学会創立 50 周年を迎えて

日仏海洋学会会長　今脇　資郎

日仏海洋学会は，海洋学や水産学の分野で活動している日本とフランスの科学者や団体の学術交流を促進することを目的として，1960 年 4 月に創立されました。当時フランスは有人潜水艇（バチスカーフ）による深海調査の分野で世界をリードしていました。1958 年にバチスカーフ FNRS-Ⅲ号が，1962 年にはアルシメード号が来日し，日本の研究者を乗せて日本海溝や千島海溝などで潜水調査を行いました。このようなフランスの先進的な活動を受けて，当時の東京水産大学教授　故佐々木忠義博士の呼びかけで，日本とフランスの海洋学と水産学の学術交流を促進するために，当学会が設立されました。初代会長の佐々木博士に宛てて，当時のパリ大学理学部教授でフランス学士院会員のルイ・ファージ博士や，当時のモナコ海洋博物館長のジャック＝イヴ・クストー氏などから賛意が寄せられています。

1963 年には学会機関誌「うみ」の発行を始めました。欧文名は“La mer”で，現在は年 4 回発行しています。今年で第 49 巻を数えます。例年 6 月に学術研究発表会と総会を開催しています。日仏海洋学会の会員は現在約 150 人です。1966 年には学会賞を，2002 年には論文賞を設けました。1984 年に，フランス国立高等研究院名誉教授ユベール・セッカルディ博士の呼びかけで，フランスにも日仏海洋学会が設立されました。日本とフランスの両日仏海洋学会は，共同して 1983 年以来ほぼ 2 年に 1 回，日本とフランスで交互に「日仏海洋学シンポジウム」を開催しています。2008 年にはフランスのマルセイユで第 13 回のシンポジウムを開催しました。

日仏海洋学会は，本拠を公益財団法人日仏会館（東京都恵比寿）に置いています。同じく日仏会館を拠点とする，人文・社会・自然科学および医学，農学，工学などのあらゆる分野の 26 学会で構成されている日仏関連学会の一つとしても活動しています。2008 年には，日本とフランスの交流が開始されて 150 年になるのを記念して，日仏会館で「日仏交流 150 周年記念日仏関連学会総合シンポジウム日仏学術交流のルネッサンス」を 3 日間にわたって開催しました。これらの，学会創立以来の 50 年にわたる活動の詳細については，次の「日仏海洋学会 50 年の歩み」をご覧下さい。

日仏海洋学会は 2010 年に学会創立 50 周年を迎えました。その記念事業として，記念シンポジウムと記念式典の開催，および学会機関誌「うみ」の記念号の発行を企画しました。創立 50 周年記念シンポジウム・式典は，第 14 回日仏海洋学シンポジウムとして，神戸で 2010 年 10 月 15 日に開催しました。これは，マルセイユの姉妹都市である神戸で隔年開催されている国際カンファレンス「テクノオーシャン」の一環として開かれたものです。記念シンポジウム・式典は，フランスからの 22 名の研究者を含む 70 名を超える参加を得て，盛大に開催されました。その詳細については，この記念号の「日仏海洋学会創立 50 周年記念行事」と「創立 50 周年記念第 14 回日仏海洋学シンポジウム」をご覧下さい。なお，この記念号の発行では，笹川日仏財団（担当：伊藤朋子氏）から格別のご支援をいただきました。

さて，この記念号を準備していた 2011 年 3 月 11 日に，東北地方太平洋沖を震源とする超巨大地震と，それに伴う超巨大津波が発生しました。さらにこの津波が原因で，福島第一原子力発電所の事故が起こり，日本はこれまでにない大災害を被りました。2 万人に近い方々が犠牲になるという未曾有の大惨事です。まさに自然の猛威を思い知らされました。被害は日本一国に留まらず，海中漂流物や放射性物質などは，近隣諸国をはじめ世界の多くの国々に大なり小なり影響を及ぼします。地震・津波の直後から，世界中の研究者や仲間からお悔みや激励のメールをいただきました。また，世界中から救援の手が差し延べられ，義援金の申し出がありました。フランスの海洋研究者からは三陸地方のカキ養殖事業に対して復興に向けての支援が届きました。今回の災害を経験して，日本は世界につながっているという思いを新たにしました。海は時々災害をもたらしますが，その恩恵も大きく，我々は将来も海に頼らざるを得ません。全人類が手を携えて海や地球との共生を図る以外に，生き延びる道はないと思います。

日仏海洋学会はこれからも日本とフランスの間の海洋学や水産学の学術交流を中心として活動を続けて参ります。今後とも，ご支援・ご鞭撻をお願いいたします。

Welcoming the 50th anniversary of society foundation

President, Japanese-French Oceanographic Society
Shiro IMAWAKI

The Japanese-French Oceanographic Society was founded in April 1960, in order to stimulate scientific exchanges between Japanese and French individuals and groups working on oceanography and fisheries. In those days, French scientists were leading the deep-sea research using manned submersibles. In 1958, *Bathyscaphe* FNRS-III and in 1962, *Bathyscaphe Archimède* visited Japan to carry out deep-sea expeditions in Japan Trench and Kuril Trench with Japanese scientists. Recognizing those advanced French activities, the late Doctor Tadayoshi Sasaki, Professor of Tokyo University of Fisheries at that time, led founding this Society, in order to stimulate scientific exchanges between Japanese and French oceanographers and fisheries researchers. Doctor Sasaki, the first President of the Society, received celebrating messages from various scientists, including Doctor Luis Fage, who was Professor of Faculty of Science, Paris University and Member of *Institut de France* at that time, and Mr. Jacques-Yves Cousteau, who was the Director of *Musée océanographique de Monaco* at that time.

In 1963, the Society started to publish the society journal "Umi," which is called "*La mer*" internationally; four issues have been published each year recently, and the latest volume is the 49th. The Society has been holding the scientific and business meeting in June every year. The Society numbers about 150 members today. The Society established the Society Award in 1966 and the Best Paper Award in 2001. In 1984, another Japanese-French Oceanographic Society was founded in France by the effort of Doctor Hubert Ceccaldi, Professor Emeritus of *L'Ecole des Hautes Études*. The Japanese-French Oceanographic Societies in Japan and France have been coordinately holding "Symposium on Oceanography in Japan and France" either in Japan or France about every two years since 1983. Its 13th symposium was held in Marseille, France in 2008.

The Society is based at *La Maison Franco-Japonaise* located at Ebisu in Tokyo, and is playing a role as a member of Japanese-French Society Consortium, which consists of 26 academic societies on humanities, social sciences, natural sciences, medical sciences, agricultures, engineering, etc. and are based at *La Maison Franco-Japonaise*. In 2008, they held a big symposium entitled "Renaissance of academic exchanges between Japan and France," celebrating the 150th anniversary of Japanese-French mutual interchange, which started near the end of "Edo" era. Those activities of the Japanese-French Oceanographic Society for 50 years since its foundation are described in details on the next section entitled "Progress of the Japanese-French Oceanographic Society in the Past 50 years".

The Society welcomed the 50th anniversary of its foundation in 2010, and decided to hold the memorial symposium and ceremony, and to publish a memorial issue of the society journal "Umi." The memorial symposium and ceremony of the 50th anniversary was held in Kobe on 15 October 2010, as the 14th "Symposium on Oceanography in Japan and France." It was held as a part of the International Conference entitled "Techno Ocean," which has been held in Kobe, a sister city of Marseille, every two years. The memorial symposium and ceremony were held successfully, being attended by more than 70 people, including 22 scientists from France. The details of those are given on sections of this special issue entitled "Commemor ative events of the 50th anniversary of society foundation" and "Commemorative symposium of the 50th anniversary of society foundation (The 14th Japanese-French Oceanography Sy mposium)". It should be noted that this special issue was financially supported by the

Fondation Franco-Japonaise Sasakawa; Ms. Tomoko Ito took special care of it.

During preparing this special issue, on 11 March 2011, Japan was attacked by the huge earthquake whose epicenter was located off the Pacific coast of Tohoku Area and subsequent devastating tsunami, which resulted in damages of Fukushima Daiichi nuclear power plants. The victims almost amounted to 20,000; it was really an unprecedented disaster. We have sincerely re-realized the rage of Nature. The damage was not limited to Japan, but drifting debris in the sea and radioactive material injected to the environment may cause more or less considerable effects to many countries in the world, especially to neighboring countries. Just after the earthquake and tsunami, we received a lot of electronic mails of sympathy and encouragement from colleagues all over the world. Japan received various kinds of relief and donation from all over the world. French oceanographers sent a specific support to fishermen in Sanriku Area to help them to recover the oyster cultivation. We have re-recognized that Japan is tightly connected with the world. On one side, we suffer damages from oceans occasionally, but on the other side, we receive tremendous benefit from the oceans and human beings shall inevitably depend on the oceans in future, too. Namely, human beings should cooperate with each other and pursue the way of living close together with the oceans and earth, which seems to be the only way for human beings to survive.

The Japanese-French Oceanographic Society will keep activities, focusing on scientific exchanges between Japan and France in the field of oceanography and fisheries. Any suggestions, encouragements and supports should be appreciated.

日仏海洋学会 50 年の歩み

日仏海洋学会副会長　森永　勤

日仏海洋学会は 1960 年 4 月 7 日に創設され，2010 年に 50 周年を迎えた。この 50 年の歳月は半世紀に当り，かっては人の一生の長さにたとえられている。これだけの期間，学会が活動・継続したことは誠にめでたい限りである。

本学会の目的は，日本とフランス両国の海洋・水産学の分野における学問的交流を組織化して，その分野での科学の協力を促進することである。このような目的の表現上の文言や字句などには経時的変化があるものの，その趣旨は発足の当時から現在まで基本的には変っていない。

日仏海洋学会は上記の目的を遂行するため，各種の事業を行っており，これらの事業を通して，歩んできた道程の諸活動を以下に振り返ってみる。

本学会が実施している研究会は，毎年，春頃に開催する学術研究発表会である。この発表会における発表件数は創立の当初は 20 件程度だったが，時代を経るにつれて次第に減少し，最近では十数件程度である。これは，学会員の専門分野，学問の細分化および研究発表の機会の増加と大いに関連していると思われる。また，研究内容の範囲は発足当時には地球科学，海洋科学，水産学を含む生物科学などの多岐にわたっていたが，時代の推移につれて次第に海洋学や水産学などの一定の分野に絞られている。なお，発表会場である公益財団法人日仏会館は最初は東京・御茶水に立地していたが，1995 年に新館落成により，恵比寿に移転，現在に至っている。

シンポジウムの開催に関しては，学会創設から約 20 年間では多くのシンポジウムが学会独自に企画され，特に深海については 10 回にも及んでいる。このことは海底資源開発を求めた産業界の要請，それに加えて，佐々木忠義初代会長（故人）の並々ならぬ熱意かと思われる。歴代会長・副会長に関しては，資料 1 を参照されたい。その後の研究内容では，時代を反映する学術諸分野のテーマに変り，1985 年頃から開催回数は減少している。この理由は本学会とフランスの仏日海洋学会との共同シンポジウムが，隔年または 3 年に一度両国で開催されていることとも関係があり，これについては後述する。最近の講演会やシンポジウムの開催では学会単独でなく，日仏会館関連諸学会をはじめとする他学会との共催で行う場合が多い。

本学会の重要事業の一つである定期刊行物は学会機関誌の「うみ」（国際名 “La mer”）である。この機関誌は学会発足 3 年後の 1963 年に第 1 巻 1 号が創刊され，最近は季刊で，2011 年に第 49 巻 1・2 号を発行した。学会誌「うみ」の掲載内容は原著論文，短報，総説，寄稿および資料などであり，学会内に編集委員会を立ち上げ，編集委員長の下で投稿論文を編集委員が査読している。印刷の刷上りページ数は年間 250 ページ程度をめどに発行してきたが，最近では総ページ数が減少している傾向にある。巻末に最近 10 年間の総目次を示す。第 22 巻 3・4 号（1984）は学会創設者，佐々木会長の追悼号であり，既刊のうち 350 ページの最大分量で特筆に値する。なお，学会誌の印刷は創刊の当初から今日まで一貫して有限会社英和出版印刷社が担当している。

学会の刊行物として，「英仏和，海洋・水産用語集」（B5 版，45 ページ）が 1967 年に発行されている。この用語集は出版当初には希少価値があり，最近では類似の事典の編集に役立っている。また，啓蒙書では，若者の読者を対象とした図書として，「海と人間」と「海に何が起っているか」が，それぞれ 1981 年と 1991 年に岩波ジュニア新書として出版され，好評を博している。さらに，会員の利便を図るため，2003 年度から研究発表会の映像を収録し，DVD に納めて保存・販売している。近年では，学会誌のバックナンバー（第 1 巻～第 45 巻）をデジタル化して全会員や関係研究機関へ無料配布している。それに加えて，2005 年度に本学会のホームページを開設して，学術情報を発信している。

学会の褒賞制度として学会賞と論文賞の授与がある。学会賞は 1966 年度に制定され，毎年，候補者推薦委員会を立ち上げて公正に選考し，評議員会の議を経て受賞者を決定している。受賞者が順次各専門分野にわたるよう配慮されている。また，論文賞は 2002 年度に制定され，若手研究者や大学院生を筆頭著者とする，「うみ」に掲載された論文を対象とし，毎年 2 件以内に授与している。これらの表彰は本学会の総会において行い，学会賞受賞者には賞状およびメダルを（創設当初は賞金も），論文賞受賞者には賞状を贈呈してい

る。資料 2 に歴代受賞者を示す。

本学会の特色として，日本・フランス両国による，調査・講演会・シンポジウムなどの共同事業がある。学会発足当時には，フランスの潜水艇による深海研究共同調査，深海に関する映画会や講演会が行われている。1985 年代の宇野寛元会長（故人）は，特に両国の水産増養殖に関して尽力し，人的交流を積極的に推進した。フランスではこの頃，国立海洋研究機関「IFREMER」が設立されている。時を同じくして，日仏会館のフランス人学長（当時の呼称）に，仏日海洋学会（1984 年にパリで設立）のユベール・セッカルデイ教授が就任し，日仏両国の交流は強固なものとなった。特に，水産学を含む海洋生物科学分野において大きな進展があった。この日仏間の協調の経緯については，本誌の第 47 巻 1・2 号（2009）に掲載された総説「海洋学および水産学分野における日仏間協調の歴史と今後」で，八木宏樹前副会長らが詳細に解説している。日本とフランスによる共同シンポジウムは 1983 年の第 1 回から 2010 年の第 14 回へと継続し，両国で開催している。資料 3 に，これまでの日仏海洋学シンポジウムの内容を示す。

以上，学会の諸活動を概観してきたが，これらを支援する主な財源は学会員や賛助会員の会費に依っている。正会員の年会費は学会設立当時 700 円，現在は 8,000 円であり，賛助会員の年会費は設立当時 5,000 円，現在は 10,000 円である。

今後，日仏海洋学会が，これまで通りの諸活動を維持・継続するには，学会の設立理念に立ち戻るのが肝要といえよう。第一には学会の「冠」である日本とフランスとの学術分野において，交流を今まで以上に一層，活発化し，それらの成果を両国の社会に還元することである。第二には，日本国内の学会活動に特色を打ち出すことである。一案として，大規模な他学会が取り組まない課題や社会的要請の強い特殊テーマの採択，開催地にフランス国内の姉妹都市や友好都市を選ぶことなどがあげられる。このためには，発展の著しい情報伝達技術を上手に活用する必要があることは言うまでもない。

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Progress of the Japanese-French Oceanographic Society in the past 50 years

Vice-President of the Japanese-French Oceanographic Society
Tsutomu MORINAGA

The Japanese-French Oceanographic Society（JFOS） was founded on April 7, 1960 and marked its 50th anniversary in 2010. The period of 50 years corresponds to a half century, and that was a human's life-span in the past. We are delighted that the society has been very active and ongoing for such a long time.

The objectives of the society are to systematize the academic exchange between Japan and France in the fields of oceanography and fisheries, and to promote scientific cooperation in those fields. The words and text for expressing such objectives have changed over time, but the intent has not changed basically from the starting time through the present.

The JFOS has been carrying out various projects to fulfill those objectives. In the following, we will look back at the activities that the society has undertaken during the process of carrying out these projects.

The society has been holding the academic research conference every year around the spring. The number of presentations at the conference was about 20 when it was started. However, the number has gradually decreased over time, and is approximately over a dozen in recent years. This may be very much related to the specialty segmentation of the society members, the segmentation of academic research, and increase in the presentation opportunity of research papers. Also, in the past, the research contents ranged widely from earth science and oceanographic science to biological sciences including fisheries science. However, they were gradually narrowed down, over time, to the fixed areas such as oceanography and fisheries science. The conference venue, the Japanese-French Hall (Maison franco-japonaise), was originally located at Ochanomizu in Tokyo; it was moved to Ebisu after the opening of the new building in 1995.

For about 20 years from the foundation of the society, numerous symposia were held by the society. In particular, symposia concerning the deep-sea research were held ten times. It is partly because there was a request from the industry, for the development of ocean floor resources, and partly because the deceased first President Tadayoshi Sasaki had an extraordinary ambition. In Document 1, all the past presidents and vice-presidents are listed. The research contents thereafter changed to various academic themes that reflect the times, and the number of symposia has decreased since around 1985. The reason for this is related to the symposia held jointly with the JFOS in France every two to three years; the details of those symposia will be described later. Recent lecture meetings and symposia are often cohosted with other societies including various societies affiliated with the Japanese-French Hall (Maison franco-japonaise).

The periodical publication of the society, which is one of the most important projects, is the journal “La mer” named “Umi” in Japanese. The journal was first published in 1963; it is three years after the foundation of the society. Lately, the journal has been issued quarterly, and Vol. 49, No. 1/2 was published in 2011. The society journal “La mer” contains original papers, short communications, reviews, contributed articles, and other information. An editorial committee has been set up in the society, and submitted papers are reviewed by committee members under the direction of the editorial committee chair. The number of printed pages used to be about 250 pages per year, but the total number of pages has been trending downward in recent years. At the end of this issue, the entire contents for the recent ten years are shown. Vol. 22, No. 3/4 (1984) was a memorial issue for the society founder, the first President Sasaki; the issue contained the largest amount of pages (350 pages) among the published issues. The society journal has always been printed by Eiwa Publishing Co., Ltd. from the first issue through the present issue.

As a publication of the society, there is the “English-French-Japanese Glossary for Oceanography and Fisheries” (B5 size, 45 pages), published in 1967. This glossary had a rarity value. In recent years, it has been useful for the compilation of similar dictionaries. As enlightening books for young readers, “Sea and Human-Beings” and “What is Happening in the Sea” were published in 1981 and 1991, respectively, in the “Iwanami Junior Shinsho” series. Both books have been well-received. Furthermore, for the convenience of the society members, videos of scientific conferences have been recorded, stored in DVD, and sold since 2003. In recent years, the back issues of the society journal (Volume 1 to Volume 45) were digitized and distributed for free to all the society members and the related research organizations. In addition, we set up the Website of the society in 2005, in order to send out academic information about the society.

The awarding system of the society includes the Society Award and Best Paper Award. The Society Award was established in 1966. Each year, we set up a candidate recommendation committee, carry out a fair selection, and decide award winners through the discussion by the council. Award winners are carefully selected so that we cover each field of specialization in turn. The Best Paper Award was established in 2002; the papers published in “La mer” by young researchers or graduate students as the first author during the latest two years are the candidates, and one or two papers are awarded each year. These awards are presented at an annual general meeting of the society. The Society Award is presented with an award certificate and a medal (also reward when it was established), and the Best Paper Award is presented with an award certificate. In Document 2, all the past award winners are listed.

As distinctive features of the society, we have carried out joint projects such as surveys, lecture meetings, and symposia by both the JFOS in Japan and JFOS in France. When our society was founded, the joint deep-sea investigations with French submarines were carried out, and the movie and lecture meetings concerning the deep sea were also held. Around 1985, the deceased third President Yutaka Uno was committed especially to aquaculture of both countries and actively promoted the exchange of people between the two countries. Around this time, the Institut Francais de Recherche de la Mer "IFREMER" was established in France. At the same time, Professor Hubert-Jean Ceccaldi made an effort to found the JFOS in Paris in 1984, and also took up the post as the French President (designation around that time) of the Japanese-French Hall (Maison franco-japonaise). Thus, the exchange between Japan and France was strengthened. In particular, there was a remarkable progress in the fields of marine biological science including fisheries science. The development of Japanese-French collaboration was described in detail, by the former Vice-President Hiroki Yagi and others, in the review paper entitled "History and Future of Japanese-French Collaboration in the Fields of Oceanography and Fisheries Science" published on "La mer" Vol. 47, No. 1/2 (2009). The Japanese-French joint symposia were repeatedly held from No. 1 in 1983 to No. 14 in 2010 in either Japan or France. In Document 3, the contents of those Japanese-French Oceanographic Symposia are listed.

As mentioned above, the society has carried out various activities. The main supporting funding for these activities is the membership dues from the society members and supporting members. The annual membership fee for a regular member was 700 yen when the society was founded, and presently it is 8,000 yen. The annual membership fee for a supporting member was 5,000 yen when the society was founded, and presently it is 10,000 yen.

For the JFOS to maintain and continue various activities hereafter as in the past, it is essential to return to the founding philosophy of the society. Firstly, we have to revitalize, more than ever, the academic exchange between Japan and France, which is the top priority of the society, and to give back the achieved results to the public of both countries. Secondly, we have to add unique features to the society activities in Japan. Followings are some suggestions; subjects which other large societies exclude and unique themes with strong societal demand should be selected as conference themes, and sister cities and friendship cities in France should be chosen as conference venues. Needless to say, we should effectively apply fast-developing communication technology for these purposes.

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資料 1 日仏海洋学会歴代会長および副会長

Document 1 President and Vice-President of the Japanese-French Oceanographic Society

期間 Period	会長 President	副会長 Vice-president	
1960-1976	佐々木 忠義 Tadayoshi SASAKI		
1977-1981	佐々木 忠義 Tadayoshi SASAKI	黒木 敏郎 Toshio KUROKI	国司 秀明 Hideaki KUNISHI
1982-1983	佐々木 忠義 Tadayoshi SASAKI	国司 秀明 Hideaki KUNISHI	高野 健三 Kenzo TAKANO
		冨永 政英 Masahide TOMINAGA	
1984-1985	冨永 政英 Masahide TOMINAGA	高野 健三 Kenzo TAKANO	森田 良美 Yoshimi MORITA
1986-1987	宇野 寛 Yutaka UNO	高野 健三 Kenzo TAKANO	内田 宏 Hiroshi UCHIDA
1988-1990	宇野 寛 Yutaka UNO	高木 和徳 Kazunori TAKAGI	
1990-2000	有賀 有勝 Yusho ARUGA	高木 和徳 Kazunori TAKAGI	岡市 友利 Tomotoshi OKAICHI
2000-2001	須藤 英雄 Hideo SUDO	青木 三郎 Saburo AOKI	今脇 資郎 Shiro IMAWAKI
2002-2003	須藤 英雄 Hideo SUDO	山口 征矢 Yukuya YAMAGUCHI	今脇 資郎 Shiro IMAWAKI
2004-2005	須藤 英雄 Hideo SUDO	山口 征矢 Yukuya YAMAGUCHI	八木 宏樹 Hiroki YAGI
2006-2007	須藤 英雄 Hideo SUDO	山口 征矢 Yukuya YAMAGUCHI	八木 宏樹 Hiroki YAGI
		小池 康之 Yasuyuki KOIKE	
2008-2009	今脇 資郎 Shiro IMAWAKI	森永 勤 Tsutomu MORINAGA	八木 宏樹 Hiroki YAGI
2010-2011	今脇 資郎 Shiro IMAWAKI	森永 勤 Tsutomu MORINAGA	小松 輝久 Teruhisa KOMATSU

資料 2a **日仏海洋学会賞受賞者および受賞課題**

Document 2a Liste des laureats du Prix de la Societe franco-japonaise d'oceanographie

1966	高野　健三 Kenzou TAKANO	風の応力と海面での海水密度の不均一を考えた海水大循環に関する一連の研究 Une seri de travau sur la circulation generale dans un ocean
1967	鬼頭　正隆 Masataka KITOU	北太平洋における毛顎動物の分布生態に関する研究―特に深層水の動きに関連して― Recherches morphologiques sur les chaetognathes du Pacifique du nord
1968	今村　　豊 Yutaka IMAMURA	漁業における火光の集魚効果とその操法研究 Etude de l'effet du feu sur la peche et de son operation
1970	杉浦　吉雄 Yoshio SUGIURA	日本近海海水の海洋化学的研究 Recherches chimiques des eaux aux environs du Japon
1971	冨永　政英 Masahide TOMINAGA	沿岸波浪および内部波に関する一連の研究 Recherches sur les vagues et les condes internes
1972	宇野　　寛 Yutaka UNO	水族生物の増養殖に関する生態学的研究 Recherches ecologiques de l'elevage de l'oreille de mer
1973	草下　考也 Takaya KUSAKA	魚類の顔面骨、特に尾舌骨の形状に関する水産学的研究 Recherches morphologiques sur l'os urohyyal et sur les osFaciauxdes poissons
1974	松生　　洽 Kanau MATSUIKE	大洋における光学的性質に関する研究 Recherches sur les proprieties optiques de l'eau en plein ocean
1975	丸茂　隆三 Ryuzou MARUMO	東京湾のプランクトン群集の遷移に関する研究 Etude sur la succession de la communaute planctoniquedans la Baie de Tokyo
1976	阿部　友三郎 Tomosaburou ABE	安定海水泡沫に関する一連の研究 Recherches sur les bulles stables d'eau de mer
1977	有賀　祐勝 Yusho ARUGA	藻類の生産に関する生理生態学的研究 Recherches physio-ecologiques sur la production organique par les algues
1978	根本　敬久 Takahisa NEMOTO	おきあみ類をめぐる生物生態に関する研究 Recherches ecologique d'etre vivant relative aux euphausuaces
1979	井上　　実 Makoto INOUE	魚類の行動と漁法に関する一連の研究 Une serie des recherché sur les comportements de poisons et La methodologie de peches
1980	岡見　　隆 Noboru OKAMI	海洋光学に関する一連の研究 Une serie des recherché sur l'optique oceanographique
1981	村野　正昭 Masaki MURANO	動物プランクトン、特にあみ類の分類学的ならびに漁業生物学的研究 Recherches taxonomiques et biologiques peches sur les Zooplanktons, particulierement Mysidaces

1982	鎌谷　明善 Akiyoshi KAMATANI	海洋における生体元素、特に珪素の循環機構に関する研究 Recherches sur les mechanisms de circulation des bioelements, particulierement du silicium, dans la mer
1983	中村　重久 Shigehisa NAKAMURA	海岸付近における波の防災科学的研究 Recherches scientifiques sur les vagues cotieres pour la Prevention des desastres
1984	竹松　　伸 Noburu TAKEMATSU	海洋循環における遷移元素の沈降機構に関する研究 Study on sedimentation mechanism of transition elements in Oceanic circulation
1985	永沢　祥子 Sachiko NAGASAWA	毛顎類の生態および海洋生態系におけるその役割に関する一連の研究 Studies on the ecology of chaetognaths and their role inmarine Ecosystems
1986	柳　　哲雄 Tetsuo YANAGI	沿岸海洋過程に関する研究 Physical oceanography on coastal processes
1987	谷口　　旭 Akira TANIGUCHI	植食性プランクトンの生産生態に関する研究 Production ecology of the planktonic grazers in the sea
1988	青木　三郎 Saburou AOKI	海底堆積物中の粘土鉱物組成及び鉱物化学的性質に関する研究 Les compositions et les proprieties chimiques des mineraux Agrileux dans les sediments marins
1989	山口　征矢 Yukuya YAMAGUCHI	植物プランクトンの基礎生産、特に低温水域の基礎生産に関する研究 Studies on phytoplankton primary productivity with special reference to low temperature waters
1990	落合　正広 Masahiro OCHIAI	河口域における懸濁有機物の挙動に関する研究 Etude sur la comportement de la matiere organique particulaire dans l’estuaire
1991	今脇　資郎 Shiro IMAWAKI	海洋における中規模渦の力学に関する研究 Study on dynamics of oceanic mesoscale eddies
1992	小池　勲夫 Isao KOIKE	海洋の窒素循環に関する研究 Study on nitrogen dynamics in the ocean
1993	岸野　元彰 Motoaki KISHINO	海洋の光環境と生物生産に関する研究 Studies on optical environment and biological production in the ocean
1994	門谷　　茂 Shigeru MONTANI	浅海域の生物起源粒子の生成・崩壊過程に関する化学的研究 Biochemical studies on the generation and decay processes of coastal biogenic particles
1995	関根　義彦 Yoshihiko SEKINE	黒潮蛇行および黒潮域を中心とした海洋過程に関する研究 A series of study on large meander of the Kuroshio and oceanic processes around the Kuroshio region
1996	小池　　隆 Takashi KOIKE	海中動物の対光行動に関する研究 Studies on behavior of marine animals under various light conditions

1997	松山　優治 Masaji MATSUYAMA	駿河湾および相模湾の内部潮汐と沿岸急潮に関する研究 Study on internal tide and Kyuchou in Suruga and Sagami Bays
1998	前川　行幸 Miyuki MAEGAWA	アラメ・カジメを中心とした大型海藻の生理生態学的研究 Physio-ecological studies on marine macro algae, *Eisenia arborea and Ecklonia cava*
1999	須藤　英雄 Hideo SUDO	北西太平洋および日本海の深層循環に関する研究 Studies on deep circulation of the northwestern Pacific Ocean and the Japan Sea
2000	關　　文威 Humitake SEKI	海洋植物網における腐食連鎖の卓越性に関する主導的研究 Original achievements leading inductivrly towards quantative evalution of detritus food chains in the marine foodweb
2001	寺崎　　誠 Makoto TERASAKI	肉食プランクトン、毛顎動物の生態学的研究 Ecological studies on carnivorous plankton chaetognatha
2002	平　　啓介 Keisuke TAIRA	直接測流による黒潮および亜熱帯環流系の研究 Studies on the Kuroshio and the North Pacific Subtropicalgyre by direct current measurement
2003	前田　昌調 Masachika MAEDA	微生物による水産増養殖環境の制御に関する研究 Interactions of microorganisms and their use as biocontrol agenta in aquaculture
2004	磯田　　豊 Yutaka ISODA	日本海の表層循環流に関する研究 Study on surface circulation current of the Japan Sea
2005	石丸　　隆 Takashi ISHIMARU	東京湾・相模湾を中心とした沿岸生態系の研究 Study on coastal ecology system in Tokyo and Sagami Bays
2008	吉田　次郎 Jiro YOSHIDA	海洋微細構造に関する研究 Study on microstructure in the ocean
2009	河野　　博 Hiroshi KOHNO	仔稚魚の分類と生態に関する研究 Study on taxonomy and ecology of fish larvae and juneviles
2010	小松　輝久 Teruhisa KOMATSU	藻場の環境と生態および分布に関する研究 Studies on environments, ecology and distributions of seagrass and seaweed beds

資料 2b　日仏海洋学会論文賞受賞者および受賞論文

Document 2b　Liste des laureats du Prix d'Article de la Societe franco-japonaise d'oceanographie

2002	森永　　勤 Tsutomu MORINAGA	Distribution of underwater irradiance and estimated light attenuation by oil slick in the ROPME sea area. La mer, 37 (4), 173-181.
	鷲見　浩一 Kouichi SUMI	Research on providing habitable environment for bivalves by use of artificial reefs. La mer, 38 (1), 11-25.
2003	堀本　奈穂 Naho HORIMOTO	The distribution of picopytoplankton across Kuroshio current off the Wastern Pacific Coast, Japan reefs La mer, 39 (4), 181-195.
2004	藤村　弘行 Hiroyuki FUJIMURA	サンゴ礁海域における二酸化炭素分圧と大気-海洋間の CO_2 フラックス.うみ 40 (3), 99-109. Carbon dioxide and air sea co_2 flux in coral reef. La mer, 40 (3), 99-109.
	謝　旭 Xuhui XIE	南大洋インド洋セクターの海氷密度に見られる西方伝播シグナル. A westward propagation signal in the sea ice concentration in the Indian sector of the Southern Ocean. 43 (3)　89-96, 2005
2008	土井　　航 Wataru DOI	Growth and reproduction of the pilumnid crab Benthopanope indica　(Decapoda: Brachyura)　in Tateyama Bay, Japan. La mer, 45 (3), 135-147.
	嶋田　啓資 Keishi SHIMADA	Distribution of density ratio in the North Pacific. La mer, 45 (3), 149-158.
2009	黒田　　寛 Hiroshi KURODA	Diurnal Tidal Current on the Eastern Shelf of Hidaka Bay -Can juvenile walleye pollock, Theragra chalcogoramma, move southeastward with the diurnal tidal current? La mer, 46 (1-2), 37-47.
	伊沢　瑞夫 Mizuo IZAWA	大船渡湾における養殖マガキからの沈降粒子フラックスの見積り ―10 年間の月別平均環境データを用いた季節変動と経年変動― Estimation of the sediment flux from the cultured Japanese oyster in Ofunato Estuary and its annual variation-Calculation by incorporating the monthly mean environmental data for ten years. La mer, 43 (4),44 (1), 117-128.
2010	安倍　大介 Daisuke AMBE	Transition to the Large Meander Path of the Kuroshio as Observed by Satellite Altimetry. La mer, 47 (1-2), 19-27.
2011	橋濱　史典 Fuminori HASHIHAMA	Automated colorimetric determination of trace silicic acid in seawater by gas-segmented continuous flow analysis with a liquid waveguide capillary cell. La mer, 47 (4), 119-127.
	Andreas A.HUTAHAEAN	Development of Algorithms for Estimating the Seasonal Nitrate Profiles in the Upper Water Column of the Sagami Bay, Japan.La mer, 48　(2), 71-86

