

Decoding Genomes of Corals and *Symbiodinium* : A possible contribution toward coral reef preservation

ゲノム研究のサンゴ礁保全への貢献の可能性

1. Decoding genome of a coral, *Acropora digitifera*
コユビミドリシのゲノム解読
2. Population genetics of *Acropora digitifera*
コユビミドリシの集団遺伝学的解析
3. Decoding genome of *Symbiodinium minutum*
サンゴ共生褐虫藻のゲノム解読

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(沖縄科学技術大学院大学 佐藤矩行)



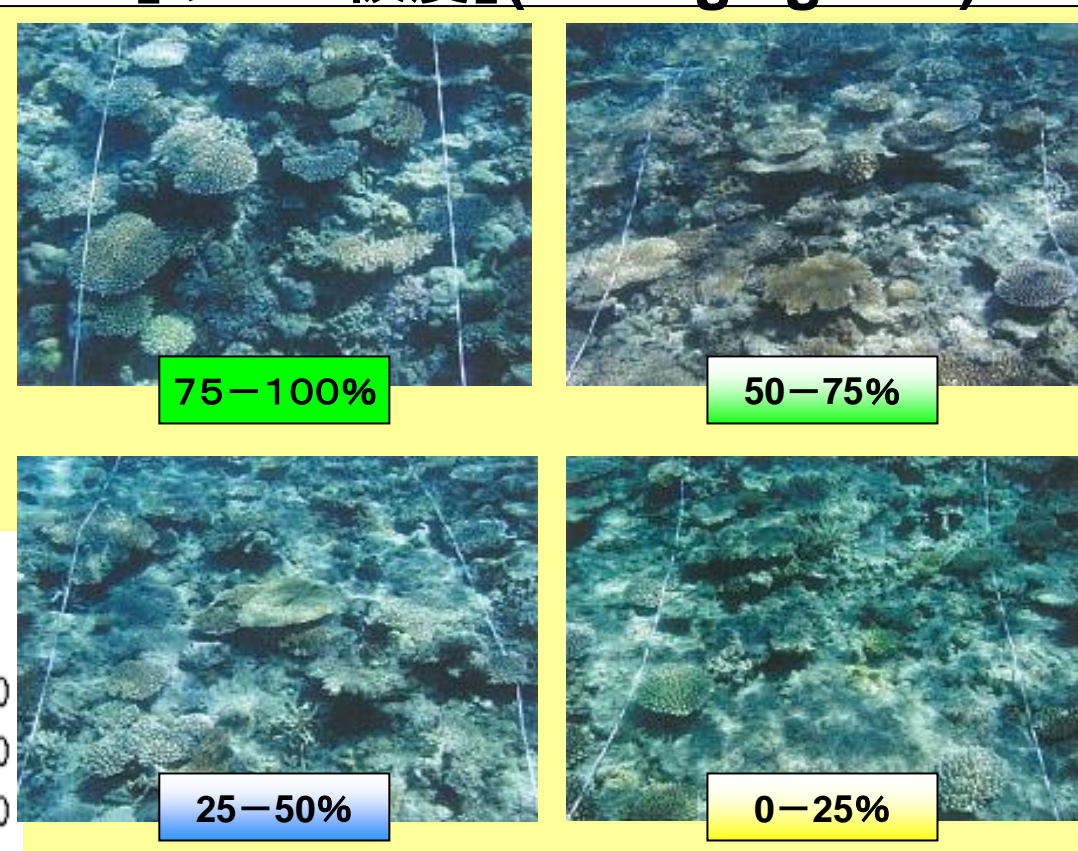
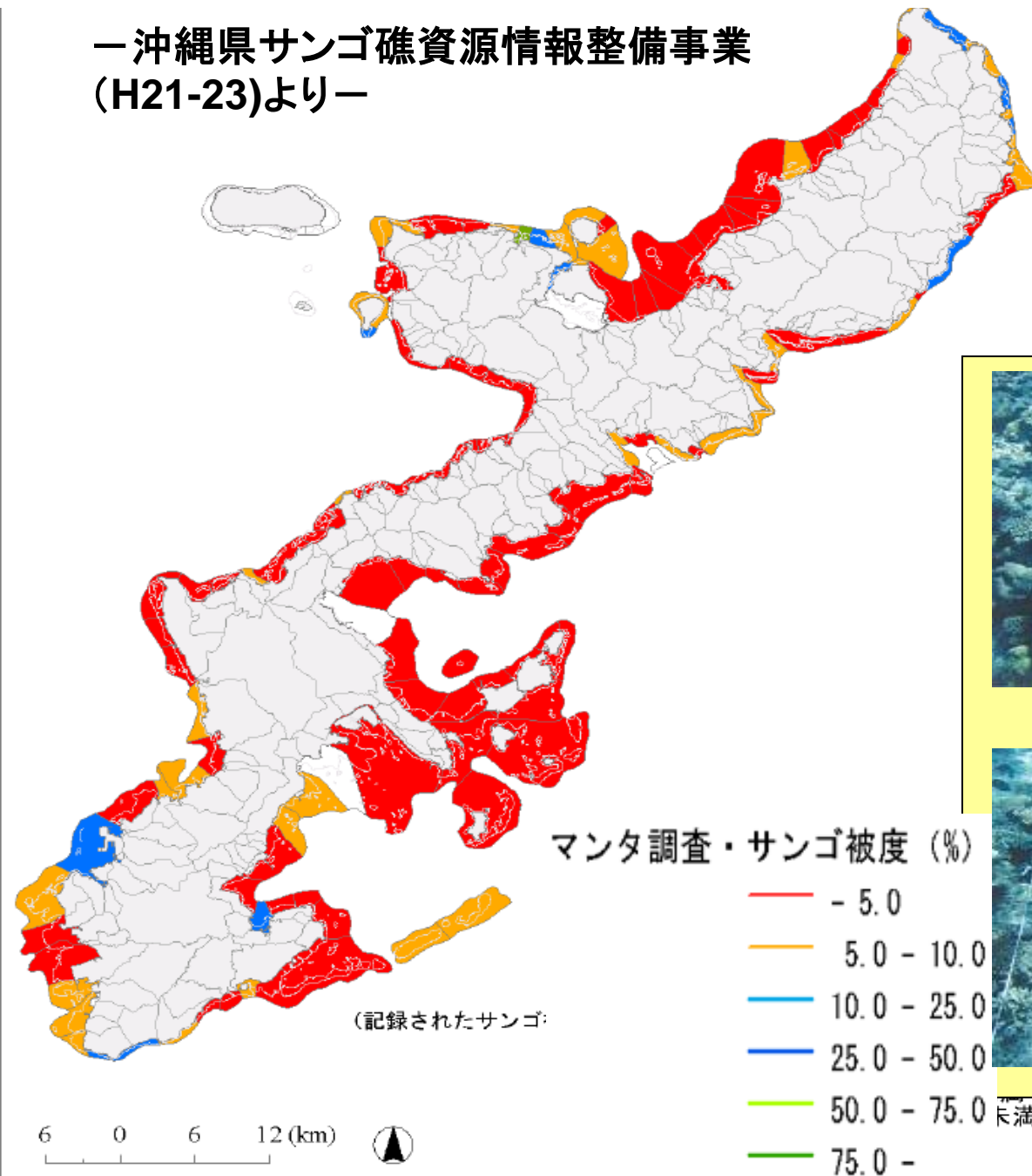
Present condition of coral reefs in Okinawa main islands

