TECHNICAL ASSISTANCE TO BUILD FOOD SAFETY CAPACITY

FOR THE FISHERIES SECTOR

Spoilage of fish and quality loss

Train-the-Trainer Training for Ocean Delight, Suriname

Prepared by: Megapesca Lda Portugal

Outline

- Spoilage of fish – autolytic and bacteriological changes
- Special safety concerns of histamine-producing fish
- The importance of measuring core temperatures
- The fish freezing curve

Spoilage of fish

Fish spoilage and quality loss

Ways in which fish spoil:

- Autolysis (digestive enzymes from the gut)
- Bacterial spoilage (bacteria naturally present in gut, slime and gills)
- Oxidative rancidity of oils (species dependent fat content up to 15-20%)

Changes in Sensory quality:

- Appearance
- Smell
- Flavour
- Texture

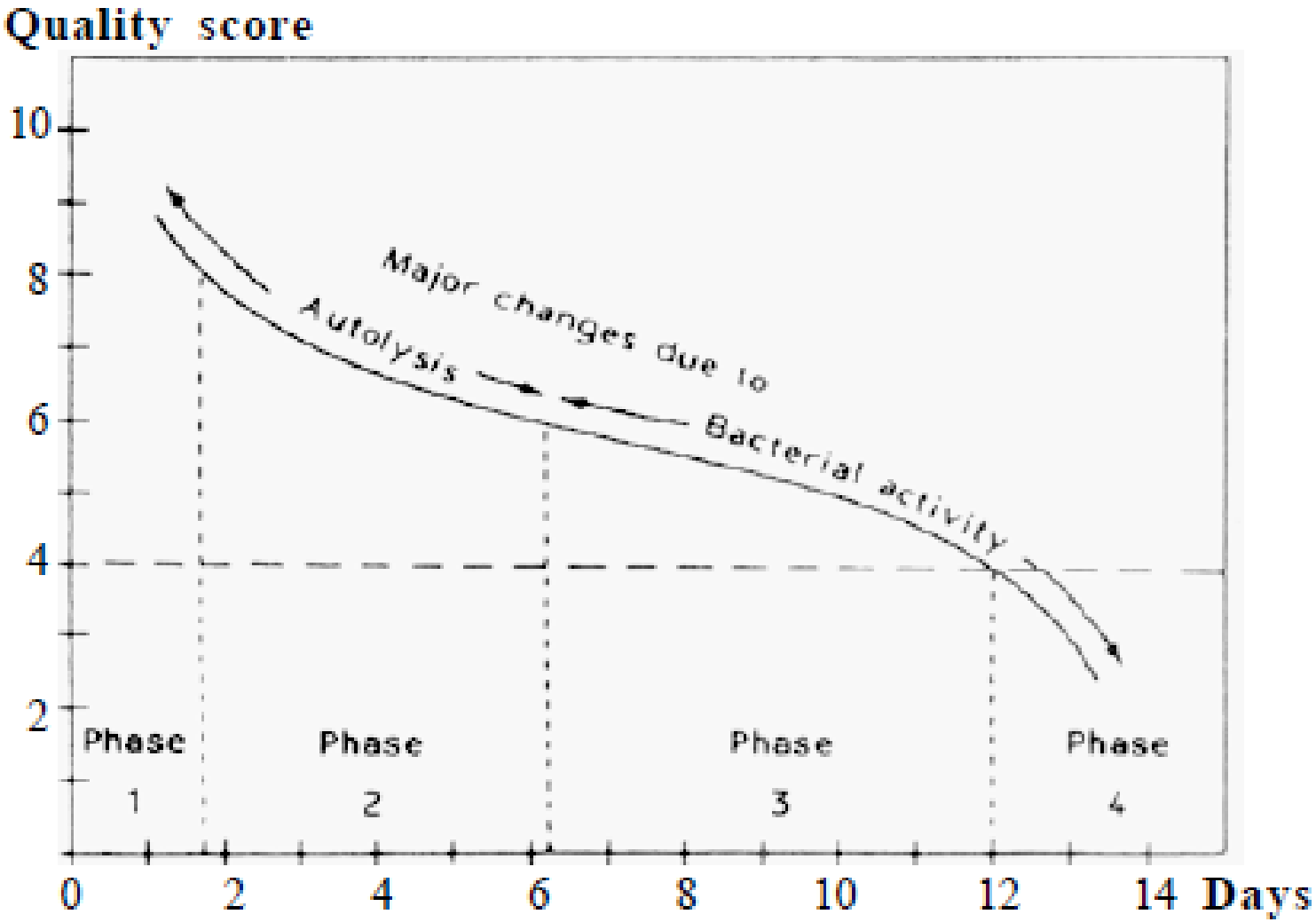
Changes in sensory quality

Table 5.2 Freshness ratings: Council Regulation (EEC) No. 103/76 OJ No. L20 (28 January 1976) (EEC, 1976)

