



**What Happens to Fish as  
it Freezes?**

# Nature of Raw Material

- **Fish/Shellfish Composition**

• <b>Protein</b>	<b>15-25%</b>
• <b>Fat</b>	<b>1-15%</b>
• <b>Minerals</b>	<b>1-2%</b>
• <b>Water</b>	<b>65-80%</b>

# **Water in Fish**

- **Free - In Muscle**
- **Transport - Dissolved Minerals**
- **Bound - Attached to Proteins**

# Freezing

- **Change State of Water**
- **Liquid to Solid**
- **Proteins aren't changed**
- **Fats aren't changed**
- **Minerals aren't changed**

# Freezing - Two Stages To Consider

- Freezing Process
- Cold Storage

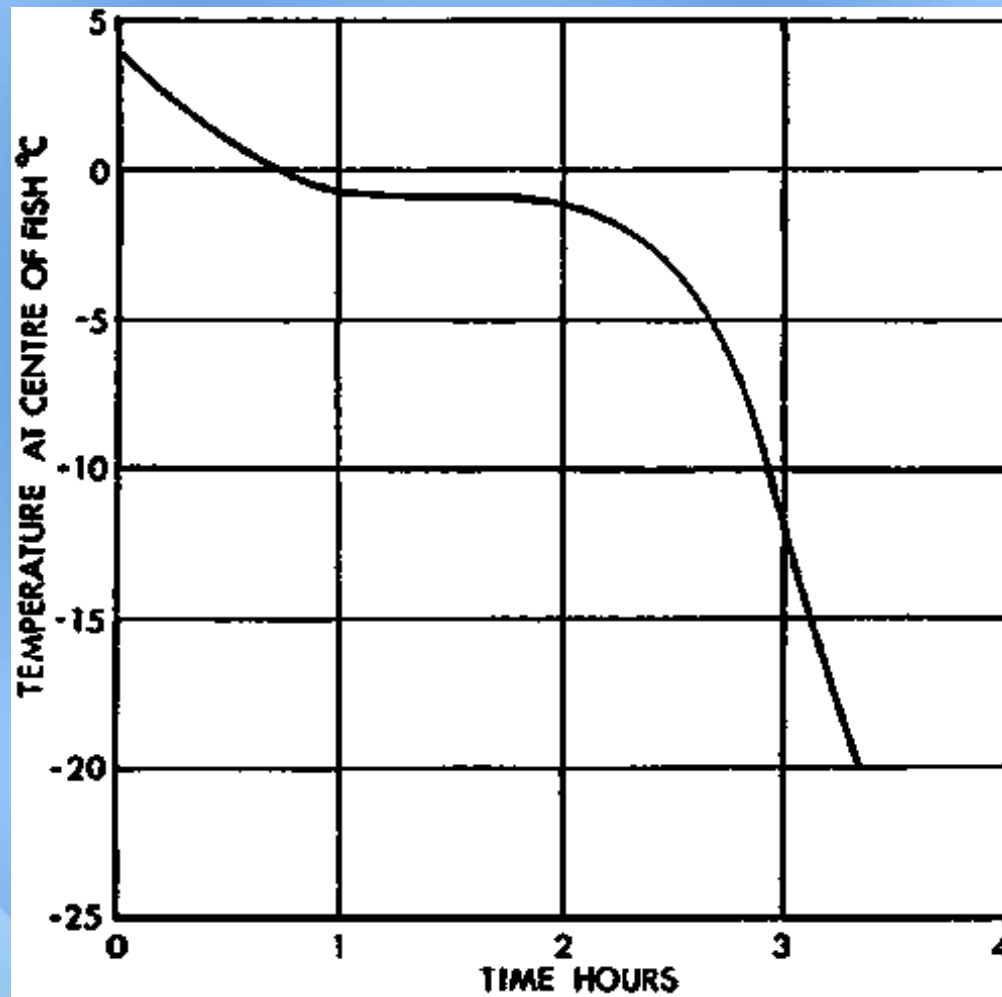
# Freezing Process

- **What Occurs - Three Stages**
- **First - Chilling/Removing Heat to the Transition Temperature**

# Freezing Process

- **Second - Phase Change - Liquid to Solid - Over a Temperature Range - Fairly Complex**
- **Third - Final Temperature Drop to Surroundings**

