

Production of kelp in Japan

- various natural resources and the established aquaculture technique -

Norishige YOTSUKURA, (Hokkaido University, Japan)

Kelp in Japan

Laminariales Migula

Akkesiphycaceae H. Kawai & H. Sasaki
Akkesiphycus Yamada & Tak. Tanaka
Akkesiphycus lubricus Yamada & Tanaka

Alariaceae Setchell & Gardner

Alaria Greville
Alaria angusta Kjellman
Alaria crassifolia Kjellman
Alaria praelonga Kjellman
Alaria taeniata Kjellman
Undaria Suringar
Undaria peterseniana (Kjellmann) Okamura
Undaria pinnatifida (Harvey) Suringar
Undaria undarioides (Yendo) Okamura



U. pinnatifida

Chordaceae Dumortier

Chorda Stackhouse
Chorda asiatica Sasaki & Kawai
Chorda kikonaiensis Sasaki & Kawai
Chorda rigida Kawai & Arai

Costariaceae C.E. Lane, C. Mayes, Druehl & G.W. Saunders

Agarum Dumortier
Agarum clathratum Dumortier
Agarum oharaense Yamada
Costaria Greville
Costaria costata (C. Agardh) De A. Saunders

Laminariaceae Boy

Arthrothamnus Ruprecht
Arthrothamnus bifidus (S.G. Gmelin) J. Agardh
Laminaria J.V. Lamouroux
Laminaria yezoensis Miyabe
Saccharina Stackhouse
Saccharina angustata (Kjellman) C.E. Lane, C. Mayes, Druehl & G.W. Saunders
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Saccharina coriacea (Miyabe) C.E. Lane, C. Mayes, Druehl & G.W. Saunders
Saccharina gyrate (Kjellman) C.E. Lane, C. Mayes, Druehl & G.W. Saunders
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Streptophyllopsis Kajimura
Streptophyllopsis kuroshioense (Segawa) Kajimura



A. bifidus

Lessoniaceae Setchell & Gardner

Ecklonia Hornemann
Ecklonia cava Kjellman
Ecklonia kurome Okamura
Ecklonia stolonifera Okamura
Eckloniopsis Oamura
Eckloniopsis radicata (Kjellman) Okamura
Eisenia J.E. Areschoug
Eisenia arborea J.E. Areschoug
Eisenia bicyclis (Kjellman) Setchell
Pseudochordaceae Kawai & Kurogi
Pseudochorda Yamada, Tokida & Inagaki
Pseudochorda gracilis Kawai & Nabata
Pseudochorda nagaii (Tokida) Inagaki



E. kurome

Kelp in Hokkaido

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Laminariacean kelp in Hokkaido

S. latissima

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Arthrothamnus bifidus (S.G. Gmelin) J. Agardh
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**Laminariacean kelp in Hokkaido and the availability of the
each specie (A > B > C >)**

Arthrothamnus Ruprecht

Arthrothamnus bifidus (S.G. Gmelin) J. Agardh **B**

Laminaria J.V. Lamouroux

Laminaria yezoensis Miyabe

Saccharina Stackhouse

Saccharina angustata (Kjellman) C.E. Lane, C. Mayes, Druehl & G.W. Saunders **A**

Saccharina cichorioides (Miyabe) C.E. Lane, C. Mayes, Druehl & G.W. Saunders **B**

Saccharina coriacea (Miyabe) C.E. Lane, C. Mayes, Druehl & G.W. Saunders **A**

Saccharina gyrata (Kjellman) C.E. Lane, C. Mayes, Druehl & G.W. Saunders **B**

Saccharina japonica (J.E. Areschoug) C.E. Lane, C. Mayes, Druehl & G.W. Saunders **A**

var. *diabolica* (Miyabe) Yotsukura, Kawashima, T. Kawai, T. Abe & L.D. Druehl **A**

var. *ochotensis* (Miyabe) Yotsukura, Kawashima, T. Kawai, T. Abe & L.D. Druehl **A**

var. *religiosa* (Miyabe) Yotsukura, Kawashima, T. Kawai, T. Abe & L.D. Druehl **A**

Saccharina kurilensis C.E. Lane, C. Mayes, Druehl & G.W. Saunders **B**

Saccharina latissima (Linnaeus) C.E. Lane, C. Mayes, Druehl & G.W. Saunders

Saccharina longipedalis (Okamura) C.E. Lane, C. Mayes, Druehl & G.W. Saunders **C**