Criteria				
	Marks			
Part of fish inspected	3	2	1	0
Appearance				
Skin	Bright, iridescent pigmentation, no discoloration Aqueous, transparent, mucus	Pigmentation bright but not lustrous Slightly cloudy mucus	Pigmentation in the process of becoming discoloured and dull Milky mucus	[1]Dull pigmentation Opaque mucus
Eye	Convex (bulging) Transparent cornea Black, bright pupil	Convex and slightly sunken Slightly opalescent cornea Black, dull pupil	Flat Opalescent cornea Opaque pupil	[1]Concave in the centre Milky cornea Grey pupil
Gills	Bright colour No mucus	Less coloured Slight traces of clear mucus	Becoming discoloured Opaque mucus	[1]Yellowish Milky mucus
Flesh (cut from abdomen)	Bluish, translucent, smooth, shining No change in original colour	Velvety, waxy, dull Colour slightly changed	Slightly opaque	[1]Opaque
Colour (along vertebral column)	Uncoloured	Slightly pink	Pink	[1]Red
Organs	Kidneys and residues of other organs should be bright red, as should the blood inside the aorta	Kidneys and residues of other organs should be dull red; blood becoming discoloured	Kidneys and residues of other organs and blood should be pale red	Kidneys and residues of other organs and should be brownish in colour
Condition				
Flesh	Firm and elastic Smooth surface	Less elastic	Slightly soft (flaccid), less elastic Waxy (velvety) and dull surface	[1]Soft (flaccid) Scales easily detached from skin, surface rather wrinkled, inclining to mealy
Vertebral column	Breaks instead of coming away	Sticks	Sticks slightly	[1]Does not stick
Peritoneum	Sticks completely to flesh	Sticks	Sticks slightly	[1]Does not stick
Smell				
Gills, skin abdominal cavity	Seaweed	No smell of seaweed or any bad smell	Slightly sour	[1]Sour

Source: http://www.fao.org/3/v7180e/v7180e06.htm

Phases of fish spoilage



Changes in the eating quality of iced (0°C) cod (Huss, 1976)

Phase I (Autolytic changes, caused mainly by enzymes): Fish just caught is very fresh and has a sweet, sea weedy and delicate taste. There is very little deterioration, with slight loss of the characteristic odour and flavour. In some tropical species this period can last for about 1 to 2 days or more after catching.

Phase II (Autolytic changes, caused mainly by enzymes): There is a significant loss of the natural flavour and odour of fish. The fish becomes neutral but has no off-flavours, the texture is still pleasant.

Phase III (Bacteriological changes, caused mainly by bacteria): The fish begins to show signs of spoilage. There are strong off-flavours and stale to unpleasant smells. Texture changes are significant, fish becoming either soft or dry.

Phase IV (Bacteriological changes, caused mainly by bacteria): Fish is spoiled and putrid, becoming inedible.

Summary of Autolytic Changes in Chilled Fish

Enzyme(s)	Substrate	Changes Encountered	Prevention/Inhibition
glycolytic enzymes	glycogen	production of lactic acid, pH of tissue drops, loss of water-holding capacity in muscle high temperature rigor may result in gaping	fish should be allowed to pass through rigor at temperatures as close to 0°C as practically possible pre-rigor stress must be avoided
autolytic enzymes, involved in nucleotide breakdown	ATP ADP AMP IMP	loss of fresh fish flavour, gradual production of bitternes with Hx (later stages)	same as above rough handling or crushing accelerates breakdown
cathepsins	proteins, peptides	softening of tissue making processing difficult or impossible	rough handling during storage and discharge
chymotrypsin, trypsin, carboxy-peptidases	proteins, peptides	autolysis of visceral cavity in pelagics (belly- bursting)	problem increased with freezing/thawing or long- term chill storage
calpain	myofibrillar proteins	softening, molt-induced softening in crustaceans	removal of calcium thus preventing activation?
collagenases	connective tissue	gaping" of fillets softening	connective tissue degradation related to time and temperature of chilled storage
TMAO demethylase	TMAO	formaldehyde-induced toughening of frozen gadoid fish	store fish at temperature <= -30°C physical abuse and freezing/thawing accelerate formaldehyde-induced toughening

Source: http://www.fao.org/3/v7180e/v7180e06.htm

Table 1. Spoilage processes and food characteristics [1].

Food	Process	Products	Effects
Pectin (fruits)	Pectinolysis	Methanol, uronic acids	Loss of fruit structure, soft fruits
Proteins (meat, fish)	Proteolysis, deamination	Amino acids, peptides, amines, H_2S, ammonia, indole	Bitterness, souring, bad odour, sliminess
Carbohydrates (starchy foods)	Hydrolysis, fermentations	Organic acids, CO_2, mixed alcohols	Souring, acidification
Lipids (butter)	Hydrolysis, fatty acid degradation	Glycerol and mixed fatty acids	Rancidity, bitterness

Table 2. Typical spoilage compounds during spoilage of fresh fish stored aerobically or packed in ice or at ambient temperature [1].

Specific microorganisms	Typical spoilage compounds produced
Shewanella putrefaciens	TMA, H_2S, CH_3SH, $(CH_3)_2S$, hypoxanthine (Hx)
Photobacterium phosphoreum	TMA, Hx
Pseudomonas spp.	Ketones, aldehydes, esters, non-H_2S sulph..
Vibrionaceae	TMA, H_2S
Anaerobic spoilers	NH_3, acetic, butyric and propionic acid

Source: Abbas et al (2009).

