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TA DX FROM WEST COAST NORTH AMERICA

by Nick Hall-Patch and Bruce Portzer

Over the years, a number of articles have appeared concerning medium wave trans-Atlantic DX from east coast North America (ECNA), but very little has appeared concerning reception of European and African stations from west coast North America (WCNA). Generally, the implication has been that since MW signals on low latitude TA paths to ECNA are the most likely to be heard there, then such low latitude signals are the most likely to be heard further west in North America.

So, what are the necessary conditions for TA DX on the east coast? Richard Eckman in "Transatlantic DXing" (IRCA Foreign Log, Vol. 7) notes that it helps to have a loop antenna and a good receiver with sufficient selectivity to separate splits from domestics. Quiet geomagnetic conditions for at least several days are necessary for good high latitude TA reception. Quiet conditions are indicated by a low geomagnetic index (A-index less than 5) for several successive days. The A_{BO} index is one such index and is transmitted by WWV. Peak TA DX time tends to be in the autumn months. Mark Connelly's "ITU Frequency Allocations and Their Impact on TA DXing" (IRCA Foreign Log, Vol. 8) contains an analysis of likely TA receptions from Virginia through Maritime Canada. The most probable receptions according to this article, are from Iberia, then northwestern Africa and southern Europe, Britain, then northern Europe, the Middle East, and way down the list, the Baltic USSR. This list assumes that the power and frequency of stations in different zones are similar.

"MW Signal Paths" by Gordon Nelson (NRC reprint P1) doesn't cover a great deal about WCNA reception of TA's, but shows that the southern edge of the auroral zone (a slightly oval doughnut shaped ring of charged particles 50-80 km above the earth's surface, centered on the north magnetic pole) defines the northernmost TA path that is viable to ECNA. One map in this article shows a WCNA TA path south of the leading edge of a northerly auroral zone, one which would follow "a very long period of auroral quiet in a year of a sunspot minimum". The article affirms that such a far northerly location of the auroral zone would not be common except in years of sunspot minimum.

Gray Scrimgeour in "Relation Between Geomagnetic Measurements and MW DX Conditions" (IRCA reprint T26) observed that receptions of European signals in La Jolla, CA during October through December of 1965 occurred on days with a low geomagnetic index, though days with a low A index did not not necessarily mean that TA's would be heard. The article states that "a period of low geomagnetism was associated with each of these receptions". Low geomagnetism is defined (as in Eckman's TA DX article) as a preferably lengthy period when the daily A-index does not rise above about 5. Scrimgeour suggested that TA reception on days with a higher A-index were at the end of a period of TA reception and that the higher A value was due to an increase in geomagnetic activity after the final TA's were logged on that day. Gordon Nelson in "Limitations of the A-index for MW DX Purposes" (NRC reprint P12) expands on this idea.

How do the various observations regarding TA reception on ECNA and the WCNA observations above match up with actual loggings of TA's from WCNA? We have sifted through loggings from DX News (dating back to 1960), DX Monitor (from its inception in 1964) and the IRCA Foreign Logs, and with some assistance from Roy Millar, have compiled a list of all known loggings of European and African stations from California, Oregon, Washington and British Columbia, from September 1960 to April 1981. From these loggings we have related reception to a number of different variables. For the purpose of this article, Europe and Africa are divided into four zones. Zone 1 is on a 10-25° bearing from all WCNA (there's not much difference in bearings when looking at Europe from WCNA, e.g. Warsaw is 23° from Los Angeles, 22° from Seattle), and covers Scandinavia, Eastern Europe and the Middle East. Zone 2 is from 25-40° and covers Western Europe and North Africa. Zone 3 is from 40-55° and covers Iberia and northwestern Africa, while Zone 4 is from 55-70° and covers West Africa. WCNA is divided into two zones--Zone A is from southern British Columbia to southern Oregon, while Zone B is all of California.

