Reviewing & Updating the Mariner's 1-2-3 Rule "Danger Area to Avoid"

By Lee Chesneau

The 2016 hurricane season officially began June 1st for the North Atlantic Ocean, & May 15th for the eastern North Pacific Ocean, east of the International Dateline, (180 degrees longitude). The season has already gotten off to an early start in the North Atlantic Ocean with out of season January Hurricane Alex that affected Portugal's Azores. However, this does not necessarily mean that the hurricane season will be above normal. In the North Atlantic Ocean, the average number of Tropical Cyclones (TCs) is 11, and in the eastern North Pacific Ocean, the normal number is 15.

The tragedies of the tall sailing ships S/V Fantome & HMS Bounty in past years, and now even more so recently the loss of the M/V El Faro, with 33 souls on board last early October, clearly make headlines and the Monday morning quarterbacking that follows. I routinely teach about TCs and especially their avoidance in my education and training endeavors at a number of continuing professional maritime education and training institutions around the country. The tactics employed for TC avoidance are based on different methods today, and thus their methods needs to be better understood throughout the maritime industry, whether it involves large commercial container ships, or blue water cruising sail boats.

The most important vessel routing tactic in dealing with TCs is avoiding them in the first place. The Mariner's 1-2-3 utilized today, originally was an adaptation made from a U.S. Navy training film *"A Time for All Measures"* which was in use during the early 1970's. Then, the U.S. Navy adopted a procedure of creating a radius of 30 knot winds to a storm's initial and forecast center predictions. This was at a time when there were considerable forecast track errors for a TC's storm center, let alone its intensity. Back then also, the 30 knot wind radius for avoidance was very large because of the greater uncertainty of a TC's forecast of center errors, and then the U.S. Navy coupled that by adding an additional wind radius onto the original forecast radius for the same 30 knot wind (call it a *"buffer zone"*).

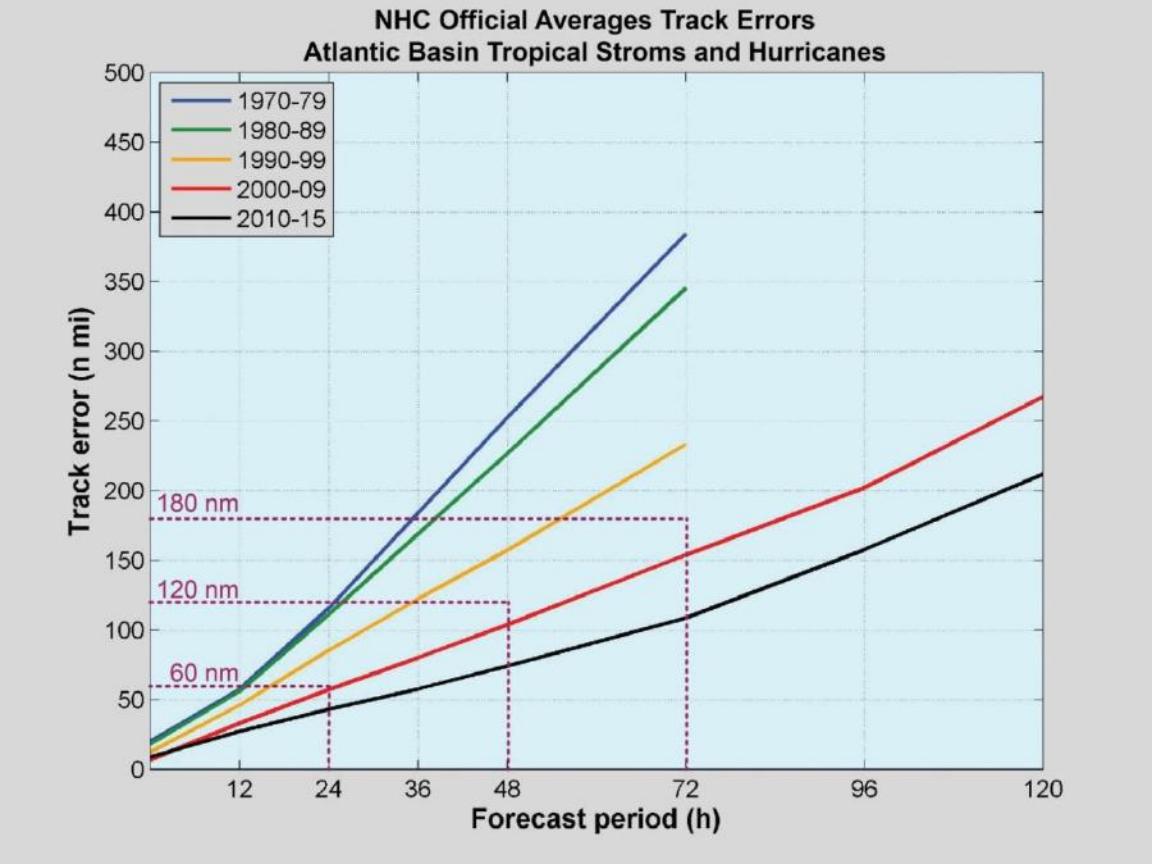
Today, we have modified the same concept that the U.S. Navy used, but incorporate a different minimum wind radius standard. The 34 knot wind radius, measured from the storm's center in nautical miles (nm), replaces the Navy's 30 knot wind radius standard. Keep in mind that sustained winds of 34 knots also becomes the lower range for a Gale Warning (34-47 knots). We also include a relatively smaller *"buffer zone"* added onto the initial or forecast 34 knot wind radius. This radius is built upon 10 year forecast averages for TC's forecast center position skill scores. We call this 34 knot wind radius plus the *"buffer zone"* combined as the *"Danger Area to Avoid"*.