Table 5.7 Substrate and off-odour/off-flavour compounds produced by bacteria during spoilage of fish

Substrate	Compounds produced by bacterial action
TMAO	TMA
cysteine	H_2S
methionine	CH_3SH, $(CH_3)_2S$
carbohydrates and lactate	acetate, CO_2, H_2O
inosine, IMP	hypoxanthine
amino-acid s (glycine, serine, leucine)	esters, ketones, aldehydes
amino-acids, urea	NH_3

Source: http://www.fao.org/3/v7180e/v7180e06.htm

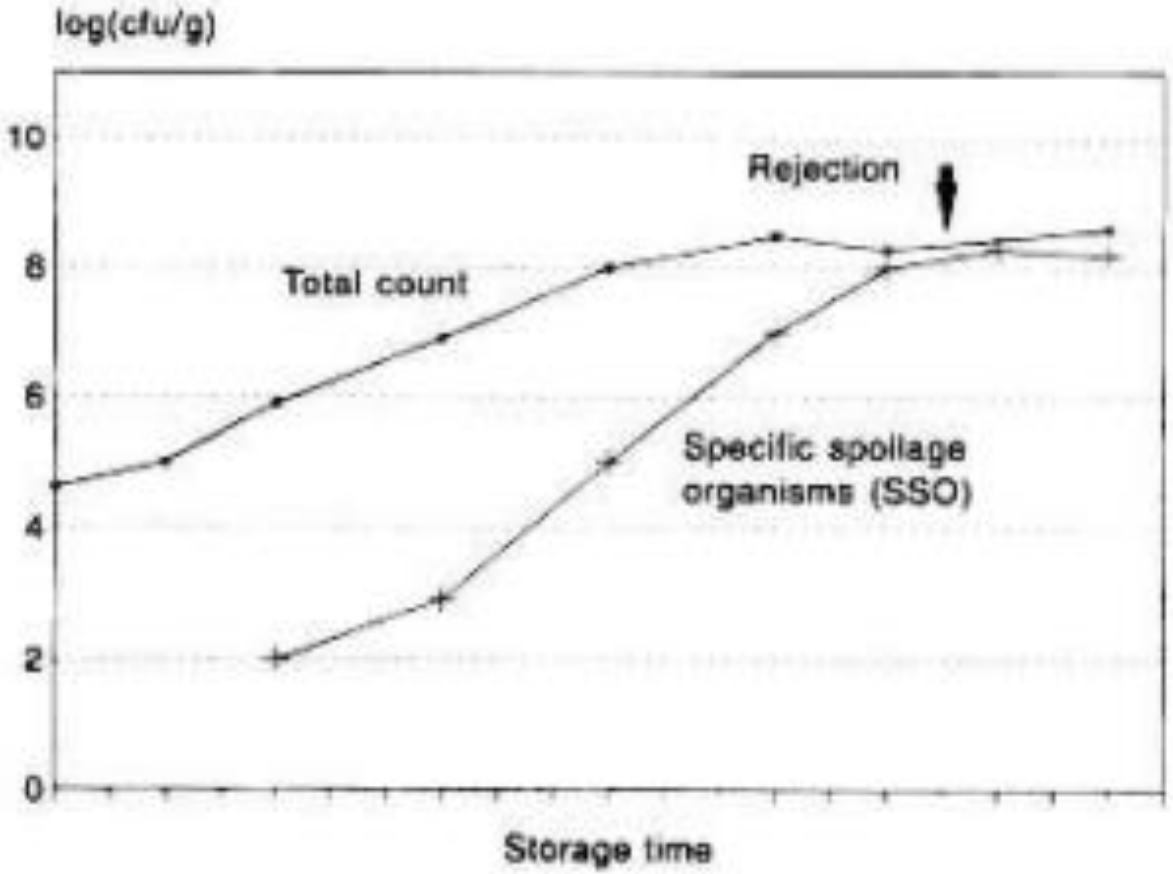
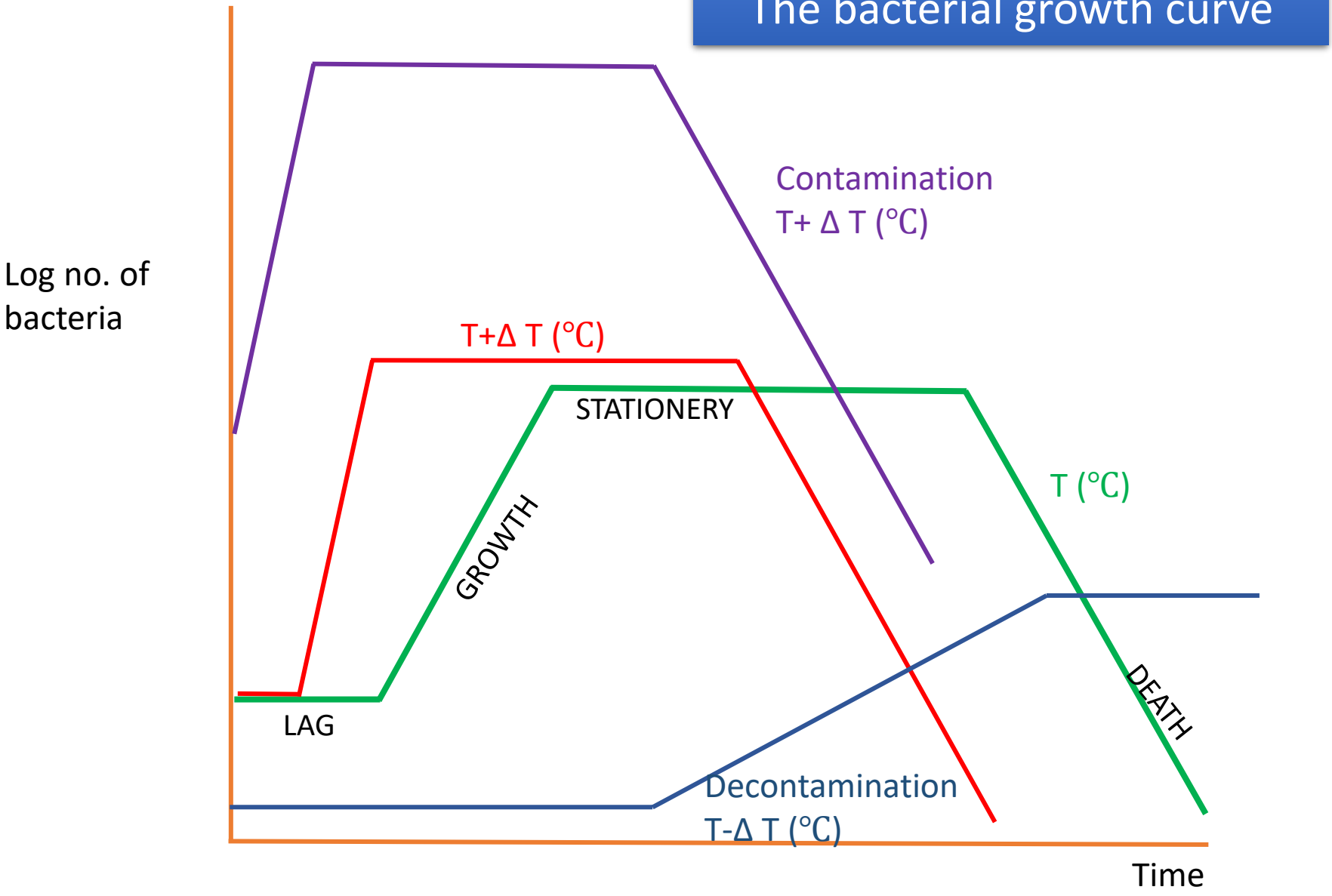