沖縄本島のサンゴ礁の現状

— 沖縄県サンゴ礁資源情報整備事業 (H21-23) より —

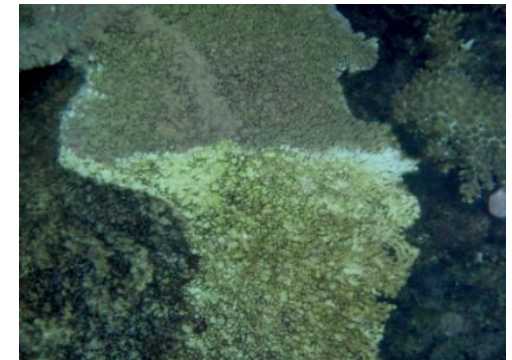
沖縄県ほぼ全域の礁斜面、礁池を調査
(H21) 沖縄本島周辺海域
(H22) 慶良間、久米島、八重山周辺海域
(H23) 宮古島、他離島

【サンゴ被度】(damage grade)



Preservation and restoration of coral reefs are urgent subject サンゴ礁の保全・再生はまったなしの課題

- Nearly one-thirds of coral reefs in the world now under critical condition due to climate changes and human activities: **bleaching**
- **白化現象**: 現在地球の1/3のサンゴ礁が危機的状況に直面：水温の上昇、海水の酸性化、人的活動によるとみられる。