The National Hurricane Center (NHC), housed on the campus of Florida International University in Miami, FL. is widely international in scope. The NHC is also a prominent major national center of the National Weather Service (NWS), and has the ultimate responsibility for forecasting TCs. That responsibility focuses on formulating and issuing advisories & forecasts for the different intensity stages of TCs, beginning with the early stage- Tropical Depression (or TD), with sustained wind up to but not greater than 33 knots, the Tropical Storms (TS) stage, & associated TS Warnings, with sustained winds that range between 34-63 knots, & the Hurricane stage, with its associated Hurricane Warnings, the sustained minimum winds are 64 knots (and it gets higher from there where there are different categories of hurricane strength). The area of forecast responsibility for the NHC covers the entire North Atlantic and North Pacific Oceans east of 180 degrees longitude (180).

Since the 1970s, the statistics the NHC uses to evaluate its skill in forecasting TCs are based on officially named TS & Hurricanes. Additionally, the TC track extends from the storm's center initial position & continues with sequential forecast extension information through 72 hours. Since 2010, however, the NHC forecast skill scores for TC storm center positions now extend further out in time from 72 hours through 120 hours. Below is ***figure # 1***, which represents the graphical skills scores for the NHC forecasting of TC center positions. This statistical graphical format provides the most

up to date forecast skill scores that one can visually compare to previous decades quite easily. The consistent improvements through the decades from the 1970s are obvious. Currently, the latest skill scores extend from 2010 to 2015 & continues to show steady improvement, but are only 5 year averages. So we will have to wait another four years until 2019 to consider 2010-2019 as a decade forecast average to compare the other decades with.

Figure # 1: NHC skill scores for the North Atlantic Basin, both Tropical Storms & Hurricanes. Included in this illustration are the overlaid incremental degrees of latitude in nm (60 nm-120nm-180 nm) or "1-2-3" degrees from 24-48 & 72 hours out, to form the basis for the Mariner's 1-2-3 Rule "Danger Area to Avoid" ("buffer zone)". It can be deduced further, that the 2000-2009 skill scores (the "red" tracking line), becomes the more logical "buffer zone" to add to the outer radius of 34 knot winds as contained within NHC's official Tropical Cyclone (TC) advisories & warnings.



Now, before one constructs any *"Danger Area to Avoid"*, one must access NHC's TC advisories and associated warnings which are widely disseminated in the public domain by a variety of different means, but needs to be explained and understood. NHC's official text formatted TC bulletin is known as the Tropical Cyclone Message (TCM). The TCMs are formatted specifically for the Federal Emergency Management Agency (FEMA), and not really constructed with an ocean navigator in mind. Thus, in this article, utilizing ***figure # 2*** below for **TROPICAL STORM ERNESTO- ADVISORY # 9**, we will "highlight" in yellow only the pertinent information within the TCM that an ocean navigator must know and extract.

The NHC issues the TCM into the public domain every six (6) hours. The issuance time is posted within the message header. For **TROPICAL STORM ERNESTO- ADVISORY # 9**, the issuance time & date is 2100 UTC FRI AUG 3rd. One will note that this exactly matches the same *"valid time & date"* of the initial TC center position, otherwise known as the "advisory position date/time". FEMA also receives the TCM at the same issuance time, which is what they have requested from the NHC all along. However, the TCM is still organized in a chronological time sequence that for each of the forecast segments tracking the storm's center positions and strength, an ocean navigator can follow with some degree of logic. In publication however, the TCMs still will be hard to read and understand without clearer explanations.

So, in deciphering the TCM, the ocean navigator first needs to read past the TCM's product indentation header

before reviewing the specific initial storm conditions, which are all based on the "advisory time & date". As indicated in ***figure # 2,*** the *"advisory time & date"*- 2100 UTC FRI AUG 3rd, will always be three (3) hours ahead of the standard *"synoptic time & date"*- 1800 UTC FRI Aug 3rd (please note that UTC now was formerly GMT). Thus, within the TCM for the initial storm information format, depicted is the *"advisory position, time & date".* However, in ***figure # 2***, the initial storm position, date/time is depicted in a bit different order; 13.9N 64.1W at 03 Aug 2100 UTC. This is followed by additional information includes the storm's direction & forward speed of movement in knots, 275 degrees or west 05 knots, the maximum winds near the center 45 gusts to 55 knots, & then finally, the central barometric pressure, which is given in millibars (mb)-1002 mb.