Figure 5.9 Changes in total counts and specific spoilage bacteria during storage (modified after Dalgaard (1993)

Source: http://www.fao.org/3/v7180e/v7180e06.htm

Microbiological spoilage
The bacterial growth curve



Special safety concerns of histamine-producing fish species

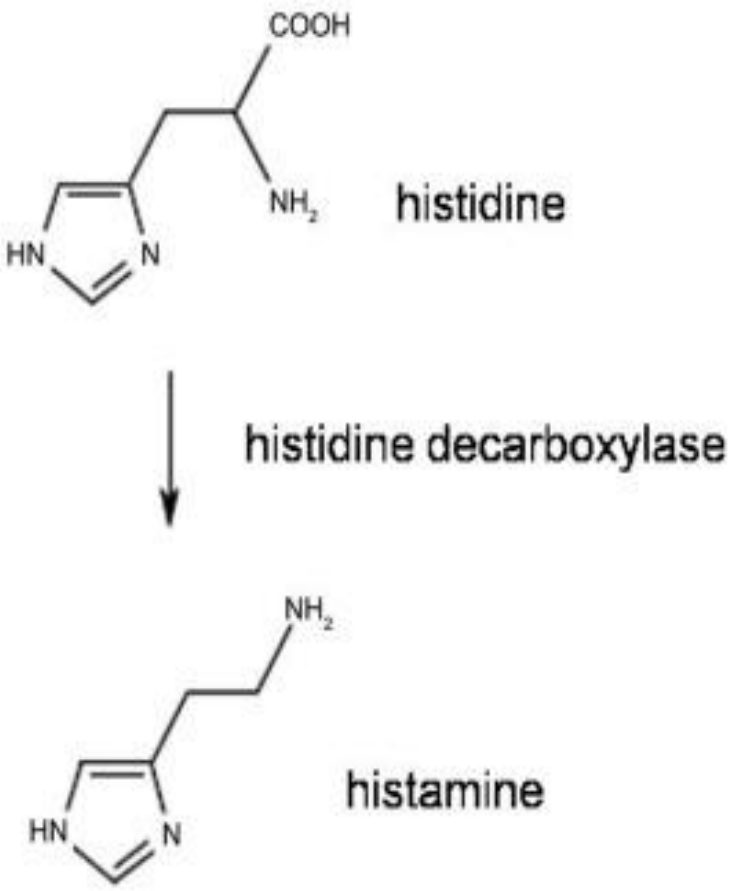
Histidine

- Histidine - a naturally occurring amino acid that is present in higher proportions in the muscle of certain fish species, particularly those of the Scombridae family.
- Present in Scombrid (mackerels, tunas, and bonitos), Clupeid (herrings) and Carangid (jacks)

Scombroid food poisoning is primarily associated with consumption of fish flesh in species rich in free histidine