Saccharina sachalinensis (Miyabe) Yotsukura & L.D. Druehl **B**

Saccharina longissima (Miyabe) C.E. Lane, C. Mayes, Druehl & G.W. Saunders **A**

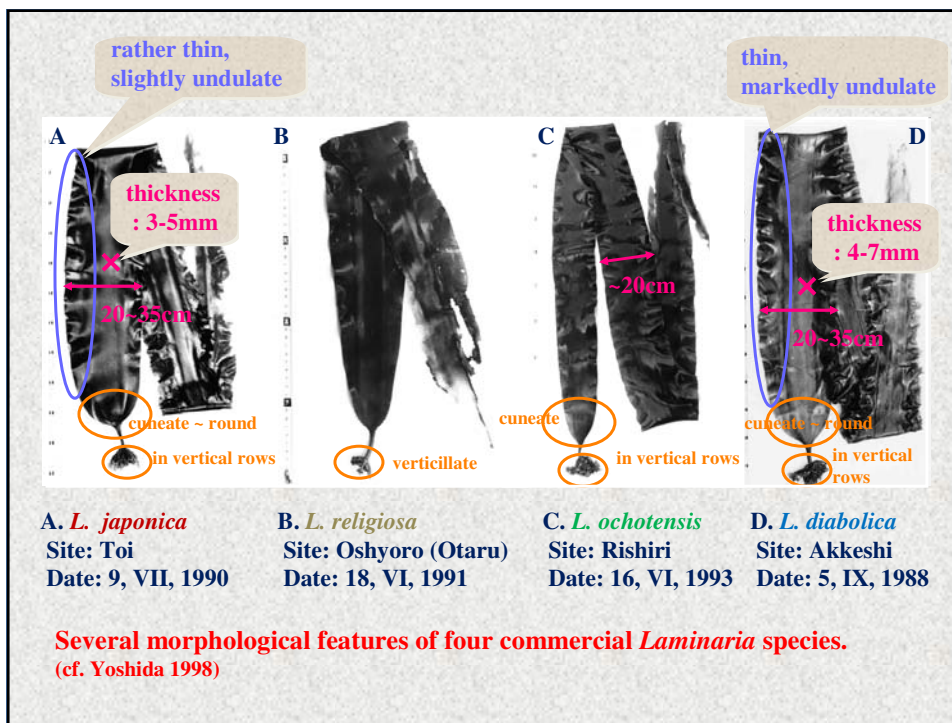
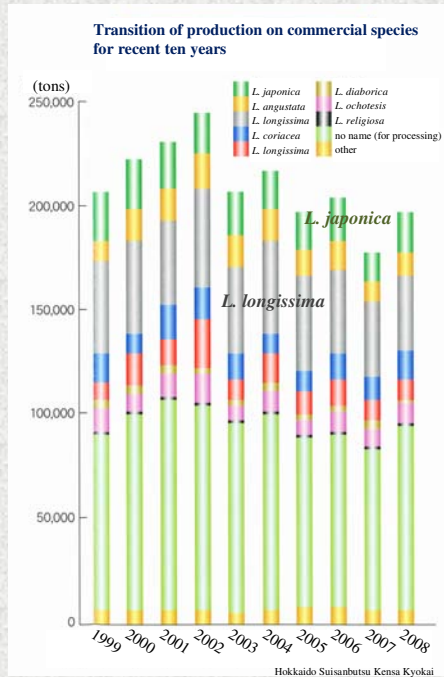
Saccharina sculpera (Miyabe) C.E. Lane, C. Mayes, Druehl & G.W. Saunders **A**

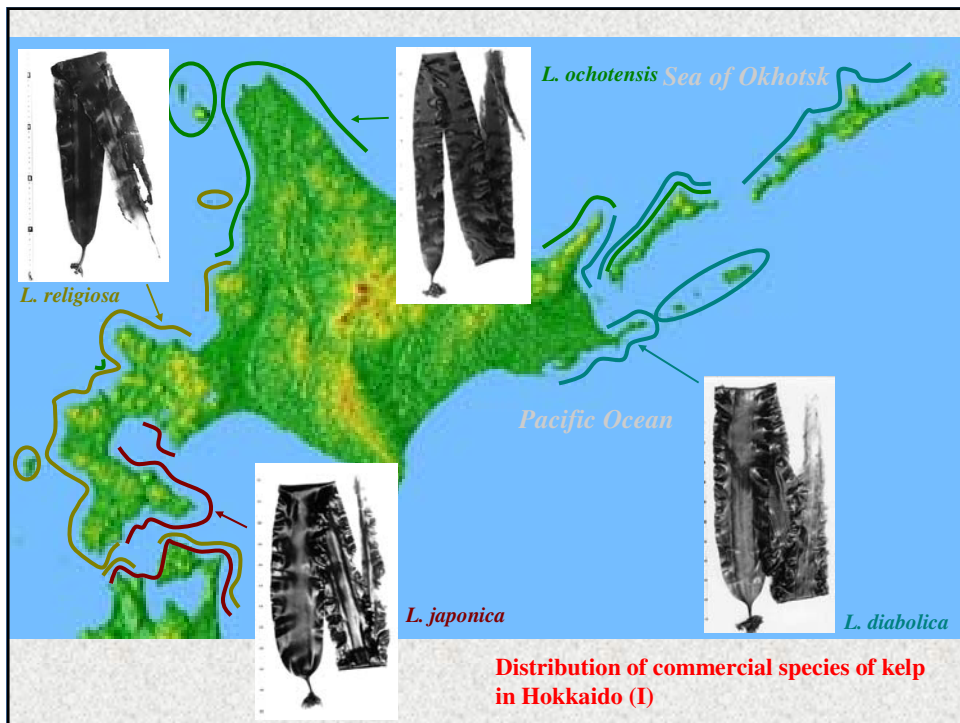
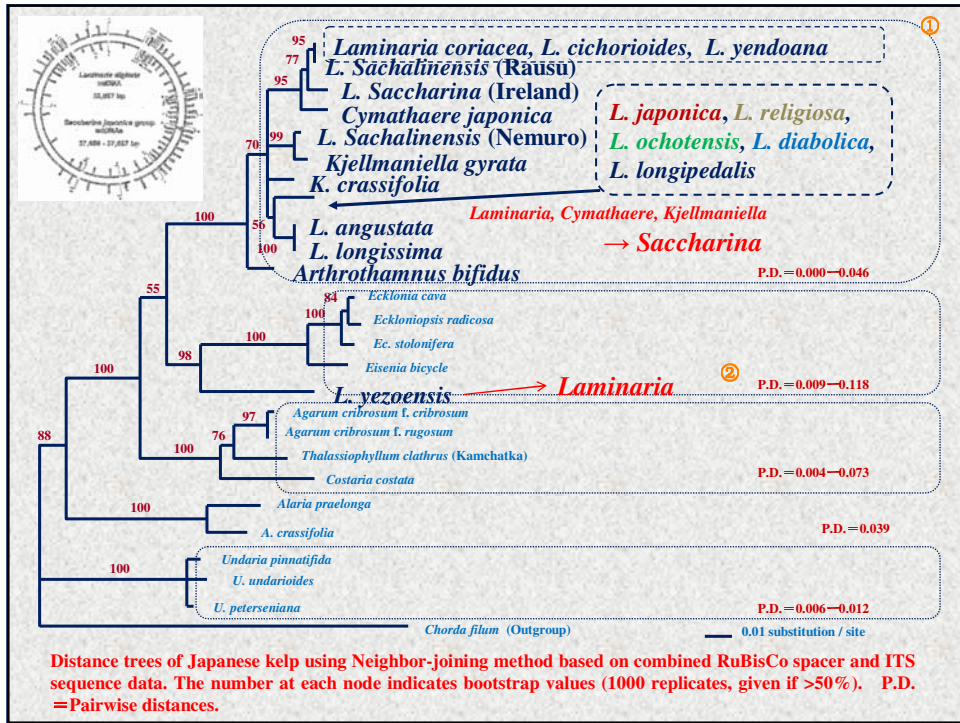
Saccharina yendoana (Miyabe) C.E. Lane, C. Mayes, Druehl & G.W. Saunders

