Precooking Tuna:

A heat treatment to confirm a 5-log reduction of the histamine forming bacterium ***Morganella morganii***

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Presentation to I.F.T.P.S.
Bangkok, Thailand Nov 16, 2016

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This is the 4th presentation on

tuna precooking to I.F.T.P.S.

- Nov 2012 – I.F.T.P.S. (BKK) – Fred Nolte
  - "Validating Tuna Precookers"
- Nov 2012 – I.F.T.P.S. (BKK) – Fred Nolte
  - "End-Point Internal Product Temperature (EPIPT) Control of Histamine in Tuna Precooking step"
- Feb 2014 – I.F.T.P.S. (San Antonio) – Fred Nolte
  - "Statistical Considerations for Monitoring End Point Internal Product Temperature (EPIPT)"

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The Team

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Purpose of the seminar

- To introduce a practical method of confirming a precooking heat treatment to achieve a 5-log reduction in the histamine forming bacterium ***Morganella morganii*** for a precooked batch of tuna.

- Why is this important

  - To extend the current FDA recommended Critical Limit (CL) of 12 hours allowed for processing from thawing until *Re-Freezing* or *Retorting*

  - Proper precooking of the fish will extend that time by a minimum of 12 hours

Vogl, F., R. Salazar, F. Nolte, G. Kontoh, G. Ybanez. 2012. Validation for pre-cooking as a control for potential histamine production in tuna loins for subsequent canning. Paper presented at: TAFT 2012. Proceedings of the 4th Trans-Atlantic Fisheries Technology Conference; Oct 30-Nov 2, 2012; Clearwater Beach, Florida.

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Purpose of precooking tuna

- To set or fix the protein so the skin, bones and red meat is easy to remove from the edible striated meat
- Historically, the completion of precooking has been finished when the minimum core temperature of the batch of fish has passed 135˚F (57.3˚C), based on Peterson's patent of ~1971
- Now a controlled precook can be used to control the formation of histamine

Peterson, E. W. July 1971. Multipurpose precooker method. U.S. Patent. 3,594,196.

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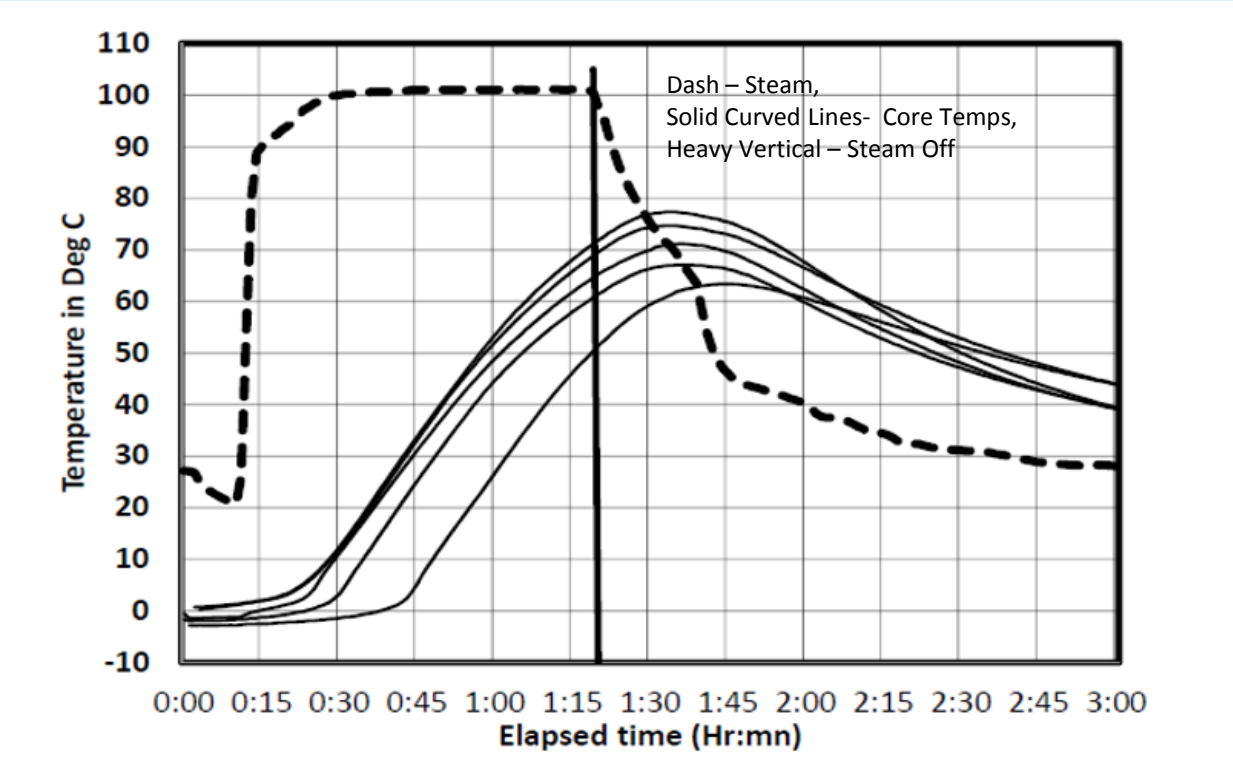
Temperature profile of a Conventional Atmospheric Precooker



- The tuna is heated in direct steam with the heat entering the fish from the outside and going to the center

- The heating curve at the core follows a very typical pattern with a lag phase / heating phase / continued heating after the steam is turned off

Conventional Atmospheric Precookers (CAPs): What effects precooking times the most?

- Fish size – accounts for 93% of the variation in precooking time
- Initial temperatures (ITs) + size - 95% of the variation
  - So ITs account for another 2%
  - NO FROZEN FISH
- Minor variation in ambient steam temperatures – No impact

DeBeer, John, Fred Nolte, and Christopher W. Lord. 2015. Precooking Tuna: A study of the factors impacting the time required for precooking. *Food Protection Trends*. 35(6):448-460.

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Histamine Review

- Histamine is a toxin produced by bacterial growth after the death of tuna with improper or no temperature control
- Enache et al. measured the heat resistance of *Morganella morganii* and 4 other species of histamine forming bacteria (HFB)
- *Morganella morganii* is the most histaminogenic bacterium and the most heat resistant

Enache, E., A. Kataoka, D. G. Black, M. Hayman, L. Weddig, and K. Bjornsdottir-Butler. 2013. Heat resistance of histamine producing bacteria in irradiated tuna loins. J. Food Prot. 76:1608-1614.

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Histamine Review

- Bacterial heat resistance is measured in D and z values and is specific to an organism (i.e., the bacterium)

- The D value is the number of minutes at a specific temperature which reduces a population of a specific bacterial organism by 90% or one log cycle (log base-10).

    - The *z*-value is the number of degrees change which will result in a 10-fold difference in the D value.

    - Enache et al's results of the heat resistance studies of *M. morganii*
        - $D_{60^{\circ}C}$ of ***M. morganii*** =0.26 min
        - z value = 4.1˚C

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Heat Resistance Example

- As an example, in the case of *M. morganii*, the bacterial populations would be reduced 1-log or 90% after 0.26 minutes at 60°C , while at a temperature of 1-z value (4.1°C) lower, i.e., 55.9°C , bacteria populations would be reduced 1-log after 2.6 minutes.

- Thus, one minute at 55.9°C has the equivalent *M. morganii* lethality of 0.1 minutes at 60°C.

- As the minutes pass in the bacterium's lethal zone, the log lethality accumulates, and this accumulation of log lethality will be used to the tuna processors' advantage so the fish need not be overcooked.

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How to use these lethality values in a factory

- With the D-values and the z-values, we can then measure at what times or temperatures the *M. morganaii* populations have been reduced by 5 logs
    - A 5-log reduction is a common value for Ready-to-Eat (RTE) foods, for example:
        - Juice – Juice HACCP – 21CFR120 – Jan 19, 2001
        - Almonds – Almond Board – 5-log process may be labeled as pasteurized

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What are the initial populations of histamine forming bacteria (HFB) in tuna accepted for processing?