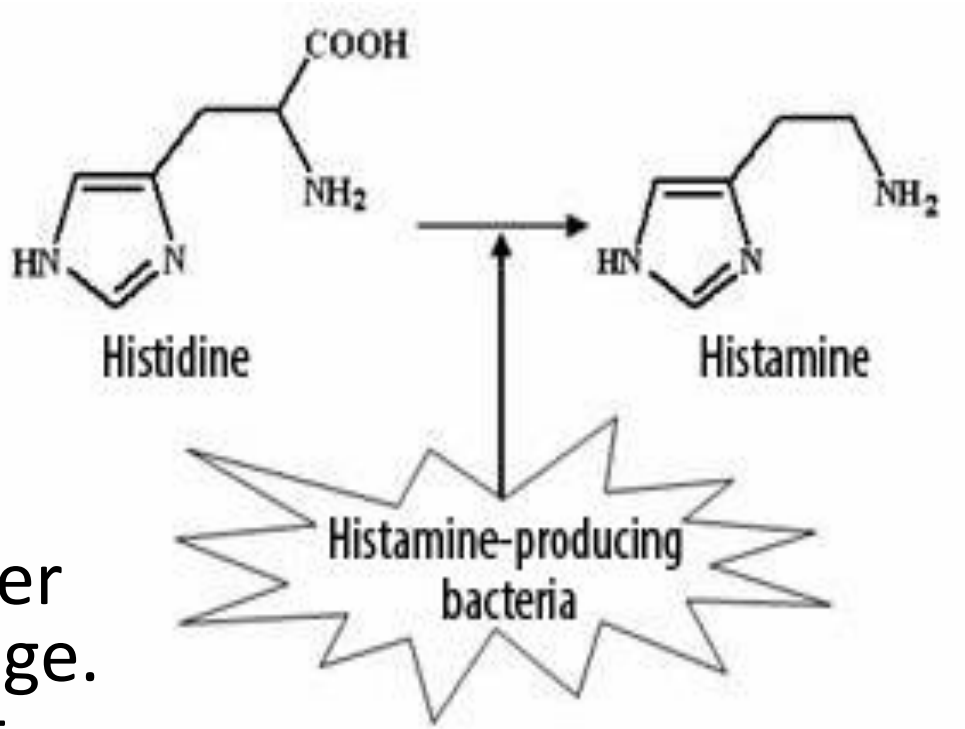
Histidine decarboxylase

- Certain bacteria produce the enzyme **histidine decarboxylase** during growth.
- Breaks down free histidine present in the fish (post-mortem) → **histamine**.
  - ❖ Enzyme can remain active even after the bacteria responsible for producing it have been inactivated or killed.
  - ❖ Continues histamine production slowly at refrigeration temperatures and remains stable if frozen, thus allowing it to rapidly recommence activity after thawing.
  - ❖ Enzyme can be inactivated by cooking, but once histamine has been produced, it cannot be eliminated by normal cooking or freezing temperatures → toxicity remains intact.



Histamine-forming bacteria

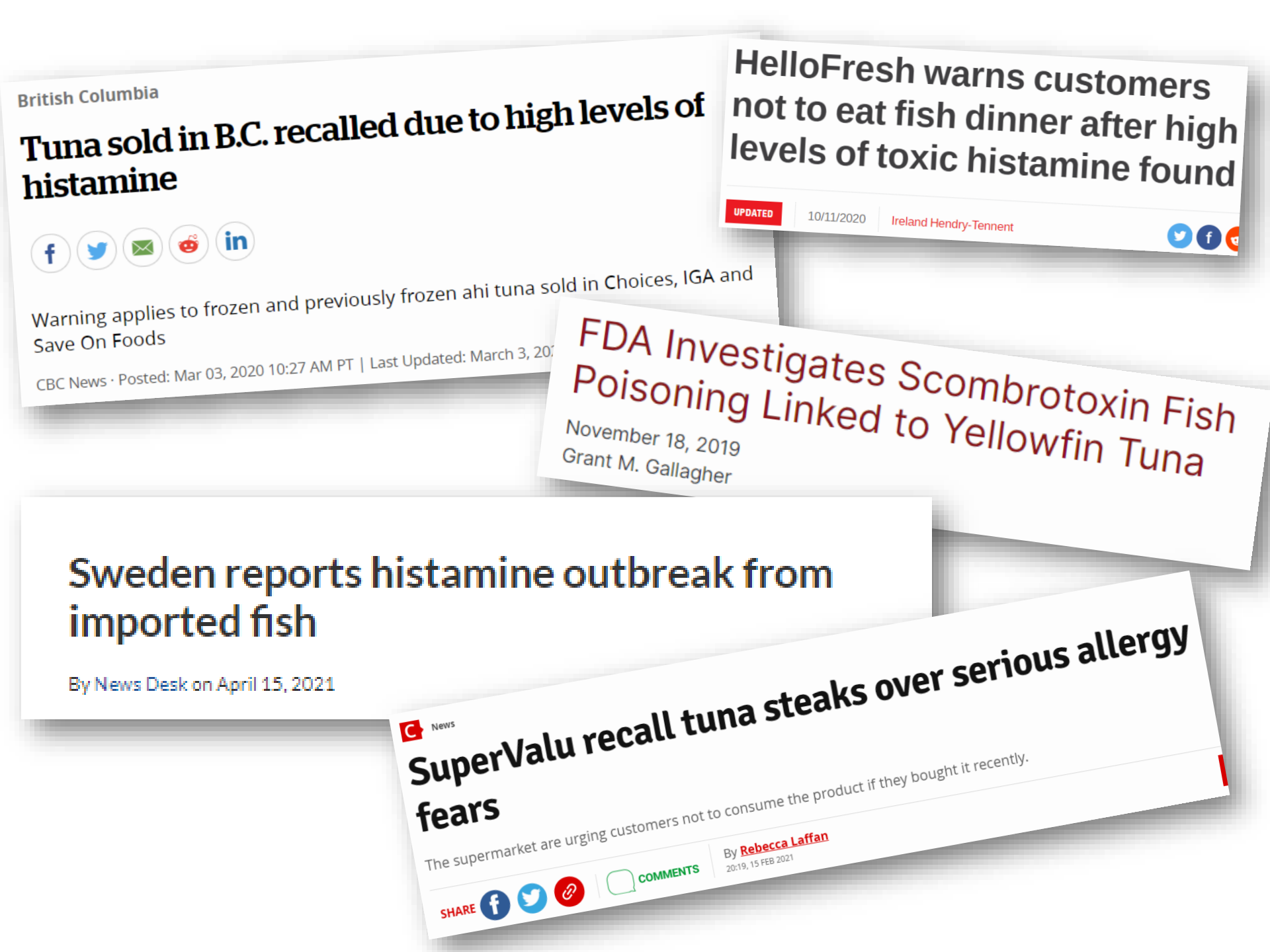
- Histamine-producing bacteria include:
  - ❖*Morganella morganii*
  - ❖*Klebsiella* spp.
  - ❖*Pseudomonas*
  - ❖*Clostridium*
  - ❖*Citrobacter freundii*
- Capable of growing and producing histamine over a wide temperature range. Growth is more rapid at high temperatures e.g. above 30°C.