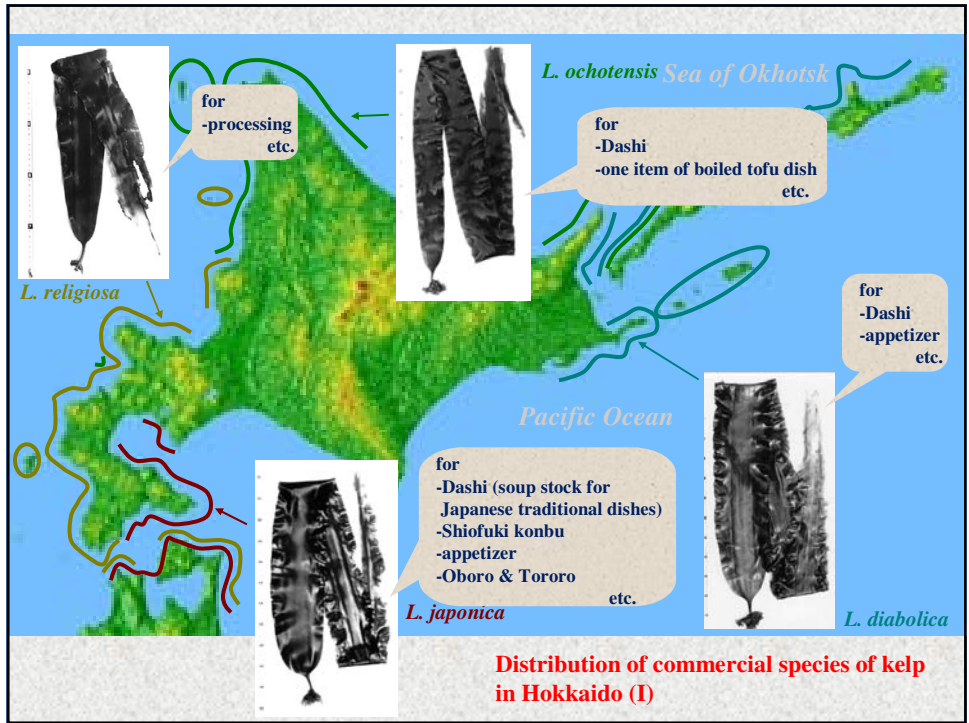
**Commercial kelp species belonging to “A” category
in Japan**

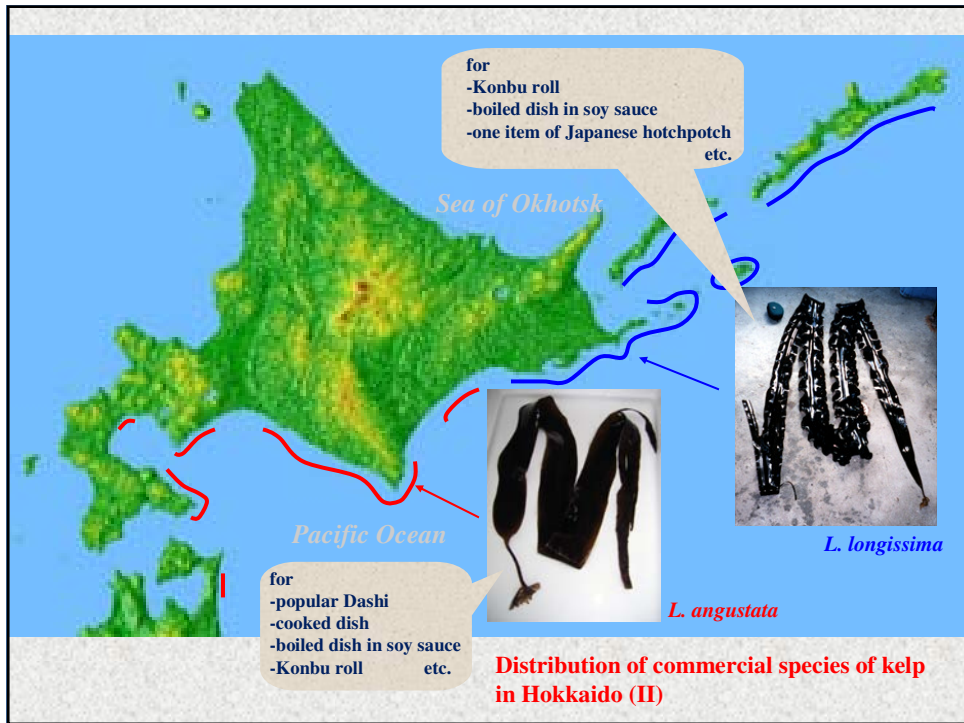
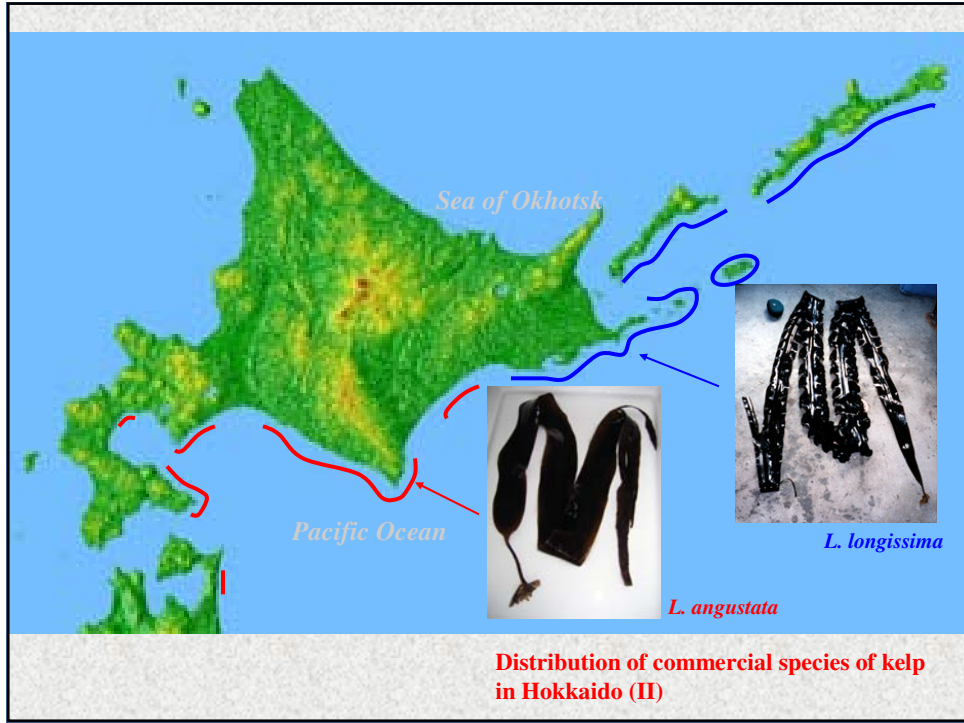