There have been several papers that detail this

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Populations of HFB in Good Fish

Author - year	Species	Max CFU/gm	Brief summary
198 – Taylor and Sprekles	Skipjack tuna (Katsuwonus pelamis)	**Not measured**	Only 3 out of 10 fish had any histamine forming bacteria on them
1994 - Lopez-Sabater	Bluefin (Thunnus thynnus)	**1.1 x 10^3 CFU/gm,**	Histamine-producing bacteria counts between 4 CFU/g and 1.1 x 103 CFU/g were only found in three samples from the last step of the canning process before heat sterilization. In fact, post-catching contamination has been considered Spain, fish from the Pacific Ocean
1996 - Lopez-Sabater	Bluefin (Thunnus thynnus)	**1.1 x 10^1 CFU/gm**	Tuna was gutted and chopped up. Very low numbers on HFB. Enterobacteriaceae counts < 10^3 CFU /gm Fish from Retail markets in Spain
2011 - Koohdar, et al	Skipjack tuna (Katsuwonus pelamis)	**10^3 CFU/gm, Hi-Histamine 10^2 CFU/gm, low histamines**	Oman Sea, Histamines near 200 ppm, but HFB at 10^3/CFU/gm – The authors did not even use log numbers on the Y-axis for CFU/gm count. Histamines under 50 ppm, HFB at almost 10^2 levels.
2013 - Garcia-Tapia	Yellowfin (Thunnus albacares)	**10^4 CFU/gm - adjusted**	Mexico - Mesophilic HFB – 10^4, Histamine @ 40 ppm HFB CFU/gm – 5x10^3, (SD - 2.3 x 10^3)
2012 - Koohdar, et al	Longtail tuna (Thunnus tonggol)	**3 x 10^3 CFU/gm, Table 2**	Histamines over 50 ppm, but HFB at 10^3/CFU/gm – The authors did not even use log numbers on the Y-axis for CFU/gm count. Histamines under 50 ppm, HFB at almost 200 CFU/gm levels.
2015 – Hongpattaraker et al.	Longtail tuna (Thunnus tonggol)	**1 x 10^3 CFU/gm**	Thailand – Fresh fish Max Initial viable count @ 10^3 CFU/gm Histamine max @ 11ppm

Populations of HFB in good fish

- The worst case scenario for histamine forming bacteria in good fish
  - Garcia-Tapia – Estimated maximum numbers of histamine forming bacteria (HFB) was 10^4 CFU/gm

- A 5-log reduction of HFB is suitable for the task

García-Tapia, G., Barba-Quintero, G., Gallegos-Infante, J. A., Aguilar, R. P., Ruíz-Cortés, J. A., & Ramírez, J. A. (2013). Influence of physical damage and freezing on histamine concentration and microbiological quality of yellowfin tuna during processing. *Food Science and Technology (Campinas)*, *33*(3), 463-467.

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How to use these lethality values in a factory

- Nolte et. al. showed that when the core temperature reaches 60˚C with a very conservative (fast) heating rate (2˚C/min), that the log lethality has reached 5-log reduction in bacterial populations of *M. morganii.*

- 2˚C/min heating rate is very fast – small fish.

- Back on Slide 6, the heating curve for 1.8 – 2.2 kg fish, the heating rate was ~ 1.3˚C/min

- Let's look at the calculations

Nolte, Fred, D. Glenn Black, John DeBeer, Elena Enache. 2014. Use of end point internal product temperature to control histamine formation in tuna at pre-cooking step. *Food Protection Trends*. 03/2014. 34:94-100.

DeBeer, John, Fred Nolte, Christopher W. Lord, Javier Colley and Lisa Weddig. 2016. Draft of "Setting HACCP critical limits for Precooking CCP's" for publication.

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Log Lethality of *M. morganii* with different time & temperature combinations

Heating Rate: **2˚C/min**				
D-60C	per min	0.26		
z	Deg C	4.1		
		x=10^ ((deg C – 60°C)/4.1)		
Deg/min		2		
Hr:Min	deg C	Lethal Rate	Log Reduction	Accum D
0:00	50.00	0.004		
0:01	52.00	0.011	0.043	0.043
0:02	54.00	0.034	0.132	0.175
0:03	56.00	0.106	0.407	0.582
0:04	58.00	0.325	1.251	1.833
0:05	60.00	1.000	3.846	5.679
0:06	62.00	3.075	11.826	17.505
0:07	64.00	9.454	36.361	53.866

Note at 60˚C on this chart @ 5 min, the accum log-lethality is > 5.6

Note at 62˚C on this chart @ 6 min, the accum log-lethality is 17.5

Heating Rate: **1˚C/min**				
D-60C	per min	0.26		
z	Deg C	4.1		
		x=10^ ((deg C – 60°C)/4.1)		
Deg/min		1		
Hr:Min	deg C	Lethal Rate	Log Reduction	Accum D
0:00	50.00	0.004		
0:01	51.00	0.006	0.025	0.025
0:02	52.00	0.011	0.043	0.068
0:03	53.00	0.020	0.075	0.143
0:04	54.00	0.034	0.132	0.275
0:05	55.00	0.060	0.232	0.507
0:06	56.00	0.106	0.407	0.914
0:07	57.00	0.185	0.713	1.628
0:08	58.00	0.325	1.251	2.878
0:09	59.00	0.570	2.193	5.072
0:10	60.00	1.000	3.846	8.918

Note at 60˚C on this chart @ 10 min, the accum log-lethality is > 8.9

Alternative times and temperatures to achieve a 5-log reduction in *M. morganii*

What happens if we heat the fish fast (2˚C/min) and then hold at a fixed temperature – for example, a vacuum precooker

Log lethality after holding the fish at a fixed core temperature Degrees C - Fixed after a 2˚C/Min Heating Rate								
Min	62˚C	61˚C	60˚C	59˚C	58˚C	57˚C	56˚C	55˚C
0	17.5	9.9	5.7	3.2	1.8	1.0	0.6	0.3
1	29.3	16.7	9.5	5.4	3.1	1.7	1.0	0.5
2	41.1	23.4	13.3	7.6	4.3	2.4	1.4	0.8
3	52.9	30.2	17.2	9.8	5.6	3.1	1.8	1.0
4	64.8	36.9	21.0	12.0	6.8	3.9	2.2	1.2
5	76.6	43.6	24.9	14.2	8.1	4.6	2.6	1.5
6	88.4	50.4	28.7	16.3	9.3	5.3	3.0	1.7
7	100.2	57.1	32.5	18.5	10.6	6.0	3.4	1.9
8	112.0	63.9	36.4	20.7	11.8	6.7	3.8	2.1
9	123.9	70.6	40.2	22.9	13.1	7.4	4.2	2.4
10	135.7	77.3	44.1	25.1	14.3	8.1	4.6	2.6
11	147.5	84.1	47.9	27.3	15.6	8.8	5.0	2.8
12	159.3	90.8	51.7	29.5	16.8	9.5	5.4	3.1
13	171.1	97.6	55.6	31.7	18.1	10.2	5.8	3.3
14	183.0	104.3	59.4	33.9	19.3	11.0	6.2	3.5
15	194.8	111.0	63.3	36.1	20.6	11.7	6.6	3.8

Alternative times and temperatures to achieve a 5-log reduction of *M. morganii*

What happens if we measure core temperatures one time and the wait and re-measure again later

Accumulated Log Reduction of *M. morganii*				
	Ending temp after 10 min - deg C			
Initial BB Temp	60	59	58	57
60	40.3			
59	32.5	24.1		
58	25.7	18.5	13.8	
57	20.9	14.6	10.6	7.8
56	17.5	11.9	8.4	6.0
55	15.0	10.0	6.8	
54	13.1	8.6	5.7	
53	11.7	7.5		
52	10.6	6.7		
51	9.7	6.0		
50	8.9	5.5		

Accumulated Log Reduction of *M. morganii*					
	Ending temp after 15 min - deg C				
Initial BB Temp	60	59	58	57	56
60	59.5				
59	47.2	35.1			
58	37.2	26.9	20.0		
57	30.2	21.2	15.3	11.4	
56	25.1	17.2	12.1	8.7	6.5
55	21.4	14.3	9.8	6.9	
54	18.6	12.2	8.2	5.6	
53	16.4	10.6	7.0		
52	14.7	9.4	6.0		
51	13.4	8.4	5.3		
50	12.3	7.6			

HACCP Critical Limits

- A *CRITICAL LIMIT* is a maximum and/or minimum value to which a biological, chemical or physical parameter must be controlled at a critical control point (CCP) to prevent, eliminate or reduce to an acceptable level of occurrence of a food safety hazard.