資料 3 日仏海洋学シンポジウム一覧
Document 3 List of the contents of Japanese-French Oceanographic Symposia

	テーマ Theme	開催地 Location	開催年度 Year
第 1 回 First	水産増養殖 Aquaculture	モンペリエ Montperllier	1983
第 2 回 Second	水産増養殖 Aquaculture	仙台 Sendai	1984
第 3 回 Third	沿岸域における管理と計画 Coastal management and littoral planning	マルセイユ Marseille	1985
第 4 回 Fourth	海洋学の全般 General oceanography	清水 Shimizu	1988
第 5 回 Fifth	瀬戸内海における海藻公園の創設 Founding an algal park in Seto-nai-kai	広島・東野 Hiroshima, Higashino	1989
第 6 回 Sixth	海岸線と法律規制 Coastline and conflicts	東京 Tokyo	1990
第 7 回 Seventh	海における生物資源供給の決定論 Determination of biological recruitment at sea	東京 Tokyo	1990
第 8 回 Eighth	水産増養殖の生長の決定要因、 Determing factors of the growth in aquaculture 漁業経済と管理、 Economy and management of fisheries 沿岸域の漁業とレジジャー活動との共同開発 Co-development of fisheries and leisure in coastal zones	ナント Nantes	1991
第 9 回 Ninth	オーシャン・フラックス Oceanic fluxes	東京 Tokyo	1991
第 10 回 Tenth	バイオテクノロジイと環境 Biotechnology and environment 海の生物資源供給の決定論 Determinism of biological recruitment at sea	東京 Tokyo	1992
第 11 回 Eleventh	沿岸海域の観測・予報および継続 Coastal zone observation and forecast in the medium and long term	パリ Paris	1997
第 12 回 Twelfth	日本とフランスの海洋学と水産の相互理解 Mutual new understanding for research in oceanography and fisheries, in France and in Japan	東京 Tokyo	2005
第 13 回 Thirteenth	地球変動；人類と海洋環境の相互作用 Global change: interaction mankind/marine environment	マルセイユ Marseille	2008
第 14 回 Fourteenth	海洋の持続可能な利用と管理に向けて Towards sustainable use and Management of the oceans	神戸・東京 Kobe，Tokyo	2010

学会創立 50 周年記念事業

日仏海洋学会　庶務幹事　荒川　久幸

1. 記念事業の概要

日仏海洋学会（1960 年 4 月創設）は 2010 年に創立 50 周年を迎えた。その記念事業として，日仏海洋学会創立 50 周年記念シンポジウム（第 14 回日仏海洋学シンポジウム）を開催し，記念式典を挙行した。また，La mer の特別号（本号）を発刊し，学会 50 年の歩みとともに，記念シンポジウム・式典の記録などを掲載した。

2009 年 6 月の総会において，2010 年度に学会創立 50 周年事業を行うことが確認され，実行委員会が設立された。実行委員会は，今脇資郎会長を委員長とし，河野博庶務幹事および小松輝久副会長を，それぞれ，記念シンポジウム第 1 部担当副委員長およびフランス訪日団担当副委員長，森永勤副会長を記念シンポジウム第 2 部担当副委員長とした。その他の実行委員は，八木宏樹，吉田次郎，田中祐志，小林雅人，木谷浩三，寺崎誠，和泉充，中田英昭，小池康之，井上敏彦，山崎秀勝，神田穣太，茂木正人，堀本奈穂，荒川久幸の 15 名である。実行委員会は数回の会合を重ね，幹事会とも連携して準備を進めた。2010 年 5 月に La mer 48 巻 1 号の発送に併せて，記念事業の概要が会員に配布された。

学会創立 50 周年記念シンポジウムは 2 部で構成され，第 1 部は 2010 年 10 月 15 日（金）に神戸国際展示場で，第 2 部は 10 月 19 日（火）に日仏会館で開催された。いずれも多数の参加者を得て，成功を収めた。このシンポジウムの中で，日本，フランス両国の海洋学分野での交流は一層促進され，今後のさらなる発展を約束した。創立 50 周年記念式典は，神戸での記念シンポジウム第 1 部に続いて挙行された。

2. 創立 50 周年記念式典

学会創立 50 周年記念式典は，2010 年 10 月 15 日（金）16 時 45 分から神戸国際展示場第 3 ホールにおいて森永副会長の進行により挙行された。初めに今脇会長の式辞があり，続いて，フローランス・リヴィエール＝ブリス在日フランス大使館科学技術参事官（祝辞を小松副会長が代読），矢田立郎神戸市長（小柴義博副市長が代読），ディディエール・レオーマルセイユ市代表，マルク・アンベール日仏会館フランス事務所代表（小松副会長が代読），小池勲夫日本海洋学会会長，浦環テクノオーシャン・ネットワーク理事長（堀田平理事が代読），およびユベール・セッカルディ仏日海洋学会会長から祝辞をいただいた。これらの式辞および祝辞のオリジナルとその仏・和訳を以下に掲載する。仏訳に際しては，学習院大学文学部のマルチヌ・カルトン講師にご協力いただいた。

続いて，本会の発展に永年貢献していただいた以下の賛助団体に，今脇会長より感謝状を贈呈した：いであ株式会社，JFE アドバンテック株式会社，海洋生物研究所，EMS 株式会社，英和印刷（当日ご欠席のため，10 月 19 日の総会において贈呈）。次に，参加者全員に記念品として「ツナミン」（八洲商事株式会社）を配布した。最後に，マルセイユ海洋研究センターのイワン・ディケゼール博士が閉会の言葉を述べた。記念式典には約 70 名（うちフランス側 22 名）の参加があった（写真 1）。式典の式次第を本号の 64 ページに示す。

Commemorative events of the 50th anniversary of society foundation

General Affairs Secretary, Japanese-French Oceanographic Society
Hisayuki Arakawa

1. Summary of the Commemorative events

Japanese-French Oceanographic Society, founded in April 1960, reached its 50th anniversary in 2010. As memorial events, we held the commemorative symposium of the 50th anniversary, which was regarded as the 14th

Japanese-French oceanography symposium. In addition, we held the commemorative ceremony of the 50th anniversary. We also published a special issue (this issue) of the Society journal *La mer*, in order to document the progress of the Society over the last 50 years, and record the commemorative symposium and ceremony.

In the general meeting of the Society in June 2009, it was decided that the 50th anniversary events would be performed in 2010, and an ad hoc Executive Committee was established.Shiro IMAWAKI,the President of the Society,led the Executive Committee as the Chair; Hiroshi KONO, General Affairs Secretary of the Society, was appointed as the Vice Chair in charge of commemorative symposium Part 1, Teruhisa KOMATSU, the Vice President of the Society, as the Vice Chair in charge of affairs of French visitors, and Tsutomu MORINAGA, the Vice President of the Society, as the Vice Chair in charge of commemorative symposium Part 2. Other members of the Committee were Hiroki YAGI, Jiro YOSHIDA, Yuji TANAKA, Masato KOBAYASHI, Kozo KITANI, Makoto TERASAKI, Mitsuru IZUMI, Hideaki NAKATA, Yasuyuki KOIKE, Toshihiko INOUE, Hidekatsu YAMASAKI, Jyota KANDA, Masato MOTEKI, Naho HORIMOTO and Hisayuki ARAKAWA.The Executive Committee met repeatedly and pushed forward the preparations, collaborating with the secretary group of the Society. In May 2010, the summary of the commemorative events was informed to the Society members on the occasion of distributing *La mer* Vol. 48 No. 1.

The commemorative symposium of the 50th anniversary consisted of two parts; the Part 1 of the symposium was carried out at the Kobe International Exhibition Hall on October 15, 2010, and the Part 2 was carried out at "la Maison Franco-Japonaise" in Tokyo on October 19, 2010. Both meetings were well attended with a great success.The interchange in the field of oceanography between Japan and France was promoted quite well by this symposium, and we promised further development in the future. The commemorative ceremony of the 50th anniversary was held just after the Part 1 of the commemorative symposium in Kobe.

2. Commemorative ceremony of the 50th anniversary

The commemorative ceremony of the 50th anniversary of foundation of the Japanese-French Oceanographic Society was carried out by chairmanship of Vice President MORINAGA at the Third Room of the Kobe International Exhibition Hall from 16:45 on October 15, 2010, just after the Part 1 of the commemorative symposium. Firstly the opening address was given by the President of the Society, Dr. IMAWAKI. Successively, congratulatory messages were given by Mrs. la Conseillere Florence RIVIERE-BOURHIS (Scientific Counselor, Embassy of France in Japan; the message was read by Vice President KOMATSU), Mr. Tatsuo YADA (Mayor of Kobe City; read by Vice Mayor Yoshihiro KOSHIBA), Mr. Didier REHAULT (Representative of Marseille City), Prof. Marc HUMBERT (Director of Maison Franco-Japonaise de Tokyo; read by Vice President KOMATSU), Prof. Isao KOIKE (President of the Oceanographic Society of Japan), Prof. Tamaki URA (President of Techno-Ocean Network; read by Director Hitoshi HOTTA), and Prof. Hubert CECCALDI (President of the Soci été franco-japonaise d'Océanographie de la France). The originals of these messages with their French or Japanese translations are recorded below; for French translation, we received great contribution from Dr. Martine CARTON, Lecturer of the Department of Literature, the Gakushuin University.

Then, President IMAWAKI presented gratitude letters to the following support members who have contributed to the development of the Society for long years; IDEA Consultants, Inc., JFE Advantech Co., Ltd., Marine Ecology Research Institute, EMS Inc., and Eiwa Press Ltd. After that, we distributed "Tunamin" (Yashima Shoji Co., Ltd.) to all the participants as souvenirs. Finally, Dr. Ivan DEKEYSER (Center of Oceanography of Marseille) made the closing remarks. Approximately70 people, including 22 from the French side, participated in the commemorative ceremony (see Photograph 1). The program of the ceremony is shown on p. 64 of this issue.


Techno-Ocean 2010
A New Era of the Ocean
October 14-16, 2010 KOBE, JAPAN
KOBE INTERNATIONAL EXHIBITION HALL 2
Célébration du 50ème Anniversaire
de la Société franco-japonaise d'Océanographie

写真 1（Photo 1）

学会創立 50 周年記念シンポジウム
（第 14 回日仏海洋学シンポジウム）

「海洋の持続可能な利用と管理に向けて」

日仏海洋学会は学会創立 50 周年を記念して 2010 年 10 月にシンポジウムを開催した。記念シンポジウムは 2 部構成で，第 1 部を 10 月 15 日に神戸国際展示場で開催し，第 2 部を 10 月 19 日に東京日仏会館で開催した。

記念シンポジウム第 1 部は，本学会が共催団体として参加した，テクノオーシャン・ネットワーク主催の国際コンベンション「Techno-Ocean 2010」の一部として開催した。コンベンションの全体テーマは “A New Era of the Ocean（今はじまる海洋新時代）” であった。その中で記念シンポジウムのテーマは “Towards sustainable use and management of the oceans（海洋の持続可能な利用と管理に向けて）” であった。シンポジウムは 2010 年 10 月 15 日（金）8 時 30 分から神戸国際展示場第 3 ホールにおいて行われた。まず基調講演として，ドゥニ・バイイ教授（フランス西ブルターニュ大学）と柳哲雄教授（九州大学）の講演があり，続いて 16 題の口頭発表と 20 題のポスター発表があった。最後に，日本側およびフランス側研究者による円卓会議でシンポジウムを締めくくった。シンポジウムには約 70 名の参加があった。

記念シンポジウム第 2 部は同年 10 月 19 日（火）に東京恵比寿の日仏会館大ホールにおいて，日仏会館の共催，笹川日仏財団の後援の下で行われた。今脇資郎会長の挨拶に続き，「海洋学分野における 50 年の日仏協力とその成果」をテーマに，森永勤副会長，イブ・エノック博士（IFREMER），ユベール・セッカルディ仏日海洋学会会長の 3 名による講演があった。続いて藤原義弘博士（JAMSTEC）とパスカル・ジャニー氏（マルセイユ市）による「海洋における生物多様性の重要性」に関する講演があった。シンポジウムには 28 名が参加した。

以下に，まず記念シンポジウム第 1 部のプログラムを掲載する。続いて学会創立 50 周年記念式典の式次第を示す。最後に記念シンポジウム第 2 部のプログラムを示す。

4. Commemorative symposium of the 50th anniversary of society foundation
(The 14th Japanese-French Oceanography Symposium)

“Towards sustainable use and management of the oceans”

The Japanese-French Oceanographic Society held the commemorative symposium in October 2010, celebrating the 50th anniversary of society foundation. The commemorative symposium consisted of two parts; the Part 1 of the symposium was carried out at the Kobe International Exhibition Hall on October 15, 2010, and the Part 2 was carried out at “la Maison Franco-Japonaise” in Tokyo on October 19, 2010.

The Part 1 of the commemorative symposium was held as a part of the International Convention “Techno-Ocean 2010”, which the Society participated in as a co-sponsor. The theme of the whole convention was “A New Era of the Ocean”. The theme of our commemorative symposium was “Towards sustainable use and management of the oceans”. The symposium was held at the Third Room of the Kobe International Exhibition Hall from 8:30 on October 15, 2010. At first, two keynote lectures were given by Professor Denis BAILLY (University of Bretagne Occidentale) and Professor Tetsuo YANAGI (Kyushu University). After that, we had 16 oral presentations and 20 poster presentations. Finally the symposium was completed by a round table discussion by researchers from both Japanese and French sides. Approximately 70 participants attended the symposium.

The Part 2 of the commemorative symposium was held at the Main Hall of "la Maison Franco-Japonaise" in Ebisu, Tokyo on October 19, 2010 under the co-sponsorship of "la Maison Franco-Japonaise" and the support of "Fonda tion Franco-Japonaise Sasakawa". At the beginning, Shiro IMAWAKI, the President of the Society, made an opening address. Under the theme of "Cooperation between Japan and France in the oceanography field for 50 years and its results", three presentations were given by Tsutomu MORINAGA, the Vice President of the Society, Dr. Yves HENOCQUE (IFREMER), and Prof. Hubert CECCALDI, the President of the Société franco-japonaise d'Océanographie de la France. Then, under the theme of "Importance of the biodiversity in the ocean", two lectures were given by Dr. Yoshihiro FUJIWARA (JAMSTEC) and Mr. Pascal JANIE (Marseilles City). 28 people participated in the symposium.

The program of the symposium Part 1 is shown below, followed by the program of the commemorative ceremony, and finally the program of symposium Part 2 is given.

"Célébration du 50ème Anniversaire de la Société franco-japonaise d'Océanographie"
Theme: Towards sustainable use and management of the oceans

(A) Commemorative Symposium Part 1
Meeting Place: 3rd Room of the Kobe International Exhibition Hall
Date: October 15, 2010

08:30－09:30
Chair persons: **Dr. Yves HENOCQUE** (Division of Prospective and Strategy, IFREMER / Ocean Policy Research Foundation, Japan) and **Dr. Shiro IMAWAKI** (JAMSTEC)

Keynote presentations
Prof. Denis BAILLY (Centre of Law and Economy of the Sea, University of Bretagne Occidentale)
An attempt to develop new tools to represent natural processes, economical and social parameters in the use of coastal systems: the SPICOSA project
Prof. Tetsuo YANAGI (Research Institute for Applied Mechanics, Kyushu University)
Concept and practices of Satoumi in Japan and lessons learned

Coffee break

09:45－11:45
Oral presentations (Part 1)
Chair persons: **Prof. Jiro YOSHIDA** (Faculty of Marine Science, Tokyo University of Marine Science and Technology) and **Prof. Denis BAILLY** (Centre of Law and Economy of the Sea, University of Bretagne Occidentale)

1. Understanding of ecosystem and its model
(1) **Dr. M.C.VILLANUEVA** (Channel and North Sea Fisheries Department, IFREMER)
The Charm Project: Defying the Channel's loss by facing environmental challenges across borders
(2) **Prof. Kisaburo NAKATA** (Faculty of Marine Scinece, Tokai University)
Coastal ecosystem model as a tool of environmental management

2. Water quality and its control
(3) **Prof. Mitsuru HAYASHI** (Research Center for Inland Seas, Kobe University)
Dissolved Inorganic Nitrogen budget for the inner part of Manila Bay, Philippines
(4) **Dr. M. Etienne CLAMAGIRAND** (Architeuthis Ltd.)
The Cap Sicié ecological restoration unit for marine environment

Chair persons: **Prof. Hiroshi KOHNO** (Faculty of Marine Science, Tokyo University of Marine Science and Technology) and **Dr. Georges STORA** (Center of Oceanography of Marseille, University of the Méditerranée)

3. Fisheries impact on marine ecosystems and sustainable use of fish stock

(5) **Dr. Patrick Prouzet** (Laboratory of Fisheries Resources of Aquitaine, IFREMER)
Toward a systemic approach to fisheries management: The European eel (*Anguilla anguilla*) case

(6) **Dr. Minoru Tomiyama** (Chita Agriculture, Forestry, and Fisheries Office, Aichi Prefecture)
Practice of sandeel fisheries management in Ise Bay toward responsible and sustainable fisheries

4. Ecosystem management across borders

(7) **Mr. Genki Terauchi** (Northwest Pacific Region Environmental Cooperation Center & NOWPAP CERAC)
Satellite based monitoring of marine and coastal environment of the Northwest Pacific

(8) **Dr. Delphine Thibault-botha** (Center of Oceanography of Marseille, University of the Méditerranée？)
The MERMeX program for the Mediterranean Sea

11:45－13:00
Group photo and lunch

13:00－13:30
Poster session

13:30－15:30
Oral presentations (Part 2)
Chair persons: **Prof. Hisayuki Arakawa** (Faculty of Marine Science, Tokyo University of Marine Science and Technology) and **Prof. Ivan Dekeyser** (Center of Oceanography of Marseille, University of the Méditerranée)

5. Technology for sustainable development

(9) **Dr. Emilia Medioni** (Department of Sustainable Development, Marseille City)
Prado reefs program: an exemplary Marseille coastal management project

(10) **Dr. Guy Herrouin** (Pôle Mer, Provence Alpe Côte d'Azur)
New ecological engineering for the marine coastal areas

6. New monitoring method

(11) **Dr. Masahiko Sasano** (National Maritime Research Institute)
A new method for coral monitoring using boat-based fluorescence imaging lidar

(12) **Dr. Madeleine Goutx** (Center of Oceanography of Marseille, University of the Méditerranée)
New observation tools (fluorescence sensors) for monitoring pollutants in marine areas submitted to urban inputs

Chair persons: **Prof. Jota Kanda** (Faculty of Marine Science, Tokyo University of Marine Science and Technology) and **Prof. Hubert Jean Ceccaldi** (University of the Méditerranée & Academy of Sciences, Letters and Arts of Marseille)

7. Marine policy

(13) **Mr. Takashi Ichioka** (Ocean Policy Research Foundation)
Initiatives toward integrated coastal management in Japan

(14) **Mr. Jean-Charles Lardic** (Secretary General, Marseille City)
Marseilles Municipality: major improvement in marine governance and international cooperation to contribute to "peaceful" management of the Mediterranean Sea

8. Education for protection and sustainable use of marine environments

(15) **Prof. Hiroshi Kohno** (Faculty of Marine Science, Tokyo University of Marine Science and Technology)
An introduction to EDOMAE ESD: Education for a sustainable Tokyo Bay learning through a university and coastal communities partnership

(16) **Prof. Hubert Jean Ceccaldi** (University of the Méditerranée & Academy of Sciences, Letters and Arts of Marseille)
An important and original teaching method to sensibilise the pupils and the student to protect marine environments: "Mer en Fête" (Sea in Festival)

15:30－16:15
Round table discussion
Moderator: **Prof. Teruhisa Komatsu** (Atmosphere and Ocean Research Institute, the

University of Tokyo)
Speakers:
Prof. Teruaki SUZUKI (Research Institute, Meijyo University)
Mr. Jean-Charles LARDIC (Secretary General, Marseille City)
Dr. Yves HENOCQUE (Division of Prospective and Strategy, IFREMER / Ocean Policy Research Foundation, Japan)
Prof. Tetsuo YANAGI (Research Institute for Applied Mechanics, Kyushu University)
Prof. Denis BAILLY (Centre of Law and Economy of the Sea, University of Bretagne Occidentale)

(B) **Commemorative Ceremony of the 50th Anniversary of the Society**
Meeting Place: 3rd Room of the Kobe International Exhibition Hall
Time and date: 16:45－17:45, October 15, 2010

Presider: **Prof. Tsutomu MORINAGA** (Vice President of the Société franco-japonaise d'Oceanographie du Japan)

Opening address: **Prof. Shiro IMAWAKI** (President of the Société franco-japonaise d'Oceanographie du Japan)
Congratulatory message: **Mme la Conseillere Florence RIVIÈRE-BOURHIS** (Scientific Counselor, Embassy of France in Japan)
Congratulatory message: **Mr. Tatsuo YADA** (Mayor of Kobe City)
Congratulatory address: **Mr. Didier REAULT** (Representative of Marseille City)
Congratulatory message: **Prof. Marc HUMBERT** (Director of La Maison Franco-Japonaise)
Congratulatory address: **Prof. Isao KOIKE** (President of the Oceanographic Society of Japan)
Congratulatory message: **Prof. Tamaki URA** (President of Techno-Ocean Network)
Congratulatory address: **Prof. Hubert CECCALDI** (President of the Société franco-japonaise d'Océanographie de la France)

Presentation of gratitude letters
Souvenirs given to all the attendees

Closing remarks: **Dr. Ivan DEKEYSER** (Director of Center of Oceanography of Marseille, University of the Méditerranée)

(C) **Commemorative Symposium Part 2**
Meeting Place: Main Hall of *Maison Franco-Japonaise*, Ebisu, Tokyo
Date: October 19, 2010

Opening speech (10：00-10：05)
Dr. Shiro IMAWAKI (President of the Société franco-japonaise d'Oceanographie du Japan)

Session 1: Cooperation between Japan and France in the oceanography field for 50 years and its results
10：05–10：30 History of Japanese-French Oceanographic Society
Prof. Tsutomu MORINAGA (Vice President of the Société franco-japonaise d'Oceanographie du Japan)
10：30–10：55 Japan-France cooperation in the oceanography in France
Dr. Yves HENOCQE (IFREMER)
Prof. Hubert Jean CECCALDI (President of the Société franco-japonaise d'Océanographie de la France)

Session 2: Importance of the biodiversity in the ocean
10：55–11：25 The life supported by whales which sank to the seabed: the diversity of a biotic community around whalebones
Dr. Yoshihiro FUJIWARA (JAMSTEC)
11：25–11：55 Draft plan of Calanque national park establishment, towards sustainable use and management of the Mediterranean Sea
Mme. Pascale JANNY (Department of Environment and Urban Space, and Integrated Management and Governance of Coastal Zone, Marseille City)

Ending speech (11：55–12：00)
Dr. Ivan DEKEYSER (Director of Center of Oceanography of Marseille, University of the Méditerranée)

日仏海洋学会創立 50 周年記念式典　式辞

日仏海洋学会会長
今脇　資郎

2010 年 10 月 15 日（金）
神戸国際展示場における記念式典に際して

皆様，本日は日仏海洋学会の創立 50 周年記念式典にご参列いただき誠にありがとうございます。デディエール・レオー　マルセイユ市代表，ユベール・セッカルディ日仏海洋学会フランス会長，小池勲夫日本海洋学会会長にご臨席いただいています。フローランス・リヴィエール＝ブリス在日フランス大使館科学技術参事官，矢田立郎神戸市長，マルク・アンベール日仏会館フランス事務所代表，浦環テクノオーシャン・ネットワーク理事長からはお祝のメッセージをいただいています。また遠くフランスから大勢の方々にご参列いただいています。当学会を代表して篤く御礼を申し上げます。

日仏海洋学会は，海洋学や水産学の分野で活動している日本とフランスの科学者や団体の学術交流を促進することを目的として，50 年前の 1960 年 4 月に創立されました。当時フランスは有人潜水艇（バチスカーフ）による深海調査の分野で世界をリードしていました。バチスカーフ FNRS-Ⅲ号が 1958 年に来日し，日本の研究者を乗せて日本海溝などの調査を行いました。1962 年にはバチスカーフ　アルシメード号が来日し，千島海溝で潜水調査を行っています。このようなフランスの先進的な活動を受けて，当時の東京水産大学教授佐々木忠義博士のご尽力により，日本とフランスの海洋学と水産学の学術交流を促進するために，当学会が設立されました。佐々木先生は初代の会長を務められました。

日仏海洋学会の会員は現在約 150 人です。例年 6 月に学術研究発表会と総会を開催しています。1963 年には学会機関誌「うみ」の発行を始めました。欧文名は「La mer」で，現在は年 4 回発行しています。今年で第 48 巻を数えます。1966 年には学会賞を，2002 年には論文賞を設けました。

1984 年にフランスにも日仏海洋学会が設立されました。設立にご尽力されたのは，本日ご臨席のフランス国立高等研究院名誉教授ユベール・セッカルディ博士で，初代の会長を務められました。日本とフランスの両日仏海洋学会は，共同して，1983 年以来ほぼ 2 年に 1 回，日本とフランスで交互に「日仏海洋学シンポジウム」を開催しています。2 年前にはフランスのマルセイユで第 13 回のシンポジウムを開催しました。その際，当学会の創立 50 周年記念行事となる今回の第 14 回シンポジウムを，マルセイユの姉妹都市である神戸で，国際カンファレンス「テクノオーシャン」の一環として開催することにしました。これが，当学会の創立 50 周年記念式典を今回神戸で開催することとなった経緯です。なお，今回のシンポジウム・式典の開催では，笹川日仏財団から格別のご援助をいただきました。

日仏海洋学会はこれからも日本とフランスの間の海洋学や水産学の学術交流を中心として活動を続けて参ります。皆様方の旧倍のご支援・ご鞭撻をお願いいたします。本日はご臨席を賜り誠にありがとうございました。

Discours a l'occasion de la Cérémonie pour le 50e anniversaire de La Société franco-japonaise d'Océanographie

Le Président de La Société franco-japonaise d'Océanographie, Japon
Shiro IMAWAKI

à l'occasion de la Cérémonie
au Kobe International Exhibition Hall, le vendredi 15 octobre 2010

Mesdames et Messieurs,

Permettez-moi d'abord de me présenter: Shiro Imawaki, président de la Société franco-japonaise d'Océanographie.

Sont réunis aujourd'hui, Mr. Didier REHAUT, le représentant du Maire de Marseille, le Prof. Hubert J. CECCALDI, de la Société franco-japonaise d'Océanographie en France, le Prof. Isao KOIKE, président de la Société japonaise d'Océanographie. J'ai reçu les messages de félicitations pour cet anniversaire de la part de Mme Florence RIVIÈRE-BOURHIS, Conseillère pour la science et la technologie de l'Ambassade de France au Japon, de Mr. Tatsuro YADA, le Maire de Kobe, du Prof. MarcHumbert, directeur français de la Maison franco-japonaise, le Prof. Tamaki URA, président du conseil administratif du Techno-Ocean Network. De nombreux membres de la délégation française sont venus de loin. Je vous remercie de tout mon coeur pour votre participation et pour les messages comme celui du président de la Société franco-japonaise d'Océanographie.

La Société franco-japonaise d'Océanographie a été créée en avril 1960 pour promouvoir les échanges académiques de chercheurs et de groupes qui travaillaient entre le Japon et la France sur l'océanographie et la pêcherie. A cette époque, la France était leader dans le domaine de l'exploration des fonds marins abbyssaux grâce aux bathyscaphes que les chercheurs pouvaient utiliser. Le bathyscaphe, le《FNRS III》, est venu au Japon en 1958 et a plongé avec des chercheurs japonais dans la fosse au Japon. Puis l'《Archimède》 est venu en 1962 pour l'exploration de la fosse de Chishima (Kuril). A ce moment, Dr. Tadayoshi SASAKI, professeur de la section de la Science de la Pêcherie à l'Université de Tokyo, a été très impressionné par ces recherches très avancées. Il a fondé cette société pour contribuer à élargir les échanges entre les deux pays. Donc, il a été le premier président de la société.

Maintenant, plus de 150 personnes sont membres de la Société franco-japonaise d'Océanographie. Chaque année, une assemblée et un colloque ont lieu à la Maison franco-japonaise au mois de juin. En 1963, la société a lancé son propre périodique académique,《Umi》 dont le nom français est《La mer》. Ce périodique sort quatre fois par an et cette année, c'est le volume 48 qui est publié. En, 1966, nous avons créé le Prix de la Société franco-japonaise d'Océanographie pour le décerner à un membre contribuant au progrès de l'océanographie et le Prix du meilleur article publié dans《La mer》 en 2002.

La Société franco-japonaise d'Océanographie fait partie de l'Association des Sociétés franco-japonaises qui partagent la Maison franco-japonaise à Ebisu à Tokyo comme point de ralliement. Cette association est composée de 26 sociétés dédiées à tous les domaines, les sciences humaines, les sciences sociales, les sciences naturelles, la médecine, l'agriculture et la technologie. Il y a deux ans, cette association a organisé pendant trois jours《Le Colloque compréhensif de l'Association des Sociétés franco-japonaises: la Commémoration du 150è Anniversaire des Echanges entre la France et le Japon》 à la Maison franco-japonaise à Ebisu.

Suite à la création de la Société franco-japonaise d'Océanographie au Japon, en 1984, une société a été fondée en France à l'initiatve du Dr. Hubert Jean CECCALDI, professeur éméritus à L'Ecole des Hautes Études. Il a été le premier président de cette société. Les deux

Sociétés franco-japonaises d'Océanographie au Japon et en France organisent《Le Colloque franco-japonais d'Océanographie》en alternance en France et au Japon environ une fois tous les deux ans, depuis 1983. Il y a deux ans, nous avons organisé le 13ème colloque à Marseille et Paris. A cette occasion, nous avons décidé d'organiser ce 14ème colloque à Kobe, la cité jumelle de Marseille, dans le cadre du colloque international,《Techno-Ocean 2010》. C'est pour cela que cette cérémonie du 50é anniversaire de la fondation de la Société franco-japonaise d'Océanographie a lieu à Kobe.

La Société franco-japonaise d'Océanographie continue ses activités d'échanges académiques sur l'océanographie et la science de la pêcherie entre la France et le Japon, je vous demande de l'encourager. Je vous remercie encore de votre participation d'aujourd'hui à cette cérémonie.

(Traduction: Teruhisa KOMATSU)

Message de félicitations pour le 50e anniversaire de La Société franco-japonaise d'Océanographie

Conseillère pour la Science et la Technologie, Ambassade de France au Japon
Florence RIVIÈRE-BOURHIS

à l'occasion de la Cérémonie
au Kobe International Exhibition Hall, le vendredi 15 octobre 2010

Monsieur le Président de la Société franco-japonaise d'Océanographie, Mesdames et Messieurs,

Permettez-moi d'abord de me présenter: Florence RIVIèRE-BOURHIS, Conseillère pour la science et la technologie de l'Ambassade de France au Japon.

C'est un grand plaisir pour moi de prononcer, au nom de l'Ambassade, ce message à l'occasion de la cérémonie du 50e anniversaire de la fondation de la Société franco-japonaise d'Océanographie.

Tout d'abord, je tiens à féliciter M. Shiro IMAWAKI, Président de la Société, et ses collaborateurs pour un demi-siècle d'histoire de leur organisme et pour leurs actions de coopération entre la France et le Japon dans le domaine des sciences de la mer.

La Société franco-japonaise d'Océanographie a été mise en place en 1960 par le regretté Professeur Tadayoshi SASAKI. Il fut le premier chercheur japonais à participer aux plongées scientifiques effectuées par des bathyscaphes français dans des eaux japonaises : en 1958 avec le《FNRS III》, puis en 1962 avec l'《Archimède》. Impressionné par la grande qualité des sciences de la mer en France et compte tenu de son affection personnelle pour ce pays, le Professeur SASAKI créa cet organisme pour contribuer à élargir les échanges entre les deux pays. Ces échanges, qui étaient alors limités au niveau des chercheurs individuels, se sont étendus jusqu'à celui de la communauté scientifique, voire du public non-scientifique des deux pays.

Parmi diverses activités remarquables de cette société, j'en citerai deux. L'une est le bulletin trimestriel《La mer》, qui traite d'un grand éventail de domaines dans les sciences de la mer. Lancé en 1963, ce périodique est un témoin de longue date des travaux océanographiques et aquacoles effectués par des chercheurs japonais, souvent en collaboration avec des chercheurs français. Je me réjouis de la haute qualité scientifique de cette publication, qui arrive cette année au volume 48.

L'autre activité est l'organisation du Colloque franco-japonais d'Océanographie, dans le cadre duquel cette cérémonie a lieu. Cette manifestation, dont ceci est la 14e édition, est organisée en commun avec la Société franco-japonaise (française) d'Océanographie, fondée et présidée par Monsieur Hubert J. CECCALDI, qui nous fait l'honneur d'être parmi nous. Ces deux sociétés jumelles encouragent ensemble, par cette rencontre, des échanges de chercheurs provenant d'organismes des deux pays et, par conséquent, contribuent à la mise en place des projets de recherche communs à moyen et long terme. Un des intérêts récents des deux sociétés est la formation de jeunes chercheurs. J'attends beaucoup de cette initiative qui contribuera à la coopération entre chercheurs de la prochaine génération.