Now for the TCM in ***figure # 2***, the *"synoptic date/time & position"* is at 03 Aug 1800 UTC 13.8N 63.3W, is depicted in a different order than the "advisory position & date/time", but will always be 3-hours behind . Keep in mind in the standard meteorological & oceanographic world, there are four traditional *"synoptic times"* - 00/06/12/ & 18Z, each of the six (6) hourly *"synoptic times"* are built around various analyses and forecast products with the same *"valid times"* six (6) hours apart in sequence (e.g., the ever popular & reoccurring NWS Surface Pressure Analyses). The *"synoptic date/time & position"* information can be found directly below the *"advisory position, date & time"* (where it is repeated again for the second time). Now the ocean navigator can compare both *"advisory & synoptic date/time & positions".* These are provided with precise latitude & longitude information, and are conveniently located underneath one another for easy comparison. It will be readily apparent to the ocean navigator that the latitude & longitudes will be in close proximity, except for very fast moving storms. This will depend of course on the forward speed of the storm. In the case for **TROPICAL STORM ERNESTO- ADVISORY # 9**, the forward speed is rather slow, only 05 knots. In addition to storm center initial & forecast positions, there are the associated 64, 50, and 34 knot wind radii given in quadrants, that extends outward from each of the storm's center segments given in nm. For ***figures # 2 & 3,*** only the 34 knot wind radius information is provided as there is no 50 knots radius.

From the *"advisory & synoptic date/time & positions"*, there are the sequential forecasts segments. The specific time & date sequence extends from 12-24-36-48-& 72 hours out. However, each of the forecast time & date sequences should only be based from the current valid "synoptic date/time & position". It is important to mention this in fine detail at this point, because the same type of storm information as contained within the initial "advisory & synoptic positions date/ times" is also within the forecast segments of storm information that follow in the same aforementioned chronological order. Note also, that for each of the incremental sequential segment forecasts, the *"valid date/times "* match up equally from the original base valid *"synoptic date/time"* (03/1800Z for **TROPICAL STORM ERNESTO- ADVISORY # 9**). There are also further abbreviated forecast segments of information which extend out to 96 and 120 hours. However, the latter two extended forecast segments *"valid date/ time, & positions"* will just depict the latitude and longitude as well as maximum wind intensity near the storm's center, without any wind radii forecasts. The purpose of the latter two forecast segments are for a general outlook for position and intensity trends. At the end of the TCM in ***figure # 2***, the next updated TCM's issuance date & time will be depicted; for example, NEXT ADVISORY 04/0300 UTC, located just above the forecaster's name "BLAKE". Note, that the TCM, like the NWS's Surface Pressure Analyses, are disseminated every six (6) hours by the NHC and are received in very close proximity with one another.

Thus, the information needed for an ocean navigator to plot out the "Danger Area to Avoid" begins with the current *"synoptic date/ time & position,"*. For ***figure # 2***, the specifics for **TROPICAL STORM ERNESTO- ADVISORY # 9** have already been noted above. This is then followed by the sequential 24-48- 72 hour incremental forecast segments (excluded are 12-36-96- 120- hour segments). The pertinent data to plot is the storm center positions and their *"valid date/times"* (for this article we have manually annotated the forecast hours in "red" to the left). Note that the exact times in hours are determined simply by inspecting each of the *"valid date/times"* for each forecast segment. It is recommended that the ocean navigator should always reference the original valid *"synoptic date/time & position.* The specific storm segment information again for viewing convenience is "highlighted in yellow"; *"valid date/time"* along

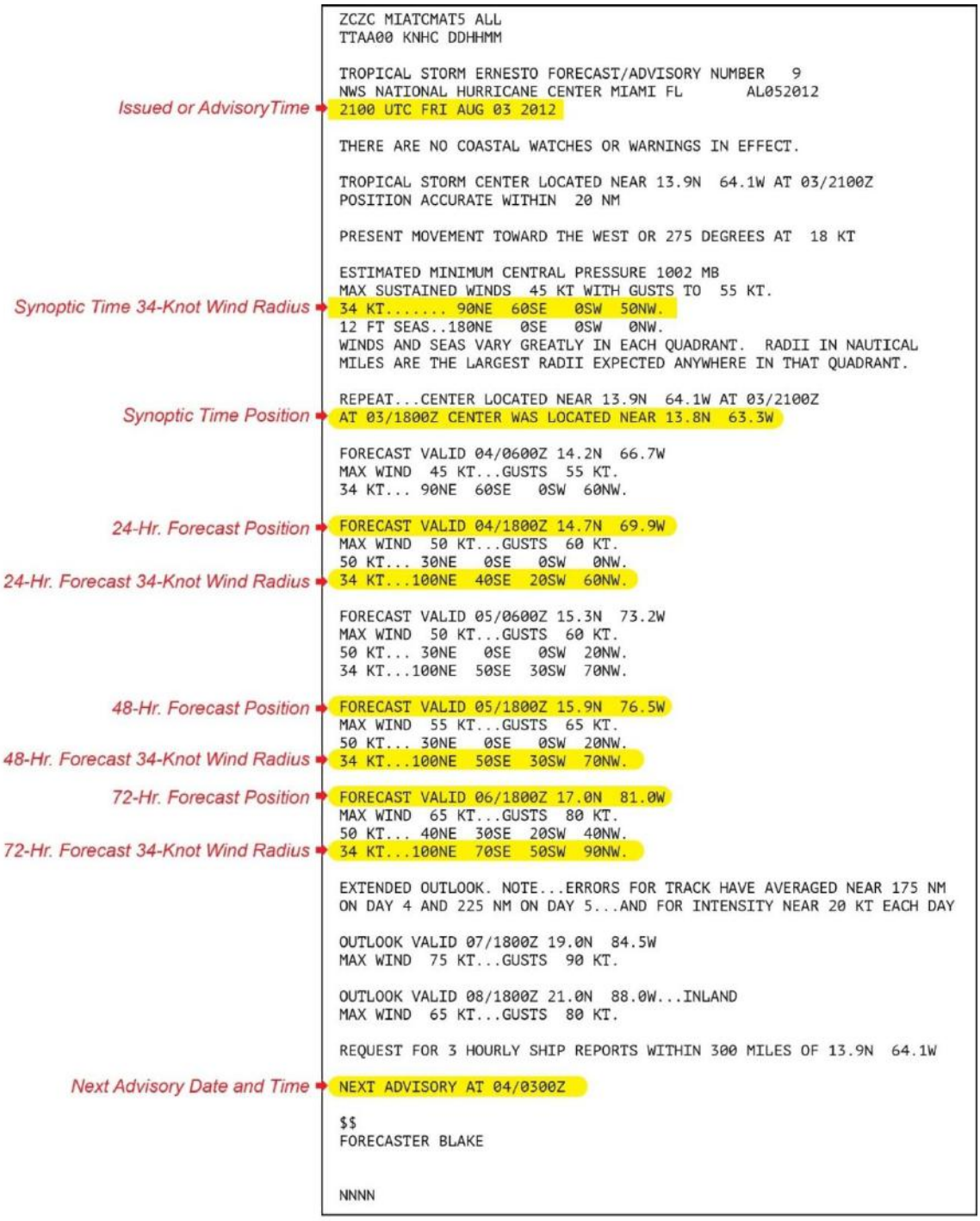
with the latitude & longitude positions, and of course the 34 knot wind radius (we leave out the 50 knot wind radius). This specific block of information of course is contained within all TCMs. So, from ***figure # 2*** … we lay out the sequential forecast segments of information to be read in the horizontal;