A points system was used to total TA loggings for analysis. Each logging of a TA station carrier counted as one point; a station with weak and perhaps occasionally readable audio rated a multiplier of two; a station with good, mostly readable audio rated a multiplier of three. So if four TA loggings occurred on 10/21/65, one with fairly good audio (3), one with carrier only (1) and two with weak audio (2), then the "quality" total for that day was 3+1+2+2 = 8 points for four stations logged. These quality totals are what were used to compute graphs of reception vs. season etc., rather than just the totals of TA stations and carriers logged.

A statistician would probably throw up his hands in horror at what we've done, because searching for TA's from WCNA is not something that is done regularly by highly-skilled and well-paid monitors. Extraordinary receptions are noted only if any of a small number of DXers were listening at the time. Then these DXers must have reported their catches to a DX journal so that we could gather the data some years later. For example, it's very difficult to say if it is significant that in 1966/67, TA's were logged from California only, or that in 1980/81 they were logged from Oregon north only. It might simply mean that nobody was listening from the areas that didn't report TAs. Also, DXers tend not to report "easier" TA catches as an opening progresses, and often don't report all carriers heard during an opening, which would tend to make excellent openings seem less impressive in pure totals. On the other hand, in a "dry" season, every tiny carrier might be reported.

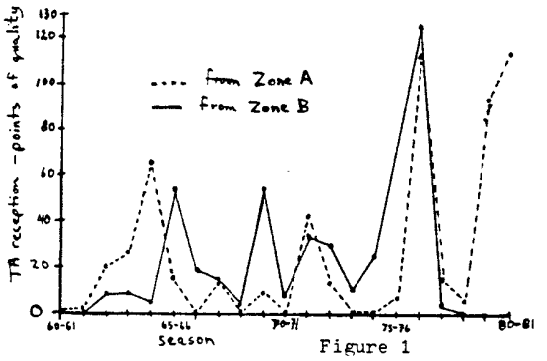

Figure 1

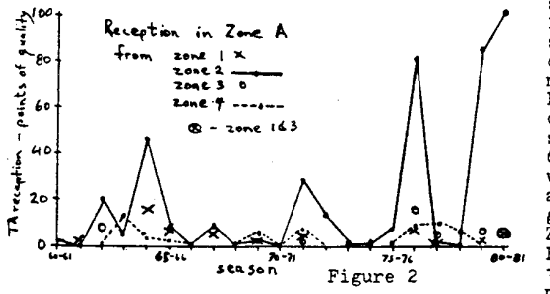

Figure 2

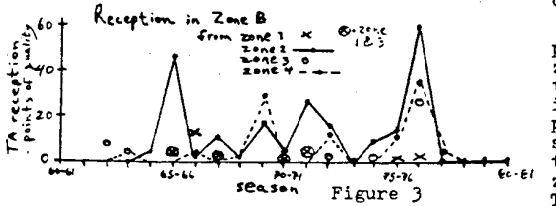

Figure 3

First, we plotted TA receptions (taking quality into account) against seasons, to give us an idea of how TA reception has varied over the years. Figure 1 shows total TA receptions in both zone A and zone B. Generally, the number of days of TA reception follow the same pattern as quality of TA reception, though the variation from minimum number of days to maximum number of days is less exaggerrated. In Figure 2, receptions from each zone in Europe and Africa from Zone A are plotted against time. In Figure 3, these receptions are from Zone B.

Keeping in mind that sunspot minima occurred in 1964 and in 1976, it would seem that good reception occurred during sunspot minima in both Zones A and B. But the good openings of 79-81 occurred around sunspot maximum, and the 69-70 and 71-72 openings were quite a few years off a minimum. Looking at the graphs of receptions from Zones 1-4 to Zone A or Zone B in WCNA, shows that receptions from Zone 2 had a major effect on the graph of overall TA receptions.

For the 20½ year period, totals for each TA zone were tallied for the two WCNA zones. These are in Table Ia on the next page. Total individual stations logged were also tallied for the two WCNA zones, and are indicated in Table Ib.