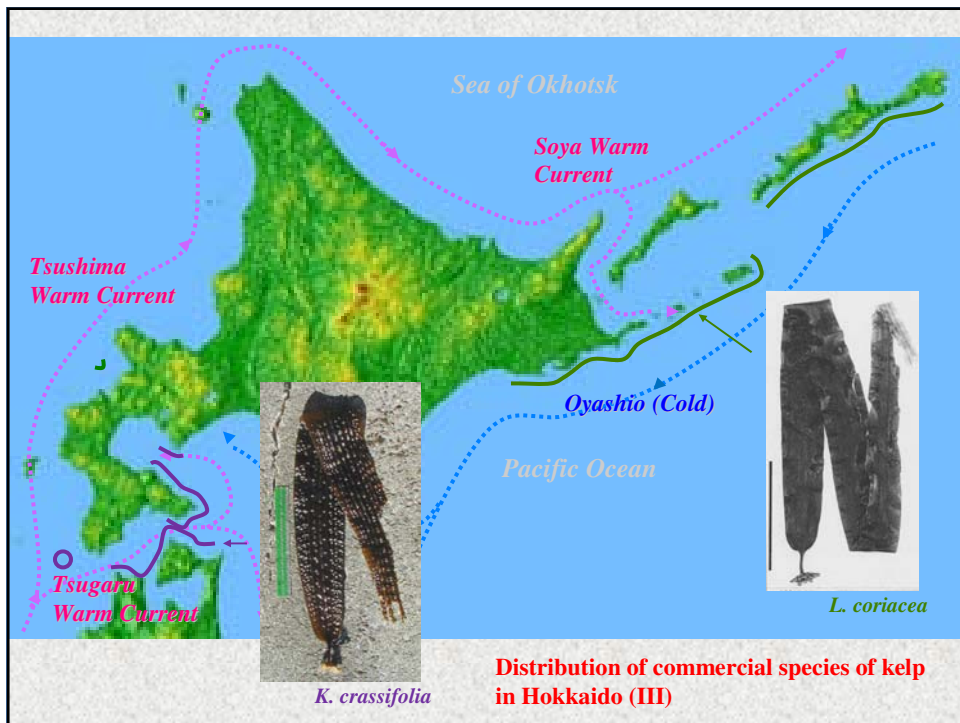
Biological Species Name	Current Commercial Species Name in Japan	Japanese Name
<i>Saccharina angustata</i>	<i>Laminaria angustata</i>	Mitsuisi-konbu
<i>Saccharina coriacea</i>	<i>Laminaria coriacea</i>	Atsuba-konbu
<i>Saccharina japonica</i>	<i>Laminaria japonica</i>	Ma-konbu
var. <i>diabolica</i>	<i>Laminaria diabolica</i>	Oni-konbu
var. <i>ochotensis</i>	<i>Laminaria ochotensis</i>	Rishiri-konbu
var. <i>religiosa</i>	<i>Laminaria religiosa</i>	Hosome-konbu
<i>Saccharina longissima</i>	<i>Laminaria longissima</i>	Naga-konbu
<i>Saccharina sculpera</i>	<i>Kjellmaniella crassifolia</i>	Gagome-konbu