Parallèlement aux riches activités des chercheurs et des associations, dont témoigne ce colloque, les gouvernements japonais et français collaborent depuis de longues années. Il y a un an, le 13 octobre 2009, la 23e session du Sous-Comité Mixte franco-japonais en Océanographie se réunissait à Tokyo. Y. participaient des représentants japonais et français des ministères, d'instituts de recherche et d'universités, dont l'Institut Français de Recherche pour l'Exploitation de la Mer (IFREMER) et la Japan Agency for Marine-Earth Science and Technology (JAMSTEC). Ce Sous-Comité s'inscrit dans le cadre de l'Accord de Coopération Scientifique et Technique entre les gouvernements japonais et français, signé en 1974 puis renouvelé en 1991. Dès l'année de la première signature de cet accord, un Sous-Comité spécifique en océanographie avait été créé et depuis, soit pendant plus de 30 ans, une réunion est organisée alternativement en France et au Japon environ tous les 18 mois. Je souligne que c'est le seul domaine de cet accord de coopération qui ait maintenu une telle activité au niveau intergouvernemental depuis aussi longtemps.

A l'heure actuelle, nous devons faire face à des problèmes globaux comme le changement climatique, la protection de l'environnement, le tarissement des ressources naturelles et l'accès à l'alimentation et à l'eau. Ce mois-ci, la dixième réunion de la Conférence des Parties de la Convention sur la Diversité Biologique (COP 10) se tiendra à Nagoya en vue de discuter du maintien et de l'utilisation durable de la biodiversité. Lorsque l'on évoque de toutes ces questions, il est essentiel de tenir compte des océans qui sont un moteur majeur de la régulation de la température et de la quantité de CO_2 dans l'atmosphère terrestre et qui sont un grand réservoir de ressources énergétiques et alimentaires. Il est maintenant important de fournir tous les efforts à l'échelle mondiale pour les résoudre et que la coopération franco-japonaise en matière d'océanographie donne l'exemple de la voie à suivre.

En remerciant tous les membres de la Société franco-japonaise d'Océanographie et ses collaborateurs pour leurs efforts continus, je souhaite que le rôle important de la Société dans la coopération franco-japonaise et internationale ne se démente pas et que d'autres se retrouvent ici dans 50 ans.

Je vous remercie de votre attention.

日仏海洋学会創立 50 周年記念式典　祝辞

在日フランス大使館科学技術参事官
フローランス・リヴィエール＝ブリス

2010 年 10 月 15 日（金）
神戸国際展示場における記念式典に際して

日仏海洋学会会長並びにご列席の皆様，

在日フランス大使館科学技術参事官のフローランス・リヴィエール＝ブリスでございます。

日仏海洋学会創立 50 周年式典に際し，フランス大使館を代表して祝辞を申しあげる機会をいただいたことは，私にとって大変喜ばしいことでございます。

はじめに，今脇資郎会長ならびに会員各位に，日仏海洋学会の半世紀にもわたる歴史と海洋科学における仏日間の協力活動にお祝いを申しあげます。

日仏海洋学会は 1960 年に故・佐々木忠義先生によって創立されました。先生はフランスのバチスカーフ（深海潜水艇）が日本領海において調査潜水を行った際，日本人としてはじめて乗船した研究者でした。その調査は，まず「FNRS Ⅲ」号によって 1958 年に，続いて「アルシメッド」号によって 1962 年に行われました。フランスの高度な海洋科学技術に感銘を受けるとともに，フランスに対して個人的にも良い感情をもたれた佐々木先生は，日仏両国の交流に発展させる目的で日仏海洋学会を設立されました。それまで，日仏交流は研究者間の個人的なレベルに留まっていましたが，学会設立によって両国の科学分野だけでなく，一般レベルにまで広められたのです。

この学会のめざましい数々の活動の中で，私は二つの活動を取り上げたいと思います。第 1 番目は，海洋科学の分野を網羅する季刊誌「La mer：うみ」です。年 4 回発行されるこの学会誌は 1963 年に発刊されて以来，日本の研究者による，

また，フランスの研究者との協力による海洋学研究，水産学研究の長い歴史の証人であります。科学的に高い評価を受けたこの機関誌の発行数が今年48巻に達することは，大変喜ばしいことです。

第2番目は，まさにこの式典が行われている，日仏海洋学シンポジウムの開催であります。今回で14回目を迎えるこのイベントが，ユベール・ジャン・セッカルディ氏が創設・主宰したフランス側の仏日海洋学会によって共催されていることを誇りに思います。この会合を通じて，二つの姉妹学会は，両国から集まった研究者の交流を促進し，中長期的な共同研究の実現に貢献しています。二つの学会の最近の関心の一つは，若手研究者の育成です。次世代における研究者間の交流に貢献するこの取り組みに大いに期待しています。

このシンポジウムで示された研究者と学会の活発な活動と平行して，日仏両国政府も長い友好関係を継続しています。1年前の2009年10月13日，東京において日仏の関係省庁，大学や研究機関の代表が参加し，第23回日仏海洋開発専門部会が開催されました。フランス国立海洋開発研究所（IFREMER）や日本の海洋研究開発機構（JAMSTEC）も加わっています。この専門部会は，1974に調印され，1991年に更新された日仏両政府間の科学技術協力協定に組み込まれています。本協定の最初の調印直後から，海洋学に特化した専門部会が設立され，その後30年以上にわたり，18ヵ月毎に交互の国で会議が開催されています。日仏政府間の科学技術協力協定の枠組みで，これほど長期間にわたりこのような活動が維持されている専門部会は海洋分野をおいて他にはないことを強調したいと思います。

今日，私たちは，気候変動，環境保全，天然資源の枯渇，食糧危機，水資源危機等々地球規模の問題に直面しております。今月には，名古屋において，生物多様性条約第10回締約国会議（COP10）が開催され，生物多様性の維持と持続的利用に関する議論が行われます。これらの問題を考えるとき，気温や大気中の二酸化炭素量を制御する一大原動力であり，エネルギー資源と食料資源の大貯蔵庫である海洋を考慮に入れることが不可欠であります。世界的レベルにおいて，今，これらの問題解決に向けて努力をするとともに，海洋学分野における日仏協力が模範となる方向を提示することが大切です。

日仏海洋学会の全会員と関係者一同の継続的な努力に感謝を申しあげるとともに，日仏および国際協力の役割が変わることなく，次の50年後にもここで再会されることを願っております。ご静聴ありがとうございました。

（訳：小池康之）

日仏海洋学会創立 50 周年記念式典　祝辞

神戸市長
矢田　立郎

2010 年 10 月 15 日（金）
神戸国際展示場における記念式典に際して

日仏海洋学会の今脇会長はじめ会員の皆様，また，ご列席の皆様，日仏海洋学会の創立 50 周年，おめでとうございます。

このような記念の日にお招きいただき，また，多くのすばらしい研究者の方々が一堂に会する場で神戸市として祝辞を述べさせていただくことに，大変感謝しております。

日本とフランスとの間で，半世紀にわたって，海洋に関する研究分野で協力・交流を続けてこられたことに強い感銘を受けるとともに，長らく学会活動を継続してこられました関係者の皆様に心より敬意を表します。

また，1986 年から 2 年に一度神戸で開催しております，海洋の科学技術に関する国際コンベンションである「テクノオーシャン」に学会として参加していただき，しかも 50 周年の記念シンポジウムを開催されることは，私どもにとりましても大変に嬉しく，有意義なことであります。あわせて御礼申し上げます。

皆様もよくご存じのように，神戸市は，古くから港を中心として発展してきた国際港湾都市であります。同じく港町であるフランスのマルセイユ市とは，1961 年に姉妹都市提携を結び，交流を続けております。今年の 5 月には，マルセイユ市のジャック・ロカ・セラ副市長がお見えになられましたし，私自身も 4 年前にマルセイユ市を訪れました。両市の，姉妹都市提携も来年には 50 周年を迎えることとなります。今回のシンポジウムにもマルセイユ市の関係者の方々も参加していただいてき，感謝しております。

さて，今，「海洋」をめぐっては，海洋資源の問題に加え地球温暖化や生物多様性などに関連して，非常に関心が高まりつつあります。そのような中で，「海洋を持続的に利用し管理をしようという」テーマを掲げられたシンポジウムを開催されたことは，まことに時宜を得たものであり，意義深いものであると思います。今回のシンポジウムを契機として，海洋に関する研究がますます充実し，大きな成果がもたらされることを期待いたしております。

創立 50 周年を迎えられた日仏海洋学会が，今後ますます長きにわたって充実・発展されることを祈念して，私のお祝いのごあいさつとさせていただきます。

Message de félicitations pour le 50e anniversaire de La Société franco-japonaise d’Océanographie

Le Maire de la Cité Kobe
Tatsuro Yada

à l’occasion de la Cérémonie
au Kobe International Exhibition Hall, le vendredi 15 octobre 2010

Monsieur le président de la Société franco-japonaise d’Océanographie, les membres de la Société, Mesdames et Messieurs,

Au nom du Maire de la cité de Kobe, je vous remercie vivement pour votre invitation à cet anniversaire et je vous souhaite toutes mes félicitations pour le 50e anniversaire de la Soci été franco-japonaise d'Océanographie.

C'est un grand plaisir pour moi de prononcer ce discours devant cet auditoire composé d'excellents chercheurs.

Je suis très impressionné par la longue histoire d'un siècle et demi de coopération et d'échange dans le domaine des recherches océanographiques entre le Japon et la France. Je félicite les membres de la Société pour la poursuite de ses activités scientifiques pendant cette longue période.

Je suis très heureux de la participation de la Société franco-japonaise d'Océanographie à Techno-Ocean 2010, qui est une rencontre internationale sur les sciences océanographiques, organisée à Kobe, tous les deux ans depuis 1986. Aussi, il est très important pour nous que la Société franco-japonaise d'Océanographie organise son colloque dans le cadre de Techno-Ocean 2010.

De plus, La Société franco-japonaise d'Océanographie a organisé un colloque intitulé "**Towards sustainable use and management of the oceans**". Ce collogue qui est très important car les citoyens s'intéressent de plus en plus à la mer et aux ressources marines, à la biodiversité et au réchauffement climatique.

J'espère que ce colloque permettra de développer davantage les recherches marines et qu'il apportera de bons résultats.

La cité de Kobe, comme vous le savez, est une cité portuaire internationale, qui s'est développée depuis longtemps autour de son port. Depuis 1961, Kobe est jumelée avec Marseille, qui est aussi une cité portuaire. En mai dernier, l'adjoint au Maire de Marseille, Monsieur Jacques ROCCA SERRA est venu visiter Kobe, et moi-même, j'ai eu l'occasion de visiter Marseille il y a quatre ans. La coopération de jumelage entre ces deux cités fêtera son 50ème anniverssaire l'année prochaine. Pour cela, je profite de l'occasion pour présenter également tous mes remerciements aux participants de la ville de Marseille présents à ce Colloque aujourd'hui.

Pour finir mon discours, je souhaite un plein succès à ce colloque et beaucoup de réussite pour la Société franco-japonaise d'Océanographie qui fête aujourd'hui ses 50 ans.

(Traduction: Yasuyuki KOIKE)

Message de félicitations pour le 50e anniversaire de La Société franco-japonaise d'Océanographie

Le Directeur Bureau français, Maison Franco Japonaise,
UMIFRE 19 CNRS-MAEE
Marc HUMBERT

à l'occasion de la Cérémonie
au Kobe International Exhibition Hall, le vendredi 15 octobre 2010

Mesdames et Messieurs les élus nationaux et locaux, Mesdames et Messieurs les présidents et directeurs d'institutions internationales, nationales et locales, Mesdames et Messieurs, Mes Chers Collègues et Chers Amis,

C'est un grand honneur pour moi de vous adresser un message de félicitations en cette occasion qui vous réunit à Kobe où je ne peux malheureusement être parmi vous.

Vous voici réunis dans le cadre de Techno-Ocean 2010, pour un thème de réflexion essentiel pour le futur de l'humanité 《une nouvelle ère pour l'océan》 et nous attendons beaucoup - nous attendons tout - de vos débats. Parmi les co-organisateurs de cette manifestation fondamentale, nous avons la Société franco-japonaise d'Océanographie fondée en 1960 et nous en fêtons donc le 50e anniversaire. Je m'associe à tous les souhaits d'excellent anniversaire qui sont adressés aujourd'hui à cette pimpante organisation !

Techno Ocean est aussi le cadre où se tient ce 14e Colloque franco-japonais d'Océanographie, dont la première édition avait eu lieu à Marseille en 1985. Notre collègue, le Professeur Hubert Jean Ceccaldi en avait été la cheville ouvrière, il est aujourd'hui présent à la tête d'une impressionnante délégation française et a œuvré avec le président Imawaki Sirô pour la préparation de cette grande opération 2010. Bravo et merci à tous les deux de tenir si haut la coopération franco-japonaise en océanographie !

Il me faut ajouter un mot de présentation pour ceux à qui le nom de la Maison Franco Japonaise, et le titre de directeur français ne disent rien. La Maison Franco Japonaise est une institution créée en 1924, à l'initiative de Paul CLAUDEL, ambassadeur de France et à la demande de Eichii Shibusawa, banquier et industriel japonais à la tête d'une association de Japonais souhaitant le développement de relations culturelles et intellectuelles avec la France. Ils ont établi une Fondation Maison Franco Japonaise pour accueillir un《bureau français》constitué de délégués scientifiques emmenés par un directeur français, une petite équipe que la France envoie et renouvelle régulièrement depuis lors. Le professeur Hubert Jean CECCALDI a été l'un de ces directeurs français, il y a quelques années, et j'ai l'honneur d'être l'un de ses successeurs.

Ce n'est plus le bureau français seul qui organise la venue au Japon de savants et d'int elletuels français pour débattre avec des partenaires japonais. La tâche est partagée avec tous ceux qui agissent activement dans la Fondation MFJ, à savoir, depuis 1980 la direction et les comités culturels et scientifiques de cette Fondation et depuis 1930 les nombreuses sociétés savantes franco japonaises qui se sont créées peu à peu autour de la MFJ après cette date. Elles sont aujourd'hui au nombre de 26 et œuvrent au développement des échanges intellectuels et savants entre la France et le Japon, dans tous les compartiments de la production de connaissance. La Société franco-japonaise d'Océanographie, je l'ai rappelé, a été créée en 1960 et a toujours son siège, bien sûr à la MFJ. Elle a été mise en place par le

Professeur Tadayoshi SASAKI, qui a été le premier savant japonais a descendre dans la grande fosse sous marine du Japon, en plongeant en 1958 avec la bathyscaphe FNRS-III, puis, en 1962, avec le bathyscaphe Archimède1. La création de cette société a été saluée par un message de soutien de Jacques-Yves COUSTEAU, alors directeur du Musée Océanographique de la principauté de Monaco. C'est dire que, dès son origine cette société porte haut dans son domaine les relations de collaboration scientifique de niveau mondial entre la France et le Japon. Je suis heureux de voir que vous continuez sur la voie tracée par vos aînés, je vous renouvelle mes félicitations et je vous souhaite un plein succès pour vos travaux et, en particulier, pour ceux de ce colloque.

日仏海洋学会創立 50 周年記念式典　祝辞

日仏会館フランス事務所代表
（フランス外務省国立科学研究センター第 19 在外共同研究所）
マルク・アンベール

2010 年 10 月 15 日（金）
神戸国際展示場における記念式典に際して

内外各地よりご参列の議員，国内外および国際機関の代表，フランス代表団，友人の皆様，皆様が神戸に参集されるこの機会に，私は残念ながら同席できませんが，祝辞を申しあげる機会をいただき大変光栄に存じます。

皆様は，「今はじまる海洋新時代」という人類の将来にとって考えなければならない必須の課題のために，ここテクノオーシャン 2010 に参集されました。私どもは，皆様方の議論を多いに期待し，すべての議論について待っております。このシンポジウムの共催者である「日仏海洋学会」は 1960 年に創設され，今ここに 50 周年記念の祝典を迎えております。この晴ある祝典に際し，心よりお喜びを申しあげます。

テクノオーシャンとの共催で開催される第 14 回日仏海洋シンポジュウムは，その第 1 回が 1985 年にマルセイユにおいて行われました。その際，中心となって活躍された私どもの同僚であるユベ−ル・ジャン・セッカルディ教授が今回もフランス代表団団長として参加され，今脇資郎会長とともにこの 2010 年の一大イベントを開催する労をとられました。海洋学における日仏間の強い協力体制を継承して下さったお二人に，敬意を表すとともに心からお礼を申しあげます。

ここで，フランス事務所代表という立場を離れて，日仏会館について少しご紹介いたしたいと思います。日仏会館は 1924 年，フランス大使ポール・クローデルの発意と日本の銀行家，実業家で，日本の協会の代表であった渋沢栄一が文化と学術に関する日仏交流の発展を強く望んだことにより創設されました。そして，フランス事務所を設けるために，財団法人日仏会館が創設されました。ここには開設以来フランス人デイレクターの指揮の下に，フランスから定期的に派遣される学術研究員のグループが駐在しています。ユベ−ル・ジャン・セッカルディ教授は数年前にフランス事務所のデイレクターの責務を果たされ，私も後任の一人として，その栄誉をいただいております。

しかしながら，日本の識者と交流するために学者や技術者の来日を推進するのは単にフランス事務所だけに限りません。この役割は 1980 年以来，日仏会館基金の元で活発に活動するグループによって分担されております。また，1930 年以来，日仏会館傘下の日仏学術系学会が次々と設立されました。現在その数は 26 に達し，それぞれの分野で日仏間の学術交流の発展を推進しております。私の知るところでは，日仏海洋学会は 1960 年に佐々木忠義教授によって創設され，現在も日仏会館に所属しております。佐々木先生は 1958 年にバチスカーフ FNRS-Ⅲにより，さらに 1962 年にはアルキメデス号によって日本の深海に潜水した初めての日本人学者であります。本学会の設立に対し，ジャック＝イヴ・クーストー氏およびモナコ公国海洋博物館の代表から賛辞が寄せられております。このことは，本学会が設立当初から海洋学分野の日仏学術交流が国際水準で期待されていたことを証明しております。

いま，皆様が先学の築いた道を踏襲されている

のを拝見できて大変幸せに存じますと共に，あらためてお祝いを申しあげます。

最後に，このシンポジウムにおける皆様の研究交換の成功をお祈り申しあげます。

（訳：小池康之）

日仏海洋学会創立50周年記念式典　祝辞

日本海洋学会会長
小池　勲夫

2010年10月15日（金）
神戸国際展示場における記念式典に際して

日仏海洋学会がここに創立50年を迎えられたことを心からお喜び申し上げます。海洋に関する学術団体の中で日本とフランスとの海洋関係の学術交流を推進する目的で設立された日仏海洋学会は我が国でもユニークな存在です。それは，多くの海洋関係の学会は海洋分野の研究対象別に作られているからです。我が国の近代的な学術研究は明治の初めにその第一歩を踏み出し，海洋関係の学会も日本造船学会（現在は日本船舶海洋工学会）のような応用分野の学会は既に100年以上の歴史を持っています。私が会長を務めます海洋に関する物理，化学，生物と言った基礎的な分野を扱う日本海洋学会は，これらの応用分野からだいぶ遅れて昭和になってから設立されています。また，最近では，マリンバイオテクノロジー学会や日本サンゴ礁学会のように新たに発展した海洋分野が学会を設立しています。従って，これらの学会は日仏海洋学会を除き，すべて海洋の様々な研究対象別に作られていることになります。しかし，これらの学会の多くは国内の研究者が中心であり，学会誌は別にして国際的な連携・協力の面ではあまり積極的でないのが現状です。

海に国境が無いのと同様に研究の世界にも国境は無く，今では電子ジャーナルやメールによって様々な海洋関係の学術情報が世界を飛び交っています。また，多くの国際シンポジウムや国際ワークショップが頻繁に開催されています。このように，自然科学における研究の進展には，国際的な情報交換や共同研究が不可欠です。しかし，創立50周年を迎える日仏海洋学会が設立された当時は，海洋分野に限らず学術分野の国際交流はかなり限られたものでした。この時代に海洋の国際交流を一つの大きな目的として日仏海洋学会の発足に当たられた我が国の佐々木忠義先生などの先見の明とそのご尽力に深い敬意を表したいと思います。創立以来，日仏海洋学会はフランスと我が国の海洋学や水産学の研究者の学術交流に努力され，海底科学や水産養殖などの分野で大きな成果を挙げ，我が国の海洋の科学の進展に大きく貢献されました。また，我が国に26ある日仏関連学会の一つとして海洋学を超えた学際的な活動を行っている点もユニークです。

ヨーロッパもEUと言う共同体としてこれから発展して行こうとしております。この50周年を一つの区切りとして，フランス＋EUといったより広い交流を視野に入れた日仏海洋学会の更なる発展を祈念してお祝いの言葉といたします。

Message de félicitations pour le 50e anniversaire de La Société franco-japonaise d'Océanographie

President of the Oceanographic Society of Japan
(Le Président de la Société japonaise d'Océanographie)
Isao KOIKE

à l'occasion de la Cérémonie
au Kobe International Exhibition Hall, le vendredi 15 octobre 2010

Monsieur le Président de la Société franco-japonaise d'Océanographie, Mesdames et Messieurs,

Permettez-moi d'abord de me présenter, je m'appelle Isao KOIKE, je suis le Président de la Société Japonaise d'Océanographie.

Tout d'abord, je félicite de tout mon coeur la Société franco-japonaise d'Océanographie pour le 50ẽ anniversaire de sa fondation. La Société franco-japonaise d'Océanographie a été créée pour promouvoir les échanges académiques dans le domaine de l'océanographie entre le Japon et la France. Parmi toutes les sociétés établies au Japon selon leurs champs de recherches, c'est la seule spécialisée en océanographie.

Au Japon, la démarche de recherche scientifiques a commencé dès le début de la période Meiji. Donc, les sociétés scientifiques appliquées comme celle d'architecture navale ont une histoire datant de plus de cent ans. La Société japonaise d'Océanographie, dont je suis le Président, comporte les sciences basiques, la biologie, la chimie et la physique, elle a été créée à la période Showa. Donc, elle est moins ancienne que les autres sociétés scientifiques appliquées.

Récemment, des chercheurs scientifiques ont développé de nouveaux champs de recherches en rapport avec la mer et ont créé leurs propres sociétés comme la Société de la Biotechnologie Marine et la Société des récifs coralliens au Japon. Ces sociétés ont des objectifs de recherches différents de ceux de la Société franco-japonaise d'Océanographie. De plus, la plupart des membres de ces sociétés sont des chercheurs japonais. Ces sociétés n'encouragent pas la coopération et la collaboration internationales, bien qu'elles acceptent les articles écrits par les chercheurs étrangers.

Il n'y a pas de frontières dans le monde de la recherche comme il n'y a pas de frontières dans la mer. Maintenant, les informations académiques sur l'océanographie sont échangées dans des périodiques et des courriers électroniques. Des colloques et ateliers de recherches internationaux sont très souvent organisés. Les échanges d'informations et de coopération internationale sont essentielles pour le progrès des recherches scientifiques.

Quand la Société franco-japonaise d'Océanographie a été créée, les échanges académiques internationaux étaient très limités. A cette époque-là, le Professeur Sasaki a créé cet organisme pour contribuer à élargir les échanges des recherches océanographiques entre les deux pays. Je félicite le Professeur Sasaki pour son anticipation et ses efforts tournés vers l'avenir de l'océanographie. Depuis sa création, la Société franco-japonaise d'Océanographie contribue au progrés de l'océanographie japonaise avec les échanges académiques des chercheurs océanographiques et aquacoles. Elle a obtenu de très bons résultats dans le domaine de la Géologie marine et de l'Aquaculture. La Société franco-japonaise d'Océanographie a contribué concrètement au progrès des sciences marines au Japon, aussi, parmi les 26 sociétés franco-japonaises, elle est celle dont le champ d'activité dépasse largement son sujet, l'Océanographie.

L'Europe se développe autour de《l'Union Européenne》. Je souhaite que la Société japonaise d'Océanographie développe encore ses activités et que son 50ẽ anniversaire soit le point de départ à l'élargissement des échanges entre le Japon et la France et l'Union Européenne.

(Traduction: Teruhisa KOMATSU)

日仏海洋学会創立 50 周年記念式典　祝辞

テクノオーシャン・ネットワーク理事長
浦　環

2010 年 10 月 15 日（金）
神戸国際展示場における記念式典に際して

日仏海洋学会の会長，会員のみなさま，およびご列席のみなさま，このたびは，日仏海洋学会の創立 50 周年，おめでとうございます。

テクノオーシャン・ネットワーク理事長の浦でございます。「テクノオーシャン 2010」を主催しております，テクノオーシャン・ネットワークを代表いたしまして，一言，ご祝辞を申し上げます。

テクノオーシャンも，先ほど矢田神戸市長からもご紹介がありましたが，1986 年の開催から 24 周年，第 13 回を迎えることとなりました。

その倍以上，半世紀もの間，日本とフランスとの海洋に関係する研究を，日仏海洋学会のみなさま方は支え続けてきたわけです。ひと口で言うと 50 年ですが，昨今の「海洋」を取り巻くいろいろな情勢の変化を考えますと，二国間での海洋研究を 50 年間行い続けるということは，ものすごい努力の賜物であると拝察いたします。

そもそも 1960 年代に，フランスのバチスカーフと総称される深海潜水艇が日本で最初の潜水を行ったことが，日仏両国の海洋研究者の交流の始まりであると聞いております。当時のフランスの海洋学あるいは水産学にはわが国が学ぶべき点が多く，個人的交流だけではなく，広く，深く，交流をする，ということを目的として，学会が設立されたとのことです。私自身も，小学生の時に，バチスカーフが来日して日本海溝へと潜航したことを，新聞やラジオで聞いて感動したことを今更のように覚えております。その感動は，1985 年の Nautile 来日に引き継がれました。世界初の実用 AUV “Epaulard” の開発と展開など，フランスの深海技術の高さとチャレンジ精神に強く感銘を受け，フランスの海洋技術を目の当たりにするたびに「冒険者」としての心が高揚いたします。

テクノオーシャンも，海洋に関する最新の科学技術を集め，それを専門家だけではなく，一般の方々にも，広く，知っていただくための国際的な集まりであります。その場に，日仏の海洋の研究を行っている多くの研究者の方々が参集していただき，日仏海洋学会の創立 50 周年をお祝いすることができるのは，テクノオーシャン・ネットワークの理事長としても大変光栄に思っております。

これを機に，今後ますます日仏の海洋学会が発展をとげられ，多岐にわたる海洋研究の成果がもたらされ，日仏の深い絆ができることをお祈り申し上げます。本日はおめでとうございました。

Message de félicitations pour le 50e anniversaire de La Société franco-japonaise d'Océanographie

Le président du conseil administratif de Techno-Ocean Netwok
Tamaki URA

à l'occasion de la Cérémonie
au Kobe International Exhibition Hall, le vendredi 15 octobre 2010

Monsieur le Président de la Société franco-japonaise d'Océanographie, les membres de la Société, Mesdames et Messieurs,

Permettez-moi d'abord de me présenter, je suis Tamaki Ura, président du conseil administratif de Techno-Ocean Netwok.

Au nom de Techno-Ocean Netwok, je vous félicite pour le 50e anniversaire de la fondation de la Société franco-japonaise d'Océanographie qui organise le Techno-Ocean 2010.

Cette année est la 24e édition de Techno-Ocean Network qui se tient depuis 1986 et c'est ici que s'est tenue la 13e Convention, comme l'a dit Monsieur YADA dans son discours, le Maire de Kobe.

Les membres de la Société franco-japonaise d'Océanographie ont soutenu les relations de recherches océanographiques entre le Japon et la France pendant un demi-siècle, deux fois plus que notre organisation Techno-Ocean Network. Lorsque nous pensons à l'évolution de la situation autour de la mer, je suis sûr que la poursuite des recherches océanographiques entre les deux pays pendant ces 50 années était le fruit d'efforts admirables des deux côtés.

J'ai entendu dire que les échanges scientifiques des chercheurs océanographiques entre la France et le Japon ont commencé à l'occasion des plongées effectuées par des bathyscaphes français dans des eaux japonaises, dant les ann ées 60. A cette époque, les chercheurs japonais devaient apprendre beaucoup de choses sur les sciences de la mer et l'océanographie appliquée en France. La Société franco-japonaise d'Océanographie a été créée pour contribuer à élargir non seulement les échanges de chercheurs individuels, mais aussi les échanges scientifiques plus larges et plus profonds entre les deux pays. Et, je me souviens comme si c'était hier, de l'impression que j'ai eu en entendant les nouvelles annoncées par la radio et les journaux sur les bathyscaphes français qui ont plongé dans les eaux du Japon. A l'époque, j'étais à l'école primaire. Cette impression s'est reproduite au moment de la visite du Nautile au Japon en 1985. Mon esprit "aventurier" a été ému à chaque fois que je voyais les nouvelles technologies marines de la France; comme celle du premier développement et déploiement mondial de l'AUV pratique [Epaulard].

Techno-Ocean est non seulement une réunion internationale de spécialistes qui cherchent à rassembler les nouvelles technologies et les résultats scientifiques sur l'océan, mais c'est aussi une occasion qui permet de transférer ce savoir-faire aux citoyens et pas uniquement aux savants. C'est un grand honneur pour moi, en tant que Président du conseil administratif de Techno-Ocean Network, d'accueillir ici les chercheurs des Sociétés franco-japonaises d'Océanographie du Japon et de la France et de célébrer le 50e anniversaire de la Société du Japon.

A cette occasion, je souhaite que les Sociétés franco-japonaises d'Océanographie de la France et du Japon se dévéloppent encore, réussissent dans leurs diverses recherches océanographiques afin de renforcer encore les relations entre les deux pays.

Je vous présente, encore une fois, mes plus sincères félicitations.

(Traduction: Yasuyuki KOIKE)

Message de félicitations pour le 50e anniversaire de La Société franco-japonaise d'Océanographie

Le Président de La Société franco-japonaise d'Océanographie, France
Hubert CECCALDI

à l'occasion de la Cérémonie
au Kobe International Exhibition Hall, le vendredi 15 octobre 2010

Monsieur le Président de la Société franco-japonaise d'Océanographie,
Madame le Conseiller pour la Science et la Technologie
Monsieur le Maire de Kobé
Monsieur le Conseiller Général
Monsieur le Président de la Société d'Océanographie du Japon
Monsieur le Directeur de la Maison Franco-Japonaise de Tokyo
Monsieur le Représentant de Techno-Ocean 2010
Messieurs les Présidents,
Chers amis

C'est avec un très grand plaisir que je participe à ce Cinquantenaire de la Société franco-japonaise du Japon.

Il y a environ 40 ans, le Professeur SASAKI Tadayoshi m'accueillait dans son laboratoire à l'Université des Pêches de Tokyo (Tokyo Suisan Daigaku) et, devant un verre de whisky, me racontait ses plongées en bathyscaphe. Ce fut lui le fondateur de la Société franco-japonaise d'Océanographie du Japon.

Depuis cette époque, nous avons parcouru beaucoup de chemin dans d'amicaux travaux communs et des coopérations entre la France et le Japon.

Je ne pourrai pas rappeler ici tous les noms de ceux qui ont participé à ces coopérations: leur nombre est trop important. Mais je ne veux pas oublier de citer les noms de mes proches amis japonais avec lesquels nous avons travaillé sur des sujets communs, soit en France, soit au Japon:

KANAZAWA Akio, YAGI Hiroki, NAKAGAWA Heisuke, KAYAMA Mitsu, KITTAKA Jiro, HIRANO Reijiro, TESHIMA Shun-Ichi, OKAICHI Tomotoshi, HIRAYAMA Kazutsugu, YAMAGUCHI Katsumi, TOMINAGA Masahide, NOMURA Tadashi, UNO Yutaka, KAJIHARA Takeshi, KONOSU Shoji, ARUGA Yusho, SUDO Hideo etc., sans parler de l'équipe actuelle: IMAWAKI Shiro, KOMATSU Teruhisa, KOHNO Hiroshi, KOIKE Yasuyuki, MORINAGA Tsutomu, YOSHIDA Jiro, KANDA Jyota, ARAKAWA Hisayuki

Du côté français, les chercheurs intéressés par des coopérations avec nos collègues japonais ont été et sont nombreux.

Yves HENOCQUE, Jean-Claude et Maguy GUARY, François SIMARD, François GALGANI, Jean-Marie THIERRY, Béatrice CHATAIN, Joël QUERELLOU, Catherine MARIOJOULS, Patrick SAFRAN, Denis BAILLY, Richard SEMPERE, Alain Van WORMHOUDT, Eric DELORT, Mathias GIRAULT, Ivan DEKEYSER, Georges STORA, etc., sans oublier Lucien LAUBIER, récemment disparu.

Au sujet de ces coopérations, je voudrais insister sur trois points:

Tout d'abord sur ce tissu de relations personnelles qui s'établit entre nous, toujours amicales, sur l'aide que l'on s'apporte les uns aux autres, des conseils, des échanges interculturels, qui nous font mieux comprendre les différences de fonctionnement des sociétés dans lesquelles nous vivons, les uns et les autres.

Ensuite, sur le fait que ces Sociétés franco-japonaises ont une grande valeur: elles permettent de réunir dans chacun des deux pays, de façon informelle, des spécialistes appartenant à des universités, des centres de recherche, des administrations, des entreprises privées, des ingénieurs, ce qui permet une approche plus complète et plus globale des problèmes traités.

Enfin, sur l'importance que joue la Maison franco-japoniase dans ce dialogue entre les deux cultures, car, à cette précieuse approche pluridisciplinaire s'ajoute toujours une dimension interculturelle, bi-nationale, très fructueuse, une facette spécifique d'un dialogue entre deux pays qui ont chacun une longue histoire, et une grande richesse culturelle.

