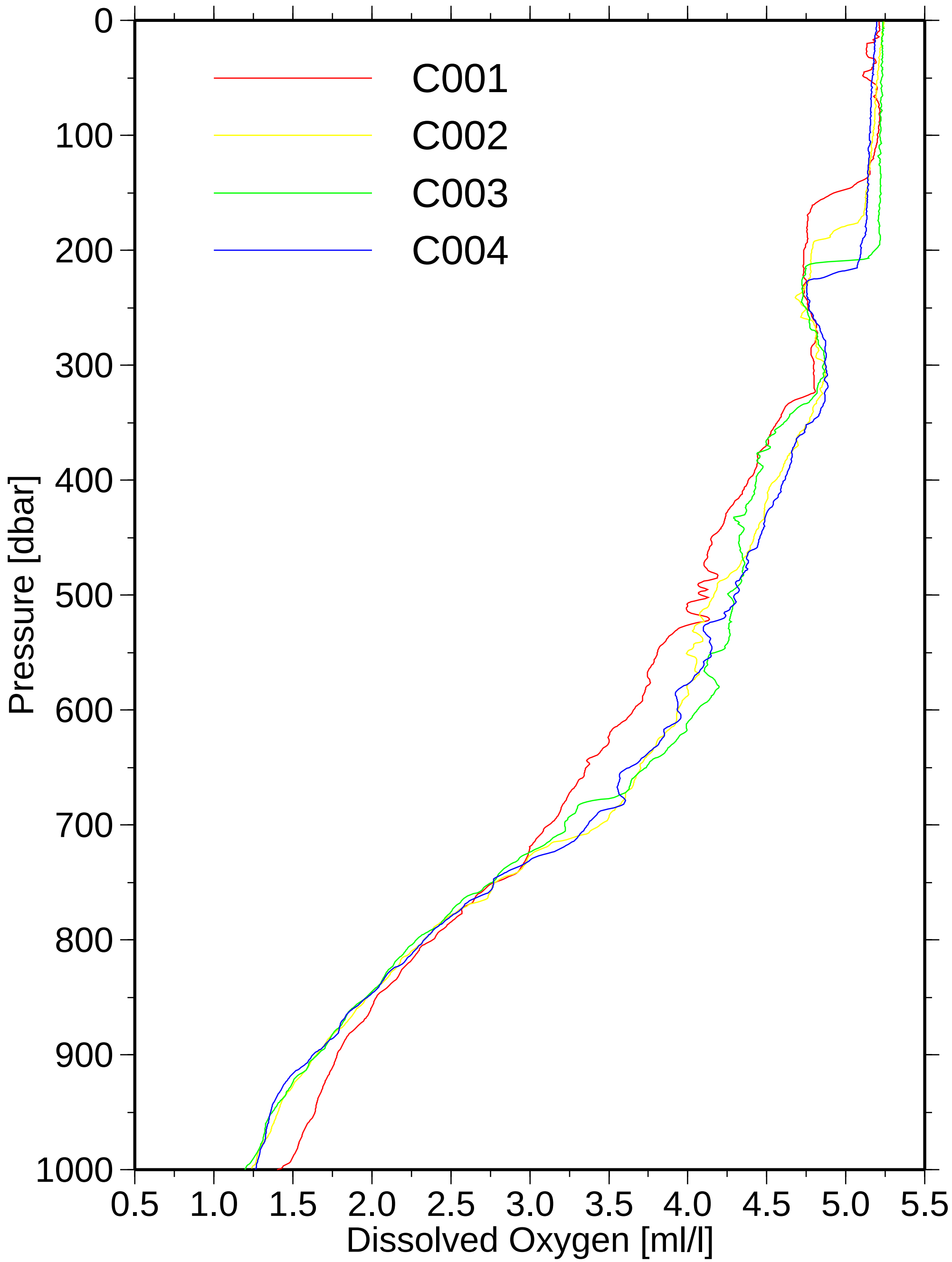


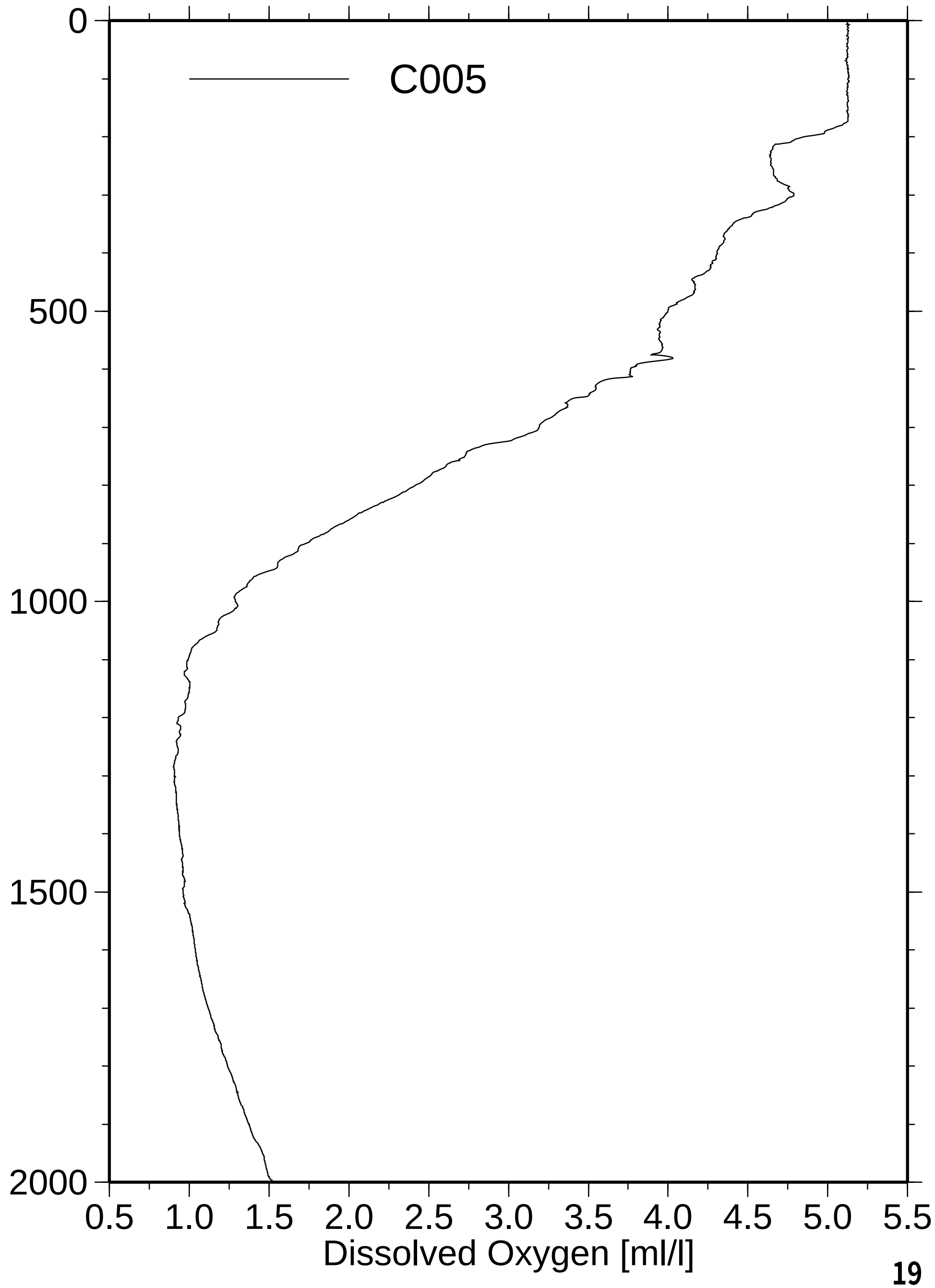

C001
C002
C003
C004
Pressure [dbar]
0
100
200
300
400
500
600
700
800
900
1000
34.0
34.2
34.4
34.6
34.8
Salinity

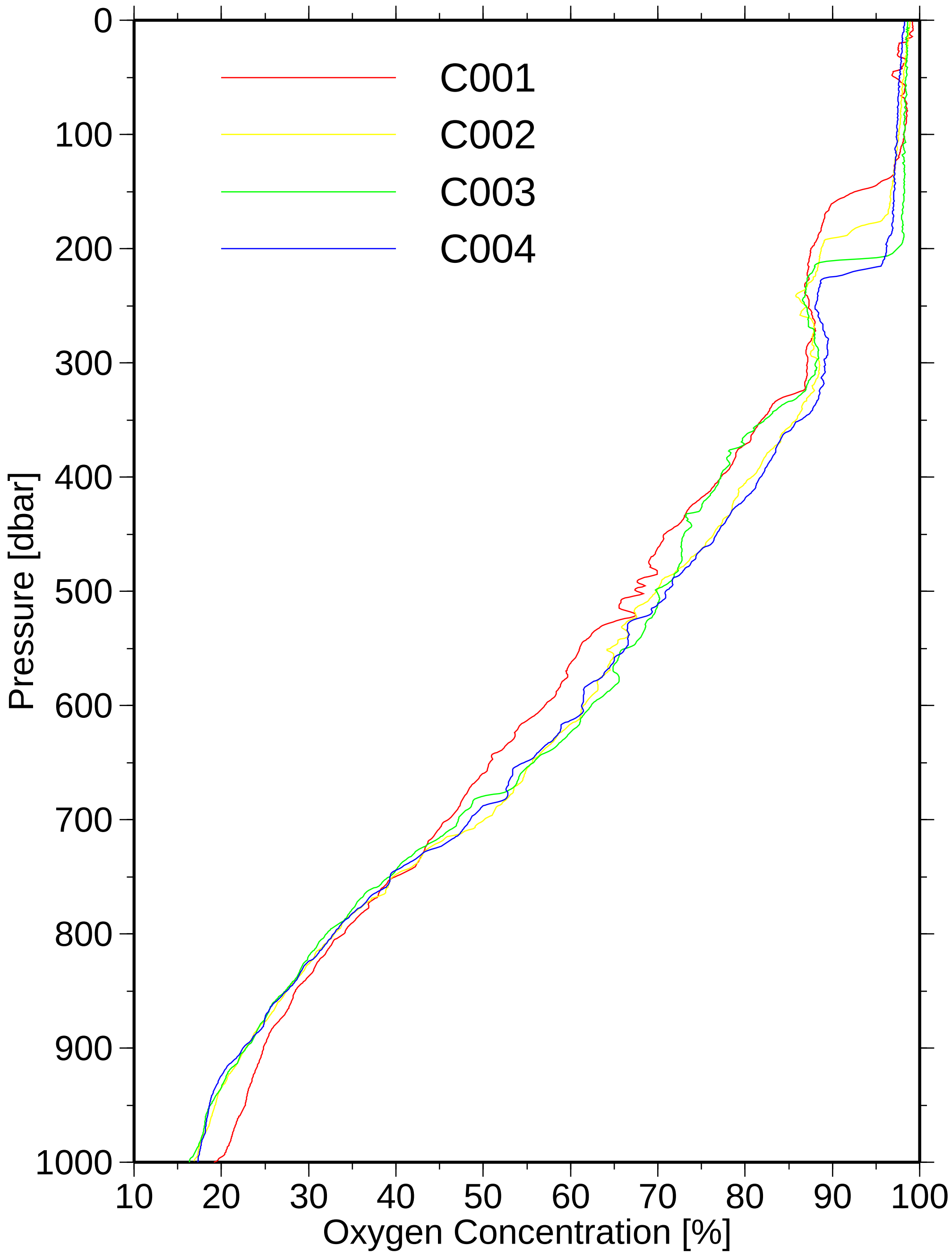

C005
0
500
1000
1500
2000
34.0
34.2
34.4
34.6
34.8
Salinity



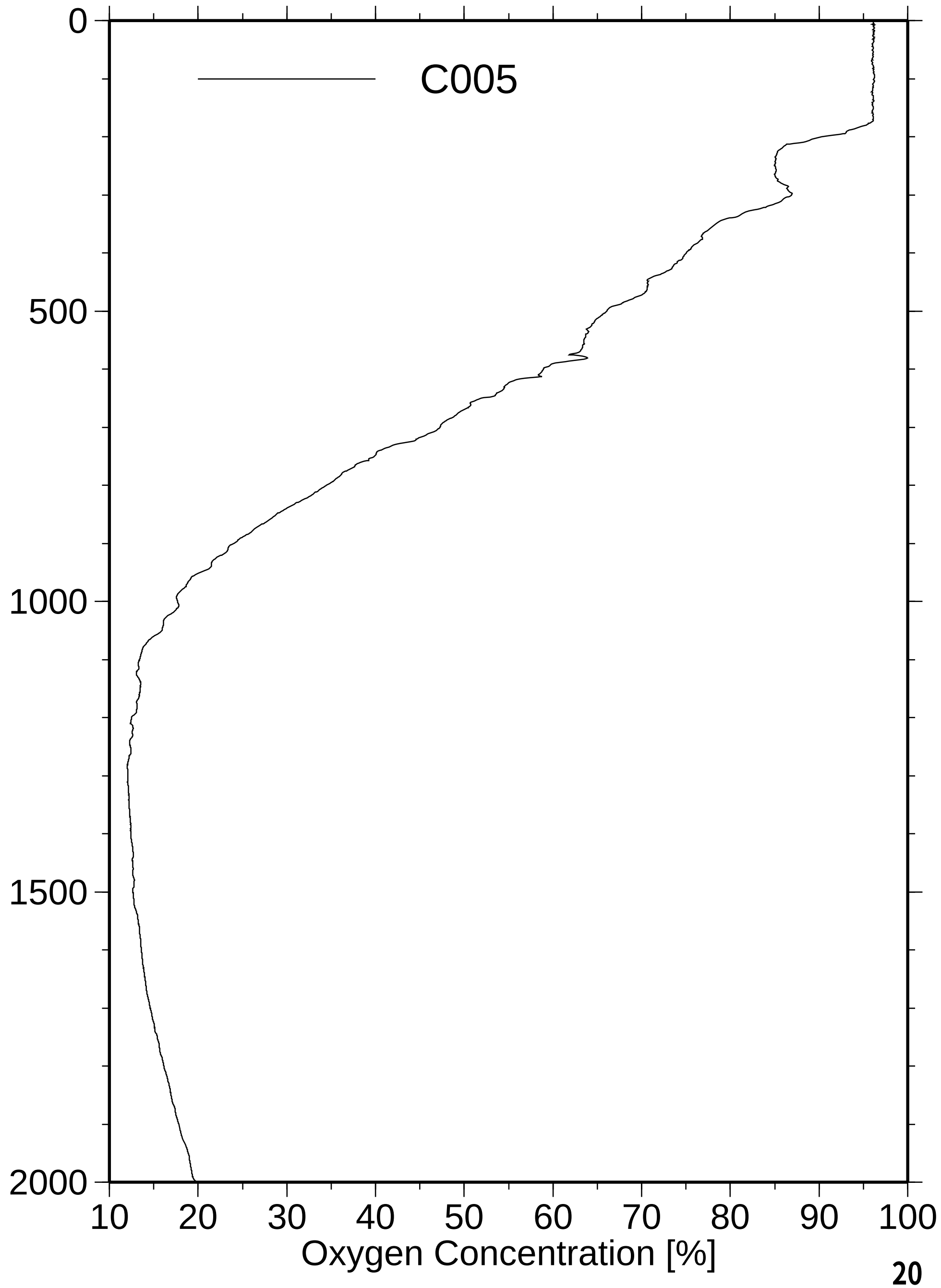
C001
C002
C003
C004
C005
25
26
27
Potential Temperature [ºC]
Salinity
20
15
10
5
0
34.0
34.2
34.4
34.6
34.8