FORECAST VALID 04/18Z 14.7N 69.9W FORECAST VALID 05/18Z 15.9N 76.5W FORECAST VALID 06/18Z 17.0N 81.0W

34 KT ….100NE 40SE 20SW 60NW 34 KT ….100NE 50SE 30SW 70NW 34 KT ….100NE 70SE 50SW 90NW

Thus, from ***figure #2*** , each extracted 24-hour forecast segment as depicted horizontally above, & is to be read from left to right (24-48-72 hours)… once again, will <u>always extend</u> from the original valid *"synoptic date/time & position" (*for **TROPICAL STORM ERNESTO-ADVISORY # 9**) …03/1800Z- 13.8N 63.3W , 34 knot radius…90NE 50SE 0SW 50NW.

Figure # 2: NHC's TCM Advisory # 9 for Tropical Storm Ernesto

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ZCZC MIATCMAT5 ALL
TTAA00 KNHC DDHHMM

TROPICAL STORM ERNESTO FORECAST/ADVISORY NUMBER   9
NWS NATIONAL HURRICANE CENTER MIAMI FL       AL052012
2100 UTC FRI AUG 03 2012

THERE ARE NO COASTAL WATCHES OR WARNINGS IN EFFECT.

TROPICAL STORM CENTER LOCATED NEAR 13.9N  64.1W AT 03/2100Z
POSITION ACCURATE WITHIN  20 NM

PRESENT MOVEMENT TOWARD THE WEST OR 275 DEGREES AT  18 KT

ESTIMATED MINIMUM CENTRAL PRESSURE 1002 MB
MAX SUSTAINED WINDS  45 KT WITH GUSTS TO  55 KT.
34 KT..... 90NE  60SE   0SW  50NW.
12 FT SEAS..180NE   0SE   0SW   0NW.
WINDS AND SEAS VARY GREATLY IN EACH QUADRANT.  RADII IN NAUTICAL
MILES ARE THE LARGEST RADII EXPECTED ANYWHERE IN THAT QUADRANT.

REPEAT...CENTER LOCATED NEAR 13.9N  64.1W AT 03/2100Z
AT 03/1800Z CENTER WAS LOCATED NEAR 13.8N  63.3W

FORECAST VALID 04/0600Z 14.2N  66.7W
MAX WIND  45 KT...GUSTS  55 KT.
34 KT... 90NE  60SE   0SW  60NW.

FORECAST VALID 04/1800Z 14.7N  69.9W
MAX WIND  50 KT...GUSTS  60 KT.
50 KT... 30NE   0SE   0SW   0NW.
34 KT...100NE  40SE  20SW  60NW.

FORECAST VALID 05/0600Z 15.3N  73.2W
MAX WIND  50 KT...GUSTS  60 KT.
50 KT... 30NE   0SE   0SW  20NW.
34 KT...100NE  50SE  30SW  70NW.

FORECAST VALID 05/1800Z 15.9N  76.5W
MAX WIND  55 KT...GUSTS  65 KT.
50 KT... 30NE   0SE   0SW  20NW.
34 KT...100NE  50SE  30SW  70NW.

FORECAST VALID 06/1800Z 17.0N  81.0W
MAX WIND  65 KT...GUSTS  80 KT.
50 KT... 40NE  30SE  20SW  40NW.
34 KT...100NE  70SE  50SW  90NW.

EXTENDED OUTLOOK. NOTE...ERRORS FOR TRACK HAVE AVERAGED NEAR 175 NM
ON DAY 4 AND 225 NM ON DAY 5...AND FOR INTENSITY NEAR 20 KT EACH DAY

OUTLOOK VALID 07/1800Z 19.0N  84.5W
MAX WIND  75 KT...GUSTS  90 KT.