Histamine - characteristics

- Heat stable (even canning)
- Onset minutes/hours
- Typical allergic reactions:
  - ❖Cutaneous (rash, urticaria, oedema, localized inflammation)
  - ❖Gastrointestinal (nausea, vomiting, diarrhoea), haemo-dynamic (hypotension)
  - ❖Neurological (headache, tingling, oral burning and blistering sensation, flushing and perspiration, itching).
- Potentiated by other amines (eg.TMA)

Hazard category	Hazard	Typical species implicated	Main control method(s)
BIOLOGICAL HAZARDS			
Biogenic amines	Histamine	Scads (*Decapterus* spp.) Four winged flyingfish (*Hirundichthys affinis*) Blackfin tuna (*Thunnus atlanticus*) Cero mackerel (*Scomberomorus regalis*) Dolphinfish (*Coryphaena hippurus*) Wahoo (*Acanthocybium solandri*) Frigate tuna (*Auxis thazard thazard*) Bullet tunas (*Auxis rochei*) King mackerel (*Scomberomorus cavalla*) Little tunny (*Euthynnus alletteratus*) Serra Spanish mackerel (*Scomberomorus brasiliensis*) Albacore (*Thunnus alalunga*) Atlantic bonito (*Sarda sarda*) Bigeye tuna (*Thunnus obesus*) Black marlin (*Makaira indica*) Northern bluefin tuna (*Thunnus thynnus*) Skipjack tuna (*Katsuwonus pelamis*) Yellowfin tuna (*Thunnus albacares*)	Lowering temperature post-mortem < 4.4°C



British Columbia

Tuna sold in B.C. recalled due to high levels of histamine

Warning applies to frozen and previously frozen ahi tuna sold in Choices, IGA and Save On Foods

CBC News · Posted: Mar 03, 2020 10:27 AM PT | Last Updated: March 3, 20

HelloFresh warns customers not to eat fish dinner after high levels of toxic histamine found

UPDATED 10/11/2020 Ireland Hendry-Tennent

FDA Investigates Scombrotoxin Fish Poisoning Linked to Yellowfin Tuna

November 18, 2019
Grant M. Gallagher

Sweden reports histamine outbreak from imported fish

By News Desk on April 15, 2021

News

SuperValu recall tuna steaks over serious allergy fears

The supermarket are urging customers not to consume the product if they bought it recently.

SHARE COMMENTS By Rebecca Laffan 20:19, 15 FEB 2021

Company fined after five suffer food poisoning from fish

By News Desk on October 2, 2020

A catering company in Wales has been fined in relation to five people who became ill from eating mackerel in July 2019.

DM Catering (Pembs) Ltd. was fined £2,550 ($3,300) by Haverfordwest magistrates in late September after pleading guilty to storing foods likely to support the growth of pathogenic microorganisms or the formation of toxins at a temperature above 8 degrees C (46.4 degrees F).

The prosecution was brought by Pembrokeshire County Council's Environmental Health department.

The court heard that in late July 2019, five people who had eaten mackerel at Martha's Vineyard restaurant on Milford Marina became unwell with gastrointestinal symptoms and headache. One person also experienced a skin rash, short, rapid breathing, a rapid pulse and a temperature. Another person's symptoms begun before leaving the restaurant.

Histamine or Scombroid fish poisoning can be caused by eating species of marine fish such as mackerel that have high levels of histamine in their tissues. Onset of symptoms can range from minutes to several hours following ingestion of toxin.

Food had been taken home by the group to finish later. That sample of mackerel was collected and sent by the council for testing by the Public Analyst. Analysis found it was unfit for human consumption.

Histamine controls

- **Rapid chilling after harvest:**
  - Fish should be placed in ice or in refrigerated seawater or brine at 4.4°C or less within 12 hours of death
  - Fish exposed to air or water temperatures above 28°C should be placed in ice (including packing the eviscerated belly cavity of large fish with ice) or in refrigerated seawater or brine below 4.4°C or less within 6 hours of death.
- **Check by temperature and time monitoring**
- **Maintain traceability records**