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WCNA zone #		TA zone # 1	2	3	4
	A	51	412	41	53
	B	27	202	54	106

Table Ia--total TA reception points

WCNA zone #		1	2	3	4
	A	12	29	3	2
	B	5	21	9	3

Table Ib--total TA stations heard

It becomes immediately obvious that we're looking at quite a different set of TA catches from those known to the ECNA DXer. The easier low latitude TA stations for the ECNA DXer seem to be rather more unusual for the WCNA DXer, especially the DXer in Zone A, where only two high power Algerians and a single Portuguese station have been definitely heard in 20½ years. Yet the more common TA catches on the west coast seem to be higher latitude path north Europeans and even, in Zone A, the highest latitude path Eastern Europeans. There appears to be a healthy number of loggings from Zone 4 considering the scarcity of target stations, but Zone 4 appears much more likely from California than from further north.

Next, totals were made of days of each month over 20½ years that TAs from different zones were heard, and the probability of hearing TA's in each month was calculated. Total quality of reception (using the system described above) for each month over 20½ years was also calculated. Table IIa and IIb below speak for themselves. Probability of receiving any TA of any strength in Zone A seems best in October, followed by March, September and November. Best strength TA's in zone A were in October, then in March, November and September. November seems the best month for Zone 4 and Zone 1 receptions however. In Zone B, October also seem the most probable month for receiving TAs with good strength, but November and December follow in order of likelihood. March is way down in total days when TA's were received, but Jim Young cleaned up on March 6, 1977 which pushes the quality up for that month. Jim's loggings on December 3 and 4, 1976 also pushed up December's quality ratings considerably. Like we said, a statistician would be horrified... Zone 4 and Zone 1 seem to be favored in California in November, and in general, Zone 4 is best November through February.

Table IIa--Daily probablity for WCNA TA reception by month

	Month	# of days that TAs heard from zone 1	2	3	4	Total days of TA reception	Possible days over 20½ years	Probability (%) zones 1	2	3	4	total
Zone A	Jan	1	3	0	3	6	620	0.2	0.5	0.0	0.5	1.0
	Feb	0	0	0	0	0	565	0	0	0	0	0
	Mar	1	15	3	3	22	620	0.2	2.4	0.5	0.5	3.5
	Apr	0	1	0	3	4	600	0	0.2	0	0.5	0.7
		------no TA receptions in May, Jun, Jul, or Aug------										
	Sep	1	14	3	1	16	630	0.2	2.2	0.5	0.2	2.5
	Oct	7	28	3	7	35	651	1.1	4.3	0.5	1.1	5.4
	Nov	7	10	3	8	20	630	1.1	1.6	0.5	1.3	3.2
	Dec	3	7	0	3	9	651	0.5	1.1	0	0.5	1.4
Zone B	Jan	0	8	4	5	13	620	0	1.3	0.6	0.8	2.1
	Feb	0	1	1	7	9	565	0	0.2	0.2	1.2	1.6
	Mar	0	2	2	3	6	620	0	0.3	0.3	0.5	1.0
	Apr	0	0	0	0	0	600	0	0	0	0	0
		------no TA receptions in May, Jun, Jul, or Aug------										
	Sep	1	6	0	4	7	630	0.2	1.0	0	0.6	1.1
	Oct	6	23	5	6	28	651	0.9	3.5	0.8	0.9	4.3
	Nov	4	14	1	8	27	630	0.6	2.2	0.2	1.3	4.3
	Dec	2	9	2	13	18	651	0.3	1.4	0.3	2.0	2.8

Months	Jan	Feb	Mar	Apr	Sep	Oct	Nov	Dec	
Zones									
1	3	0	1	0	2	18	19	11	Zone A
2	14	0	116	1	104	130	37	25	
3	0	0	12	0	8	4	5	0	
4	6	0	13	4	3	13	16	4	
Total	23	0	142	5	117	155	77	40	
Zones									
1	0	0	0	0	1	7	13	2	Zone B
2	15	2	13	0	21	77	23	65	
3	5	2	13	0	0	11	2	14	
4	8	17	5	0	7	12	25	22	
Total	28	21	31	0	29	107	81	103	

Table IIb--TA reception quality (in points) per month

Scrimgeour stated in his article that a period of low geomagnetism was associated with each of the TA receptions that he had observed in 1965. Was this true of all TA receptions over the 20½ year period? In general, the answer must be yes. However, extremely low geomagnetism didn't seem to be necessary for TA's to reported on WCNA. Incidentally, different A-indices had to be used for different periods over the 20½ years. Richard Eckman kindly supplied the planetary A-indices for dates up to 1970, Fredericksburg indices were used up to 1979, and Boulder indices up to 1981.