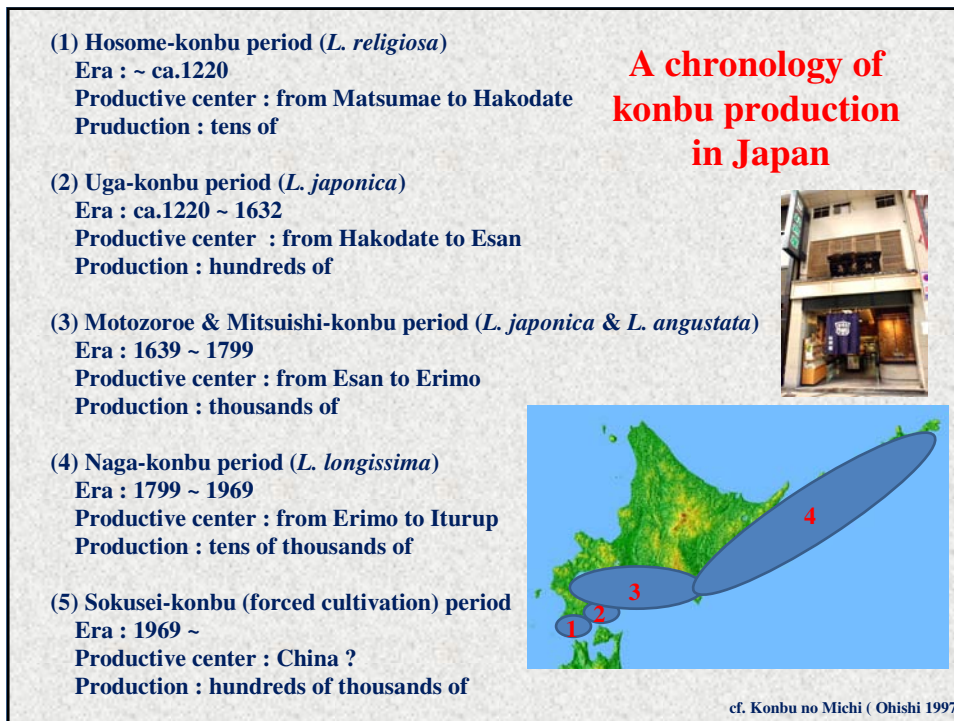










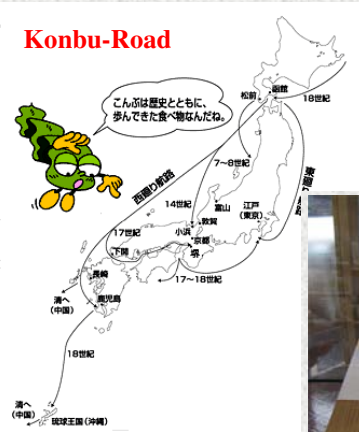




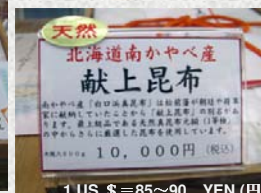
Old kelp fishery



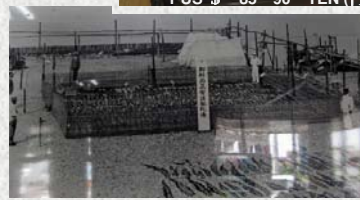
Konbu-Road



Kelp for presentation to the Emperor



Kitamae-bune



Wild Collecting

Product Name (dry weight from Hokkaido in 2009) :

L. longissima (5113 tons) , *L. coriacea* (1352 tons), *L. japonica* (600 tons),
L. ochotensis (600 tons), *L. angustata* (590 tons), *L. diabolica* (309 tons),
L. religiosa (25 tons), *A. bifidus* (2 tons), *K. crassifolia* (0.1 ton),
K. gyrata (0.03 ton), others without species name such
as “kelp for processing” (6035 tons).

Total : 14,587 tons (75% of the total)

(Production value : 17.4 billion JPN Yen (68% of the
total) *1US \$ =85-90 JPN Yen

Harvest Season : from July to October.

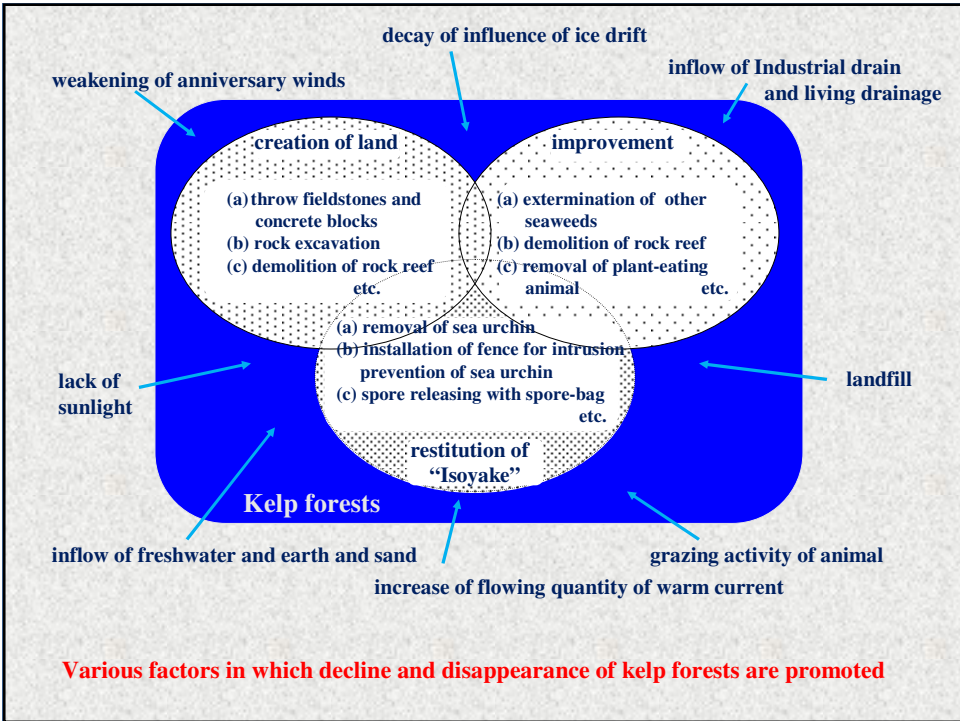
Fishery : small scale management by unit of family
; collecting by outboard using special equipments
such as “hydroscope”, “Makka”, “Kama”, “Kagi” etc.