# Freezing Curve



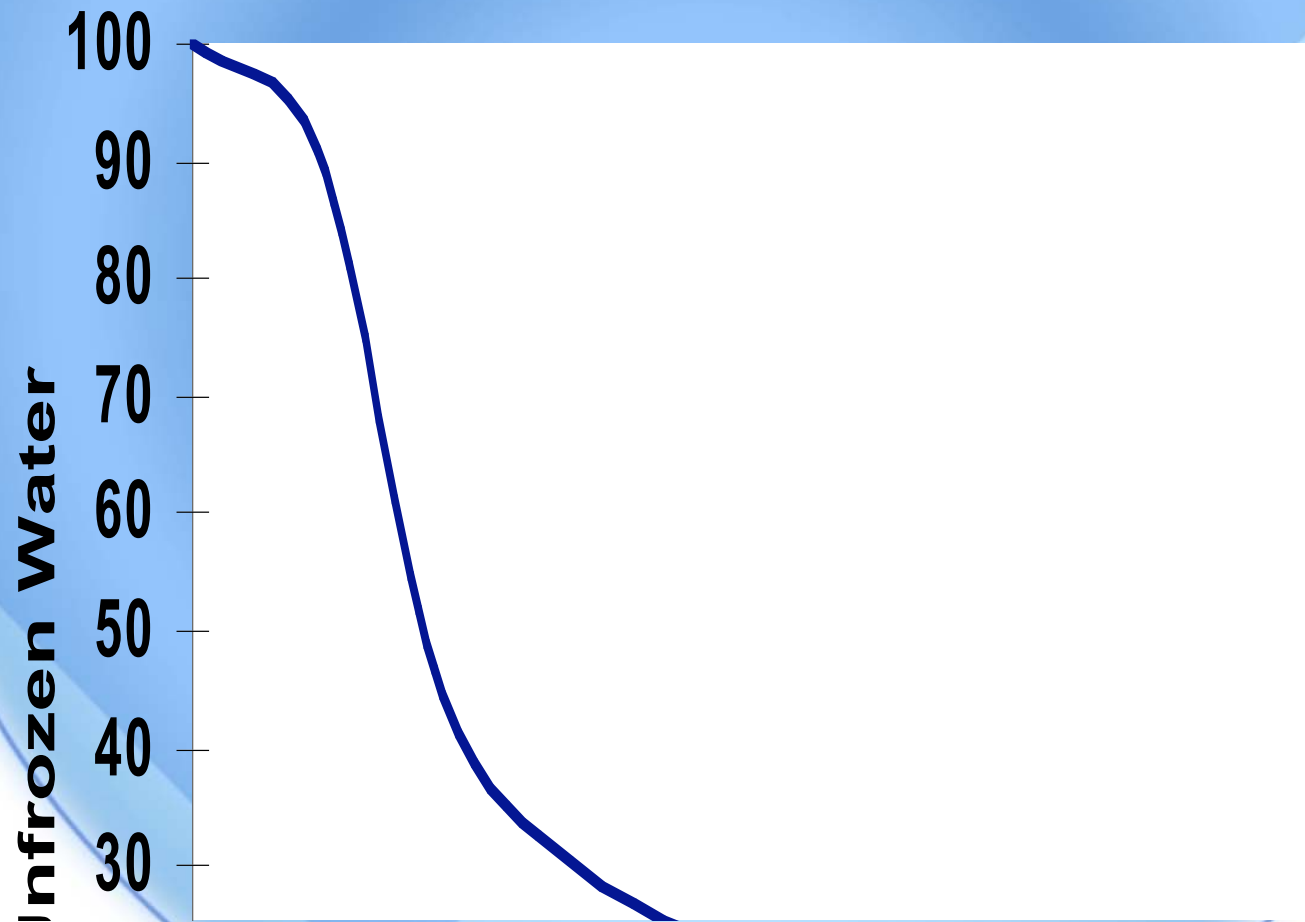
# Phase Change Happenings

- As Temp Decreases Through "Critical" Zone
- Pure Water Freezes in Crystals Starting Around 28F