OUTLOOK VALID 08/1800Z 21.0N  88.0W...INLAND
MAX WIND  65 KT...GUSTS  80 KT.

REQUEST FOR 3 HOURLY SHIP REPORTS WITHIN 300 MILES OF 13.9N  64.1W

NEXT ADVISORY AT 04/0300Z

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FORECASTER BLAKE


NNNN
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The methodology of just focusing on the storm center position and the 34 knot wind radius as gleamed from ***figure # 2***, should make it easier for the ocean navigator to quickly review and evaluate only the necessary pertinent information as contained within the TCM…which will be always be depicted in the vertical. Thus, an ocean navigator can immediately extract what information is needed in plotting out the "Danger Area to Avoid". It does becomes apparent also that the ocean navigator will also need to do their own "highlighting" for subsequent TCMs as a matter of standard format for simplistic logical viewing and plotting procedures.

Now we are ready to start constructing a *"Danger Area to Avoid".* The often asymmetrical nature of a TC's wind field is such that the wind radii for wind strength (e.g. 64, 50 & 34 knots) may not be equal during a significant portion of the storms life cycle. However, we will always use only the 34 knot wind radius as the standard minimum sustained winds any vessel needs to stay clear of. We need to repeat again, that the radius of 34 knot winds extends outward from the storm's center *"synoptic date/time & position"*, as measured in nm. The wind radius is given in quadrants; NE, SE, SW, and NW. For easier plotting, one should make the largest quadrant the same for all other quadrants. Also, in the storm's current initial conditions segment for both *"advisory & synoptic date/time & positions"*, the radius of 12 foot seas is also provided, but not available with any of the incremental forecast segments, and therefore will not be utilized for constructing the *"Danger Area to Avoid".* ***Figure # 3*** below illustrates the graphical representation of the aforementioned initial *"advisory & synoptic" conditions* as gleam from **TROPICAL STORM ERNESTO-ADVISORY # 9.**

Figure # 3: The 34-knot wind radius data as compiled from the "advisory & synoptic positions" information for TROPICAL STORM EARNESTO-* ADVISORY # 9; *the 34 knot wind radius drawn will be 90 nm from the center as illustrated for easier construction & viewing (the NE quadrant being the largest and made equal for all quadrants, regardless how small the other quadrant's 34 knot wind radius are). Note that the 12 foot seas radii are not only be available in any of the sequential forecast segments.

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ESTIMATED MINIMUM CENTRAL PRESSURE 1002 MB
MAX SUSTAINED WINDS  45 KT WITH GUSTS TO  55 KT.
34 KT....... 90NE  60SE   0SW  50NW.
12 FT SEAS..180NE   0SE   0SW   0NW.
WINDS AND SEAS VARY GREATLY IN EACH QUADRANT.  RADII IN NAUTICAL
MILES ARE THE LARGEST RADII EXPECTED ANYWHERE IN THAT QUADRANT.
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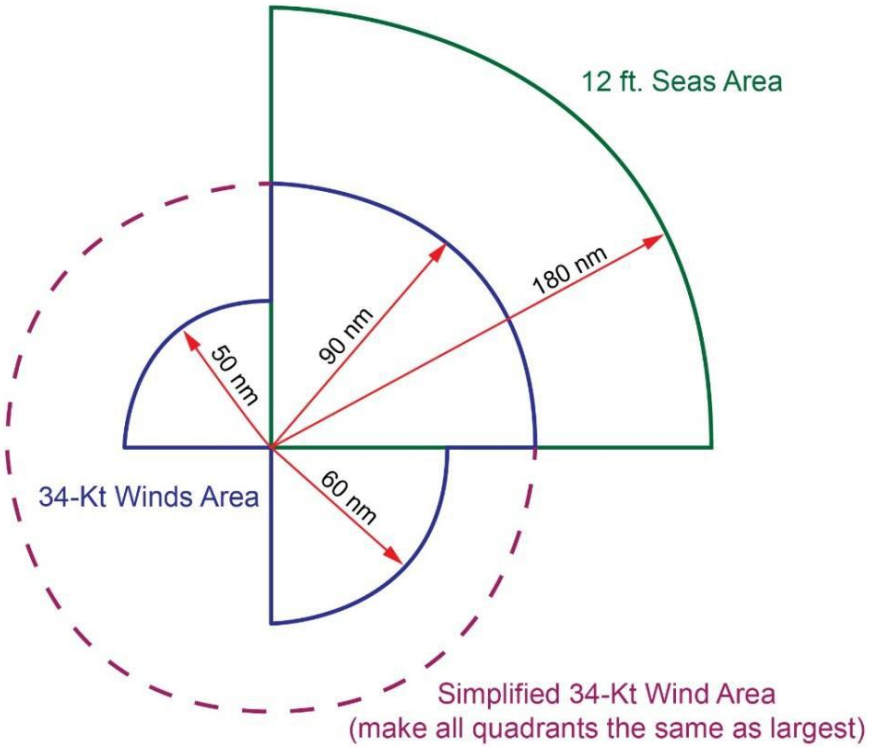
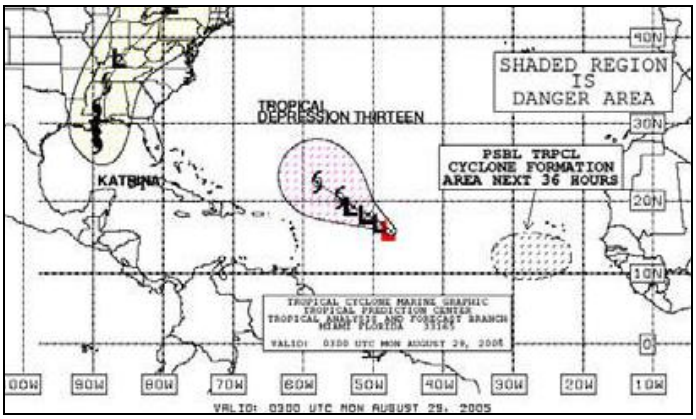
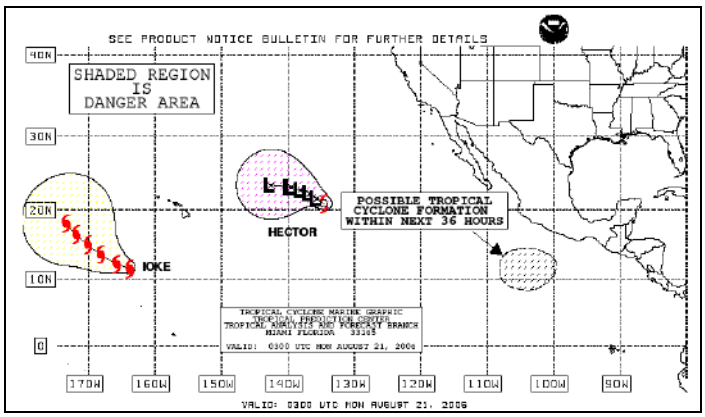