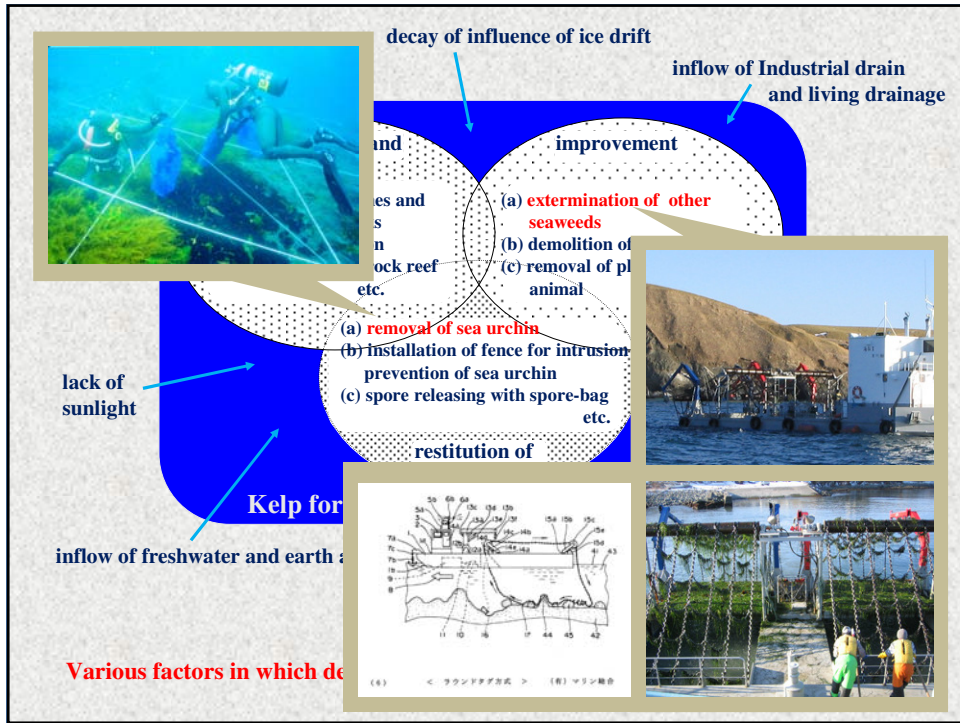


L. longissima

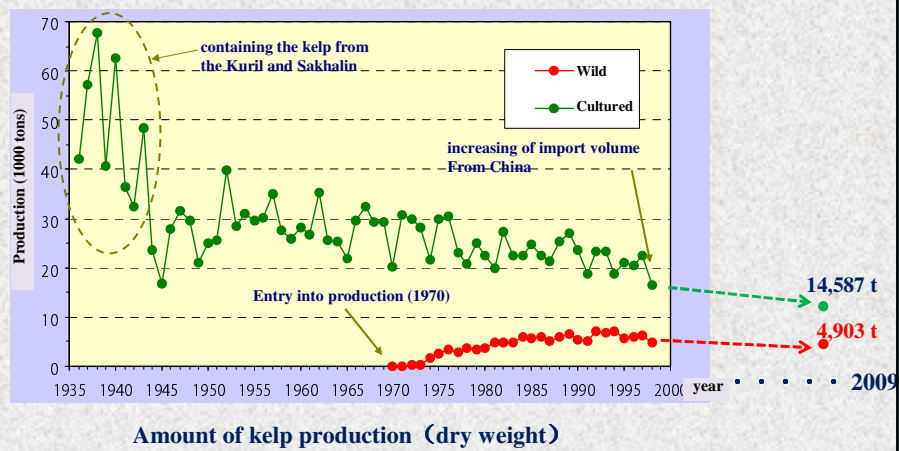
Operation







Transition of kelp production in Hokkaido



Cultivation

Hokkaido Localities: Minamikayabe, Hakodate (South), Rishiri-Rebun, Soya (North), Rausu, Shiretoko (East).



Product Name (dry weight from Hokkaido in 2009) :

L. japonica (1228 tons), *L. ochotensis* (290 tons), *L. diabolica* (189 tons),
L. angustata (156 tons), *L. religiosa* (8 tons), *L. coriacea* (1 ton),

others without species name such as “kelp for processing” (3031 tons).

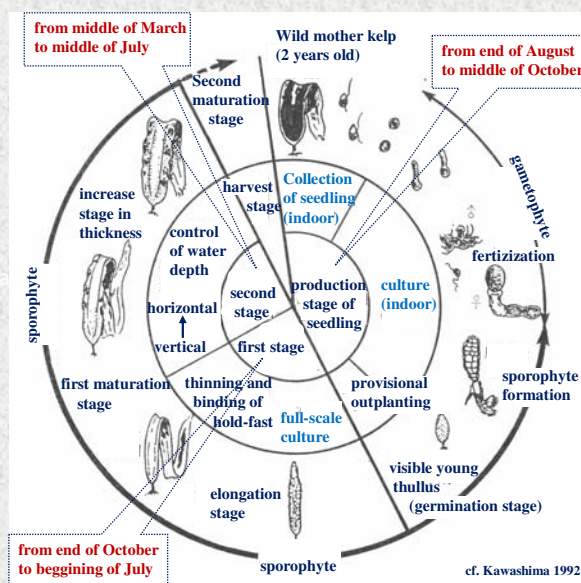
Total : 4,903 tons (25% of the total)

(Production value : 8.3 billion JPN Yen (32% of the total))

Harvest Season : from June to September.

Cultivation : (1) collecting of wild spore-bearing kelp, (2) producing of seedling line, (3) seedling culture indoors, (4) moving to sea, (5) full-scale cultivation (1-3 are done by the fisheries coop); forced cultivation (1 year) and 2 years cultivation protocols.

The production process of forced cultivated konbu



end of August

-mother kelp collecting by diver from prohibited fishing area

-drying in the shade (overnight)



Seedling production



end of August



-zoospore releasing

-control of the number of zoospore
(ca. 5-10 spores in one eye shot under the microscope (x 150))

-zoospore collecting to "Spore Collector"



Center for seedling production operated by the Fisheries Cooperation




ca. 300m of string

spore collector



28 pools (30 tanks/pool)








-the preparation for culture is started on May

-fresh water (filtrated mountain runoff) bath system for cooling

-culture by ES medium (sterilized seawater)

-culture for about 50 days (up to ca. 1 cm)

*water temperature : 8.5 ~ 9.0°C

*light intensity : 1,000 ~ 2,000 ~ 3,000 ~ 4,000 lux

*photoperiod : 12L-12D ~ 13L-14D ~ 14L-10D

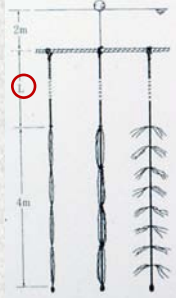
*aeration system

administrative cost : 60 million JPN Yen/year (about 80% is for energy)