C001
C002
C003
C004
Pressure [dbar]
Dissolved Oxygen [ml/l]
0
100
200
300
400
500
600
700
800
900
1000
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
5.5

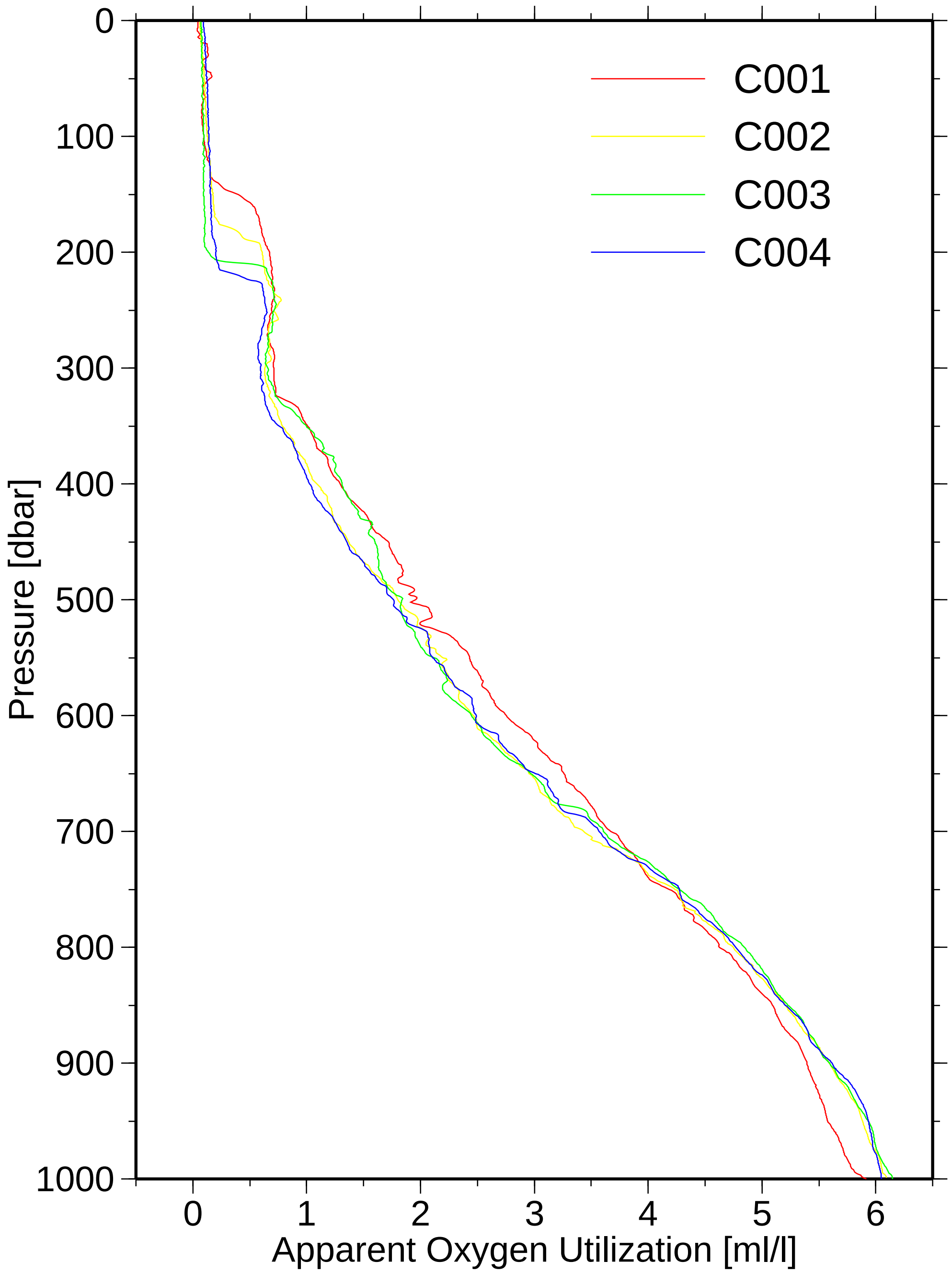

C005
Dissolved Oxygen [ml/l]
0
500
1000
1500
2000
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
5.5

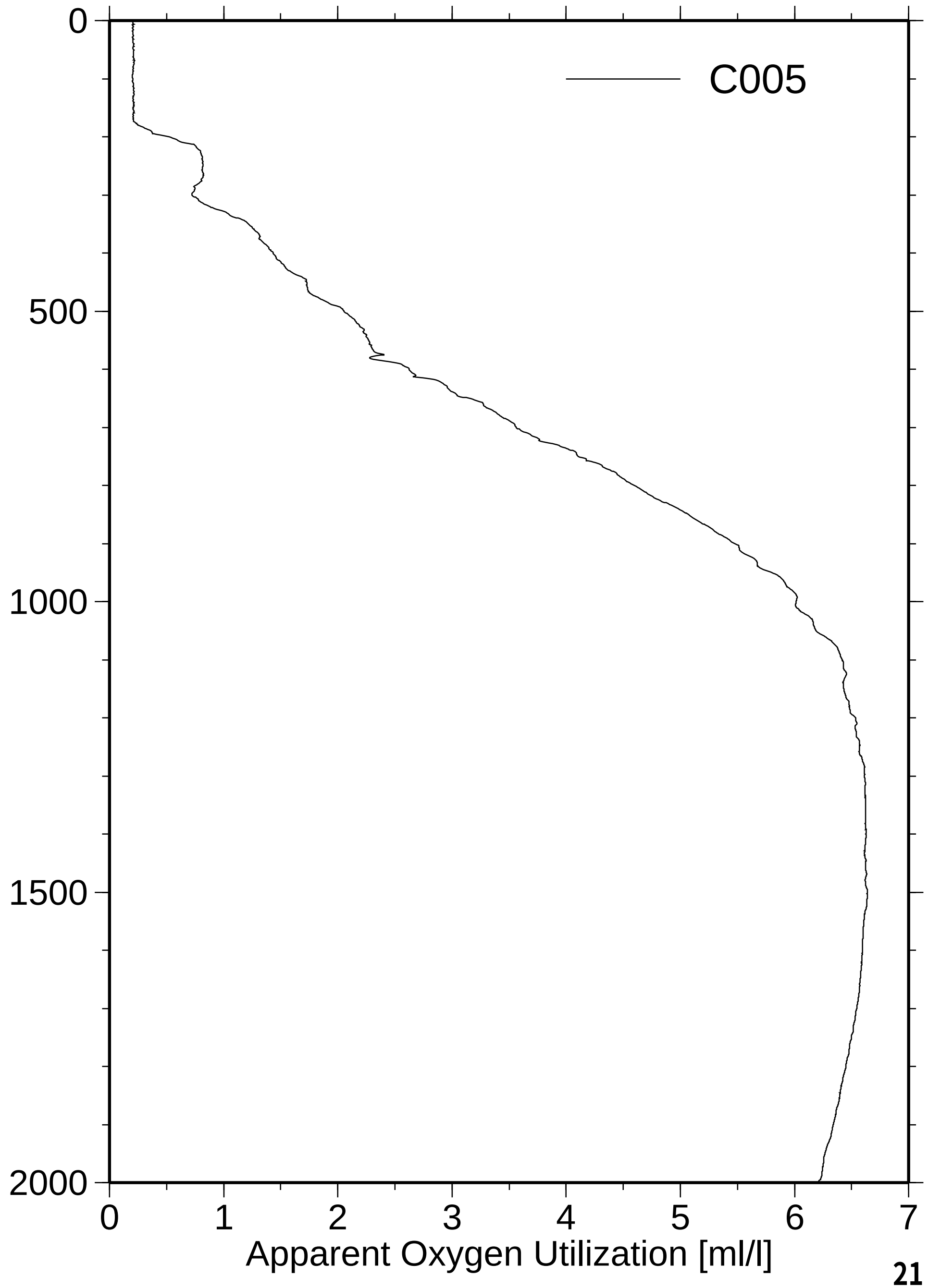


C001
C002
C003
C004
Pressure [dbar]
0
100
200
300
400
500
600
700
800
900
1000
10
20
30
40
50
60
70
80
90
100
Oxygen Concentration [%]



C005
0
500
1000
1500
2000
10
20
30
40
50
60
70
80
90
100
Oxygen Concentration [%]


C001
C002
C003
C004
Pressure [dbar]
0
100
200
300
400
500
600
700
800
900
1000
0
1
2
3
4
5
6
Apparent Oxygen Utilization [ml/l]


C005
0
500
1000
1500
2000
0
1
2
3
4
5
6
7
Apparent Oxygen Utilization [ml/l]

09. UCTD&XCTD Observation

Takeyoshi Nagai
(Tokyo University of Marine Science and Technology)

Underway-CTD (UCTD) observations were conducted along the observation line of square shape (Figure 1). The tow-yo UCTD observations were started from northwestern edge of the square southward (Leg A: U01-U10) first. However, after the westernmost transect observations, we have realized that the UCTD conductivity sensor on the probe (245) not working properly. We had to replace the sensor with the new sensor probe (281). While we were changing the probe, two expendable conductivity temperature depth (XCTD) sensors were deployed along the southernmost transect line (Leg B: X01-X02) from west to east. After two casts of XCTD, we restarted the UCTD observations from U11 to U18 in the same line (Leg B: U11-U18), which is followed by the easternmost transect measured northward from U19-U30 (Leg C), and the northernmost transect sampled from east to west from U31-U42 (Leg D).

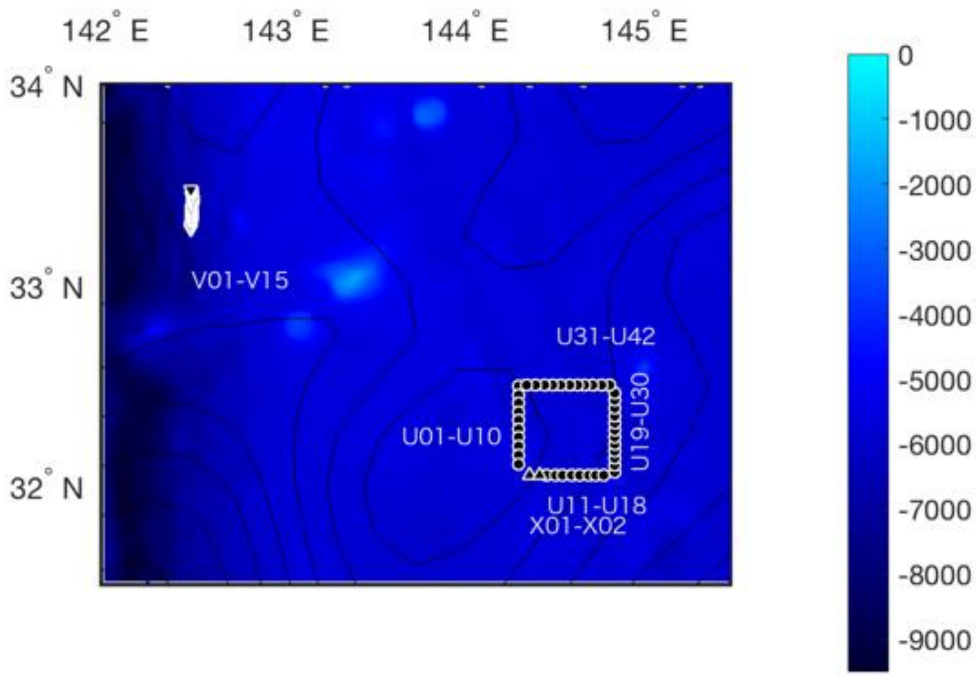


Figure 1 Observation stations for (●) Underway-CTD, (▲) XCTD, and (▼) Underway-VMP. Text on the map indicates stations for each leg.

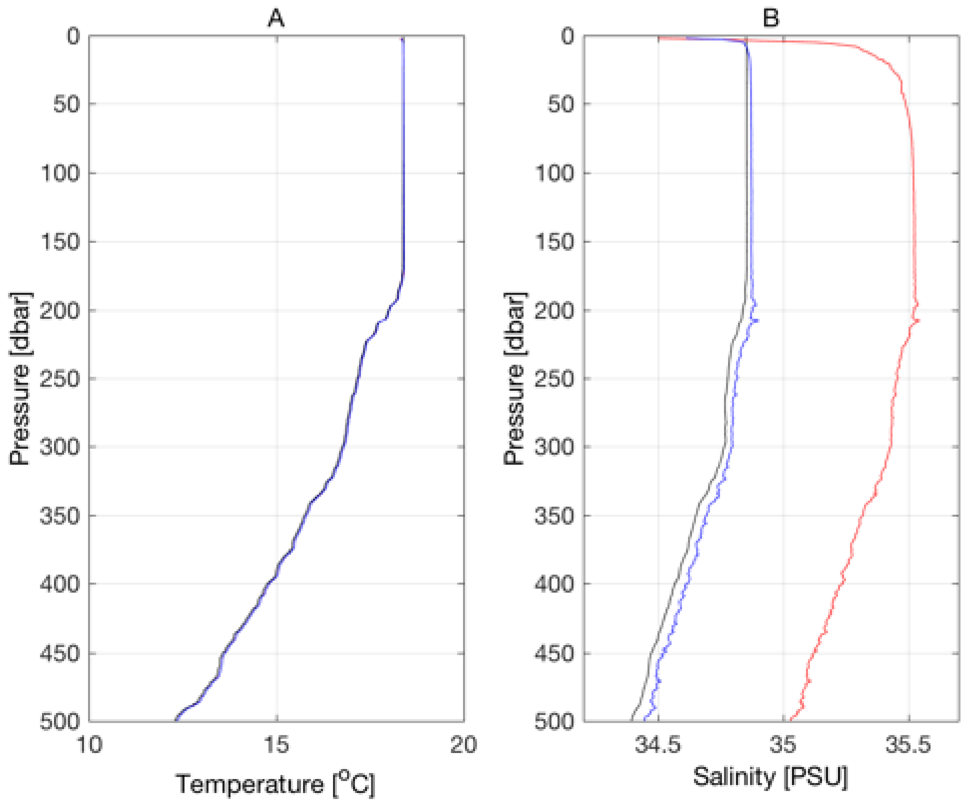


Figure 2 Comparison between Underway-CTD data, which was attached on the CTD-frame, and the data obtained with the standard SBE CTD cast at Stn. C005, Jan. 28, 2018 for (A) temperature, and (B) salinity with (black) CTD, (red) UCTD sensor 245, and (blue) UCTD sensor 281. Both UCTD temperature data agree with the calibrated CTD temperature data. However, salinity of UCTD especially for sensor 281 show a substantial offset. The UCTD sensor 245 was used in the Leg A for U01-U10. Accordingly, the salinity data for entire Leg A shown in Figure 4B are not reliable. The UCTD sensor 281 was used for rest of the UCTD observations.