So, as illustrated in ***figure # 3*** above, constructing a symmetrical 34 knot wind radius from the storm center is what an ocean navigator should utilize for each of the forecast segments that follows. By keeping the largest quadrant equal for all of the other quadrants in each of the 24-48 and 72 hour forecast segments, we are replicating what we constructed from the conditions given in the *"synoptic date/time & position" segment*, skipping the interim 12 and 36 hour forecasts segments.

Once we have plotted and evaluated the TC center positions and the associated 34 knot wind radius for each of the sequential forecast segments as gleamed from the TCM, next we need to manually add the "buffer zone" to complete the "Danger Area to Avoid". The NHC's webpage offers their own graphical representation look of the "Danger Area to Avoid" through 72 hours, but based on 1990s skill scores (***Figures # 4A & 4B* below**).

Figures # 4A & 4B are the NHC's graphical depiction of "Danger Area to Avoid" for real time named "TCs" for the North Atlantic & Pacific Oceans east of 180; See NOAA's "Tropical Cyclone Danger Area to Avoid" graphic explanation:
http://www.nhc.noaa.gov/pdf/TAFB_danger_graphic.pdf

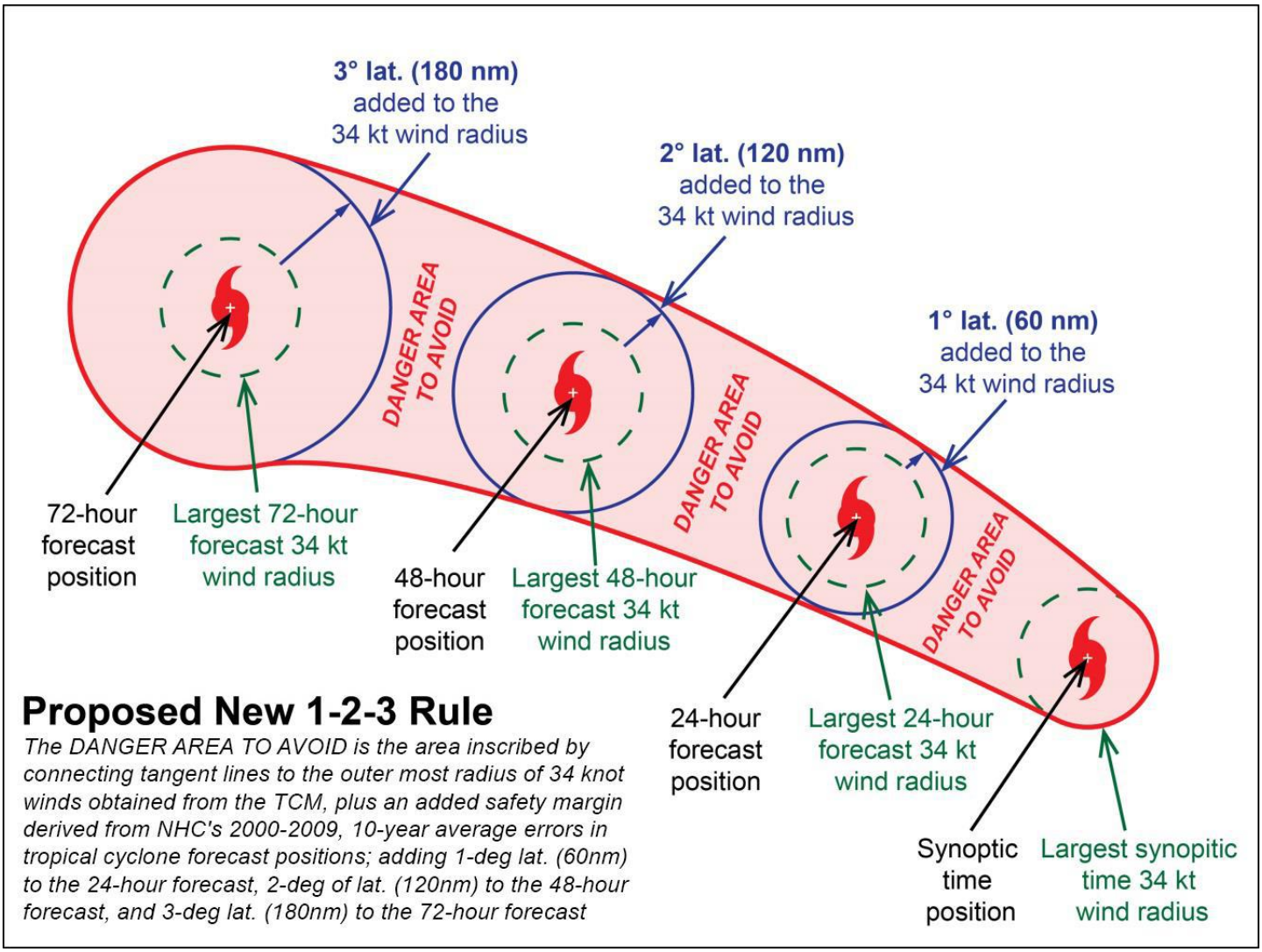




However as already noted in ***figure # 1*** previously, the overall skill scores of the NHC for TC tracks of storm centers over the decades since the 1970's, have significantly improved. When one reviews the steady and compelling NHC forecast improvements, we can easily adjust accordingly and construct a more realistic "buffer zone" to add to the TCM's 34 knot wind radius that better fits today's realities. This means including the most current and more accurate NHC skill score data, the 2000-2009decade skill scores as tabulated in ***figure # 1.***

When we recognize the 34 knot wind radius as the standard wind force to avoid, we are referring to just the minimum winds for "Gale Force", where the higher wind conditions for that category of warning can range up to 47 knots; thus the corresponding sea states can and do OFTEN get exponentially higher. When one considers the persistence of these conditions over an extended period of time (e.g. 24- hours or more), such persistence will not only favor the generation of fully developed high sea states, but even extreme waves, which can be double the normal significant wave heights (defined as the average of highest 1/3 of the waves present). A storm that is building in strength even over a relatively short time span, results in enhancing or extending the size of a given wind radius, will also likely increase the fetch area and thus