Et je me trouve toujours, toutes proportions gardées dans la situation du Petit Prince de Saint Exupéry, que les Japonais connaissent tous très bien depuis leur enfance: "l'essentiel est invisible pour les yeux".
Ce sont ces relations personnelles, toujours amicales et fidèles., qui n'ont pas de prix.

Merci.

日仏海洋学会創立50周年記念式典　祝辞

日仏海洋学会フランス会長
ユベール・セッカルディ

2010年10月15日（金）
神戸国際展示場における記念式典に際して

日仏海洋学会会長，在日フランス大使館科学技術参事官，神戸市長，マルセイユ市代表，日本海洋学会会長，日仏会館フランス事務所代表，テクノオーシャン・ネットワーク理事長，代表の方々，友人の皆様

日仏海洋学会50周年記念の祝典に参列できたことはこの上ない喜びであります。

東京水産大学の研究室で佐々木忠義教授が私を招いて，ウイスキーのグラスを前にバチスカーフでの潜水について語られたのはおよそ40年前でした。この佐々木先生が，日仏海洋学会の創設者であります。

この時代から，私たちは，日仏間の友好的な共同研究や協力の道を長く歩いて参りました。これらの協力に参加された方々は多すぎるため，すべての方の名前を思い出すことはできません。しかし，フランスあるいは日本において，共通の課題にともに取り組んできた日本の友人の名前を忘れるわけにはいきません。

金沢明夫，八木宏樹，中川平介，嘉山三津，橘高二郎，平野礼次郎，手島俊一，岡市友俊，平山和継，山口克己，富永正英，野村正，宇野寛，梶原武，鴻巣昭二，有賀祐勝，須藤英雄，そして，現在の日仏海洋学会の今脇資郎，小松輝久，河野博，小池康之，森永勤，吉田二郎，神田穣太，荒川久幸。

フランス側では，日本人の同僚との協力に関心を持った研究者は多くおられます。

Yves HENOCQUE, Jean-Claude et Maguy GUARY, François SIMARD, François GALGANI, Jean-Marie THIERRY, Béatrice CHATAIN, Joël QUERELLOU, Catherine MARIOJOULS, Patrick SAFRAN, Denis BAILLY, Richard SEMPERE, Alain Van WORMHOUDT, Eric DELORT, Mathias GIRAULT, Ivan DEKEYSER, Georges STORA, などの方々。そして最近亡くなられたLucien LAUBIER氏を忘れることはできません,

これらの協力に関して，三つの点について強調しておきたいと思います。

まず，最初は，私たちの間につくられた常に友情あふれる個人的な関係の糸，つまり，お互いにもたらす援助，助言，知的交換であります。それらのおかげで，それぞれの社会の機能の違いを，双方ともよりよく理解することができるのです。

次に，日仏海洋学会がもつ大きな価値であります。日仏海洋学会は，両国のそれぞれで，大学，研究所，行政，企業に属する人や，技術者，取り扱う課題のより完全な，そして，より全体的なアプローチを可能にする人を，非公式に集めることができます。

最後の点は，両国の文化間の対話では日仏会館が重要な役割を担っていることであります。なぜなら，二国間の知的な大変実りの多い次元，つま

り，長い歴史と文化の豊かさをそれぞれが持つ両国間の固有の面を，つねにこの貴重で多用な学問分野にまたがるアプローチに加えるからであります。

そして，日本人が子供のときからよく知っている，調和を守るということは，サンテ・エクジュペリの “Le Petit Prince”（日本語訳は，星の王子様）の場面の「大切なものは目には見えないんだ」ということではないかといつも思います。それは，つねに友情にあふれ，忠誠を尽くす，個人的な関係であり，金銭で計れるものではありません。

ありがとうございました。

（訳：小松輝久）

La mer 49 : 83-92, 2011
Société franco-japonaise d'océanographie, Tokyo

The CHARM Project: Defying the Channel's loss by improving communication on ecosystem knowledge across borders

M.C. VILLANUEVA[1)], S. VAZ[1)], B. ERNANDE[1)], L. Gardel[1)], F. COPPIN[1)], A. CARPENTIER[1)], C. MARTIN[2)], P. EASTWOOD[3)], Y. OTA[4)], S. HARROP[5)]

Abstract: The Channel Habitat Atlas for Marine Resource Management (CHARM) is a transborder collaboration project between France and United Kingdom. It has become, since 2003, a growing network of scientists geared on investing in science through joint collaboration, communication and knowledge management. The initial objective of the project is to provide an atlas for the Eastern English Channel that will serve as significant support to stockholders and policy-makers towards sustainable exploitation and management of this ecosystem. The project started as a pilot program collecting information and "translating" these into comprehensive and integrated knowledge. The two published version of the CHARM atlas which focused on the Dover Strait and Eastern English Channel, respectively, feature a combination of map-based information and inventories on environment, living resources, exploitation and sensitive areas. Integrated studies were conducted in the second volume through construction of food web (ECOPATH) and systematic conservation planning (MARXAN) models. The project is actually in its third phase (2009–2012) which aside from providing map-based inventories of information covering the whole English Channel is geared towards a better understanding of this complex environment an ecosystem-based approach covering more aspects on integrated modeling such as trophic network dynamics, climate change effects, habitat map classification, economics and systematic conservation planning.

Keywords: *English Channel, ecosystem-based approach, ecosystem census, systematic conservation planning, transborder collaboration*

I. Introduction

The English Channel is facing major challenges due to human actions that are causing unprecedented impacts on ecosystem health [1]. This is a crisis that needs to be apprehended as it threatens the collapse of its living resources and the benefits to human society offered by this ecosystem.

The CHARM project aims to awaken consciousness and emphasize a commitment of a cross-section of international experts on the Channel to focus on how to better sustain and conserve this fragile ecosystem. It focuses on habitats which is an important factor especially in explaining the occurrence and distribution of living resources that lives in it. Studying habitats can also provide information about modifications in abundance of biological resources and identify the factors that can lead to these changes.

In 2003, French and English researchers from eight institutes were gathered to collaborate in establishing an initial protocol for collecting environmental and biological data along the Dover Strait [2]. During the second phase

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(2006–2008), scientific efforts were geared on exhaustive data collection and map-based representation of environmental, social and biological information of the Eastern English Channel (Fig. 1). Initial attempts were also done to describe and determine ecosystem state as well as defining better management and conservation options in order to slow down the system's degradation process [3]. Scientific experts assembled were devoted in developing synthesized data focused on specific issues and actions to achieve a better comprehension of system health and pin down current threats while outlining the consequences related to identified challenges and gaps. This is at the same time providing an opportunity for the popularization of information and approaches developed within the context of the project. Critical needs that were identified and covered by the project to date include: (1) provide information on biology and ecology of aquatic living resources, (2) establish ecological links and functioning, (3) comprehension of fisheries dynamics, (4) synthesis and distribution of available data (5) fishers' perception of marine environment and their socio-economic context (6) enhance comprehension and facilitate implementation of regulation in and between states and (7) knowledge on ecosystem management and conservation.

II. Documenting, mapping and modeling

In order to produce a comprehensive atlas, there is a need to provide a census of marine life. This means that it was necessary to identify the existing species, where they occur and what is their habitat. Information on environment (physical and hydrobiological features), living resources (fish and benthic organisms), fisheries and exploitations and existing regulations were collected for the first and second phases of the project were based on existing historical and newly collected data (Fig. 2). A summary of collected information are enumerated below. These along with data integration modeling techniques (habitat, food web and systematic conservation models) used in the atlas [3] can be found in the atlas and can be downloaded in this URL site : http://www.ifremer.fr/charm.

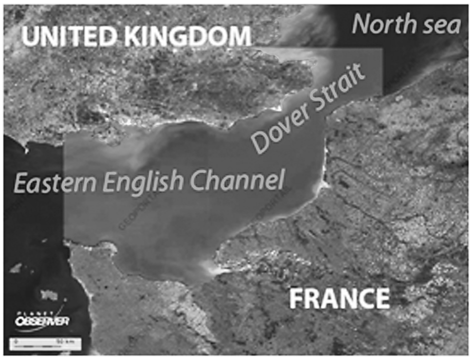

Fig. 1. The Dover Strait and the Eastern English Channel (Source: www.geoportail.com).

A. Physical environment

Most of the data concerning the physical factors such as water temperature and salinity were from in-situ measurements provided by IFREMER's Channel Ground Fish (CGFS) [4] and Beam Trawl Surveys (BTS) [5]. These scientific sea surveys collect abiotic parameters aside from providing species abundance indices in the eastern Channel since 1988 and 2007, respectively. Chlorophyll-*a* concentration were derived from the Sea-viewing Wide Field-of-View Sensor (SeaWIFS) [6] satellite images and IBTS in-situ data. Remote sensing also provided complementary information on temperature and suspended particulate matter [7]. Hydrodynamic models were used to map bed shear stress (proxy data for tidal current pressure from Aldridge and Davies [8]) and depth. Sediment types were based from Larsonneur et al [9].

B. Biological species list

Three large biological groups were considered in the project: benthic invertebrates, cephalopods and fishes.

Information on benthic organisms were from two sources. A qualitative but exhaustive benthic community investigation collected during the early seventies through cooperative research program entitled "*Benthos de Manche*" (RCP Manche) [10]. These data were complemented by characterization studies of macrobenthic communities made under the MAcroBEnthos of the Eastern English Channel and the south of the North Sea (MABEMONO) programme from 2004–2006.

For fish and cephalopod species data were mainly based on CGFS and CEFAS' Beam Trawl Survey (BTS) from the period between 1988 until 2006 and 1986–2006, repectively. For fish species, data concerning different life stages were collected. For fish eggs were in-situ collections using a Continuous Underway Fish Egg Sampler (CUFES) employed during IBTS surveys. Larvae were from bongo net sample from two spring periods: 1995 and 1999. Juvenile and adult fishes were collected during summer and autumn annually in the eastern part of the Channel from 1989 until 2006. Complementary data on juveniles were collected at nursery areas (i.e., estuary mouth, coastal areas) from Young Fish Surveys (YFS) from 1977 until 2006 (see atlas for further information regarding sample collection during sea surveys).

C. Fisheries and dynamics

After identifying vessel types and gears used for commercial littoral, in-shore, artisanal or mixed fisheries, landings and fishing efforts by commercial fishing vessels were collected. French and English fishery data were taken from the national centre of statistical analyses (CNTS) and from the Department for Environment, Food and Rural Affairs (DEFRA), respectively. For other states exploiting the area, data were also collected but information were mainly based on European logbooks and from auction halls for vessels longer than 10 m and /or so at sea for more than 24 hours. For France, data are also collected for vessels less than 10m in length. Average landing per species and fishing frequency numbers per fleet were mapped at coarse resolution per International Council for the Exploration of the Sea (ICES) division cells (i.e., each cell is 1° longitude and 0.5° latitude grid).

D. Fishermen communities

A certain number of semi-structured interviews (20–100 minutes) among several fishing categories were carried out mainly focused on small-scale fishing communities. Questionnaires included information concerning fishing activities and methods, targeted species and distribution of fishing locations. Fishermen were interviewed regarding their life history in 10 English (Ramsgate, Folkstone, Rye and Hastings) and French (Calais, Boulogne-sur-Mer, Bay of Somme, Dieppe, Caen and Port-en-Bessin) cities. We also conducted the participant observation of various fishing practices. Information gathered from field interviews were then used to produce smoothed raster polygons which were then used to map fishing "hotspots" per species.

E. Acts of legislation

A thorough bibliographic and information research was made in order to compile relevant regulations on four major themes: fisheries, management, habitat conservation and marine pollution at the communal, international and state (UK and France) levels. Regulations collected were carefully validated by fishermen involved in the Channel management. In the atlas, regulations were listed and explained. Only a limited number of maps were produced and depicts only the most pertinent regulations in the Eastern English Channel.

F. Data Integration

Data integration involves the use of data collected and analyzed in models. All data collected on species abundance and occurrence (presence-absence) were tested for normality using histograms, skewness and Kurtosis analyses. Based on skewness and Kurtosis values obtained, data were transformed if a normalizing function for data improvement is found. Kriging interpolation [11]was then

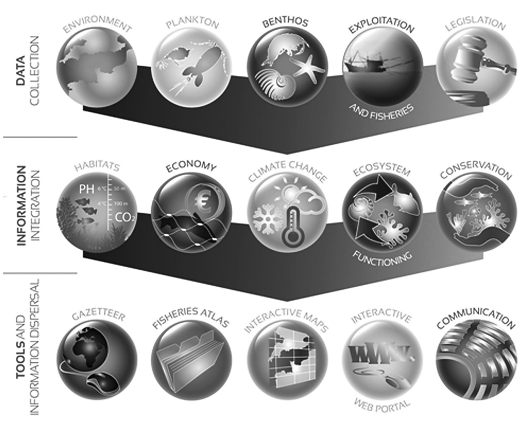

Fig. 2. Schematic representation of data collected and data integration approaches used during the second phase of the project.

used to produce most of the distribution maps.

Preferential and potential habitats were modelled using generalized linear model (GLM) [12] and Regression Quantile (RQ) [13] from abundance data while probable habitats were modeled using generalized additive model (GAM) [14] was used for presence-absence data [15, 16].

Aside from habitat spatial modeling, other modeling techniques were employed. In order to define and provide a snap-shot picture of ecosystem structure, a trophic model was built using the ECOPATH software [17]. The food web model represents the 1995 state of the eastern English Channel. This involves identifying functional groups from primary producers to top predators and establishing predator-prey interactions to depict biomass transfer from one trophic level to another.

Systematic conservation planning approach was also implemented in order to identify priority conservation zones using the MARXAN software . This involves defining planning regions as units and calculating conservation priorities or costs per unit. Based on the initial priorities specified in the model, the desired conservation targets are selected based on the minimized cost of planning units selected closely located to each other as to avoid conservation area fragmentation.

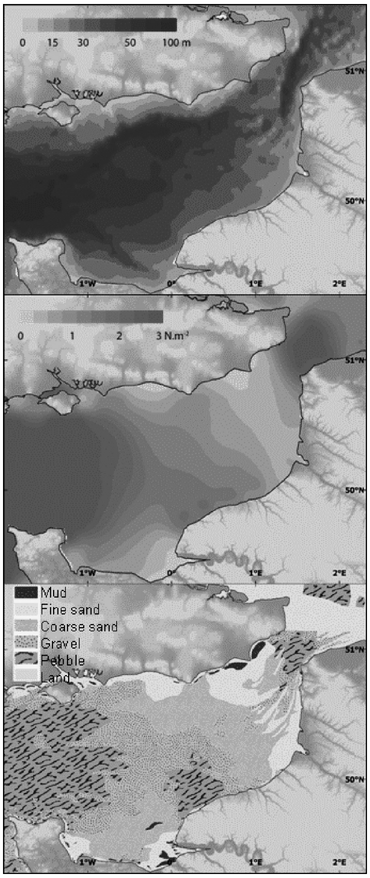

Fig. 3. Depth (above), bed shear data (middle) and bottom sediment type (below) maps of the Eastern English Channel.

III. Eastern english channel: a complex ecosystem

1. Physical environment

Several maps were produced showing the different physical and hydrological features of the Eastern English Channel. Mean average maps for depth, bed shear stress and seabed sediment types are some of the examples shown in Fig. 3. Environmental mapping of the Eastern English Channel shows that this ecosystem has diverse geomorphology. Water depth varies from 40 to 100 meters (Fig. 3 above). It is a macrotidal ecosystem. Elevated current intensities are located along the frontiers of the Eastern English Channel; the narrow area of the Dover Strait and the eastern-western channel border (Fig. 3 middle). As a result of an important hydrodynamic forcing (i.e., increasing current gradient both coast to offshore and west to east), sediments present a specific distribution with pebbles and coarse sediments in the zones of strong tidal currents and sandy muddy sediments in zones with weaker currents (Fig. 3).

2. Biological species description and habitats

The Eastern English Channel has an elevated species richness and biodiversity owing to diverse habitat features and adjacent estuaries. However, in the atlas only the most significant species in the food web and community structure and most abundant in scientific surveys were considered.

In the atlas we considered a total of 55 benthic invertebrate, cephalopod and fish species. These species were the most abundant and judged relevant in the ecosystem's structure. For a complete list of species considered, please consult the atlas [3].

For each species, information provided includes species description for possible identification, biology, feeding behavior, habitat, geographical distribution (Fig. 4 middle).

These species were considered for habitat and fisheries modeling. Average abundance maps per species were also produced based on scientific surveys. An example is shown in fig. 4 for cod in two different periods: summer (July) and autumn (October).

3. Fisheries and dynamics

Fishing activity in the Eastern English Channel is economically significant. In 2005, a total of 90 763 tons were captured only by French commercial fishing vessels (614) and landed in 42 ports (landings declared to the French Maritime affaire). This generated about 218 million Euros. Demersal species are highly exploited, especially the flatfishes (common sole) and gadoids (whiting) as well as Scombroids and clupeids. Atlantic scallops are also highly exploited. In 2003, production reached up to 8500 tons sold at 24 017 Euros.

In the atlas, the French fishing gears and vessels are enumerated based on three main categories: littoral, inshore (<12 nm) and mixed (>12 nm) fisheries. Fig.ure 5 shows a bottom trawl used to catch demersal species and how this gear is put out at sea and taken back on-board. A complete description of each fishing gears is available in the atlas.

4. Fishing communities

Small-scale fishing communities interviewed in the project reacted well to the free-style form of survey. A total of fifty fishermen were interviewed in the 10cities/ports cited above, leading to about 1–4 fishers interviewed per port and per fishing gear. In the French side, mainly trawlers and netters were interviewed whereas in the English side, some longliners and potters were also interviewed aside from the trawlers and netters. Responses accumulated from the different fishers interviewed are mainly subjective and reflected the opinions and perception of the interviewee regarding the current state and the future of the fishing industry. Based on the results of our interviews and observations we can infer that the fishing activities in the study area are complex and diverse due to

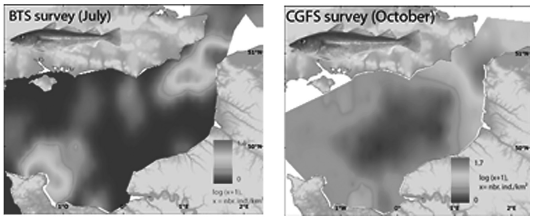

Fig. 4. Cod abundance distribution based on two scientific surveys.

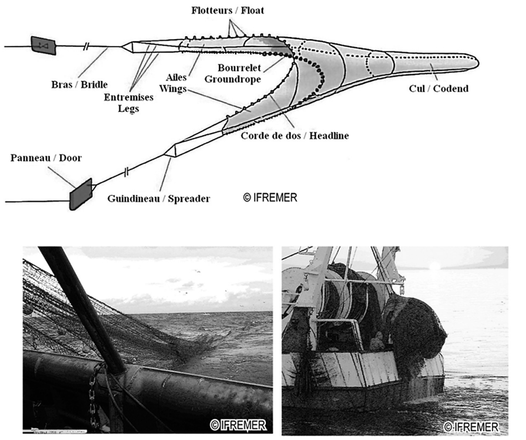

Fig. 5. Traditional bottom trawl (above). Below: Shoot (left) and haul (right) of the trawl at the stern (back) of the vessel.

the fishing history and practices, number of fishing vessels, regulations, etc. that affects the fishing industry in different ports. Fishing zones are determined by the difference in the size and power of the fishing fleets between UK and France, which is the direct result of the regulation difference. In Boulogne-sur-Mer (France) with 1000 fishers employing medium-sized trawling fleets (120) with high mobility, fishing zones cover mostly the eastern part of the channel whilst for UK small ports, such as Ramsgate, with almost all under 10m netting boats (15–20 vessels), fish only along their coastal area (Fig. 6).

5. Governance in the Eastern English Channel

A total of 216 regulations were compiled due to their relevance to the study site (Table 1). This part of the work was done in order to enhance the understanding, encourage the application and facilitate coordination of these

Table 1. Regulations compiled relevant to the Eastern English Channel on four major themes and at four application fields.

Application fields Theme	Interna-tional	Com-munity	French	British
Conservation	7	5	16	8
Fisheries	13	29	68	23
Pollution & Security	7	17	7	9
Marine works	1	-	1	5

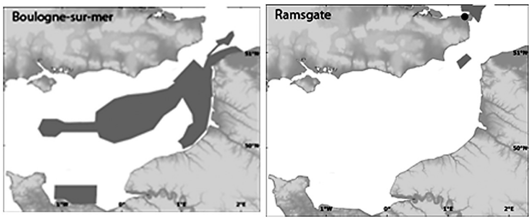

Fig. 6. Recorded fishing zones based on fishers interviewed at Boulogne-sur-Mer (France, left) and Ramsgate (UK, right) ports.

legislation. Among the four themes considered, regulations on fisheries are the most numerous totaling up to 133 laws (binding and soft), byelaws, directives, etc. at four application levels. Most international laws in fisheries are non-binding for contracting parties. State regulations complement community regulations and are put into applications when the latter is breached. The French fisheries have the highest number of regulations. Most technical measures (e.g., authorized gears, percentage of catches, etc.) related to fisheries are covered by the community regulations.

This is followed by pollution and security regulations (40) focused on environment protection. Measures are set up at the community level but cooperation at the international and between states are highly encouraged.

Regulations on conservation (36) focus on preserving marine habitats and species and protection involves the interdiction of some exploitation methods and practices. Conservation tools and establishment of conservation areas are established at the state and community levels, respectively.

For marine works, regulations (7) are established only at the international and state levels. A complete listing of these regulations as well as corresponding explanations can be consulted in the atlas [3].

6. Towards an ecosystem approach

6.1. Geostatistical analyses

6.1.1. Mapping species interaction with habitats

Several habitat maps produced for the 55 species were considered in the second volume of the atlas. This is especially true for the fish groups whose abundance distribution were mapped at different life stages: eggs, larvae, juvenile and adult. This includes 23 benthic invertebrates, 3 cephalopods and 29 fishes. Habitat modelings were done to predict probable, preferential and potential habitats for most of the species considered in the atlas. From the three modeling techniques utilized (GLM, GAM and RQ), it was observed that RQ-based models predicted the maximal response of species under ideal considerable conditions and are judged most suitable for precautionary conservation habitat planning [16]. An example using whiting is shown in fig. 6 where GLM and RQ-based map models are compared (Fig. 7). Compared with GLM analysis, RQ-based models consider the upper bounds of species-environment interactions thus providing a clearer description of how the environment is limiting species distribution.

6.1.2. Mapping fishing communities

Using interviews conducted in the fishing communities, fishing hot spot, seasonality and family history maps were created. Fishers drawings of popular fishing areas per species/-gear were used to create the shapefile polygons and once data are cumulated (overlay maps) will produce fishing hotspot maps. This is, however, a subjective snap-shot picture of favored fishing zones as the number of fishers (50) interviewed in the course of the project does not certainly represent the majority of fishers in the Eastern English Channel. In figure 8 hot spots for sole fishery along the Dover Strait zone is shown.

6.1.3. Mapping catch

Distribution of average annual landings from 2000–2006 for 25 of the most exploited fish and cephalopod species were mapped per ICES division. For each species, information on annual production by state as well as commercial value is also provided. Fig.ure 9 shows an example of fishing frequency numbers (trip numbers) of bottom trawls for stripped red mullet for every quarter of year. We can observe that the fishing activities occur considerably along the south of the North Sea during the third quarter and progress slightly to the middle of the eastern part of the Channel during the fourth quarter of the year. This species is of high commercial interest and is targeted mainly by French fleets capturing up to 97 % of annual landings. Exploitation started in 1990 with less than 300 tons and after 15 years, recorded landings had increased ten times.

6.2. Food web modeling

A total of 51 functional groups including detritus (1), primary producers (2), invertebrates (15), fishes (29), mammals (2) and seabirds (1) were considered in an ECOPATH [17] model. This type of modeling work provided a synthetic snap-shot representation of the ecosystem structure defined by food web links and energy transfers from one trophic level (TL) into another in the ecosystem [18]. The Eastern English Channel food web consists of four trophic levels: TLI consists of primary production and detritus, TLII include invertebrates such as bivalves, gastropods, small crustacean (i.e., zooplankton), small demersal fishes (i.e., stripped red mullet) and forage fishes (i.e., goby), TLIII is mainly occupied by large demersal, bentho-demersal and benthic fish species (i.e., cod, plaice, sole) and TLIV consists of high predators (i.e., shark, mammals, seabirds). It is a phytoplankton-based ecosystem owing to this primary production's contribution to support the upper TLs. Mean trophic level of capture is at TLII. TL V has very low exploitation level as functional groups belonging to this TL includes mainly marine mammals and seabirds (Fig. 10). Through this work, keystoneness [19] and important trophic roles of species were determined. Through this type of modeling, it was also interesting to see the combined trophic effects of fishing. This figure shows that the combined effects of fishing activites in the Eastern English Channel will have detrimental effects to most biomasses of functional groups.

6.3. Systematic conservation planning

The Eastern English Channel is an interesting area for designing marine protected area

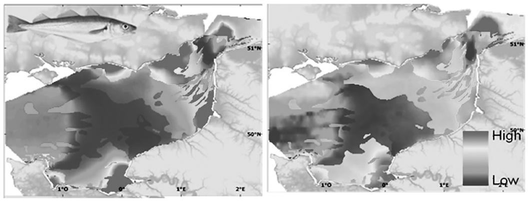

Fig. 7. Preferential (GLM-based, left) and potential (RQ-based, right) habitat models based on the interpolated mean abundance data from October 1988–2006 surveys (whiting photo courtesy of IFREMER).

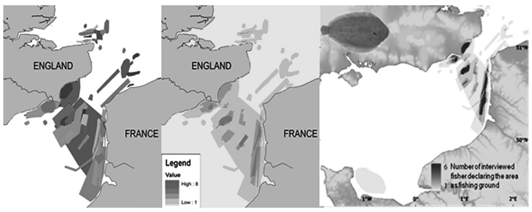

Fig. 8. Mapping of fishers' interview responses in fishing communities. Mapped fishing locations for the common sole (left) made from raster maps (middle, orange) and shapefile polygon hot spot maps (right). (common sole photo courtesy of IFREMER).

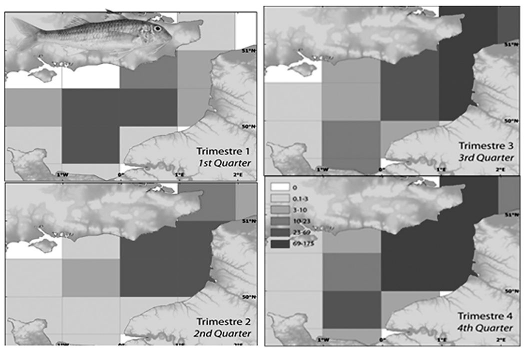

Fig. 9. Landing distribution in tonnes of stripped red mullet mapped per ICES division (stripped red mullet photo courtesy of IFREMER).

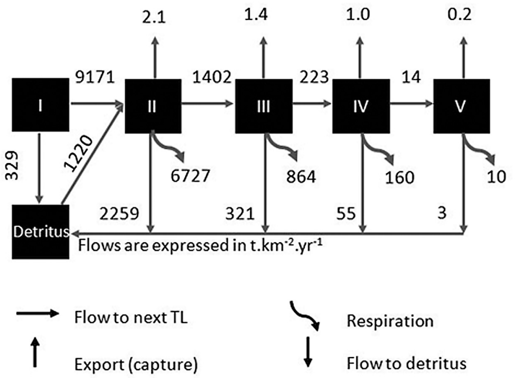

Fig. 10. A simplified representation of energy fluxes per trophic level of the Eastern English Channel.

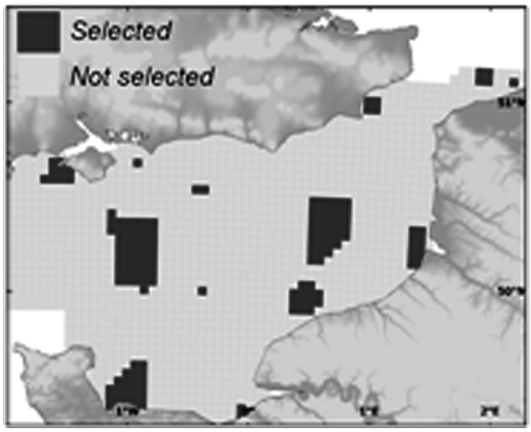

Fig. 11. Best conservation portfolio using a BLM of 500.

(MPA) networks due to the significant ecosystem services (i.e., jobs, gravel extraction, windfarming, etc.) it offers. Preliminary systematic conservation planning [20] was done in the Eastern English Channel. This involved identifying a set of conservation features (i.e., species, jobs, ecological processes, etc.) then setting numerical targets for conservation. Once this is done, the planning region is divided into planning units (PU) then simulation runs are made using annealing techniques to estimate a large number of near-optimal sets (or portfolio) of PUs. A total of 1466 PUs were created and about 17 conservation features were identified. From the identified PUs, 47 were considered as "conserved" while 123 were classified as scenario-excluded for cost metrics simulation runs. One of the hypotheses tested was the estimation of the total perimeter length of the planning unit portfolio multiplied by a boundary length modifier (BLM). MARXAN [21] minimizes the boundary length cost by choosing patches over isolated PUs. From our analyses, we chose a BLM of 500 to ensure that the conservation portfolio patches formed (dark blue patches) were generally large enough to be ecologically viable (Fig. 11) based on the metric costs used. In this scenario, establishing several discontinued MPAs seemed efficient in increasing biodiversity and mitigating effects of diverse anthropogenic activities. Modifying metrics of cost from the one considered here, however, may give other results and may require BLM adjustments. Other analyses include testing different metric costs and target values on resulting priority area spatial pattern.

IV. Reaching beyond scientific borders

This project has been carried out in four years (two phases). The amount of results generated throughout this period is considerable owing to the motivation and dedication of scientists who collaborated together to produce the atlas. Producing the atlas was not an easy task. Scientific partners working on this since its conception have overcome several challenges in order to accomplish this work. Results obtained are innovative in the sense that compiling fragmented data from different fields into a user-friendly, concise and freely-distributed tool has provided an opportunity to safeguard and revalorize existing information.

The success of scientific initiatives launched in the project since its conception is the increasing scientific recognition reflected by the ongoing growth, in terms of collaborations and scientific productions, of the Charm Consortium. It provided an opportunity of bridging the gap between scientists, managers, stockholders, policy-makers, fishermen and the grand public, creating a social-learning institution among different sectors that are concerned with marine management. The atlas has become a significant reference material of knowledge on the Eastern English Channel and its living resources. The main force relies on efficient communication of simplified, concise and useful information to different sectors. It was initially dedicated to providing contemporary map-based inventories of habitats and living resources in the Eastern English Channel [22] and is actually moving towards a greater ambition of implementing an ecosystem-based approach. Since 2009, the third phase of the project has begun covering more scientific themes and challenges. Scientific French and English research institutes and laboratories participating in this phase doubled. Currently, the whole English Channel is being covered and more integrative modeling work dealing on habitat classification, economics and climate change are considered aside from the trophic network and systematic conservation plan modeling during the second phase.

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Limiting factors of phytoplankton communities along the Ogasawara transect in North Western Pacific Ocean

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Abstract: In order to clarify the dynamics of oligotrophic ecosystems at the Subsurface Chlorophyll *a* Maximum (SCM), we investigated the distribution of phytoplankton and availability of nutrients in the euphotic layer along the Ogasawara transect (North-West Pacific Ocean). Depending on the distribution of underwater light and microphytoplankton communities a gradient between oceanic and coastal stations around Chichijima Island was identified. The vicinity of island is marked by lack of clear maximum peak of Chl. *a* and higher values of inorganic nutrients which pointed out a possible effect of island on this oligotrophic area. In contrast, significant SCMs reaching 5 times the Chl. *a* concentration at the surface were measured at the offshore stations. The SCM is located under the thermocline (60 to 68 m), the organisms mainly dominated by diatoms community were exposed to low light condition (4 to 1% of surface irradiance) and were associated with nutriclines (0.35 to 1.15 μM of nitrogen and 0.03 to 0.07 μM of PO_4^{3-}). Changes in the nutrient potential limitation were detected at the SCM. In the epipelagic layer of offshore stations, Si:N:P stoichiometries values mainly oscillated between phosphorus and nitrogen potential limitation. However, nitrogen suddenly shifted to a phosphorus potential limiting factor at the SCM. If this result can be confirmed by complementary studies, it adds evidence that regeneration or predation mechanisms and availability of phosphorus mainly control the growth of phytoplankton in this oligotrophic area.

Keywords: *Chlorophyll a, light, nutrient, N-W Pacific, oligotrophy, phytoplankton*

1. Introduction

According to recent projections, a decline of primary production associated with an extension of oligotrophic areas was reported in the Pacific Ocean. (LOPEZ-URRUTIA *et al.*, 2006; BEHRENFELD *et al.*, 2006). In this framework, identification and quantification of relationships between primary producers and oligotrophic conditions must be addressed in order to better understand the climate forcing and the ecological response.

In this low production area, previous investigations described usual subsurface Chlorophyll *a* maximum (SCM) close to the bottom of euphotic layer (EPPLEY *et al.*, 1988; FURUYA and MARUMO 1983, FURUYA 1990). The SCM takes large part of primary production in the Pacific Ocean where 90% of Chl. *a* concentration of sunlit zone can be located in this layer. Formation of SCM is a complex phenomenon links to photoacclimation mechanisms as well as nutrient availability and requirements of phytoplanktons (HENSE and BECKMANN, 2008). Irrespective of hypothesis about its development, the SCM remains currently unclear in

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the North Pacific Subtropical Gyre, (NPSG) (LU *et al.*, 2010).