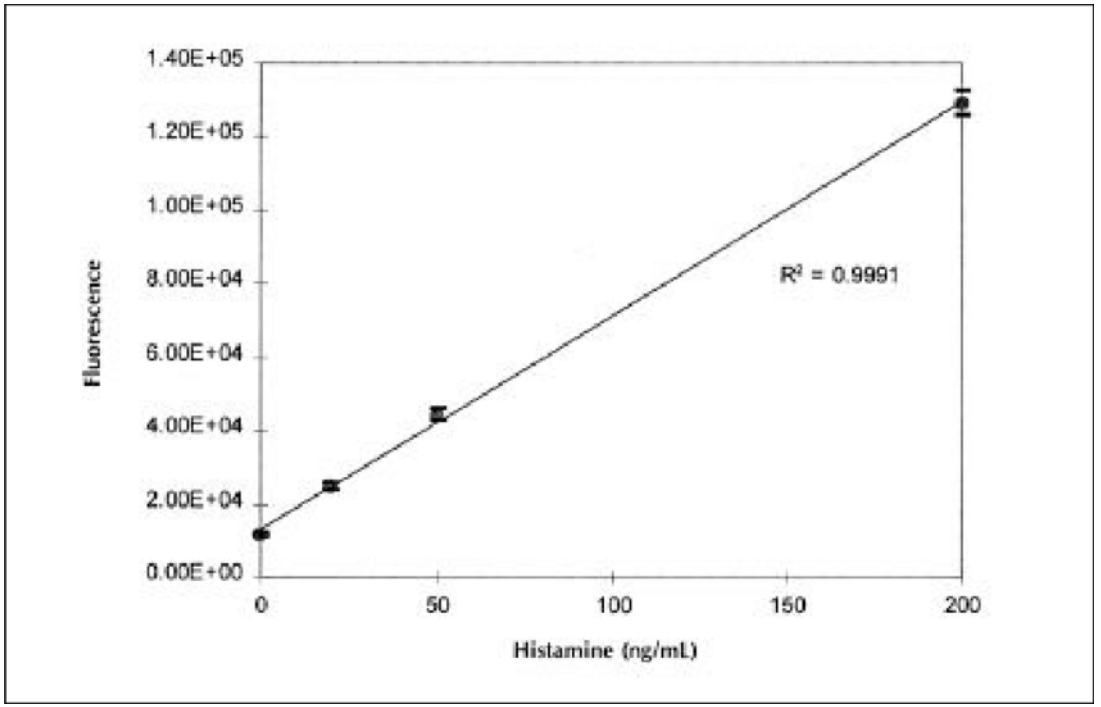
Histamine testing

- Veratox® for Histamine kit
- Technology - Competitive direct enzyme-linked immunosorbent assay (CD-ELISA)

Product Specifications

Lower limit of detection:	2 ppm
Range of quantitation:	2.5 ppm - 50 ppm
Controls provided:	0, 2.5, 5, 10, 20 and 50 ppm
Testing time:	20 minutes
Antibody cross-reactivity:	Specific for histamine

9. Read results using a microwell reader with a 650 nm filter.



- The test is read in a microwell reader to yield optical densities.
- **Principle: The optical densities of the controls form the standard curve. Sample optical densities are plotted against the curve to calculate the exact concentration of histamine.**

Measuring core temperature

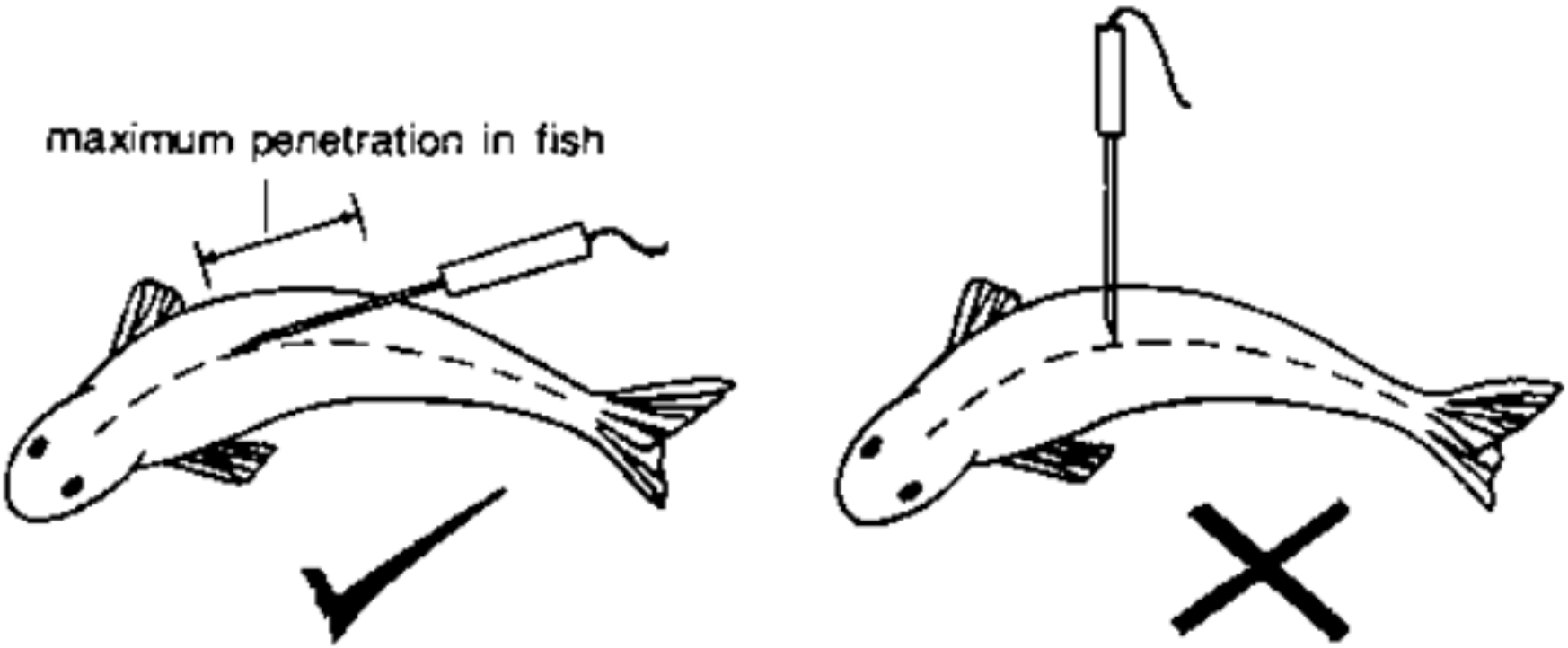
Strict control of the cold chain is essential to prevent the formation of histamine → → →
Maximum core temperature of fish allowed at arrival in the factory: 4.4°C