# Phase Change Happenings

- Salt/Solute Concentration Increases
- Amount of Unfrozen Water Left

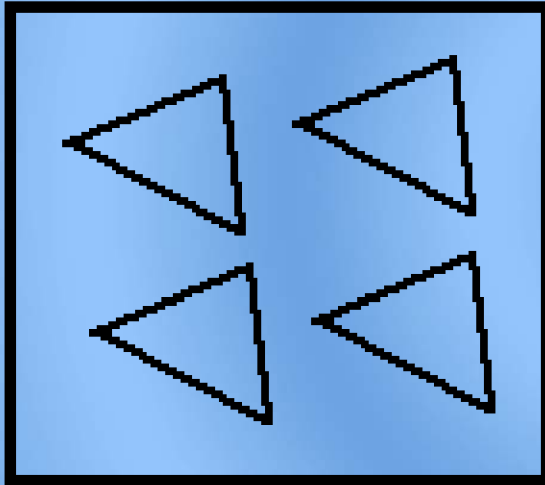
# Unfrozen Water



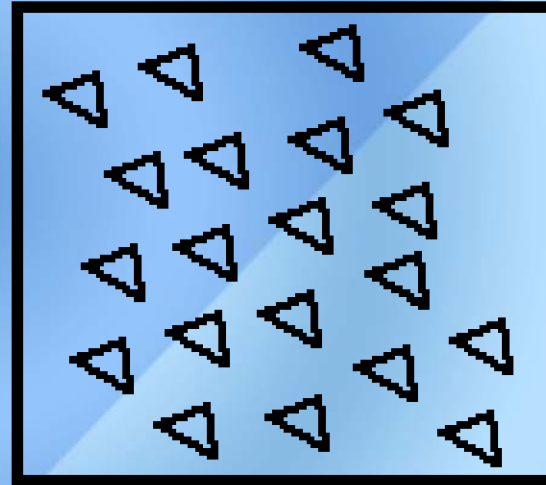
# Ice Crystals

- **Small Crystals - Fast Freezing**
- **Large Crystals - Slow Freezing**
- **Through the Phase Transition Zone**

# Ice Crystal Size



Small number of  
large crystals



Large number of  
small crystals

# Freezing Time

- Freezing Time - What is Fast?
- Hours Vs. Days
- Inches Per Hour

# Final Core Temp

- Final Temperatures - What is Best?
- -20F
- -40F

# Other Things Happening During Freezing

- Increased Enzyme Activity in Transition Zone
- Glassy State Conditions

# **Glassy State**

- **Occurs Around 5 to 10 F**
- **In Pockets - Hi Concentration of Salts/Enzymes**
- **Ice Crystals Dissolve**

# Glassy State

- **Ice Recrystallizes in Larger Chunks**
- **Quality Changes**
- **Avoid this Region**

# **Other Things Happening During Freezing**

- **Moisture Loss in Freezing**
- **Freezing in Rigor**
- **Visual Quality Concerns**

# **Moisture Loss in Freezing**

- **Depending on System, Can Lose Water From Surface**
- **Sometimes Up to 1% or 2%**

# Freezing in Rigor

- Stiffening of the salmon muscle shortly after death
- May last several hours to days depending on temperature

# Freezing in Rigor

- Don't process/handle fish in rigor
- Gaping, Drip Loss and Toughness

# **Cold Storage**

- **Severe Conditions**
- **Dry Air**
- **Temperature Fluctuations**

# Cold Storage

- **Glassy State Deterioration**
- **Freezer Burn**
- **Protection**

# Quality Changes

- **Moisture Migration and Recrystallization**
- **Hydrolytic Enzyme Activity**
- **Protein Denaturation**

# Moisture Migration and Recrystallization

- **Freezer Burn**
- **Temperature Fluctuations -  
Limit Shelf Life**

# Quality Changes

- **Fat Oxidation**
- **Microbial Changes**

# **Minimizing Quality Losses**

- **Cryoprotectants - Glazing**
- **Antioxidants**

# Glazing

- Options for Glaze
- Salt
- Sugar
- Antioxidants



# Glazing

- **Glaze Water Temperature**
- **How Much Glaze?**
- **Cold Storage Effects**

# **Minimizing Quality Losses**

- **Packaging**
- **Bleeding**

# Packaging

- **Critical Aspect of Shelf Life**
- **As Much Protection As You Can Afford**
- **Plastics/Boxes/Vac Pack**

# Shelf Life

- Time of Acceptable Quality
- Limiting Factor is Often Fat Oxidation
- Also Texture Changes

# Shelf Life

- **Depends on**
- **Water Content**
- **Fat Content**
- **Packaging**
- **Storage Temperature**