- A *CRITICAL LIMIT* is used to distinguish between safe and unsafe operating conditions at a CCP. Critical limits should not be confused with operational limits which are established for reasons other than food safety.

- *CRITICAL LIMITS* must be scientifically based. The critical limits and criteria for food safety may be derived from sources such as regulatory standards and guidelines, literature surveys, experimental results, and experts.

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Critical Limit to achieve a 5-log reduction in *M. morganii*

- In this presentation, the Critical Limit (CL) is defined as a combination of *time and temperature* that achieves a 5-log reduction of *M. morganii* by means of a precooking heat treatment.

- This is modeled after retorting processes where there is a 12-log reduction of *Clostridium botulinum* based on alternative process schedules of time and temperature.

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Acceptance Value
to test against the Critical Limit

- In this presentation, we will define an Acceptance Value (AV) as the average core temperature minus 3 standard deviations .

- This is a lower limit of core temperatures

- The Acceptance Value (AV) will be tested at fixed holding (sampling) times after precooking:
    - 0 min
    - 10 min
    - 15 min

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What does this all mean?

- What this means is that we can sample the fish after precooking, and if the AV is 60˚C or over at first measurement the lot has achieved a 5-log reduction in *M. morganii*

- Question: But what is the AV?
  - Ans: It is the lowest calculated core temperature from a statistically valid sample and the time interval at that temperature that achieves a 5-log reduction in *M. morganii.*

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What does this all mean?

- What this means is that we can sample the fish after precooking, and if the AV is 60˚C or over at first measurement, the lot has achieved a 5-log reduction in *M. morganii*

- Question: But what is the AV?
  - Ans: It is the lowest calculated core temperature from a statistically valid sample and the time interval at that temperature that achieves a 5-log reduction in *M. morganii.*

- Question: What is this sample?
  - Ans: This is ACCEPTANCE Sampling of a lot based on the core temperatures

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What does this all mean?

- What this means is that we can sample the fish after precooking, and if the AV is 60˚C or over at first measurement, the lot has achieved a 5-log reduction in *M. morganii*

- Question: What is this sample?
  - Ans: This is ACCEPTANCE sampling of a lot based on the core temperatures

- Question: What is the sample size?
  - Ans: Sample size depends on the desired confidence levels and tolerance levels

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Acceptance Sampling for tuna precooking

- Fred Nolte presented a paper on sampling for End-Point Internal Product Temperature (EPIPT) at the I.F.T.P.S. Symposium Conference in San Antonio, Texas Feb 2016
- Nolte's presentation is available on the I.F.T.P.S. website

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Acceptance Sampling

- Can be based on Attributes or Variables
    - Attributes: for example, 60˚C – how many fish exceeded 60˚C at the core?
    - Variables:
        - Based on the parameters and distribution of the core temperatures
            - Mean or average of the sample core temperatures
            - Standard deviation of the sample core temperatures
        - Core temperature values need to be normally or near normally distributed

DeBeer, John, Fred Nolte, Christopher W. Lord, Jim Colton, Javier Colley and Lisa Weddig.2016. Draft for publication of Sample Size Paper for publication.

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Acceptance Sampling – Attribute

- Attributes: for example, 60˚C
  - how many fish exceeded 60˚C at first measurement (T-0) or anytime after
- CL – ALL fish must meet or exceed the Critical Limit (CL)
  - if any below, the lot needs to be recooked
- Requires a far larger sample size than variable sampling
- Does NOT require a normal distribution of sample values

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Acceptance Sampling – Variable

- Based on the statistical parameters of the values collected
    - Average and standard deviation of the core temperature values
- The core temperatures need to be normally or near normally distributed

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Acceptance Sampling – Variable

- We are testing for the <u>lower limit</u> as the Acceptance Value (AV)
  - The lower limit is calculated at the
    - [Average temperature – (3* StdDev)] so
  - The Acceptance Value (AV) =
    Average temperature – (3*StdDev)
    - Example – average is 70˚C and StdDev is 3˚C
      - AV = 70˚C -(3*3˚C) = 61˚C (lowest temperature) or
    - Example – average is 65˚C and StdDev is 2.5˚C
      - AV = 65˚C – (3*2.5˚C) = 57.5˚C (lowest temperature)

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Tolerance Limits

Limits within which we expect a stated proportion of the population to lie.

Anonymous - http://www.itl.nist.gov/div898/handbook/prc/section2/prc263.htm

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How large does the sample size need to be?

It depends whether it's an Attribute or Variable sampling plan

Sample sizes for c=0 *ATTRIBUTE* Acceptance Sampling plans
Lot Size - Infinite.

Confidence Level	Tolerance Intervals or Percent of Population Good at X% Confidence Level		
	95%	99%	99.5%
90%	45	230	460
95%	**59**	299	598
99%	90	459	919

Sample sizes for *VARIABLE* Acceptance Sampling plan using the calculated mean and standard deviation.

Confidence Level	Tolerance Intervals or Percent of Population Good at X% Confidence Level		
	95%	99%	99.5%
90%	7	**23**	54
95%	10	**35**	86
99%	17	**65**	100+

Ref – Jim Colton – Mini-Tab – Statistics Expert

Comparison of sample sizes for Attribute and Variable Acceptance sampling plans using the calculated mean and standard deviation.

Acceptance Sampling Sample Sizes We are 95% confident that x% of the lot is acceptable						
	Conf Levels	**95% Reliability**	**99% Reliability**	**99.5% Reliability**	**Notes**	**Source**
Attribute	**95%**	59	299	593	Infinite lot size	DeBeer et al Sampling paper – Submitted for publication
Variable	**95%**	10	35	86	, s	

Testing the data distribution for normality

- Attribute samples – do NOT need a normal distribution
- Variable samples NEED to be normally distributed
- Normality can be tested with the Ryan-Joiner (R-J) method
- R-J method depends on the sample size and is easy to calculate on a computer: Thomas Ryan & Brian Joiner are / were professors at Penn State University. They were 2 of the 3 founders of Minitab.