First of all, the mean of all A-indices corresponding to dates when TA's from a certain zone were reported, was calculated and appear in Table IIIa. The mode (A-value occurring most frequently) is also indicated. A number of dates of TA reception showed reasonably high A-indices (in the 10-20 range) which leads us to Scrimgeour's suggestion that the higher geomagnetism appeared after TA's were heard on those dates. So, a new A-index was calculated for each reception; this one was the average of the A-index of the reception date with the A-indices from the two previous days. Then the mean and mode A-index for reception from each zone was claculated again and appears in Table IIIb.

WCNA zone	TA zone	A-index mean	mode
A	1	5.0	3
	2	5.8	2
	3	5.5	4
	4	5.9	3
B	1	5.7	2
	2	5.1	2
	3	4.4	3
	4	7.9	8

Table IIIa--Zonal TA reception vs. daily A-index

WCNA zone	TA zone	A-index mean	mode
A	1	4.7	3
	2	5.4	3
	3	5.3	3
	4	5.4	6
B	1	4.1	4
	2	4.7	5
	3	5.0	3
	4	7.6	5

Table IIIb--Zonal TA reception vs. 3-day average A-index

A word here about two loggings from Zone 1. A DXer (no longer in the club) in B.C. heard Estonia-1034 (carrier) and Murmansk-656 (audio) on January 1, 1968. The daily Fredericksburg A-index at that time was 17 and the 3-day average A-index was 20. The planetary A-indices were even higher. It's entirely possible that this reception took place on the date indicated, but it doesn't fit in at all well with the A-indices of other Zone 1 receptions. If this reception is included in the Zone A/Zone 1 mean A-index the index jumps from 5 to 5.9 in Table IIIa, and from 4.7 to 5.9 in Table IIIb. There are a number of interesting receptions through the years, particularly near sunspot maxima, where good receptions took place when the averaged A-index was 8 or higher. In the choice opening of September/October 1980, the A-index hovered between 6 and 8 with one reading of 3 in the entire period. It would appear that there's more to WCNA TA reception than waiting for the A-index to coast below 5 for a week.

Days of TA reception were then grouped together according to the number of points (quality) that each day rated, and the mean of the 3-day average A-index for each group was found. The results for Zones A and B are shown below in Table IV. There seems to be quite a nice movement in the table towards lower A-indices for dates of higher quality reception, until the middle of the table is reached, when things start to go haywire a bit. Two suggestions: There were very few days of really high quality TA reception, so any mean calculated could have been skewed by one larger A-index.

Quality	Average A-index Zone A	Zone B
1	5.8	8.3
2	5.5	6.6
3-4	5.0	5.4
5-6	4.6	4.6
7-8	4.0	3.0
9-10	5.0	-
11-12	-	8.0
13-14	6.3	-
15-16	4.7	-
17-18	5.5	-
20+	4.0	4.0

Table IV--Quality of daily TA opening vs. average A-index

Were TA's heard one or two days later?
Zone A: yes--47% no--53%
Zone B: yes--41% no--59%
Were TA's heard 25 to 30 days later?
Zone A: yes--15% no--85%
Zone B: yes--22% no--78%

Table V

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Possibly however, there is simply more to a good opening than a low A-index, and that slightly higher A-indices may actually be a prerequisite for a high quality opening, particularly near sunspot maximum. There will have to be a lot more high quality openings in order to make an educated guess.

TP DXers on the WC and TA DXers on the EC have generally found that there is a good chance that one will hear DX from a desired region in runs of two days or more, and that 25 to 30 days later there will sometimes be a repeat of a good opening. Do these observations apply to TA DX from WCNA as well? They certainly seem to; see Table V above. (These observations may be skewed if DXers made a point of DXing the next night or 25-30 days later, while not DXing at any other time.) When you realize that in the most probable month for TA DX, there's only about a 5% chance that a TA will be heard on any evening, 41 or 47% for next day DX looks pretty good. A 15 or 22% chance for TA DX in 25-30 days time doesn't look too bad either. Particularly in Zone A, it seems that the 25 to 30 day DX cycle is more predominant during years of low sunspot activity. It also seems that fairly often, a dead night for TA DXing may not mean the end of an opening; signals may be back in force the next night.