the potential for increased and extreme wave heights. This then increases the probability of breaking wave conditions (greater impact force on a vessel's hull). ***Figure # 5*** below, provides an updated Mariners' 1-2-3 Rule "Danger Area to Avoid", the illustration which includes both the 34 knot wind radius plus the updated "buffer zone" that an ocean navigator should adopt today for TC avoidance.

Figure # 5, the recommended updated "Danger Area to Avoid" which is inclusive of the "synoptic time", as well as each of the 24, 48, & 72 hour forecast positions, the 34 knot wind radius for each forecast position, plus the errors of uncertainty in each of the respective forecasts positions, based on 2000-2009 HNC forecast center skill scores.



For **TROPICAL STORM ERNESTO- ADVISORY # 9**, in ***figure # 2***, we will need to add 60nm to the outer radius of 34 knot winds of 100 nm at 24 hours, 120 nm to 100 nm at 48 hours and 180 nm to 100nm at 72 hours. Note the 34 knot wind radius of 100 nm is the same for each of the 24-48 & 72 valid date/time & storm center position forecasts, as conveyed in the TCM, for ***figure # 2***. Once again keep in mind the asymmetrical nature of the other quadrants for 34 knots, and by making all quadrants equal to the largest quadrant (100nm), this makes it much easier and more practical for an ocean navigator to plot out and construct the "Danger Are to Avoid".

It becomes obvious, that a vessel operating within the 34 knot wind radius will be subject to deteriorating conditions, regardless of its size, with the strategic options become significantly reduced. This is even more so applicable whenever there is a high degree of forecast uncertainty, which can happen with any TC. This may have been the case for El Faro in dealing with Hurricane Joaquin (see ***figures # 6A & 6B*** below).

Figure # 6A (left) the actual El Faro & Hurricane Joaquin tracks from 30 September to 01 October, 2015, including various wind radii as depicted from the sequential issuances of the NHC's TCMs. For Figure # 6B on the right, El Faro's apparent planned track from Jacksonville, FL to Puerto Rico combined with the official NHC's advisory # 10, issued 5 AM September 30th, 2015. The storm's center advisory and forecasts are graphically plotted including the area of uncertainty cone through 72- hour. Overlaid also is the 34 knot wind radius including the "buffer zone" for each forecast segment from the initial "advisory position" (5 AM) to the subsequent 24-48-72 sequential 2 AM forecast segments all superimposed. It is clear that the planned track of El Faro is well within the "Danger Area to Avoid".