Research of Coral Biology is essential to coral preservation
サンゴ生物学の研究推進はまったなし

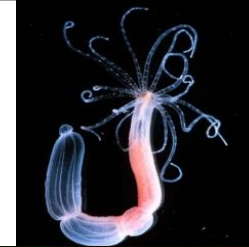
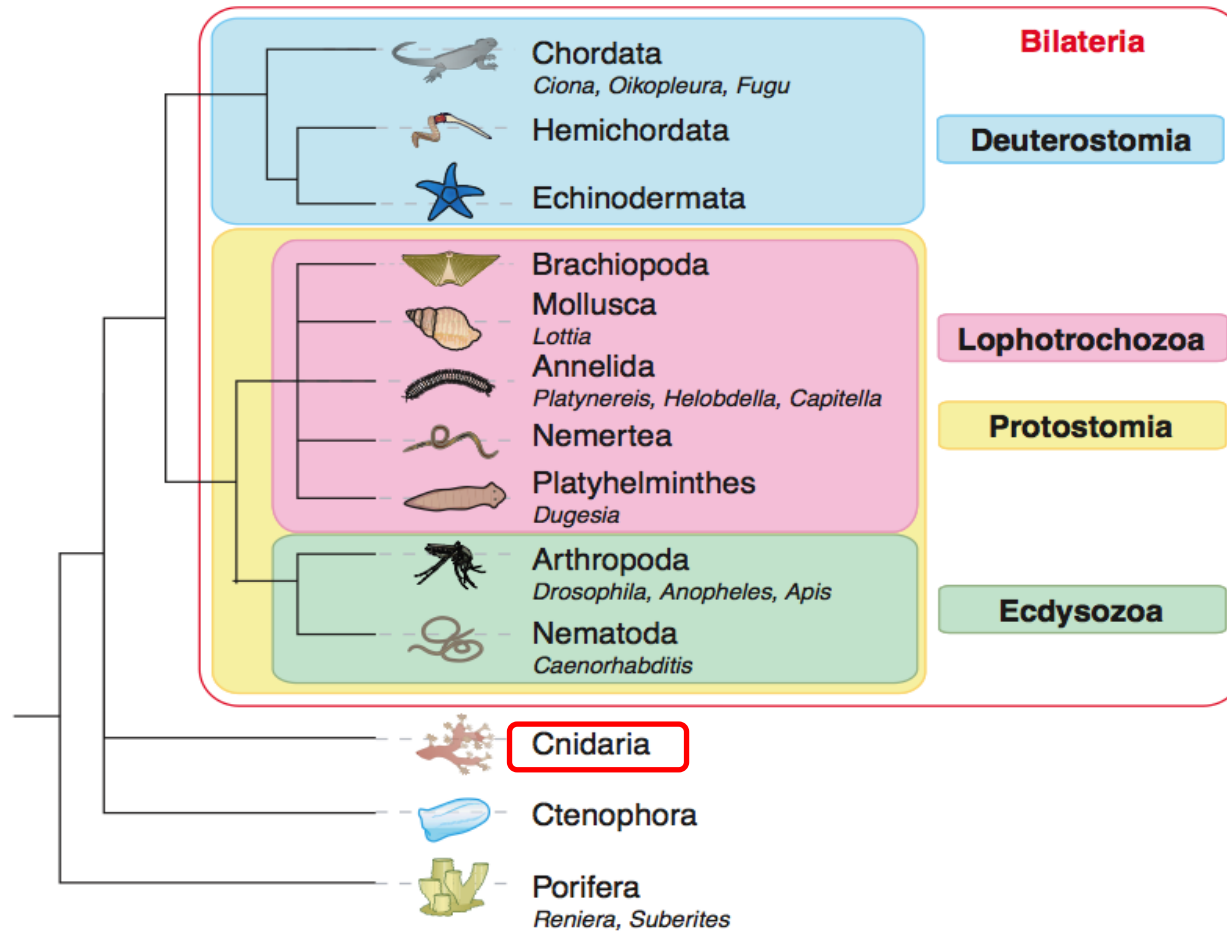


What are reef-building corals? (造礁サンゴとは?)

Corals are a group of cnidarians. サンゴは刺胞動物：クラゲやイソギンチャクの仲間

Symbiosis with dinoflagellates: 褐虫藻（渦鞭毛藻の仲間）と共生関係

Making reefs: サンゴ礁をつくる



Genome contains all genetic information ゲノムは全ての遺伝情報を含む

Coral Genome Decoding : サンゴゲノムの解読

Nature 2011年8月18日号 (2011, August 18, issue)

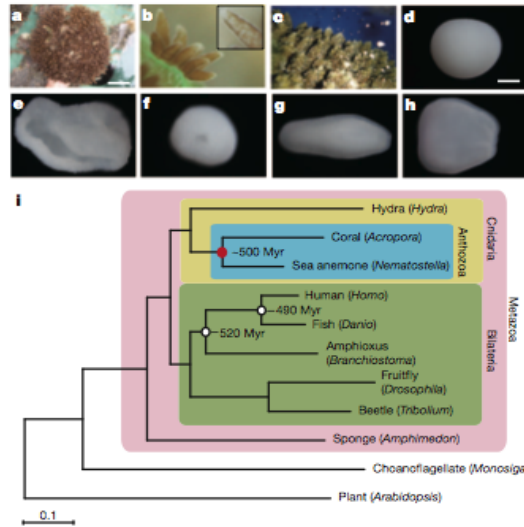
LETTER

doi:10.1038/nature10249

Using the *Acropora digitifera* genome to understand coral responses to environmental change

Chuya Shinzato^{1*}, Eiichi Shoguchi^{1*}, Takeshi Kawashima^{1*}, Mayuko Hamada^{1*}, Kanako Hisata¹, Makiko Tanaka¹, Manabu Fujie², Mayuki Fujiwara¹, Ryo Koyanagi¹, Tetsuro Ikuta¹, Asao Fujiyama³, David J. Miller⁴ & Nori Satoh¹