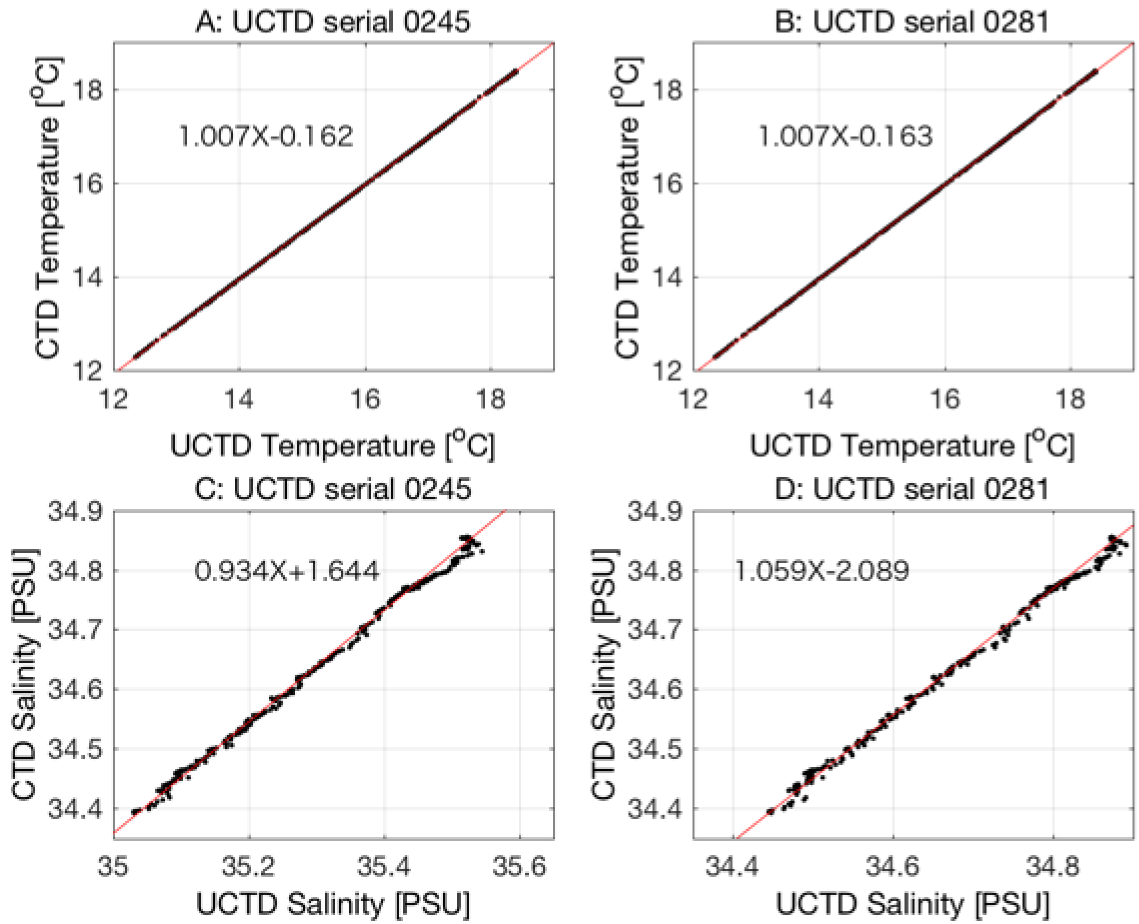


Figure 3 Scatter plot of Underway-CTD data, which was attached on the CTD-frame, and the data obtained with the standard SBE CTD cast at Stn. C005, Jan. 28, 2018 using the data between 80-500 m depth for (A-B) temperature, and (C-D) salinity with linear regression line shown as the red lines. ¥textcolor{red}{Although the conductivity sensor on the probe 245 (C) seemed to have a large offset, the linear regression was attempted}. The obtained regression coefficients shown in each panels for two sensors were used to adjust the UCTD data to the corrected CTD data in the following figures.

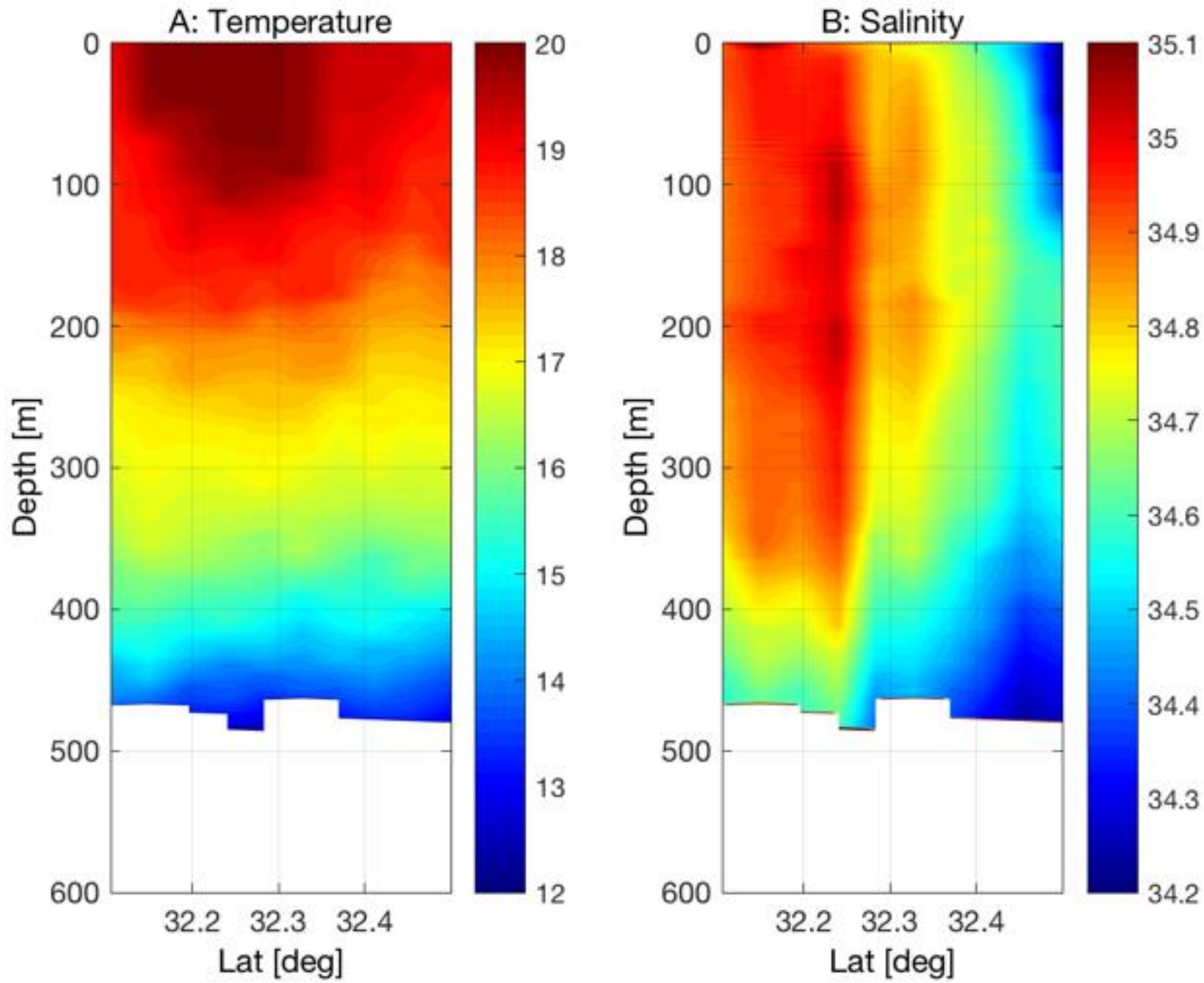


Figure 4 Underway-CTD Observation in Leg A for (A) temperature [^{o}C], and (B) salinity [PSU]. Note that since the conductivity sensor seems not working properly, it is most likely that the salinity plot in (B) does not show the correct salinity distributions.

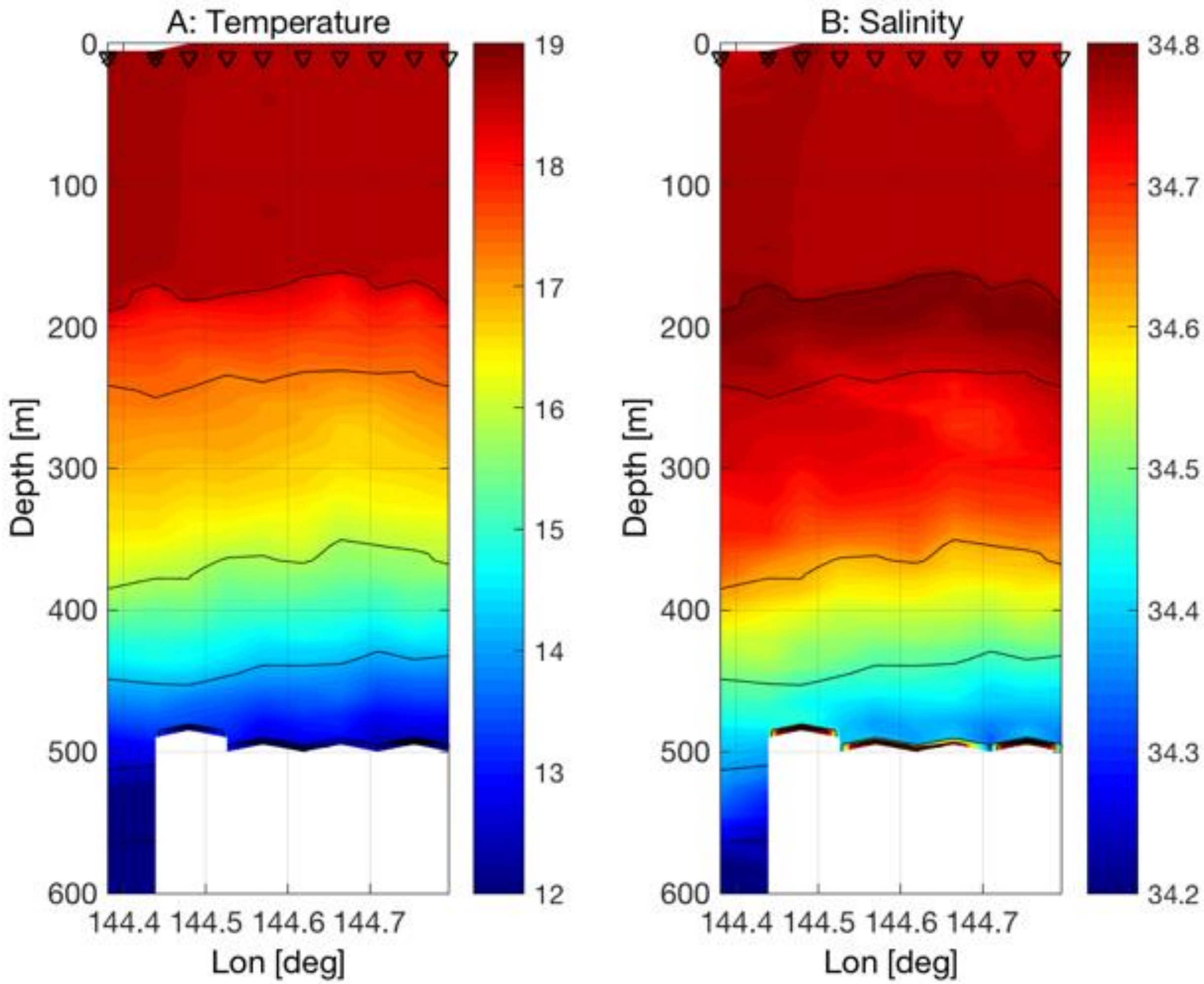


Figure 5 Underway-CTD Observation in Leg B for (A) temperature [ºC], and (B) salinity [PSU]. The westernmost two profiles are obtained by XCTD. Black contours show isopycnal.

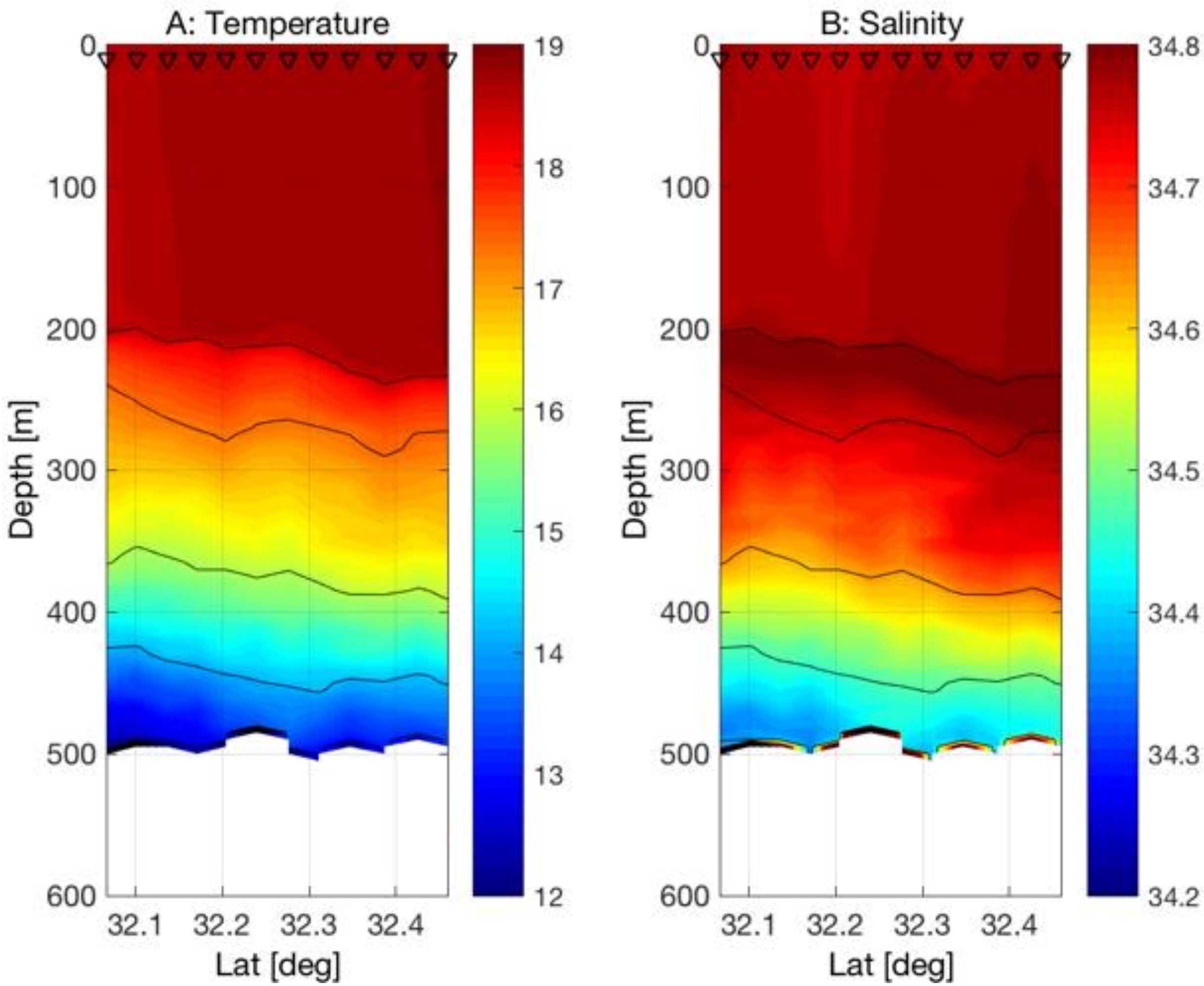


Figure 6 Same as Figure 5, but for Leg C.