Provisional outplanting of seedlings



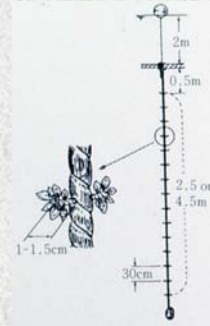
from middle to end of October



Fixation to cultivation rope



end of October to middle of November

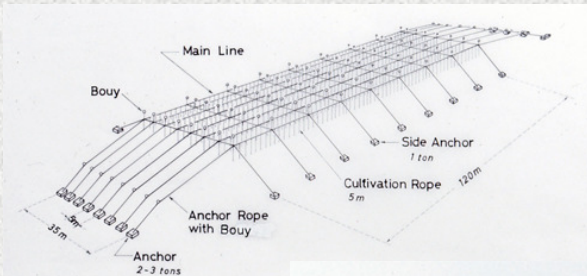


-provisional cultivation in the sea for 7-10 days

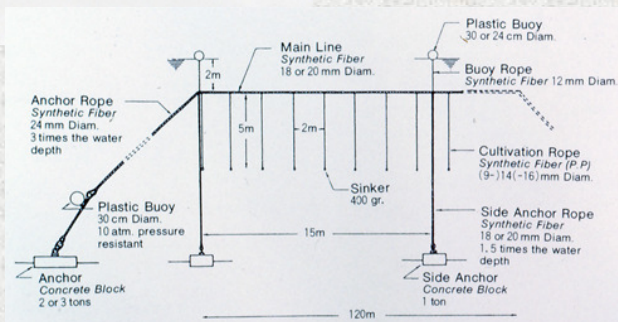
-L: 5-7m at the beginning, and thereafter shorten to 1.5 m

*Every fisherman buy the seedling from the cooperation. (ca. 170 JPN Yen/ m)

Full-scale cultivation

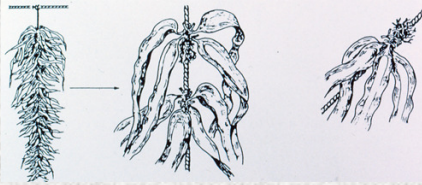


from November to June



An overview and a side view of Konbu cultivation apparatus

The first stage



thinning and binding of holdfast

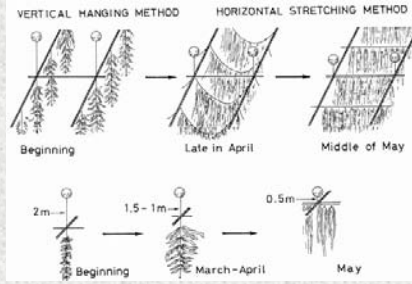


-finally 4-5 plants/
piece of seedling
string (= 12-15 plants
/meter of cultivation
rope)

-binding of unstable
holdfast using soft
synthetic tape

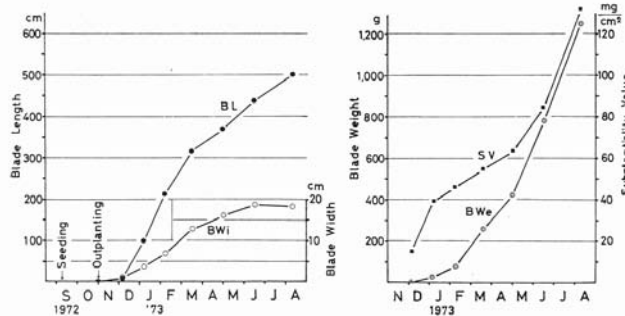
from end of December
to beginning of March

The second stage



Season	Fal	Win	Spr	Sum	Fal	Win	Spr	Sum	Fal	Kombu
Life Span										
Biennial										Natural Kombu 2 Yr. Cultivated Kombu
Biennial compressed into 1 year										Force Cultivated Kombu
Annual										Natural Kombu 1 Yr. Cultivated Kombu

Diagrammatic representation of the life history of Kombu having three different life spans (sporophyte stage). The ordinate approximately indicates the relative rate of sporophyte length. The shaded portion denotes the reproductive season and the arrow the beginning of harvest season.