Despite the enormous ecological and economic importance of coral reefs, the keystone organisms in their establishment, the scleractinian corals, increasingly face a range of anthropogenic challenges including ocean acidification and seawater temperature rise¹⁻⁴. To understand better the molecular mechanisms underlying coral biology, here we decoded the approximately 420-megabase-pair genome of *Acropora digitifera* using next-generation sequencing technology. This genome contains approximately 23,700 gene models. Molecular phylogenetics indicate that the coral and the sea anemone *Nematostella vectensis* diverged approximately ~500 million years ago, considerably earlier than the time over which modern corals are represented in the fossil record (~240 million years ago)⁵. Despite the long evolutionary history of the endosymbiosis, no evidence was found for horizontal transfer of genes from symbiont to host. However, unlike several other corals, *Acropora* seems to lack an enzyme essential for cysteine biosynthesis, implying dependency of this coral on its symbionts for this amino acid. Corals inhabit environments where they are frequently exposed to high levels of solar radiation, and analysis of the *Acropora* genome data indicates that the coral host can independently carry out *de novo* synthesis of mycosporine-like amino acids, which are potent ultraviolet-protective compounds. In addition, the coral innate immunity repertoire is significantly more complex than that of the sea anemone, indicating that some of these genes may have roles in symbiosis or coloniality. A number of genes with putative roles in calcification were identified, and several of these are restricted to corals. The coral genome provides a platform for understanding the molecular basis of symbiosis and responses to environmental changes.



コユビミドリイシ (*Acropora digitifera*) Most popular but damaged in 1998

4億2千万の塩基対:420 Mbp
23700 genes (遺伝子)



What we learn from the coral genome:

サンゴゲノム解読から分かったかこと

Acropora lost a gene for an amino-acid synthesis

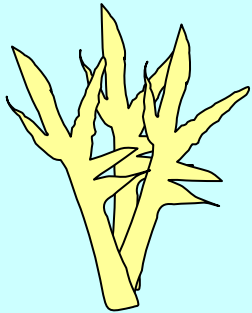
白化に弱いミドリイシはシステイン合成酵素を持たず、褐虫藻に依存してるらしい



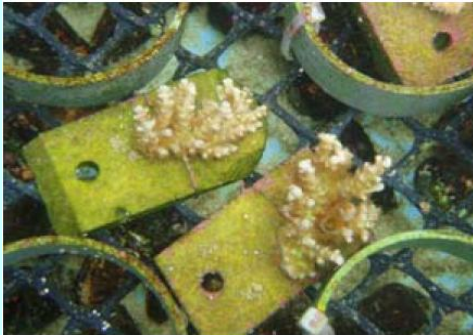
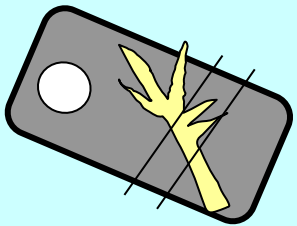
A possible reason why *Acropora* were so much damaged in 1998



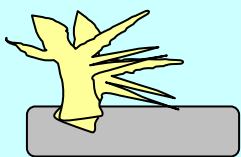
Restoration of coral reefs by transplantation of corals: (Okinawa Pref. Project) 沖縄県によるサンゴ移植によるサンゴ礁の回復事業