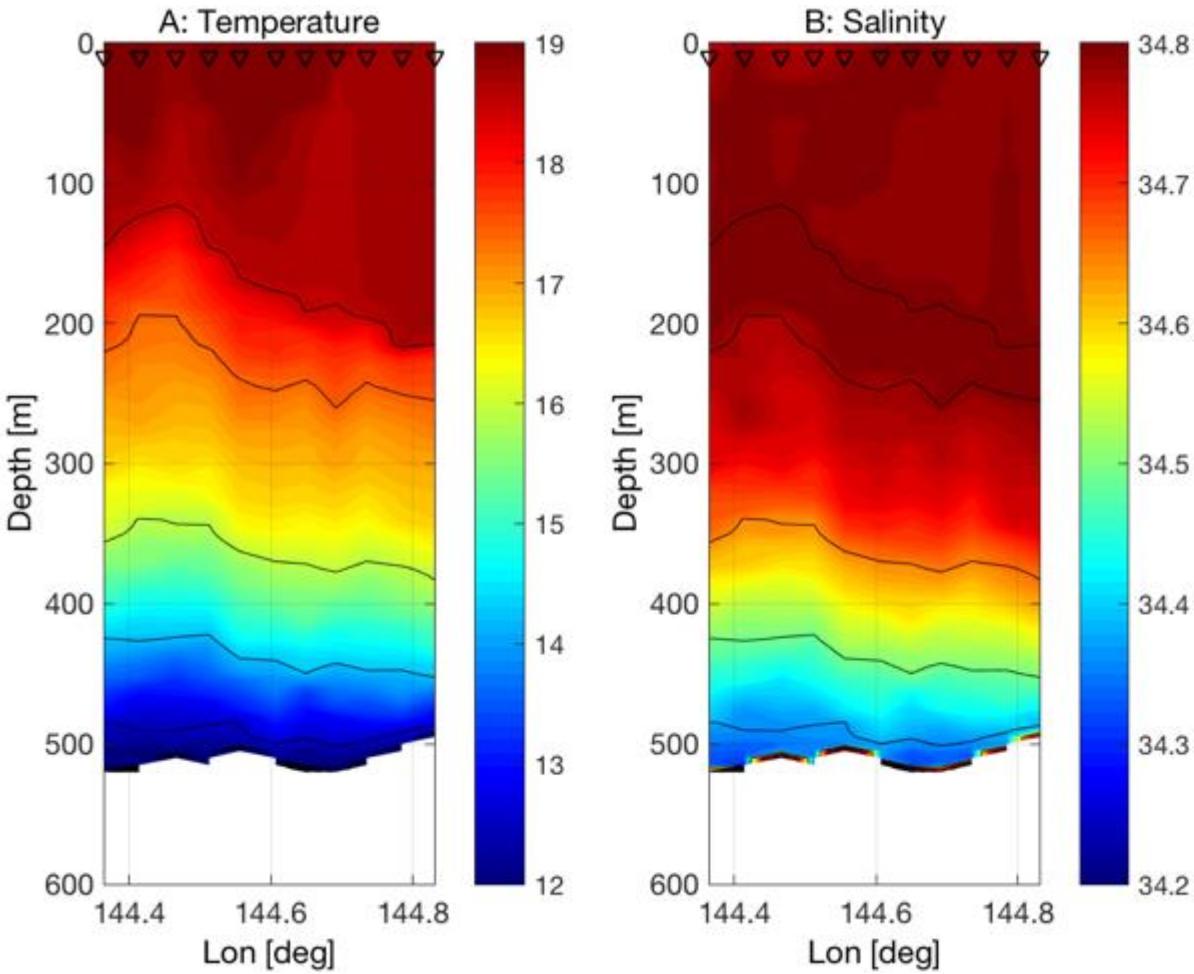


Figure 7 Same as Figure 5, but for Leg D.

10. UVMP Observation

Takeyoshi Nagai
(Tokyo University of Marine Science and Technology)

Underway-VMP (UVMP) observations were conducted in the north-south observation line (Figure 1 of Section 09).

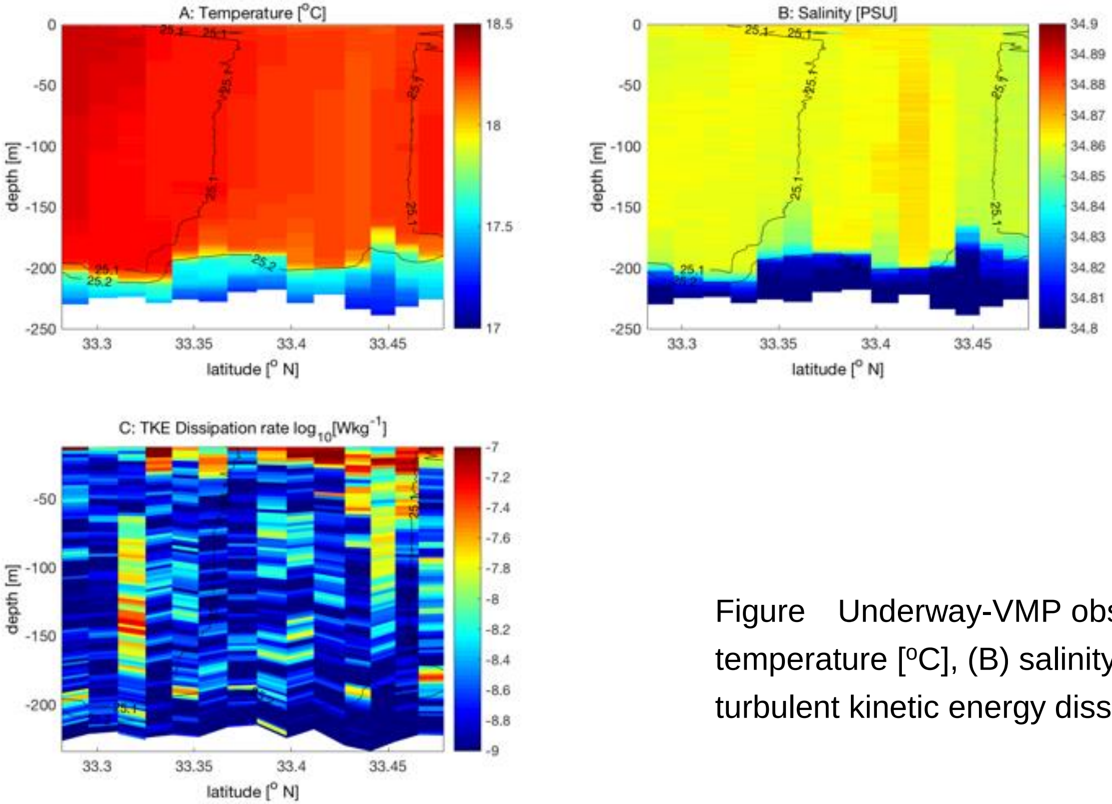
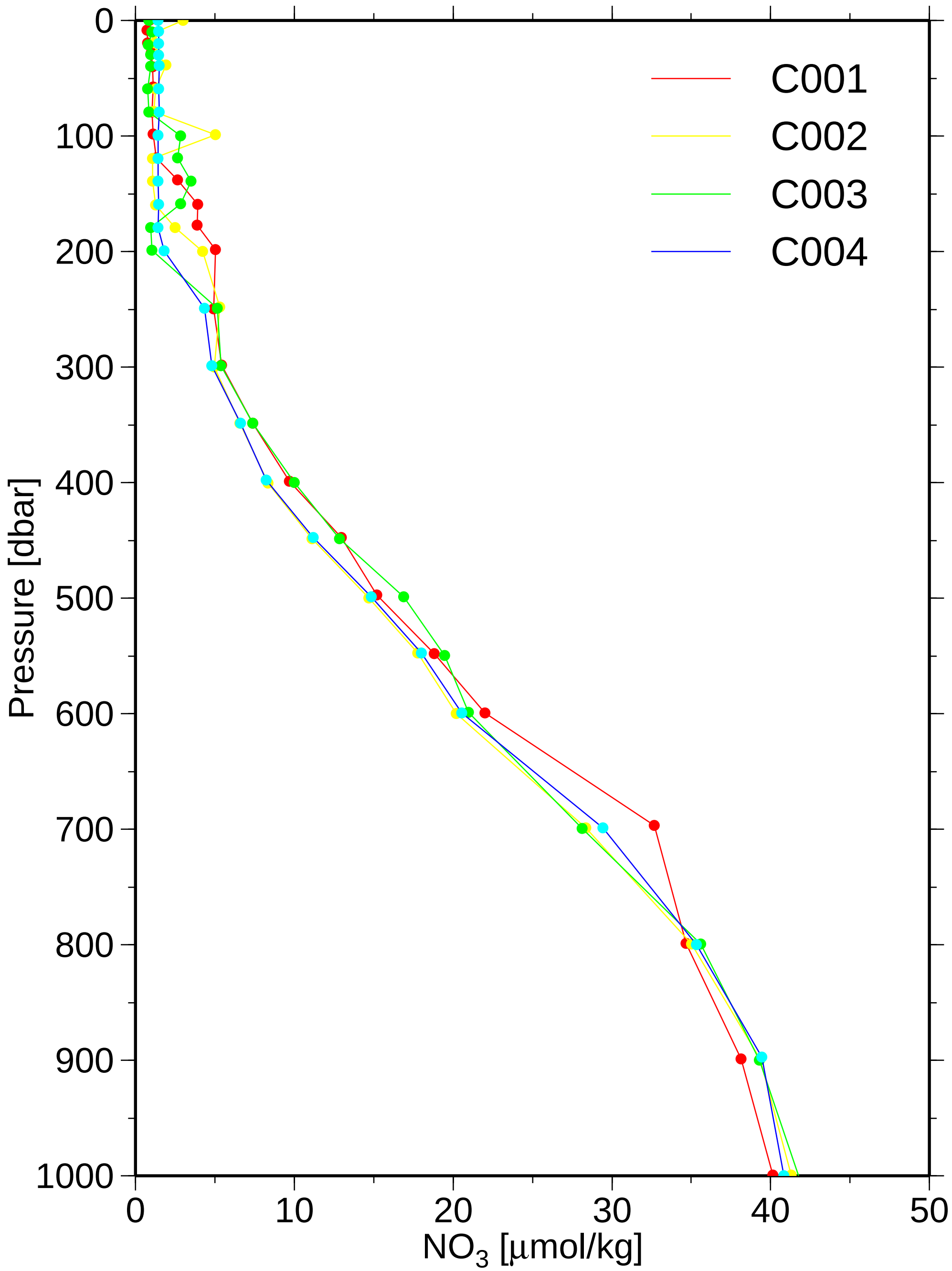
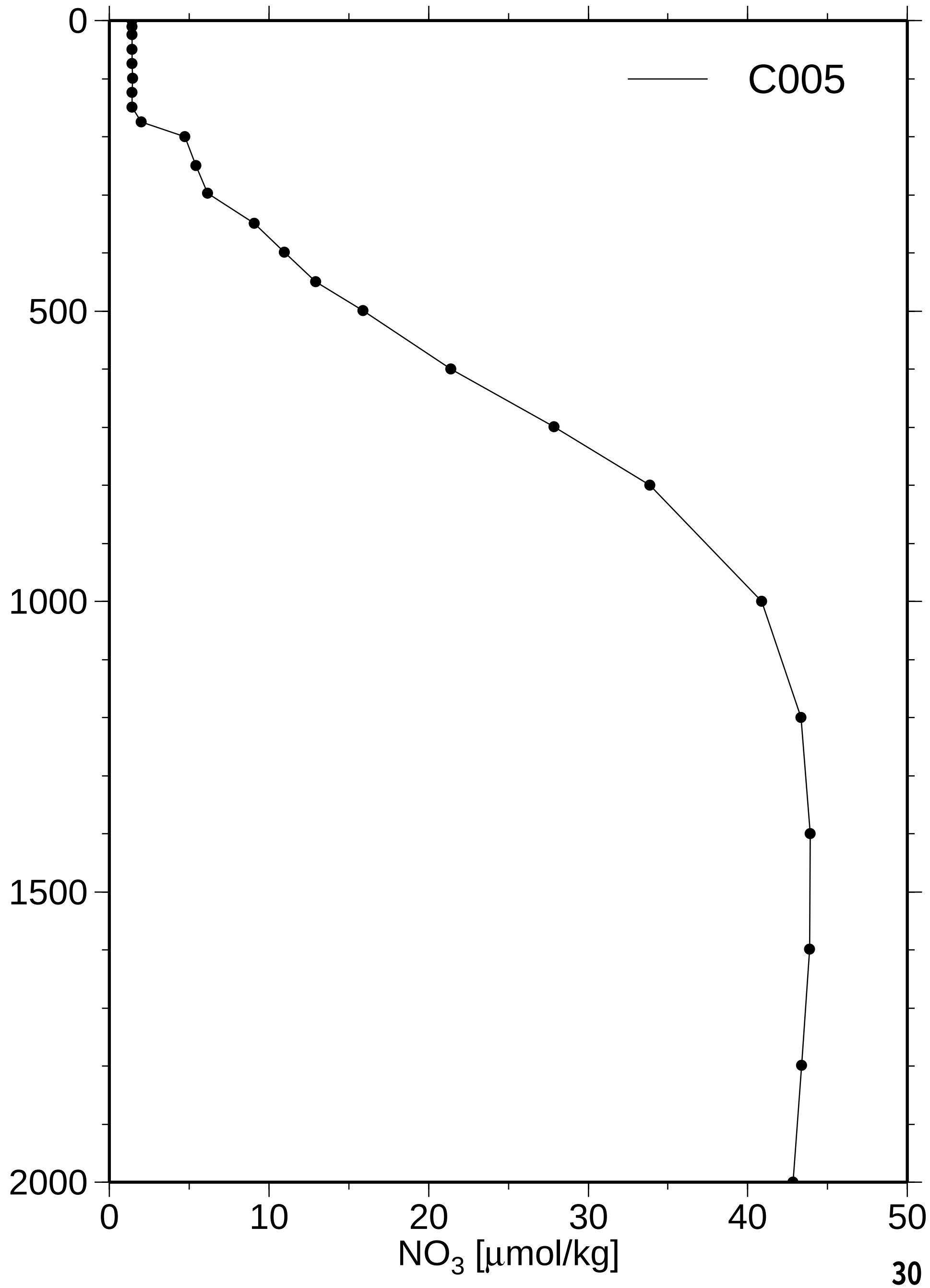