Anonymous - https://www.minitab.com/uploadedFiles/Content/News/Published_Articles/normal_probability_plots.pdf

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Testing the data distribution of precooking core exit temperatures for normality

- We tested the normality of the core exit temperatures of more than 300 tuna precooking cycles.
- Only 6 cycles failed the normality test

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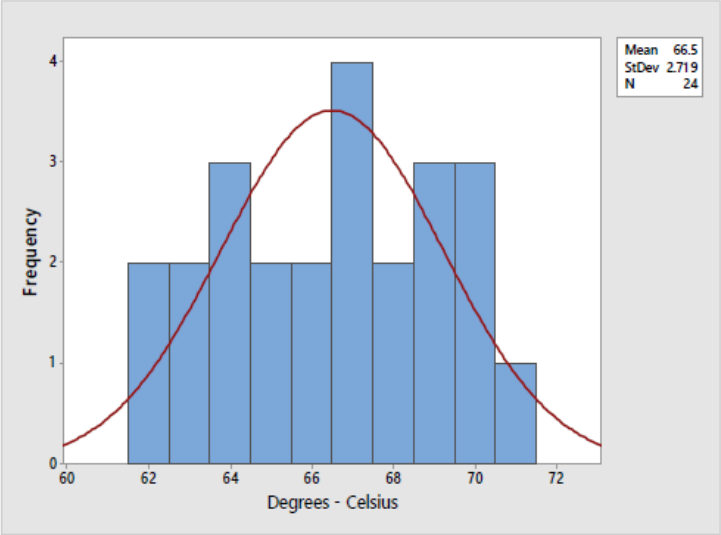
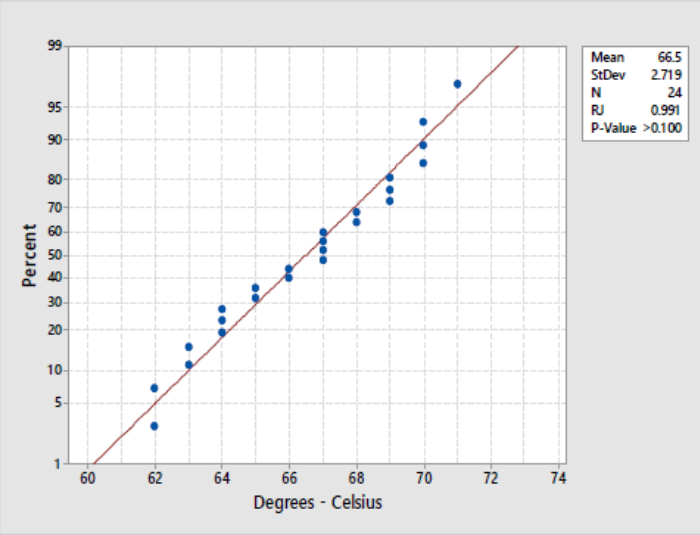
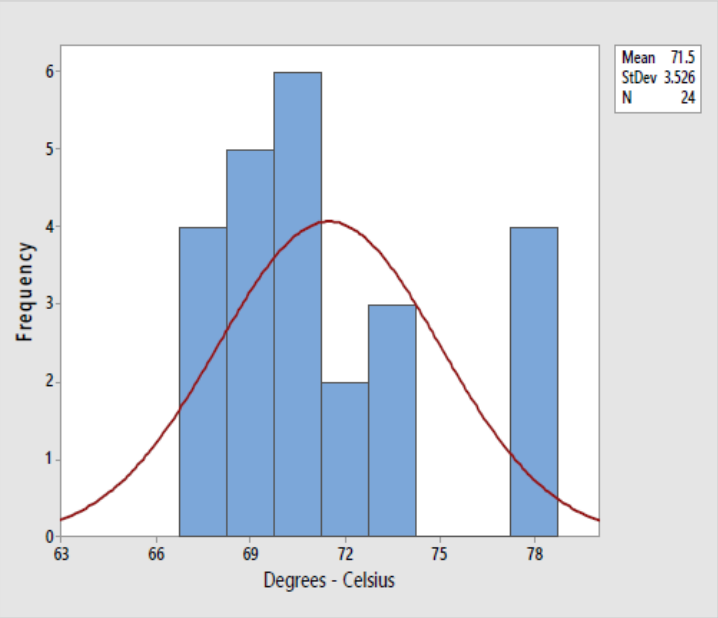
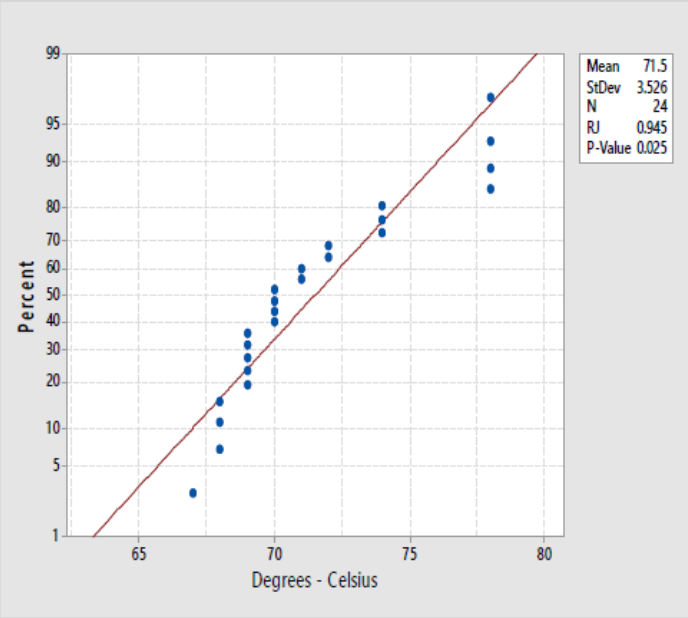
Testing A Normal Distribution of Tuna Core temperatures after Precooking - Passed





Testing A Normal Distribution of Tuna Core temperatures after Precooking - Distribution Failed the Ryan-Joiner Test





Putting it all together

- We have a table of time and temperature relationships to achieve a 5-log reduction in *M. morganii*
- We have a variable sampling plan – number of samples and method of calculating a lower limit AV
  - 24 or 36 fish are good sample sizes – from slide 31
    - ✓ 24 = 90% conf limit, and over 99% of tolerance interval
    - ✓ 36 = 95% conf limit, and over 99% of tolerance interval
  - This is NON-destructive testing… just collecting core temperatures with dial thermometers after every precooker load

Pre-requisites

- Good thawing equipment – with fast, uniform circulation of the water
- Good precooking equipment – good steam circulation is needed
- Uniform temperature distributions (TDs) of the precookers
  - Use I.F.T.P.S. published TD protocols
  - NFI Tuna Council HACCP Guidance for Canned Tuna - Appendix 5

Pre-requisites

- Conduct heat penetration (HP) studies to develop recipes by size for both thawing and precooking
  - Use I.F.T.P.S. published HP protocols
- Implement good sizing of the fish at receiving
- Store the fish by size
- Schedule the fish into the thawing and precooking process by size
- Select the largest and coldest fish at butcher to decide the correct precooking recipes and post precooking core temperature sampling

Using the core temperatures to optimize precooking

- The heating curve at the core follows a very typical pattern…
  - Lag
  - Heating
  - Continued heating after steam off
  - Cooling