断片を基盤に固定



サンゴが定着し成長



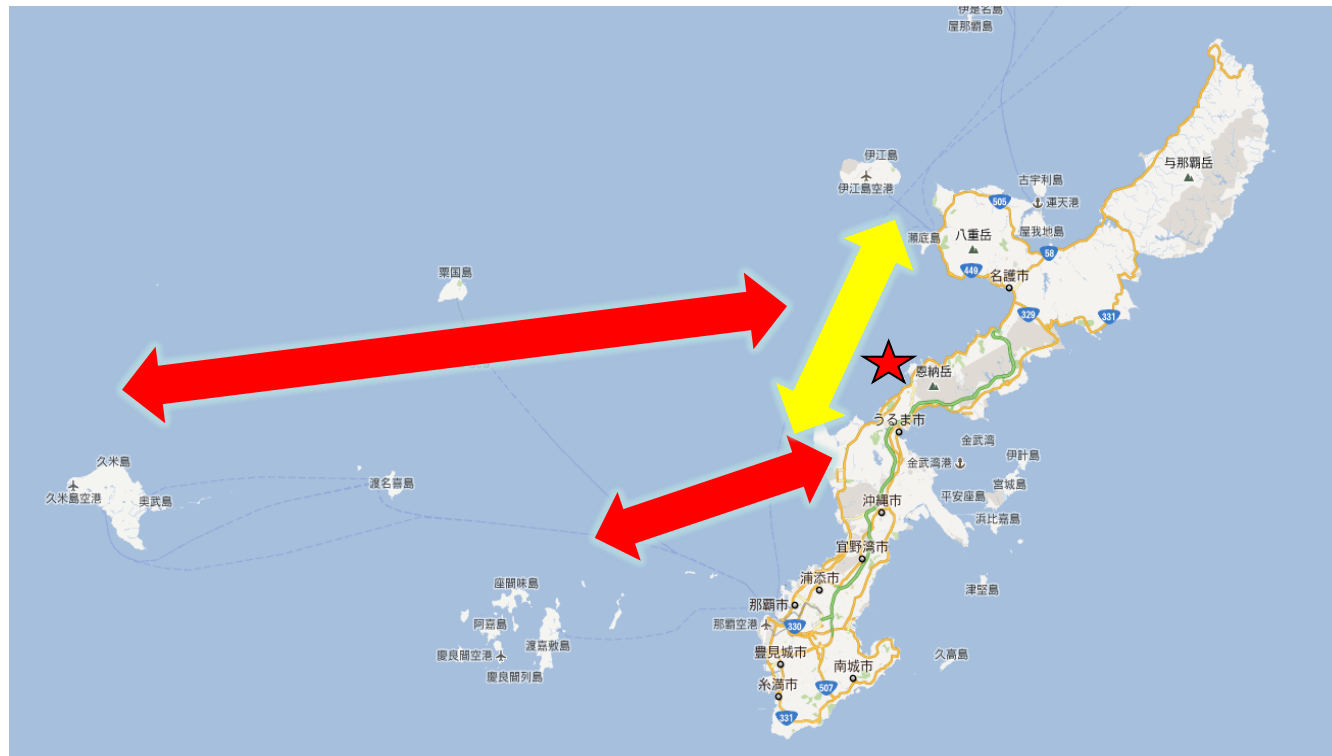
GRADUATE UNIVERSITY

恩納村漁協 の活動（比嘉）

写真提供：恩納村漁協

A question is whether populations of coral are genetically same or not.

沖縄島嶼におけるサンゴの集団遺伝学(サンゴは同じ集団とみなせるか)



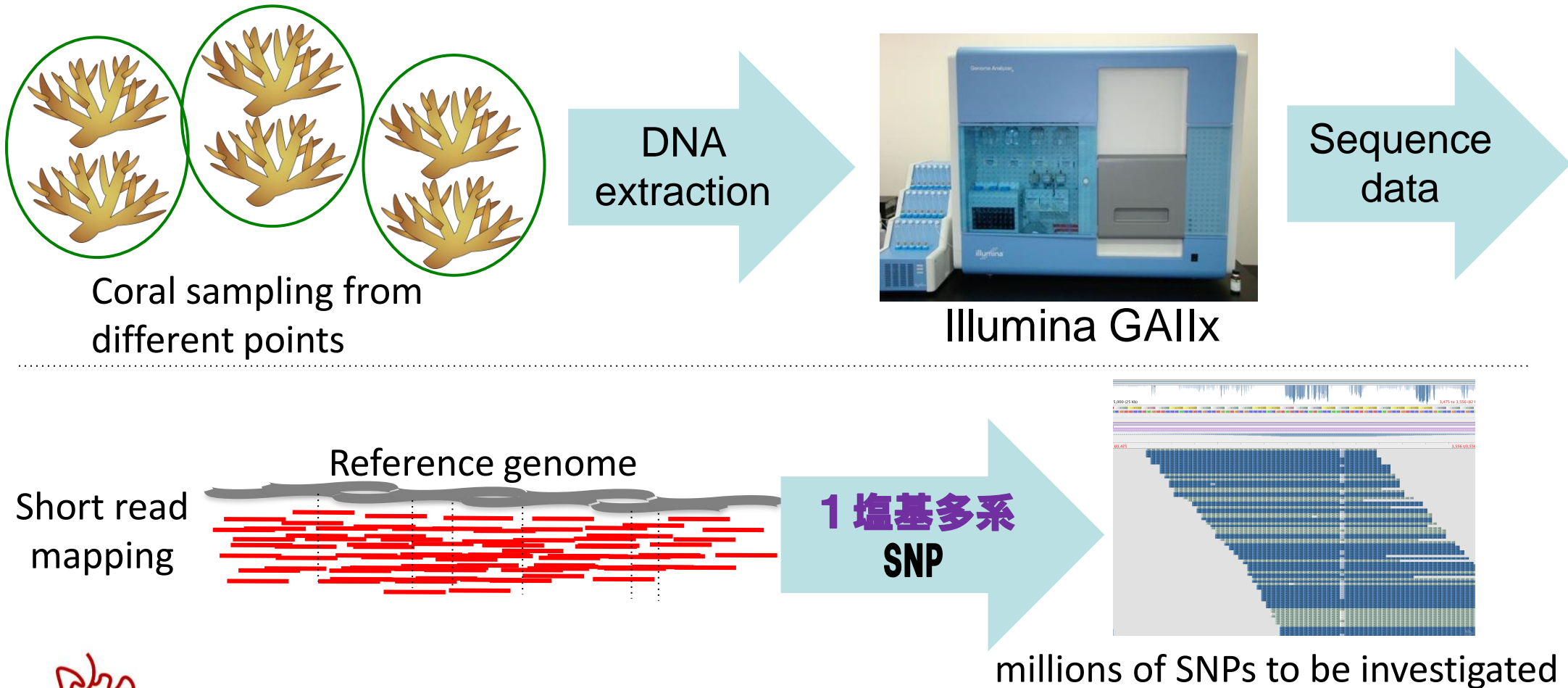
- **Populations of Okinawa main islands and/or Kerama and Yaeyama islands**
- 本島内で同一と考えてよいのか。本島内、慶良間諸島、八重山諸島との交流はあるのか。