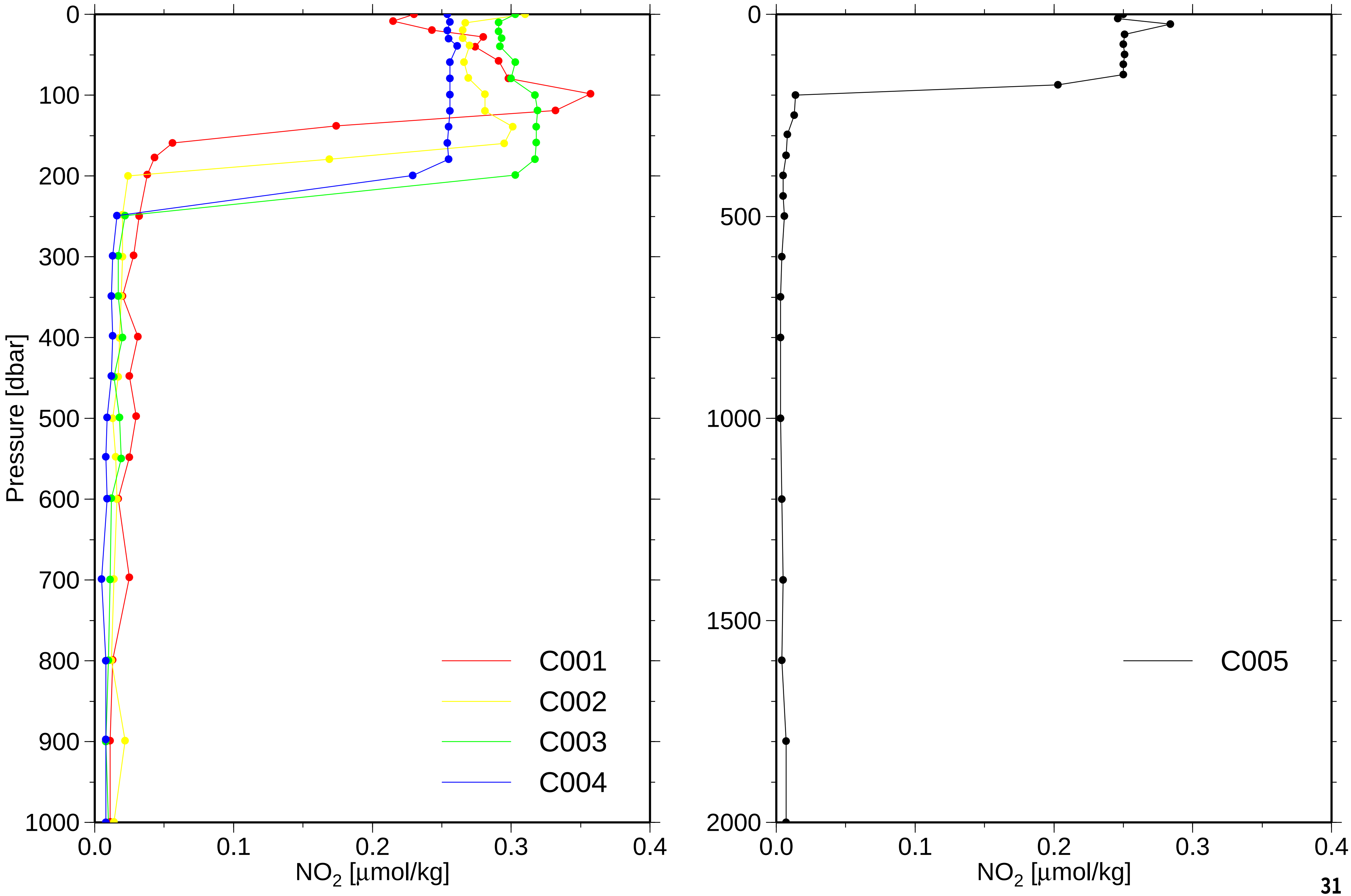
Figure　Underway-VMP observations for (A) temperature [°C], (B) salinity [PSU] and (C) turbulent kinetic energy dissipation rate $\log_{10}[\mathrm{Wkg}^{-1}]$.

11. 栄養塩 (Nutrients)

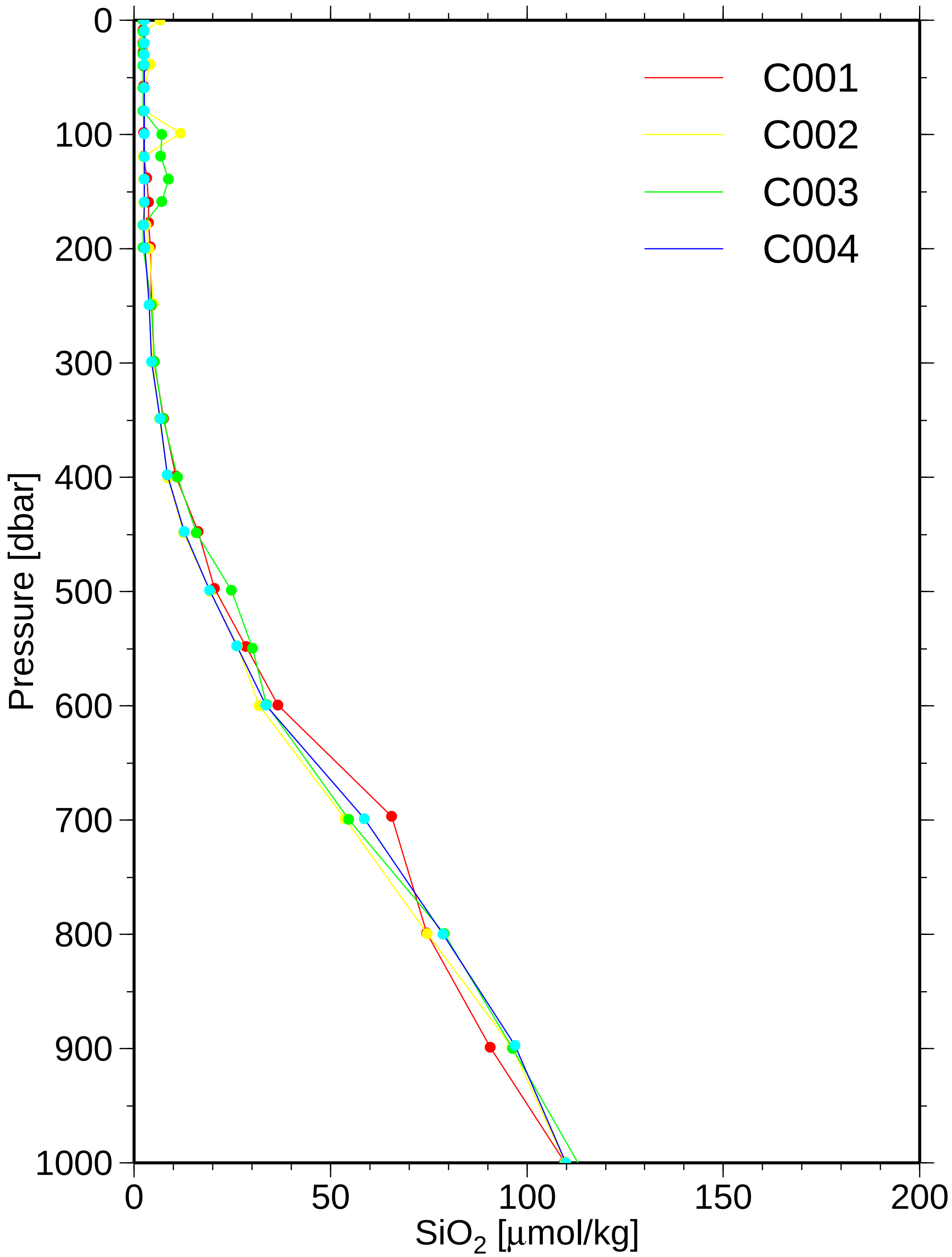
* 1st water sample for each Niskin bottle was used for the graphs.