In Medium Wave News of April, 1981, Ken Brownless wrote an article on reception of WCNA from the U.K. All stations received there have been 50 kw ones, and they range in location from Los Angeles to Vancouver. Particularly interesting receptions were of KNX-1070 at 0610 UT on May 27, 1966 (Zone 2 TAs have never been heard on WCNA later than late March. Also, August 28, 1967 showed WCNA DX in the U.K. Earliest worthwhile opening here was Sept. 14, 1964.) and KING-1090 on February 23, 1969 after a severe geomagnetic storm on the 20th. Generally, however, the A-index has been 5 or under for WCNA reception. Times when WCNA was heard in the U.K. vary from 0145 to 0800 UT which is about the same as the times TA's have been noted in WCNA, though there were one or two as early as 0100 on this side of the water.

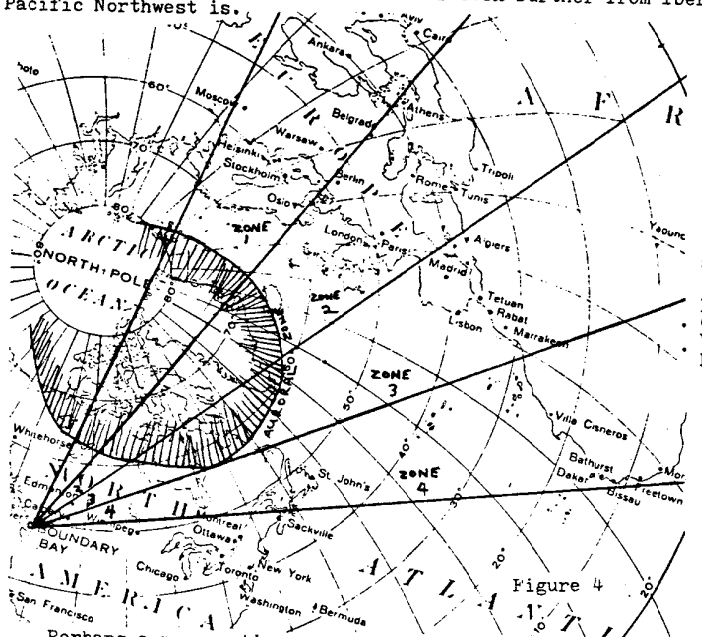
It's often assumed that DX reception is reciprocal on MW (if interference conditions allow). However, many of the openings noted in Brownless' article show no corresponding opening on WCNA, especially in the '60s. This may simply mean that here were few WCNA DXers actively searching for TA's. In the peak 64-65 season, only about 5 DXers sent in TA loggings to the DX bulletins, and only Roy Millar was living north of San Francisco.