Population genetics at genome level

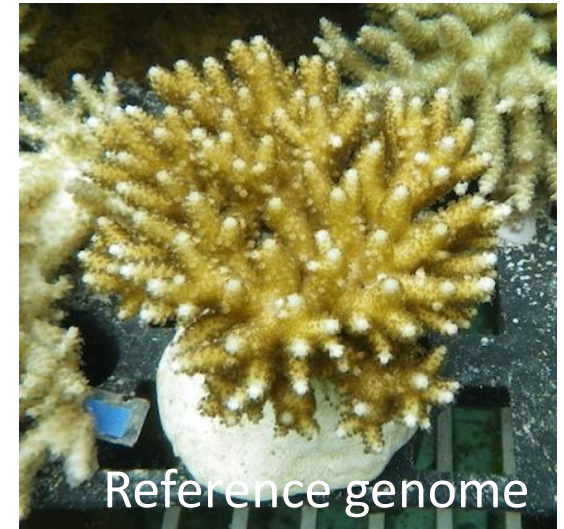
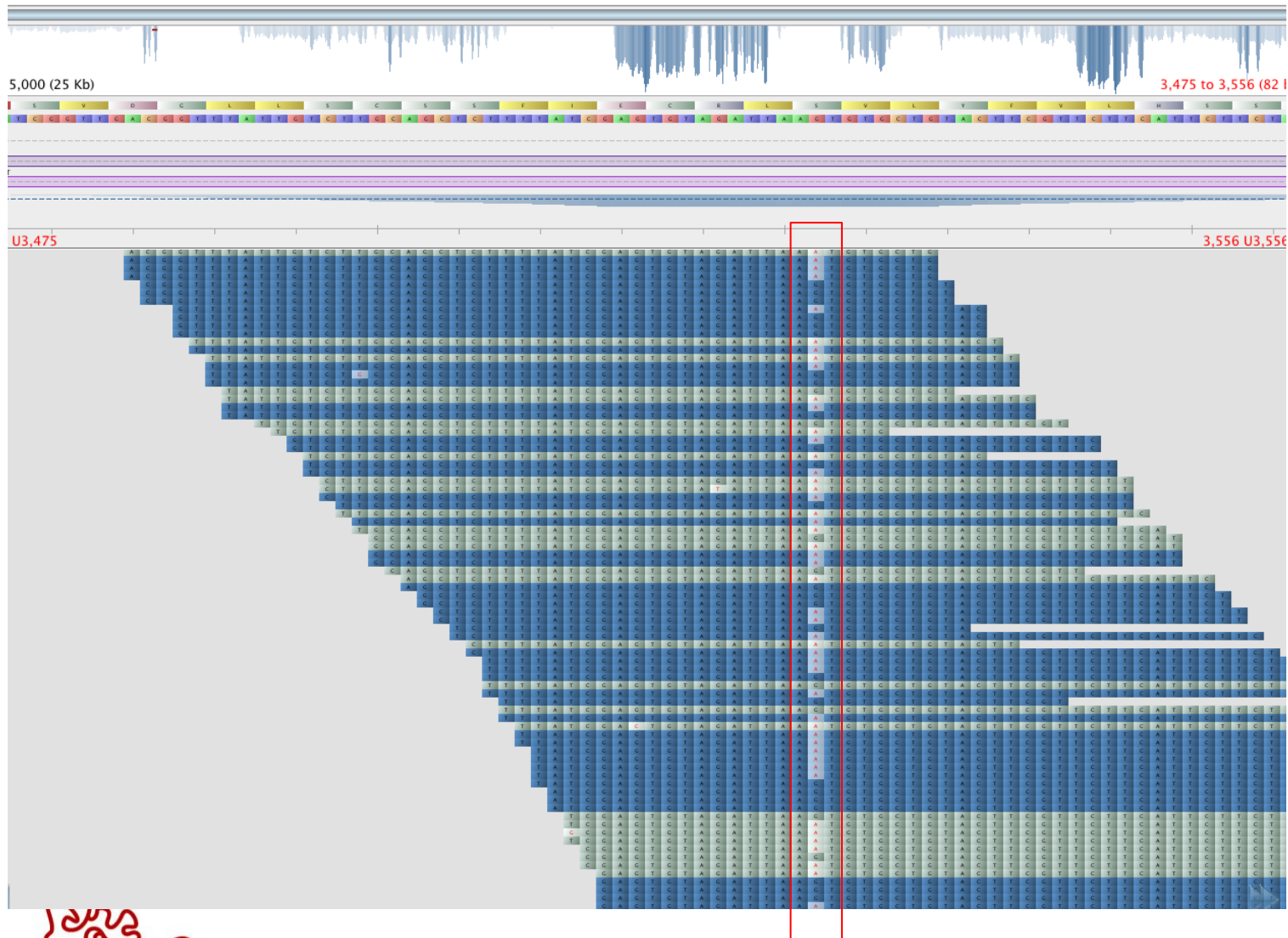
ゲノムレベルでの集団遺伝学的解析