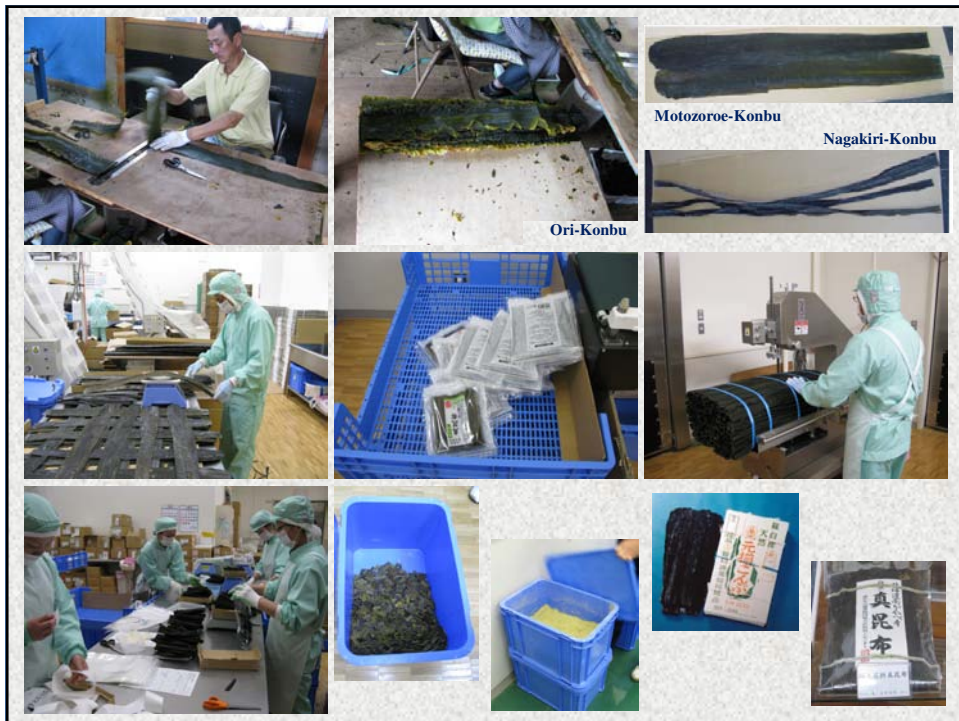


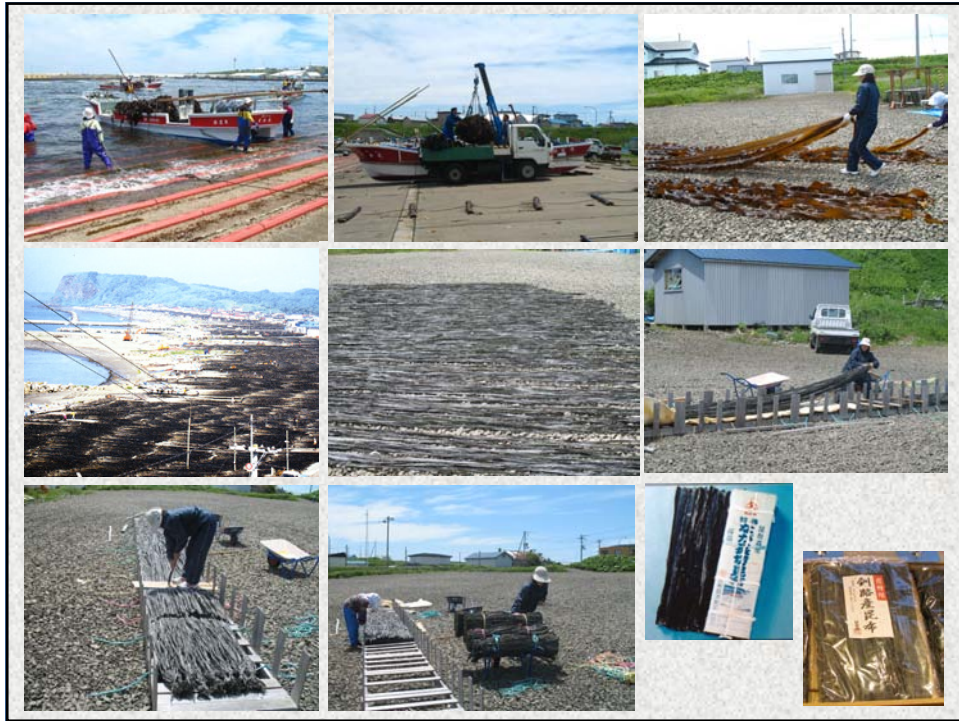
Monthly changes in the average blade length, width, wet weight and substantiality value of *Laminaria japonica* during forced cultivation. Redrawn from FUNANO and ISHIKAWA (1974).

Harvesting

from July to end of August





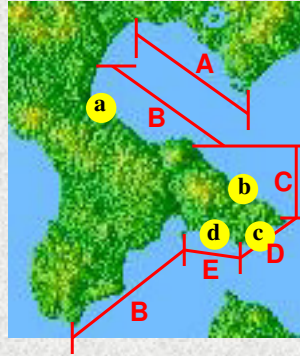


北海道水産業改良普及職員協議会

-The rank of the product is decided by the association “Hokkaido Suisanbutsu Kensa Kyokai” (designated corporate aggregate).

-The price control of the product is done by the Union of Fisheries Cooperation “Hokkaido Gyoren” (Hokkaido Federation of Fisheries Cooperative Association).

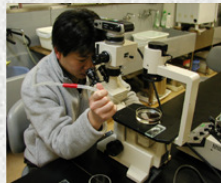
“Hamakakusa” of *L. japonica*
(The price gap by the difference
of product district)



- A. Ma-orihama
- B. Bachigai-oihama
- C. Shirokuchi-motozorohama
- D. Kurokuchi-motozorohama
- E. Honba-orihama

Wild / Cultured	Product district	Brand	Price of first-grade quality (JP Yen / kg)
Wild	Yakumo (a)	Ma-ori	2,101
Wild	Osatsube, Kakkumi (b)	Shirokuchi-motozorohama	4,500
Cultured (2 years)	Osatsube, Kakkumi (b)	Shirokuchi-motozoroe Tennen / Youshokuhama	2,100
Cultured (forced)	Kakkumi (b)	Shirokuchi-motozorohama	1,900
Wild	Shirikishinai (c)	Kurokuchi-motozorohama	3,825
Cultured (forced)	Shirikishinai (c)	Kurokuchi-nagakiri (Noshi)	2,700
Wild	Ishizaki (d)	Ma-ori (Honba-ori) Offing	2,600
Wild	Ishizaki (d)	Ma-ori (Honba-ori) Interlevel	2,750
Wild	Ishizaki (d)	Ma-ori (Honba-ori) Shore	2,950
Cultured (forced)	Ishizaki (d)	Honba-ori	1,070

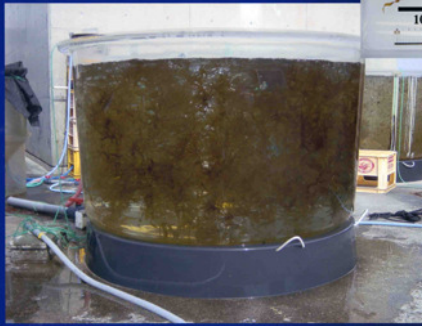
Hokkaido Federation of Fisheries Cooperative Associations



**Aquaculture
at land place**



水槽での培養



Acknowledgment to

Prof. Louis Druehl D.

Dr. Shoji Kawashima

Dr. Yoshio Hasegawa

Members of “The Minamikayabe Fisheries Cooperation”

How to make “Konbu Dashi (soup stock)”

Ingredients

Dry Konbu for Dashi : 30g

Cold Water : 1,000 ml

Recipe

- (1) Dirt of the surface of Konbu is wiped up quickly with dish towel.**
- (2) Konbu and cold water are put in a pot and are cooked up to 60 °C.**
- (3) “Konbu Dashi” is decocted at low heat for 1 hour.**
 - The water temperature was kept! -**
- (4) Konbu is took out from the pot.**