Table VI

Zone 1		Zone 2	
* Murmansk-656	(A - 6; now 657)	* Eire-566	(A-2; now 567)
* Lithuania-665	(A,B-3; now 665)	* BBC-647	(A,B-26)
Bulgaria-774	(A - 1)	BBC-648	(A - 3)
* Lebanon-836	(A - 1; now 837)	tDDR-657	(A - 2)
* Leningrad-872	(A - 2; now 873)	tBBC-693	(A - 1)
Turkey-1017	(A,B-4)	*tAndorra-701	(B - 1)
* Estonia-1034	(A,B-8; now 1035)	Holland-747	(A - 8)
*tLithuania-1106	(A - 2; now 1107)	W. Germany-756	(A -12)
*tEgypt-1106	(B - 1; now 1107)	* Andorra-819	(A,B-6)
* Sweden-1178	(A - 1; now 1179)	tItaly-846	(A,B-5)
*tHungary-1187	(A - 1; now 1188)	*tFrance-863	(A - 2, now 864)
tPoland-1206	(A - 1)	AFN-873	(A,B-6)
* Estonia-1214	(A,B-2; now 1215)	BBC-882	(A,B-24)
		W. Germany-1017	(A - 2)
Zone 3		* Austria-1025	(A - 1; now 1026)
* Algeria-529	(A - 4; now 531)	DDR-1044	(A,B-15)
* Portugal-665	(B - 4; now 666)	tBBC-1053	(A,B-2)
Portugal-782	(B - 1)	* BBC-1088	(B - 1; now 1089)
* Morocco-818	(B - 2; now 819)	* Czechoslovakia-1097	(A - 1; now 1098)
*tMorocco-827	(B - 1; now 828)	* AFN-1106	(A - 1; now 1107)
* Canary Is.-836	(B - 2; now 837)	VOA-1197	(A,B-17)
*tSpain-854	(B - 1; now 855)	France-1206	(A,B-21)
Algeria-891	(A - 3)	* BBC-1214 (to 1215)	(A,B-47, mostly CA)
* Morocco-935	(B - 1; now 936)	* Albania-1214	(B - 5; now 1215)
* Portugal-1034	(A,B-8; now 1035)	* Germany-1268	(B - 1; now 1269)
* Morocco-1043	(B - 1; now 1044)	*tFrance-1277	(A,B-2; now 1278)
		*tCzechoslovakia-1286	(B - 1; now 1287)
Zone 4		* France-1376	(A,B-4; now 1377)
Dakar-765	(A,B-47,mostly CA)	* W. Germany-1421	(B-1; now 1422)
* Sierra Leone-1205	(B -13)	* Albania-1457	(A - 1; now 1458)
Guinea-1403/4	(A,B-15, mostly CA)	* Monaco-1466	(A - 4; now 1467)
		* France-1554	(A,B-3; now 1557)
		* W. Germany-1586	(A,B-2; now 1593
		W. Germany-1593	(A - 1)
		* W. Germany-1602	(B - 1)

Perhaps we can start to tie together some conclusions from all this. First, (and of some importance to the DXer) in Table VI above, is what has been heard from various zones. In parentheses after each station is the zones of WCNA from which it has been heard and the number of loggings over 20½ years. Stations no longer on the frequency have been noted with an asterisk. Where a station was shifted only a kHz or two in the 1978 switch to 9 kHz spacing, its new frequency is fiven if it has been heard on the new frequency. Otherwise, the old frequency is given. A t indicates a tentative.

One point to note in this list of receptions is the relative lack of TA's heard above 1300 kHz in spite of a number of high powered stations on those frequencies. Another point to note is that Guinea-1404 in particular, has been received in California quite a bit more often than noted here. DXers over the years have made comments like "fairly regular" in their reports without giving specific dates. The almost complete lack of Zone 3 loggings from Zone A is particularly interesting in light of the fact that Iberia and Morocco are most common from the northeastern U.S. Relative distance is probably one reason, as Iberia is considerably further away from, say, Seattle, than northern Europe is. However, Zone 3 loggings are more common in California, which is even further from Iberia than the Pacific Northwest is.



azimuthal equidistant projection centered near Vancouver, B.C.

Figure 4

Perhaps a propagation expert can take the data herein and come up with a reasonable explanation for the TA reception patterns noted from WCNA. In the meantime, here is a possibility. East Coast DXers have usually regarded the southern edge of the auroral zone as the barrier to high latitude DX. Indeed, this seems to be true for DX from West Africa to WCNA. Usually, signals from Iberia to WCNA will be absorbed by the auroral zone, just as are signals from Sweden to ECNA. Why, then, do WCNA DXers hear higher latitude signals when Iberian and Moroccan or even West African signals are blocked? Well, the auroral zone is shaped more like a doughnut than a cap (see Figure 4 above for an approximation of the zone during an extended quiet period), and it seems likely that signals can skip under or over the auroral zone into the clear area, and then skip under or over the other side of the zone. See R.J. Edmunds' "Transpolar DX" (NRC reprint P17) for a detailed discussion of this possibility. So, the northern edge of the auroral zone would concern WCNA DX

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to hear from a propagation expert just what variations occur in the northern edge of the auroral zone during changes in geomagnetic activity.