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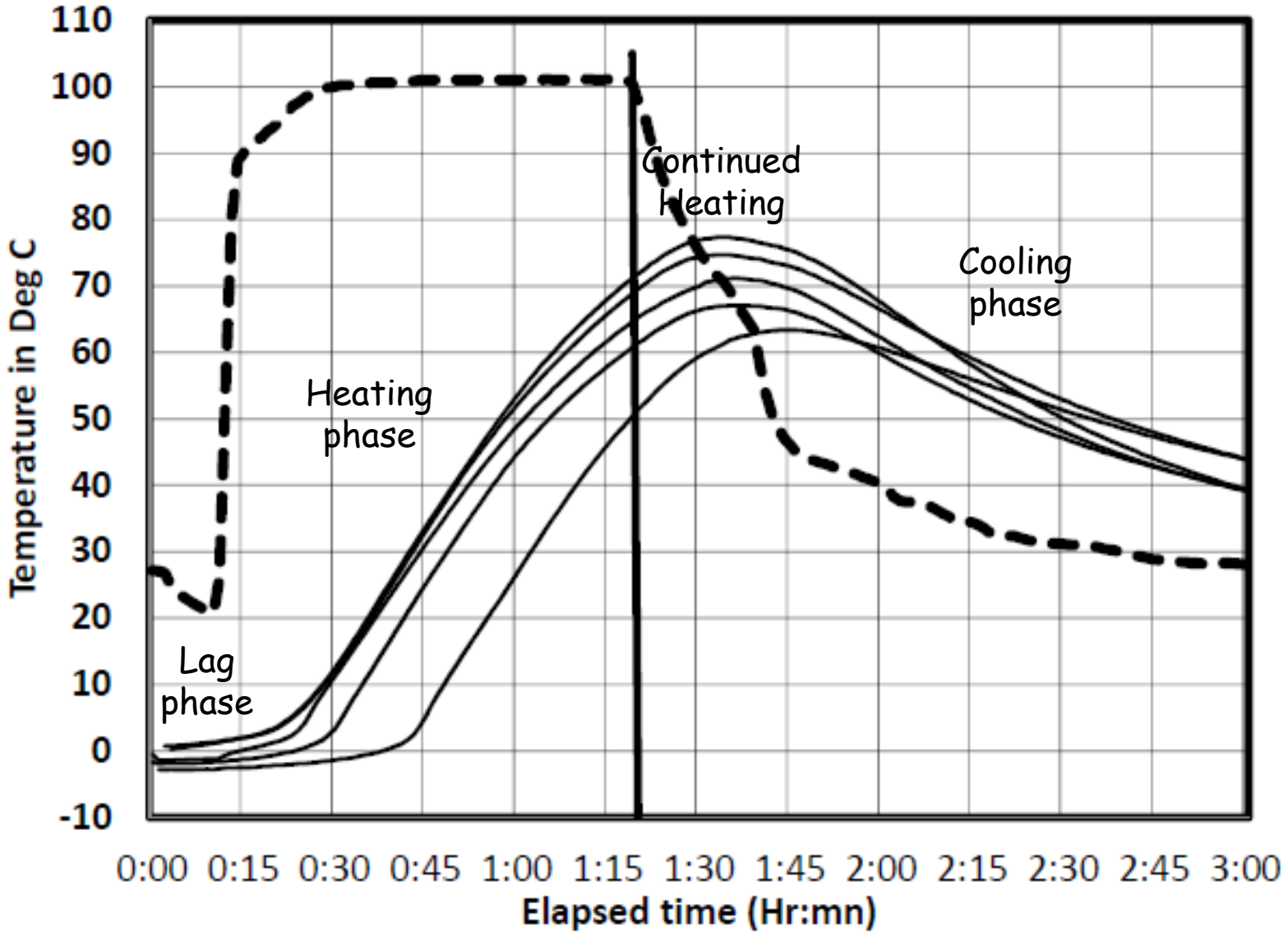
110
100
90
80
70
60
50
40
30
20
10
0
-10
Temperature in Deg C
Continued Heating
Cooling phase
Heating phase
Lag phase
0:00 0:15 0:30 0:45 1:00 1:15 1:30 1:45 2:00 2:15 2:30 2:45 3:00
Elapsed time (Hr:mn)

Steps to be followed

- Thaw the fish properly – NO frozen fish
- Measure and record the initial core temperatures (IT) and weight of 24 to 36 fish before precooking
- Follow the predetermined process schedule for the largest fish in the sample

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Steps to be followed

- Prepare enough thermometers to have one for each fish
- Insert the thermometers as the fish exit the cooker… do not stop to read them
- 10 minutes after steam off, read the thermometers, in sequence, as quickly as possible
- Record the temperatures on the datasheet.

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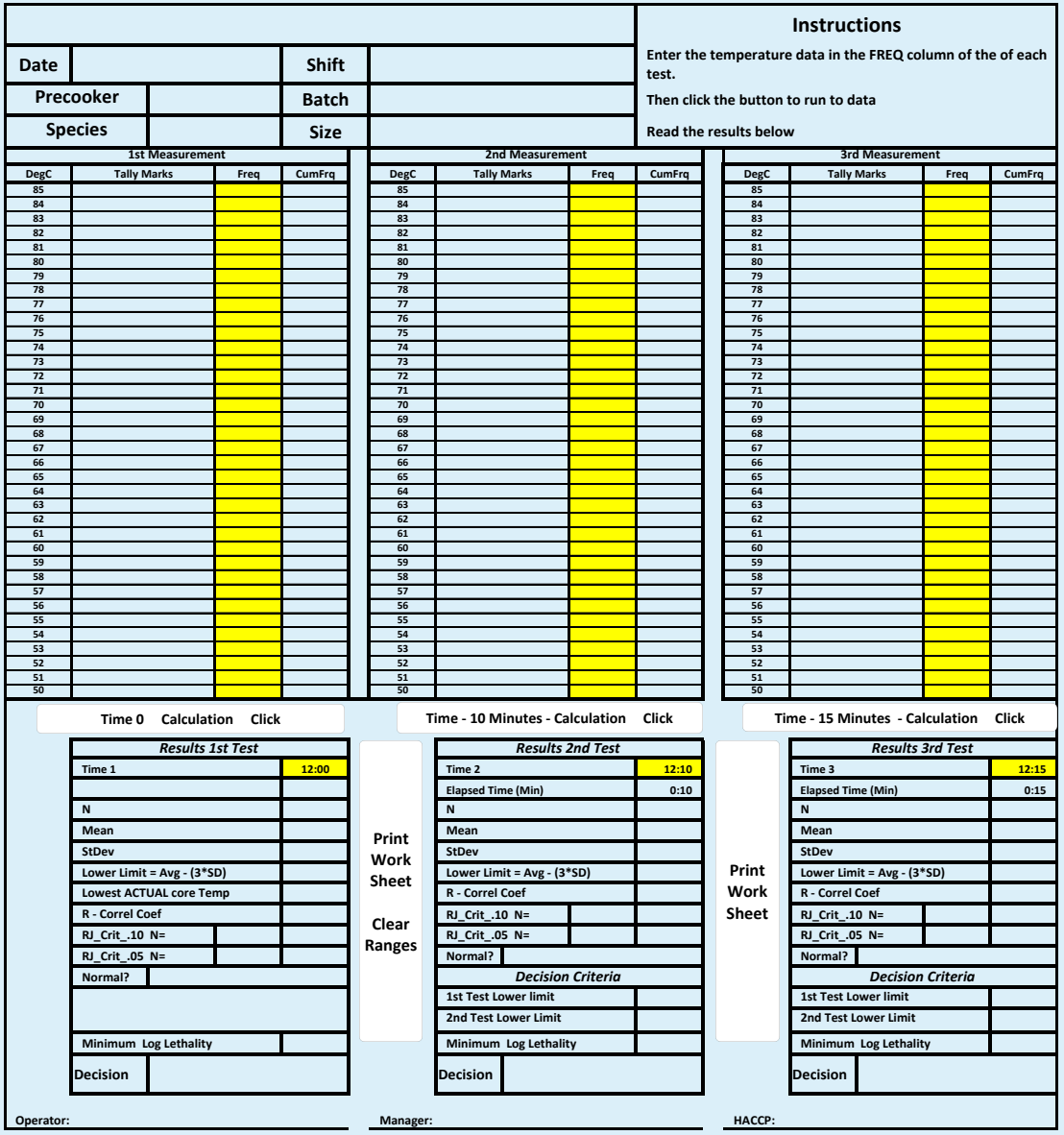
- Date collection and analysis form
- There is an active spreadsheet that will help make decisions
- We will have a link you can use



Instructions

Enter the temperature data in the FREQ column of the of each test.