The importance of measuring core temperature

Freezing times for fish products are best determined by observing the change in temperature of the warmest part of the fish throughout freezing.

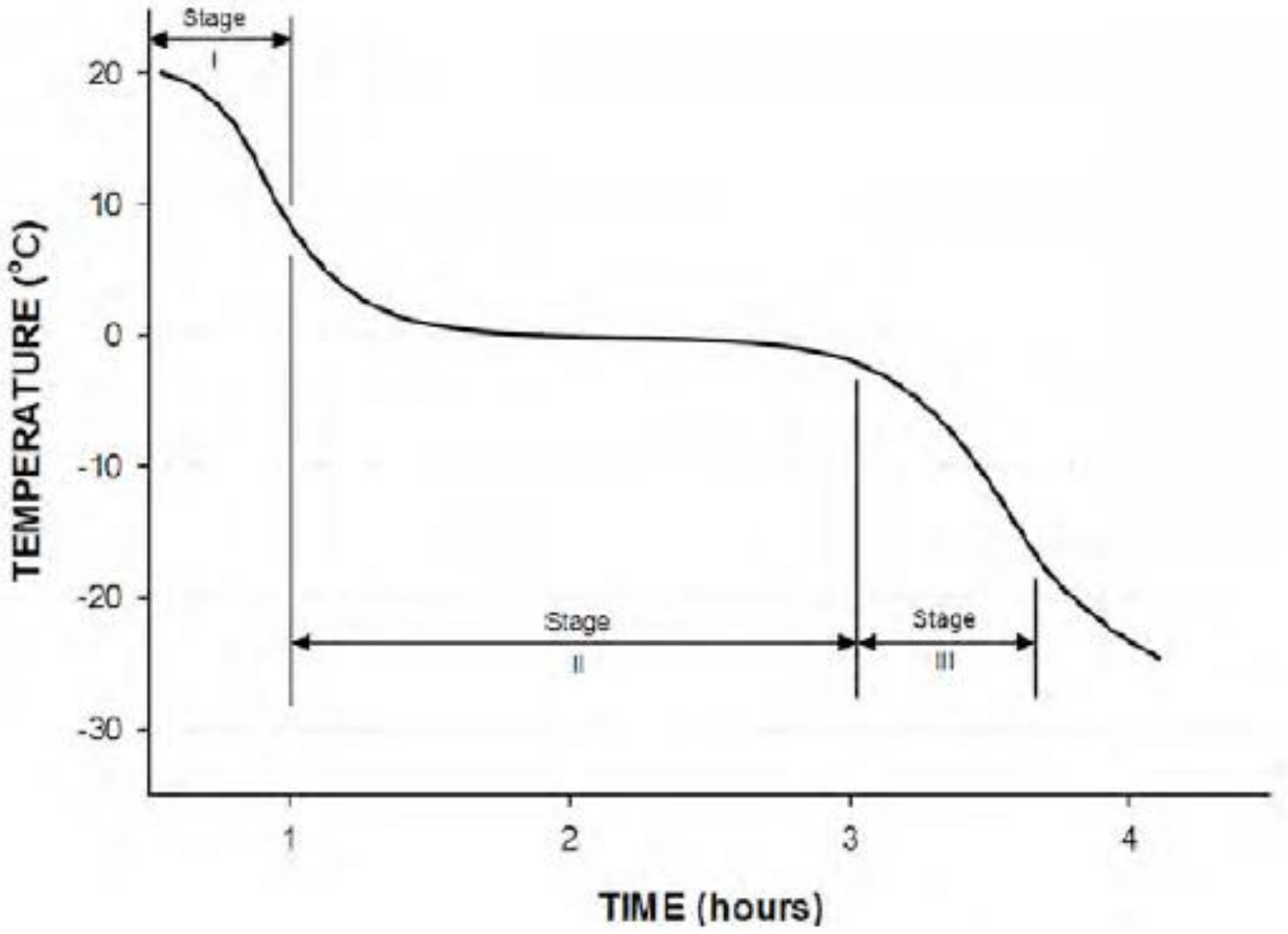
Miscalculation of freezing time can result in either inadequate cooling of the product or a reduction in output of the freezer.

INSERTION OF THERMOMETER IN FISH



Source: http://www.fao.org/3/x5992e/X5992e01.htm

Typical fish freezing curve



Chilling, freezing and cold storage → efficient methods of seafood preservation → BUT DO NOT IMPROVE QUALITY

Final quality dependent on quality at time of freezing (as well as other factors during freezing, cold storage and distribution)

Any questions?