This hypothesis may help to explain why California DXers have heard Portugeuse stations when Washington DXers have not--the signals are passing south of the auroral zone for Californians, but are being absorbed for more northerly DXers. Possibly Californians hear fewer northern Europeans because a) they're further away, and b) the more southerly path makes it more likely that signals will not successfully skip through the center of the auroral ring. In 1965 Roy Millar said in DX News that in Washington state "Dakar is the only true Trans Atlantic, others are Trans Arctic". As we move further north in western North America, it's likely that DXing conditions would become closer to what Brian Vernon and other Arctic DXers have experienced, i.e. that TA DX would become more common.

So it would seem that the WCNA DXer isn't in quite the same boat as the ECNA DXer when it comes to receiving TA's. He will certainly need a good receiver and loop (though a modified TRF and Shotgun loop have received West Germany-756 out here), and he needs a period of geomagnetic quiet in the fall for the best TA possibilities. But TA's also appear under mildly unsettled conditions in years other than the sunspot minimum, so it would seem that quiet geomagnetic conditions are not everything. In the Pacific Northwest particularly, the most likely TA's (northern Europeans) are quite unlike the most likely TA's in the northeast U.S. (Iberia, Morocco etc.). However, TA openings seem to have runs of a few days and occasionally repeat after 25-30 days just as they do in the east.

In a letter to various WCNA DXers about a year ago, Bob Foxworth suggested another approach to TA DX. For a few weeks around the winter solstice, sunrise in WCNA corresponds with sunset in north central and north western Europe. The great circle signal path follows the terminator quite closely at this time (keeping in mind that Arctic areas are in darkness) so it would appear that DXing for TA's around WCNA sunrise might also be a possibility, if conditions are right. There have been TA openings around the winter solstice during years of sunspot minimum, so it might be worth a try, especially for TA's further to the east and north. There have been a few tentative loggings of Murmansk-656 (now 657) around local sunrise from WCNA and Colorado; a NE-SW carrier was heard in Victoria on 756 on Jan. 14, 1982 when TPs were good, but it's possible that New Zealand was making a weak appearance rather than West Germany. So if good TP DX is in around December and January, why not swing the loop around and see if something is cooking on the other side of the globe?

We are now looking forward to a sunspot minimum in about 1986. If there is a 22 year DX cycle to correspond with the sunspot cycle, then we will be in for a repeat of the 1964-65 season when many interesting TA's were heard on the west coast. Ken Brownless of Medium Wave Circle feels (from observing past cycles) that DX should start picking up in the autumn of this year, so don't wait until 1986 to start hunting for TAs. Now, where are the California TA DXers? Some sort of TA warning phone network should be set up, so that DXer A will phone DXer B and so on all up and down the coast. The calls should be cheap as few enthusiastic DXers will stay on the line to chat once told that TA's are coming in! If you're interested, contact Nick Hall-Patch, 1538 Amphion St., Victoria, B.C. V8R 4Z6, Canada (phone 604-595-7666 if the TAs are in!) and we'll try to set something up. Who will be the first to log Estonia-1035?

(Special thanks to Richard Eckman, Ken Brownless, and Roy Millar for their assistance in the preparation of this article)

CUBANS THREATHEN TO FLOOD FLORIDA

By: W. George Elliott

A radio station in Vancouver, British Columbia could find itself competing with English-language broadcasts from Radio Moscow if Cuba decides to go ahead with a threat to flood Miami, Florida with the programs.

The station, CJOR, broadcasts with ten-thousand watts but at night the station will receive interference from the huge five-hundred-thousand watt Cuban transmitter.

CJOR General Manager, Ron Vandenberg, says the Cuban signal would be heard from Cuba to Alaska because of it's strenth. The Cubans threatened to flood Florida radio stations with Russian propaganda broadcast on the frequency of 600 kilohertz.

The Vancouver station also shares the frequency and Vandenberg says they have two choices. The station could boost it's power to fifty-thousand watts if the station in Cuba does cause problems. Or CJOR could change frequency, but Vandenberg notes that the move would cost a great deal of money.