Then click the button to run to data

Read the results below

Date		Shift	
Precooker		Batch	
Species		Size	

1st Measurement				2nd Measurement				3rd Measurement			
DegC	Tally Marks	Freq	CumFrq	DegC	Tally Marks	Freq	CumFrq	DegC	Tally Marks	Freq	CumFrq
85				85				85			
84				84				84			
83				83				83			
82				82				82			
81				81				81			
80				80				80			
79				79				79			
78				78				78			
77				77				77			
76				76				76			
75				75				75			
74				74				74			
73				73				73			
72				72				72			
71				71				71			
70				70				70			
69				69				69			
68				68				68			
67				67				67			
66				66				66			
65				65				65			
64				64				64			
63				63				63			
62				62				62			
61				61				61			
60				60				60			
59				59				59			
58				58				58			
57				57				57			
56				56				56			
55				55				55			
54				54				54			
53				53				53			
52				52				52			
51				51				51			
50				50				50			

Time 0 Calculation Click

Time - 10 Minutes - Calculation Click

Time - 15 Minutes - Calculation Click

Results 1st Test	
Time 1	12:00
N	
Mean	
StDev	
Lower Limit = Avg - (3*SD)	
Lowest ACTUAL core Temp	
R - Correl Coef	
RJ_Crit_.10 N=	
RJ_Crit_.05 N=	
Normal?	
Minimum Log Lethality	
Decision	

Print Work Sheet

Clear Ranges

Results 2nd Test	
Time 2	12:10
Elapsed Time (Min)	0:10
N	
Mean	
StDev	
Lower Limit = Avg - (3*SD)	
R - Correl Coef	
RJ_Crit_.10 N=	
RJ_Crit_.05 N=	
Normal?	
Decision Criteria	
1st Test Lower limit	
2nd Test Lower Limit	
Minimum Log Lethality	
Decision	

Print Work Sheet

Results 3rd Test	
Time 3	12:15
Elapsed Time (Min)	0:15
N	
Mean	
StDev	
Lower Limit = Avg - (3*SD)	
R - Correl Coef	
RJ_Crit_.10 N=	
RJ_Crit_.05 N=	
Normal?	
Decision Criteria	
1st Test Lower limit	
2nd Test Lower Limit	
Minimum Log Lethality	
Decision	

Operator:

Manager:

HACCP:

Proposed rules for Acceptance Sampling

- Use a N of 24 to 36 fish – measure the core temperatures
- T-0 – Time of ending first data collection
  - If the **ACTUAL** minimum core temperature of any sample is < 55˚C… immediately return the batch to the cooker for more **COOKING**
  - If the **ACTUAL** minimum temperature is >= 55˚C, but the AV is less than 60˚C… just **WAIT** 10 minutes and re-measure
  - If the calculated AV temperature is >= 60˚… **RELEASE**

Proposed rules for Acceptance Sampling

- T-10 – 10 minutes after the last data collection time from T-0
  - If the time / temperature combination AV produces less than a 5-log reduction… WAIT another 5 minutes
  - If the time / temperature combination AV produces more than 5-log reduction in M. morganii… RELEASE

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Proposed rules for Acceptance Sampling

- T-15 – 15 minutes after the last data collection time from T-0
  - If the time / temperature combination AV is still less than a 5-log reduction… more COOKING
  - If the time / temperature combination AV produces more than a 5-log reduction in M. morganii… RELEASE

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Practical application of the proposed rules for acceptance sampling

- The team members developed and tested an easy data collection form, and a…
- Real-time spreadsheet that produces a decision on whether the precooker batch passes or fails the critical limit (CL)

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Focused example of spreadsheet - blank

Date		Shift
Precooker		Batch
Species		Size

1st Measurement

DegC	Tally Marks	Freq	CumFrq
85			
84			
83			
82			
81			
80			
79			
78			
77			
76			
75			
74			
73			
72			
71			
70			
69			
68			
67			
66			
65			
64			
63			
62			
61			
60			
59			
58			
57			
56			
55			
54			
53			
52			
51			
50			

Time 0 Calculation Click

Results 1st Test		
Time 1		12:00
N		
Mean		
StDev		
Lower Limit = Avg - (3*SD)		
Lowest ACTUAL core Temp		
R - Correl Coef		
RJ_Crit_.10 N=		
RJ_Crit_.05 N=		
Normal?		
Minimum Log Lethality		
Decision		

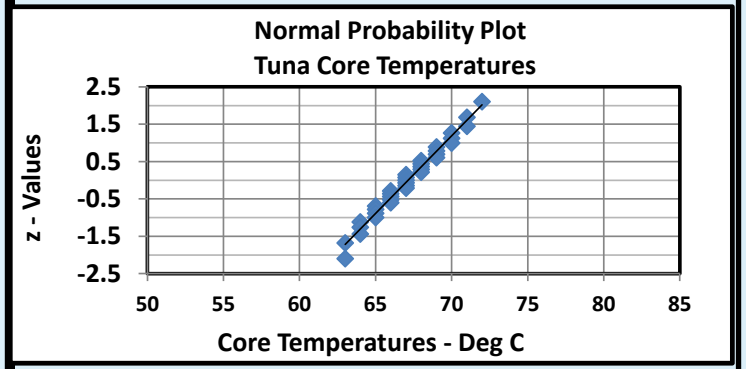
Date		Shift	
Precooker		Batch	
Species		Size	

1st Measurement

DegC	Tally Marks	Freq	CumFrq
85			
84			
83			
82			
81			
80			
79			
78			
77			
76			
75			
74			
73			
72	/	1	1
71	//	2	3
70	///	3	6
69	////	4	10
68	/////	5	15
67	//////	6	21
66	/////	5	26
65	////	4	30
64	///	3	33
63	//	2	35
62			
61			
60			
59			
58			
57			
56			
55			
54			
53			
52			
51			
50			

Results 1st Test		
Time 1		12:00
N		35
Mean		67.1
StDev		2.33
Lower Limit = Avg - (3*SD)		60.2
Lowest ACTUAL core Temp		63
R - Correl Coef		0.999
RJ_Crit_.10 N=	35	0.974
RJ_Crit_.05 N=	35	0.968
Normal?	Yes, Normal, p>= .100	
Minimum Log Lethality		5.7
Decision	RELEASE	

Operator:



73			
72			
71			
70			
69			
68			
67			
66			
65	/	1	1
64	//	2	3
63	///	3	6
62	////	4	10
61	/////	5	15
60	//////	6	21
59	/////	5	26
58	////	4	30
57	///	3	33
56	//	2	35
55	/	1	36
54			
53			
52			
51			
50			

73			
72	/	1	1
71	//	2	3
70	///	3	6
69	////	4	10
68	/////	5	15
67	//////	6	21
66	/////	5	26
65	////	4	30
64	///	3	33
63	//	2	35
62	/	1	36
61			
60			
59			
58			
57			
56			
55			
54			
53			
52			
51			
50			

Time 0 Calculation Click

Time - 10 Minutes - Calculation Click

Results 1st Test		
Time 1		12:00
N		36
Mean		60.0
StDev		2.45
Lower Limit = Avg - (3*SD)		52.7
Lowest ACTUAL core Temp		55
R - Correl Coef		0.999
RJ_Crit_.10 N=	36	0.975
RJ_Crit_.05 N=	36	0.969
Normal?	Yes, Normal, p>= .100	
Minimum Log Lethality		0.0
Decision	WAIT	

Print Work Sheet

Clear Ranges

Results 2nd Test		
Time 2		12:10
Elapsed Time (Min)		0:10
N		36
Mean		67.0
StDev		2.45
Lower Limit = Avg - (3*SD)		59.7
R - Correl Coef		0.999
RJ_Crit_.10 N=	36	0.975
RJ_Crit_.05 N=	36	0.969
Normal?	Yes, Normal, p>= .100	
Decision Criteria		
1st Test Lower limit		52.7
2nd Test Lower Limit		59.7
Minimum Log Lethality		6.7
Decision	RELEASE	

Availability of the spreadsheet

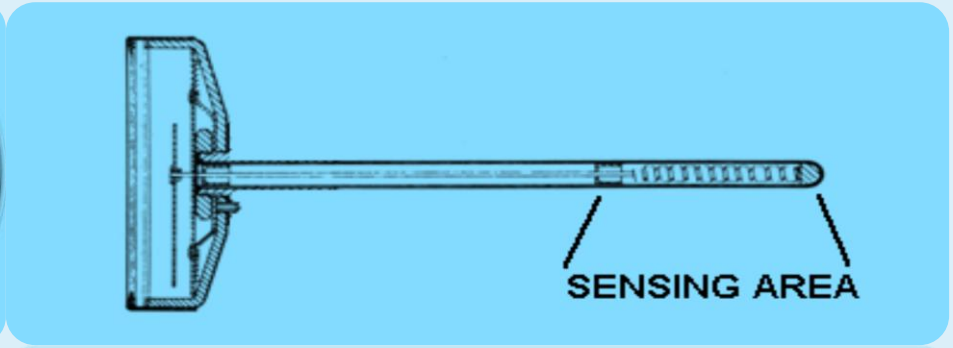
- The spreadsheet is available from John DeBeer or Chris Lord for evaluation…