Although the NPSG is a well documented area, few are known concerning the distribution of light, nutrients and phytoplanktons near the Bonin Islands and especially near the Chichijima Island (TAGUCHI, 1975). Thus, this cruise provides an interesting opportunity to detect the variability of oligotrophic conditions surrounding the island. In this report, we investigate parameters leading the distribution of phytoplankton in oligotrophic area. Special attentions will be focused on the SCM layer in order to identify the potential limiting factor depending on the environmental conditions.

2. Materials and methods

The Chichijima observations took place from November 18th to 21st 2009. The 12 sampling stations are located between the Chichijima harbor and the Tokyo Bay (Fig. 1). By using Niskin bottles, phytoplankton were sampled at three levels (surface, SCM, depth of 1% light intensity) and putted into 500 ml clean polyethylene bottles. To prevent grazing processes, Lugol's solution was immediately added. For each sampling point, 1 liter of sea water was enumerated onshore according to the Utermöhl method and references listed in the HASLE study, (1978).

Chlorophyll *a* and phaeopigment were measured on the basis of the fluorometer method (SUZUKI and ISHIMARU, 1990). During this cruise, 3 different filters were used: Whatman® nucleopore filters ~0.2 μm, glass microfiber filters, GF/D ~2.7 μm and paper filters N°1 ~ 11 μm. After sampling with Niskin bottle, 200 ml of seawater was filtrated through each filter type by lower vacuum pressure (<100 mm of Hg). Then, filters were immersed into N,N-dimethylformamide, (DMF) -containing tube, and stored in dark condition at 4℃. Analyses were made using a Turner Designs Fluorometer previously calibrated with pure Chl. *a* pigment.

The light parameters have been monitored using the Profiling Reflectance Radiometer, Instrument (PRR 600) Biospherical Instrument®. The PRR 600 simultaneously measures, Photosynthetically Active Radiation (PAR), downwelling irradiance and upwelling radiance with 10nm bandpass filters centered at 412, 443, 490, 510, 555, and 665 nm as a function of pressure, where pressure is used as a proxy for depth.

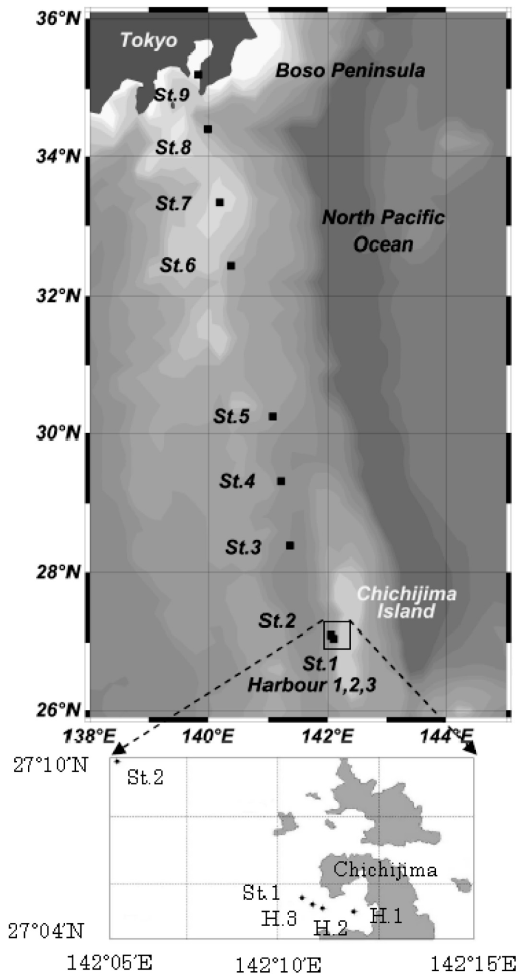

Fig. 1. Sampling stations in the North Western Pacific along the Ogasawara transect from Chichijima Island to Boso Peninsula.

Inorganic nutrients, (NO_3^-, NO_2^-, NH_4^+, PO_4^{3-}, Si $(OH)_4$), were measured at each sampling point. Nutrient samples were collected by Niskin bottles, immediately putted into cleaned plastic tube and stored kept out of the light, in a freezer compartment. Analyses of inorganic nutrients were performed by using an autoanalyzer (AACS III). NH_4^+ was measured according to KANDA method (1995). PO_4^{3-} by the method of MURPHY and RIDLEY study (1962) and others nutrients (NO_3^-, NO_2^-, $Si(OH)_4$) by methods listed in HANSEN and KOROLEFF study, (1999). By using nutrient concentrations, different types of stoichiometries were used to identify the potential limiting factors. The Redfield and Brzezinski ratios have been calculated on the basis of following stoichiometries (BRZEZINSKI, 1985) :

Si : N : P = 15 : 16 : 1

In addition to this previous calculation another nutrient ratio was estimated (JUSTIC *et al.*, 1995). Three types of potential limitation can be evidenced according to the following assessments:

(a) P limitation, $[PO_4^{3-}] < 0.1\,\mu mol.L^{-1}$, $[Si(OH)_4]:[PO_4^{3-}] > 22$ and $[DIN]:[PO_4^{3-}] > 22$,
(b) N limitation, $[DIN] < 1\ \mu mol.L^{-1}$, $[DIN]:[PO_4^{3-}] < 10$ and $[Si(OH)_4]:[DIN] > 1$,
(c) Si limitation, $[Si(OH)_4] < 1\ \mu mol.L^{-1}$, $[Si(OH)_4]:[PO_4^{3-}] < 10$ and $[Si(OH)_4]:[DIN] < 1$.
Where $[DIN] = [NO_3^-] + [NO_2^-] + [NH_4^+]$,

In contrast to the REDFIELD and BRZEZINSKI stoichiometries, JUSTIC *et al.* took into account the nutrient uptake kinetics. In view to limit bias due in part to all chemical compounds in the calculation method, threshold criterions for each nutrient were added according to DORTCH and WHITLEDGE (1992).

3. Results

3–1 Biological measurements

During the cruise, we identified 157 species including 62 diatoms, 51 dinoflagellates, 21 tintinnid species and 23 others types (copepods, radiolarians). Concentration of diatoms and dinoflagellate organisms remained relatively weak at the surface between Chichijima Island and the station 5, (respectively ∼22,750 $orgs.m^{-3}$, ∼33,250 $orgs.m^{-3}$). From station 6, abundance of diatoms showed a gradual increase and reached a maximum value near the station 9 in Tokyo Bay (∼520,000 $orgs.m^{-3}$) (Fig. 2). The spatial distribution of diatoms and dinoflagellates presented a specific pattern along the transect. On the basis of our measurements, diatoms dominated all types of microphytoplanktons at the surface of St. 4, from St.6 to St.9, maximum of Chl. *a* and bottom of euphotic layer. In contrast, our results suggested that dinoflagellates were dominant at the surface around the Chichijima Island. In the dinoflagellates community, the *Ceratium* genus appeared to be the most abundant especially the species *C. furca, C. lineatum*, and *C. pentagonum*.

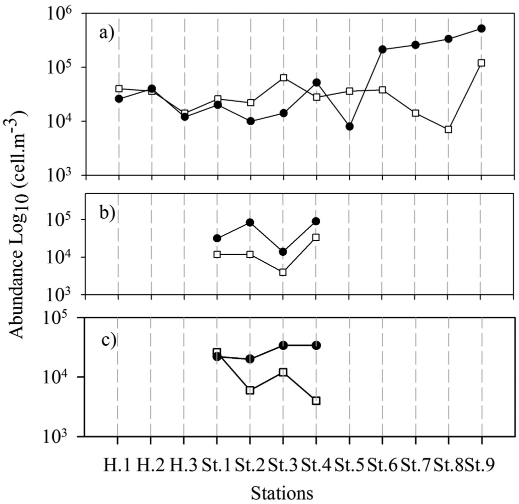

Fig. 2. Variability of diatoms (black circle) and dinoflagellates pool (white square) at three different depth levels along the Chichijima cruise. Graph a) shows the concentration at the surface, b) at the maximum of Chl. *a* and c) at 1% of incident light or at 100 meters for the station 4.

Although abundance are lower than dinoflagellates, some diatoms species like *Rhizosolenia pungens, Cerataulina pelagica* and *Pseudonitzschia* spp. were recorded especially at the SCM and at 1% of light intensity. Phytoplankton species enumerated from the stations 6 to Tokyo Bay showed that the *Chaetoceros* genus appeared to dominate the microphytoplankton community in particular with the species *C. curvisetus* and *C. laciniosum*. Concerning the zooplankton enumerations, the higher concentration of copepods and tintinnids were recorded at the SCM.

In the euphotic layer, the Chl. *a* concentration measured between the Chichijima Island and the station 5 ranged from $0.02 mg.m^{-3}$ to $0.58 mg.m^{-3}$. Similar to the increase of

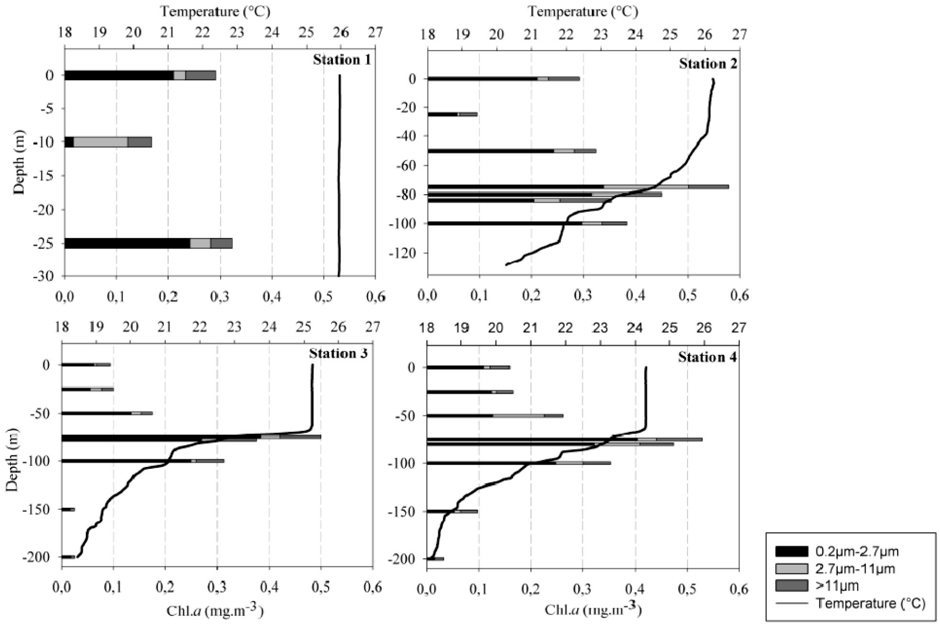

Fig. 3. Vertical profiles of Chl. *a* and temperature recorded at stations around Chichijima Island. Chlorophyll *a* ($mg.m^{-3}$) for different size classes is also shown. The black line is temperature in ℃.

abundance of diatoms mentioned above, the concentration of Chl. *a* recorded at the surface increased from station 6 to the Tokyo Bay (0.60 $mg.m^{-3}$ to 2.29 $mg.m^{-3}$). Concentrations of Chl. *a* recorded from the station 6 to Tokyo Bay were significantly different from other stations measured in the subtropical gyre (p-value < 0.05). On the basis of filter set results, the smallest fraction (0.2 μm to 2.7 μm) fixed the higher concentration of Chl. *a* in 91% of cases (Fig. 3).

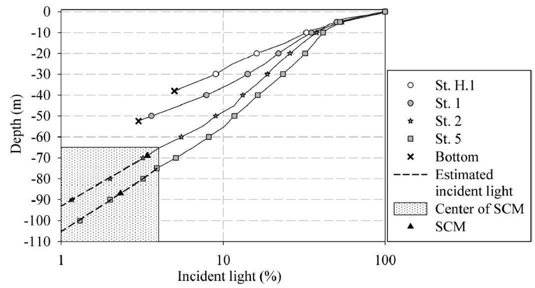

Fig. 4. Vertical profiles of incident PAR (%) from the coastal station H.1 to the offshore station 5. The intermediary stations (1, 2) were respectively located at the mouth of the Chichijima Bay and nearby the island. The black cross is the bottom of seawater column and black triangle is the depth of SCM. The dot filled rectangle shows the layer where center of SCM were detected. The continuous line shows the measured points and the dotted line the estimated incident light.

3–2 Bio-optical environment

The SCMs were detected between 69m and 86m at the stations 2, 3, 4 and 5 (Fig. 4). These significant SCMs were located under a marked thermocline and just upper the nutriclines. At these stations, limits of euphotic layer were intrinsically linked to the maximum of Chl. *a*. However, no clear peak of Chl. *a* was recorded at the stations H.1 and 1 located in the Chichijima's bay where the light reached the bottom of seawater column with respectively 5% and 3% of relative incident light.

At the stations 2 and 5, the relative PAR was ranged from 1 to 4% at the center of the SCM. The bottom of the high chlorophyll layer received 0.1 to 4% of relative light intensity while the top was exposed to 1 to 20%. Similarly to attenuation coefficient curve, (data not show),

Table 1. Classification of optical water type depending on the wavelength and Jerlov table.

	412	443	490	510	555	665
St. H1	IB	II	IB	IB	I	I
St. 1	IA	IA	I	I	IA	I
St. 2	IA	IA	IB	IA	IA	I
St. 5	I	I	I	I	I	I

a progressive separation of incident light profiles was evidenced between the station H.1 and the offshore station 5 (respectively 22.4% and 9% at 30m).

Results on the optical water type (JERLOV, 1968) were shown in the Table 1. Although the offshore station 5 was in the case I at each wavelength, a type II (443nm) was monitored at the coastal station H.1. Between these two kinds of stations the optical water type varied from case I to IB at the sampling stations 1 and 2.

3–3 Nutrients and potential limiting factors

Vertical profiles of inorganic nutrient concentration showed a low value in the shallower layer (Fig. 5). However, noticeable nitracline and phosphacline were recorded between 60m and 90m. In these nutriclines, peaks in ammonium (0.6–0.85 μM) and nitrite (0.1–0.15 μM) were measured at the SCM of offshore stations. By using the REDFIELD and BRZEZINSKI ratios, four types of potential limitations were identified. Thus, 2 potential nitrogen limitations (Si,P,N ; P,Si,N), a potential phosphorus limitation (Si,N,P), and to a lesser extent a potential silicon limitation (N,P,Si) were detected. During the cruise, the distribution of potential limiting factor appeared to indicate a clear nitrogen limitation at all stations. In contrast, the [DIN]:[PO_4^{3-}] stoichiometry identified few clear potential limitations due to the high concentration of ammonium and threshold criterions used. However, phosphorus potential limitations were detected at the SCM and an oscillation between phosphorus and nitrogen occurred in the upper layer (Fig. 6).

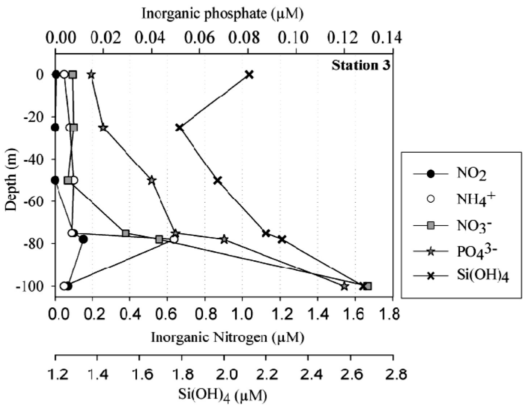

Fig. 5. Vertical distributions of concentration of inorganic nutrients at the St. 3. A primary nitrite maximum and a peak of ammonium were identified at the SCM.

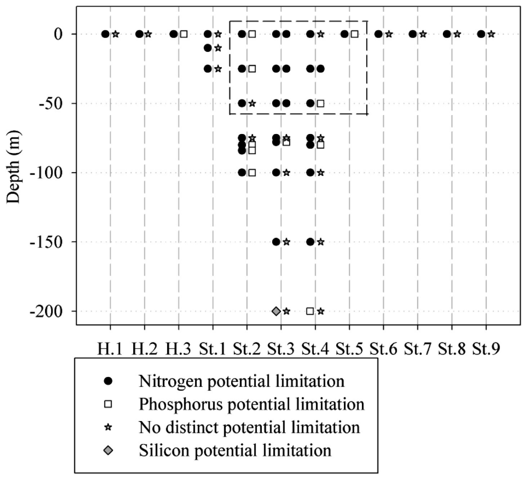

Fig. 6. Vertical distribution of potential limiting factor during the Chichijima cruise. At each depth, the REDFIELD and BRZEZINSKI stoichiometry is showed on the left side and the DIN:DIP on the right side. The black dotted rectangle point out the sampling point where the concentration measured were near the detection limit.

4. Discussion

4–1 Shifts in the phytoplankton communities depending on the environmental conditions

According to the results collected along the Ogasawara transect, our data set suggests a constant oligotrophic condition due to the low concentration of Chl. *a*, microphytoplankton and inorganic nutrients. However, two possible changes of environmental conditions depending on these parameters were identified. By using the one way analysis of variance test

(Kruskall-Wallis test) a significant difference of abundance of microphytoplankton (p-value < 0.05) was recorded between the St. 5 and the St.6. Difference of concentration was in part based on a shift of the dominant pool of microphytoplankton at the surface (dinoflagellate to diatom) and to drastic increase of abundance of the genus *Chaetoceros* spp.. Similarly, results on the Chl. *a* concentrations depending on the class sizes and nutrients appear to confirm this trend and define an area (St.6 to St.9) which was significantly different to the subtropical gyre (p-value<0.05). According to the location of stations and the sea surface temperature (Japan Oceanographic Data Center: (http://www1.kaiho.mlit.go.jp/jhd-E.html)), it's appeared that change was probably due to the Kuroshio's current conditions which differed from the Subtropical gyre area.

A second separation of data set was identified between the Chichijima Bay (H.1 to H.3) and the station St.1 to St.5. This change marked by the vicinity of island was reported on the microphytoplankton community and the distribution of light in the sea water column. According to previous report a decrease of concentration of microphytoplankton was monitored between St. H.1 and H.3 located at the mouth of the Chichijima Bay (TAGUCHI, 1975). In agreement with the TAGUCHI results, the concentration of dinoflagellates globally dominated the microphytoplankton species at the surface in the pool of stations surrounding the island and in the Chichijima Bay. However, dominant species enumerated in 1970 differed from this current study. For instance, abundance of *Peridinium* spp. were the dominant species enumerated around Chichijima Bay in 1970 but no occurrence was detected in our study. Moreover, even if the dominant species changed, no significant difference of total abundance of microphytoplankton was enumerated between the Chichijima Bay and the stations located in the Kuroshio counter current (St.1 to St.5).

Investigation of the relative light incidence condition provides a method to identify how the island modifies the surrounding area. In our data set, stations located at the mouth and in Chichijima Bay (St.1 and St. H.1) showed the higher light attenuation. Depending on the different wavelengths, variability of optical sea water types are consistent to the gradient observed but the seawater appeared more transparent than previously reported (SIMONOT and LE TREUT, 1986; EPPLEY *et al.*, 1988). Using JERLOV tables, optical water type near the absorption wavelength of Chl. *a* (665nm) did not change between the Chichijima Bay and the St. 5. In contrast, variability of different optical types is higher for the shorter wavelength and especially for maximum absorption of Chl. *a* spectrum (443nm). This classic significant absorption near the UV and declining to near zero between 650nm and 700nm is a characteristic of dissolved organic matter compound, CDOM (LOISELLE *et al.*, 2009).

The role of the inorganic particulate matter can also be putted in evidence due to the increase of upward radiance near the coastal area (data not show). In this oligotrophic condition the low light absorption coefficient associated with a greater backscattering process seemed to be a characteristic of higher turbidity near the Chichijima Island. This result involves that the reflective irradiance value due to shallow bottom is too low to modify the upward flux. As mentioned above, only 5% and 3% of incident light reached the bottom of sea water column. Thus, in contrast to the turbidity concentration, the reflective irradiance appears to be insignificant to drastically modify the upward flux of light.

Based on the optical properties, the higher nutrient concentration, CDOM and inorganic particulate matter can in part explain the lack of SCM in the Chichijima Bay. Similarly, lack of thermocline and pycnocline recorded between the station H.1 and St.1 highlighted that mixing condition was significant near the island and modify the shallow layer environment. Mixing conditions probably improved the nutrient availability in the upper layer and consequently, distribution of phytoplankton community was located in the entire sea water column. Our optical measurements were in line with the low concentration of phytoplankton enumerated during the cruise and suggested that the island modify the local distribution of microphytoplankton, but at a larger scale variability of abundance remains weakly detectable due in part to the globally constant oligotrophic condition.

4–2 Structure of SCM and limitation mechanisms

Distribution of phytoplankton has been monitored depending on the class sizes. By using filter set, our results suggested that small organisms (0.2 μm to 2.7 μm), played a significant role in the sea water column. Domination of small class size and concentration of Chl. *a* at the SCM reaching 5 times the concentration at the surface confirmed this ubiquitous phenomenon described in the NPSG (TAKAHASHI *et al.*, 1985; HENSE and BECKMANN, 2008).

Although this common structure is well documented, identification of potential limiting factor changed depending on the knowledge of seawater environment and methods used for nutrients measurement. CULLEN (1982) reported this issues regarding to biomass interpretation. In the Cullen study, location of SCM is drastically led by the nitrate availability, light and to lesser extent the temperature value which can change the chlorophyll concentration of cell by a factor 10. However, modification of Chl. *a* cell-content is also reinforced by the photoacclimation mechanisms which can inhibited 8 times the fluorescence in the upper layer (LOFTUS and SELIGER, 1975). In contrast to the high variability of Chl. *a* concentration in the sunlit zone, the low variability of microphytoplankton abundance between the surface and the other layers tends to show that a photoacclimation process occurred at the SCM.

As mentioned above, SCM is closely located at the boundary of the euphotic layer. This vicinity involves developing strategy, which according to previous reports, allow the growth of phytoplankton community under the arbitrary 1% of incident light (FALKOWSKY and OWENS, 1978; ANDERSON, 1979). The mobility of dinoflagellates organisms in the seawater column can be one favourable advantage contrasting to the slow migration of diatom species (JEPHSON and CARLSSON, 2009). Usually the dinoflagellates organisms swim upward in the morning and downward in the evening to respectively take advantage of optimal light and nutrient replete condition. In this study the domination of diatom measured in the night condition at the surface of station 4 tends to confirm this diel vertical migration. However, the lack of clear increase of dinoflagellate abundance at the bottom of sunlit pointed out the probable distribution in the shallow layer as previously described in experimental cultures (JEPHSON and CARLSSON, 2009).

Scavenging process at the SCM appears to be sizeable and can modify the relative fractioned size of Chl. *a*. Examination of large class size (>11 μm) suggested that an increase of the large size occurred under 1% of incident light. By using a microscope, our investigations revealed numerous particles at these depths mainly composed by fragments of the diatoms. Adsorption of organisms and scavenge of particles can in part explain the change of class size and the presence of Chl. *a* at these deep depth values. It should be noted that grazing pressure can explain the presence of particles at the SCM due to higher abundance of large phytoplankton predators (copepods and tintinnids) at these depths.

Grazing activity at the SCM initiate by large zooplanktons and heterotrophic bacterias was highlighted since the earliest report, (LE BORGNE, 1977; EPPLEY *et al.*, 1988; KUIPERS and WITTE, 2000). In this previous report, Le Borgne claimed that nutrient profiles can show the grazing activity due to the selective excretion of phosphate compared with the nitrate assimilation. According to the definition of LE BORGNE, our results showed the same difference between the profiles of phosphate and nitrate at the SCM. In addition, the peak of ammonium recorded at the SCM adds an evidence of regeneration of organic matter and a possible grazing activity (Fig. 5). However, due to the lack of measurement of grazing activity or picoplankton abundance in our study, discussion about the accumulation of Chl. *a* at the SCM layer remained difficult and especially to separate the photoacclimation mechanisms to sink of particles.

On the basis on the REDFIELD-BRZEZINSKI stoichiometries, identification of potential limiting factor of the area was investigated.

Variability of ratio can reflect the nutrient availability and their utilization by the plankton organisms. In our study distribution of REDFIELD and BRZEZINSKI ratios mainly shows a nitrogen potential limitation at each station. This result was consistent with previous meas urement which reported that (nitrate + nitrite): soluble reactive phosphorus, (SRP), was far below the REDFIELD stoichiometry in the western part of North Pacific Ocean (HASHIHAMA *et al.*, 2009). At the SCM, the DIN: [PO_4^{3-}] calculation seemed to be more suited for identification of the potential limiting factor due to the ammonium compound in the calculation process (JUSTIC *et al.*, 1995). In our study, the concentration of this compound appears to be significant in particular at the SCM where a peak has been recorded. The superimposition of these two indexes highlighted that the upper layer of euphotic layer oscillated between the nitrogen and phosphorus potential limitation probably due to the diazotrophy process (KARL *et al.*, 2001). However, specific pattern recorded at the SCM appears to be linked to the input of ammonium issue of the grazing activity and remineralisation mechanisms. This significant addition of ammonium and to lesser extent nitrite leads to change the nitrogen to phosphorus potential limitation at the SCM.

Finally, comparison of the depth of SCM and the light intensity tend to show two different features. The bio-optical parameters recorded in the Chichijima Bay indicated that phytoplankton communities can grow in the entire sea water column. In contrast, according to the previous studies, the SCM were systematically measured near the compensation depth for the stations located in the subtropical gyre (FURUYA, 1990). On the basis on our measurements, light intensity appears to control the access of nutrients in the gyre and allow in a stratified column to use the nutriments located under the thermocline.

5. Conclusions

Studies of some biological and physical parameters allow identification of three different oligotrophic areas in the Western part of the NPSG (Chichijima Island, the subtropical gyre, and the Kuroshio current). In these oligotrophic areas, the higher value of Chl. *a* concentration was recorded for the smallest fraction part (0.2 μm to 2.7 μm). The low concentration of microphytoplankton enumerated at each station around the Chichijima was dominated by the dinoflagellate species at the surface. The diatom pool is more dominant at the SCM and in the Kuroshio Current. Our measurements confirm that Chichijima Island appears to have specific feature in contrast to the Subtropical gyre area. In this oligotrophic location, the island seems to modify the optical properties of seawater, increase the concentration of nutrients which allowed utilisation over the entire seawater column by the phytoplankton organisms. Albeit complementary studies should be investigated, light availability and concentration of phosphorus under the thermocline appeared to be a key factor to support the growth of phytoplankton communities in the western part of NPSG.

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Dissolved Inorganic Nitrogen budget in the inner part of Manila Bay, Philippines

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Abstract: Dissolved Inorganic Nitrogen (DIN) budgets for the vertically three dis tinct layers of the Pasig River estuary in Manila Bay were elucidated for both dry and rainy seasons. The budgets were based on observational data and results of hydro-dynamic model experiments. The obtained results suggest that, in both seasons, DIN fixation by photosynthesis exceeds decomposition of organic matter in the upper layer, and that decomposition of organic matter exceeds DIN fixation in the lower layer. In the middle layer, fixation and decomposition appear to be in equ ilibrium in the d ry season, with decom position exceeding fixation in the rainy season. Fixation thus exceeds decomposition in the water column during the dry season, with the opposite relation observed in the rainy season. The main source of DIN in the middle and lower layers is regenerated DIN in the water column and sediments.

Keywords: *Nitrogen, Material Budget, Manila Bay*

Introduction

The deterioration of the water quality in Manila Bay has resulted in blooms of red tide occur in the bay. VELASQUEZ *et al.* (1997) reported the average nutrient con centrations in Manila Bay, and JACINTO *et al.* (1998) calculated the nitrogen and phosphorus budgets of the bay using the Land Ocean Interaction s in the Coastal Zone (LOICZ) biogeochemical budgeting procedure. However, these studies only estimated average annual values for the whole of Manila Bay, and seasonal variations in nutrient cycling have not yet been described. VILLANORY *et al.* (2006) characterized the horizontal distribution of *Pyrodinium* using a hydrodynamics model, and discussed the relation between *Pyrodinium* blooms and the physical dynamics of the bay, however, the influence of nutrients was not included. HAYASHI *et al.* (2006) and HAYASHI *et al.* (2008) estimated the seasonal variations of nitrogen cycling in the surface layer of Manila Bay by using a numerical ecosystem model. And it clarified the effect of dissolved inorganic nitrogen (DIN) concentrations in the lower layer and nitrog en loading from rivers to the reduction of chlorophyll *a* (Chl.*a*) and DIN concentrations in the upper layer. Nitrogen is considered the limiting nutrient for primary production in Manila Bay, and the vertical transport of nitrogen to the surface layer plays an important role in the primary production. However, a source of DIN unde r the surface layer has not been explored. It is im portant to determine the characteristics of the DIN budget not only the surface layer but also the middle and lower layers in Manila Bay. In this study we describe the DIN budget

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for three vertically distinct layers in the Pasig River estuary of Manila Bay during dry and rainy seasons. And we discuss about primary production that is bound up with DIN budget.

Material and methods

Study area

Figure 1 shows the study area of Manila Bay. The bay has two major inflowing rivers, the Pasig River and Pa mpanga River, with the Pasig River flowing through metropolitan Manila. Concentrations of DIN, Chl.a and Dissolved Oxygen (DO), water temperature and salinity were determined at depths of 1 m, the mid-depth and near the bottom in eight stations (Fig.1) during every month from March 1996 to December 1998. Water samples were collected using a 5–L Niskin sampler (General Oceanics, Inc.). Samples for the inor ganic N species (nitrate, nitrite, and ammonia) and Chl.*a* were filtered through GF/C filte rs, frozen, and analyzed later following the m ethods of PARSONS *et al.* (1984). Sam ples for DO were fixed on site and subsequently analyzed using the Winkler titration method (PARSONS *et al.*, 1984). Salinity and temperature were m easured using the Conducti vity-temperature-depth (CTD) profiler (A ML Oceanographic Ltd.). Water transparency was measured by a Secchi disc. HAYASHI *et al.* (2008) demonstrated the use of the depth-time diagrams of density, DIN and Chl. *a* concentrations in Manila Bay. Under conditions of increased discharge from the Pasig River during the rainy season, stratification is developed and high Chl.*a* concentrations are observed in the upper layer of the estuary. Therefore, the inner part of Manila Bay inside the solid line in Fig. 1 was analyzed in this study. This area is divided into three vertically distinct layers which correspond to fixed depth intervals, as shown in Fig. 2. The surface region of the study area is about 500 km^2, the length of the outer boundary is about 38 km, and the average water depth is approxim ately 10 m. The surface layer depth was fixed at 3m which is the depth of the halocline in the rainy season. The middle layer was set from 3 m to 8 m depth while the lower layer is below 8m.

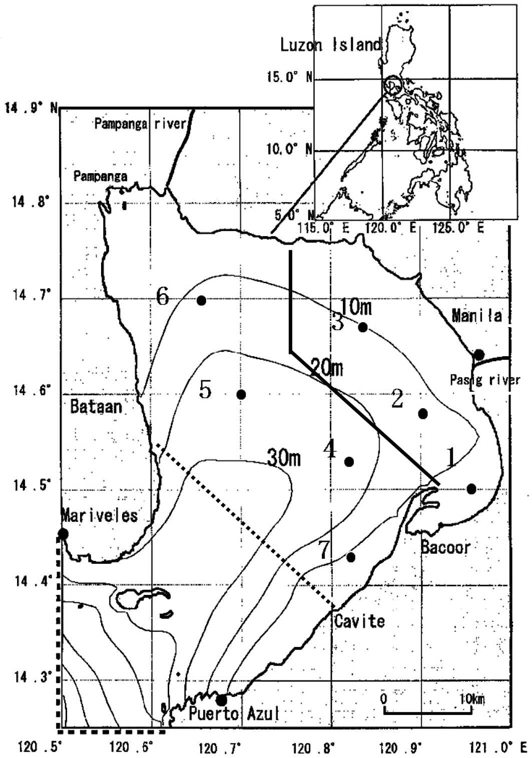

Fig. 1. Study area of Manila Bay. The solid line indicates the boundary of the study area. The dotted line indicates the boundary of the area, where averaged data were obtained. The numbers indicate sample sights.

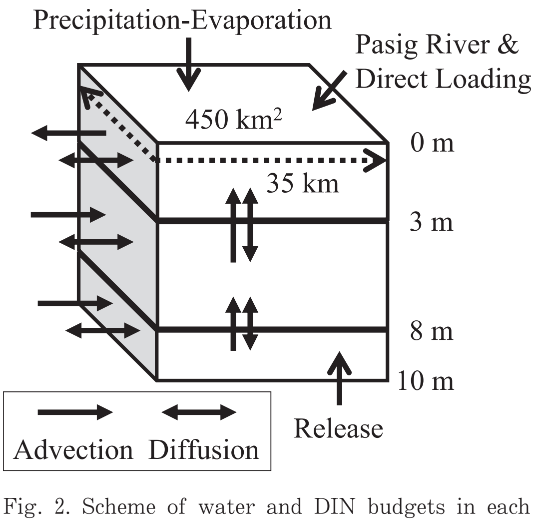

Fig. 2. Scheme of water and DIN budgets in each layer of the Pasig River estuary.