SNP: the most abundant type of genetic variation in eukaryotic genome
Small nucleotide changes can generate the different traits



Detection of single nucleotide polymorphism

1塩基多型の例



Sampling locations of *Acropora*

コユビミドリシの採集場所

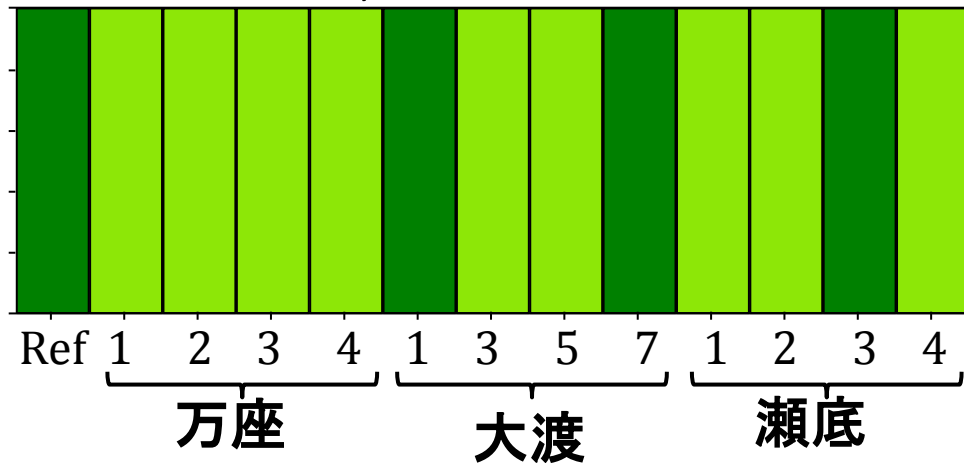


A population genetic study suggests no significant genetic difference among the corals of the main island

沖縄本島におけるコビミドリイシの集団遺伝的差異は非常に小さい

STRUCTURE (MCMC; Markov Chain Monte Carlo)

188,000 SNPs used



Fst between two (red and green) population:

0.08~0.09

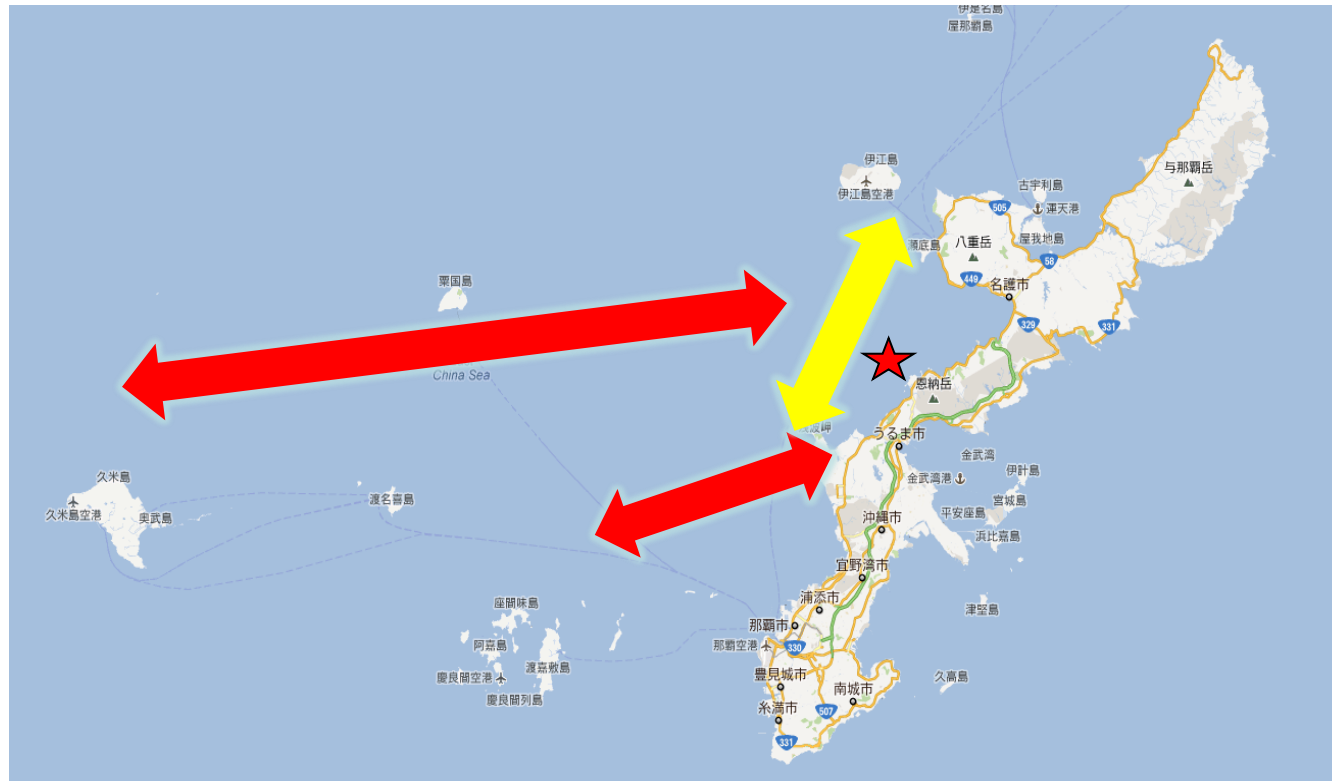
Low (no) population divergence within Okinawa island