John DeBeer
John.DeBeer@thaiunion.com

Chris Lord
protech1993@live.com

A word about thermometers…

- Purchase enough thermometers to be able to collect all temperatures as quickly as possible… one for each fish
- Check thermometers for accuracy or damage at least daily



Review and Discussion of actual precooking temperature profiles

- Some are more than 10 years old
- Some more current
- Numerous different factories
- Different species and sizes of tuna

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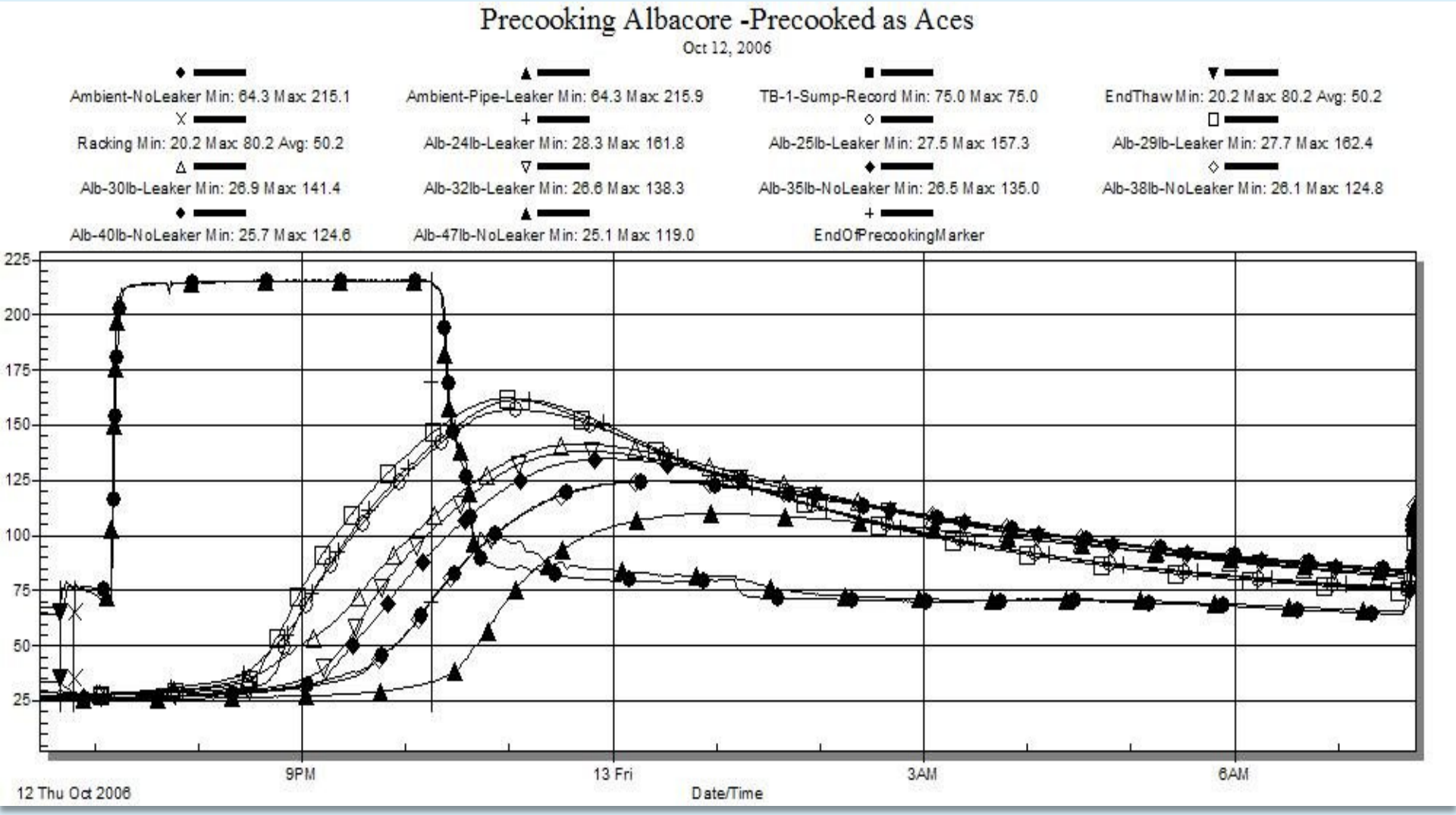
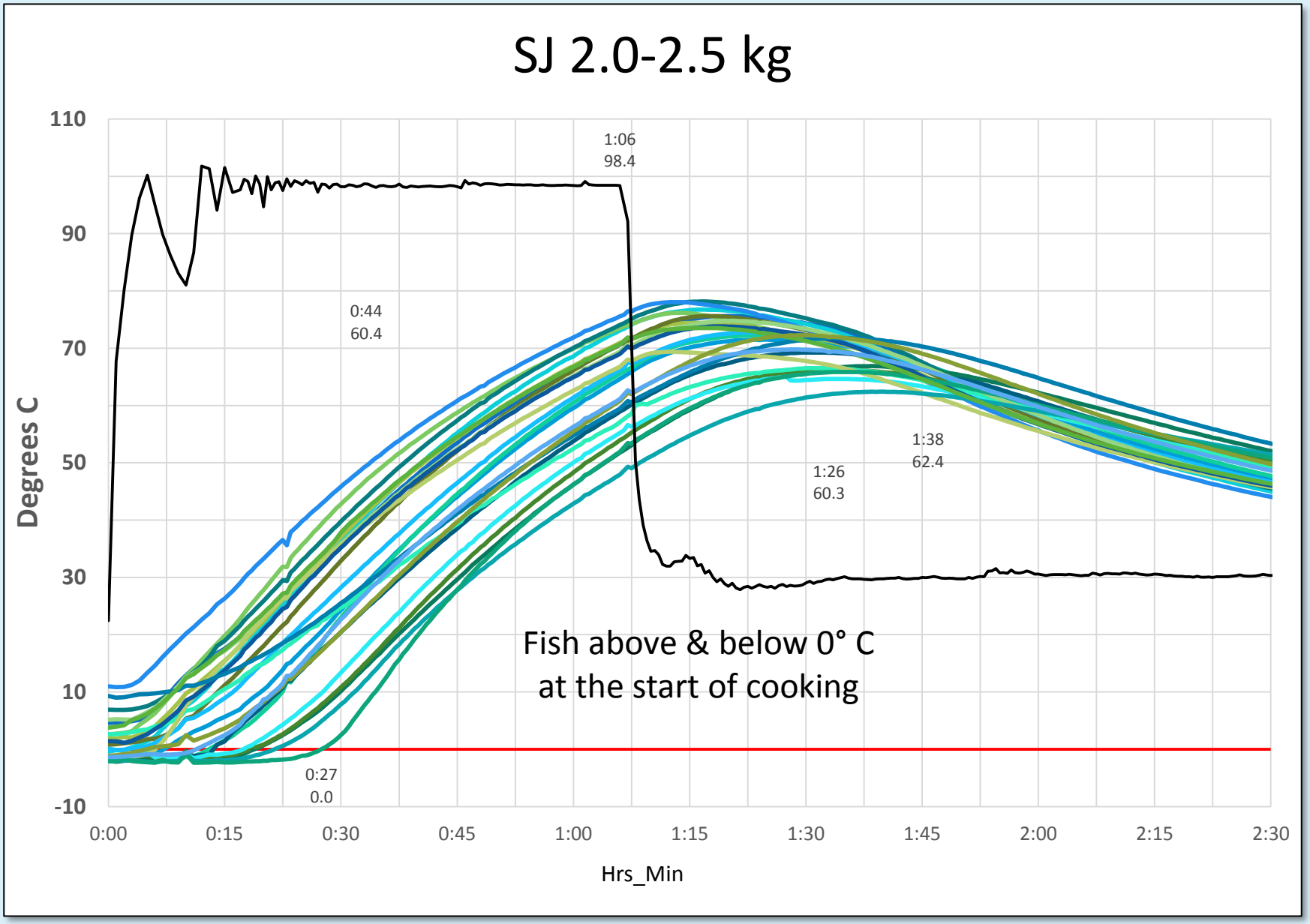
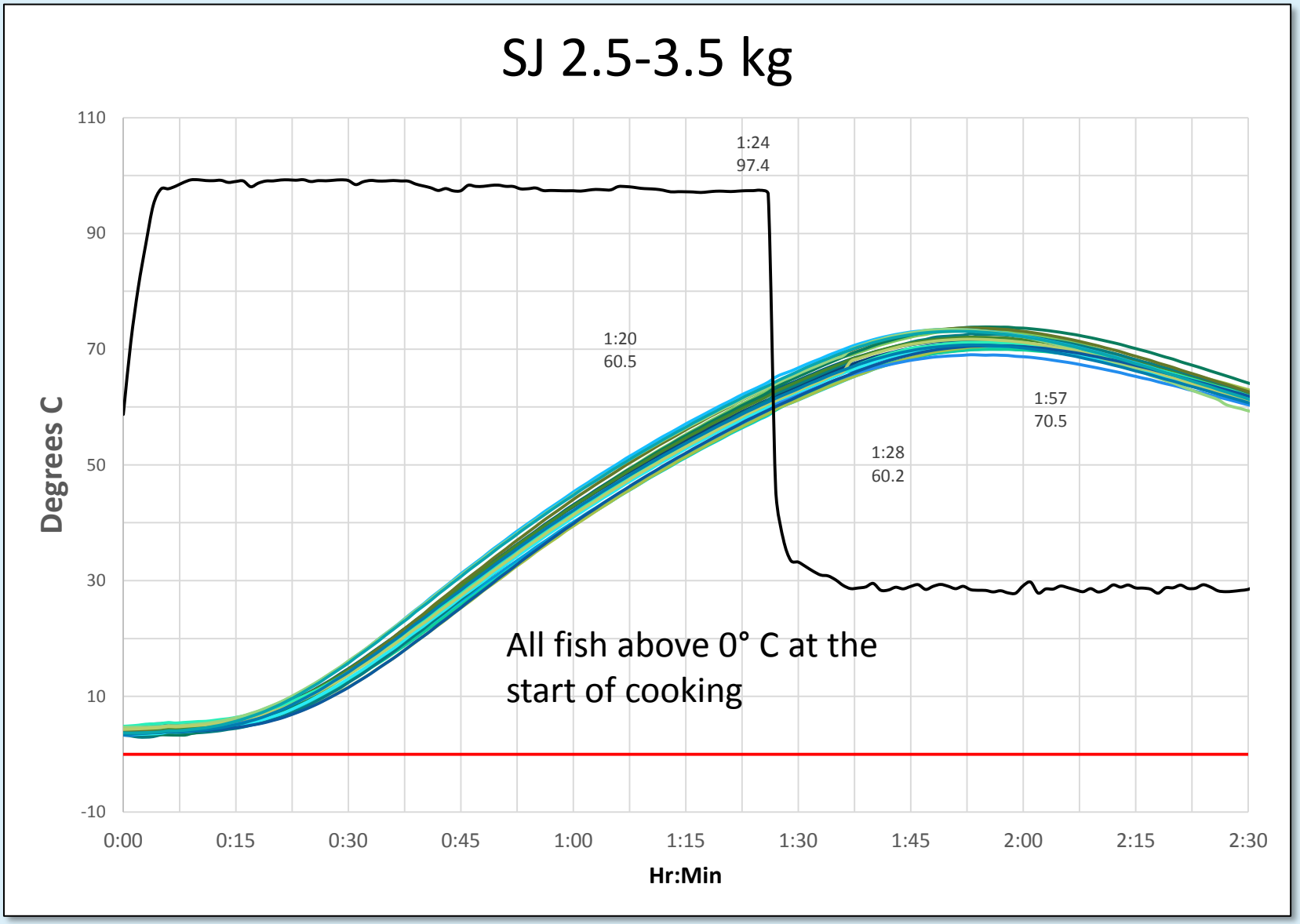
Albacore