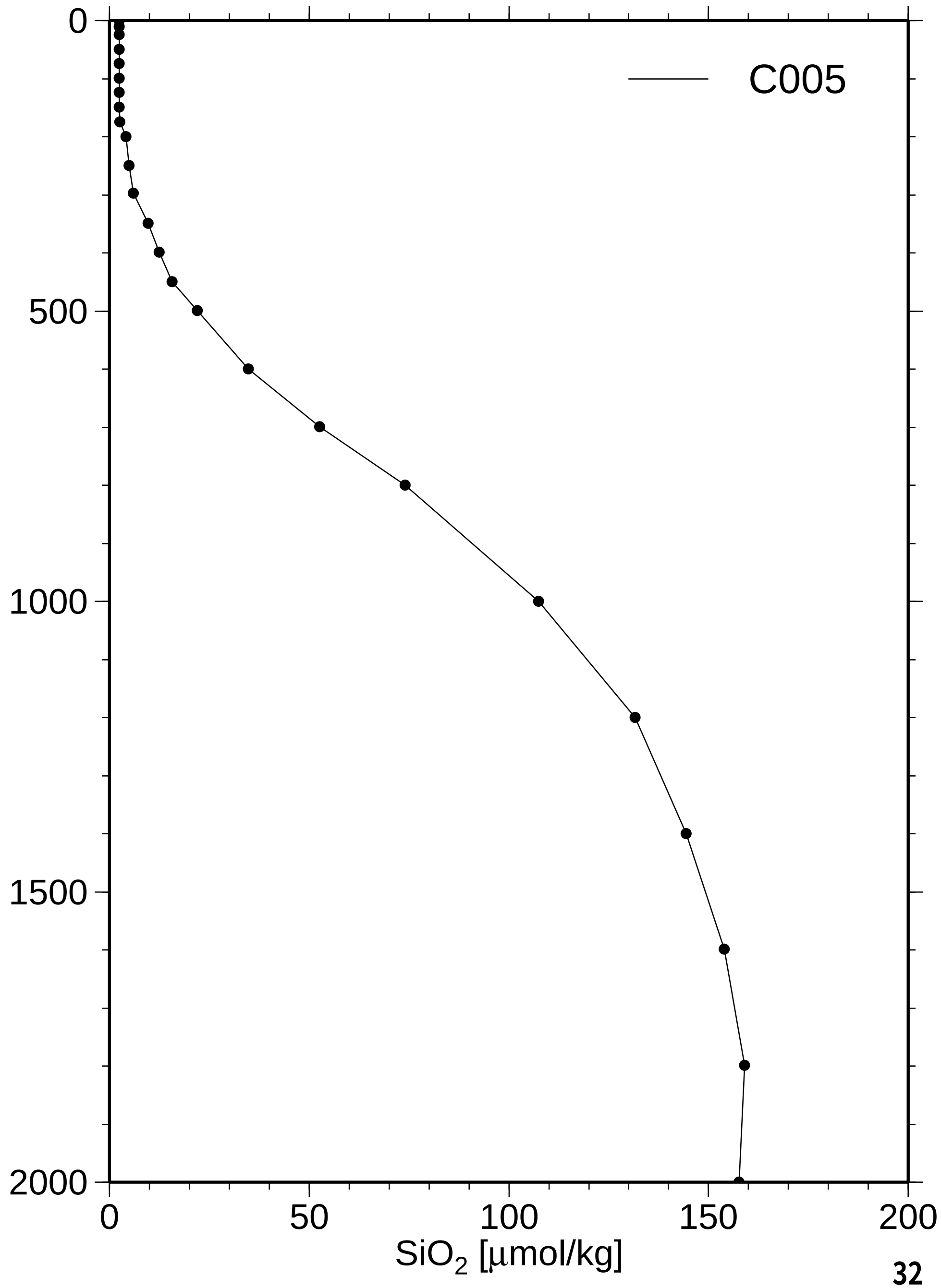


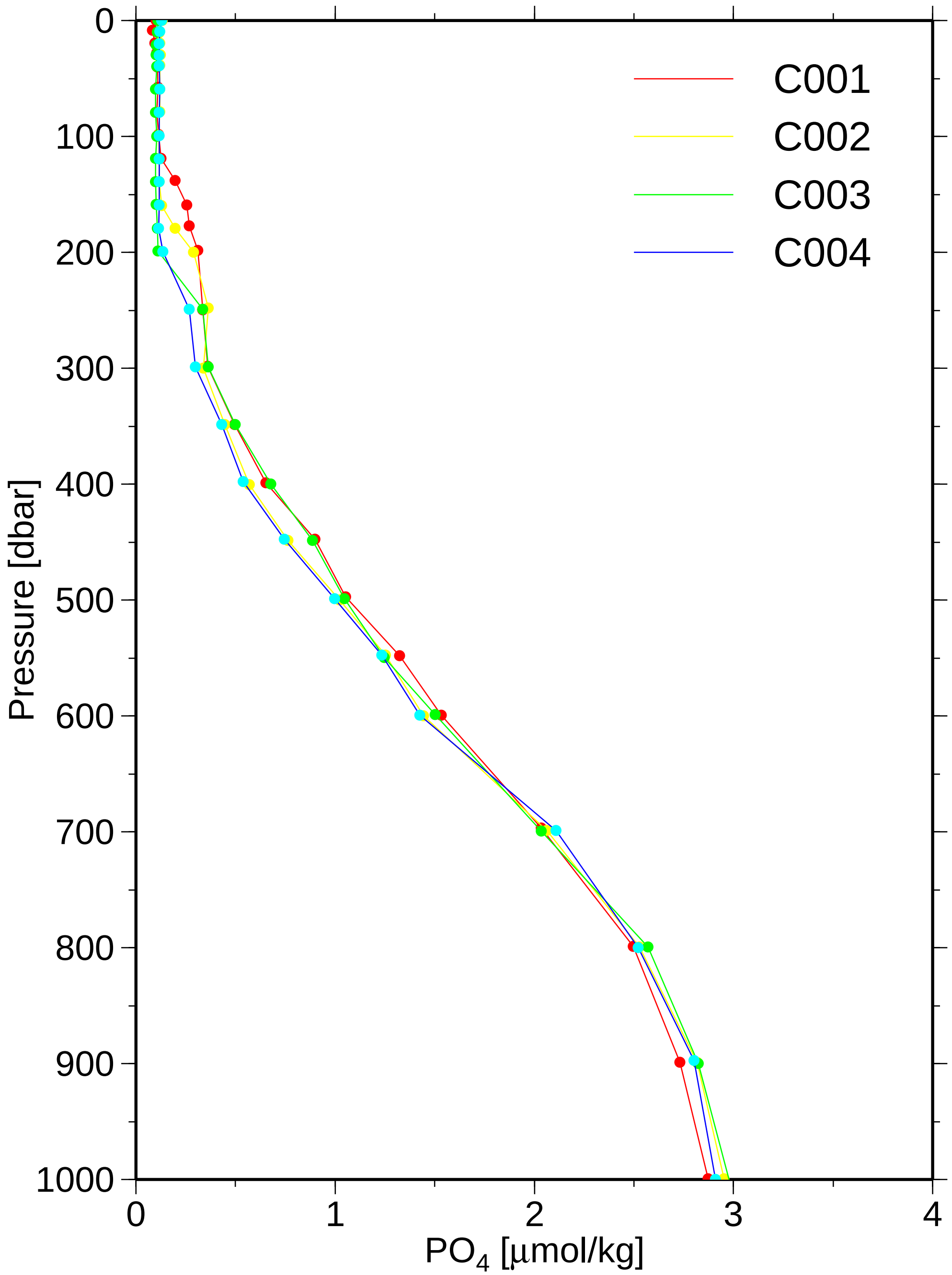


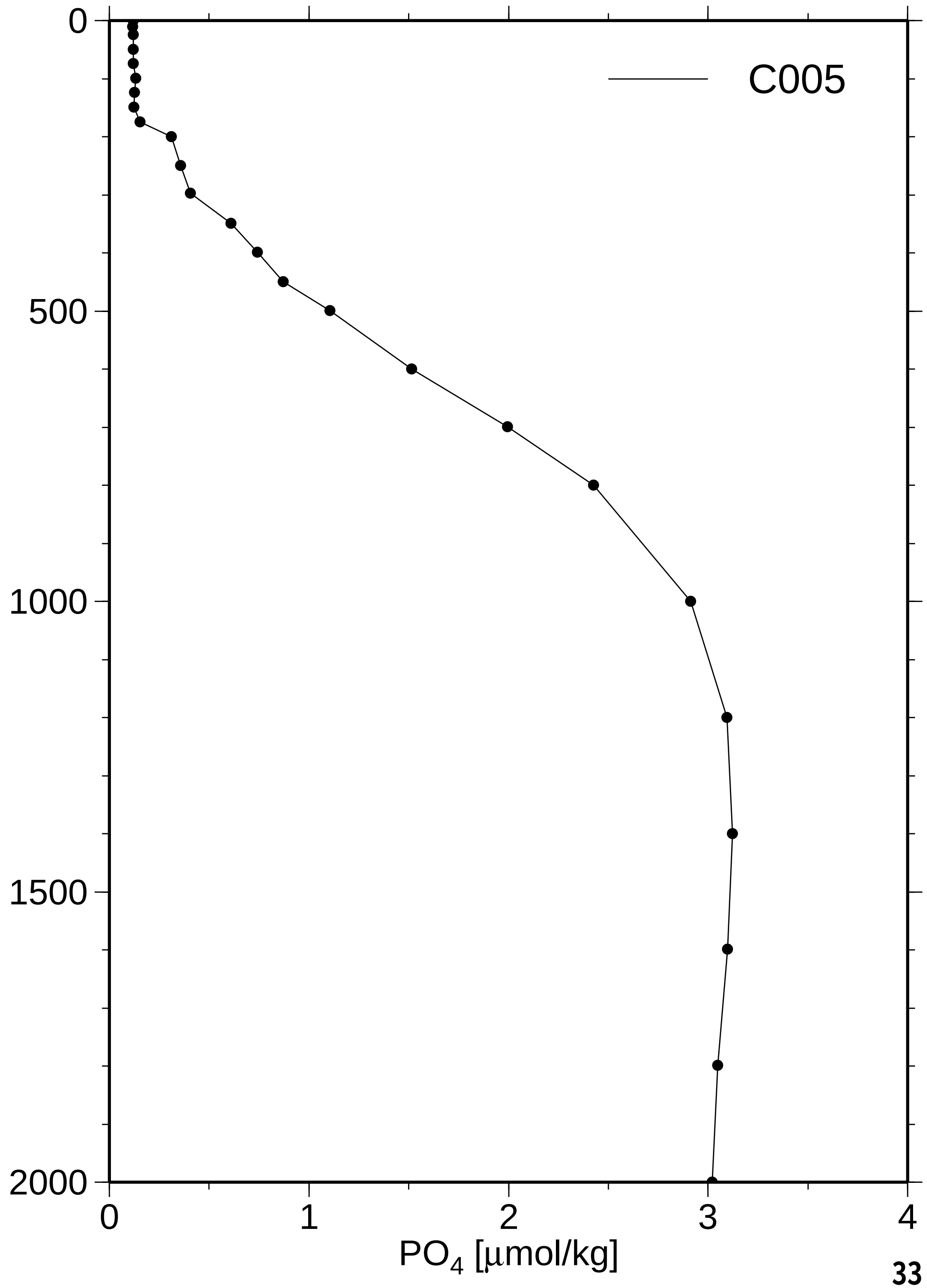


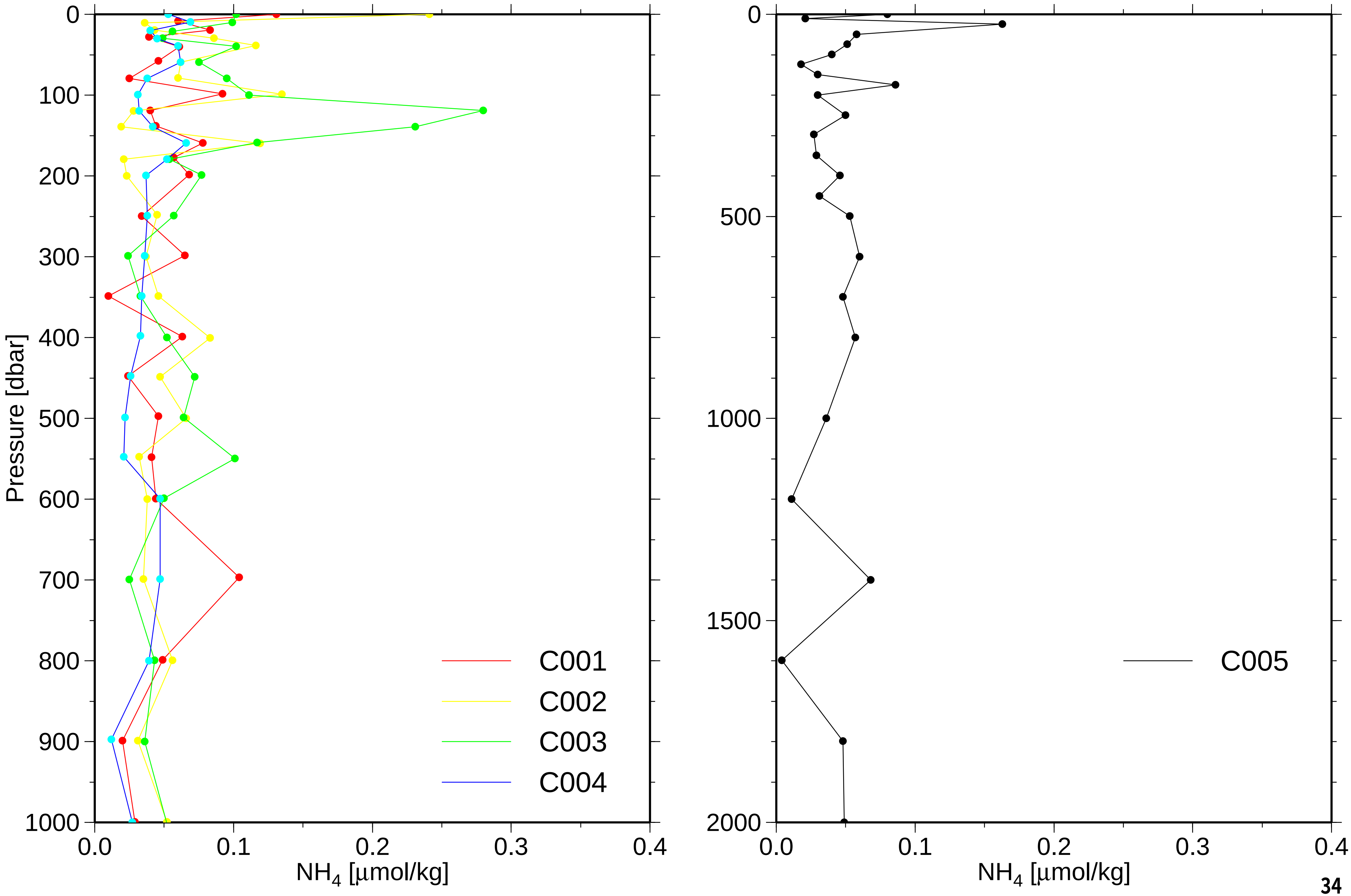
Pressure [dbar]
0
100
200
300
400
500
600
700
800
900
1000
0.0
0.1
0.2
0.3
0.4
NO2 [µmol/kg]
C001
C002
C003
C004
0
500
1000
1500
2000
C005


C001
C002
C003
C004
Pressure [dbar]
0
100
200
300
400
500
600
700
800
900
1000
0
50
100
150
200
SiO2 [µmol/kg]


C005
0
500
1000
1500
2000
0
50
100
150
200
SiO2 [µmol/kg]


C001
C002
C003
C004
Pressure [dbar]
0
100
200
300
400
500
600
700
800
900
1000
0
1
2
3
4
PO4 [μmol/kg]


C005
0
500
1000
1500
2000
0
1
2
3
4
PO4 [μmol/kg]



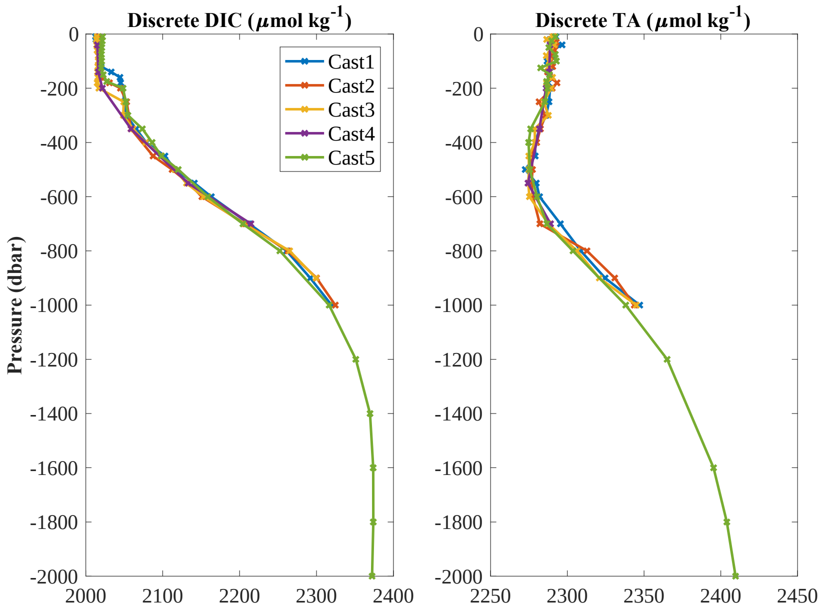
0
100
200
300
400
500
600
700
800
900
1000
Pressure [dbar]
0.0
0.1
0.2
0.3
0.4
NH4 [µmol/kg]
C001
C002
C003
C004
0
500
1000
1500
2000
0.0
0.1
0.2
0.3
0.4
NH4 [µmol/kg]
C005

12. Dissolved Inorganic Carbon, Total Alkalinity, and Spectrophotometric pH

Andrea Fassbender & Yuichiro Takeshita (MBARI)

Discrete samples for dissolved inorganic carbon (DIC) and total alkalinity (TA) were collected from Niskin bottles on the rosette that were triggered at 24 depth levels. Samples were collected following standard protocols into either 250 or 500 mL borosilicate glass bottles and preserved with either 100 or 200 µL saturated mercuric chloride, respectively, for later analysis [*Dickson et al.*, 2007]. Samples were shipped to and analyzed at the Monterey Bay Aquarium Research Institute (MBARI).

A custom analyzer, based on the original design reported by *O'Sullivan and Millero* [1998], was used to measure DIC. Briefly, a 5 mL Kloehn V6 syringe pump is used for fluid handling, delivering 1 mL of sample to a custom designed CO_2 stripping chamber. 100 µL of 5% phosphoric acid (H_3PO_4) is subsequently added to the CO_2 stripping chamber to acidify the sample, converting all DIC to carbon dioxide gas ($CO_{2(g)}$). A CO_2-free carrier gas is then bubbled through the acidified sample and $CO_{2(g)}$ evolved from the sample is delivered to a LiCOR 7000 nondispersive infrared gas analyzer. The flow rate of the carrier gas is controlled using a mass flow controller. The $CO_{2(g)}$ stripped from the seawater sample causes a peak in the LiCOR output, and the DIC concentration of the sample is proportional to the integral of this peak. Instrument performance was monitored by measuring certified reference material (CRM; provided by Andrew Dickson at SIO) approximately every hour. All samples were run in triplicate, and the results were averaged. The average standard deviation of sample triplicates was 0.58 µmol kg^{-1} DIC. The average standard deviation of replicate sample values was 0.64 µmol kg^{-1} DIC.



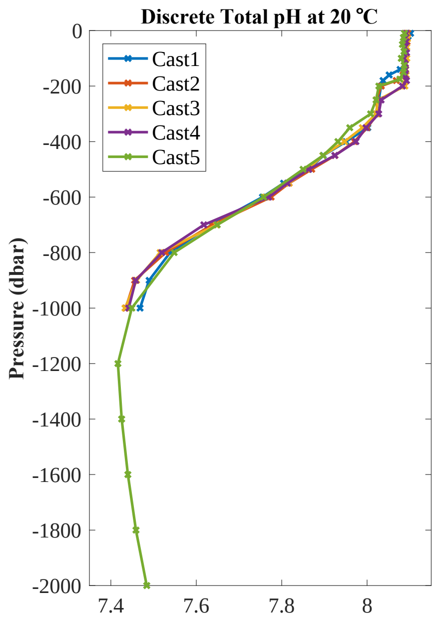
TA was analyzed using a Metrohm 855 automated titrator following an open cell alkalinity titration [*Dickson et al.*, 2003]. The titrant was comprised of 0.1 M hydrochloric acid (HCl) in a 0.7 M sodium chloride (NaCl) background solution. The titration temperature was held constant at 20.0 ± 0.2 °C throughout the titration. CRMs were run every 10 samples (approximately once every hour) to ensure accuracy. All samples were run in triplicate, and the results were averaged. The average standard deviation of sample triplicates was 0.95 µmol kg^{-1} TA. The average standard deviation of replicate sample values was 0.82 µmol kg^{-1} TA.

Dickson, A. G., J. D. Afghan, and G. C. Anderson (2003), Reference materials for oceanic CO_2 analysis: a method for the certification of total alkalinity, Mar. Chem., 80(2–3), 185–197, doi:10.1016/S0304-4203(02)00133-0.

Dickson, A. G., C. L. Sabine, and J. R. Christian (Eds.) (2007), Guide to best practices for ocean CO_2 measurements, PICES Special Publication 3.

O'Sullivan, D. W., and F. J. Millero (1998), Continual measurement of the total inorganic carbon in surface seawater, Mar. Chem., 60(1–2), 75–83, doi:10.1016/S0304-4203(97)00079-0.

Discrete samples for pH were collected into 250 mL borosilicate glass bottles from Niskin bottles on the rosette that were triggered at 24 depth levels. These samples were analyzed aboard the ship spectrophotometrically [*Clayton and Byrne*, 1993], using an automated system described in *Carter et al.* [2013]. The temperature of the sample was held constant at 20 °C using a 10-cm jacketed cell, and every sample was immersed in a 20 °C water bath for at least 25 minutes before analysis. An indicator dye (m-cresol purple, TCI) solution (2 mM) was used to assess sample pH. The sample pH perturbation caused by dye addition was quantified by adding both the normal amount and twice the amount of dye to seawater solutions of pH 7.4, 7.8, and 8.1. The perturbation (ΔpH) was determined to have the following relationship with sample pH: ΔpH = -0.0026*pH + 0.0175. To account for the use of impure dye, seawater samples spanning a pH range of 7.0 - 8.3 were analyzed using the impure dye and again using purified m-cresol purple (purchased from R.H. Byrne at the University of South Florida) following the method of *Liu et al.*, [2011]. The resulting correction for dye impurity is: $\Delta pH_{imp} = -0.02371pH^2 + 0.35397pH - 1.3334$. Measurement precision was estimated by analyzing four sets of duplicate samples from each rosette cast and was found to be ± 0.003 (n = 20).



Carter, B. R., J. A. Radich, H. L. Doyle, and A. G. Dickson (2013), An automated system for spectrophotometric seawater pH measurements, *Limnol. Oceanogr. Methods*, *11*(1), 16–27, doi:10.4319/lom.2013.11.16.

Clayton, T. D., and R. H. Byrne (1993), Spectrophotometric seawater pH measurements: total hydrogen ion concentration scale calibration of m-cresol purple and at-sea results, *Deep Sea Res. Part I Oceanogr. Res. Pap.*, *40*(10), 2115–2129.

Liu, X., M. C. Patsavas, and R. H. Byrne (2011), Purification and characterization of meta-cresol purple for spectrophotometric seawater pH measurements., *Environ. Sci. Technol.*, *45*(11), 4862–8, doi:10.1021/es200665d.