Data

Figure 2 also shows the schemes of water and DIN budget applied to the model in this study. Water and DIN are transported by estuarine circulation, i.e., advection. And DIN is also exchanged by dif fusion across the boundary line between the study area and the outer area and between the layer and layer. The advection and diffusion flux of DIN can be calculated by equation 1 and equation 2, respectively.

$$(Advection\ flux\ of\ DIN) = U_i F_i DIN_h \quad (1)$$

$$(Diffusion\ flux\ of\ DIN) = k_i F_i (DIN_h - DIN_l)/l_i \quad (2)$$

where, U_i is an advection velocity, F_i is the area of th e boundary section, DIN_h and DIN_l refer to the average DIN concentration in each layer, k_i is diffusivity and l_i is the distance between the center of the layer an d the center of the next layer . The meaning of the subscrip ts *h* and l refers to higher DIN concentration (*h*) and lower DIN concentration (*l*), respectively. DIN expands from the higher concentration area to the lower concentration area. To estimate advection and diffusion fluxes, U_i and k_i of each boundary section, DIN_h and DIN_l are required. The data for our analysis were only obtained in the dry and rainy seasons. The three-dimensional distributions of the average residual currents for Manila Bay in April (dry season) and November (rainy season) calculated by Fujiie *et al.* (2002) are used for both advection velocities and diffusivities in th is study. Horizontal diffusivity was constant at 10 m s^{-1} for the entire grid. V ertical diffusivities on the horizon tal boundary at 3 and 8 m were obtained by averaging the calculated values at these two depths. The horizontal advection velocities for the upper and m iddle layers are average values from 0 t o 3 m and 3 to 8 m, respectively, along the boundary line. Horizontal advection velocities of the lower layer and the vertical advection velocities at the 3 and 8 m boundary sections were estim ated by the application of a water budget for each layer. The water balance of the surface layer is $H_u = Q + P - E + V_3$, where H_u is the flow rate from the inside to the outside of the upper layer, and is obtained by m ultiplying the horizontal advection velocity and the area of the vertical section of the upper layer. Q is the river discha rge. P is the precipitation. E is the evaporation measured by the Philippine Atmospheric, Geophysical and Astronomical Services Administration. V_3 is the flow rate from the middle layer to the upper la yer in the box. The vertical advective velocity on the upper boundary section at 3 m is obtained by dividing V3 by the area of the horizontal section at 3 m . The water balance of the middle layer can be represented as $V_3 + H_m = V_8$ where H_m is the flow rate from inside to outside of the middle layer, and is solve d by m ultiplying of the horizon tal advective velocity by the area of the vertical section of the middle layer, and V_8 is the flow rate from the lower layer to the middle layer in the box. The vertical advective velocity at the boundary section at 8 m is obtained by dividing V_8 by the area of the horizontal section at 8 m. The water b alance of the lower layer can be expressed as to $V_8 = H_l$ where H_l is the f low rate from the outside to the inside of the lower layer. The horizontal advective velocity of the lower layer can then be obtained by dividing H_l by the area of the vertical section of the lower layer. The a verage advection velocities and diffusivities obtained using this procedure are shown in Table 1.

The DIN concentration s in each layer in the box in April and November of each year were obtained by the horizontal average of DIN concentrations of Station 1, 2 and 3. Then these concentrations were averaged over three years. The averag e DIN concen trations for outside the model domain were calculated using data

Table 1. Averaged advection velocities and diffusivities. Minus means the flow from the inside to outside.

Item	Layer	April	November
Horizontal advection velocity (m/s)	Upper	-1.54×10^{-2}	-4.97×10^{-2}
	Middle	-0.49×10^{-2}	0.07×10^{-2}
	Lower	0.82×10^{-2}	1.57×10^{-2}
Vertical advection velocity (m/s)	3m	3.82×10^{-6}	11.7×10^{-6}
	8m	9.45×10^{-6}	18.2×10^{-6}
Vertical diffusivities ($m^2\ s^{-1}$)	3m	1.95×10^{-4}	0.98×10^{-4}
	8m	2.07×10^{-4}	0.54×10^{-4}

collected from Stations 4 to 7. The average water temperature, salinity and Chl.*a* concentrations for each layer were calculated by the same protocol described above.

Runoff data for the Pasig, Pampanga and other rivers was obtained from the "River Rehabilitation Program for the Manila Bay Region". Then, the monthly average runof f in April and Novem ber were calculated. Average DIN loading by rivers into Manila Bay is approximately 900×10^6 mol yr^{-1} (JACINTO *et al.* 1998). The estimated values for total DIN loading from all river s in April and November were calculated by dividing the annual DIN loading by the ratio of monthly runoff. We then estimated DIN loads from the Pasig, Pampanga and other rivers by dividing total DI N loading by ratio of monthly runoff of those rivers. DIN may also be derived directly from sources along the coast, such as sewage water, industrial runoff, agriculture and aquaculture ponds. Average direct DIN loading into Manil a Bay is approximately 600×10^6mol yr^{-1} (JACINTO *et al.* 1998). We assumed that 50% of this DIN load is supplied to the study area.

Although DIN may also be released from the sea bottom, DIN flux from pore water by diffusion was not observed during the period 1996 to 1998. We therefore used data from the area collected in March (dry season) and November of 1999. The sampling methods and the method for estimating DIN release were the same as AZANZA *et al.* (2004). Water exchange at the water surface was taken to be the difference between precipitation and evaporation, *P-E*.

Residence time

The residence time of fresh water in Manila Bay is estimated by the following equation:

$$(Residence\ time) = V\frac{S_o - S_m}{S_o} \Big/ (Q + P - E) \quad (3)$$

where V is the volume in the water column, S_o is the maximum salinity in the outer part of the bay, and S_m is the average salinity in the water column.

Results

Water budget

Figure 3 shows our derived water budget, as well as the water temperature and salinity measurements for each layer in the dry (a) and rainy (b) seasons. The results are typical for an estuarine circulation pattern, with flows into the lower layer and flows out in the upper layer . Because the river discharge in the rainy season is greater than in the dry season, the difference in salinity of the upper and lower layers is enhanced during the rainy season when estuarine circulation and stratification

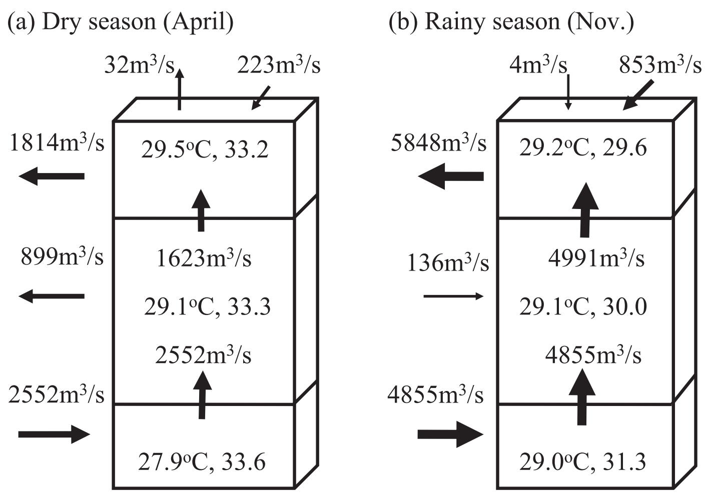

Fig. 3. Water budget (m^3 s^{-1}), water temperature (℃) and salin ity in each layer. Width of vectors represents the magnitude of flux.

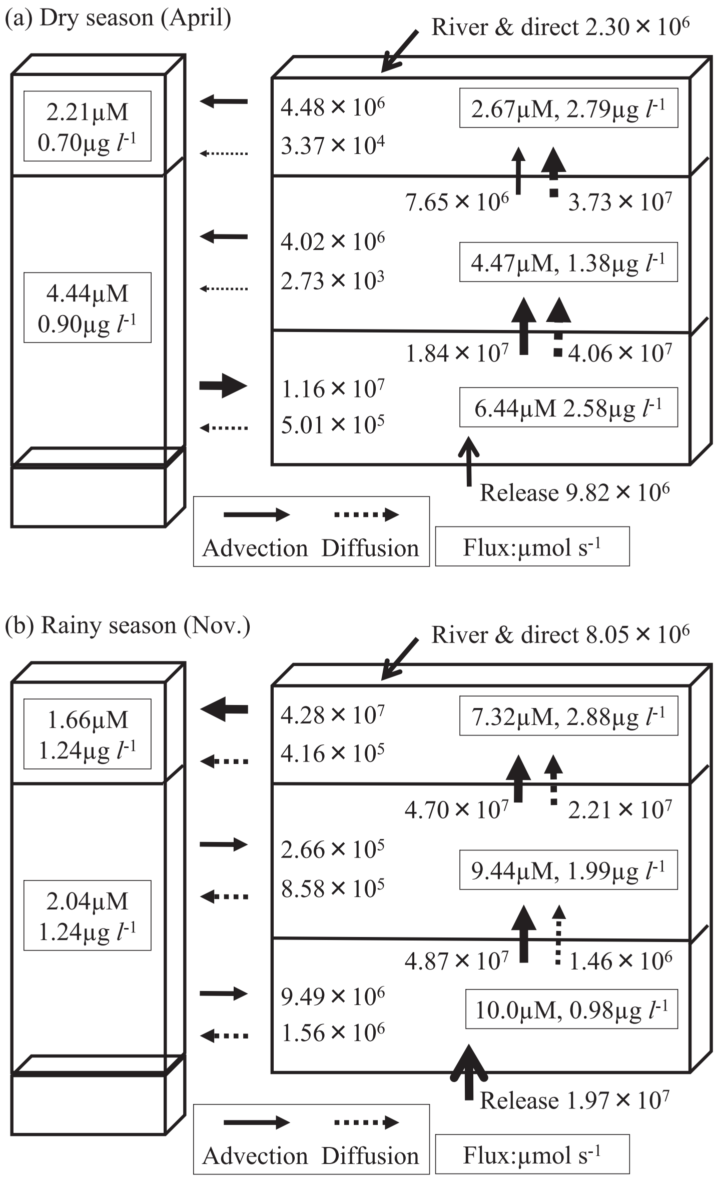

Fig. 4. DIN budget (μ mol s^{-1}), DIN concentration (μM) and Chl.*a* co ncentration (μg l^{-1}) in each layer. Width of vectors represents magnitude of flux.

are more apparent, with the inflow of bay water occurring even in the middle layer. The estuarine circulation is weaker, and water flows out from the middle layer during the dry season. Estimated residence times are 33 days in April (dry season) and as short as 16 days in November (rainy season).

DIN budgets

Figure 4 shows our calculated DIN budget, DIN concentrations and Chl.*a* concentrations for each layer in the dry (a) and rainy (b) seasons. Fig. 5 simplifies these diagrams by normalizing the DIN flux during each season when N loading from rivers and the coast in the dry season is set to 1.0 . If the inf low flux of DIN

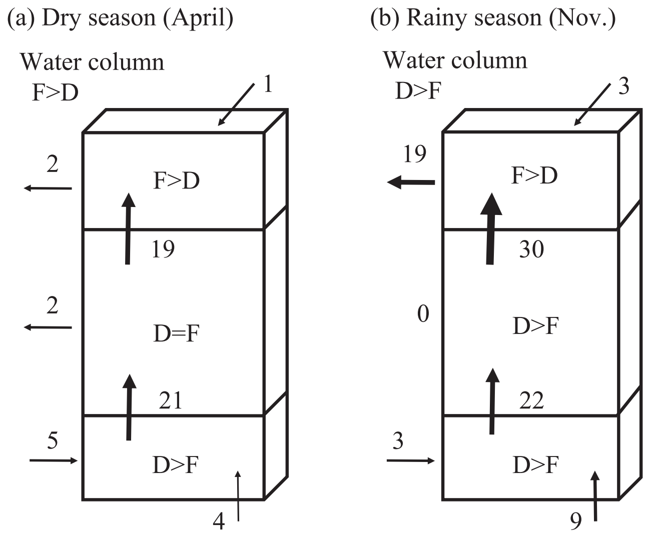

Fig. 5. DIN flux normalized by DIN flux from rivers and the coast, and com parison between DIN fixation and organic matter decomposition. Width of vectors represents magnitude of flux. F indicates nitrogen fixation. D indicates decomposition of organic matter.

in any compartment is lar ger than the outflow flux, then there is fixation of DIN to organic matter, and this is shown as "F" in the diagram. Conversely, if the out flow flux exceeds the inflow flux of DIN then decomposition of organic matter must occur and this is shown as "D".

During the dry season, the total inflow flux is 10 (=1+5+4) and the outflow flux is 4 (=2+2) in the water co lumn, implying that fixation exceeds decomposition. However, this cond ition is observed to differ in each layer, with fixa tion being dom inant in the upper layer and being balanced in the middle layer. On the other hand, decomposition is dominant in the lower layer, as the DIN regenerated by decom position in the lower layer (12=21−9) exceeds the DIN supplied from the outside and the bottom (9=5+4). The DIN concentration is h ighest in the deeper layer. Chl.*a* concentration is high in the deeper layer as well as in the upper layer. In the rainy season, the inflow flux and outflow flux in the water column are 15 (=3+3+9) and 19, respectively, indicating that decomposition exceeds nitrogen fixation, which is the opposite of the situation in the dry season. These finding are consistent with the observation that the DIN concentration in the water column in the rainy season is higher than that in the dry season. At this time, fixation in the upper layer dominates, as it does in the dry season, but the outflow flux by advection is greater compared to that of the dry season. The DIN that is not consumed by prim ary production is exported from the system in lar ge volumes due to estuarine circulation in the rainy season. At this time, decomposition in the middle layer exceeds fixation, while they were the same in the dry season. As in the dry season, decomposition is dom inant in the lower laye r. In addition to reg enerated DIN derived via decomposition in the lower layer, release from bottom sediments during the rainy season is greater than in the dry season by a factor of two.

The main source of DIN in the middle and lower layers is regenerated DIN which arises from the decomposition of organic matter in the m iddle and lower layers and f rom sediments, and that the DIN supply from outside the system is relatively small.

Discussions

Hayashi *et al.* (2008) also discus sed the factors limiting for primary production in the upper layer in Manila Bay using a numerical ecosystem model. The same observational data as this study were used in the model analysis. The limiting factors were defined as being a function of the maximum rate of specific nitrogen uptake, DIN concentration, water temperature and light intensity in the water.

That results suggested that light conditions were considered to be the most effective limiting factor in the upper layer in April, and photo-inhibition occurs in the upper layer during the dry season due to strong light intensity. Average transparencies were 2.8 m in April (dry season) and 2.4 m in November (rainy season), and the average dissolved oxygen concentrations in the lower layer were 4.96 m g l^{-1} in April and 3.47 m g l^{-1} in November. We assumed that the light intensity immediately under the sea su rface is 50% of solar radiation and an ex tinction coefficient is estimated by 1.7/ (transparency) (PARSONS *et al.*, 1984). Usins this approach, the compensation depths of 1% was estimated to be 7.6 m in April and 6.5 m in Nove mber. Thus light should reach the deeper layer somewhat more easily in the dry season compared to the rainy season. Then, the primary production should be possible in the middle and lower layers in the dry season, and fixation exceeds decom position in the water column. Regenerated DIN in the lower layer could support primary production throughout the water colum n during the dry season.

On the other hand, water temperature was consid ered more important in the upper layer in November (HAYASHI *et al.*, 2008). Since light intensity is weaker in the rainy season, Chl.*a* concentration was higher in the shallower layer. And Chl.*a* concentration in the lower layer was lower than that of the dry season. It is likely that the light intensity in the lower layer was too low for the primary production due to the self-shading effect by phytoplankton. Therefore, decomposition was greater than fixation not only in the lower layer but also in the middle layer in the rainy season.

Conclusions

We constructed DIN budgets of horizontal three layers in the Pasig River estuary in Manila Bay during both the dry and rainy seasons using observational data and the results of numerical hydrodynamic modeling. DIN fixation by photosynthesis exceeds the decomposition of organic matter in the upper laye r during both dry and rainy seasons. On the other hand, the decomposition of organic matter exceeds DIN fixation in the lower layer at all times. In the m iddle layer, the ra te of fixation is similar to that of decomposition in the dry season, but the rate of decomposition exceeds that of fixation in the rainy season. Fixation exceeds decomposition in the water column in the dry season and DIN budget in the rainy season is the opposite of the situation in the dry season.

The main source of DIN is regenerated DIN derived from the decomposition of organic matter in the water column and from bottom sediments. Thus, one would have to control the decomposition activity or the amount of particulate matter to reduce red tides in the Pasig River estuary of Manila Bay. However, these approaches are im possible to realize it immediately. A more reasonable present approach is to reduce the DIN load from the land area. HAYASHI *et al.* (2008) showed that if total nitrogen loaded from rivers is decreased to half, Chl.*a* and DIN concentrations in the upper layer are also reduced to 94% and 73% par one year, respectively. Lowering DIN loading by half is extreme, but this kind of attempt is necessary to have a significant effect. In addition, to clarify the behavior of organic matter, we should assess the effect of reduced nitrogen loading from the land area to Manila Bay by using a numerical ecosystem model.

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Daily expression patterns of growth-related genes in growth hormone transgenic coho salmon, *Oncorhynchus kisutch*

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Abstract: Growth in fish is regulated by the growth hormone (GH)/ growth hormone receptor (GHR)/ insulin-like growth factor (IGF)-I axis. This GH-IGF-I axis is influenced by several factors. With regard to hormonal effect, it is known that salmon transgenic for GH show increased growth. However, very little is known about the expression patterns of growth-related genes in GH transgenic fish. The present study examined the daily expression patterns of mRNAs for the growth-related genes after feeding in GH transgenic coho salmon (*Oncorhynchus kisutch*). GH mRNA was detected in both liver and muscle as well as in the pituitary from transgenic fish. GHR mRNA levels in the liver and muscle were higher in transgenic fish than in non-transgenic wild type fish but lower in the pituitary. The expression level of hepatic IGF-I mRNA was greater in transgenic fish. The daily GH, GHR and IGF-I mRNA expression patterns reached their peak at roughly 4–8 h after feeding, however, GHR and IGF-I mRNA expressions in the liver was observed to be irregular in non-transgenic fish. These results suggest that the daily expression patterns for growth-related genes are particularly pronounced in GH transgenic fish. Furthermore, our findings would be useful for consideration of the time of feeding and the optimum time of day for tissue sampling for analysis of growth-related genes in fish.

Keywords: *Growth-related gene; Growth hormone, Daily expression pattern; Transgenic coho salmon*

1. Introduction

The aquaculture is known to be very important to world food production. The enhancement of growth in cultured fish, therefore, has been desired and researched. In fish, growth is regulated to a major extent by liver-derived insulin-like growth factor (IGF) -I in response to pituitary-secreted growth hormone (GH) binding to GH receptors (GHR) of liver. The GH-IGF-I axis is believed to play an important role in the regulation of growth. In fish, secretion of GH is known to be under hypothalamic regulation by means of many modulators The actions of IGFs are controlled by GH and IGF binding protein and a specific receptor on the surface of target cells (DONALDSON *et al.*, 1979; DUAN, 1998; MORIYAMA *et al.*, 2000; DEANE and

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Woo, 2009; Reinecke, 2010).

Growth in fish is genetically regulated and is also influenced by cellular, endocrinological and environmental factors. The responses of endocrinal tissue are affected by the integration of external stimuli (Duan, 1998; Moriyama *et al.*, 2000; Nakano *et al.*, 2008; Deane and Woo, 2009; Reinecke, 2010). The environmental factors such as nutrition (food availability), temperature and photoperiod are major factors regarding growth and development, and seem to condition biological rhythms in fish. In the natural environment, fish exhibit feeding flexibility according to various conditions. On the other hand, in aquaculture, feeding in fish is controlled artificially and the feeding rhythms might be modified (Ayson and Takemura, 2006; Montoya *et al.*, 2010).

In many fish, growth can be significantly stimulated by treatment with exogenous GH (Donaldson *et al.*, 1979). More recently, GH transgenes have been transferred to fish with strong stimulation of growth (Devlin *et al.*, 1994). The levels of both GH and IGF-I in plasma are known to be high in GH transgenic fish. Growth abnormalities, and altered muscle and pituitary structures, high feeding motivation have been observed in GH transgenic salmon relative to normal wild type fish (Devlin *et al.*, 1995, 2004; Mori and Devlin, 1999; Rise *et al.*, 2006; Hallerman *et al.*, 2007). Accordingly, expression of transgenes might affect the many aspects of fitness such as metabolism, behavior and viability in the fish. However, little is known about the daily expression patterns of genes concerning GH-IGF-I axis in transgenic fish. We hypothesized that the expressions of growth-related genes are held high levels all day long and show unique characters in GH transgenic fish.

In the present study, we examined the changes in the mRNA expression patterns of GH, GHR and IGF-I genes after feeding in GH transgenic coho salmon (*Oncorhynchus kisutch*).

2. Materials and Methods

2.1. Fish, rearing conditions and sampling

Transgenic coho salmon (strain M77) containing the GH gene construct OnMTGH1 (Devlin *et al.*, 1994, 2004) and non-transgenic wild type coho salmon from the Chehalis River, BC, Canada were reared in the CAER Aquarium Facility. The two types of fish (transgenic and non-transgenic) were fed by hand to apparent satiation twice a day with commercially available diets (Skretting Canada, Canada) and matched their size according to the method reported previously (Rise *et al.*, 2006; Raven *et al.* 2008). Six individuals of each of transgenic fish and older non-transgenic fish of similar size were placed into each of five tanks supplied with running 10–11 ℃ well water and acclimatized for two days under natural photoperiod. Tissues from transgenic fish (mean ± SD, 20.34 ± 3.32 g) and non-transgenic fish (19.27 ± 2.15 g) were sampled at 0, 2, 4, 8 and 24 h after feeding (at 9:00 AM). Fish were sampled from separate experimental tanks at each time period, thereby avoiding repeated sampling from the same tank. Fish were anaesthetized with 100 mg/L tricane methane sulphonate buffered with $NaHCO_3$ and rapidly team-sampled for blood and tissues. Plasma was stored frozen at −80 ℃, and all tissues were immediately immersed in RNAlater (Ambion-ABI, USA) and then stored at −80 ℃ until analysis. All the protocols of fish treatment were approved by the DFO Pacific Region Animal Care Committee.

2.2. Total RNA extraction and cDNA synthesis

Total RNA was extracted from tissue using TRIzol (Invitrogen, USA) and complementary DNA (cDNA) was synthesized using the ReverTra Ace reagent kit (Toyobo, Japan) were carried out following the manufacturer's protocol and Raven *et al.* (2008).

2.3. Determination of GH, GHR, IGF-I and β-actin mRNA levels

The levels of GH, GHR and IGF-I mRNA expressions in the tissues were determined by real-time quantitative PCR (qPCR) with an equipment of Applied Biosystems Prism 7300 Sequence Detection System (USA) using β-actin as an internal standard according to Raven *et al.* (2008). Gene specific primers and TaqMan probes were used as the qPCR assays (Table 1). Values for GH, GHR and IGF-I were normalized with those of β-actin. Levels of β-actin were confirmed not to change with

Table 1. Sequences of primers and probes used in qPCR analysis.

Gene	Forward Primer (5'–3')	Reverse Primer (5'–3')	TaqMan Probe (5'–3')
GH	CAAGATATTCCTGCTGGACTT	GGGTACTCCCAGGATTCAATCA	CAGTCCTGAAGCTGC
GHR	CACTGTGGAAGACATCGTGGAA	CAAAGTGGCTCCCGGTTAGA	AACTGGACCCTGCTGAA
IGF-I	GGCATTTATGTGATGTCTTCAAGAGT	CCTGTTGCCGCCGAAGT	TCTCACTGCTGCTGTGC
β-actin	ACGGCCGAGAGGGAAATC	CAAAGTCCAGCGCCACGTA	CACAGCTTCTCCTTGATGT

respect to treatment.

2.4. Measurements of glucose levels in plasma

Plasma glucose was measured using an enzymatic assay method available in a kit (Wako Pure Chemical Industries, Ltd., Japan).

2.5. Statistical analysis

All samples were run in duplicate and results are reported as mean ± SD. All data were subjected to one-way analysis of variance (ANOVA). Multiple comparisons between groups were made by Tukey-Kramer method and results were determined statistically significant at $P < 0.05$.

3. Results

3.1. GH, GHR and IGF-I mRNA levels

GH mRNA was detected in non-pituitary tissues such as liver and muscle from transgenic fish as well as in the pituitary. GH mRNA level in pituitary was higher than in other tissues. The daily GH mRNA expression pattern in pituitary and other tissues was observed to peak at roughly 4–8 h after feeding (Fig. 1). This tendency regarding expression pattern of GH mRNA was almost same with liver and muscle in transgenic fish (data not shown).

As shown in Fig. 2, GHR mRNA levels in liver and muscle were found to be higher in transgenic fish than in non-transgenic fish. In contrast, pituitary GHR mRNA levels were low in transgenic fish, compared with non-transgenic fish (data not shown). The daily expression pattern of GHR mRNA revealed relatively high level in transgenic fish, in both pituitary and muscle 8 h after feeding, and in the liver 4 h after feeding. GHR mRNA levels were not significantly different throughout after feeding in non-transgenic fish.

The expression levels of IGF-I mRNA in the liver were found to be greater in transgenic fish, with a peak at 4 h after feeding. On the other hand, the expression pattern of IGF-I mRNA in non-transgenic fish was irregular and there was no significant difference in levels

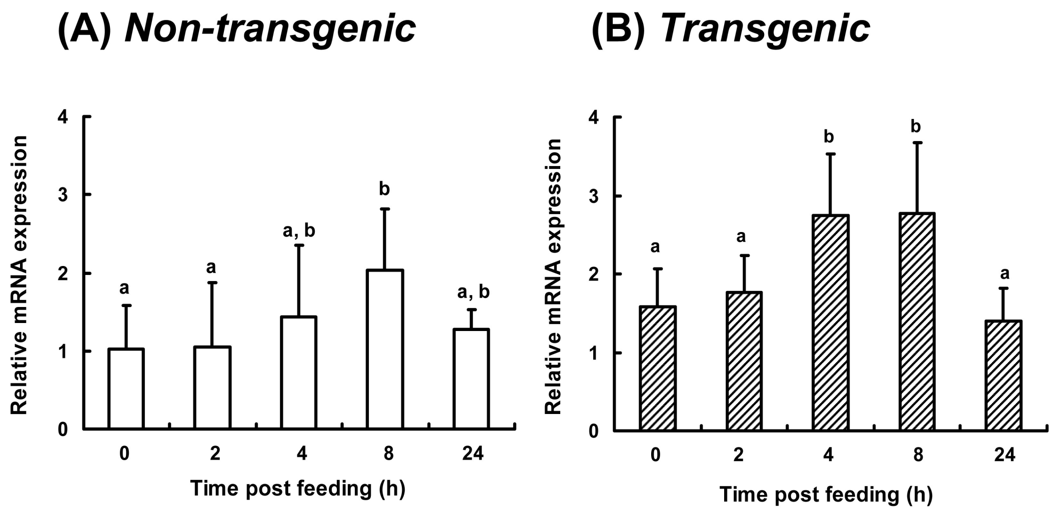

Fig. 1. GH mRNA levels in the pituitary of non-transgenic (A) and GH transgenic (B) coho salmon. Values with different letter superscripts are significantly different ($P < 0.05$). Bars are means ± SD, n=4.

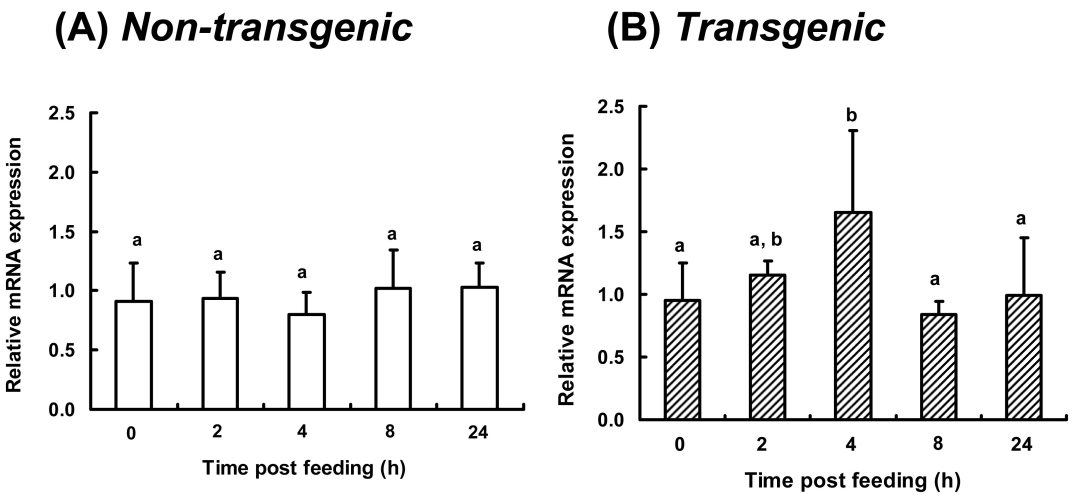

Fig. 2. GHR mRNA levels in the liver of non-transgenic (A) and GH transgenic (B) coho salmon. Values with different letter superscripts are significantly different ($P < 0.05$). Bars are means ± SD, n=4.

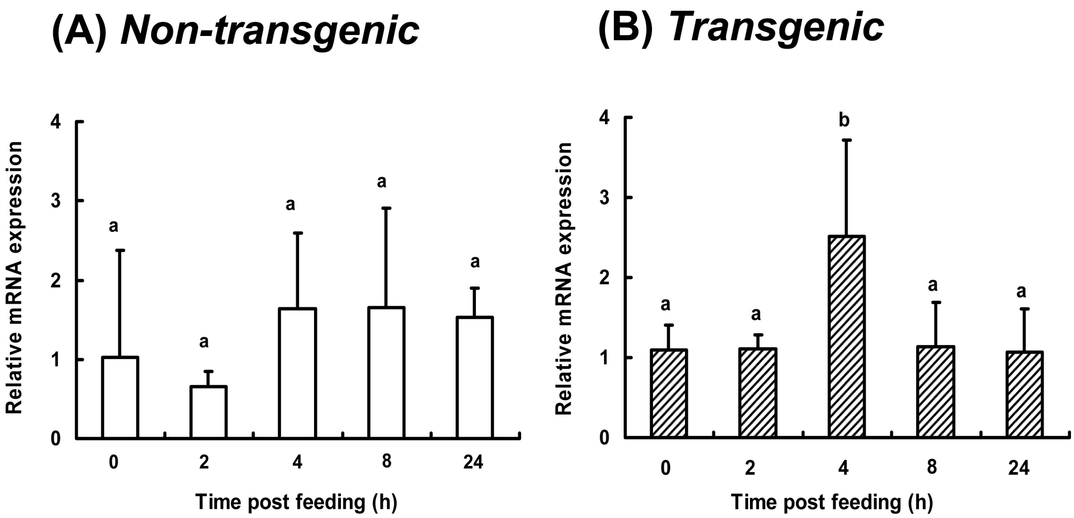

Fig. 3. IGF-I mRNA levels in the liver of non-transgenic (A) and GH transgenic (B) coho salmon. Values with different letter superscripts are significantly different ($P < 0.05$). Bars are means ± SD, n=4.

at anytime during the 24 h sampling period after feeding (Fig. 3).

3.2. Glucose levels in plasma

Plasma glucose levels in transgenic fish were higher than those in non-transgenic fish, although in both groups they increased gradually after feeding (data not shown).

4. Discussion

In the present study, the results indicate for the first time that the rhythms in the expression patterns for growth-related genes exist according to the time of feeding in GH transgenic fish and seem to be pronounced in transgenic fish compared to non-transgenic fish.

As shown in Fig. 1, significant differences were observed in pituitary GH mRNA levels during the 24 h period after feeding in both transgenic and non-transgenic fish. In liver and muscle from transgenic fish, there were no significant differences in GH mRNA expressions during the post-feeding 24 h period, although the highest GH mRNA levels occurred 4–8 h after feeding. This expression patterns suggest the presence of a diurnal pattern of GH expression in coho salmon, which therefore differs from results obtained for several fish species (GOMEZ *et al.*, 1996; AYSON *et al.*, 2007). In rabbitfish, GH mRNA levels during day time were lower compared with the levels during night time (AYSON *et al.*, 2007), and plasma GH levels in fasting fish increased (THISSEN *et al.*, 1999).

GHR mRNA expression in transgenic fish is regular and increases gradually after feeding compared to non-transgenic fish (Fig. 2). Both mRNA and protein levels of GHR are affected by several factors, such as exogenous cortisol, stress and fasting, in fish and mammals (MORIYAMA *et al.*, 2000; FOX *et al.*, 2006; SMALL *et al.*, 2006; NAKANO *et al.*, 2008; KAMEDA *et al.*, 2008; DEANE and WOO, 2009). In the present study, a clear increase in GHR mRNA levels after feeding was observed in all tissues analyzed from transgenic fish. Consequently, food appears to be one of the important factors influencing the expressions of GH and GHR mRNAs in GH transgenic fish.

The mRNA expression of IGF-I in the liver of transgenic fish reached its peak at 4 h after feeding (Fig. 3). IGF-I gene expression in the liver of fish has also been reported to be influenced by environmental factors (LEUNG *et al.*, 2008; NAKANO *et al.*, 2008). Liver expression of IGF-I is regulated by GH and GHR located on the surface of hepatocytes (MORIYAMA *et al.*, 2000). Hence, the patterns of IGF-I mRNA liver expression would synchronize with the mRNA expressions of both GH and GHR in coho salmon. This phenomenon seems to be obvious in transgenic coho salmon (Figs. 1–3), and higher expression levels of growth-related genes in GH transgenic fish than in non-transgenic fish is consistent with RAVEN *et al* (2008).

At present, the reason for the irregularity of GHR and IGF-I gene expressions in the liver of non-transgenic fish is not clear. The daily expression patterns of growth-related genes alter under several conditions in fish (AYSON, *et al.*, 2006; AYSON, *et al.*, 2007).