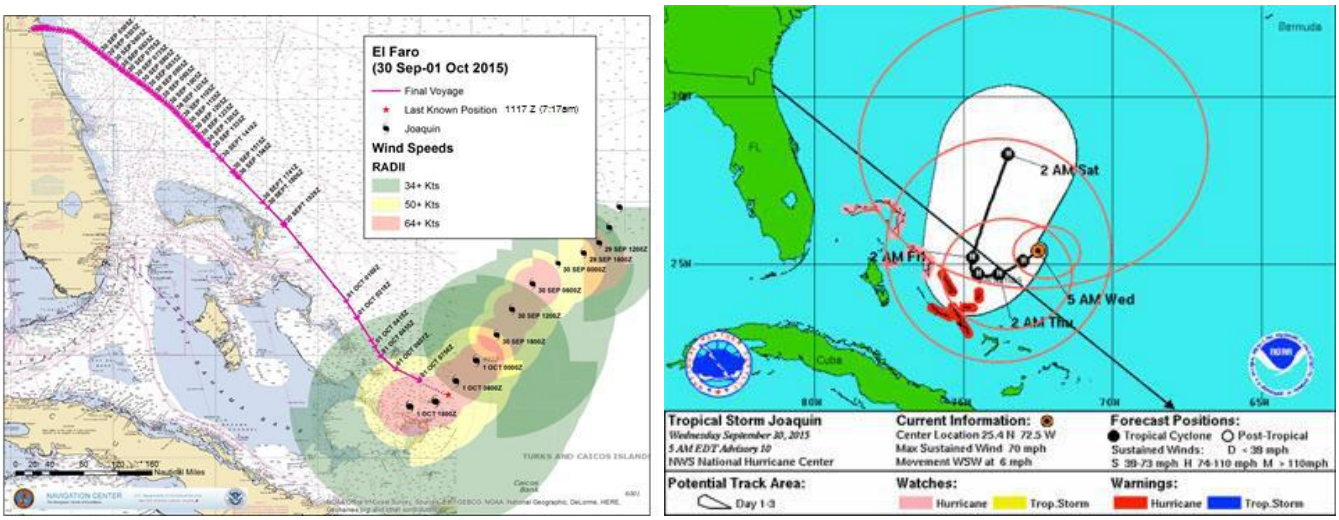


Figure # 6A on the left (from the USCG public hearings) reveals El Faro's track vis a vis Hurricane Joaquin from 30 September, through 01 October, 2015, whom underwent a steady intensification into a major hurricane as it was developing and intensifying initially as a Tropical Storm. Each storm center plot also reflected the six hourly positions as reflected for the "advisory date/time & positions" and the different wind radii (64, 50 & 34 knots).

Figure # 6B on the right (courtesy from Locus Weather, Camden, ME) was El Faro's apparent planned voyage track to Puerto Rico from Jacksonville, FL, plus the NHC's Hurricane Joaquin's advisory # 10 from the "advisory date/time & forecast positions" through 72 hours, as depicted graphically from the TCM. In addition, the forecast storm center tracks are encased with the typical forecast error cone in white (all based on NHC's 1990's skill scores). However, also superimposed in "red" is the "Danger Area to Avoid" of 34 knot wind radius, based on 2000-2009 NHC skill scores. The overlay of El Faro's planned voyage track depicts just how far inside the "Danger Area to Avoid" El Faro would be, and as it turned out, seemingly disregarded applying the Mariner's 1-2-3 Rule for avoidance. At the time El Faro left Jacksonville, FL, Joaquin was developing as a TS. El Faro did not make any apparent significant adjustments to its route plan as she continued sailing directly into the storm's core winds when Joaquin became a major hurricane. What was the likely thought process, other than the possible original thinking of whether TS Joaquin would not develop into what it became? It would be speculation at this point as to whether the route plan may have not been different if Joaquin was already a hurricane before El Faro's departure from Jacksonville. So what if it was, Tropical Storms are as much a threat to any vessel, large or small, slow moving, or fast!

As gleamed from the 18 page "Nimitz Typhoon Letter", the most profound key excerpt any ocean navigator can be reminded of: ***"The time for taking all measures for a ship's safety is while still able to do so. Nothing is more dangerous than for a seaman to be grudging in taking precautions lest they turn out to have been unnecessary. Safety at sea for a thousand years has depended on exactly the opposite philosophy".*** Typhoon Cobra, as it was unofficially named, & the follow up and aftermath of the most devastating weather related disaster that occurred in the Pacific theater, during WW11, was profound and has lasting impacts, even today. The one online link amongst quite a number of excellent links, one can examine further (e.g., http://www.usshullassociation.org/DD350/Hull350-2.htm). There are also several books that have been written as well, but *"Typhoon the Other Enemy"* by C. Raymond Calhoun, stands a bit above the rest

My concluding comments are that mariners need to take the initiative and embrace the updated "Danger Area to Avoid" concept. TCs and their critical impacts often come well before a storm has reached its peak intensity and has already disrupted commerce and the shipping lanes! Mariners need to further respect the power of these storms, especially more so when they are still in their infancy. Even though the skill scores of TC storm center prediction have significantly improved over the decades, the ability of the NHC to predict their intensity lags behind! The NHC will readily admit to

that (hence another reason for the “buffer zone”). The bottom line for an ocean navigator’s decision making process is to physically plot the TCMs pertinent information as pontificated in this article on a navigation plot, especially its “Danger Area to Avoid”. This will allow for analyzing precise visuals for the ability to engage in rational prudent planning and decision making!!