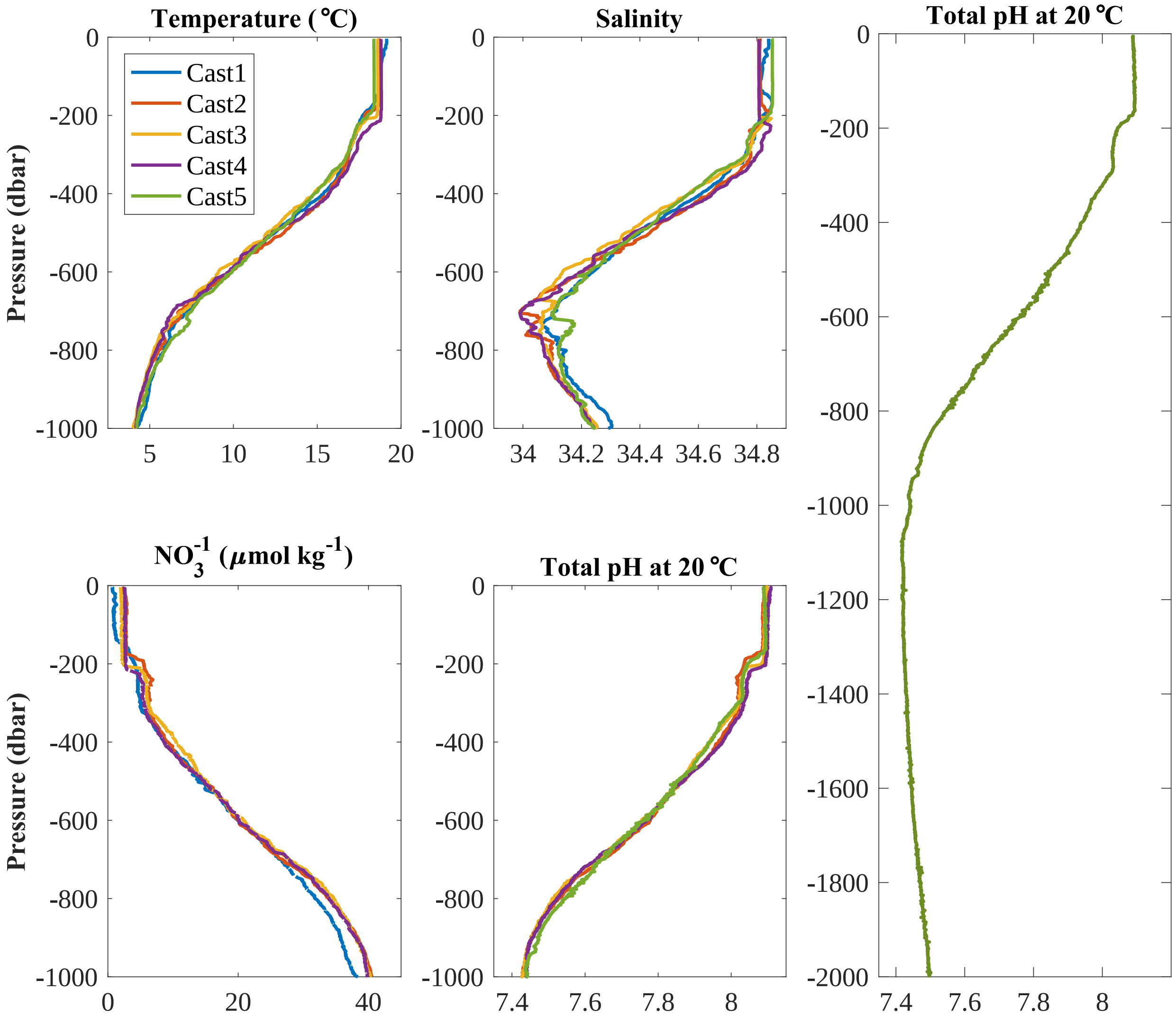
13. Nitrate and pH (profile)

Andrea Fassbender & Yuichiro Takeshita (MBARI)

Vertical water column profiles of pH and nitrate at 1 m resolution were obtained at each sampling station using a Deep-Sea-Durafet (DSD) pH sensor [*Johnson et al.*, 2016] and In Situ Ultraviolet Sensor (ISUS) for nitrate [*Johnson and Coletti*, 2002]. Both instruments were custom built in the Chemical Sensor Lab at MBARI and were calibrated in the laboratory prior to the cruise. The DSD was mounted horizontally on the rosette frame and integrated into the pumped flow stream of the SeaBird Electronics (SBE) 911 conductivity-temperature-depth (CTD) sensor. The ISUS was mounted vertically on the rosette frame approximately 50 cm above the SBE911. Nitrate concentration was calculated from the ISUS UV absorbance spectra (200-240 nm) using an updated algorithm, where the bromide spectra is calculated from salinity [*Sakamoto et al.*, 2009]. Both sensors collected data at approximately 1 Hz. The raw sensor data was combined with CTD data by matching the time stamps to compute pH and nitrate values. Data from the downcast were used and binned at 1 m interval.

DSD pH data were adjusted by applying an offset to the reference potential, k_0, to minimize the residual between sensor and discrete pH data [*Johnson et al.*, 2016]. k_0 was adjusted by 500 μV, which translates to approximately 0.008 pH. Data from cast 1 for the DSD is not reported due to rapid sensor drift observed during rehydration of the sensor surface [*Bresnahan et al.*, 2014].

ISUS data were adjusted in two ways. First, the wavelength used to correct for bromide UV light absorption [*Sakamoto et al.*, 2009] was changed from 210 nm to 208 nm to account for a temperature-dependent bias in the nitrate data that was observed at higher temperatures [*Pasqueron de Fommervault et al.*, 2015]. Second, a constant offset was applied to the nitrate profile minimize the residual with discrete samples collected at > 750 m: 0.26 μmol kg^{-1} for cast 1, and -1.02 μmol kg^{-1} for cast 2-4. After correction, the ISUS data agreed with discrete samples to within -0.05 ± 0.29 (1σ) μmol kg^{-1} (n = 81). ISUS Data were not collected during cast 5.


Temperature (℃)
Salinity
Total pH at 20 ℃
Cast1
Cast2
Cast3
Cast4
Cast5
Pressure (dbar)
NO_3^{-1} (μmol kg^{-1})
Total pH at 20 ℃
Pressure (dbar)

Bresnahan, P. J., T. R. Martz, Y. Takeshita, K. S. Johnson, and M. LaShomb (2014), Best practices for autonomous measurement of seawater pH with the Honeywell Durafet, *Methods Oceanogr.*, *9*(October), 44–60, doi:10.1016/j.mio.2014.08.003.

Johnson, K. S., and L. J. Coletti (2002), In situ ultraviolet spectrophotometry for high resolution and long-term monitoring of nitrate, bromide and bisulfide in the ocean, *Deep Sea Res. Part I Oceanogr. Res. Pap.*, *49*(7), 1291–1305, doi:10.1016/S0967-0637(02)00020-1.

Johnson, K. S., H. W. Jannasch, L. J. Coletti, V. A. Elrod, T. R. Martz, Y. Takeshita, R. J. Carlson, and J. J. Connery (2016), Deep-Sea DuraFET: A pressure tolerant pH sensor designed for global sensor networks, *Anal. Chem.*, acs.analchem.5b04653, doi:10.1021/acs.analchem.5b04653.

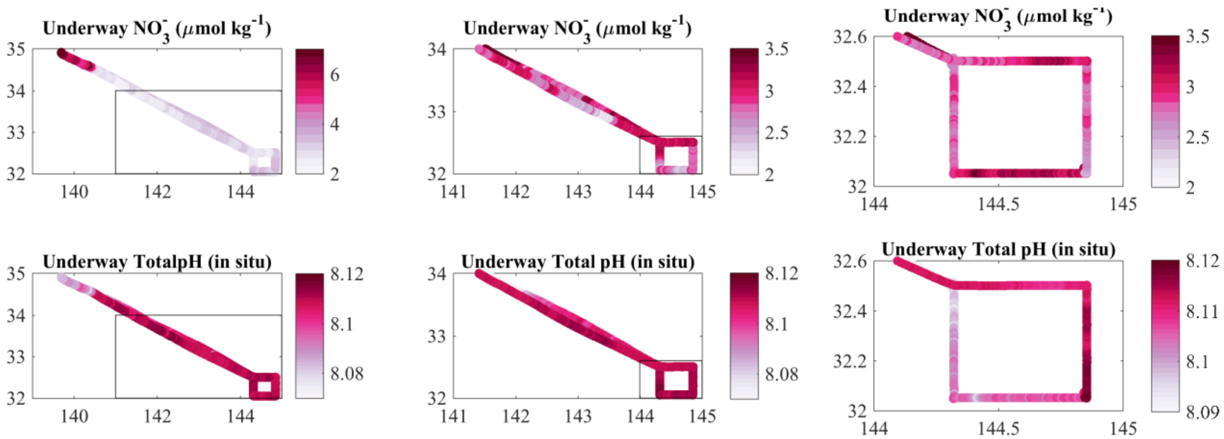
Pasqueron de Fommervault, O. et al. (2015), Seasonal variability of nutrient concentrations in the Mediterranean Sea: Contribution of Bio-Argo floats, *J. Geophys. Res. Ocean.*, *120*(12), 8528–8550, doi:10.1002/2015JC011103.

Sakamoto, C. M., K. S. Johnson, and L. J. Coletti (2009), Improved algorithm for the computation of nitrate concentrations in seawater using an in situ ultraviolet spectrophotometer, *Limnol. Oceanogr. Methods*, *7*, 132–143.

14. Nitrate and pH (underway)

Andrea Fassbender & Yuichiro Takeshita (MBARI)

A prototype, dual pH-nitrate instrument was integrated into the ship's underway system. Nitrate was measured using an In Situ Ultraviolet Sensor (ISUS) [*Johnson and Coletti*, 2002], and pH was measured using a Deep-Sea-Durafet (DSD) [*Johnson et al.*, 2016]. An SBE45 thermosalinograph was located directly downstream (< 10 cm) of the flowcell for underway temperature and salinity measurements near the sensors. The instruments were powered through an isolation transformer to prevent ground loop issues. The system was polled using a LabView interface, and measurements were made every 15 to 20 seconds. The pH sensor was calibrated by taking discrete samples from the underway line (n = 9) throughout the cruise. An offset of -1.8 µmol kg^{-1} was applied to the ISUS, based on comparison with the discrete surface samples collected at each of the 5 casts (n = 5).



Johnson, K. S., and L. J. Coletti (2002), In situ ultraviolet spectrophotometry for high resolution and long-term monitoring of nitrate, bromide and bisulfide in the ocean, Deep Sea Res. Part I Oceanogr. Res. Pap., 49(7), 1291–1305, doi:10.1016/S0967-0637(02)00020-1.

Johnson, K. S., H. W. Jannasch, L. J. Coletti, V. A. Elrod, T. R. Martz, Y. Takeshita, R. J. Carlson, and J. J. Connery (2016), Deep-Sea DuraFET: A pressure tolerant pH sensor designed for global sensor networks, Anal. Chem., acs.analchem.5b04653, doi:10.1021/acs.analchem.5b04653.

15. Chlorophyll-*a*

Chiho Sukigara
(Tokyo University of Marine Science and Technology)

[Method]

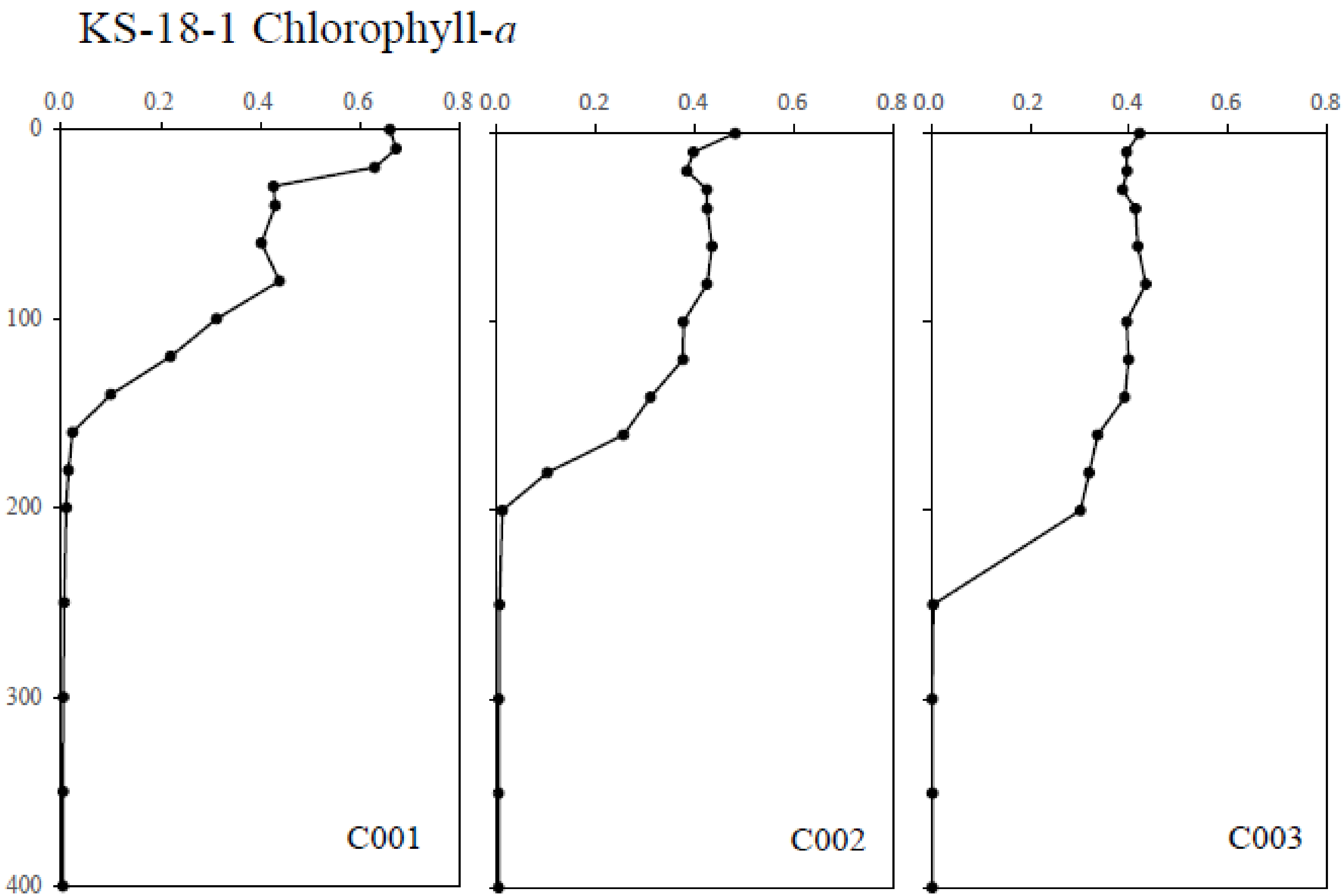
A CTD-RMS system with 24 Niskin bottles was used for collecting water samples of chlorophyll-*a*. Water samplings were conducted in 17 layers at 0 (by a bucket), 10, 20, 30, 40, 60, 80, 100, 120, 140, 160, 180, 200, 250, 300, 350, 400 m. Sample waters were moved from Niskin bottles to brown high-density polyethylene (HDPE) bottles directly. Sample waters (250 mL) were filtered on a 25 mm glass filters (GF/F, Whatman) using polysulphone filter funnels (PALL) under moderate pressure (< 100 mmHg). Chlorophyll-*a* on filters were measured by fluorometer (Welschmeyer, 10-AU, Turner Design) after extraction with 7 mL of N,N-dimethylformamide (DMF) for more than 24 hours in dark in a freezer at -20 ºC. A concentration of chlorophyll-*a* in sample water were estimated using a following equation;

[Chlorophyll-*a* (µg L^{-1})] = [raw fluorescence intensity] × K_x × Vol_{ex} ÷ Vol_{filt}