The higher plasma glucose levels in GH transgenic fish than in non-transgenic fish observed in the present study have been reported (EBERT *et al.*, 1988; JHINGAN *et al.*, 2003). High levels of GH in GH transgenic animals should promote lipolytic and gluconeogenic metabolism, so enhancing the utilization of glycogen stores (JHINGAN *et al.*, 2003). Higher glycolysis in muscle is observed in growth-enhanced transgenic fish owing to a higher energy requirement (KRASNOV *et al.*, 1999; HILL *et al.*, 2000). Indeed, the food (energy) intakes, food conversion efficiency, carbohydrate degradation, utilization of lipids and proteins of GH transgenic fish are greater than those of non-transgenic fish (HUANG *et al.*, 2004; RAVEN *et al.*, 2006; LEGGATT *et al.*, 2009). Accordingly, GH transgenic fish are characterized by enhanced metabolism and energy availability due to their high levels of circulating GH.

In conclusion, the daily expression patterns for growth-related genes in GH transgenic coho salmon were found to be rhythmic. Most organisms display daily rhythms in biological and physiological functions, which affect growth, development and ability to adapt to environmental conditions (AYSON and TAKEMURA, 2006; MONTOYA *et al.*, 2010). Our results reveal that feeding time should also be important as a major synchronizer of growth-related gene expression rhythms in GH transgenic fish.

Studies of the beneficial effect of nutritional conditions on growth-related gene expression are now in progress to enhance the performance of GH transgenic fish. Also under consideration are experiments with coho salmon to determine the effects of environmental factors such as stress and photoperiod on physiological rhythms, since there is much yet to learn about the relationship between physiological and environmental factors, growth-related gene expression and growth in GH transgenic fish.

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Absolute salinity measurements of standard seawaters for conductivity and nutrients

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Abstract: We measured the density salinities (ie. absolute salinities) of International Association of the Physical Sciences of the Ocean (IAPSO) Standard Seawater (SSW) batches P144–P152 and Reference Material for Nutrients in Seawater (RMNS) lot BF by using an oscillation-type density meter. Practical Salinity, silicate, nitrate, total alkalinity (TA) and dissolved inorganic carbon (DIC) were also measured. The measured density salinities were compared with the absolute salinities calculated from two models by using measured Practical Salinity, silicate, nitrate, TA and DIC data. The absolute salinities estimated from one model using all of these parameters agreed relatively well with the measured density salinity, especially for the RMNS. However, the absolute salinities of the IAPSO SSW estimated from another model by using Practical Salinity and a simple relationship with silicate were overestimated because of a difference in composition from natural seawater caused by dissolution of silicate from the glass bottles. The rate of increase of the density salinity of the IAPSO SSW caused by dissolution of silicate was estimated to be 0.0005 g kg^{-1} y^{-1}. The results suggest that RMNS, in which the composition of real seawater is maintained, has substantial potential as a reference liquid for density measurements.

Keywords: *"Density salinity", International Thermodynamic Equation of Seawater 2010 (TEOS-10), International Association of the Physical Sciences of the Ocean (IAPSO) Standard Seawater, Reference Material for Nutrients in Seawater (RMNS)*

1. Introduction

In June 2009, the International Thermodynamic Equation of Seawater 2010 (TEOS-10) was endorsed by the Intergovernmental Oceanographic Commission (IOC) of the United Nations Educational, Scientific and Cultural Organization (UNESCO) as the replacement for the International Equation of State of Seawater 1980 (EOS-80) (IOC *et al.*, 2010). Another substantial change from previous practice is the use of absolute salinity (g kg^{-1}) instead of Practical Salinity (S_P) in TEOS-10 (MILLERO, 2010).

Density of seawater is a function of absolute salinity (S_A) rather than conductivity. To date, however, there is no sensor that can precisely measure absolute salinity in situ (MILLERO, 2006). Therefore, an algorithm to estimate absolute salinity was provided along with TEOS-10 (MCDOUGALL *et al.*, 2009). The absolute salinity of International Association of the Physical Sciences of the Ocean (IAPSO) Standard Seawater (SSW) (Ocean Scientific International Ltd., Havant, UK) has been examined and used to define the Reference-Composition Salinity (S_R) scale (MILLERO *et al.*, 2008). Practical Salinity can be converted to Reference-

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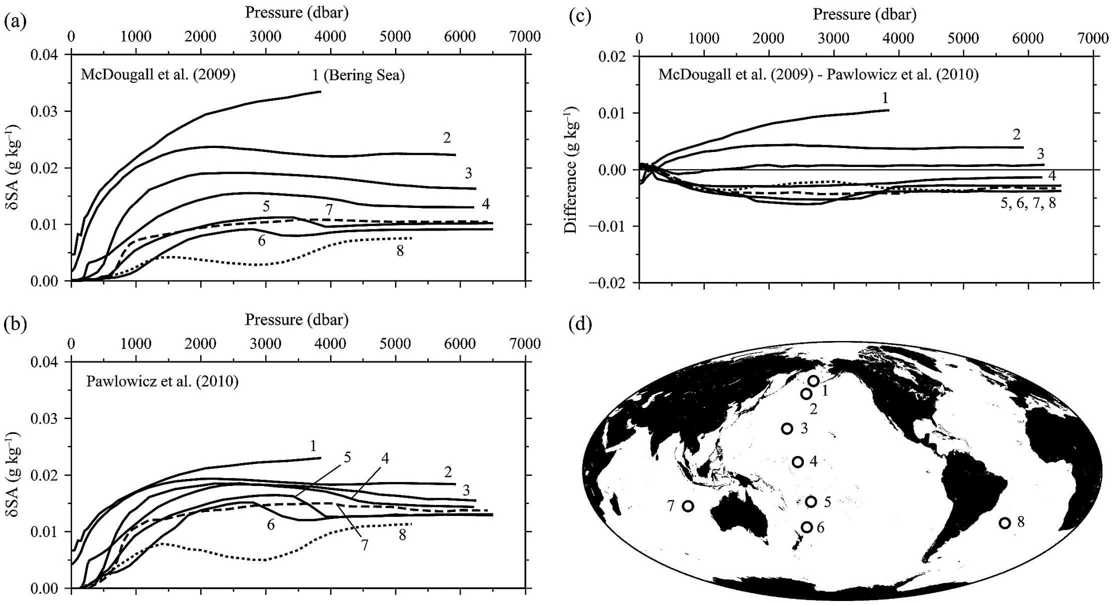

Fig. 1. Vertical profiles of absolute salinity anomalies (δS_A) estimated from the models of (a) McDOUGALL *et al.* (2009) and (b) PAWLOWICZ *et al.* (2010), and (c) difference of the absolute salinity anomalies between the two models. Locations of the data used for the estimation are shown in (d) with the numbers. High-quality hydrographic data obtained on the R/V Mirai cruises (UCHIDA and FUKASAWA, 2005; KAWANO and UCHIDA, 2007; KAWANO *et al.*, 2009; UCHIDA *et al.*, 2011) were used for the estimation.

Composition Salinity over the range of concentrations where Practical Salinity is defined: $S_R = (35.16504 \text{ g kg}^{-1}/35) \times S_P$.

To estimate the absolute salinity (also called "density salinity") for a particular seawater sample, the algorithm exploits the correlation between the absolute salinity anomaly (δS_A) relative to the Reference-Composition Salinity and the silicate concentration, making use of the global atlas of silicate concentrations (McDOUGALL *et al.*, 2009, Eqs. [3–6]). However, δS_A estimated from the model from McDOUGALL *et al.* (2009) shows latitude-dependent systematic discrepancy from δS_A estimated from another model from PAWLOWICZ *et al.* (2010) which exploits more precisely the correlation between δS_A and nutrient concentrations and carbonate system parameters based on mathematical investigation using a model relating composition, conductivity, and density of arbitrary seawaters (Fig. 1). A bias in the density data for the North Pacific obtained in the 1970s may partly contribute to the discrepancy by overestimating the latitude-dependent coefficient in the model from McDOUGALL *et al.* (2009). Therefore, values for absolute salinity as well as Practical Salinity, nutrient concentrations, and carbonate system parameters should be accurately collected for evaluation and future updating of the estimation method, especially in the North Pacific, coastal and marginal seas and oceanic areas in which density salinities have not yet been measured. If certified standard seawater were available as a density reference with an uncertainty on the order of 0.001 kg m^{-3}, seawater density could be measured more accurately relative to this standard seawater with metrological traceability by means of an oscillation-type density meter (PICKER *et al.*, 1974).

In this study, we evaluated standard seawaters used for conductivity and nutrient measurements for their potential as such a reference liquid by measuring their density salinities with an oscillation-type density meter. The density salinities of the standard seawaters were compared with the absolute salinities calculated from the two models

(McDougall *et al.*, 2009; Pawlowicz *et al.*, 2010) by using measured Practical Salinity, nutrient concentrations, and carbonate system parameters.

2. Materials and Methods

In this study we used standard seawaters for conductivity (IAPSO SSW batches P144–P152) and for nutrients (Reference Material for Nutrients in Seawater [RMNS] lot BF; Kanso Technos Co., Ltd., Osaka, Japan). Seawater densities were measured with a DMA 5000M oscillation-type density meter with an Xsample 122 sample changer (Anton-Paar GmbH, Graz, Austria). The sample changer was used to load samples automatically from up to ninety-six 12-mL glass vials. Practical Salinity was measured with a salinometer (Autosal 8400B; Guildline Instruments Ltd., Ontario, Canada), which was standardized with IAPSO SSW batch P152. Nutrients were measured with an autoanalyzer (TRAACS 800 system; Bran+Luebbe, Norderstedt, Germany). Total alkalinity (TA) and dissolved inorganic carbon (DIC) were measured with a custom-made spectrophotometer and a total-CO_2 measuring system (Nippon ANS, Inc., Fuchu, Japan), respectively (Uchida *et al.*, 2011) (Table 1).

Densities of pure water and standard seawaters were measured at 20.001 ℃ and atmospheric pressure in the laboratory with a standard deviation of about 0.001 kg m^{-3}. Time drift of the density meter was monitored by periodically measuring the density of ultra-pure water (Milli-Q water, Millipore, Billerica, Massachusetts, USA) prepared from Yokosuka (Japan) tap water in July 2010, density standard water (Kyoto Electronics Manufacturing Co., Ltd., Kyoto, Japan), and standard seawaters (Fig. 2).

The true density of the Milli-Q water was estimated from the isotopic composition (Menaché and Girard, 1973) and International Association for the Properties of Water and Steam (IAPWS) -95 standard (Feistel, 2008). The isotopic composition for hydrogen (δD) and oxygen (δ^{18}O) relative to Vienna Standard Mean Ocean Water (VSMOW) was determined for the Milli-Q water and density standard water by using an isotope-ratio mass spectrometer (IRMS) MAT 252 with an equilibration device (Thermo Fisher Scientific Inc., Waltham, Massachusetts, USA) ; the true density of the Milli-Q water was estimated to be

Table 1. Concentrations of salinity, nutrient, and carbonate system parameters in standard seawaters. Practical Salinity (S_P) was measured on August 25, 2010, and absolute salinity (S_A) was measured on August 26, 2010 for several bottles of the standard seawaters. Nutrient concentrations were measured on July 14, 2010; average of two measurements for one bottle is listed. Total alkalinity (TA) was measured on September 12, 2010. Dissolved inorganic carbon (DIC) was measured on November 7, 2010 for IAPSO SSW lot P152 and on September 11, 2010 for RMNS.

Lot no.	Date of manufacture	S_P [PSS-78]	S_A [g kg^{-1}]	NO_3	SiO_2 [μmol kg^{-1}]	TA	DIC
IAPSO SSW							
P152	2010/05/05	34.9926	35.1578	0.04	22.16	2298.9	2055.9
P151	2009/05/20	34.9984	35.1632	0.03	32.39	2303.7	–
P150	2008/05/22	34.9920	35.1572	0.39	38.91	2306.2	–
P149	2007/10/05	34.9945	35.1594	0.04	40.95	2307.4	–
P148	2006/10/01	34.9932	35.1574	0.96	45.16	2307.6	–
P147	2006/06/06	34.9914	35.1581	1.36	69.40	2309.5	–
P146	2005/05/12	34.9898	35.1559	0.47	78.48	2302.6	–
P145	2004/07/15	34.9913	35.1600	0.06	69.77	2317.3	–
P144	2003/09/23	34.9940	35.1626	0.08	90.52	2318.6	–
RMNS							
BF	2007/04/11	34.6138	34.7906	41.39	150.42	2376.3	2218.9

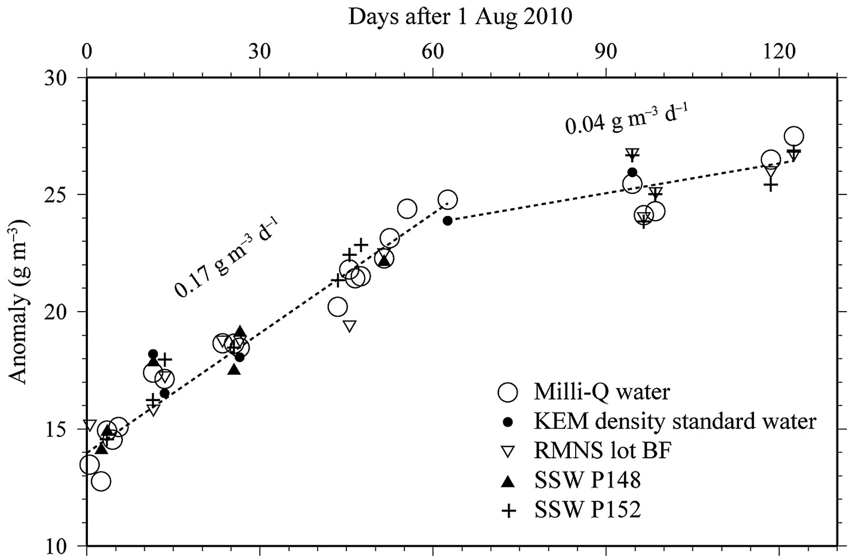

Fig. 2. Time drift of the density meter, as estimated from repeated measurements of pure waters (Milli-Q and density standard water) and standard seawaters (IAPSO SSW and RMNS). Measured values were averaged for each day and density anomalies for Milli-Q water are shown relative to the estimated true value (998.2038 kg m^{-3}). For the other waters, anomalies from the temporal mean were added to the mean of the anomalies for Milli-Q water measured at the same time. Dashed lines show the regression lines for Milli-Q water before and after day 62.

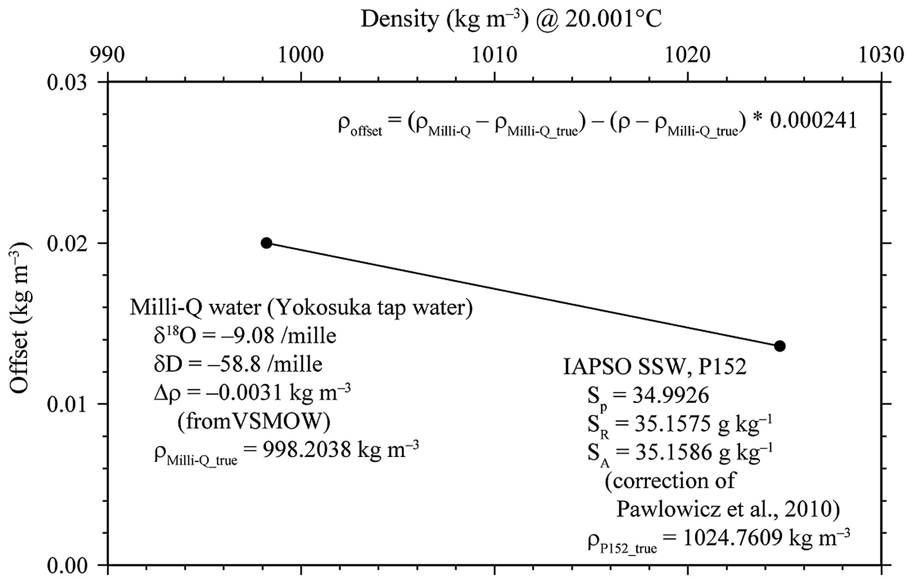

Fig. 3. Mean density offset from the estimated true value for IAPSO SSW batch P152 (first 7 measurements in Fig. 2) and for Milli-Q water measured at the same time. The true density for the Milli-Q water at 20.001 ℃ and atmospheric pressure was estimated from the isotopic composition of water and the IAPWS-95 standard (Vienna Standard Mean Ocean Water [VSMOW]) for the thermodynamic properties of water; for the IAPSO SSW, true density was calculated from absolute salinity calculated by using the model of PAWLOWICZ *et al.* (2010) and TOES-10.

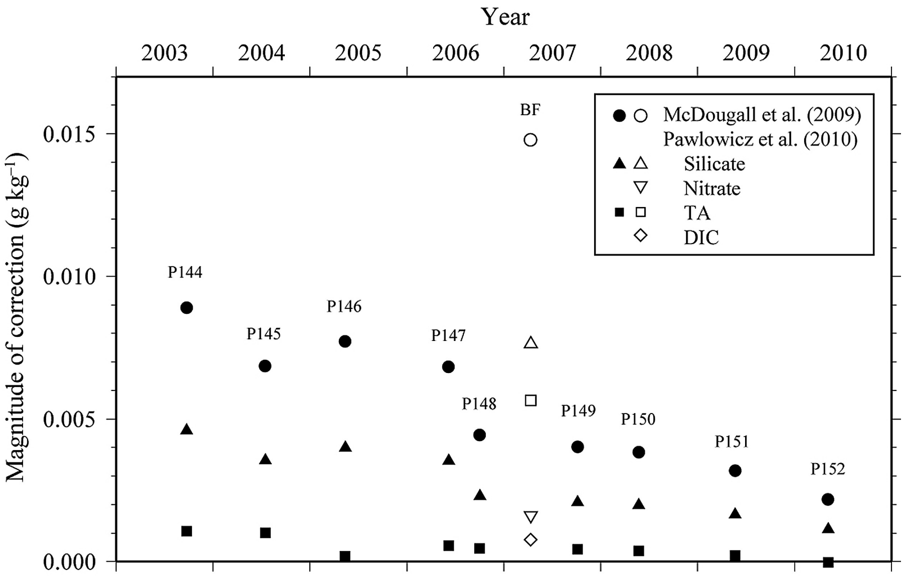

Fig. 4. Magnitude of corrections for the absolute salinity of IAPSO SSW (batches P144–P152) and RMNS (lot BF) from the Reference-Composition Salinity plotted against the date of manufacture. Filled and hollow circles indicate the total corrections for the models of McDougall *et al.* (2009) and Pawlowicz *et al.* (2010), which include corrections for measured silicate, nitrate, TA, and DIC. For the IAPSO SSW, corrections for nitrate and DIC are not shown because they were small (0.00002 ± 0.00002 g kg^{-1} for nitrate and -0.0001 g kg^{-1} for DIC in batch P152).

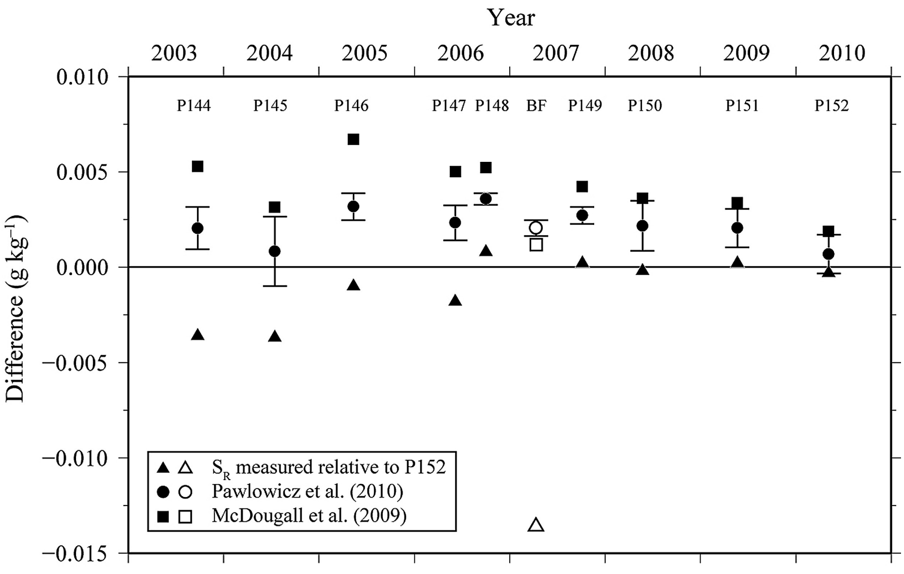

Fig. 5. Differences between the absolute salinities of IAPSO SSW and RMNS, as estimated from the models of McDougall *et al.* (2009) and Pawlowicz *et al.* (2010), and those estimated from the density measurements, plotted against the date of manufacture. Error bars show standard deviation. Also shown is the difference between the Reference-Composition salinity (S_R) and the measured density salinity.

998.2038 kg m^{-3} (Fig. 3). For the density standard water (certified density, 998.204 ± 0.015 kg m^{-3}), the true density as estimated from the isotopic composition (998.2050 kg m^{-3}) agreed with the measured density (998.2058 kg m^{-3}) as corrected with the Milli-Q water measurements.

The true density of IAPSO SSW batch P152 manufactured in May 2010 was estimated from the Reference-Composition Salinity calculated from the labeled Practical Salinity with the slight correction (+0.0011 g kg^{-1}) of PAWLOWICZ *et al.* (2010) for absolute salinity and TEOS-10 (IOC *et al.*, 2010) (Fig. 3) ; however, there could be some ambiguity (a few mg kg^{-1} in S_R) in the labeled Practical Salinity (KAWANO *et al.*, 2006).

We used a method similar to the substitution method (WOLF, 2008) to apply an offset correction to the measured density by using the Milli-Q water measurements with a slight modification of the density dependency (Fig. 3), under the assumption that the density meter was stable over about 9 h for a series of measurements of up to 96 samples. We expected the effect of dissolved air on measured densities (about -0.0024 kg m^{-3} at 20 ℃; HARVEY *et al.*, 2005) to be cancelled out, as the measured density of pure water was adjusted to the IAPWS-95 standard.

3. Results

By using measured nutrient concentrations and carbonate system parameters, we examined the magnitude of corrections for the absolute salinity anomaly of the IAPSO SSW and RMNS by using two models (Fig. 4). The first model is from MCDOUGALL *et al.* (2009) :

$$\delta S_A[\mathrm{g\ kg^{-1}}] = 9.824 \times 10^{-5}[\mathrm{SiO_2}] \quad (1)$$

and the second is from PAWLOWICZ *et al.* (2010):

$$\delta S_A[\mathrm{g\ kg^{-1}}] = (5.07[\mathrm{SiO_2}] + 3.89[\mathrm{NO_3}] + 5.56\ \Delta \mathrm{NTA} + 0.47\ \Delta \mathrm{NDIC}) \times 10^{-5}, \quad (2)$$

where $[SiO_2]$ is silicate concentration, $[NO_3]$ is nitrate concentration, ΔNTA is TA anomaly normalized to a salinity of 35 (= TA − [2300 × S_P/35]), and ΔNDIC is DIC anomaly normalized to a salinity of 35 (= DIC − [2080 × SP/35]) (all in units of μmol kg^{-1}). Although the algorithm to estimate absolute salinity provided along with TEOS-10 is consisted from latitude-dependent equations for each ocean basin (MCDOUGALL *et al.*, 2009, Eqs. 3–6), the simple relationship with silicate obtained by fitting to the data from throughout the world ocean (MCDOUGALL *et al.*, 2009, Eq. 2) is used for the standard seawaters, because locations where the source water was taken from are unknown.

For the IAPSO SSW, the magnitude of the corrections for nitrate, TA, and DIC in Eq. (2) was small. However, silicate concentrations were higher in IAPSO SSW with earlier dates of preparation (Table 1), probably as a result of dissolution of silicate from the glass bottles used for SSW. Therefore, the magnitude of the correction for silicate in both Eqs. 1 and 2 was substantially larger for the older batches of the IAPSO SSW, and the rate of increase in silicate concentration was estimated to be 0.0005 g kg^{-1} y^{-1}, although this rate is about half of the previous estimate (0.0012 g kg^{-1} y^{-1}) (FEISTEL *et al.,* 2010).

We examined the differences between the absolute salinity of the IAPSO SSW and RMNS estimated from the two models (Eqs. 1 and 2) and the density measurements (Fig. 5). The correction term for DIC in Eq. 2 was excluded for the IAPSO SSW calculation because DIC was not measured, except in batch P152. The absolute salinities estimated from Eq. 2 agreed well with the measured density salinities. However, the absolute salinity of the IAPSO SSW estimated from Eq. (1), which uses a simple relationship with silicate, was overestimated, probably because of a difference in composition from natural seawater caused by dissolution of silicate from the glass bottle. For the RMNS, the difference was relatively small for both models.

4. Discussion

The absolute salinity of the IAPSO SSW estimated from Eq. (1) was overestimated (Fig. 5). The coefficient of Eq. (1) does not represent the effect of SiO_2 alone, and it represents both SiO_2 and the combined effects of TA, DIC, NO_3, and so on. All of these parameters are relatively correlated in the deep ocean, and so it might be reasonable to empirically correlate the total effect to a single one of them. However, since the chemistry inside the bottle of IAPSO SSW is somewhat different, the coefficient of Eq. (1) can not represent the effect of the aging of the IAPSO SSW.

The discrepancy (0.006 kg m^{-3}) in the density offset between the Milli-Q water and the IAPSO SSW was found (Fig. 3). Uncertainty of the Reference-Composition Salinity Scale for the determination of the absolute salinity of SSW may be as large as 0.05 g kg^{-1} (WRIGHT *et al.*, 2011). Moreover, it is possible that IAPSO SSW now available has a slightly different conductivity/density relationship than the SSW that was used when most of the conductivity/density measurements were made in the 1970s. Therefore, certified standard seawater for density is needed for density measurements. The results we obtained suggest that RMNS has substantial potential as a reference liquid for density measurements, because the RMNS maintains the composition of natural seawater (OTA *et al.*, 2010) and is stable for at least 3 years. The use of a magnetic levitation densimeter (KANO *et al.*, 2007) to measure the absolute density of RMNS could be an effective solution to the problem of finding a reliable density reference.

Acknowledgments

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Operation RECIFS PRADO : a model for management of the Marseille coast

Emilia MEDIONI

Abstract: In 2000, the City of Marseille launched the "PRADO REEFS" program involving the construction and submersion of underwater ecological habitats designed to repopulate, in a few years, previously unproductive seabeds. It was a national, European and mediterraneanscale pilot project; in fact, nearly 30,000 m^3 of reefs have been submerged at depths of 25–30 m, over an area of 200 ha, off the coast of Marseille.

The "PRADO REEFS" project is a true sustainable development project, an example of what a community can do to protect and enhance its environment and support its socioeconomic activities.

Keywords: *artificial reef, Marseille, restoration*

I. Introduction

The rehabilitation of the soft sea-bottom of Prado Bay is an important operation in territory restoration, one that fits in with a program for sustainable management of the Marseille coast (Fig. 1). The aim of this project is to increase natural resources and ensure the permanence of human activity on the coast.

With this program, the city of Marseille has decided to act in a global and coordinated fashion, by initiating a voluntary approach in favour of the Management Plan for the Roadstead of Marseille (known by its French acronym PGRM - Plan de Gestion de la Rade de Marseille).

This restoration policy and management plan consists mainly in reaching an adequate balance between:

- natural environments that must be preserved due to their exceptional value in terms of ecology and scenery,
- sites that have become definitively "artificial" to satisfy the needs of maritime activities (such as ports).

Between these two extremes are intermediary urban spaces, such as Prado Bay and the Frioul archipelago, sites with ecological and economic potential that have heretofore been neglected, but which now could be developed and enhanced.

The dual advantage of restoring former marine productive zones that have disappeared (such as dead seagrass bed matter of Posidonia oceanica that points to the rise by several metres of the lower limit of the living one) is that it directly benefits users of the sea, particularly fishers, and relieves pressure on the sensitive and threatened natural zones that have been damaged by overuse.

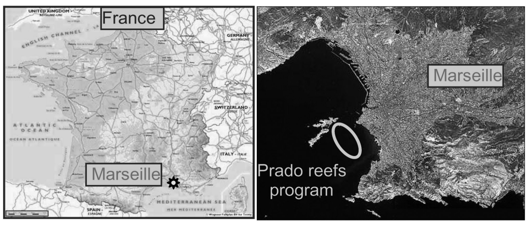

Fig. 1. Localisation of Marseille and Prado program

II. General principles

The main goal of the artificial reef immersion project is to increase the diversity and stability of marine resources in the soft bottom of

Prado Bay.

The basic idea is to provide new hard-substrate undersea habitats, immersed between 25 and 30 m below the surface, which are adapted to the ecological needs (maximum of habitats diversity) of a greater number of marine organisms. With a massive input of rock-like habitat, the productivity and biological diversity of the current sandy bottom will increase considerably, along with the value for both ecology and fishing activities [3] [9].

Diverse research projects carried out in the Mediterranean over the past two decades are now considered to be sufficiently conclusive [2] [5] [7], providing support for the Marseille project to adopt a very ambitious qualitative and quantitative objective from the start. This has made the project more significant at the national level: the immersion of nearly 30,000 cubic metres of reef, for a total investment of 6 million euros (40% from Europe [european founds for fishery], 30% from the Mediterranean Rhone and Corsican Water Agency, 20% from the city of Marseille and 10% from the Regional Council in Provence, Alps and Côte d'Azur). This objective was met in 2008 with the immersion of the last of the 400 artificial reefs (table 1).

From the start, the city of Marseille has built its project on the active collaboration of all partners, brought together onto a Scientific and Technical Monitoring Committee that reunites State institutions, scientific and expert groups, and stakeholder representatives [8]. Its essential mission is to discuss and validate each big step in the project, at the scientific, technical and administrative levels [3] [9] [11] [4] [6]. Over the past ten years (2000–2010), the committee has held 10 plenary meetings at Marseille City Hall.

From the very start of project development, the involvement of professional fishers has resulted in active participation of the Local committee of Maritime Fishers [8], transfer of European financing on structural funds destined for fishing, the application of a **ban on all forms of fishing** during the consultation period until December 31, 2012 in the regulated fishing zone, and their **willingness to undertake self-surveillance** of reef zones and sustainable and reasoned management of the halieutic resource.

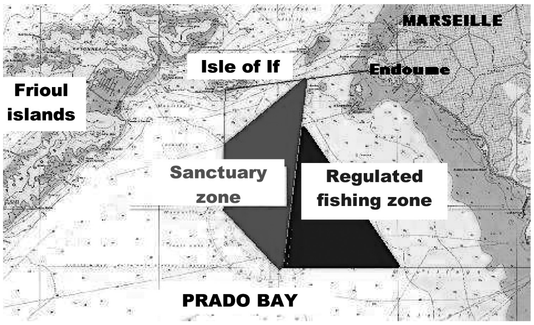

Fig. 2 The Prado reefs area

III. Anticipated organisation

In agreement with the main partners involved, it was finally decided to limit the sector of immersion to two zones: **a sanctuary zone** of 100 ha, in which all uses are forbidden outside of surface navigation and **a regulated zone** of 100 ha, in which fishing will not be allowed during the transition period until December 2012 (Fig. 2). This delay will be used to develop management of this zone with all stakeholders.

Prado Bay has many positive features for type of project: easy access and surveillance; **protection afforded by the Frioul archipelago against waves from the open sea; the existence of nearly permanent marine currents** that change direction depending on the dominant winds (mistrals, eastern winds) ; proximity of a **vast Posidonia bed** and significant natural rocky zones that guarantee rapid colonisation by local submarine flora and fauna; the possibility of **restoring former plant bed zones** that have disappeared and which form vast flat bottoms that are favourable to reef installation [6]; the existence of ferry way (Marseille-South developed zone) that enables a **sanctuary for marine fauna** to be included in this zone without engendering new constraints.

IV. Description of reef architecture

The objective is to provide marine plant and animal life with the features of hard substrates, a range of ecological habitats that are as large and diversified as possible (dimensions

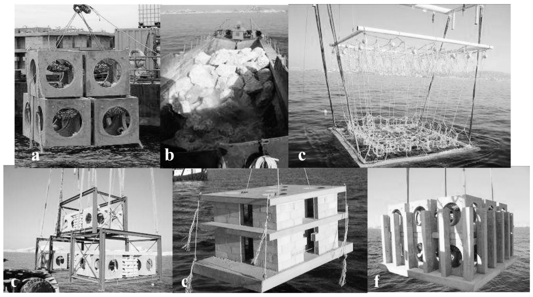

Photo 1. The different types of artificial reefs used in the PRADO REEFS operation in Marseilles
a : pile of concrete cubes, b : pile of stone Cubes, c : floating rope, d : metal basket, e : chicane, f : fakir basket

of cavities between a few decimetres and a few millimetres) to provide food sources and shelter to all stages of biological cycles of the different species (Photo 1).

Ecological optimisation of these structures that are organised on land, essentially focuses on the interior three-dimensional complexity and uniformity, obtained with the materials used in their fabrication (concrete, steel, synthetic cords for guard lines) and the interior packing using units of different sizes and functions (1.7m^3 concrete cubes, blocks, oyster shell nets, octopus pots).

Project studies have led to three overall types of reefs being retained (large volume "basket" models, piles of concrete cubes, quarry rocks) and two types of guard lines ("high" floating ropes, which are independent units of two floors and "low" floating ropes, that are always combined in four groups; there are three specific models : the metal basket reef, the chicane reef and the piles of concrete cubes) (Photos 1).

Biological effectiveness is provided by the system known as "chaotic piles" which has proven to be valuable in the Mediterranean. But the legal obligation to plan for the eventual possibility of reef removal (due to the temporary nature of territory acquisition in the public maritime domain) has led to significant constraints. As well, studies have been done on the design of large-volume units (58 to 306 m^3) (Table 2) that are solid and stable on the bottom, that are easy to manufacture and immerse (as well as to remove).