Fst (The fixation index): measure of population differentiation, genetic distance, based on genetic polymorphism data, such as SNPs or microsatellites. Fst=0 indicates no divergence between population



We are now analyzing populations between Okinawa and Yaeyama Islands

沖縄におけるサンゴの集団遺伝学(サンゴは同じ集団とみなせるか)



- **Although populations of Okinawa Island look similar, how about between Okinawa and Yaeyama islands**
- **本島内では同一集団と考えるとよいと思われる。**
- **本島内、渡嘉敷諸島、八重山諸島との交流はあるのか。**



Decoding of *Symbiodinium* genome is essential to understand coral biology

サンゴの成り立ちを理解するために:次に 共生褐虫藻のゲノム解読 に挑戦



Symbiodinium
共生褐虫藻

Symbiosis
共生



Acropora digitifera
コユビミドリシ

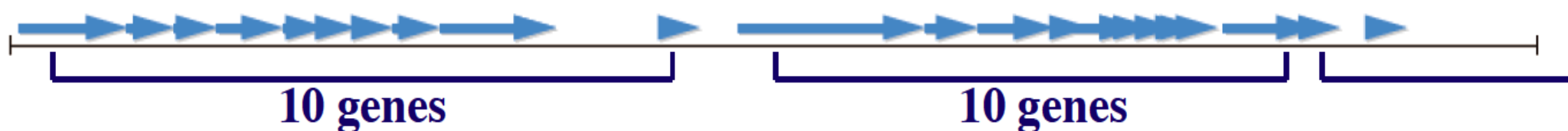


The genome of *Symbiodinium* is quite unusual among eukaryotes

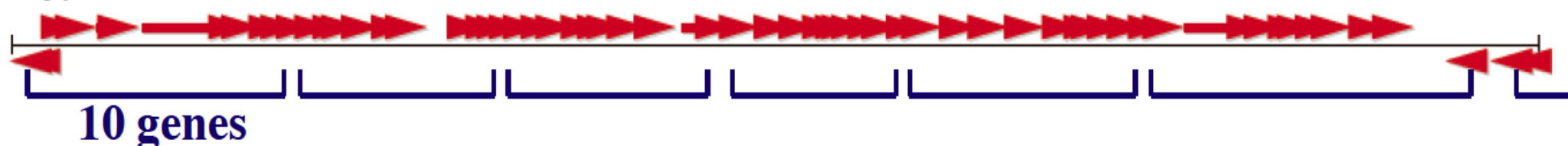
褐虫藻のゲノムはこれまでに報告がないほど変化に富んでいる

(1) 遺伝子が直線状に並んでいる

Symbiodinium minutum-Mf1.05b Scaffold 11.1: 1-200000



Trypanosoma brucei Chromosome 3: 1-200000



Plasmodium falciparum psuIPf3D7_07:1..200000



Tetrahymena thermophila scf_8254010:1..200000



Decoding Genomes of Corals and *Symbiodinium*

A possible contribution toward coral reef preservation

ゲノム研究のサンゴ礁保全への貢献の可能性

1. We have now genomic information of both coral and *Symbiodinium*.

サンゴおよび共生褐虫藻の両方のゲノム情報をえることができた。

2. Population genetics of corals

コユビミドリシの集団遺伝学的解析

3. Studies of mechanisms involved in the establishment and collapse of symbiosis

共生の成立と崩壊のメカニズムの解析