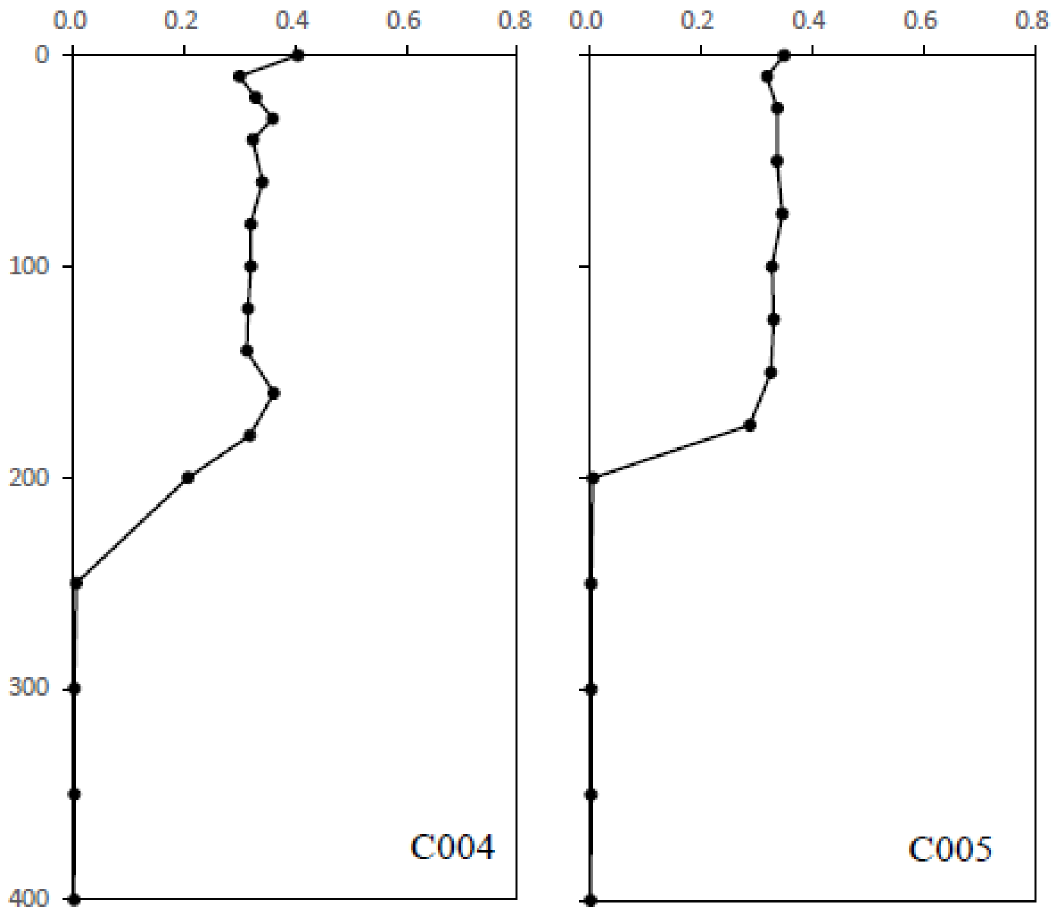
K_x: the coefficient between fluorescence intensities and chlorophyll-*a* concentrations. (L: 1.518, M: 1.546, H: 1.568)

Vol_{ex}: the volume of DMF (7 mL)

Vol_{filt}: the volume of sample water (250 mL)


KS-18-1 Chlorophyll-a
0.0
0.2
0.4
0.6
0.8
0
100
200
300
400
C001
C002
C003

KS-18-1 Chlorophyll-*a*



16. Suspended particles

Chiho Sukigara
(Tokyo University of Marine Science and Technology)

[Method]

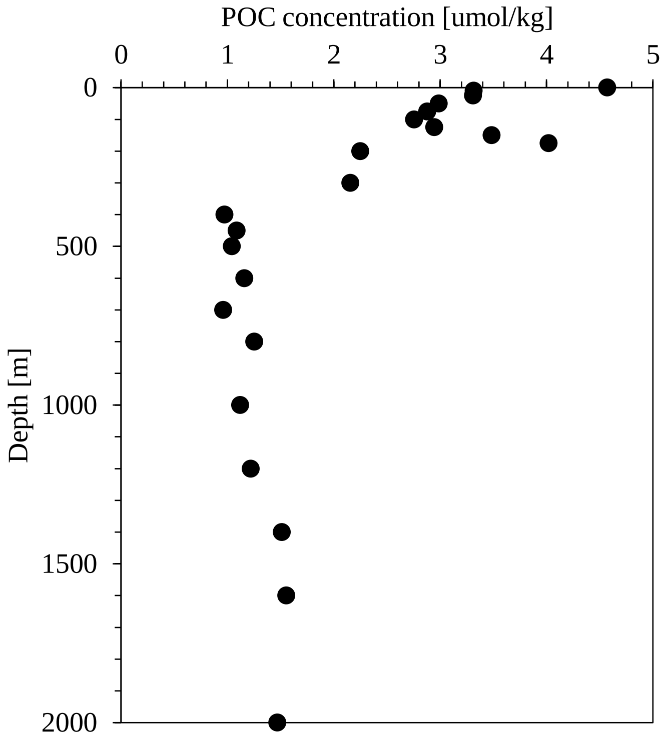
Samplings of suspended particle were conducted at C005 on 21st January 2018. Water samples of 8 L for suspended particles were collected by CTD/Carousel Water Sampling System with Niskin bottles and a bucket at 25 depths from 0m to 2000m. Samples were filtered through pre-combusted GF/F filter with (ϕ47 mm, Whatman)

The filters were kept frozen at -20 °C until analysis on board and shore.

In the laboratory in Nagoya University, samples on filters were exposed overnight to HCl fumes to remove carbonates, dried in a vacuum desiccator, and then pelletized with a tin foil. Mass fractions of particulate organic carbon (POC) in the pellets were measured with an elemental analyzer (Flash EA1112, Thermo Fisher Scientific). The precision for POC mass fraction analysis were better than 5 %, which was estimated from repeated measurements of laboratory standards (Alanine, SI Science) along with the samples.

[Result]

See a right figure.



17. Incubation Experiment

Chiho Sukigara
(Tokyo University of Marine Science and Technology)

[Method]

Daily primary productivity was determined by means of 24 h on-deck simulated in situ incubations. An incubation experiment was conducted at C005 on 21st January 2018. Water samples were collected using Niskin bottles from depths corresponding to 100%, 50%, 10%, and 1% of PAR at the sea surface, which were determined from the PAR profile in the previous CTD cast. The samples were poured into WOCE-type DO bottles from Niskin bottles using silicone tubes. Samples were placed inside on-deck incubator boxes equipped with constantly suppling surface seawater to maintain the ambient water temperature. Neutral density filters were used to simulate the irradiance levels at the original sampling depth. For each depth, two bottles were immediately fixed oxygen in the bottle as initial sample (t=0) and analyzed DO concentration by Winkler method. Whereas three bottles (Light bottles) and three bottles covered aluminum foil (Dark bottles) in each depth were incubated for 24hours in the incubator boxes and measured DO concentration after incubation by same manner as initial samples.

Community respiration (CR), gross primary productivity (GPP), and net community productivity (NCP) were estimated by following equations;

Community Respiration (CR) = [DO in t=0 bottles] – [DO in dark bottles after incubation]

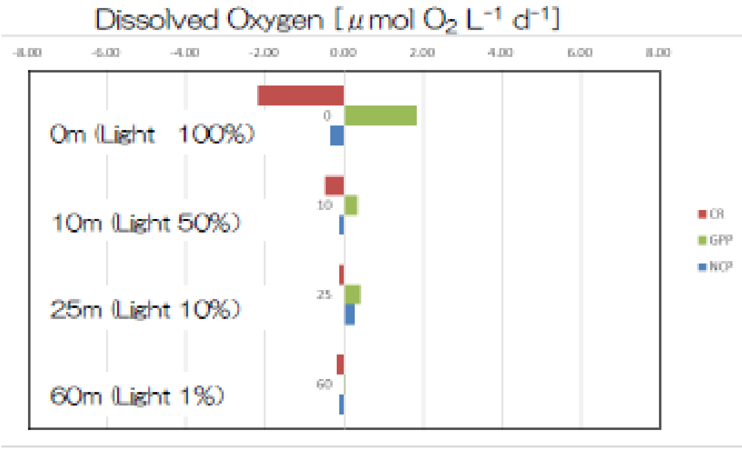
Gross primary productivity (GPP) = [DO in dark bottles after incubation] – [DO in light bottles after incubation]

Net community productivity (NCP) = [DO in light bottles after incubation] - [DO in t=0 bottles]

Respiration and productivities in the euphotic zone were calculated by trapezoidal integration.

Primary Productivity

KS-18-01, C05P



Community Respiration ((CR)
DO in Dark bottles after incubation −
DO before incubation

Gross Primary Productivity (GPP)
DO in Dark bottles after incubation −
DO in Light bottles after incubation

Net Community Productivity (NCP)
DO in Light bottles after incubation −
DO in before incubation

Primary Productivity (Integrated in the euphotic zone, 0 -60 m)

	CR	GPP	NCP
	[mmol O_2 m^{-2} d^{-1}]	[mmol O_2 m^{-2} d^{-1}]	[mmol O_2 m^{-2} d^{-1}]
KS-18-1 C05P	-23.5	24.5	0.5

18. フロートの投入（Profiling Float Deployment）

Ryuichiro Inoue (JAMSTEC)

Overview

For time-series observations of relation between physical and biogeochemical processes from winter, when mixed layer deepens, to spring, when the ocean surface is restratified, we deployed two profiling floats equipped with dissolved oxygen sensor, chlorophyll sensor, scatterometer, FDOM sensor, and nitrate sensor (BGC floats hereafter) and one profiling float with electromagnetic current meter (EM-APEX), all at C005.

BGC float status

Type: Navis
Manufacturer: Sea-Bird Scientific
Float S/N: F0883
WMO ID: 2903329
Deployment time (UTC): 2018/01/28　02:41
Deployment location: 33-15.0617N, 142-30.0002E
Observation cycle: 1 day
Parking pressure; 1000 dbar
Profiling pressure: 2000 dbar
Layer number: 500 (1000 for CTD)

Type: Navis
Manufacturer: Sea-Bird Scientific
Float S/N: F0884
WMO ID: 2903330
Deployment time (UTC): 2018/01/28　02:45
Deployment location: 33-15.1138N, 142-29.9960E
Observation cycle: 1 day
Parking pressure; 1000 dbar
Profiling pressure: 2000 dbar
Layer number: 500 (1000 for CTD)

Data from the two BGC floats will be publicly available through the international Argo program.

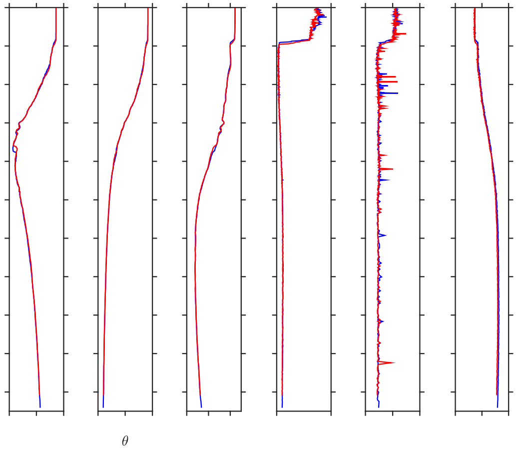


Figure First profiles (except for nitrate) obtained by 2903329 (blue) and 2903330 (red).

EM-APEX status

Type: APEX

Manufacturer: Teledyne Webb Research

Float S/N: 7823

Deployment time (UTC): 2018/01/28 02:51

Deployment location: 33-15.2021N, 142-29.9879E

Observation cycle: variable

Parking pressure: variable

Profiling pressure: variable

Layer number: variable

The data from the EM-APEX can be open.

19. グライダーの投入 (Glider Deployment)

Ryuichiro Inoue (JAMSTEC)

Overview

The aim of glider observation is to observe submesoscale eddies formed after the winter mixed layer formation in the formation region of the subtropical mode water for an understanding of surface restratification in the eddies and its impact on primary production.

The glider deployed is Seaglider manufactured by Kongsberg Maritime, and is equipped with temperature, conductivity, dissolved oxygen, and pressure sensors. The glider was deployed at C005 using an A-frame, and is going to be recovered in the Shinsei-maru KS-18-4 cruise scheduled in April 2018.

Deployment status

Time (UTC): 2018/01/28 03:17

Location: 33-15.4851N, 142-29.9016E

Data

The data from the glider can be open.

20. 放射計 (Radiation)

Ryuichiro Inoue (JAMSTEC)
Yoshimi Kawai (JAMSTEC)

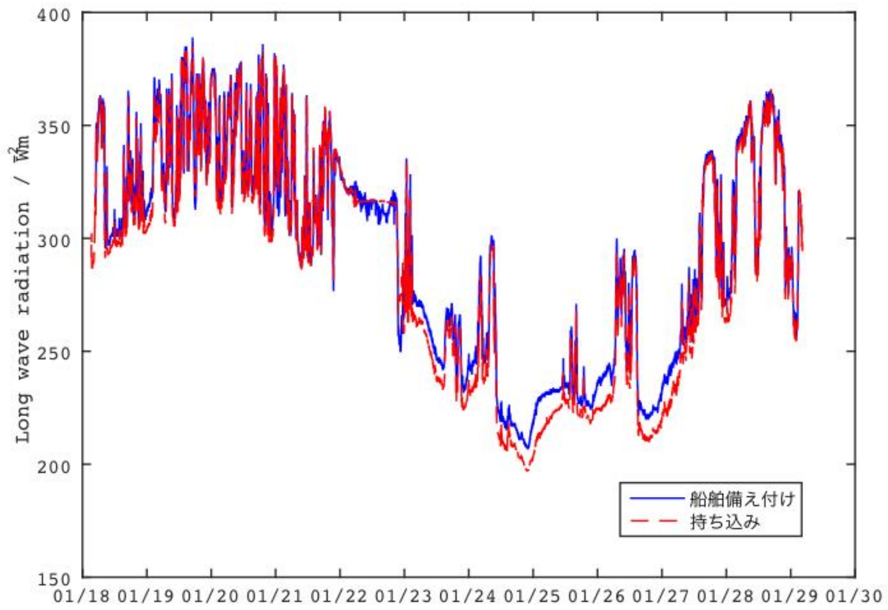


Figure　Time-series of long-wave radiation measured by radiometer of ours (red) and the Shinsei-maru (blue)

Overview

To obtain a relation between the winter mixed layer formation and surface heat flux during the cruise, we made time-series observations using short-wave and long-wave radiometers installed at the top deck of Shinsei-maru. The data obtained at 1 minute interval were recorded in the PC via the logger.

Instruments

Short-wave radiometer: CM-21 manufactured by Kipp & Zonen
Long-wave radiometer: CG-4 manufactured by Kipp & Zonen

Data

Measurements by the short-wave radiometer failed throughout the cruise period. Measurements by the long-wave radiometer were successful and coincided with those by the ship's radiometer, except for the evacuation period at the Yokosuka port. All the data obtained in this cruise can be open.

21. 放射性セシウム（Radioactive Caesium）

Eitarou Oka (AORI, Univ. of Tokyo), Michio Aoyama (Fukushima Univ.)

Objectives

To grasp spreading in the North Pacific and its temporal variation of radioactive caesium released by the accident of Fukushima Daiichi nuclear power plant in March 2011.

Observation

20 liters of surface water was collected at C001.

Time (JST): 2018/01/19　18:19

Location: 32-30.05N, 144-19.20E