V. Plan for implantation

The general objective is to favour the distribution of a large number of reef units (surface effect) rather than a great concentration in the form of a few big piles, and to facilitate accessibility by mobile fauna to all lower parts of the reef units, as well as communication among the reefs using linkages.

Two overall types of unit grouping were thus adopted, enabling optimal occupation of all available surfaces (220 ha) : the villages (6 triangles of 300 m on each side, made of 51 to 57 units) and linkages (8 segments of 300 m in length made up of 9 units).

Reef density in the Prado area is 0.014 m^3 per m^2 of plot. In Europe, the program with the biggest volume of submersed reefs is found in Portugal, with 102 000 m^3 scattered over

Table 1. Number and volume of the different models used

Types of reef	Number	Total volume (m^3)	Percentage %	
			Number	Volume
Piles:	245	10 000	34	36
- Concrete Cubes (CCP)	202	3 100	28	11
- Stone Cubes (SCP)	43	6 900	6	25
Modules:	142	8 585	20	31
- Metal Basket Reef (MBR)	21	4 880	3	18
- Fakir Basket Reef (FBR)	21	1 705	3	6
- Chicane Reef (CR)	100	2 000	14	7
Ropes:	337	9 025	46	33
- Low (LR)	323 (x4)	5 500	44	20
- High (HR)	14	3 525	2	13
TOTAL	724	27 610	100	100

Table 2. Data on the weight and volume of the reefs

Module or pile	Volume (m^3)	Weight (tons)	Total volume and weight
Pile of 6 Concrete Cubes (CCP) + low ropes (LR)	volume of one cube = 1.7 m^3 pile of 6 cubes+ LR = 25 m^3	1 block = 0.750 t 4.5 t + link	202 CCP = 5 050 m^3 (= 1 000 t)
Stone Cube Pile (SCP)	160 m^3	500 t	43 SCP = 6 880 m^3 for 21 500 tons
Metal Basket Reef (MBR) + low ropes (LR)	1 element = 45 m^3 MBR = set of 3 piled elements + LR = 266 m^3	16 t 48 t	21 MBR = 5 580 m^3 for 1 000 tons
Fakir Basket Reef (FBR)	75 m^3	48 t	21 FBR = 1 575 m^3 for 1 000 tons
Chicane Reef (CR) + low ropes (LR)	50 m^3	15 t	100 CR = 5 000 m^3 for 1 500 tons
High rope (HR)	252 m^3	Ballast = 6 m^3 of concrete = 14 t	14 HR = 3 525 m^3 for 200 tons of ballast
TOTAL			26 610 m^3 26 200 tons

Table 3. Ground cover of the reefs

Type of reef	Number of reefs	Ground cover of one reef (m^2)	Total ground cover (m^2)	Percentage of ground cover (%)
Pile of Concrete Cubes	202	6.25	1 262.5	0.063
Pile of Stone Cubes	43	50	2 150	0.108
Metal Basket Reef	21	15	315	0.016
Fakir Basket Reef	21	25	525	0.026
Chicane Reef	100	9,6	960	0.048
High Ropes	14	36	504	0.025
		TOTAL	5 716.5 m^2	0.286 %

50 km^2. But, in terms of volume for the same surface, the Prado reefs are 7 times denser than the Portuguese reefs.

In regard to ground cover, the Prado reefs cover only 0.35% of the 200 ha of the plot. The highest reef cover is the pile of stone cubes (Table 3).

VI. Monitoring and development programme

The territory acquisition decree anticipates initial scientific reef monitoring over a period of 10 years, based on the measurements and observations carried out over the different “stage zero studies”.

Monitoring is based on the use of two complementary methods: experimental fishing (by professional fishers and supervised by an expert in halieutics) and direct population inventories using a visual reporting technique in undersea diving. Control monitoring of reef stability and wear will also be carried out during diving expeditions.

The stakeholders in the project have hoped to go further than the compulsory monitoring program. An operation of this scope is an opportunity to develop a research program aimed at a better understanding of ecosystem function in “artificial reefs” and its relationship to the environment. The scientific community and its partners have therefore been solicited to suggest other types of monitoring of the zone.

The marine science centre in Marseille and the Subaquatic Environment and Biology Commission of Department Committee 13 of the French Federation of Undersea Studies and Sports have therefore suggested additional means of monitoring: organic matter, plankton communities, genetic origins of populations, biological surveillance. Other means of scientific monitoring are being discussed with new partners.

A socioeconomic study will evaluate the impact of these reefs on activities and uses, in particular the economic spin-offs for professional fishing. The study will use surveys and analysis of specific indicators.

The involvement of professional fishers is essential, as it will enable monitoring of their catches over a set period to compare them with the period before the reefs were set up.

VII. Regulations and management

Fishing, diving and anchoring are forbidden throughout the zone until December 31, 2012 to allow species and food chains to establish themselves naturally.

During this period, **consultation** with stakeholders helps to define the modes of use over the regulated zone (south zone, outside the channel). The north zone (inside the navigation channel) is destinated to be a sanctuary where all activities are forbidden. The existence of two differently managed zones may assist in evaluating a conservation zone and population evolution.

VIII. Promoting the operation

The highly attractive nature of the images so far obtained, and the educational potential of these artificial reefs, make them ideal for communication and raising awareness about the marine environment and sustainable development. Several initiatives of this type are being developed, both for the general public and for schools :

– one of the "**concrete cube pile**" reefs was not submerged. It is exhibited near the beaches of the Prado. Decorated under scientific supervision, it gives passersby an idea of the size of the reef and of the contrast between the concrete at the time of submersion and the surface colonised by marine organisms several months later;

– in collaboration with National Education and the "Centre Pédagogique de la Mer", a municipal structure to teach the public about the marine environment, several primary school classes **sponsor** a reef village every year. These classes are provided with technical information, photos, and accurate scientific data about the sponsored village. Each class makes a clay plaque which is placed in the underwater village by a scientist diver. At the end of the year, the classes get together for a day to show each other their work (an ABC, a song, an electronic circuit reef, scale model, etc.) and to meet the institutional and scientific partners involved in the operation;

– to help circulate information and messages, a **set of tools** is being designed and updated : teaching pack, exhibition, internet site, teaching booklet, leaflet for the general public, etc.. Some of these will be put together to form a teaching pack, available for classroom use and for anyone interested in artificial reefs, even those outside the sponsorship programme;

– conferences have been arranged to present the operation and information about what is happening on the reefs. Held once or twice a month, they provide an opportunity to learn about the marine environment and the need to preserve it.

– the Marseille experience is **promoted** along the coast in France and abroad.

IX. Conclusion

From the moment of conception to the immersion of the last reef, the immersion of nearly 30,000 m^3 of artificial reefs in Marseille has taken 10 years. The city of Marseille and its partners (state, local skateholders, fishermen, scientists, marine users) have mobilised and involved themselves in carrying the operation PRADO REEFS successfully to term, the first project of this scope in France. The artificial reefs are an excellent tool for sustainable management of the coast and coastal activities. Spearheaded by the Plan de Gestion de la Rade de Marseille [Management plan for the Marseille coast], a program of integrated coastal zone management, this unifying project should open the way for other restoration zones to support small coastal fishing endeavours, restore irretrievably degraded zones or make certain sites more accessible for scuba diving.

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Importance of fishers' knowledge in innovating adaptive co-management in sandeel fisheries

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Abstract: Adaptive co-management has recently been discussed as an efficient approach for managing small-scale fisheries. One type of local ecological knowledge, fishers' knowledge, has been highlighted as a useful way for adapting fishers to a management system of fisheries resources. We present a case study from Japan to demonstrate a practical process of evolving fisheries management systems into adaptive co-management by introducing fishers' knowledge. Fishers recombined elements at hand during fishing procedures for innovation of the system. Their reflections are considered to represent the concept of *bricolage*, as proposed by Lévi-Strauss: i.e., making do with what is at hand. Fishers' bricolages appear to be indispensable for successful implementation of adaptive co-management.

Keywords: *fishers' knowledge, adaptive co-management, sandeel, Ise Bay, bricolage*

1. Introduction

Japanese sandeel (*Ammodytes personatus* Girard) stock is one of the most important resources of two-boat pelagic trawl fisheries in Ise Bay, which opens to the Pacific Ocean in central Honshu, Japan (Fig. 1). At present, about 200 fleets are engaged in this fishery, and the annual amount of sandeel landed in Aichi and Mie prefectures exceeds two billion yen (~265 million USD). From 1950 to 1982, the sandeel stock was managed using a command-and-control method by the local government. However, the abrupt depletion of sandeel stock in Ise Bay in the 1980s drove fishers to regulate the resource (TOMIYAMA *et al.*, 2008). The Fisheries Research Institute of Aichi Prefecture is also currently addressing issues related to local sandeel fisheries. This collaboration may foster progress in the co-management of fisheries resources in Ise Bay (TOMIYAMA *et al.*, 2005).

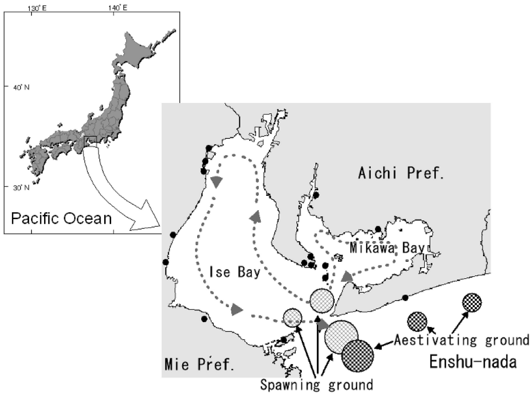

Fig. 1. Schematic view of migration routes of sandeels from spawning grounds to nursery grounds in Ise Bay and Mikawa Bay, as they develop from eggs to adults. Arrows indicate the migration paths of larvae and juveniles. Closed circles indicate the locations of sandeel landing ports around Ise Bay and Mikawa Bay.

Co-management can be defined as a partner-

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ship arrangement in which the community of local resource users (fishers), the government, other stakeholders (boat owners, fish traders, boat builders, business people), and external agents (non-governmental organizations [NGOs], academic and research institutions) share the responsibility and authority for management of the fishery (POMEROY and RIVERA-GUIEB, 2006). Through consultations and negotiations, the partners develop a formal agreement on their respective roles, responsibilities, and rights in management. Co-management covers various partnership arrangements, adjusts the degree of power sharing, and integrates local informal relations, traditions, and customs to centralize government management systems (ARMITAGE *et al.*, 2007; TOWNSEND and SHOTTON, 2008). Co-management of fisheries can be classified into five broad types according to the roles of government in relation to fishers (SEN and NIELSEN, 1996) : instructive, consultative, cooperative, advisory, and informative. Our case involves informative co-management because the local government has delegated fisheries scientists, who provide valuable information on fish resources, to attend meetings of fisher groups that decide upon some fisheries measures; the scientists are then responsible for informing the local government of these decisions.

One of the distinguishing features of the process of evolving to adaptive co-management is the introduction of fishers' knowledge. Fishers' knowledge, which has recently received attention in fisheries studies, is considered one type of local ecological knowledges (e.g., JOHANNES *et al.*, 2000; HAGGAN *et al.*, 2007; RUDDLE, 2007; GARCIA-QUIJANO, 2007; MAMUN, 2010). Such knowledge corresponds to *bricolage,* as proposed by LÉVI-STRAUSS (1962) in his book *La pensée sauvage* (often translated into English as The Savage Mind). *Bricolage*, as described by LÉVI-STRAUSS (1962), means that "there still exists among us an activity that on the technical plane provides a good understanding of what a science we prefer to call 'prior' rather than 'primitive,' could have been on the plane of speculation" (LÉVI-STRAUSS, 1962). Recently, the concept of *bricolage* was introduced into management science to describe the process of making do by applying combinations of the resources at hand to new problems and opportunities (BAKER and NELSON, 2005).

In Japan, some large-scale fisheries are managed by top-down or command-and-control methods such as total allowable catch. But most fisheries conducted in coastal areas of Japan are small scale (MATSUDA *et al.*, 2010). In most cases, successful resource management is conducted by co-management or self-management methods. In this paper, we present several important points concerning the operation of fisheries management (UCHIDA and MAKINO, 2008). In addition, we provide examples of fishers' knowledge being introduced into an adaptive co-management system. We discuss this knowledge introduced into the process as a type of bricolage in management science, i.e., making do with what is at hand (BAKER and NELSON, 2005). It is also very important to analyze development process of sandeel resources co-management system in Ise Bay to clarify what factor contributes to develop the system by applying a newly developed analytical model of knowledge creating process.

2. Sandeel fishery management in Ise Bay

The sandeel stock in Ise Bay experienced declines in the 1970s and 1980s (Fig. 2) (FUNAKOSHI, 1997; TOMIYAMA *et al.*, 2005; TOMIYAMA *et al.*, 2008). Following the collapse of the stock in Ise Bay, a co-management system was implemented in the 1980s.

Autonomous organizations of fishers in Aichi and Mie Prefectures have played a central role in co-managing the sandeel fishery. The history of the shift from command-and-control management to co-management of sandeel fisheries in Ise Bay can be divided into three periods: (1) Sandeel pelagic trawl fisheries were licensed in 1950 by the Aichi and Mie prefectural governments (TOMIYAMA *et al.*, 2005) ; (2) the sandeel stock in Ise Bay and Mikawa Bay collapsed from late 1978 to 1982 because of overexploitation and environmental deterioration (TOMIYAMA, 2009). After this collapse, fishers in Mie and Aichi prefectures and fisheries scientists belonging to the prefectural fisheries research stations of Mie and Aichi

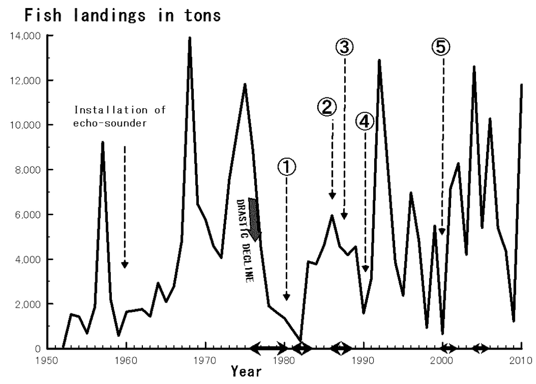

Fig. 2. Annual landing of sandeel in Aichi Prefecture from 1950 to 2004. Black arrows and boxed legends outline the regulatory practices of resource management. Black lines with arrows on the horizontal axis show periods of the large meander of the Kuroshio Current, which causes abnormally low water temperatures in coastal waters along the Pacific coast near Ise Bay and Mikawa Bay. ① Regulation of fishing during the spawning period. ② Regulation of the fishing of large juveniles. ③ Opening day control of the fishing season by the fisheries management simulation model. ④ Establishment of the closing day. ⑤ Adaptive establishment of fisheries refugia

began to discuss regulatory measures in Ise Bay and Mikawa Bay in 1980 based on collaboration between Aichi and Mie prefectures. They decided to apply the first co-management system to sandeel fisheries in 1983. (3) By introducing fishers' knowledge, co-management was innovated into an adaptive co-management in 1990. The main innovations occurred through the following three measures: (a) protection of spawning sandeels, (b) decisions concerning opening day, and (c) decisions concerning the closing day of the sandeel fishery.

3. Fishers' knowledge for innovation of a management system

A collaborative survey between fishers and fisheries scientists is essential for achievement of sustainable co-management based on scientific research design, which is a key factor in a co-management system. The practical tools for the management system have been innovated using fisher's knowledge that is to say *bricolage.*

(a) Protection of spawning sandeels

Fisheries scientists belonging to the prefectural fisheries experimental stations of Aichi and Mie gathered data regarding the migrating area of spawning sandeels using by-catch and echo-sounder information in December. As for fishers' knowledge, fishers have noticed that sandeels spawn earlier when by-catch of sandeel in whitebait trawl fisheries has occurred earlier than in a usual season. Using information on time of the by-catch, we set refugia for spawning sandeel at the mouth of Ise Bay. Moreover, in mid-January, sandeel fishers voluntarily conducted a survey to catch spawners. An open meeting was organized to examine the ovary samples and estimate the timing of sandeel spawning. Related fishers and fisheries scientists belonging to both Mie and Aichi prefectures attended the meeting, during which the parties involved engaged in vigorous discussion and decided on the timing of the opening day for sandeel fisheries in early spring, as discussed below.

(b) Decision concerning opening day

Bongo-nets are plankton sampling gear consisting of two circle rings with a net but no bridle. The lack of a bridle reduces net avoidance by plankton, which are often deterred by the approach of a bridle. Thus, this net is a very effective tool for forecasting the catch of the 0–year-group sandeel before the fishing season (Tomiyama, 2007). When the body length (BL) of sandeel reaches 8 to 10 mm, we evaluated the 0–year-group fish stock size using density data from bongo-net catches (frame diameter of 60 cm, net length of 3 m, and mesh size of 0.335 mm).

Under a co-management framework, the opening day for sandeel fishing was set for the day when sandeel larvae reach 35 mm in BL. Therefore, accurate growth predictions were required. The error caused by avoidance of bong-net mouths is not negligible because of the improved swimming ability attained by larvae at 10 to 12 mm in BL. To overcome this problem, the Aichi Fisheries Experimental Station, along with sandeel fishers, needed to

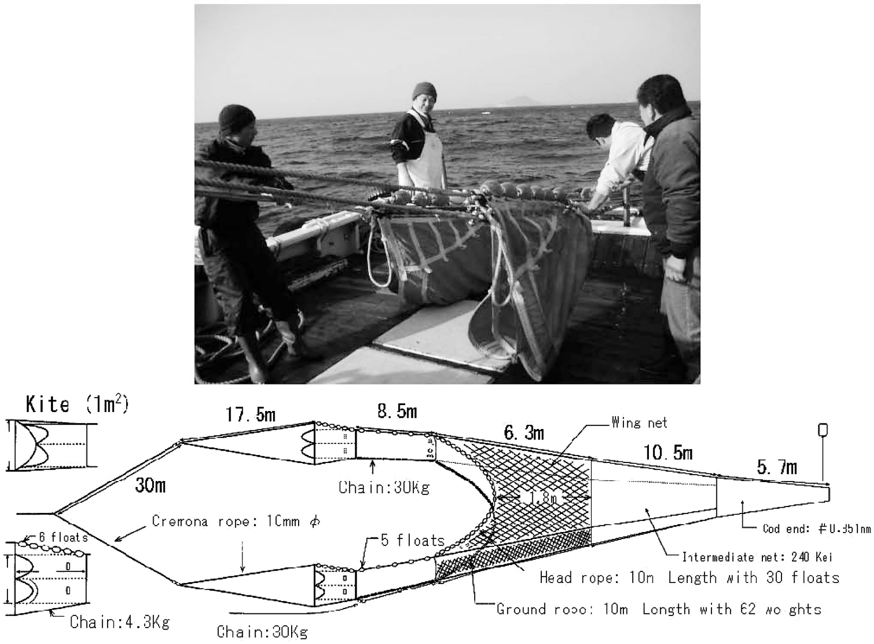

Fig. 3. Photograph showing fishers participating in sandeel larvae sampling using a kite-net (upper panel) and a diagram of the kite-net (lower panel).

develop a new sampling gear that can capture sandeel larvae larger than 10 mm in BL (TOMIYAMA, 2007). At the beginning of gear development, a fisheries scientist of Aichi prefecture requested fishers to transfer their experiences on trawl nets to capture sandeel larvae larger than 10 mm in BL. Mid-water trawl fishers voluntarily made a net set consisting of mesh net tube (mesh size: 1.54 mm) recycled from their mid-water trawl net that had actually used for sandeel fisheries. Thus, this new sampling net was based on fishers' know-how of making trawl net set. The net mouth has a diameter of about 3 m and opened by a canvas kite (Fig. 3) developed by Nichimo Co., Ltd. (TOMIYAMA, 2007). The opening mechanism prompted the name "kite-net." Checking shape of the net deployed in the field at first, fishers took the initiative of experiment. Towing the net near the sea surface from their boat, fishers observed whether the net had wrinkled or not. Then the fishers put down and towed the net in the middle layer, and surveyed cross-section view of the net using their echo-sounder equipped in their boat. Thus, this net innovation represents an example of *bricolage* within co-management. Finally, the kite-net can collect sandeel larvae of a wide size distribution ranging from 10 to 30 mm in BL.

(c) Decision concerning the closing day of the sandeel fishery

Adaptive co-management of sandeel resources requires to protect spawning sandeel throughout successive reproductive seasons during the fishing season. Therefore, many researches pointed out that marine protected areas (MPAs) were necessary for sustainable sandeel fisheries in Ise Bay (TOMIYAMA *et al.*, 2008; TOMIYAMA, 2009; MATSUDA *et al.*, 2010) (Fig. 4). MPAs are defined by the International Union for Conservation of Nature (IUCN, 1994) as "any area of intertidal or subtidal terrain, together with its overlying water and associated flora, fauna, historical and cultural features, which has been reserved by law or other effective means to protect part or all of the enclosed environment." The present case is applied the MPAs classified as Category IV meaning that they are designated for resource

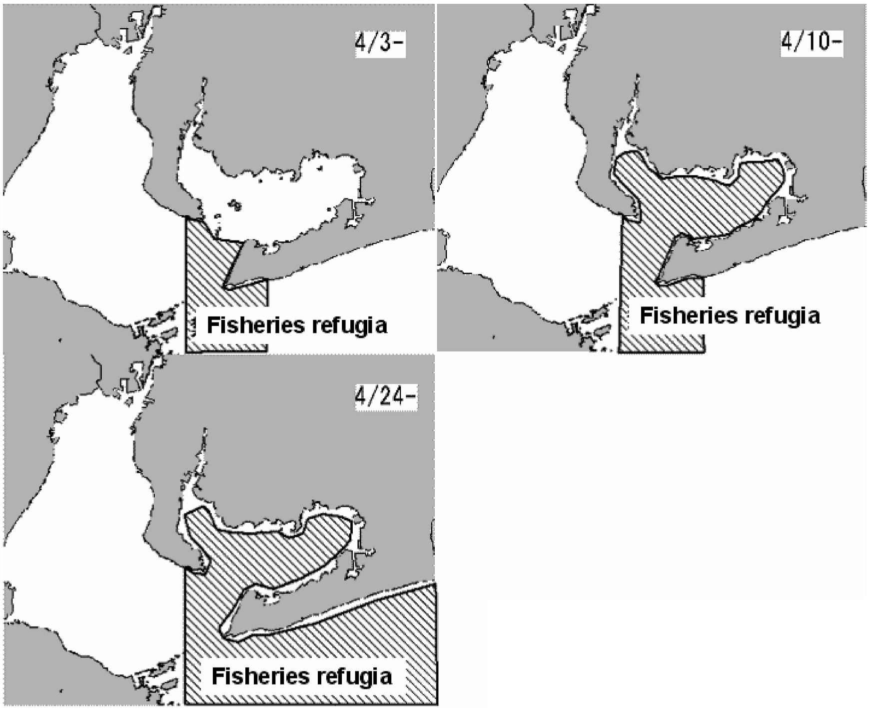

Fig. 4. Fisheries refugia for sandeel in Ise Bay and Mikawa Bay, Japan in 2005. The locations of fisheries refugia were changed weekly based on information regarding the migration routes of spawners detected by fishers.

management (IUCN, 1994). While no fish can be caught within the MPAs throughout the year, it is not practical for sandeel resources whose spawning grounds change during a fishing season (Fig. 4). Another type of protected area is fisheries refugia (PETERSON and PERNETTA, 2006), which are defined as "spatially and geographically defined, marine or coastal areas in which specific management measures are applied to sustain important species [fisheries resources] during critical stages of their life cycle, for their sustainable use." Thus, fisheries refugia has been established since 2001 (Fig. 1). Scientists from the fisheries experimental stations in Aichi and Mie prefectures determined fisheries refugia that protected spawning sandeel during the fishing season (TOMIYAMA, 2009) (Fig. 4). The refugia locations are changed according to migration of spawners. These adaptive co-management procedures use diverse information obtained by modern fishing equipments, such as echo-sounders, GPS plotters, fishery radios on fishing boats, and cellular telephones of fishers, all of which also represent examples of *bricolage*. For example, the distribution of sandeel shoals was investigated using echosounders operating at both 50 and 200 kHz. Fishers' knowledge can identify a shoal of sandeel larvae with its shape and appearance on echograms at two different frequencies (TOMIYAMA and YANAGIBASHI, 2004).

As larvae develop into juveniles and eventually adults, sandeels gradually move from the interior to the mouth of Ise Bay, where they enter into aestivation in May-June (Fig. 1) when bottom water temperatures exceed 17℃ (TOMIYAMA and YANAGIBASHI, 2004). Fisheries scientists estimate distribution area of adult larger sandeel from collecting catch data of sandeel by interview or phone to fishers. Based on the estimation, fisheries scientists and a dozen leaders of sandeel fishers discuss and decide area of refugia. The fisheries refugia are regulated by only fishers. Thus, both local

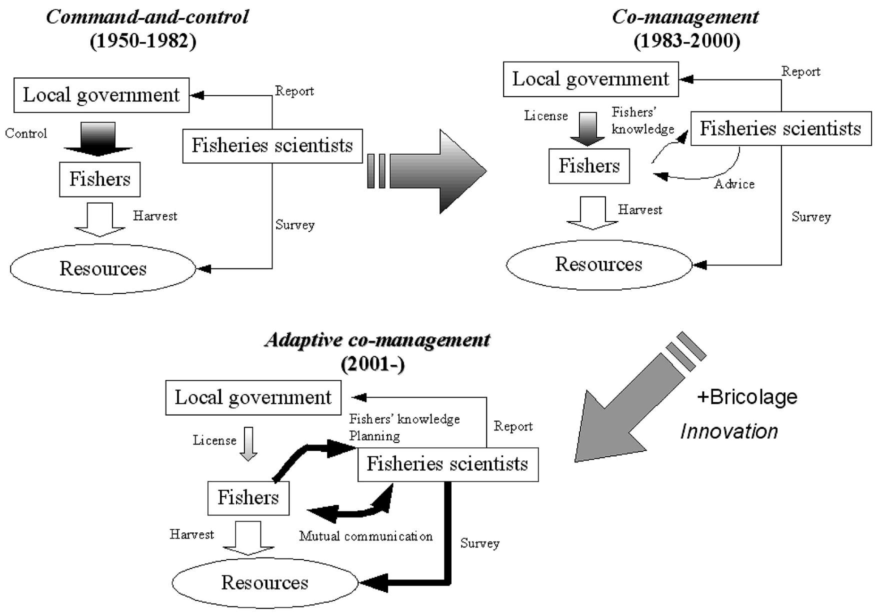

Fig. 5. Conceptual models depicting sandeel management systems ranging from command-and-control to adaptive co-management through co-management.

governments of Aichi and Mie prefectures don't take responsibility for control of fisheries in the refugia. On the other hand, they allocate adequate fisheries scientists of both prefectures to establish the refugia and monitor sandeel resources, and support financially research activities. These scientists of Aichi and Mie prefectures announce fishers remained stock of sandeel estimated from daily landing data.

To determine the onset of aestivation, fisheries scientists use a "karatsuri" rake at the sandeel aestivation grounds in May-June. This rake was developed based on fishing gear used to catch burrowing flatfish in the sand and is applied to quantify the number of remaining spawners burrowing in the sand in the summer. This gear is a modification of Tanda and Okamoto's (1992) rake. Developed using fishers' input and modified from the actual fishing gear used to catch burrowing flatfish (TOMIYAMA and YANAGIBASHI, 2004), the karatsuri rake represents another example of *bricolage*.

4. Innovation of the management system

In many cases, resource depletion motivates fishers to begin fishery management, in what is called "the depletion crisis model" (BERKES and TURNER, 2006). For the sandeel stock in Ise Bay, co-management began when depletion became apparent around 1980. Also in the case of entrepreneurial firm, innovations often occur under shortage of human or financial resources (BAKER and NELSON, 2005). The several innovations based on *bricolage* mentioned above were introduced to the management system, which developed into adaptive co-management from the previous co-management system (Fig. 5). When the parties involved discussed the management of sandeel stock, knowledge of fishers played an important role in the "adaptive" aspect of the approach (BERKES, 2007, 2009). Local ecological knowledge (OLSSON and FOLKE, 2001; GADHAV *et al.*, 2003; MAMUN, 2010), traditional ecological knowledge (INGLIS, 1993; RUDDLE, 2007), and fishers' knowledge (JOHANNES *et al.*, 2000; STEAD *et al.*, 2006; GARCIA-QUIJANO, 2007; HAGGAN *et al.*, 2007; HILBORN, 2008) have been treated as important factors in resource management. In contrast to other types of local ecological knowledge, the sandeel fishers' knowledge is not a traditional

Table 1. Shortages in scientific knowledge, application of *bricolages*, and components of fishers' knowledge

	Shortage in scientific knowledge	*Bricolages* by fishers' knowledge
Improvement of larval sampler	Usual sampling gear could neither catch larger larvae nor be operated by small boat.	Fishers ameliorate wing net with a net mouth larger than usual sampling net from pelagic trawl net for halfbeak (*sayori*).
Development of karaturi-rake	No gear were available to capture sandeel burrowing in sand during aestivation.	Fishers' knowlegde on fishing gear for capturing flatfish hints to develop a new sampling gear, karatsuti-rake, to catch sandee burrowing in sand.
Setting fisheries refugia for conservation of spawners in the next year	Little was known about the migrating path.	Survey by fishers revealed the migrating path of sandeel school using echosounders equipped in the boats and fisheries radio.

but rather an on-site or practical knowledge. Table 1 presents three cases of *bricolage* in which fishers' knowledge was used to overcome a shortage in scientific knowledge. These three cases of *bricolage* correspond to BAKER and Ne lson's definition of *bricolage* (BAKER and NELSON, 2005), i.e., "making do by applying combinations of the resources at hand to new problems and opportunities."

To understand the success of co-management of sandeel resources and apply it to another fishery, it is very interesting to clarify the process of co-management development in which the stakeholders play roles. Considering the roles of fishers and fisheries scientists, we can apply an analyzing model to the process (Fig. 6). We use here SECI model developed by NONAKA and TAKEUCHI (1995) who analyzed how the knowledge creating process works with tacit and explicit knowledge in an organization, especially enterprises. They classified four stages (Socialization, Externalization, Combination and Internalization) in knowledge creating process. At first, socialization process focuses on tacit to tacit knowledge linking. Tacit knowledge goes beyond the boundary and new knowledge is created by using the process of interactions, observing, discussing, analyzing, spending time together or living in same environment. The socialization is also known as converting new knowledge through shared experiences. Externalization process focuses on tacit to explicit knowledge linking. It

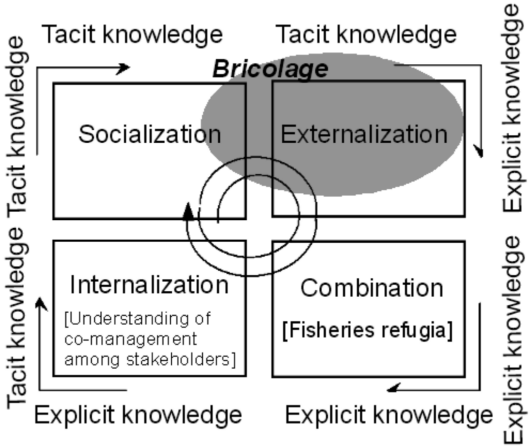

Fig. 6. Applying the creating model, SECI model, proposed by Nonaka and Takeuchi (1995) to adaptive co-management of sandeel resources. Dark area shows a rauge of bricolage.

helps in creating new knowledge as tacit knowledge comes out of its boundary and became collective group knowledge. Combination is a process where knowledge transforms from explicit knowledge to explicit knowledge. By internalization, explicit knowledge is created using tacit knowledge and is shared across the organization. When this tacit knowledge is read or practiced by individuals then it broadens the learning spiral of knowledge creation. Organization tries to innovate or learn when this new knowledge is shared in Socialization process. According to the SECI model, fishers knowledge and management measures are defined as tacit and explicit knowledge, respectively, under four conversion phases: Socialization, Externalization, Combination and Internalization (Fig. 6).

We apply this model to the case of sandeel's stock management. In Socialization phase, tacit knowledge common among all fisher is integrated under initiatives of fishers' leaders. So, the tacit (fishers') knowledge is shared by the fishers' group. Fishers' *bricolage* is effective in Externalization phase, in cooperation with fisheries scientists. In this phase, tacit (fishers') knowledge is converted into explicit knowledge, such as management measures. Furthermore, the measures are easily gained consensus-building among fishers because it contains tacit knowledge in itself. In Combination phase, explicit knowledge of equipments for co-management such as kite-net, karatsuri raker are combined to deciside opening and closing days of sandeel fishery and fishery refugia for protection of spawning sandeel. In Internalization phase, fishers participating monitoring of sandeel's stock, their understanding will spiral upward. This analysis suggests that *bricolage* is a key to start creation of co-management of sandeel resources. Therefore, it is very important for fisheries scientists, who are charged in explicit knowledge, to contact closely fishers for developing co-management of fish resources.

Most of coastal fisheries in Japan are small scale (Matsuda *et al.*, 2010). Resource management methods for small-scale fisheries should be distinct from those used in industrial fisheries, e.g., individual quota or individual transferable quota methods. As shown here, the introduction of fishers' knowledge into coastal fisheries can be very effective. By adopting *bricolages* based on fishers' knowledge, expensive research equipment is not needed to establish an effective resource management system because fishing boats can be used as research vessels and fishing gear can serve as sampling gear. Our practices highlight the potential for co-management of small-scale fisheries using the concept of *bricolage* and participation by related fishers not only in Ise Bay but also in other areas. In addition, intrduction of fisheries refugia acceptable for fishers is very effective for co-management.

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