Pre-cooking frozen fish

Poor scheduling… fish butchered too early




SJ 2.0-2.5 kg
110
90
70
50
30
10
-10
Degrees C
1:06
98.4
0:44
60.4
1:38
62.4
1:26
60.3
Fish above & below 0° C
at the start of cooking
0:27
0.0
0:00
0:15
0:30
0:45
1:00
1:15
1:30
1:45
2:00
2:15
2:30
Hrs_Min


SJ 2.5-3.5 kg
110
90
70
50
30
10
-10
Degrees C
1:24
97.4
1:20
60.5
1:57
70.5
1:28
60.2
All fish above 0° C at the start of cooking
0:00
0:15
0:30
0:45
1:00
1:15
1:30
1:45
2:00
2:15
2:30
Hr:Min

"Executive Summary"

Prerequisites

- Calibrate temperature measuring equipment
- Conduct formal survey of equipment at cooking & thawing
- Conduct temperature-distribution testing of equipment at cooking & thawing
- Develop categories for different sizes of tuna
- Sort fish properly at receiving
- Store fish by size
- Conduct heat penetration testing at cooking & thawing for each fish size
- Develop thaw & cook schedules from heat penetration data

Make sure all equipment is functioning as intended…

- ★ Calibrate temperature measuring equipment
- ★ Survey equipment at cooking & thawing
- ★ Conduct temperature-distribution testing of cooking & thawing equipment

Ensure consistent segregation of fish by size…

- ★ Develop categories for different sizes of tuna
- ★ Sort fish sizes at receiving and…
- ★ Store it by size

Establish formal thawing & cooking schedules…

- ★ Conduct heat penetration testing at cooking & thawing for each size category of tuna
- ★ Develop formal thaw & cook schedules from heat penetration data

In-Process

- Schedule fish for a smooth flow from cold store to cooking
- Avoid unnecessary delays through thawing & butchering
- Verify critical factors (initial temperature & fish weight) before cooking… No frozen fish
- Verify thermometer accuracy
- Collect temperatures quickly & accurately after cooking
- Evaluate temperatures after cooking to verify 5-log reduction of M. morganii
- Document lot identification details & processing data (times, temperatures, weights, etc.)

Schedule fish for a smooth process flow…

- ★ Schedule fish by size through thawing and butchering to ensure a direct flow to cooking
- ★ Avoid unscheduled delays

Make sure measuring does not impact results…

- ★ Have enough thermometers on hand to do the job
- ★ Train precooker personnel to collect temperatures quickly & accurately
  - Verify calibration at least daily

Verify that you have achieved what you intended…

- ★ Before cooking: Verify critical factors (initial temperature & size) are within the parameters used to establish the cooking schedule
- ★ After cooking: Verify minimum log lethality (5.0) of Morganella morganii has been achieved
  - Train precooker personnel to evaluate core temperature data

Executive Summary

★ Make sure all equipment is functioning as intended…

★ Ensure consistent segregation of fish by size…

★ Establish formal thawing & cooking schedules…

★ Schedule fish for a smooth process flow…

★ Measure in a manner that does not influence results…

★ Verify that you have achieved what you intended…

Any questions??

Thanks for your attention

John DeBeer
John.DeBeer@thaiunion.com

Chris Lord
protech1993@live.com

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